5th INTERNATIONAL SYMPOSIUM ON INDUSTRIAL ENGINEERING

FACULTY OF MECHANICAL ENGINEERING
UNIVERSITY OF BELGRADE
INDUSTRIAL ENGINEERING DEPARTMENT
and
STEINBEIS ADVANCED RISK TECHNOLOGIES
STUTTGART, GERMANY

SIE 2012

PROCEEDINGS

Editors: Dragan D. Milanović
Vesna Spasojević-Brkić
Mirjana Misita

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PREFACE

The aim of the 5th International Symposium on Industrial Engineering – SIE 2012 is to contribute to a better comprehension of the role and importance of Industrial Engineering and to mark **the twentieth anniversary of the Industrial Engineering program in Serbia**, established at FME, Belgrade. The Symposium aims to provide a forum for academics, researchers and practitioners to exchange ideas and recent developments in the field of Industrial Engineering. The Symposium is also expected to foster networking, collaboration and joint effort among the conference participants to advance the theory and practice as well as to identify major trends in Industrial Engineering today. According to these goals the Symposium addresses itself to all experts in all fields of Industrial Engineering to make their contribution to success and show capabilities achieved in the work that has been done are very welcomed.

The objective of the 5th International Symposium on Industrial Engineering is to provide an international forum for the dissemination and exchange of scientific information in industrial engineering fields through the following topics:

- Decision Analysis and Methods
- E-Business and E-Commerce
- Engineering Economy and Cost Analysis
- Engineering Education and Training
- Enterprise Information Systems
- Entrepreneurship
- Engineering Economy
- Engineering Management Systems
- Facilities Planning and Management
- Global Manufacturing and Management
- Human Factors
- Intelligent Manufacturing Systems
- Inventory Management
- Logistics and Supply Chain Management
- Manufacturing Systems
- Operations Research
- Production Planning and Control
- Project Management
- Quality Control and Management
- Reliability and Maintenance Engineering
- Service Innovation and Management
- Systems Modelling and Simulation
- Operations Management
- Service Engineering
- Safety, Security and Risk Management including special topic "*Risks and Opportunities of New Industrial Technologies*"

The book brought together around 150 authors from 16 countries, namely from Serbia, Germany, Portugal, Spain, Egypt, Finland, Bulgaria, Slovakia, Canada, Lybia, FR Macedonia, Austria, Croatia, Slovenia, Bosnia and Herzegovina. The authors ranged from senior and renowned scientists to young researchers. We expect that papers and discussions will contribute to better comprehension the role and importance of Industrial Engineering in this country, both in domain of scientific work and everyday practice.

Our efforts in organizing would not succeeded without the considerable help of the members of Scientific Programand Editorial Board and the financial help of the sponsors was greatly supportive for the success of the entire project.

At the end, the editors hope, and would like, that this book to be useful, meeting the expectation of the authors and wider readership and to incentive further scientific development and creation of new papers in the field of industrial engineering.

Welcome to the 5th International Symposium on Industrial Engineering – SIE 2012!

Belgrade, June 2012

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PLENARY SESSION

SIE 2012

THE TWENTIETH ANNIVERSARY OF INDUSTRIAL ENGINEERING DEPARTMENT AT THE FACULTY OF MECHANICAL ENGINEERING UNIVERSITY OF BELGRADE

Dragan D. Milanović, Vesna Spasojević-Brkić, Mirjana Misita, Uglješa Bugarić
Industrial Enginering Department, Faculty of Mechanical Engineering,
University of Belgrade

Abstract. *This paper presents formation and development of Industrial Engineering studies at the Faculty of Mechanical Engineering in Belgrade. It contains instructional plans and programs, and main work results of studies over the past 20 years.*
Keywords: *Industrial engineering, plans, programs, students*

FORMATION OF INDUSTRIAL ENGINEERING

Birth and development of industrial engineering is related to France at the time of Napoleon, when "Polytechnic School" (Ecole Polytechnique) was founded in 1794. In 1829, the school was renamed "Central School of Art and Industry" (Ecole Centrale des Arts et Manufactures) and this year can be taken as the year of appearance of industrial engineering studies [1]. The first department of Industrial Engineering was established in 1908 at the University of Pennsylvania in the USA [2]. In the first half of the 19th century, leading industrial countries such as Britain, Spain, Austria, Germany, Switzerland and the United States made a significant contribution to development of industrial engineering. Methods and techniques of industrial engineering development and their application in business, conditioned the appearance of university plans and programs in this field. Industrial engineering became well known and accepted by business people from the industry. Prior to mid 1950s IE was primarily concerned with human interactions in manufacturing systems, and after that period, with appearance of new mathematical/statistical methods IE shifts from qualitative to quantitative problem solving [6].

Industrial Engineering has been defined by the American Institute of Industrial Engineering, in 1955, and it states that [1]: Industrial Engineering deals with designing, specialization and installation of integrated systems of machines, materials and people. It uses scientific knowledge in mathematics, natural and social sciences, linking them with the modern principles of engineering analysis, in order to determine predictions and assessments of results obtained from these systems [2].

Since 1950's, the scientific disciplines in the field of industrial engineering appear at the Faculty of Mechanical Engineering in Belgrade. During the school year of 1948/49, lectures on the subject “Scientific organization of labor” were held. In order to come closer to American plans and programs, which have been proven as very successful, the subject Scientific organization of labor has transformed into subjects Organization and economy of production, and the Organization of production 2, and afterwards, following subjects have been introduced: Organization of production, Organization and preparation of production, Organization operation A and B, Methods of quantitative analysis, Study and measurement of work, Engineering economy, Ergonomics, Maintenance of machinery and Organization of production problems. Back then, study direction name was the Organization of production. Industrial Engineering study, under current name was formed in 1991, at the Faculty of Mechanical Engineering, University of Belgrade.

It has been accepted with great interest and enthusiasm by the students of Faculty of Mechanical Engineering in Belgrade. It was established thanks to great persistence and work of professors who held lectures in this area. The survey was conducted in the economy and it showed that 70% of employed graduated mechanical engineers worked in the area of industrial engineering. Survey conducted in 26 companies of domestic industry showed that at that time there was a lack of 418 experts in the field of Industrial Engineering and predictions showed that in the next 10 years that number will be tripled.

Events in the period that followed have fully confirmed the validity of such predictions. Educational plans and programs of department of

Industrial Engineering at the University in Belgrade were created, as a result of extensive analysis of plans and programs of Mississippi State University (USA) and specially Purdue University Indiana, West Laffayette.

At the Faculty of Mechanical Engineering, the field of Industrial Engineering is perceived as the process of integration of technical -technological components of production and human factors in order to successfully manage production and business at companies. Preparing a graduate for a wide variety of jobs upon graduation is one of the unique aspects of IE program [8]. Complexity of problems to be solved requires a multidisciplinary and interdisciplinary approach.

Industrial Engineering as the department at the Faculty of Mechanical Engineering in Belgrade is very attractive and interesting for a number of students, as predicted by U.S. Department of Labor, Bureau of Labor Statistics, industrial engineers are expected to have employment growth of 20 percent over the projections decade, faster than the average for all occupations [4].

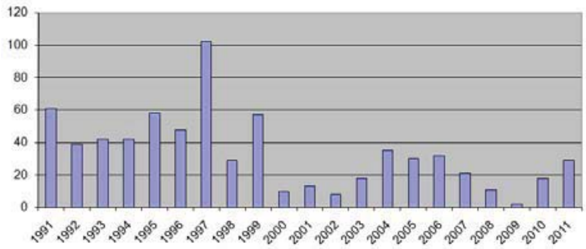

Table1. Enrolled students at Industrial Eng.Dep.

Almost every year, due to the limited number of students registered at departments, it happens that the number of enrolled students is less than the number of interested persons. Tables 1 and 2 show the number of enrolled students and number of graduates in the last 20 years.

During the last 20 years, total number of enrolled students was 705 or approximately 34 students per year, and the number of graduates was 545 or approximately 26 students.

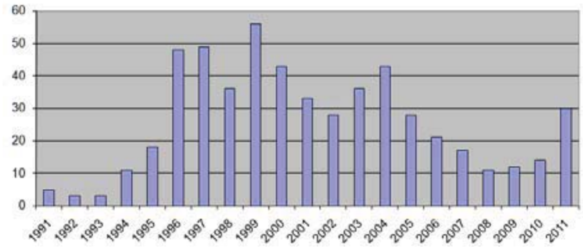

Table 2. Graduates at Industrial Eng. Dep.

These results, according to the number of enrolled students and graduates, distinguishes department of Industrial Engineering at third position in relation to other departments at the Faculty of Mechanical Engineering in Belgrade. Significant activities of department of Industrial Engineering are master and PhD studies, for which there is a great interest among students. In the same period of time, 41 master theses were defended, as well as 24 doctoral dissertations. The biggest contribution to the great success and popularity of department of Industrial Engineering at the Faculty of Mechanical Engineering in Belgrade is provided by members of department of Industrial Engineering by their high quality and professional work, and by giving great importance to the work with students in order to provide complete theoretical and practical knowledge.

Table 3 presents elective subjects belonging to the Industrial Engineering at the bachelor level and teacher's names.

INDUSTRIAL ENGINEERING – Bachelor Studies

Hours weekly	1st year		2nd year		3rd year	
	1	2	3	4	5	6
1–5	Mathematics 1	Mathematics 2	Mathematics 3	Thermodynamics B	Fluid mechanics B	Electrical and electronic engineering
6–10	Mechanics 1	Basic of strenght of constructions	Mechanics 2	Mechanics 3	Numerical methods	Control engineering
11–12	Constructive geometry and graphics	Engineering graphics	Machine elements 1	Machine elements 2	Manufacturing technology	6.3.5 Business-production information systems Professor: Dragan D. Milanović
13–15	Strength of materials	(cont.)	(cont.)	(cont.)	(cont.)	(cont.)
16–17	Physics and measurements	Enigneering materials 1	Enigneering materials 2	4.4.5 Business management Professor: Slobodan Pokrajac / Managemeng of production processes Zorica Veljković Mirjana Misita	5.4.5 Production management 1 Professor: Vesna Spasojević Brkić	6.4.5 Maintenance management Professor: Uglješa Bugarić
18–20	(cont.)	Basic of sociology and economics	(cont.)	(cont.)	(cont.)	(cont.)
21–22	English 1	English 2	3.5.5 Introduction to industrial engineering Professor: Dragan D. Milanović / Engineering economy analysis Professor: Dragan Lj. Milanović	SKILL PRAXIS B-IIE Professors: Vesna Spasojević Brkić Mirjana Misita	5.5.5 Industrial ergonomics Professor: Aleksandar Žunjić	Final course with a report (B.Sc. work)
23–25	Programming	Computer tools	(cont.)	(cont.)	(cont.)	(cont.)

Table 3. Basic academic studies (Bachelor)

Table 4 presents subject modules and elective subjects of the section of Industrial Engineering Master of academic studies as well as the names of the teachers.

INDUSTRIAL ENGINEERING – Master studies

1st year		2nd year	
7	8	9	10
1.1.5 Production management 2 *Professor: Dragan D. Milanović*	**2.1.5 Industrial logistics** *Professor: Dušan Petrović*	**3.1.5 Operations research** *Professor: Uglješa Bugarić*	
1.2.5 Quantitative methods *Professor: Zorica Veljković*	**2.2.5 Ergonomics design** *Professor: Aleksandar Žunjić*	**3.2.5 Database** *Professor: Mirjana Misita*	
Mechanics M or Fluid mechanics M	**2.3.5 Engineering economy** *Professor: Dragan Lj. Milanović*	**3.3.5 Industrial mangement** *Professor: Slobodan Pokrajac*	**4.9 M.Sc. thesis (Diploma work)**
Thermodynamics M or Mechatronics	**2.4.5 Terotechnological risk management** *Professor: Vesna Spasojević Brkić*	**3.4.5 Organizational design** *Professor: Vesna Spasojević Brkić*	
1.5.5 Management information systems *Professor: Mirjana Misita*	**2.5.5 Design of logistic and warehouse systems** *Professors: Dušan Petrović Uglješa Bugarić*	**3.5.5 System man-machine design** *Professor: Aleksandar Žunjić*	

Table 4. Master academic studies

The most important resource of this section, are the employees at the Department of Industrial Engineering. Department consists of three organizational units: Department of Industrial Engineering consisting of nine graduate mechanical engineers, the Cabinet for social and economic sciences which consists of three graduate economists and Department of Foreign Languages, which has 2 English language lecturers.

Department of Industrial Engineering	1. Prof. PhD Dragan D. Milanović 2. Asoc.prof. PhD Uglješa Bugarić 3. Asoc.prof. PhD Dragan Lj. Milanović 4. Asoc.prof. PhD Vesna Spasojević-Brkić 5. Asoc.prof. PhD Aleksandar Žunjić 6. Asoc.prof. PhD Dušan Petrović 7. Ass.prof. PhD Zorica Veljković 8. Ass.prof. PhD Mirjana Misita 9. MSc Tamara Sedmak, assistant
The cabinet for social and economic sciences	1. Prof.PhD Slobodan Pokrajac 2. Asoc.prof. PhD Nikola Dondur 3. MSc Sonja Josipović, assistant
Department of foreign languages	1. Mr Nada Krnjajić-Cekić 2. Mr Tijana Vesić-Pavlović

Table 5. Teaching staff and co-workers for the Industrial Engineering section

Table 5 shows personnel employed at the Department of Industrial Engineering.Along with the full commitment to teaching and working with students, teachers and staff also achieve significant results in scientific research in the field of Industrial engineering. As a contribution to that statement there is a large number of papers published in international and national journals and at conferences. Books for almost all subjects and a number of monographs in the field of industrial engineering have been published as well. At the same time members of the Department participate in several national and international projects. Actual projects at this moment are:

1. Design and evaluation of user interface for remote collaborative management of production systems, bilateral cooperation - program of scientific and technological cooperation between Serbia and the Republic of Portugal for the period of 2011-2012.
2. Development of new generation of crane cabins as integrated visual systems for detection and interpretation of environment, Eureka project, E!6761, 2011-2014.
3. TR 35017 - Development of a stochastic model of determining the elements of the cycle time of production and their optimization for series production in the metal industry and in the process of recycling, MPNRS, 2011-2014.
4. FP7 – iNTEgRIsk, Early Recognition, Monitoring and Integrated, Management of Emerging, New Technology Related Risks, 2008-2013. Coordinator: EU-VRi European Virtual Institute for Integrated Risk.
5. Development and conquering of economic and special systems for the use and maintenance of fleets of vehicles and the development and implementation of an appropriate information system, Ministry of Science and Environmental Protection, the period of 2008-2011.

Department of Industrial Engineering has very good and successful cooperation with universities: Universidade do Minho, Braga/Guimaraes, PORTUGAL, University of Alberta Edmonton, Alberta CANADA and Universitat de Girona, Girona, SPAIN. This cooperation is significant in terms of internationalization of teaching processes and adjustment of plans and programs with the European and International university standards, to ensure mobility of students and professors.

PERSPECTIVES OF INDUSTRIAL ENGINEERING

During the last few years, department has made effort to improve the laboratory work by purchasing new equipment. Providing funds for equipment and laboratory accreditation is one of the most important tasks in the near future.

Department of Industrial Engineering aims to follow the development of industrial engineering, which, significantly differs from Industrial Engineering at its beginning. The scope of theoretical knowledge is getting wider, new methods and techniques are developing and perfecting, which is increasing the use of computers and other technical systems to solve problems in this area [7]. That is why the teachers and co-workers are being asked to continuously improve and coordinate teaching plans and study programs. Earlier studies presented in literature [5] and surveys with graduates, students and employers have revealed that IE education has problems such as theoretical approach to problem solving, insufficient understanding of real-life problems, and poor communication skills.

The last time that new teaching plans and programs were formed in accordance with the Bologna Declaration was in 2005. In 2010 their modification was carried out and since then they are under constant supervision and control of the teachers. It is required from students, in addition to current knowledge, to constantly improve knowledge and application of information technology in order to successfully manage and make decisions in companies. Large dynamic of events in the field of industrial engineering requires expertise and wisdom of teachers to maintain permanent knowledge and basis of industrial engineering as well as adaptability and flexibility, brought by the times in which we operate and live.

The labour market in the EU is evolving towards the service sector even if manufacturing still represents a significant share of both IE employment and gross domestic product. On average, IE in the EU is still within the framework of the 'market-driven' paradigm, which contrasts with the knowledge society aims pursued by the 'Bologna process'. R&D resources and human capital are identified as major success factors to overcome current limits for IE development in the EU [9].

Perhaps the most critical issue facing Industrial Engineering still is the need to increase the visibility of educational and career opportunities, going together with lack of knowledge about what Industrial Engineering Technology is since industrial engineers job titles differ from their profession's name [7].

To solve future challenges Quality Function Deployment framework usage is proposed. Good practice of QFD usage is seen in Sweden, where QFD process was used to develop a Mechanical Engineering Programme which was more responsive to changes in industry [11] and to improve IE education quality at the Middle East Technical University in Turkey [12].

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FUZZY SYSTEMS TO SUPPORT INDUSTRIAL ENGINEERING MANAGEMENT

Isabel L. Nunes
Faculdade de Ciencias e Tecnologia, Universidade Nova de Lisboa, Portugal

Abstract. *This paper presents the potentialities of Fuzzy Set Theory to deal with complex, incomplete and/or vague information which is characteristic of some industrial engineering problems. Two systems that were developed to support the activities of industrial engineering managers are presented as examples of the use of this mathematical methodology.*

Key words: *Ergonomics, Work Related Musculoskeletal Disorders, Supply Chain, Resilience, Disturbances*

1.INTRODUCTION

Many problems in Industrial Engineering are complex and have incomplete and/or vague information. Also the dynamics of the decision environment limit the specification of model objectives, constraints and the precise measurement of model parameters (Kahraman et al., 2006). Fuzzy Set Theory (FST) developed almost fifty years ago by L.A. Zadeh (Zadeh, 1965), is an excellent framework to help solve these problems. According to (Kahraman, 2006) Industrial Engineering is one of the branches where FST found a wide application area. (Kahraman et al., 2006) present an extensive literature review and survey of FST in Industrial Engineering. A review of the application of FST to human-centred systems can be found in (Nunes, 2010).

This paper presents two application examples of fuzzy decision support systems aiming to support industrial engineering managers in two different areas of risk management: ergonomics and supply chain disturbances management.

2. FUZZY SET THEORY

FST provides the appropriate logical/mathematical framework to deal with and represent knowledge and data, which are complex, imprecise, vague, incomplete and subjective (Zadeh, 1965). It allows the elicitation and encoding of imprecise knowledge, providing a mean for mathematical modeling of complex phenomena where traditional mathematical models are not possible to apply.

A fuzzy set (FS) is the generalization of classical (crisp) set. By contrast with classical sets which present discrete borders, FS presents a boundary with a gradual contour. Formally, let U be the universe of discourse and u a generic element of U, a fuzzy subset A, defined in U, is a set of dual pairs:

$$A= \{(u, \mu_A(u)) \mid u \in U\}$$

where $\mu_A(u)$ is designated as membership function or membership grade u in A. The membership function associates to each element u, of U, a real number $\mu_A(u)$, in the interval [0,1], which represents the degree of truth that u belongs to A.

Using FST it is possible to evaluate the degree of membership of some observed data, originating either from an objective source or a subjective source, to some high-level concept. Let us consider, for example, the evaluation of the *delay disturbance* based on the continuous membership function presented in Figure . A low degree of membership to the disturbance concept (i.e., values close to 0) means the delay is acceptable; while a high degree of membership (i.e., values close to 1) means the delay is unacceptable (Nunes & Cruz-Machado, 2012).

The human-like thinking process, i.e., approximate reasoning is well modeled using Fuzzy Logic (FL), which is a multi-value logic concept based on FST (Zadeh, 1996). Thus FL permits to process incomplete data and provide approximate solutions to problems that cannot be solved by traditional methods. It allows handling the concept of partial truth, where the truth value may range between completely true and completely false. Furthermore, when Linguistic Variables (LV) are used, these degrees may be managed by membership functions (Zadeh, 1975a; 1975b; 1975c). A LV is a variable that admits as values words or sentences of a natural language (Figure 2), their terms can be modified using linguistic hedges (modifiers) applied to primary terms.

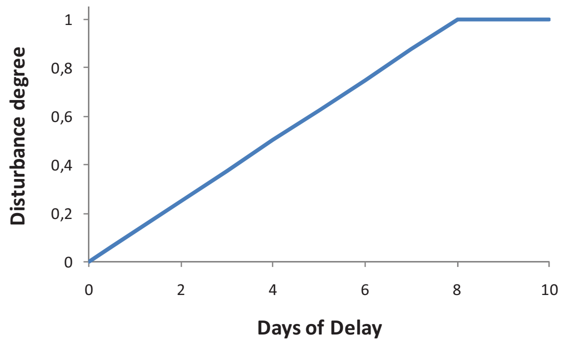

Figure 1 - Fuzzy set *delay disturbance* (Nunes & Cruz-Machado, 2012)

FST can be used in the development of, for instance, fuzzy expert systems or fuzzy decision support systems. The following cases are examples of these types of systems that can support industrial engineering managers' activities.

3. EXAMPLES OF FUZZY SYSTEMS

3.1 FAST ERGO X

Work-related musculoskeletal disorders (WMSD) are diseases related and/or aggravated by work that can affect the upper and the lower limbs as well as the neck and lower back areas. WMSD can be defined by impairments of bodily structures such as muscles, joints, tendons, ligaments, nerves, bones and the localized blood circulation system, caused or aggravated primarily by work itself or by the work environment (Nunes & Bush, 2012).

FAST ERGO_X (Figure 3) is a fuzzy expert system designed to identify, evaluate and control the risk factors existing in a work situation, due to lack of adequate ergonomics that can lead to the development of WMSD (Nunes, 2006; Nunes, 2009).

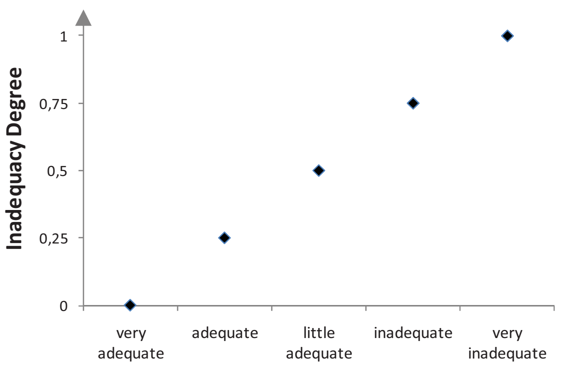

Figure 2 - Linguistic variable *inadequacy* used to evaluate "protection inadequacy" (Nunes & Simões-Marques, 2012)

FAST ERGO_X evaluates the risk factors based on objective and subjective data and produce results regarding the degree of possibility of development of WMSD on the upper body joints and about the main contributing risk factors. The results (Conclusions) are presented both quantitatively (as membership degrees to *inadequacy* fuzzy set, defined in the interval [0, 1]) and qualitatively (as terms of a linguistic variable *intensity*). For instance "The possibility for development of a WMSD on the Right Wrist is extreme (0.92)". The Conclusions can be explained (Explanations) by presenting the computed risk factors inadequacy degrees that contributed to the overall result, e.g. "The number of Repetitions performed by the Right Wrist is very high". The system also presents Recommendations that users can adopt to eliminate or at least to reduce the risk factors present in the work situation. Some of the recommendations are in the form of good practices and graphical illustrations.

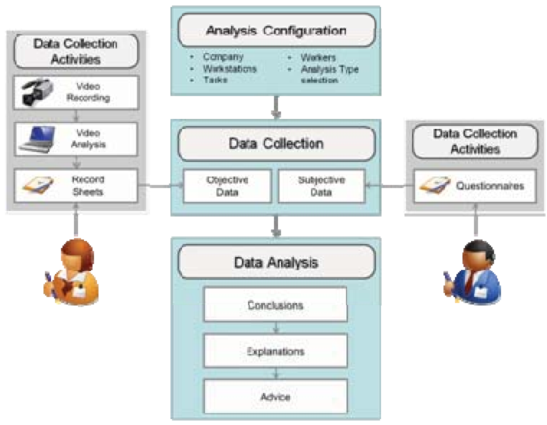

Figure 3 - Activities performed on the analysis of a work situation by FAST ERGO_X (Nunes, 2009)

3.2 A Fuzzy Decision Support System to manage supply chain disturbances

Supply Chains (SC) are subject to disturbances that can result from acts or events that are originated inside of the SC (e.g., supplier failures, equipment breakdown, employees' absenteeism) or may result from extrinsic events (e.g., social turmoil, terrorist attacks, or acts of God such as volcanic eruptions, hurricanes or earthquakes) (Nunes & Cruz-Machado, 2012). The Supply Chain Disturbance Management Fuzzy Decision Support System (SCDM FDSS) developed by (Nunes et al., 2011) was designed to assess the SC and the organizations belonging to the SC based on their performance considering the following different scenarios, normal operation, when a disturbance occurs and when mitigation and/or contingency plans are implemented to counter the disturbance. The aim of the SCDM FDSS is to assist managers in their decision process related with the choice of the best operational policy (e.g., adoption of mitigation and/or contingency plans) to counter disturbance effects that can compromise SC performance.

The system combines the use of FST to model the uncertainty associated with the disturbances and their effects on the SC with the use of discrete-event simulations using the ARENA software (a commercial simulation tool) to study the behavior of the SC subject to disturbances, and the effects resulting from the implementation of mitigation or contingency plans. The block diagram of the proposed SCDM FDSS is illustrated in Figure 4.

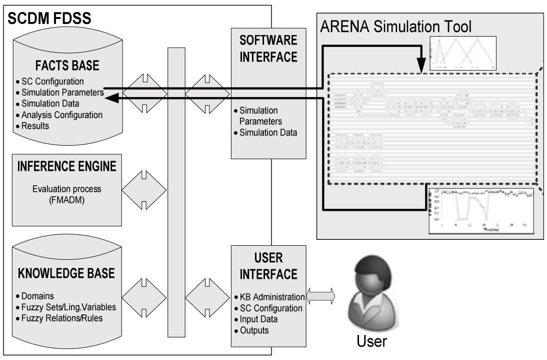

Figure 4 - Relationship between SCDM FDSS and ARENA (adapted from (Nunes et al., 2011)).

The Inference Engine offers the reasoning capability of the system. It performs the FDSS analysis using a Fuzzy Multiple Attribute Decision Making model, and fuzzy data that characterizes the analyzed situation, using for instance fuzzified Key Performance Indicators (KPI). The inference process includes 7 steps (Nunes et al., 2011):

1 - Computing the KPI for each scenario and SC entity for each simulation time period. The KPI are obtained at the end of each ARENA SC simulation;

2 - Synthesizing the time discrete KPI into an equivalent KPI for the relevant period considered (obtained through a mean function);

3 - Fuzzifying the equivalent KPI into a fuzzy KPI (FKPI). Fuzzy sets convert KPI in normalized FKPI, i.e., fuzzy values in the interval [0, 1], where a fuzzy value close to 0 means a bad performance and a fuzzy value close to 1 means a good performance;

4 - Computing of a fuzzy performance Category Indicator (CI) for each scenario and SC entity using weighted aggregations of FKPI, through the following expression:

$$CI_{ik} = \sum_{j=1}^{n} w_{ijk} \times FKPI_{ijk}$$

here:

CI_{ik} – is the fuzzy performance Category Indicator for i^{th} category of KPI and for k^{th} SC entity;

$FKPI_{ijk}$ – is the j^{th} Fuzzy Key Performance Indicator of the i^{th} category of KPI and the k^{th} SC entity;

w_{ijk} – is the weight of j^{th} Fuzzy Key Performance Indicator of the i^{th} category of KPI and the k^{th} SC entity.

5 - Computing of a fuzzy Performance Index (PI) for each scenario and SC entity using a weighted aggregation of CI, using the following expression:

$$PI_k = \sum_{i=1}^{m} w_{ijk} \times CI_{ik}$$

where:

PI_k – is the Performance Index of k^{th} SC entity;

CI_{ik} – is the fuzzy performance Category Indicator for i^{th} category of KPI and for k^{th} SC entity;

w_{ik} – is the weight of the i^{th} category of KPI and the k^{th} SC entity.

6 - Computing of a fuzzy Supply Chain Performance Index (SCPI) for each scenario using a weighted aggregation of PI, using the following expression:

$$SCPI = \sum_{k=1}^{p} w_k \times PI_k$$

where:

SCPI – is the Supply Chain Performance Index of the SC for the current scenario;

PI_k – is the Performance Index of k^{th} SC entity for the current scenario;

w_k – is the weight of the k^{th} SC entity.

7 – Ranking alternatives. Scenario results for each entity and for the SC are ranked based on their PI and SCPI, respectively, in order to identify the operational policy with more merit.

Using the results produced by the system (PI and SCPI) managers can: forecast the effects of disturbances in SC entities and on a SC as a whole; analyze the reduction of the negative impacts caused by the disturbance when operational policies are implemented; and selecting the operational policy that makes the SC more resilient. The best operational policy corresponds to the implementation that leads to the highest PI/SCPI value.

The use of fuzzy modeling and simulation offers several benefits, *inter alia*, promotes a proactive SCDM, and improves the understanding of the impact of applying different operational policies meant to prevent or counter the effects of disturbances, allowing the selection of the ones that are more effective and efficient.

4. CONCLUSIONS

FST has been used since the sixties as a way to deal with complex, imprecise, uncertain and vague data in different areas of industrial engineering.

In this paper the main characteristics and advantages of the use of FST were highlighted. Two examples of fuzzy systems applied to support decision-makers in the industrial engineering context were very briefly presented (one in the field of ergonomics and other in the field of supply chains' management).

The objective was to raise awareness to the industrial engineers present in this conference to the potential that FST offers as a modelling tool to address complex phenomena that many industrial problems present.

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MANAGING COMPETENCES FOR COMPETITIVE WORKING FORCE IN INDUSTRIAL ENGINEERING AND MANAGEMENT

Robert Minovski[1]
[1]Professor, Faculty of Mechanical Engineering,
University of St. Cyril and Methodius in Skopje, Macedonia

Abstract **.** The rapidly changing environment is setting new standards to the companies that want to be successful. In order to fulfill those new demands, among other things, the companies have to be equipped with competent and motivated working force. In that direction, universities have to follow those changes and ought to offer study programs that will produce competitive graduates. Competences and Competence Based Learning are some of the tools that can help in achieving those goals.
In this paper the focus is on balancing generic and specific competences in order to obtain improved study program that will answer the growing and changing demands of the employers in the area of Industrial Engineering and Management.
Key words: Generic and specific competences, Industrial Engineering and Management.

INTRODUCTION

It was not that far in the past when universities, including the technical ones, focused their educational efforts almost entirely on the theoretical fundamentals. The practical aspects were generally underestimated or totally neglected and they were left to be "treated" after the employment of their students. This produced relatively long period of adaptation of the newly employed engineers. Of course, the companies themselves were not very happy with this fact, since their natural interest is to have productive working force as soon as possible (this issue was additionally emphasized in the last few decades when the dynamic became the main characteristic of the market). In order to shorten this period, the pressure was transferred to the universities to focus also on the practical aspects of the future engineers. This, together with some essential changes in the global space for higher education (bigger number of universities with substantial number of private universities) pushed the competence based learning in front of the traditional way of learning.

COMPETENCES

There are numerous definitions on competences. Regarding the space limitation, here only one of them will be offered – "The capacity to apply the integrated (theoretical and practical) knowledge, skills and attitudes that are described in the learning outcomes of a study program in a concrete working situation at the end of the educational process", [n.n. 2011].
Additionally, there also several ways of categorising the competences. Here the focus will be only on one of the most frequently used ones – generic and specific competences. Generic competences can be defined as those that are general ones, not connected with a certain area of expertise. Specific competences are those that are relevant to a particular area of expertise.

COMPETENCE BASED LEARNING

Competence based learning can be defined as learning approach where competences are deployed as a focal point of the learning process and all important phases of that process are adopted and connected in direction of obtaining the desired output described in competences.
"Competence based learning encompasses the selection of the content and the evaluation is based on the tasks alumni have to perform competently and on the (problem) situations they have to solve competently and realistically", [n.n. 2011].
This approach differs in several aspects from the traditional way of learning and it causes certain changes in the learning process. There are several prerequisites for successful implementation of competence based learning [n.n. 2011]. Here, only two of them will be identified. Introduction of significant adaptations in the evaluation sub-process is one of those essential rudiments. Additional obstacle and reason for not implementing this approach may be the negligence of the need for certain organizational support in order to obtain sustainability of the approach [Minovski R., 2011].

CASE STUDY

The case study presented in this paper is a part of one research that was undertaken in scope of a TEMUS project [n.n. 2009], which gathered several higher educational institutions from EU and WB (Western-Balkan) countries. The general idea was to set the basis for competence based learning in the WB countries on the example of several study programs.

The implemented project-methodology was following [Beinhauer, R., Frech B., Wencel R., 2010]:

(1) Preparing and conducting of focus groups interviews
(2) Analysis of focus groups
(3) Compiling of the questionnaire
(4) Execution and analysis of the quantitative survey
(5) Development of the competence matrix
(6) Competence matrix software
(7) Planning of activities and methods for assessment
(8) Evaluation

Due to the space limitations, the more detailed description of the methodology will be avoided. In the following text the focus will be on the description of the generic and specific competences and the analysis of the obtained results.

The analysed study programs at the Faculty of Mechanical Engineering in Skopje were the undergraduate and postgraduate study programs for Industrial Engineering and Management (IE&M). It has to be pinpointed (especially for the definition of the specific competences and further analysis of the results) that the obtained degree in the undergraduate studies is Bachelor in Mechanical Engineering in the field of IE&M and in the postgraduate studies Master of Science in IE&M. Due to the limitation of space, here only results from the undergraduate study program will be presented.

Generic and specific competences defined in the research are given later in Table 2. Both generic and specific competences had certain particulars that had to be considered in the research.

The main challenge concerning the generic competences was the fact that they were not defined when the study programs were developed. As it was already mentioned, in the past this kind of the competences was almost not treated at all (one of the main challenges of this research was to analyse the need of these competences in the future work of the graduates). So, they had to be defined at this stage. Initial list of the generic competences was obtained by the focused groups by all WB universities. This initial list was than analysed by all participating universities. This analysis gave the following final list of nine generic competences, utilized in the survey:

(1) **Creativity -** Ability to solve a problem in a new way
(2) **Flexibility -** Ability to adapt and be open to new situations
(3) **Teamwork and Relationship Building -** Ability to work in teams and to utilize appropriate interpersonal skills to build relationships with colleagues, team members and external stakeholders
(4) **Critical/Analytical -** Ability to analyze problems and situations in a critical and logical manner
(5) **Self and Time Management -** Ability to organize oneself, one's time and schedule effectively and reliably
(6) **Leadership -** Ability to take responsibility for a task, give direction, provide structure and assign responsibility to others
(7) **Ability to see the bigger picture -** Ability to see how things are interconnected; ability to think both strategically and operationally, working across borders
(8) **Presentation -** Ability to prepare and deliver effective presentations to different audiences
(9) **Communication -** Ability to communicate clearly and concisely, the ability to use communication skills to positively influence individual behavior, using a range of verbal and written methods.

The specific competences had different type of challenge(s). Namely, every subject (study course) has several specific competences (3-4 in average) and every study program has normally 30-40 subjects which leads to 90-160 specific competences that have to be evaluated during the survey. So, evaluating all specific competences in such detailed level would most probably led to a complex questionnaire that would need a significant time for filling in and a very small return rate at the end. In that direction, the generalization of the specific competences had to be done. In normal case of building the competence based learning (top-down approach – starting with the general competences and ending with the competences in each subject) this should not be a problem. But, in this case where the study programs were built with the bottom-up approach (starting with the competences in each subject and ending with the general competences), the generalisation of the specific competences had to be done for the sake of the project. The way this generalization was done is shown on one example in Table 1.

It is clear from the example given in Table 1 that these general competences are joined in their nature. So, this generalisation has also certain drawbacks – the main one is the problem in evaluating such combined competences (one may think that one part of the general specific competence is important, but the other part is not – in the example in Table 1, one may consider that the ability to carry out production planning and control is very important, but the ability to design complete production systems may be totally irrelevant).

RESULTS OF THE SURVEY

The basic idea of the survey was to evaluate the need for certain competences through the investigation of the opinion of four groups of participants on 3 aspects of the generic and specific competences for two aforementioned study programs.

The four groups of participants were the following, (i) alumni with bachelor degree, (ii) alumni with postgraduate degree, (iii) employers of the alumni with bachelor degree and (iv) employers of the alumni with postgraduate degree. The 3 aspects were (a) obtained level of competences from the study program, (b) needed level of competences at the working place and (c) future need for the competences at the working place. Having in mind the several limitation factors like, project duration, restricted number of potential participants in the study (most of the WB universities lacked alumni associations in the real meaning of the word) and other, it was decided that 20 questionnaires per group i.e. 80 in total will be sufficient for the purposes of the study. In order to ensure that the competences are result of the higher educational process, the alumni had to have max. of 3 years of working experience.

The obtained results are given in Table 2. These results offer several possibilities for analysis – analysis of the absolute values for certain competences, comparison of the values between the alumni and employers, etc. Here only two topics will be briefly elucidated, Table 3.

Still, one of the most interesting results were the extraordinary values of the need of the generic competences – they are evaluated with remarkably higher values compared to the values of the most of the specific competences – both by the alumni and employers. This can lead to a conclusion that these competences have to be integrated in the process of designing of study programs.

Table 1: Example on generalisation of the specific competences

<table>
<tr><th colspan="9">SPECIFIC COMPETENCES FOR II&M – BECHLOR DEGREE</th></tr>
<tr><th colspan="3">Specific competences on level I</th><th colspan="3">Specific competences on level II</th><th colspan="3">Specific competences on level III</th></tr>
<tr><th>Code</th><th>Name</th><th>Description</th><th>Code</th><th>Name</th><th>Description</th><th>Code</th><th>Name</th><th>Description</th></tr>
<tr><td rowspan="8">SCB80</td><td rowspan="8">PRODUCTION SYSTEMS (PS) - technology, design of PS, management of PS and automation</td><td rowspan="8">To identify and define technological production processes, machines and tools for processing of the materials; to design complete production systems (factories); to carry out production planning and control (PPC); to apply the basic principles of maintenance management; to identify the elements of automation and to analyze the justification of their application.</td><td>SCB81</td><td>MACHINES AND TOOLS</td><td>…</td><td>…</td><td>…</td><td>…</td></tr>
<tr><td rowspan="4">SCB82</td><td rowspan="4">DESIGN OF PRODUCTION SYSTEMS</td><td rowspan="4">To be familiar with the details of the structure of production systems and their subsystems; to design complete production systems (factories); to design subsystems (parts of factories); to carry out rationalization, modernization and extension of production systems.</td><td>SCB821</td><td>Organizational structures of the PS</td><td>To organize the structure of the PS</td></tr>
<tr><td>SCB822</td><td>Subsystems of the PS</td><td>To be familiar with the certain subsystems of the PS</td></tr>
<tr><td>SCB823</td><td>Design of PS</td><td>To design certain subsystems of the PS and complete PS</td></tr>
<tr><td>SCB824</td><td>PS of the future</td><td>To understand the concepts of the PS of the future</td></tr>
<tr><td>SCB83</td><td>PRODUCTION SYSTEMS-PPC</td><td>…</td><td>…</td><td>…</td><td>…</td></tr>
<tr><td>SCB84</td><td>MAINTENANCE MANAGEMENT</td><td>…</td><td>…</td><td>…</td><td>…</td></tr>
<tr><td>SCB85</td><td>AUTOMATION</td><td>…</td><td>…</td><td>…</td><td>…</td></tr>
</table>

Table 2: Results from the survey

GENERIC COMPETENCES	Alumni			Employers		
	Needed	Acquired	Future	Needed	Acquired	Future
1. Creativity	2,348	2,217	2,696	2,461	2,231	2,923
2. Flexibility	2,87	2,306	2,783	2,461	2,387	2,923
3. Teamwork and Relationship Building	2,87	2,652	2,826	2,384	2,307	2,769
4. Critical/Analytical	2,479	2,217	2,694	2,31	2,233	2,538
5. Self and Time Management	2,739	2,085	2,565	2,384	2,079	2,846
6. Leadership	2,392	1,914	2,304	2,154	2	2,769
7. Ability to see the bigger picture	2,26	2,174	2,652	2,461	1,848	2,769
8. Presentation	2,219	2,435	2,437	2,31	2,308	2,769
9. Communication	2,826	2,566	2,653	2,538	2,387	2,846
SPECIFIC COMPETENCES	Alumni			Employers		
	Needed	Acquired	Future	Needed	Acquired	Future
1. Mathematics	1,44	0,91	0,56	1,54	1,54	1,23
2. Technical mechanics	0,74	1,48	0,17	1,00	0,85	0,46
3. Mechanical materials	0,26	1,17	-0,13	0,54	0,92	0,54
4. Mechanical elements, mech. design and eng. graphics	0,91	1,30	0,52	0,54	0,85	0,92
5. Energetics	-0,31	1,00	-0,44	0,31	0,69	0,54
6. Management	2,61	2,55	2,35	2,38	1,93	2,23
7. Operational research and project management	2,22	2,17	2,48	1,85	1,77	2,00
8. Production systems	1,43	1,74	1,91	1,39	1,46	2,00
9. Quality management	1,78	2,35	2,13	1,69	2,00	2,31
10. IT	2,26	2,17	2,35	1,46	1,62	2,55
11. Development issues	2,09	2,00	2,30	2,08	1,77	2,15
12. Human resource management and design of work places	1,83	2,13	2,17	1,54	1,85	2,15
13. Economic, legal and social issues	1,83	1,48	1,74	1,54	1,39	2,42
14. Entrepreneurship and small business	1,87	1,83	1,96	1,39	1,54	2,08
15. Transport equipment and business logistics	1,13	1,61	1,26	0,85	0,69	1,16
16. Foreign language	2,69	2,74	2,83	2,50	2,38	2,77

Remark*: The maximal value is 3 and minimal value is 2.*

Table 3: Some of the raised topics from the survey

Topic 1	Topic 2
Probably the weakest points in the whole curricula are some basic engineering topics. The alumni stressed in most of the cases that they are not very much needed in their career development. **Comment:** The problem is that they have a degree in: "Mechanical Engineering – Industrial Engineering and Management", meaning that they have to have such subjects for this degree. **Actions:** (1) If, in the near future, the degree becomes only "Industrial Engineering and Management", the reduction of such subjects to a certain extent may be considered. Viability: Very uncertain, since it is depending on the University and Faculty policy. (2) At this moment, the possible action would be to rearrange the syllabuses of those subjects/courses. Viability: Very low, since its feasibility is beyond the project group authority and is mostly depending on the personal attitude of certain professor.	*The generic competences are generally evaluated as a very good. Especially "Team work" and "Presentation skills". We still think that there is a plenty of room for improvement of (some of) the generic competences.* **Comment:** The good results in the above mentioned competences are result of certain changes in the curricula more than 15 years ago and now we can see the results. Some of the generic competences (here we especially mean about the "Ability to see the bigger picture", "Leadership" and some others) are not well recognized among the lecturers and as a result of that are not well emphasized in the subjects/courses. The main problem with them (e.g. "Leadership") is that they understood as a very difficult to be monitored and evaluated by the responsible lecturers and thus they are usually avoided. **Actions:** (3) More concrete integration of some of the generic competences ("Ability to see the bigger picture", "Leadership" and some others) in some subjects/courses. Viability: Very high, since this action can be undertaken in scope of the subjects/courses of the professors that are in the project group.

CONCLUCSION

It has to be stressed that this is not exactly and only quantitative research, since it is not statistically founded – on the contrary, it is more qualitative research; its main idea was to get initial overview of the situation and to set the directions for further investigations in the area. In that direction, the results of this survey and every other similar survey should be carefully analyzed due to the influence of numerous factors that can affect the results. Some of those factors are the following:

- *Type of industry of the participants.* For example, the needed lower level of specific competences in some general technical areas may be under the influence of the bigger presence of the participants from the service sector in the survey. The general structure of the industry and economy of the country may have similar impact.
- *Working experience of the participants in the survey.* Although the study is limited to participants that have maximum 3 years of working experience, it is still relatively long period and the differences in the working experience (few months vs. few years) may cause significant differences in the results.
- *Intensity of the additional education of the participants after the graduation.* The scope of the research is limited on the evaluation of the undergraduate and postgraduate formal education in IE&M. Obtained knowledge through other forms of education i.e. informal education, should not be taken into consideration
  Still, it is very difficult to separate the acquired knowledge considering the type (undergraduate education, seminars, workshops, specializations, postgraduate education, etc.), especially if it comes from one dominant source i.e. institution (e.g. the engineer obtained both degree diploma and certain certificates from different seminars offered by the same faculty/department).
- *Changes in the curricula.* The present dynamic environment affected also universities in direction of more frequent changes in the curricula. In that way, the participants may have gained the diploma under different curricula which clearly shows the possibility for additional distortion of the results.
- Etc.

Anyhow, in the recent time the interesting breakthrough was done in the design of the study programs and curricula by introducing the "voice of the customer". Still, it should not be exaggerated. The curricula should not be tailored only to certain demands by the industry. Universities should not forget their visionary role. Enterprises can be often trapped in their short term needs and may not consider the future demands – paraphrasing Ford who said, "if I asked people what do they want, they would say faster horses". In that manner, several stakeholders should be defined, besides the certain enterprises and universities. Some of those vital stakeholders should be the chambers of commerce, clusters, different state and local governmental institutions with their developmental plans, etc.

As a final remark, it should be said that one of the main findings of the survey was the great need for the generic type of competences, declared both by the alumni and employers. This clearly shows the necessitate to balance the generic and specific competences when designing future study programs. In favor of this conclusion go the findings of some studies that show that significant percent of the engineers globally do not work in the area where they have obtained their diploma. Who knows, in the near future we may face some awkward situations from today's standpoint – to educate/train the students mainly in the generic competences and to use the specific ones only as an aid/examples.

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PRACTICAL APPLICATION OF NEW EU- APPROACHES FOR OPTIMIZATION OF OPERATION AND MAINETENANCE OF REFINERY PLANTS IN SERBIA

A. Jovanovic[1], D. Balos[1], R. Guntrum[1], S. Eremic[2]
[1]Steinbeis Advanced Risk Technologies GmbH, Germany
[2]NIS GaspromNeft Refinery Pančevo, Serbia

Abstract. *The paper highlights the application of EU- approaches in the area of HSE and RBI-based asset management as applicable to the refinery plants in Serbia. The main elements of the application are (a) the integrated risk management concept (b) the normative reference and (c) software "iRiS-Petro" applied in the petrochemical industry.*
The integrated concept covers several engineering aspects among which the most important ones are RBI, RCM, RCFA and HSE/HSSE, as a company-wide Intranet-Extranet-based platform.
The normative part relies on (a) applicable EU-directives like Seveso, IPPC, REACH and similar regulation, (b) generally applicable ISO standards like ISO 31000 and (c) the specific normative documents like CWA 15740:2008 or API 580/581 standards. The iRiS-Petro systems support the above in applications such as the one presented in this paper.
The final result of the application has been (a) significant gain in availability/safety/reliability (with a respective gain in production) and (b) significant savings on inspection and maintenance.
Key words: *risk management, risk-based approaches, optimization of inspection and maintenance,*

1. INTRODUCTION

The basis of the work presented in this paper is the project on Risk management and use of risk-based approaches in inspection, maintenance and HSE analyses of NIS a.d. plants under the contract between the Petroleum Industry of Serbia and Steinbeis Advanced Risk Technologies, Germany (R-Tech).
As the first step in the project a comprehensive critical review of the state of client's assets has been made and the integrated web-based system for Risk Based Inspection (RBI), Reliability Centered Maintenance (RCM), Root Cause Failure Analysis (RCFA) and Health, Safety/Security and Environment (HSE/HSSE) analysis installed and applied on sample cases (units, systems, pieces of equipment). Corresponding training, education and certification measures have been undertaken as well to allow to the client's staff to gain the professional skills needed to apply the methods and use the system.
The solution proposed and implemented by R-Tech has included methods which are transparent and which are based on innovative, but recognized methodologies (USA, EU), widely used nowadays by the leading industrial companies, and on use of the state-of-the-art methods and software tools. This solution has provided the support for the client to understand the major issues needed for RBI, RCM, RCFA and HSE methodologies and to apply them efficiently in the shortest possible time and, in most of the cases, without having to change/replace the existing system(s).

2. CONCEPT

The applied concept covers the aspects of the safety and asset management as described below and presented in references [7] to [11] and other.

2.1 Data/Asset Management

Each piece of equipment in the system gets an appropriate data sheet for the given type of equipment that can hold all the information as required per standard specification (i.e. EN, API or ASME). In this way, the engineering and asset knowledge is centralized in one single point. Directly from the data sheets, the information can be used at the same time as equipment specification (i.e. as replacement order).
For each piece of equipment, the appropriate inspection records are kept ensuring traceable and a

detail view how the state of equipment has changed trough time, The early signs of problems can be easily identified and pinpointed. Furthermore, the inspection records can be directly used in RBI and RCM evaluations.

2.2 RBI

RBI software suite consists of the following modules:

1. Management System Evaluation Module (MSEQ)
2. API 581 unit-based module for qualitative analysis (screening) -(QLTA)
3. API 581 component-based module for qualitative, semi-quantitative and quantitative analysis
4. RIMAP-based assessment (option to be agreed with the end-user in each particular case).

The MSEQ module is questionnaire-based software for evaluation of Management Systems made according to the APPENDIX D in API 581 Base Resource Document (API 581 BRD).

QLTA is based on the Workbook for Qualitative Risk Analysis given in Appendix A of the API 581 BRD and it is used to determine the likelihood and consequence category for a given unit. Depending on the nature of the chemicals in the unit, the consequence category can be determined based on the flammable or toxic hazards for the unit. Flammable consequences are represented by the Damage Consequence Category, since the primary impact of a flammable event (fire or explosion) is to damage equipment. Toxic consequences fall under the Health Consequence Category, since their impact is usually limited to adverse health effects.

API 581 component-based module performs all the tasks necessary to determine the risk rank of the equipment and optimize the inspection plan for the equipment based on qualitative, semi-quantitative or quantitative approach.

2.3 RCM

RCM covers all the aspects of the classical RCM approach, namely:

- Failure Mode and Effects Analysis (FMEA)
- Failure Classification (FCn)
- Failure Characteristics Analysis (FCA)
- Maintenance Strategy Selection (MSS)

The RCM application allows definition of equipment templates where all the data for all four phases of the analysis can be predefined, thus allowing fast and efficient data entry. The module is completely web-based and integrated with other elements of the system.

2.4 RCFA

The RCFA identifies most significant annual losses in an organization and supplies knowledge needed to identify the causes and possibly eliminate their recurrence in the plant in the future. RCFA relies on the comprehensive and effective data collection which is absolutely needed in order to manage the knowledge about failures and their (root) causes.

RCFA provides better insight both in what could go wrong and in what has gone wrong, using Basic Failure Modes & Effects Analysis (FMEA) and Opportunity Analysis. The end result of the analyses build a business case for which events are the best candidates for Root Cause Analysis based on the Return-On-Investment.

2.5 HSE/HSSE

HSE/HSSE is concerned with protecting the safety, health, security, environment and welfare of the employees, organizations, and others (such as customers, suppliers, public…). The module in iRiS-Petro is based on current European and American standards in the area (Seveso II, ATEX, EPA requirements…); it is designed as a checklist against the requirements in order to identify critical equipment and show compliance with protection/mitigation measures.

3. NORMATIVE REFERENCE

The basic normative references are those listed under [6] to [13].

The core of the assessment is the procedure given in Figure 1.

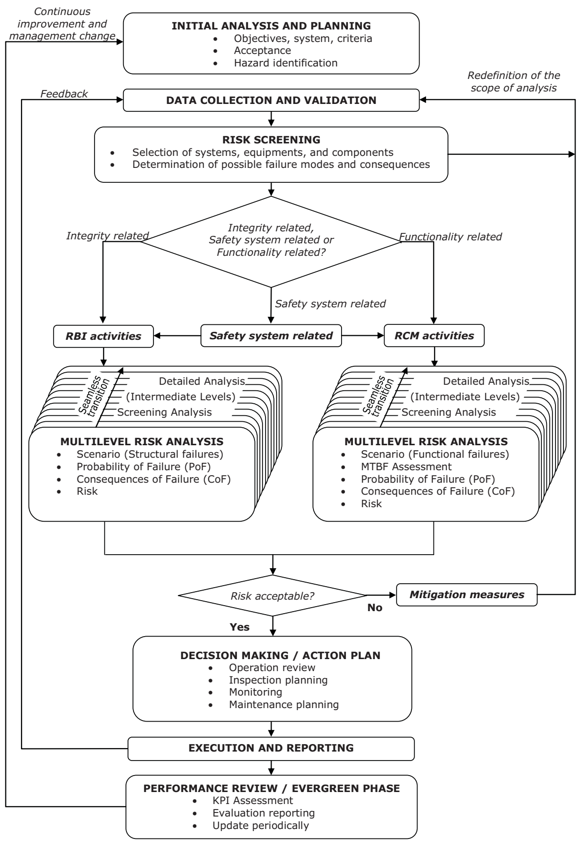

Figure 1: Framework of RIMAP procedure within the overall management system [3]

4. THE METHODOLOGY AND THE TOOL

4.1 Scope

The scope of an RBI study is to cover all the equipment items and related piping in a plant. The scope of work presented in this paper covered the following activities:

1. Understanding the system. This includes activities like HAZOP analysis, review of design assumptions, process flow diagrams, P&IDs, survey of all maintenance, inspection documents, repair and modification records, operating conditions, PSV settings, stream data, materials of fabrication, vessel coating and insulation details, review of financial data including cost of plant shut down and averages cost of process plant.
2. Preparation of Simplified Process Flow Diagrams (PFDs) with all data essential to the RBI analysis of the equipment items.
3. Development of corrosion circuits and determination of corrosion rates based on inspection history
4. Data entry and analysis using R-Tech iRIS-Petro software.
5. Preparation of documentation of corrosion rates and assessment of damage mechanisms and mode of failure.
6. Review of inspection records
7. RBI analysis and results checking
8. Preparation of RBI analysis report.

4.2 Identifying the Damage Mechanisms

The damage mechanisms of interest are those which develop over a period of time, gradually weakening the pressure boundary integrity of components until failure is predicted. Damages were identified based on supplied data, standard industry process knowledge and using the API 581 BRD together with R-Tech material and corrosion expertise.

The identified damage mechanisms included:

- External Damage (Corrosion under insulation)
- Internal thinning (generalized / Localized thinning)
- Fatigue damage on the piping systems
- Creep and other elevated temperature related damage mechanisms
- Potential of brittle fracture in the process parts.

4.3 Calculating the Likelihood of Failure

The likelihood of failure of a piece of equipment or pipe is a direct function of the nature and rate of the damage mechanisms to which it is subjected. The essential steps are to:

- identify the damage mechanism(s)
- predict the rate of degradation
- assess the inspection history.

For each equipment item, the driving damage mechanism has been identified for inspection. Based on the inspection planning targets, the Likelihood Factor for the relevant driving damage mechanism is then reduced by assigning appropriate number and effectiveness of inspection. The actual inspection scope to satisfy the assigned effectiveness is then developed based on API inspection guideline for each relevant damage mechanisms.

4.4 Calculating the Consequence of Failure

The consequences are calculated taking into account the nature and amount of the fluid released. The amount and rate of fluid released depends on factors such as the size of the hole, the fluid viscosity and density and the operating pressure.

Each piece of equipment or piping has a certain generic (industry average) probability of failure either by a pinhole type leak, a medium size hole, a large hole or a rupture. The consequence of each type of failure is calculated and later combined with the probability for that failure; to calculate the overall risk associated with each piece of equipment.

4.5 Calculating the Risk

This is now a very simple step, where the risk associated with each piece of equipment is essentially given by the formula:

RISK = Likelihood of Failure x Consequence of Failure

Understanding the two-dimensional aspect of risk allows new insight into the use of risk as an inspection prioritization tool. The consequences are calculated based on fluid properties, temperatures, pressures and inventory. The likelihood is based on “generic” or “average” failure frequency data.

4.6 Remaining life assessment

The remaining life for the equipment and piping items based on the hoop stress is performed according to the recommendations given in the API 581 BRD where applicable. R-Tech Software iRIS-Petro has been used for the analysis. It accounts for both internal thinning and external corrosion rates. The remaining life is calculated in three steps:

1) First, determine the Minimum Wall Thickness (t_{min}) to be used

There are 3 options available for specifying this t_{min}:

- using the Design Corrosion Allowance taken from design documents (a default option)
- using User-defined Minimum Thickness taken from local codes or other considerations such as structural stability
- using Calculated Minimum Thickness which is based on ASME code formula:

$$t_{\min} = \frac{PR}{E_{joint} S - 0.6P}$$

$$t_{allowance} = t_{original} - t_{\min}$$

2) Determine the Remaining Corrosion Allowance where:

$$\mathrm{Re}\,mCorrAllow = (Initial\ Corrosion\ Allowance) - (Total\ Wall\ Loss)$$

in which,

Initial Corrosion Allowance is determined from step (1) and Total Wall Loss = Internal Wall Loss + External Wall Loss

3) The Nominal Remaining Life is then calculated as follows:

NomRemLife = (RemCorrAllow) / (Total Corrosion Rate)

in which,

Total Corrosion Rate = Internal Thinning Rate + External Corrosion Rate.

4.7 Developing an Inspection Plan

The key piece of data for the development of an inspection plan is the Likelihood Factor. The Likelihood Factor for each piece of equipment is a composite i.e.

Likelihood Factor (LF) = LFThinning + LFCUI(ClSCC) +……

Since an inspection needs to be tailored to fit the type of damage expected at a particular piece of equipment, the key considerations are:

- high total Likelihood Factors
- high overall risks
- the Likelihood Factor per damage type
- short or zero probabilistic remaining life.

5. SAMPLE RESULTS

In order to be able to perform the given analysis in the project in the matter, the following activities have taken place:

1. Training and certification in RBI methodology and presentation of qualitative methods
2. Complete implementation of the qualitative assessment tool in a form of Web-based software tool
3. Integration of the software tool in the project web site
4. Export facility in the software in order to allow offline completion of the questionnaire
5. Basic demonstration of the methodology and training
6. Data collection and assessment

Final, main practical result is a clear picture of "where are the gains" thanks to improved risk-based asset management (Figure 2).

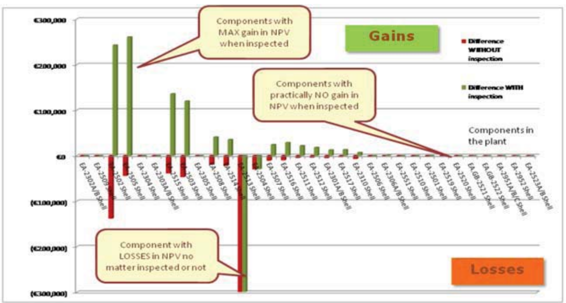

Figure 2: Main results: savings + inspection plan

6. CONCLUSIONS

Typical results of introduction of iRiS –Petro system and its application are

- satisfying legal requirements
- improving overall business practice and
- savings due to, e.g., loss prevention, improved used of resources or reduced insurance costs.

Typical deliverables are

- risk management system implemented
- database providing overview of all risk/relevant factors and
- "risk maps" and risk & safety reports.

The form of R-Tech solution spans from small, ad-hoc consulting actions for on-going activities and pilot-projects, to large projects covering large nets of plants or whole countries. They include on-the-job and academic training and certification, if so desired by the client.

On the refinery side, the solution consists of:

- one central data/application server running database system for data collection, processing and presentation is foreseen
- one central web server
- web-browser based clients
- reports and other data presentation tasks have web-based interface (Offline data presentation / browsing capabilities are also available)
- the implementation architecture provides the following benefits primarily in terms of reduced maintenance costs and reliability and simplicity of the maintenance/updating procedure:
  - data stored at one place and available for all authorized persons trough web-based interface
  - data collection is also done trough web-based interface, which allows interaction with data without any client software, apart from standard web browser
  - the maintenance and further development of this part of the system is done on the central web- and data/applications servers only.

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ADVANCED MANUFACTURING SYSTEMS AND ENTERPRISES: CLOUD AND UBIQUITOUS MANUFACTURING AND AN ARCHITECTURE

Goran D. Putnik
Department of Production and Systems Engineering, University of Minho, Portugal

Abstract. *In this paper, in the first part an introduction to development of the concepts of Ubiquitous and Cloud Manufacturing is presented, as a model of advanced manufacturing systems and enterprises. In the second part an architecture, that might guide the implementation and exploitation of the Ubiquitous and Cloud Manufacturing is presented through an informal and conceptual presentation.*
Key words: *Ubiquitous Manufacturing. Cloud Manufacturing, Manufacturing System, Architecture,Service Systems, Paradigm*

1. INTRODUCTION

The traditional Manufacturing was superseded. The new dynamic and global business model forced traditional production processes to change in the sense of to be integrated in a global chain of resources and stakeholders. The agility and quick reaction to market changes is essential, and the high availability and capacity to effectively "answer" to requirements is one of the main sustainability criterion.

"*Globalization, innovation and ICT are transforming many sectors to anywhere, anytime platforms*", towards an intelligent business model under "*design anywhere, make anywhere, sell anywhere"* paradigm (Elliott, 2010). We would add "anytime" too. Traditional suppliers and customers are "transformed" in services, where supplying or using profiles are a question of needs or context. One service (a *Calculator*, for instance) can execute (supply) something using other services (*Add*, *Sub*, *Mult* and *Div* operations) (Usmani, Azeem, & Samreen, 2011).

All these performances are considered on Ubiquitous and Cloud Manufacturing.

(Putnik, 2010; Putnik & Putnik, 2010) and (Xu, 2012) suggest a manufacturing versionof ubiquitous and cloud computing (respectively) – ubiquitous and cloud manufacturing – and manufacturing with direct adoption of ubiquitous and cloud computing technologies. In this context, resources are seen as services, essentially. This manufacturing service-oriented network can stimulate production-oriented to service-oriented manufacturing (Cheng et al., 2010).

Many of existent infra-structures are already ubiquitous and/or cloud based or are changing towards these virtual architecture. To use efficiently those infra-structures the applications must be transformed and follow services oriented applications pattern.

In this paper, in the first part an introduction to development of the concepts of Ubiquitous and Cloud Manufacturing is presented, as a model of advanced manufacturing systems and enterprises. In the second part an architecture, that might guide the implementation and exploitation of the Ubiquitous and Cloud Manufacturing is presented through an informal and conceptual presentation.

2. MANUFACTURING AS SERVICE SYSTEMS

Industrial and Product-Service Systems (IPS^2) represents a "paradigm shift from the separated consideration of products and services to a new product understanding consisting of integrated products and services creates innovation potential to increase the sustainable competitiveness of mechanical engineering and plant design. The latter allows business models which do not focus on the machine sales but on the use for the customer e.g. in form of continuously available machines. The business model determines the complexity of delivery processes. Characteristics of Industrial Product-Service Systems allow covering all market demands" (Meier H., Roy R., Seliger G., 2010).Figure 1shows service offer of Mori Seiki, while Figure 2**Figure** andFigure 3shows types of Product-Service Systems and scientific fields of action respectively.

Figure 1. Service offer of Mori Seiki ((Mori Seiki CO., LTD), cited in (Meier H., Roy R., Seliger G., 2010)).

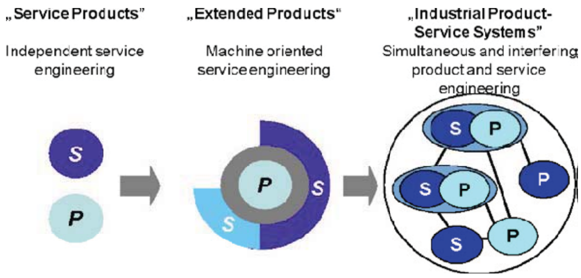

Figure 2. Types of Product-Service Systems (Meier H., Roy R., Seliger G., 2010)

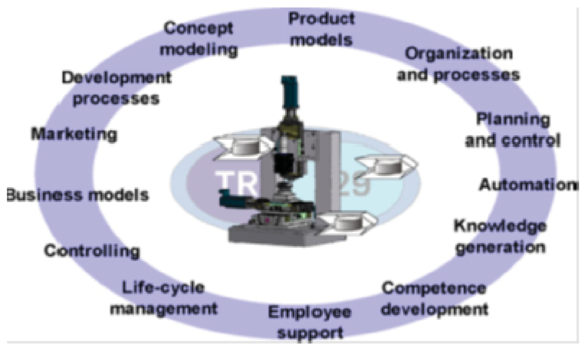

Figure 3. Scientific fields of action (Meier H., Roy R., Seliger G., 2010)

3. UBIQUITOUS STSTEMS

Ubiquity is a synonym for omnipresence, the property of being present everywhere (Wikipedia). "The state or quality of being, or appearing to be, everywhere at once; actual or perceived omnipresence.… omnipresence : the ability to be at all places at the same time; usually only attributed to God" (Wiktionary).

According to Weiser (1993) Ubiquitous Computing represents: "Long-term the PC and workstation will wither because computing access will be everywhere: in the walls, on wrists, and in "scrap computers" (like scrap paper) lying about to be grabbed as needed."

Computing technology has evolved up to the point when Ubiquitous Computing System development and operation are possible, using present network devices, protocols and applications.

From the other hand, ubiquity has been addressed in relation to manufacturing systems as well. In (Foust, 1975) "the term "ubiquitous"" is "explicitly defined to be functional in an empirical context …The types of manufacturing which are both market oriented and have a frequency of occurrence greater than a specific limit which can be empirically defined are ubiquitous. …".

Foust (1975) cites Alfred Weber's definition of ubiquitous manufacturing too: "Ubiquity naturally does not mean that a commodity is present or producible at every mathematical point of the country or region. It means that the commodity is so extensively available within the region that, wherever a place of consumption is located, there are … opportunities for producing it in the vicinity. Ubiquity is therefore not a mathematical, but a practical and approximate, term (praktischerNaherungsbegriff)."

To the above definitions (by (Foust, 1975) and (Weber, 1928)), which consider ubiquity of resources – anywhere, we add the ubiquity in time – anytime, which (the "anytime"), from its "side", implies the dynamic, on-line, seamless, enterprises' organizational and manufacturing system networking and reconfigurability, or adaptability, that requires new organisational architectures and meta-enterprise organizations as creating and operating environments, makes the UMS a true new paradigm.

Theredore, Ubiquitous Manufacturing Systems and Enterprises concept is related to the availability of management, control and operation functions of manufacturing systems and enterprises **anywhere**, **anytime**, using direct control, notebooks or handheld devices. It is related with Ubiquitous Computing Systems.

Ubiquitous Manufacturing Systems (UMS), therefore, implies ubiquity of three general types of resources in organizations:

- *material processing resources* (e.g. machine tools and other manufacturing/production equipment as resources),
- *information processing resources* (e.g. computational resources – includes hardware and software), and
- *knowledge resources* (i.e. human resources, considering the humans as unique resources for knowledge generation and new products and services creation, and, at the end, the ultimate effectiveness of organizations).

However, there are two quite different approaches to the concept of UMS.

- The first concept, considers ubiquity of the MS based on, i.e. uses, the ubiquitous computational systems (UCS), Figure 4.a; while
- The second one which is original our approach, considers ubiquity of the MS as a homomorphism ,

i.e. it is a mapping, of the ubiquitous computational systems (UCS), Figure 4.b, (Putnik et al.; 2004), (Putnik et al.; 2006), (Putnik et al.; 2007).

The similar idea was referred in (Murakami &Fujinuma; 2000), (ref. in (Serrano & Fischer; 2007)). This approach is referred as well as "Ubiquitous networking" that "emphasises the possibility of building networks of persons and objects for sending and receiving information of all kinds and thus providing the users with services anytime and at any place".

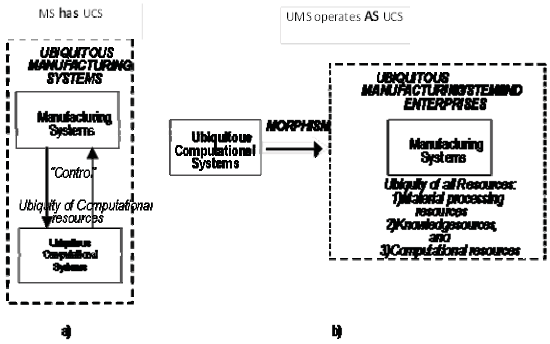

Figure 4.a) UMS has UCS as an operating system only – Ubiquity of Computational resources only; b) UMS operates as UCS – Ubiquity of all Resources: Material processing, Knowledge, and Computational resources (Putnik, 2007)

The hypothesis is that UMS should be based on a "hyper"-sized manufacturing network, consisting of thousands, hundreds of thousands, or millions of "nodes", i.e. of manufacturing resources units, freely accessible and independent, Figure 5.

Further implications are that

1) UMS manufacturing units should be, in the limit,"primitive", i.e. individuals, or individual companies, and individually owned headwear/software resources,
2) Management and operation of UMS should ne informed by the discipline of "chaos and complexity management in organizations", e.g. Chaordic System Thinking (CST) model (see e.g. (Eijnatten, 2007)),
3) Specific instruments should be used, such as meta-organizations (e.g. Market of Resources model), brokering and virtuality,
4) These UMS "hyper"-sized manufacturing networks could be seen as manufacturing resources *Internet of Things*,
5) These UMS "hyper"-sized manufacturing networks could be seen as manufacturing production *social networks*,
6) These UMS "hyper"-sized manufacturing networks form and use *clouds*.

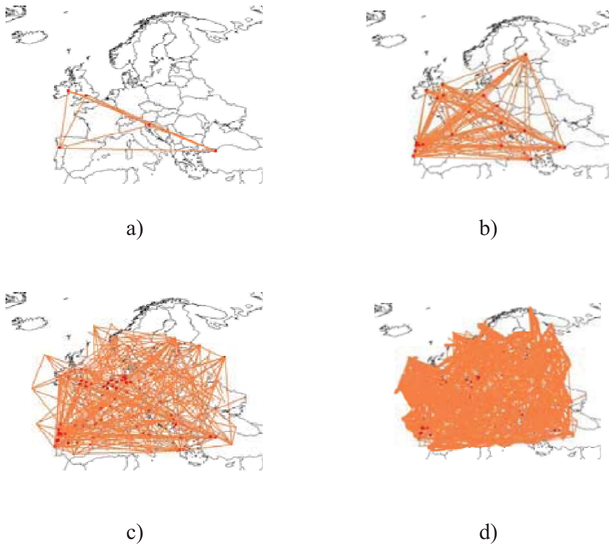

Figure 5: Figurative presentation of VE evolution: from conservative, minimal network domain (a), towards ubiquitous network domain (d)

4. CLOUD BASED PLATFORM

Presentation of the 'cloud' is transcribed from (Schubert L., …) - as the reference source created within the EC initiative and therefore it is the most relevant for an advanced Manufacturing Systems and/or enterprise.

"A '*cloud*' is a platform or infrastructure that enables execution of code (services, applications etc.), in a managed and elastic fashion, whereas "managed" means that reliability according to pre-defined quality parameters is automatically ensured and "elastic" implies that the resources are put to use according to actual current requirements observing overarching requirement definitions – implicitly, elasticity includes both up- and downward scalability of resources and data, but also load-balancing of data throughput."

Cloud has a number of "particular characteristics that distinguish it from classical resource and service provisioning environments: (1) it is (more-or-less) infinitely scalable; (2) it provides one or more of an infrastructure for platforms, a platform for applications or applications (via services) themselves; (3) thus clouds can be used for every purpose from disaster recovery/business continuity through to a fully outsourced ICT service for an organisation; (4) clouds shift the costs for a business opportunity from CAPEX to OPEX which allows finer control of expenditure and avoids costly asset acquisition and maintenance reducing the entry threshold barrier; (5) currently the major cloud providers had already invested in large scale infrastructure and now offer a cloud service to exploit it; (6) as a consequence the cloud offerings are heterogeneous and without agreed interfaces; (7) cloud providers essentially provide datacentres for outsourcing; (8) there are concerns over security if a business places its valuable knowledge, information and data on an external service; (9) there are concerns over availability and business continuity – with some recent examples of failures; (10) there are concerns over data shipping over anticipated broadband speeds."

Concerning the EU policy towards clouds, the document refers two main recommendations:

Recommendation 1: The EC should stimulate research and technological development in the area of Cloud Computing

Recommendation 2: The EC together with Member States should set up the right regulatory framework to facilitate the uptake of Cloud computing

Concerning the types of clouds, for an advanced Manufacturing Systems and/or enterprise, the most important are the concepts of cloud types: (1) ***IaaS*** - Infrastructure as a Service, (2) ***PaaS*** - Platform as a Service, (3) ***SaaS*** - Software as a Service, and "collectively ****aaS*** (Everything as a Service) all of which imply a service-oriented architecture."

5. AN OVERALL SYSTEM ARCHITECTURE FOR ADVANCED MANUFACTURING

Advanced manufacturing system architecture,Figure 6, is a 'cloud' based architecture that represents the manufacturing system as a service system, integrating the services for

(1) *Real-time Data Acquisition Services* for real-time data acquisition from the equipment through the embedded intelligent information devices – services type/group '*Equipment Intelligent Monitoring Systems*',

(2) Product Design Services, that integrates four environments: 1) Computer Aided Design, 2) Product data repository with embedded Intelligent System for Decision Making (for accessing all relevant data, actual and historic as well as data analysis) from the equipment in use, 3) Mixed-reality Environment, and 4) Co-Creation (Collaborative) Environment for co-creative design – services type/group '*Product Design Services*';

(3) Equipment Operation Services, that integrates four environments: 1) Equipment Data Real-time with embedded Intelligent System for Decision Making, that provides all relevant data, actual and historic as well as data analysis and management suggestions, necessary for the productuion management 2) Management environment, for monitoring, scheduling and controlling management activities, with embedded Intelligent System for Decision Making, 3) Mixed-reality Environment, and 4) Co-Creation (Collaborative) Environment for co-creative management – services;

(4) The 'cloud' infrastructure, that will provide the 1) infrastructure for the manufacturing system applications – of all three types of resources: material processing resources, information processing resources (i.e. computational resources), and knowledge resources – in the form of **IaaS** - *Infrastructure as a Service*; 2) platform for the manufacturing system applications in the form of **PaaS** - *Platform as a Service*, and 3) manufacturing system software 'business' applications in the form of **SaaS** - *Software as a Service*.

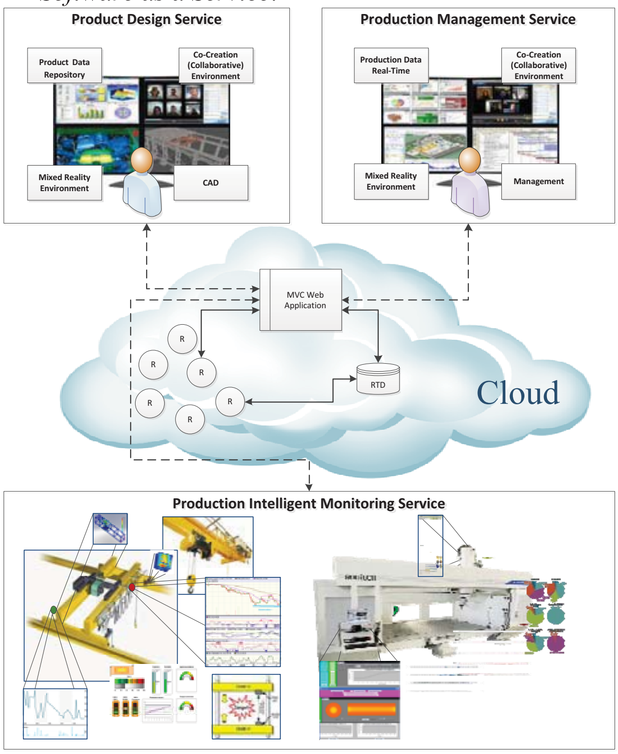

Figure6. Overall System Architecture for development, implementation and validation

ICT Platform Architecture

The logical architecture of the ICT Platform is architecturefor integration of "Representation", "Mixed-reality representation", "Real-time management model", and "Communication for collaborative management".

It is basically a 3.tier layer architecture consisting of (1) Presentation Layer, (2) Business Layer and (3) Data Layer.

The 'Presentation Layer' represents/defines applications and support for all interfaces, views, presentations and communications for users.

The 'Business Layer' represents/defines applications and support for all 'business' applications such as Decision Making applications, *Intelligent System* applications, Services Workflows.

The 'Data Layer' represents/defines applications and support for all applications for data repository and management, including knowledge bases (e.g. for Intelligent System on the upper level).

For each layer the corresponding technology to be employed is referred.

Co-Creation and Semiotics and Pragmatics platform

Advanced manufacturing system architecture will integrate environments, or so-called, co-creative platforms, for three co-creative environments: 1) for product design processes, 2) for operation, or production, management processes, and 3) for integrated design-production processes.
It means that the co-creative processes both group of agents will perform independently, i.e. the designers will be capable to perform their processes in their own environment separately from the managers – '1st **Co-Creative cycle**', and the managers will be be capable to perform their processes in their own environment separately from the designers– '**2nd Co-Creative cycle**',. However, additionally, both groups will be capable to perform their processes jointly in a fully integrated and ***systemic*** way – '**3rd Co-Creative cycle**', Figure 7.
The supporting technique will be the multi-user video-conferencing with auxiliary functionalities. A vision is presented on the Figure 8.
These three cycles, and the video-conferencing environment, will provide full semiotic/pragmatics effects and support in order to enhance to maximum the cognitive and creative capacities of the participants, and a full "*co-creative*", or *co-design* or *co-evolving*, and truly ***systemic*** environment.
Sustainability
The three aspects of sustainability: economic, environmental and social should be implemented in the following way:

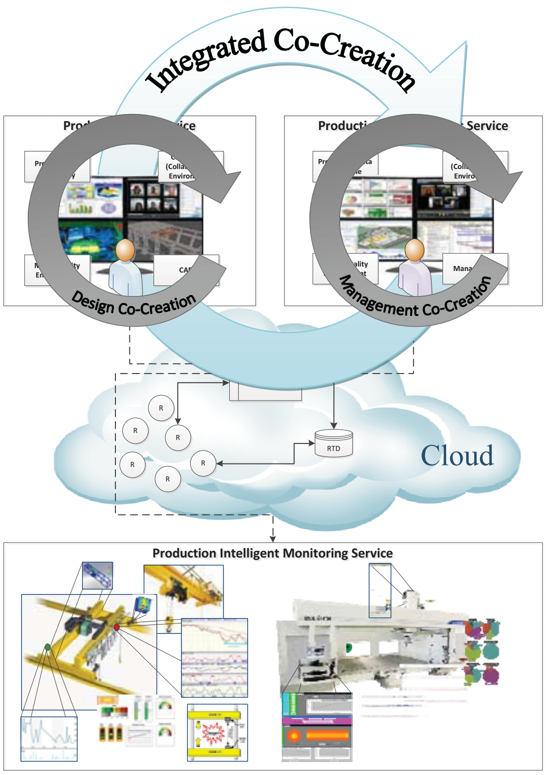

Figure7. Advanced manufacturing system co-creative platform, for three co-creative environments: 1) for product design processes, 2) for operation, or production, management processes, and 3) for integrated design-production processes.

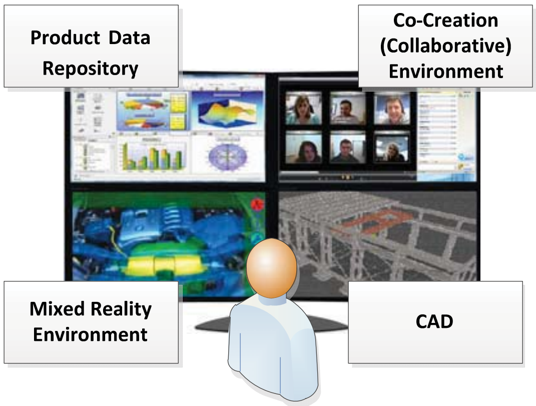

Figure8.A vision of the multi-user video-conferencing system as the co-creative environment

Economic and environmental sustainability: Economic and environmental sustainability will be based on implementation of specific softwaremodules, with corresponded analytical models, for continuous evaluation of energy consumption and costs, environmental pollution and associated costs.
These models and applications will be embedded in data acquisition services, see the System Architecture,Figure 15.
Social sustainability: Advanced manufacturing system components will support Social sustainability goals enabling "The creation of new jobs" – This effect will be possible because the advanced manufacturing system is conceived as a service system meaning a great degree of "openness" for performing these services, the maintenance management and design services, by individuals ("free-lancers"), micro and small companies, that would form a dynamic network of services providers. In this way a potential for new jobs creation will be dramatically increased.

6. CONCLUSIONS

The architecture presented is of a general nature andopen in various aspects, with structural elements, in nature and in number, that enables development of an advanced manufacturing system or enterprise on different complexity levels – which is on of the primary requirements for the capacity of achieving sustainability. Therefore, the architecture presented may have a number of implementation forms.
It would be useful to remind that a number of underlying technologies should be considered, and which were not possible to analyze due to the paper's limited space. E.g. *embedded intelligent information devices*, *real-time management (and design)*, *mixed reality and augmented reality*, semiotics and pragmatics, *co-creation*, chaos and complexity management, *the theory of sustainability*, *web 2.0 to web 4.0*, and others. In short, many of technologies are already present.

However, from the other hand, there is a number of open technical, organizational and conceptual problems that requires hard work in the future. Two of the virtually most important problems to work on are the interoperability, or integration, of the Ubiquitous and Cloud Manufacturing and their adoption in society (and industry of course).

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WORKING PAPERS

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USABILITY OVERVIEW

Isabel L. Nunes
Faculdade de Ciencias e Tecnologia, Universidade Nova de Lisboa, Portugal
Mário Simões-Marques
CINAV, Marinha Portuguesa, Portugal

Abstract. *The paper presents a brief overview on Usability, its main goals, characteristics and the phases of the system life cycle where a user-centred design and implementation is crucial. The paper also refers some methodologies that are adequate to deal with the collection of user requirements, the development of a user-friendly design and the evaluation of implementation solutions that are suited for their context of use.*
Key words: *User-centred Design*

1. INTRODUCTION

The fast pace of evolution of digital technologies is introducing many technological, organizational, and methodological changes affecting the workers workload, many times in a negative way. A crucial issue derived from this type of evolution is systems' usability, and in particular of their users' interfaces. Usability can be seen as a quality or characteristic of a product that denotes how easy this product is to learn and to use (Dillon, 2001). Usability represents also an ergonomic approach and a group of principles and techniques aimed at designing usable and accessible products, based on user-centred design (Nielsen, 1993; Nunes, 2006, Simões-Marques & Nunes 2012).

Bearing in mind the importance of ensuring that Industrial Engineering practitioners are aware of and consider Usability principles on their activity this paper presents a brief overview of the main topics related with this thematic.

2. USABILITY

According to (ISO9241, 1998) usability is defined as the effectiveness, efficiency and satisfaction with which specific users achieve goals in particular environments, while performing their tasks with given equipment. These definitions relate directly with 3 questions: How can users perform their tasks? What resources must users spend to achieve a given outcome (e.g., time, effort)? How much do users like the products they have? Figure shows schematically the set of factors to consider in evaluating the usability of a system, within the framework of this standard.

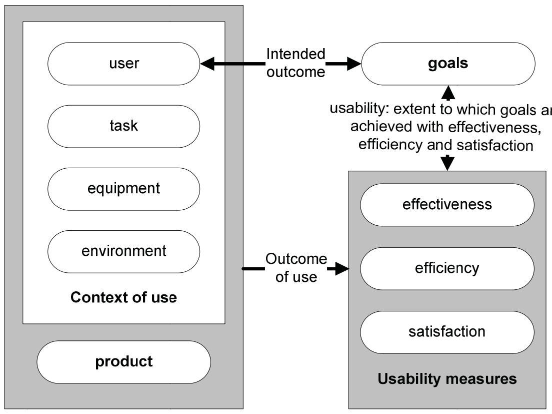

Figure 1. Usability framework, according to the ISO 9241-11 standard

Besides the economical detriments (e.g., a system that is hard to understand also has expensive problems in its life cycle), the lack of care about users' needs can lead to solutions that tend to cause errors or that provide users with inadequate information.

Usability is not a single, one-dimensional property of a user interface. Usability has multiple characteristics that contribute to systems' acceptability by users. The description of the main attributes that characterize usability are (Nielsen, 1993):

Ease to learn - the system must be intuitive, i.e. easy to use, allowing even an inexperienced user to be able to work with it satisfactorily;

Efficiency of use - the system must have an efficient performance, allowing high productivity, i.e., the

resources spent to achieve the goals with accuracy and completeness should be minimal;
Memorability - the use of the system must be easy to remember, even after a period of interregnum;
Errors frequency - the accuracy and completeness with which users achieve specific objectives. It is a measure of usage, i.e. how well a user can perform his task (e.g. set of actions, physical or cognitive skills necessary to achieve an objective);
Satisfaction - the attitude of the user towards the system (i.e., desirably a positive attitude and lack of discomfort). Ultimately measures the degree to which each user enjoys interacting with the system.
The usability attributes are also summarized in the ergonomic interface principles, which apply to the design of dialogues between humans and information systems (ISO9241, 1996): suitability for the task; suitability for learning; suitability for individualization; conformity with user expectations; self descriptiveness; controllability; and error tolerance.
In some countries usability is also a legal obligation. For instance, in European Union according to the Council Directive, 90/270/EEC, of 29 May, on the minimum safety and health requirements for work with display screen equipment, when designing, selecting, commissioning and modifying software the employer must take into account principles that generically are the above listed.
In fact, an adequate usability is important because it is a characteristic of the product quality that leads to improved product acceptability and reliability, increased users' satisfaction, and is also financially beneficial to companies (Ribeiro & Nunes, 2008). Such benefit can be seen from two points of view, one related with workers' productivity (less training time and faster task completion), and the other with product sells (products are easier to sell and market themselves when users have positive experiences).

2. USER-CENTRED DESIGN

User-centred design is a structured product development methodology that involves users throughout all stages of product development process, in order to create a product that meets users' needs (Nunes, 2006; Averboukh, 2001). According to (ISO13407, 1999) there are four essential user-centred design activities, to incorporate usability requirements into the development process (refer to Figure 2): understanding and specifying the context of use; specifying user and organizational requirements; producing designs and prototypes; and carrying out user-based assessments The four activities are carried out iteratively, with the cycle being repeated until the particular usability objectives have been achieved. These activities are discussed a bit further below. After a successful performance of these activities, an easy to use and useful product can be delivered to users.

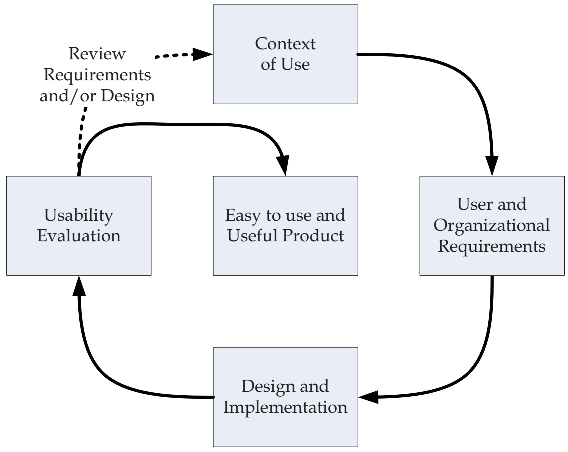

Figure 2. Relationship between product development and user-centred design activities according to the (ISO13407, 1999) standard

As referred before defining the context of use is important since it is very unlikely to find products with high usability qualities for universal applications. An example of a methodology developed for this stage of product development, is the "Context of use analysis" (Thomas & Bevan, 1996), which is a technique used for eliciting detailed information on user, tasks and environment. This information is collected during meetings of product stakeholders, which should occur early in the product lifecycle. The results should be continually updated and used for reference. Questionnaires can be used to evaluate current systems as an input or baseline for development of new systems. Other methodologies, such as the "Task analysis" can also be helpful for defining the context of use.
During the design and implementation stages several methodologies can be used in support the required activities, from the early design till the prototyping. The spectrum of problems dealt with in these stages is very broad therefore the methodologies developed are quite diverse, both in terms of goals and focus. Examples of such methodologies are the Brainstorming (Osborn, 1953), the Cognitive walkthrough (Wharton et al., 1994) or some Heuristic evaluations (e.g., Nielsen Heuristics (Nielsen, 1994)). Nevertheless, independently of the product to implement some basic principles must be observed (Jordan, 1998):
Consistency - similar tasks are performed in the same way;
Compatibility - the method of operation is compatible with the expectations of users, based on their knowledge of other types of products and the "outside world";
Consideration of user resources - the operation method takes into account the demands imposed to the resources of users during the interaction;

Feedback - actions taken by the user are recognized and a meaningful indication of the results of such activities is given;
Error Prevention and Recovery - designing a product so that the user likely to err is minimized and that, if errors occur, there may be a quick and easy recovery;
User Control - user control over the actions performed by the product and the state in which the product is are maximized;
Visual Clarity - the information displayed can be read quickly and easily without causing confusion;
Prioritization of Functionality and Information - the most important functionality and information are easily accessible by users;
Appropriate Transfer of Technology - appropriate use of technology developed elsewhere in order to improve the usability of the product;
Explicitness - offer tips on product functionality and operation method.
The design has also to consider the finite capability of humans to process information, to take decisions, and to act accordingly. These human characteristics have been thoroughly studied in the last decades, considering the Human Computer Interaction. Researchers that became a reference are, for instance (Hick, 1952), (Fitts, 1954), or (Miller, 1956).
The usability evaluation can follow different approaches. It can be based, for example, on observation of users, application of questionnaires to users or analytical methods. The observation can be made in laboratory, but since the context of use is very important in usability studies, performing the study in the working environment where the system is intended to be used is preferable. Some of the methodologies and tools that can be used for this purpose are: Cognitive workload (e.g. Subjective Mental Effort Questionnaire (Zijlstra, 1993) and Task Load Index (NASA, 1986)); Cognitive walkthrough (Wharton et al., 1994); Eye-tracking (Nielsen & Pernice, 2009); Heuristic evaluation (e.g., Nielsen Heuristics (Nielsen, 1994)) or psychometric methods (e.g., SUMI (Kirakowski, 1994)).

3. USABILITY OF TOUCHSREEN DEVICES

Currently the use of touch and multitouch screens are becoming frequent and gaining importance as interfaces for computer and mobile devices. The use of these kinds of screens has several potential benefits, usually because they have intuitive functionality, they are easy to use and flexible, reducing the need of other input devices (e.g., keyboards, mouse) and for simple tasks they allow fast interaction. Touch screens are particularly adequate for devices that require high mobility and low data entry and precision of operation. Examples of application of these types of screens are tablets, smartphones, information kiosks or checkout terminals.
However, designing for touchscreens presents some usability challenges. For instance, designers must take into account issues such as: fingers/hand/arm can hide the screen, the lack of tactile feedback, the parallax error resulting from the angle of view or the display may be overshadowed by dirt, stains or damage on the screen or on the protective film.

4. CONCLUSIONS

Usability is a critical aspect to consider in the development cycle of software applications. Intuitiveness, efficiency, effectiveness, memorization and satisfaction are attributes that characterize the usability of a system.
A system with a high usability allows decreasing the time to perform tasks, reducing errors, reducing learning time and improving system users' satisfaction.
User-centred design and usability testing are key issues in product development. The design and testing cannot ignore the context of use, the characteristics of users, tasks to perform and environmental context (social, organizational and physical) for which the product is intended to.
There is a variety of methodologies that can be used to identify and assess the usability of a system, therefore contributing for its improvement. The selection of these methodologies depends on the objective to achieve, which usually is related with the development phase in which the system is in.
Finally, designing for touchscreens presents some usability challenges, since the body of knowledge for these interfaces is still very limited. Nevertheless there is a significant number of guidelines and best practices and formal or industrial standards that may be adopted.

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COMBINING SYSTEM DYNAMICS AND DISCRETE EVENT SIMULATIONS - OVERVIEW OF HYBRID SIMULATION MODELS

Bojan Jovanoski[1], Robert Minovski[2], Siegfried Voessner[3], Gerald Lichtenegger[4]
[1]Teaching assistant and PhD student, Faculty of Mechanical Engineering, University of Ss. Cyril and Methodius, Skopje, Macedonia
[2]Professor, Faculty of Mechanical Engineering, University of Ss. Cyril and Methodius, Skopje, Macedonia
[3]Professor, Institute of Engineering and Business Informatics, TU Graz, Austria
[4]Assistant professor, Institute of Engineering and Business Informatics, TU Graz, Austria

Abstract. Simulation and modelling has been widely accepted as one of the most important aspects of the Industrial engineering. The application and use of simulation models has grown exponentially since the 1950' until today. Over the years, the complexity of the simulated aspects has been adapted to the complexity of the analysed cases which has risen proportionally too. That is why techniques used many years ago, can often not give an adequate representation of the real world any more. For that reason, we propose to use hybrid simulation models, which are a combination of simulation paradigms in order to cope with this problem. In this paper, we will give an overview of selected researches and applications with an emphasis on Discrete Event Simulation and System Dynamics, as one of the core simulation based techniques in that area.

Key words: Hybrid, Simulation, Model, System Dynamics, Discrete-event simulation.

INTRODUCTION

The advances in Industrial Engineering (IE) have gone a long way since the early beginnings and the experiments of Taylor, Gilbreth, Babbage, Towne and others. Not so much in the area of the field, but in the direction of tackling even the smallest details possible. In order to do this the complexity of the problems grew, with that the data needed to be obtained and processed was also getting bigger. The computers played huge factor in keeping the Industrial Engineering alive and constantly being in trend. Not only because of the hardware possibilities and the calculations that could have been made now, but also from the point of view that many software packages have been developed in order to solve some kind of an IE problem. There are solutions for finding an optimal layout, managing production processes, tackling ergonomic issues, calculating cost/profit etc. (the intention is not to name vendors here).

Simulation and modelling has been widely accepted as one of the most important aspects of the Industrial Engineering. The application and use of the simulation models has grown exponentially since the 50' until today. This is mainly because of the advances in the computation field, but also because of the increased number (percentage) of acceptance by the academia and the industry (Robinson 2004a). The complexity of the simulated issues has been adapted to the complexity of the real world cases and has risen proportionally. Many of the tools and techniques used many years ago can not present the level of details that is needed today in some cases. One of the theses for future trends in the field of simulation by Robinson (2004) is that in order to deal with this, a combination of techniques would be required. Also, in (Banks et al. 2003) few of the experts asked for bigger accent to be put in interoperability of simulation software. In that direction, the best from the selected techniques would be taken and they would complement each other, resulting in the synergy factor. In this paper, a comparison and combination of System Dynamics and Discrete Event Simulation (DES) will be presented. At the end one research example will be presented, showing why and when this should be done.

SYSTEM DYNAMICS

System Dynamics (SD) is a relatively new technique that has been populated in the last 20 years. The basic principle underlying system dynamics is that the structure of a system determines its behaviour over time (Forrester 1968; Sterman 2006). SD is all about the whole and looking at the system as a unit. In normal cases, a lot of people use the divide-and-conquer system in order to solve complex problems. The philosophy of SD is that every element is connected somehow with other element(s) and those relationships determine how the system performs over time. It is best used when modelling very complex systems that are very hard to perceive and understand.

There are two main approaches that help define a SD model. The first one is the causal loops (and feedback loops), which are widely spread and very useful. Most of the time, they are the first step in developing a SD model, helping in the conceptualisation. The second tool is the stock and flow diagrams, which aid to describe the model using data. The easiest way to describe this is to think of models like system of water tanks with pipes and valves (Meadows 2008).

In the research conducted by Helal et al. (2007) they have stated that "using SD at the operational level of the manufacturing system has failed to offer the needed granularity (Godding et al., 2003; Barton et al., 2001; Baines and Harisson, 1999; Bauer et al., 1982). The same was observed by Choi et al. (2006) who could not use SD to model the performance of the individual processes in a software development system". In (Özgün & Barlas 2009) the authors needed to increase the values of some variables by tenfold in order for SD to "capture" them and for the model to make sense.

In addition, while SD permits the study of the stability of the system over the long range, the trends of behaviour that it generates do not indicate what specific actions to be made and at what values of the action parameters. Such specifications require more detailed considerations that SD does not seem to work with, while DES has been effective at.

DISCRETE EVENT SIMULATION

DES is a more widely established simulation technique (Banks et al. 2004). "The system is modelled as a series of events, that is, instants in time when a state-change occurs", (Robinson 2004). The models are stochastic and generally represent a queuing system. From the beginning until now, the models are based on a specific code that manages the simulation.

At the beginning, DES was developed and used in the manufacturing sector. But, as the times have changed, so have the areas where DES has found its applicability (hospitals, public offices, document management etc.) Still, the main advantages and principles have never changed no matter if the simulated entities are products, people, documents etc. (Law 2006; Banks 1998).

COMPARISON

The SD and DES are very different approaches when trying to model a situation and there are distinctive communities that follow each, respectively. Little bit inspired by the title of Sherwood (2002), the following comparison will be made in order to clarify some things. If a task of analysing a forest is given to these two types of modellers, the SD modellers will try to look at the forest from above, or from far away. They will look at the landscape, see how the trees are spread and grouped, analyse the types of trees etc. Meanwhile, the DES modellers will try to go in the forest and search in it, look at every tree as an entity, the leaves of the trees, the structure of the trees etc. Having this in mind, it was not very difficult to accept SD a technique for the attempt to model strategic decisions and use DES for the operational processes and decisions. Based on the work of Chahal & Eldabi (2008c) and Lane (2000) a meta-comparison of both approaches is shown in Table 1.

There are numerous articles that describe and compare these techniques, particularly. Maybe one of the first attempts was done by Ruiz-Usano et al. (1996) and before that Crespo-Márquez et al. (1993) concentrating on discrete vs. continues systems. All of them give some kind of proposition or direction what technique is most suitable in which cases. Most of them (Brailsford & Hilton 2001; Özgün & Barlas 2009; Sweetser 1999; Huang et al. 2004; Wakeland & Medina 2010) share the idea of the authors, presented earlier that SD is more suitable when modelling a system and analysing it as whole and DES when more details are needed for the better representation. The researches have been mainly focused on developing two same models in the different approaches and analysing and sharing the results (Robinson & Morecroft 2006; Crespo-Márquez et al. 1993; Wakeland & Medina 2010; Johnson & Eberlein 2002). Tako & Robinson (2008) have gone a step further and have analysed a model building process by five SD and five DES modellers on a same situation- a prison population problem. One of the detailed and structured comparison has been done by Chahal & Eldabi (2008), dividing the analysis in more than thirty categories and explaining every one of them. There are even researches that deal with the third possible option when simulating (e.g. a supply chain) - simulation with agents and compare that along the previous two (Owen et al. 2008).

Table 1: Meta-Comparison of DES and SD

DES	SD
Problem	
Seeking to understand the impact of randomness on the system	Aiming to understand the feedback within the system and its impact
Scope	
Operational	Strategic / Policy
System	
High level of detail that physically represents the system (detail complexity)	More macro level of detail that summarises the system (dynamic complexity)
Methodology	
Process view	Systems view
Philosophy	
Randomness	Feedback

COMBINING TWO MODELLING TECHNIQUES

There are couple of examples where the idea of hybrid models has been taken and proved useful, especially combining SD and DES. They will be analysed according the area/industry for which the model was created, how the models are connected, to which level this was applied in the organization, are the models dependent\independent and the format of the hybrid model. In the next section, we will share our insights regarding each of these issues and present you an example of a hybrid model being developed in mean time.

Area/industry of application

In the manufacturing industry, there is a good example for modelling hierarchical production systems (Venkateswaran et al. 2004; Venkateswaran & Son 2005). The authors are concentrated on the production and production related elements, and have developed a SD model for the long-term plans (developed by the "Enterprise-level decision maker") and short-term plans (developed by the "Shop-level decision maker"). In the paper (Rabelo et al. 2005) the authors have also examined a manufacturing enterprise, where they used SD to simulate a financial (reinvestment) policy and DES to simulate the production process of one machine. They have represented the number of machines in the SD model, so by "multiplying" this variable with the output of the DES process they can generate the production output of the enterprise. Based on the framework of (Helal et al. 2007), same has been tested and a hierarchical production model has been developed (Pastrana et al. 2010).

In the recent decade, the healthcare management has been seen as a very interesting field for the industrial engineers (the Institute of Industrial Engineers <www.iienet.org> have classified Healthcare Management in the same importance as Lean & Six Sigma, Supply Chain Management, Ergonomics, Quality systems etc. and some universities have a special IE curriculum for Healthcare management, e.g. TU Eindhoven <www.tue.nl>). This interest has also been shown in using the simulation for tackling issues in the healthcare. Chahal and Eldabi (2008a) have distinguished three formats how the models inside a hybrid mode can communicate: Hierarchical, Process- Environment and Integrated format. Later they have suggested a framework for hybrid simulation in the healthcare (Chahal & Eldabi 2010). In the work of Brailsford et al. (2010) the authors used the hybrid models to represent two case. The first one is when the DES model simulates a process of a patient being examined with a whole configuration of a hospital, while the SD simulates the community and how a specific disease would spread. In the second case, the DES was used to simulate operations of a contact centre, and SD to simulate demographic changes of the population being examined.

The use of hybrid modelling has found its applicability in the civil engineering as well (Peña-Mora et al. 2008; SangHyun Lee et al. 2007; Alvanchi et al. 2009) dealing with problems that are more complex to be solved with independent simulation models or project management tools. One of the few advantages that the authors found with this approach is the benefit of proposals for improvement they got from the models. In the same direction as the previous two papers, Martin and Raffo (2001) have also suggested a hybrid approach in the software industry. They have worked on an issue that can be managed with project management software as well, but they argue that the benefit of the hybrid simulation is the experimentation that can be done. The use of agent-based modelling and SD as hybrid architecture can be also adapted for the automotive industry (Kieckhafer et al. 2009).

Type of connection

Combining the two different models in one hybrid one is one of the most important thing in this whole process. This defines also how the models will communicate, share data, behave at a certain time point etc. Back in the 1999 there were two papers that stress out the possibilities and the advantages when using HLA (High Level Architecture) to combine two or more models (Schulze 1999; Davis & Moeller 1999). Some research done so far has employed this tool in order to combine their models (Venkateswaran et al. 2004; Rabelo et al. 2003; Alvanchi et al. 2009). Clearly, the benefits are enormous, but also the effort, time and the technicality when using this approach. Some have used a more usual ways to do this, like Excel and Visual Basic for Applications (Brailsford et al. 2010). There are even cases where a specific

research has been conducted in order to define a generic module in order for SD and DES models to communicate and function (Helal et al. 2007).
There are even examples where the modellers have a single software solution (Anylogic, <www.xjtek.com>) and combined a DES model with differential equations (Marin et al. 2010). Maybe it is not as same as the rest of the cases, but is worth mentioning as an approach.

Scope of the hybrid model
In this section we would like to address at what scope is the hybrid model applied inside one area/organization; whether the hybrid model is about whole organization, two different functional areas inside organization, only one functional area etc. For example, the work of Brailsford et al. (2010) has two different cases, but both use DES to simulate inner situations (hospital and calling centre operations), while SD simulates very broad scenarios (whole community or population demographics). In the case of (Martin & Raffo 2001) the model is a representation of a project being under away. Rabelo et al. (2005) have modelled two different functional areas – SD for the decisions concerning allocation of the financial resources (of the plants) and DES for operational decisions of the plant (number of machines, people etc.). In the case of (Venkateswaran et al. 2004), the whole hybrid model is about the production in the enterprise; SD for the aggregate-planning level and DES for detailed-scheduling level.

Dependent\independent models inside hybrid model
The intention of the authors was to distinguish if the singular models inside the hybrid one are independent or dependent on each other. The idea was that maybe two different modellers can model their own model "independently" and then combine the model, which is thought of as very practical and less time consuming. This was very hard to distinguish during the research of the papers, because there is not so specific information regarding this issue. The authors have made experiments by themselves regarding this and have successfully paired two independent models.

Type of hybrid model format
Chahal and Eldabi (2008a) have distinguished three formats how the models inside a hybrid model can communicate: Hierarchical, Process - Environment and Integrated format.
The works of (Venkateswaran et al. 2004; Rabelo et al. 2005; Rabelo et al. 2003; Pastrana et al. 2010) have a hierarchical model. (Brailsford et al. 2010) and (Martin & Raffo 2001) both deal with processes and how the environment deals with the changes that they bring. In (Brailsford et al. 2010) the authors argue that no one until now has achieved to develop a hybrid model by the Integrated format, but given the progress of the development of hybrid models, the gap is getting narrower.

EXAMPLE / CASE
For the research that is going on right now, we are in a process of developing a hybrid model, based on the case of one production enterprise. This was not possible to be done in DES only environment, and when we experimented only with SD we did not get the needed detail level of the production.
Because of the nature of the situation, we are developing two separate models. One SD model that will represent the top management decision about how many sales personal need to be (hired/fired) and one DES model about the process of production of the products been sold. The models are of hierarchical format according the classification of (Chahal & Eldabi 2008a) and aid each other so that the number of sales personnel is according the demand, but also according the production capacity (from the DES model). The connection was established using the built-in functions of the used software (Plant Simulation for DES and PowerSim for SD) and we used Excel as data storage media through the simulation runs. The functioning of the hybrid model is presented in Figure 1.

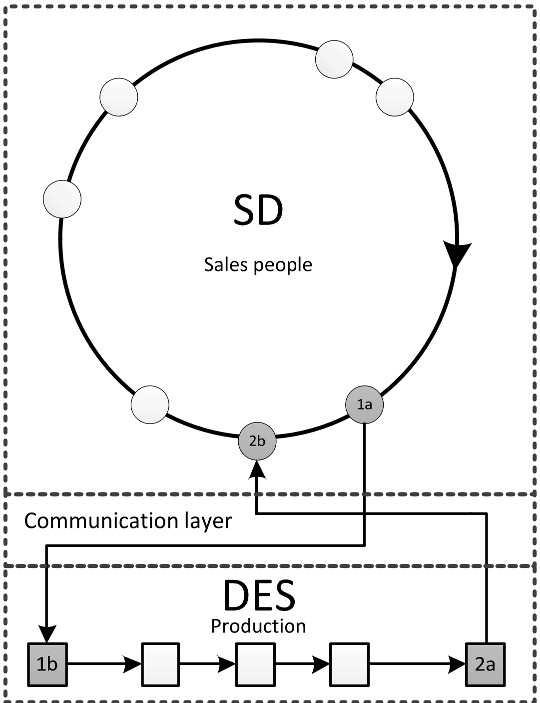

Figure 1: Structure of the hybrid model

The model works in that way that the SD model runs and triggers the DES model (the production) and sends the information regarding the demand. After the production cycle is finished, it sends back to the SD model the number of produced products. This information is received and taken in the SD model in order to calculate the possible sales that is one of the main inputs for determining the number of sales people (which was the initial goal of the simulation model).

CONCLUCSION

This paper summarizes and analyses different hybrid simulation models from selected papers. This is a relatively new area and only handful of research papers exist. Based on the papers and the authors view, the need for this kind of models is very justified and will be even more important in the near future. In order to get the most appropriate and convincing representation of the real world, the suitable modelling approach should be used. Because we try to simulate very complex scenarios, the need for hybrid simulation and modelling is inevitable. For our needs, the usage of System Dynamics and Discrete Event Simulation has been proven most suitable.

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SUPPLY CHAIN MANAGEMENT INVESTEMENT TO GAIN SUSTAINABLE COMPETETIVE ADVANTAGE

Petar Kefer[1], Dragan D. Milanovic[2]
[1]Omni Surfaces, Toronto, Ontario, Canada
[2]Faculty of Mechanical Engineering, University of Belgrade, Serbia

Abstract. *A key goal is to help supply chain professionals to think clearly about the investment issues they face when they need to take in consideration sustainable competitive advantage. In addition this work should help them to consider how investments in key areas might achieve other beneficial results for the company.*
The report focuses on explaining where companies make investment in supply chain management, what are major areas related to competitive advantages that shown promise to create long term benefits.
At the end report will show sustainable advantage within the context of Supply Chain Management investment on long term.
While a more comprehensive assessment would be useful, this work covers the aspect which represents newly emerging benefits that should be considered.
The report utilizes data from an ongoing research initiative, which included several sets of interviews with senior supply chain leaders from global companies.

TRADITIONAL INVESTMENTS IN SUPPLY CHAIN MANAGEMENT

Various investments in supply chain systems fall into three categories that (1):

- Reduce operating cost within the supply chain, primarily by reducing inventory
- Increase scale by allowing the company to address broader scope such a higher demand
- Increase flexibility by enabling the company to easily add a new product line in a plant or a new sales channel etc.

Clearly any money spent on technology that measurably reduces operating cost, such that the payback is within 6 to 12 months is extremely attractive during tough economic times. For example, if an OEM (Original Equipment Manufacturer) can reduce their inventory liability from product obsolescence and as a result reduce write-offs through investing in supply chain collaboration technology and show positive ROI (Return On Investment) within 6 to 12 months, then that is a good investment to make even during the bad times.
Another example of such an investment is for a consumer goods company that upgraded its demand planning system to ensure it can meet retailer's requirements while reducing excess inventory and increase customer's loyalty.
Such an investment is good investment even during the tough times. It not only reduces cost, but also prevents losing customers to competitors, loss that gets amplified during the tough times when the revenue is tight.
In general any investment that allows the company to increase scale can be delayed, since during the tough times most companies are more short term focused and not thinking about the end of the tunnel, when the revenues can begin to grow again.
An example is investing in new demand planning system that allows a company to use better statistical forecasting methods, manage more SKUs and enable collaborative techniques to ensure consensus among all stakeholders. Clearly such an investment is designed to support growing demand. Making a business case for such an investment in tough economic times is a challenge. However there are exceptions. If a company is market leader and financially strong, it may be worthwhile investing in scale during the tough times, knowing that it will come out of the recession poised to gain even more market share and increase profits through such investment.

Any investment in flexibility is in the proverbial grey area. Flexibility is both a luxury and necessity during the downturn.

Operational flexibility allows a company to profitably make tactical moves to seize customers from a competitor, reduce short term costs in a limited manner or even test new strategies under cover in a limited geography. In such scenarios an investment in systems and technology that increase flexibility is attractive. On the other hand, many companies go into survival mode during tough times and want to burn as little cash as possible, waiting for those companies that do not have an appetite to invest in technologies which increase flexibility during these times.

Adding to the confusion is the fact that a technology investment can fall into different buckets for different companies, based on their competitive landscape and their operating environment. For example, one company may find that the performance of their demand planning system begins to decrease as they increase number of SKUs. Clearly investment in demand planning system for this manufacturer falls in the “scale” category. They can afford to delay selecting and deploying a new system. However, another manufacturer may see investment in demand planning system as a way to ensure that they can significantly improve forecast accuracy, significantly reduce stock outs for their key customer and simultaneously lower excess inventory for other items. For them, demand planning investment may be critical even during the tough times, as they can reduce their operating costs and increase customer retention.

SIMPLIFIED DECISION MAKING PROCESS FOR INVESTMENT IN SUPPLY CHAIN MANAGEMENT

Most large corporations go through the annual budget and process of creating proposals for capital investments. These investments need to be justified with projected savings, return on investments, and so on. Asking the following two key questions can simplify decision making process related to investing in Supply Chain Management[2]:

Question #1

Does the proposed investment create any competitive advantage for the company? This question looks like rhetoric, but can be made quite objective. Identify the financial metric that is being targeted through this competitive advantage, it could be reduced cost, increased revenues, lower inventory, lower working capital, better margins, enhanced asset turnover or anything else that the company is trying to achieve as a result of the investment. It can also be an operational metric if that is what is being targeted. For example, if two projects are being targeted to reduce working capital (an inventory optimization system or a bid-optimization system), it is relatively easy to convert their projected benefits to impact on working capital.

Question #2

How sustainable is the competitive advantage created by the investment? Remember, all competitive advantages are bound to disappear as other firm’s catch-up. Therefore, assessing the sustainability of an advantage is very important. Between two investments with identical returns, the one that creates more sustainable advantage is definitely the winner.

After assessing the two questions, decision needs to be evaluated to see how the competitive advantage can be made more sustainable and aligned to business strategy.

SUPPLY CHAIN MANAGEMENT COMPETITIVE ADVANTAGE

In simple terms, a firm will have competitive advantage, if its products are superior or if it provides superior customer service.

If the advantage comes from superiority, then what makes something superior to another? What creates superiority in a product or service management?

Let me review the question from the point of view of supply chain management, assuming that superior supply chain management will create competitive advantage for a company. I contend that supply chain management is superior when it has at least one of the advantages you can see on the following chart:

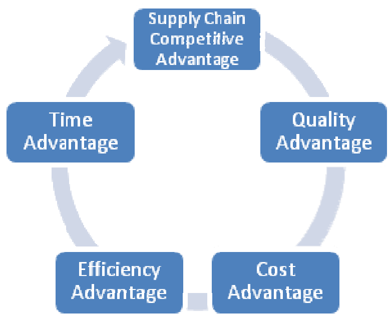

Chart 1: Superior Supply Chain Management

Time Advantage

Time advantage is created when one of the business processes is faster than the other in achieving the same result. Time advantage is best exemplified with the time to market examples. Time advantage is typically created though careful analyses of all the activities supporting a process and elimination of those that don’t add any value to the process, but only add lead time.

Time advantage can create product premiums, increased revenues, longer product life cycles, and intangible differentiator levels (such as brand value or an image of being innovative or agile). It becomes a competitive advantage when the firm develops processes that will enable it to quickly introduce new products to the market and portray the company as a pioneer and when the firm's business strategy leverages such differentiation through a premium brand image to grow market share and increase revenues.

Cost Advantage

Cost advantage is created when superior business process is cheaper to operate than an inferior one. Cost advantage can be created through elimination of waste from the process, but also by optimizing the process within the process constrains. A lot of supply chain processes fall in this category and can provide finite cost advantages when implemented correctly. Inventory planning processes within the supply chain function is a good example in this category.

Every revised iteration of the original business process can potentially improve the existing cost structure and provide a continued superiority afforded by process. These improvements are necessary to sustain the advantage over time. Cost advantage allows the company to become more profitable or expand its market share.

Efficiency Advantage

Efficiency advantage is created when the superior business process provide higher throughput. Throughput measures the output of a process per unit time. Sometime, efficiency may mean asset utilization, such as the utilization of the assembly line in a manufacturing context, blast furnace utilization in steel production, or a jockey's utilization in the warehouse of a retailer.

Assets in the context of efficiency can be people, machinery, or technology anything that is costs to maintain and provides a useful function in the business process. The efficiency advantage can be created by automating, simplifying, or expending a process. Efficiency advantage normally results in more favorable cost structure and supports a cost-based business strategy.

Quality Advantage

Quality advantage is created when the superior business process creates fewer defects than the inferior one. Quality advantage is generally a result of standardizing, automating, or simplifying a process. In the manufacturing context, a statistical process control (SPC) that allows companies to monitor the health of the process to reduce defects is a good example of this advantage.

SUSTAINABLE COMPETITIVE ADVANTAGE IN SUPPLY CHAIN MANAGEMENT

Sustainable competitive advantage is the prolonged benefit of implementing some unique value-creating strategy based on unique combination of internal organizational resources and capabilities that cannot be replicated by competitors[3].

Sustainable competitive advantage allows the maintenance and improvement of the enterprise's competitive position in the market. It is an advantage that enables business to survive against its competition over a long period of time. Managers should be committed to creating economic value to their stakeholders, and the best means to create that value is to focus on sustainable competitive advantage as the key.

The four criteria of sustainable competitive advantage you can see on the following chart:

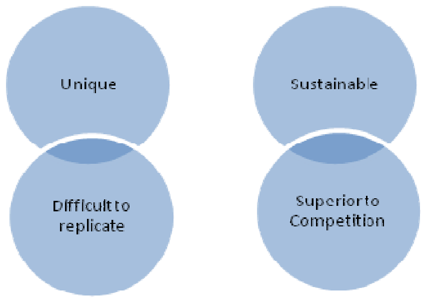

Chart 2: Sustainable competitive advantage criteria

Organizational capability approach vs. traditional functional paradigm, in the capability model, senior managers are predominantly concerned with issues about the quality of products and services provided to customers(external and internal), the flow of value-added work, and roles and responsibilities.

The dominant view on performance measurement shifts from the traditional focus of actual versus budget to a more balanced model that includes the timeliness, quality, and cost of providing products and services to customers.

Allocation and budgeting of resources moves from the traditional practice of individual units verifying for resources based on their own needs toward cross-group teams that jointly assess resource needs based on the flow of work needed to create value to customers. Problem solving would seldom involve situations in which unit managers had to compete with each another. Instead, organizations would adapt departmental interdependence, recognizing that issues are best addressed through cross-group problem-solving sessions focused on providing services to customer and the required flow of work.

Capabilities as basis of your competitive advantage through continued use, become stronger and more difficult for competitors to understand and imitate.

As a source of competitive advantage, a capability should be neither so simple that it is highly imitable, nor so complex that it defies internal steering and control. Capabilities grow through use. How fast they grow is critical to your success.

According to the new resource-based view of the company, sustainable competitive advantage is achieved by continuously developing existing and creating new resources and capabilities in response to rapidly changing market conditions. Among these resources and capabilities, in the new economy knowledge represents the most important value creating asset.

Distinctive and reproducible capabilities are opportunity for your company to sustain competitive advantage. They are determined by capabilities of two kinds: distinctive and reproducible and their unique combination creates very own synergy.

Your distinctive capabilities, the characteristics of your company which cannot be replicated by competitors, or can only be replicated with great difficulty are the basis of your sustainable competitive advantage. Distinctive capabilities can be of many kinds, patents, exclusive licenses, strong brands, effective leadership, teamwork, or tactic knowledge.

Reproducible capabilities are those that can be bought or created by your competitors and they cannot be a source of competitive advantage. Many technical, financial and marketing capabilities are of this kind. Your distinctive capabilities need to be supported by an appropriate set of complimentary reproducible capabilities to enable your company to sell its distinctive capabilities in the market it operates.

For creating a culture of innovation the first step is to understand where the greatest deficiencies lie, and which levels will deliver the most impact. For many organizations, the most critical levels to assess initially include structure and metrics. This is through establishing innovation processes and providing employees with new skill sets which are also critical drivers of culture.

CONCLUSION

Increased competition is a key feature of the new economy. New customers want it quicker, cheaper, and they want things their way. The fundamental quantitative and qualitative shift in competition requires change and investment in supply chain management. Today, sustainable competitive advantage should be built upon corporate capabilities and must be constantly reinvented.

The supply chain is a highly complex area. As a result, it can be source of great efficiency and cost-savings gains. Companies are realizing that more than ever, supply chain excellence drives competitive advantage, customer relationship and shareholder value.

One unfortunate fact to keep in mind here is that it is not as easy as it may seem to study business's sustainability from supply chain perspective. It is actually a lot more complicated. The very implementation of the supply chain's structure itself is very difficult already.

Sustainable supply chain management is one of the most strategic aspects of the business. Hence it requires ongoing investments to ensure sustainability, efficiency and effectiveness to provide competitive edge where possible.

A good framework, built on crystal clear understanding of major parameters and processes in good and bad times, is critical guide for investments to gain sustainable competitive advantage.

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THE APPLICATION OF DECISION ANALYSIS IN THE MANUFACTURING PROCESS

Katarina Monkova[1], Peter Monka[2]
[1]Department of Technological Devices Design, Faculty of Manufacturing Technologies of Technical Universty in Košice with the seat in Prešov, Štúrova 31, Prešov, 080 01, Slovakia; katarina.monkova@tuke.sk
[2]Department of Manufacturing Technologies, Faculty of Manufacturing Technologies of Technical Universty in Košice with the seat in Prešov, Štúrova 31, Prešov, 080 01, Slovakia; peter.monka@tuke.sk

Abstract: *Today´s technologies enable to substitute the simple geometric shaped parts by one complex shaped part. On the other hand the manufacturing of such complex shaped parts is more difficult, especially if the drawing and technological documentations don´t exist (parts are made manually, documentation has disappeared,...) The paper deals with the possibilities of individual technologies utilization for the manufacturing of the selected undefined complex-shaped parts with regard to used material, technical plant equipment and requests of precision, too. Summary of some characteristics of selected technologies, which are suitable for the manufacturing of complex shaped parts, are well-arranged in the table. This article originates with the direct support of Ministry of Education of Slovak republic by grants KEGA 035TUKE-4/2011 and ITMS num. 26220220155.*

Key Words: *Complex shaped parts, decision analysis, manufacturing technology,*

1. INTRODUCTION

Currently, in connection with the entry of foreign investors in the Slovak market returns to the forefront of interest in industrial production. Its development is driven by a competitive match and increases the technical level, while there is a substantial effort to reduce overall production time and increase productivity.

Achieving a good indicator of profit and the ability to quickly respond to market demands is the only way for companies to survive and prosper. In the mechanical engineering industry and manufacturing technologies, it is much more. Being faster to market while increasing quality, this is a crucial competitive advantage of successful business future, which raises the need to address complex problems in all phases of development and production of selected products with the using of available technical, information and automation systems.

2. TECHNOLOGICAL ASPECTS OF COMPLEX SHAPED PARTS

The development of automobile industry in Slovakia has brought a new thinking of designers, in which simple geometric shaped parts are connected to groups substituted by one complex shaped part. The choice of production technology in this case can have a major impact not only on the costs of production but also the main period of production. The same product from the same material can be produced by various technological manners, including their combinations.

Technologist at the suggestion of technological process plan processes a large amount of information that results from a workshop drawing and from the specific conditions of production. Processing of this file of information is made on the basis of known technological rules obtained by exact methods and many years of practice. The results of their decision-making process technologist prepare a certain sequence of commands that should guarantee the most economical way to manufacture parts in the existing conditions. His work is based not only on the requirements of the product (design, configuration, quality, accuracy, etc.), but also he has to reflect on the appropriate use and utilization of equipment, as well as labour and working subjects. It is realized by using of the capabilities, characteristics of speed and versatility of machines at the working equipment; at the working objects it is realized by the using materials so that reduce the proportion of material losses and waste, while increasing the quantity per unit weight, area or volume of the basic material.

At the labour power it is used the skills and experiences as well as mental and physiological abilities of man. In other words, the level of technology can be evaluated according to the use of all elements of production processes to improve the quality and functional properties of the elements, as are products or performances. The technology determines not only the utilization of production equipment, but also the working mode of action items with the goal to create new product. A serious challenge is the selection of efficient technology, which allows with the lowest cost to achieve the best quality and functional properties of products. [5]

The production process is done on bases of manufacturing process planes, creation of which is subject to the existence and interaction of factors and elements. The most important are:

- product, technology, material, raw product
- machine, production equipment
- personnel (qualification and expertise)
- energy (type, method of transfer, amount)
- organization (time and space structure).

Although the classification of elements listed above that influence the drafting of the manufacturing process is a greatly simplified, considerable complexity result from it at the decision about the concrete used technologies, rows, production equipments, parameters, etc. Based on the impact of these factors and business possibilities, the suggestion of the suitable technology for part production is in progress, usually in this succession:

1) Design- technological assessment of the product drawing – it is analysed:
   a) starting and final state of part material
   b) the shapes of surfaces and dimensions
   c) the prescribed tolerance
   d) surface characteristics.
2) For the selection of a suitable variant of the production are on the base of previous step determined:
   a) production technology;
   b) row product,
   c) technological methods of processing the various features of component, which are mainly considered in the technological limitations, the possibility of concentration of operations (minimizing of running production time) and technical-economic conditions.
3) Determination of sequence of operations and a detailed proposal:
   a) choice of production equipment,
   b) the scheme part set up
   c) jigs and fixture preparations
   d) sections and sequence of operations.

This sequence of steps eventuates into the such structure of the process plan, which guarantees the best technical and economic conditions of the production. In this way, by analysing of the input information (e.g. about the production object, technology, production equipment,...) the process plans has to be optimized in order to achieve the required output values in the fields of extremes functions optimization criteria. [2]

Although the application of technological documentation is complex and difficult task, it cannot be done at once, but it can be carried out in several successive steps, in which some solutions are selected (technological methods of production and auxiliary equipment or process parameters). The choice or suggestion of the solution in a given stage depends on previous solutions. The sequence of decision steps may vary. The multi-stage decision gradually narrows the set of eligible solutions. E.g., the determining of the machine is given by the technology operations choice and the choice of instruments will be limited by the previous selection of machines. There are a large number of variants that are equivalent in terms of ensuring the production of all areas with the required properties. But they are not comparable in cost and labour productivity. According to the test function (minimum cost or maximum productivity), these variants will be optimized. Each variant is evaluated on the basis of the test function. This variant, which satisfies the extreme, is the optimal plan of technological process.

Priority (hierarchy) of test functions is chosen according to the production conditions. Minimum cost and maximum productivity of single-part production requires minimizing of the number of used machines, non-standard jigs and fixtures, tools, etc. As for mass production, first is minimized the number of part orientations, maximized the number of simultaneously working tools, the operators with high productivity ratios and automation degree are preferred. [4]

In Table 1 are clearly prepared some of the characteristics of selected technologies suitable for producing complex shaped parts, whereby it is possible to suggest appropriate technology for their production.

2. DECISION ANALYSIS

The philosophy of the individual steps within the decision analysis was applied to the choice of production technologies for the group of similar complex shaped components. It is concerned to the templates for the stator windings of electric household appliances with different power. (Fig.1) Displayed parts were necessary made from structural steel with high precision, therefore the casting couldn't be chosen as production technology.

Table1. Some characteristics of the selected technologies suitable for complex shaped parts production

	Advantages	Disadvantages
CONVENTIONAL TECHNOLOGIES		
Cutting	- possibility of stereometric complex products production - precision operations - all kinds of machined materials - from single-part to mass production	- long running time of production - at the using of standard metallurgical rows usually high waste material
Volume mechanical working	- improve the mechanical properties of the product - usually a good material utilization - smith forging is suitable for single part production	- expensive machines and tools - it requires technological aids - fixed forging is suitable medium mass production - wasted material – burnout and veining - thermal affection of material - energy consumption
Surface mechanical working	- product accuracy - usually a good material utilization - using universal production tools already suitable from single-part production	- expensive machines and tools - usually appropriate to the mass production
Casting	- production of stereometric complex products - according to the type of casting from single part to mass production - good material utilization	- the possibility of obtaining inadequate material structure - energy consumption
Welding	- creation of the light and solid skeletons - creation of large skeletons - suitable for repairs and renovations	- thermal affection of material - the possibility of the of internal stress and deformation origin in material
UNCONVENTIONAL TECHNOLOGY		
Electroerosion machining	- working of hard machinable materials - machining of complex shaped parts - precision machining - low characteristics of surface roughness	- only electrically conductive materials - it is not possible to produce a product with sharp edges
Spark erosion work	- working of hard machinable materials - machining of complex shaped parts	- only electrically conductive materials - higher values of surface roughness characteristics
Electrochemical machining	- working of hard machinable materials - machining of complex shaped parts	- only electrically conductive materials - the loss of the tool shape in machining process
Ultrasonic machining	- machining is independent on the electrical conductivity of material - machining of hard materials - machining of complex shaped parts	- restrictions from the view of the instrument size
RAPID PROTOTYPING TECHNOLOGIES		
Stereolitography SLA (liquid acrylic, epoxy and urethane fotopolymer resin)	- rapid assessment of design - manufacturing of the moulds for casting	- only limited testing of working models
Automatical laminating LOM (paper, plastic foil)	- rapid assessment of design - manufacturing of the moulds for casting	– the lower level of parts detailing
Fibre application FDM (wax, ABS)	- rapid assessment of design - manufacturing of the moulds for casting	- only limited testing of functionality and the ability of assembling
Hybrid 3D printing (Metal and plastic powder, starch-based powders, wax and epoxy infiltrates)	- rapid assessment of design - manufacturing of the moulds for casting - testing of the ability of assembling	- only limited testing of functionality
3D Printing (Waxes)	- manufacturing of the moulds for investment mould method - components of smaller dimensions - design evaluation	- only limited testing of functionality and the ability of assembling
Selective laser sintering SLS (plastic, metal and composite powders)	- fully functional prototypes for mechanical assemblies - rapid assessment of design - manufacturing of moulds for casting - production of fully functional prototypes of products in small batches in series quality.	- high cost for the equipment and its operation

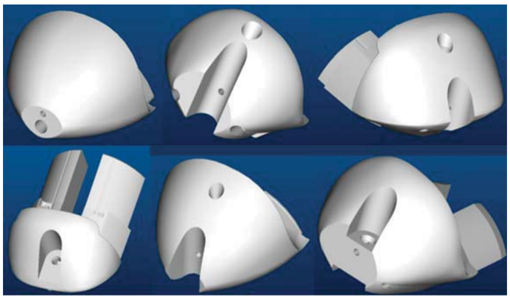

Figure 1. Various types of templates for stator winding of electromotor

Based on available plants opportunities and machinery, and also in view of the drawings referred to undefined shape parts, it was selected 5-axes milling as production technology. The NC program creation in manual way was not possible with regard to the undefined shape of part surface. CAD/CAM systems allow to complex solve the development-design and production phase of a new product. Integrating CAD and CAM modules into a single unit can be preserved a single data platform, which ensures a smooth transfer of information. [1] NC programmers and engineers work in one technology environment and they have for the disposal the full tree (history) of the model creation with all information. The result is a reduction of development time and greater opportunity to optimise the project. At present, almost all the technology of machining, cutting, welding and forming are supported by CAD/CAM systems. [3]
Since the shape of the template was not defined and the line of space surface cannot be clearly specified analytically or by the using of 3D measuring machine, it was necessary to define the surface data obtained by other means. To the digitising of surface data of the template was selected method of the area scanning. As a scanning device was chosen the scanner LPX 250, which was available at FMT TU Kosice with seat in Presov and that meets the requirements for scan precision and for the dimensions of scanned object. So-called scanning cloud of points was obtained by scanning incident the surface of the template in a format that would need to be transformed into the neutral IGES or STEP format and then import into choices CAD/CAM system Pro/Engineer. In this system, using the tools that the software offers, the virtual model was created and it becomes the basis for cutter location (CL) data generating in the CAM system.
After the cutter location data are generated, post processing is done to get machine executable codes for actual production. A tool path interval that is too large can result in a rough surface while one that is too small can increase the machining time, making the process inefficient. Due to the complex geometry of the surface, tool body and tool holder interference with the surface pose many constrains on tool path generation. By means of postprocessor were CL data processed into the NC program for a specific control system of selected CNC machine.

3. CONCLUSIONS

From the very beginning of the project the established IS served for a suitable analysing of individual real database objects, i.e. new analytical tools were created when required. Established solution serves the purpose of easier and faster assigning of the process parameters, shortening of the computer aided process planning documentation time in real production conditions, and it also supports the effective utilization of the production plant based on the model mathematization of object variation of the computer aided process planning, fulfilling the combination of the required characteristics within the given production conditions. Output system data can be used for processing of the details for the warehouse, economic and wage records as for their control and optimization. The current production of templates for electromotor stator winding was performed manually abroad by grinding in antitemplate. The average delivery time of the template is longer than three months after order, so the manufacturing organization had to build up the inventories of this plant component. With regard to that each type of electromotor requires a different way of winding (different number of turns, other minimum winding diameter, variable thickness wire, etc.), it is the number of types of templates used in the production organization of the order of tens. After 3D models creating and its verifying, and after NC program generation, times to delivery of Slovak producer were shorted than the original foreign manufacturer in the 90-98% (in 80 to 88 days from the initial 90 days), the number of reserve template in the store is possible to reduce at least in 50% and the price of templates made in Slovakia is lower at least 60% with regard to the original foreign supplier.

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DESIGN PROCESS MODELLING

Ştef Dorian, Drăghici George, Florica Stelian [1]
"Politehnica" University of Timişoara, Romania
(stefdorian@gmail.com; gdaghici@eng.upt.ro; f_stelian@yahoo.com)
Corresponding author Ştef Dorian, E-mail: stefdorian@gmail.com

Abstract: *This paper proposes a first step for developing an integrated methodology for product development in the context of digital factory, by detailing the process model in the detailed design activities. By this decomposition, we want to recognize and to identify an architecture that can be implemented in development of this methodology. To achieve this goal will be considered design process model proposed by Pahl and Beitz as representative. The model will be detailed in the activities of lifecycle by using IDEF0 from iGrafx2011.*
Key words: *Lifecycle, design, design model.*

1. INTRODUCTION

The existing business structures tend to reflect conventional patterns of thinking and work, because the new processes and methods are not yet practical in a comprehensive manner, only a limited amount of economical potential is saved by using single IT solutions. The real possibilities offered by Digital Factory (DF) are accessible only through an appropriate network of all resources, in conjunction with a restructuring of processes and hierarchical organization. Will also be necessary to review and redistribution of the skills and the responsibilities in all departments from the entire company (Coze, 2008).

Therefore, it is necessary to develop an integrated methodology to design and manufacture of the product, that covering the entire cycle of the digital factory. The Digital Factory (DF) cycle, in the product lifecycle, that is starting with the need perceive and goes up to eliminate the product form the market, (Fig. 1), is represented by the design stage (Draghici, 1999).

The design activity, which is interposed between the desires of a consumer (client) and the functions that the product must to offer to satisfy them. Requirements or wishes of consumers should be fully understood and translated into a set of technical requirements which are then defined as the product file which is reflected in the product. A robust conception begins with what is desired to obtain and complete a finished product that meets more of the requirements imposed by the user (User Centered Design).

To establish a methodology to be implemented within the platform structure integrated design and manufacturing activities required to analyze the concept of product life cycle.

Therefore, inherently, to develop an integrated methodology to design and manufacturing is necessary to detail the design process. The methodology it uses resources that integrates life cycle, with considerable potential available of IT solution that can be capitalized and bring many advantages to the company. The interface for designer must become more intuitive. After all, the designer creativity should not be subordinated to actual software formalities, ideas must be implemented and tested quickly and easily, by using the computer (Bracht, 2005).

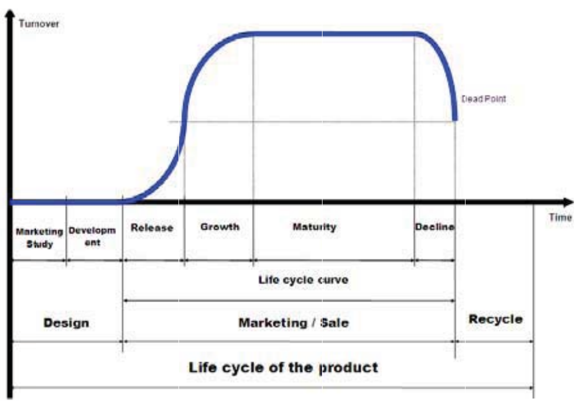

Figure 1. Product life cycle stages (Draghici, 1999)

The objective proposed in the research is to developing an integrated methodology for product development in the context of digital factory. The first step for achievement this objective it represents the modeling of the design process. By this, we want to recognize and to identify an architecture that can be implemented in development of this methodology. To achieve this goal will be considered the systematic model of design process proposed by Pahl and Beitz in 2007 as representative. This model is based on a sequential design process (hierarchical sequence of stages). For graphic representing of the design activity will use the IDEF0 module form the program iGrafx2011. For modeling as clear and complete, the life cycle of a product, is appropriate to adopt an descendent approach, that will allowing the progressive transition from general to particular.

2. LIFE CYCLE MODEL

The product life cycle can be seen as a set of activities (Fig. 2) To represent the product life cycle model was used iGrafx 2011 program, which contains the module IDEF0 (Integration Definition Function) (Banciu, 2011)
The IDEF0 modeling language is a graphics and text based notation used to model a system or process. An IDEF0 model is composed of a hierarchical series of diagrams that gradually display increasing levels of detail within the context of a process.

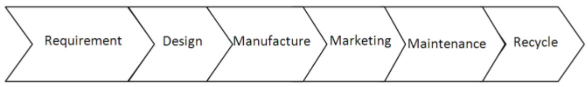

Figure 2. Lifecycle activities (Banciu, 2011)

In iGrafx 2011 each activity can be recorded in a modular form and graphics provided with arrows that have specific significance. The activity aims is to transform input data's into output data, using the means of assistance, namely control, allowing the onset or control his conduct (Fig.3).

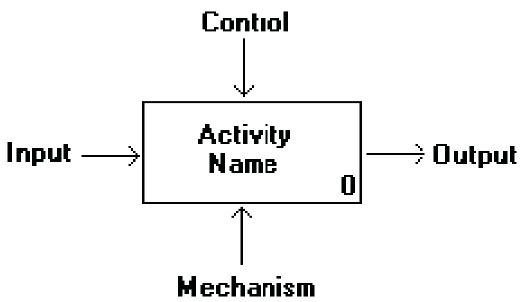

Figure 3. The chart A0 diagram of the model

The first diagram includes a statement of the diagrams purpose and viewpoint. The statement of purpose expresses the reason why the model is created, and viewpoint describes the perspective from which you view the model.
The top-level diagram (Fig.4) in the model provides the most general or abstract description of the subject represented by the model. This diagram is followed by a series of child diagrams providing more detail about the subject

The top-level diagram, also called the A-0 diagram, contains life cycle activities specified above taking into account inputs, outputs, methods of assisting and constraints incumbent on each activity, as shown in Figure 5.

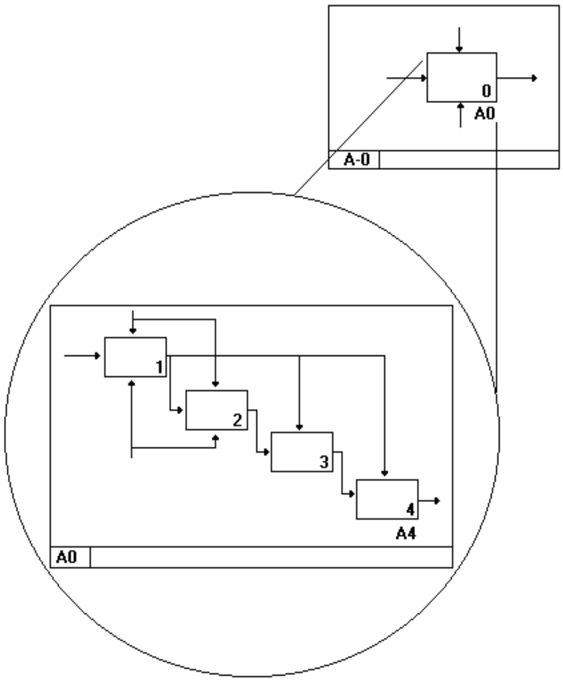

Figure 4. The decomposition of A0 diagrame

To develop products more clearly and completely the product life cycle is taken a descendent approach, allowing gradual transition from general to particular. Thus, each activity is subject to decomposition respectively openness several subtasks which in turn can be decomposed in the further.

3. PROCESS MODEL DESIGN

3.1 Design activity

In (Draghici, 1999) and (Ramani, 2008) states that "developers spend about 60% of the design time looking for information, which is characterized as one of the most frustrating activities undertaken by an engineer". Design activity is the step that requires the longest amount of time and phase with the highest consumption of resources throughout the product life cycle.
One of the models representing for process design is proposed by Phal and Beitz in 2007. The systematic approach "is not trying to have the last word on the subject is trying to created good design practice and education, to provide a range of methods used in design, to highlight the importance of fundamental knowledge, principles and guidelines and be useful as a guide designers and managers in the successful development of products, this approach is based on a specific method, but the methods apply more or less know where they are appropriate and useful for specific tasks and work steps "(Pahl, 2007).

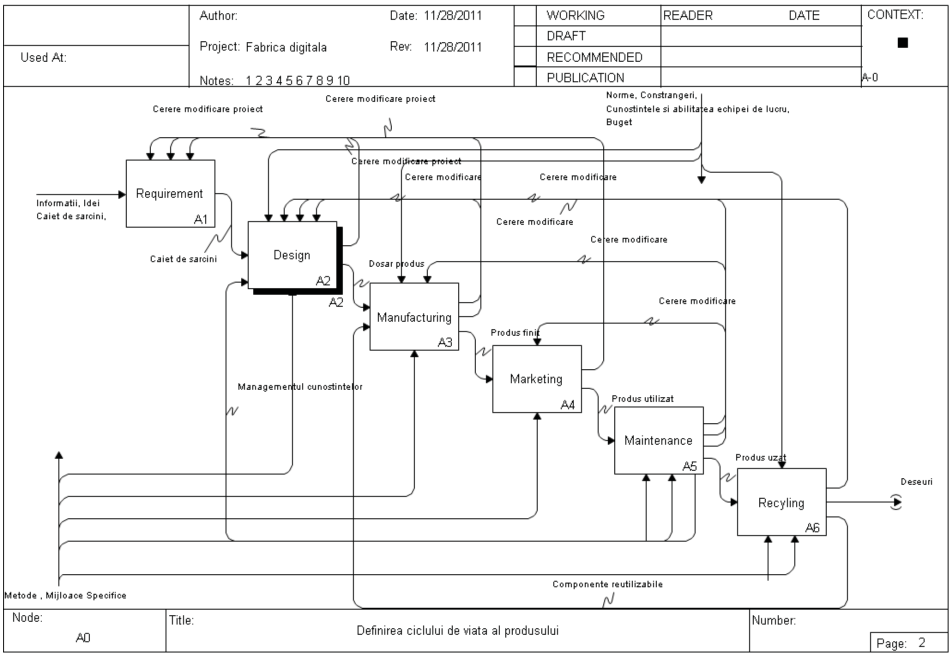

Figure 5. Chart A0: The product life cycle diagram

Figure 6.

The Pahl and Beitz model consists of a hierarchical sequence of design phases, the prevailing logic is the convergence:

• First phase - Clarify the task (clarification and planning tasks), the resulted is a initial description of the product, stated as a list of product characteristics and functions that the product must to achieve, whit a constraint system and certain objective on the cost efficiency and a good time to release the product on the market.

• The second phase - conceptual design lead to a principle solution or product concept. The objective of this phase is to find a solution to resolve the task that was stated on the first phase.

• The third phase - embodiment design (design concept) lead to a first physical product solution based on the main solution determined in the conceptual design phase.

• The fourth phase - detailed design, the final results of this phase lead to the development of all documentation required to start de real fabrication of the product by sending the product final file to the work shop.

The designing work phase, split using the model described by Pahl and Beitz, is represented in Figure 6.

3.2 The embodiment design activity

The embodiment design represent the activity in which the designer or the design team developing a full technical description and structure of the final product in terms of shapes and sizes. Also in this phase, the tasks of analysis, evaluation and synthesis, are sequential and are complements before reaching an optimal solution of the product.

During the embodiment design phase the design team must to establish the preliminary design of the product spatial form (3D model), materials used, components, general arrangement and spatial compatibility and the assembly functionality, and for any ancillary functions needed to provide product solutions. The conceptual solution is developed using scale drawings with a critically reviewed, 3D models (feature and assembly), the digital mock-up, testing and evaluation reports which are subject to technical and economic evaluations.

•The A22 diagram (Fig.7), expresses the phase's embodiment design activity and is detailed in: Virtual Design, in this phase the design team prepare all the documentation (CAD model, DMU, etc.) for the product The designer completely and thoroughly defines each component, specifying its size, the physical (material), diagrams and detailed plans, costs, and a description of its process of operation and use;

If in the virtual design, the designer find that some task are incorrect mentioned, he send back to the project or some components of the project to clarify the task phase.

•Virtual Prototyping, this is the phase that enabling the designer to examine, manipulate and test product designed using different software that facilitates communication between different departments involved in the concept design phase.

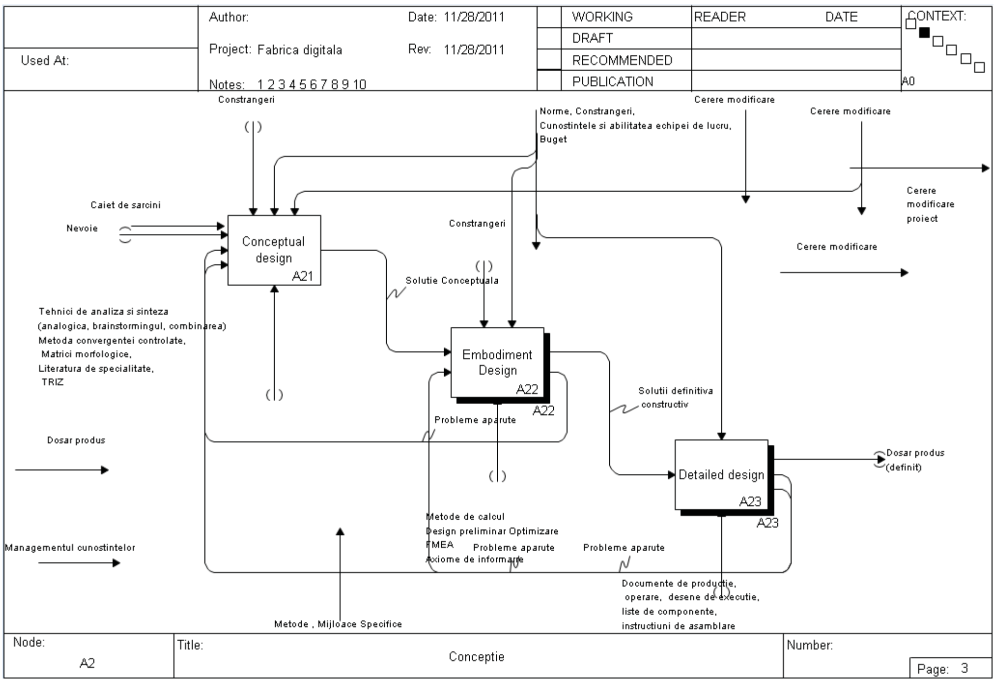

Figure 7. Chart A2: Design activities

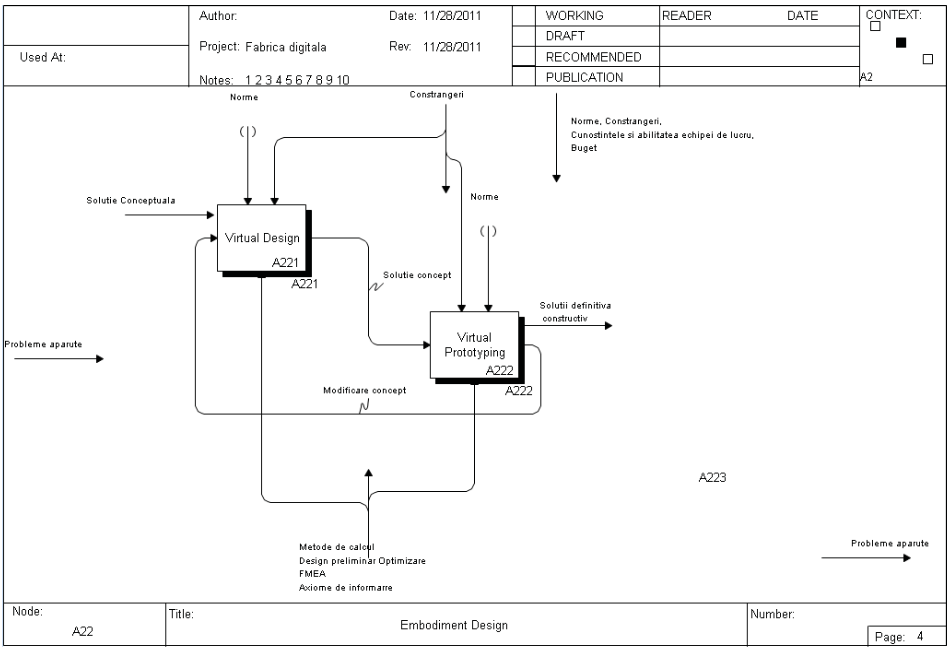

Figure 8. Chart A22: Embodiment design

3.3. The Virtual Design activity

Virtual modeling and visualization techniques is the concept of abstraction and representation of various phenomena to which it is subject to future product, in the context of geometric modeling through the use of different systems.

A geometric model is defined as a comprehensive representation of a complete object by using the graphical information (drawings, sketches, etc.), and of the non-graphic (specifications, lists the functions, features, etc.). In terms of graphical objects can be represented in two and a half dimensions (2D models), in which case have a uniform cross section or three dimensional (3D models), having a variable cross section.

Therefore, the virtual design is decomposed into diagram A221 (Fig.8) in activities necessary for abstraction of the product, the methods, resources and constraints relating to each activity, are:

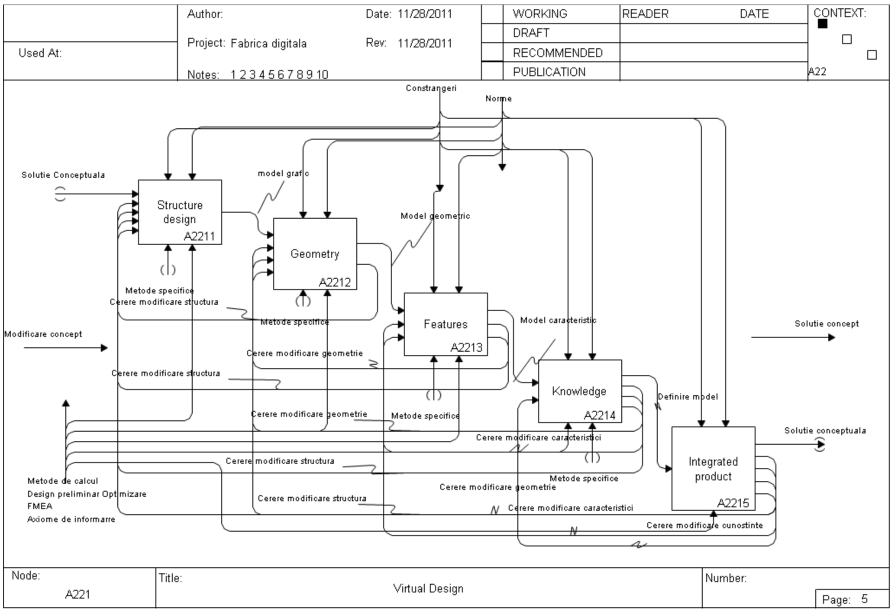

Figure 9. Chart A221: Virtual Design

•Structure design – the design of the structure is the heart of product, in this activity one of the principal step is the specifications data's of the product that can be stored using structure-oriented models;
•Geometric modeling - geometric models are widely used in the CAD/CAM software's , this kind of modeling satisfy the basic requirements for representations of shape, but are not capable to describe non-geometric information regarding the product;
•Assembly modeling – this kind of modeling are designed in the first instance for the representation of general form models, the concept is representation of all components (different geometrical elements that are included) of the real product;
•Modeling ergonomics - is a model developed using artificial intelligence techniques. This model tolerate rational information, referring to the designer expertise and experience on a class existing products during the modeling process.
•Digital Mock-up - is the functional combination of all models of the products presented. DMU is an integrated product model, used to help all future work based on functional analysis, environmental impact, process planning, numerical programming, manufacturing and product assembly, to final inspection.

3.4. The Virtual Prototyping activity

Manufacture the first product is a major waste of time, energy and materials, in order that product can be complied with specification requirements in the conceptual design phase. Following virtual product design activities the next step necessary is to design a set of tests in which the model of the product is tested. Therefore, digital mock-up that was created in virtual design phase can be imported into a specialized application that will be subjected to several tests, which can occur during real operation of the product. The tests that are designed for the product can be both simulated and evaluated for any forces that are apply on different components of the assembled product.
Garcia, et. al. state that the Department of Defense (DoD) defines a virtual prototype as "A computer-based simulation of a system or subsystem with a degree of functional realism comparable to a physical prototype" and virtual prototyping as "The process of using a virtual prototype, in lieu of a physical prototype, for test and evaluation of specific characteristics of a candidate design (Garcia, Gocke, and Johnson 1993)."
Virtual prototyping is an aspect of information technology that permits analysts to examine, manipulate, and test the form, fit, motion, logistics, and human factors of conceptual designs on a computer monitor
Virtual prototyping activity (Fig.9) is a simulation in a graphics software for a tangible product that can be presented, analyzed and tested in terms of product life cycle phases of design, production, sales / service and recycling, as a physical prototype.
•Therefore, virtual prototyping activity decomposes into the following phases: Product testing using numerical techniques - is the numerical technique for calculating approximate solutions of partial differential equations, and integral equations.
•Testing the concept of ergonomically - simulation and evaluation technique is effective for the use of movement, different body segments or whole, to carry out manual tasks.
•Testing product environmental impact - is the technique of simulation and evaluation of environmental impact throughout the life cycle
•Testing product life cycle (life estimate) - the technical evaluation and simulation of operation of the product and service life estimation

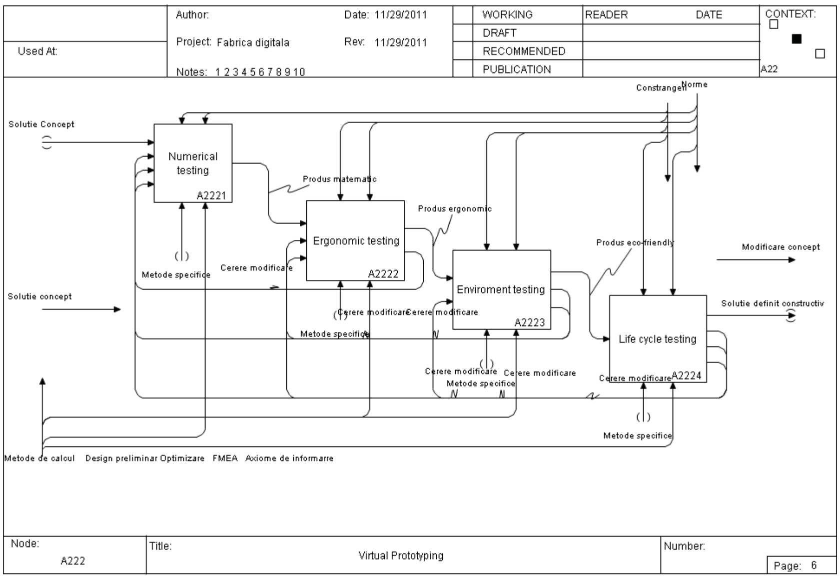

Figure 10. Chart A222: Virtual Prototyping

4. CONCLUSIONS

Today when it comes to developing new products and integrated approach ensures shortening design and product launch, increase quality, while reducing production costs.

By adopting a descendent approach to decompose the life cycle, that allowing progressive passing for general to particular, is desired to identify steps needed for design a product.

Therefore, having at the base the systematic model of design process proposed by Pahl and Beitz, this is decomposing in the following activities: clarify the task, conceptual design, embodiment design and detailed design. The embodiment design activity it is decomposing in: virtual design and virtual prototyping. The goal of this study was to analyze the design process, to establish a starting basis to developing a methodological approach for designing the product, defined in the digital factory context.

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TOWARDS A DIGITAL FACTORY - RESEARCH IN THE WORLD AND OUR COUNTRY

Prof. Dr. Vidosav D. Majstorović
University of Belgrade, Faculty of Mechanical Engineering, Laboratory for Manufacturing Metrology and TQM, Serbia.vidosav.majstorovic@sbb.rs

Abstract: *This paper presents an analysis and synthesis of research carried out in the field of digital factory and digital manufacturing. The aim was to present different approaches and concepts, digital manufacturing and digital factory, for the purpose of establishing a common research approach. The engineering model of manufacturing based on digital models of products, processes and resources is the future of manufacturing engineering in this area, and are therefore subject to analysis in this study particularly important. At the end are particularly given to future research directions in the field of digital factory and of manufacturing.*
Keywords: *Digital factory, Digital manufacturing, Manufacturing, Modeling.*

1. INTRODUCTION

Today's business structure is more complex and dynamic than ever before. The market requires rapid changes in the industry with new products, which directly reflects on the work of the factory. On the other hand, digitization and information technology (IT) provide new, unimagined possibilities, engineers in the design and planning. These two approaches have led to two concepts that have since emerged: the digital factory and digital manufacturing. They allow to improve the engineering product development and create a new era in business and manufacturing, where the sustainability of one of the most important factors of business [1]. Targets set in the digital factory are: to improve the manufacturing technology, reduce the costs of planning, improving the quality of manufacturing / products, and increase adaptability to new demands of customers and markets [2]. In the area of production, the words digital factory, digital manufacturing, product modeling, etc., are now widely used. What do these concepts actually mean? The answer is not simple, because the meaning of these terms depends on the views of users, their perception, application, knowledge, and much more. This requires very careful use of these terms. There are some concepts and acronyms that are related to the digital factory and digital manufacturing, which are essential to highlight. This specifically includes the definition of the concept of virtual factories and virtual manufacturing [3], the same types of problems encountered and the digital factory and digital manufacturing. Definitions of these concepts varies depending on the time of research and researchers who appointed them.

The definition of virtual factory should be synonymous with the digital factory, a virtual manufacturing should be synonymous with digital manufacturing. Our research shows that we should not distinguish between the concept of virtual and digital factory / manufacturing in this area. According to [4] there are some common characteristics in the research areas of digital / virtual manufacturing, factories and enterprises. These are, for example: (a) an integrated approach to improve products, processes and technologies (integrated digital model), (b) the application of computer tools, such as modeling and simulation, planning and analysis of real technological processes, and (c) framework for the application of new technologies, including development of new methods and systems.

2. BASICS OF THE DIGITAL FACTORY AND DIGITAL MANUFACTURING

2.1. Basic digital factory

No universally accepted definition for the digital factory, but can give some of them: *(a)* on the digital factory make animated visualization and simulation, which includes: advanced methods and processes in planning, integration of software tools and a competent staff, *(b)* digital factory a static model that includes geometric, technical and logistics data, given as an image object. Digital Factory contains digital information on the plant and its resources: location, media, logistics, simulation tools, and so on, [5] *(c)* is a generic digital factory digitized model of the factory, with its technological systems as key model from which others derive models as a mirror of the real manufacturing system. The digital factory design information (and present), evolving from the initial state of design, the final state, passing through various stages of reconfiguration. Information on manufacturing equipment and its features, tools, clamping accessories, material handling devices, etc., were also identified in the digital model. Therefore, we can say that digital information platform of factories manufacturing system in its lifetime, *(d)* digital factory generic term for a wide network of digital models, methods and tools, including simulation and 3D visualization [6]. If we now go from the foregoing definitions, one can derive common features for the digital factory / manufacturing, [7] as: *interoperability, database / knowledge, information capture and digital plant architecture. Interoperability* data, together with the portability, expandability and scalability is the most important features of information models [30]. To achieve this, the models should be in a neutral format, which provides that the models and explicit information for them, or the system is independent. One way to achieve this is to use existing standards for information modeling [8]. *Database / knowledge* is used to generate different models of digital factories, which are associated IT tools for modeling and performing various processes in it. The most common approach is to develop joint / unified data base for the digital factory, which develops after defining the information architecture of the digital factory. The most common option is the development of these models in a neutral format, because the information model is the core of the digital factory. In developing the information model must also be taken into account the life cycle of information, their domain, resources and processes that affect them. But the truth is here to say that the single database is not the only solution, and the second solution is a distributed database, which reduces the problems that appear errors in it. But no matter which solution is used, it is necessary to have a good information architecture and IT tools for its support. *Information capture and digital plant architecture* - generally speaking, digital factory planning is not only digital, but should be a database for her life. Therefore the main issue, as the its structure and organization affects an enormous amount of information that is generated and used constantly. As noted above, the digital factory is mainly used for digital planning products, processes and resources for manufacturing, and therefore for each of the elements necessary information. But here it must be noted that all of this information need not be in the digital oblku. What does it depend. The answer is that it depends on what we mean by the definition of business system, factory, manufacturing system and its operation [9]. Only when these things have clearly defined, then we can define the scope of information for our definition of a digital factory. If we look at the digital factory as a technological system, it is a product of its materialization rather than design. This means that the digital product model should not be included in a digital model of factories. But on the other hand, on (digital model of the product) must be compatible with the digital model of factories, to make it possible simulation of manufacturing. As a result, digital factory should be configured in the resource and process information. The process is a set of one or more activities related to the work process or work flow processes, the manufacturing of products in the factory itself. This manufacturing process is necessary and appropriate support: tools, accessories, transportation, maintenance, etc., because the factory can not function without them. Models of support processes provide better knowledge of them and reduce the volume of uncertain knowledge in the factory. Resources in the digital factory include: human resources (employees and their skills), physical resources such as machinery and equipment (all operating data on them) and information resources (management and administration of the factory). Processes and resources are defined in such a way to organize an information model, but that's not enough, when the plant operates on the basis of models of manufacturing activities. Because of this process and resource model should be presented so that their information domain can be modeled as an activity.

2.2. Basic digital manufacturing

Today there are real industrial plants, based on the concept of digital factory. Also, these studies deal with the load by research institutions, so the concept of digital manufacturing will be considered from two angles. From the perspective of industrial applications [10], manufacturing of digital computer includes support for the planning, engineering and 3D computer visualization. On the other hand in [12], the digital output is defined as a methodology that uses depth IT knowledge and technology. Profound knowledge in this model is used in digital form. CIRP dictionary, defines manufacturing as follows:" the whole of interrelated economic, technological and organizational measures, directly related to the processing of materials, ie. all functions and activities that directly contribute to the creation of goods. It includes all activities and operations relating to the product and its maintenance after manufacturing, and everything in between" [11]. In this case, the digital output of the digital factory. This definition is used by all researchers, members of the CIRP's. For example, the manufacturing model of the web-based multi agent system is defined as a digital manufacturing

[5]. This concept promotes collaboration between product development and manufacturing, but different plants, using a digital model of the product. Another example [14] proposes a model of STEP-NC manufacture, using a digital concept, which includes: (a) vane-standardized data exchange and use, (b) web communication and decision making, and (c) integration of the entire chain of manufacturing process. From the above analysis we can conclude that the volume of digital manufacturing can vary, depending on the definition that we use. Generally speaking, becomes the three most important elements that determine what is a digital manufacturing: IT system and its application, the theoretical concept of digital manufacturing - the scope of profound knowledge is used as a digital manufacturing methodologies, and using specific techniques and methods, such as for example web-based multi agent systems and the like [4,5]. When we talk about the basic characteristics necessary information in digital manufacturing, we can say is: its digital format, multiple use and its independence of distance, time and place of use. Another aspect of digital manufacturing of its framework and the principles it uses. If we start from the principle, first defining the model, indicating that the two approaches for this purpose may be used. The first is - common denominator for simplification and abstraction of something that may not be realistic [10]. The second is - If we look at an object B, which is building a model, and we ask him about the object A, and from him (facility B) to get an answer on the object A [13]. If this definition digital transfer of manufacturing, it is a virtual stock manufacturing, and these actions are performed on models of manufacturing systems and factories. Thus, the digital output should be a mirror of actual manufacturing with a few limited detail. Digital manufacturing for example uses a digital information product, you can verify the digital manufacturing through various aspects of the planning process. That's why we say that product information is extremely important in the context of various activities carried out in the factory and they'd never could be performed without them. Each product should have a digital model that can be used to simulate the benefits of digital manufacturing at the factory or for verification of different planning scenarios. All this means that the essential compatibility between digital product models and factory. The purpose of the digital output is: (a) verification through simulation facilities for manufacturing process planning, tool path and sensors for the inspection, (b) verification and performance analysis of digital manufacturing with the simulation of flow, geometry or performance machine tools. Forward the facts clearly define the scope of digital manufacturing, related to all manufacturing activities from beginning to end development of a product, where the IT system only tool to support digital manufacturing [14, 16].Digital manufacturing is performed and the analysis and simulation of digital factories, creating its model, using some or all models of the product, so that digital manufacturing includes resources and processes of the factory. This means that digital manufacturing is a way to verify the manufacturing of appropriate options for the type of product. The analysis shows that today still perform specific research in the field of digital manufacturing / factory, with no uniform definitions for these areas. For these reasons, all studies in this area of work, you need to start from the definition of digital manufacturing / factory which is used in this study.

3. OUR RESEARCH ACTIVITIES IN DIGITAL MANUFACTURING

Serbian as National Technology Platforms related to the Manu*future* ETP was created in individual Member States and adopt the main development goals identified in both Manu*future* – a vision for 2020 and the current document [18-20]. This initiatives can also encourage the emergence at regional levels of equivalent concepts promoting competitiveness by stimulation of the synergy between sciences, education and industry in Serbia. Our national Manu*future* initiatives, while adopting different models of organisation, should share the common Manu*future* vision and aim to promote widening acceptance of, and participation in, Manu*future* by Serbian industry, by [18-20]: (a) alerting public opinion and politicians to the challenges that Serbian manufacturing faces, as well as to industry's critical role in delivering economic output, skilled employment and sustainable growth, (b) aligning the interests of the R&D community and technology providers in strong and effective cooperation networks that develop and source knowledge and technology, and (c) identifying and strengthening the highly competitive local networks of large companies, SME suppliers, technological partners, consultants and R&D contractors.

The most important contributions of these Serbian initiatives should be in: (i) build a clear link to and incorporate a wide SME participation, as especially smaller SMEs can harder participate on European levels of platforms than international large companies, (ii) horizontal integration, coordination and synchronisation of R&D efforts in Serbia, (iii) vertical application of competitive technologies, products, methods and processes in enterprises (both OEMs and SMEs) – including multidisciplinary networks coordinating R&D activities in new industrial sectors such as medical technologies, telematics, nanotechnologies and mechatronics in EU and Serbia. Manu*future* will promote successful Europe-wide implementation of solutions at various levels facilitating the structuring of effort and funding, and encouraging pan-European convergence between regional centres of industrial competitiveness [18-20]. Over the next decade, the integration of Serbia in EU will have a significant influence on European manufacturing of products for global markets. In a strategy of integration and cohesion, they could become world-class suppliers to OEMs [18-20]. This can be seen as an EU/Serbia strategy of transition, to maintain strong national/regional sectors in the interim period, opening a competition between EU members in all areas, even in R&D as a key factor to promote excellence and fostering the European manufacturing progresses connected to the high-added-value industrial paradigm [17-20]. Serbian as national initiatives will be particularly important in the new MS, such as Serbia. After many years of socialist regulation, their move towards market economy – in R&D, as in other spheres – is a major mental, organisational, technical and financial challenge.

4. CONCLUSIONS

Starting from the facts stated in the text, according to some directions for research in the field of digital factories, such as: (a) establishing a single definition, scope and structure of the digital factory, (b) decomposition of the information structure of digital factories and the use of ISO 10303 standards, (c) explore suitable IT architecture that will be used for the development, transfer and use different models of digital products, processes and resources, and (d) development of an ontological concept for linking models and their structure in a digital factory. Our research is now related to the last aspect of the systemic approach to the development of digital manufacturing and digital factory [17-20].

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TRANSFORMING FROM SMALL TO MEDIUM ENTERPRISE: DO WE NEED A HELP FROM SCIENCE?

Valentina Mladenović[1], Ilija Ćosić[2], Dragan Šešlija[2]
[1]Politechnic – School of New Technologies, Belgrade, [2]Faculty of Technical Sciences, Novi Sad

Abstract: *This paper points out how it is possible to react on the level of production systems, by combining methods of the well-known, scientifically developed, approaches in order for the enterprise to be adapted to the new situation and survive in the market when transforming from small to medium-sized enterprise and from individual production to higher types of production.*

A case study of the small enterprise that in a short period experienced rapid growth in production, profit and employment and the problems that accompany growth is shown. Also, a new technological, manufacturing and organizational structure appropriate to medium-sized company is proposed.

Key words: small enterprise transformation, firm growth, facility layout, cellular manufacturing

1. INTRODUCTION

Successful small manufacturing firms are run mostly by people with vision and good sense of marketing and business, which usually do not have education in the area of management and manufacturing systems and are successful until the company holds in frame of small enterprise. The survival of such companies is promoted also with local actions, because the employees themselves perceive smaller problems in their workplaces and correct them. If the company operates well, it grows and transforms itself from a small to medium scale enterprise. The border crossing of that transformation is not clearly defined, but when it happens, it is not possible to manage the company only through local interventions. Instead, the systematic approach must be taken, and this approach have to rely significantly on the support of science. A special problem is if, during this develoment, occurs also the transition from individual to small-batch or medium-batch production. Lack of awareness about the necessity of change in the approach to management and organizational issues, during the transformation of small enterprises into the medium and/or the transition from individual to small-batch or medium batch production, is a frequent cause of deterioration of many companies.

2. BACKGROUND RESEARCH

Production systems can be classified by the type of manufactured product (e.g. discrete versus continuous), by the type of layout (e.g. functional, cell, line), the timing of production (e.g. design to order, production to order, production for the warehouse), etc... One of the frequently used classifications is based on the ratio of products and processes that define a small number of types of production systems (design, workshop, serial flow, line flow and continuous flow). Askin and Standridge [1] suggest that the choice between them is based on (i) the number of products and (ii) the quantity in which they are produced. Sekine [2] proposed a Pareto analysis of the annual production quantity and according to the shape of the curve, it is determined, by applying certain rules, the type of production system that should be applied. Groover [3] sets the boundary of 100 products a year between the Low and Medium Production but it distances itself that it is arbitrary opinion of the author. It connects Low Production mostly with Job Shop type of production and for Medium Production it notes two main types: Batch production and Cellular Manufacturing. In addition, various types of production systems are used in various stages of product's life cycle. At the start of production, before defining the actual demand, the product is usually made in the job shop type of the production. During the phase of sales growth, production is transferred to the serial flow type, and if the product design stabilizes and demand is sufficient, production switches to the line-type production system that uses dedicated equipment. As the company typically manufactures more types of products, and they can be in different phases of life, it leads to the fact that different types of production systems [4] can often encounter within the same company. The concept of One-Piece Flow Production has also been introduced [2, 4] and it seems to be very significant in current competitive manufacturing environment. By applying the "one-piece-flow" organization is made a significant reduction of material that is in the process [4]. The closest theory to one-piece production was brought by Burbridge as Production Flow Analysis [5]. Production flow analysis (PFA) is a technique for planning the change to Group technology (GT) in existing batch and jobbing production factories. It finds a total division into groups, using the existing machines and methods to make the existing parts, without any need to buy additional machine tools [6]. Group technology (GT) is a method of organization for factories in which organizational units (groups) each complete a particular family of parts with no backflow, or cross flow between groups, and are equipped with all the facilities they need to do so [6]. The change of production request also the change of layout i.e. it is usually necessary to design a new allocation of production departments in the existing facilities for manufacturing or design new plants. It is also necessary to determine, within each facility, the position of each technological system and auxiliary equipment in accordance with the new flow of materials. Facility layouts play a significant role in the efficiency of production systems, but it does not attract the attention of researchers in comparison, for example, with cell formation in cellular manufacturing systems [7]. The role of cell formation is to transform the discrete flow of materials in almost continuous flows of materials in order to organize production as "one-piece" production [5]. A production system that grows and transforms in the course of development must be flexible enough to respond to market changes and customer needs in order to survive in the market. An important problem is how to help companies that are supposed to, due to a rapid increase in workload, shift from previous individual production or manufacture of the project type to the series production. It is not sufficiently examined in which moment of the development of small businesses it makes sense to apply the scientific approach in order to adapt its production structure to the new conditions. In this case study is shown that this is possible and desirable to do it very early and in doing so, it is not enough to act only at the level of deployment of equipment, but also to focus the planned investments on optimizing the facility layout of the entire system.

3. CASE STUDY

For the case study was selected the company established in the year 2002, which is engaged in manufacturing and designing in the field of metal structures and processing techniques. It was chosen because it meets the characteristics of increasing growth performance. Growth performance is defined as growth in market share, return on sales (ROS) growth, and return on investment (ROI) growth. These three aspects of firm growth performance capture a variety of financial and market outcomes and have been long established in the literature [8]. Due to steady growth and changing external influences, the company has set a task to function in a manner quite different from its previous experience [9]. Although in [3] the lower limit for the application of cellular manufacturing systems is determined on 100 products per year, this study shows that even with significantly lower quantity of products (25) the principles of group technology can successfully be applied and can form one-piece-flow lines. For the optimization of production, a simplified and modified production flow analysis procedure (PFA) is applied in order to apply a group technology [6].

3.1. Analysis of existing conditions

Characteristics of this production are:

- production is of the project type, the realization of major individual projects are being negotiated, but it also began to emerge the products that are supposed to be contracted as continuous operations in smaller batches,
- there is a significant increase in business volume and profits, in continuity;
- number of employees, for 8 years, increased from 10 to 130, and by beginning of 2013 a jump to 200 is predicted. This shows that the company has rapidly transformed from a small to medium sized enterprise;
- there was no balanced and planned development of all segments, or systemic approach to development and consequently many problems are generated;
- in the last three years there have been attempts to achieve improvements by the means of local intervention but no substantial results yielded;
- business owner and his team are aware of the danger of sudden collapse of a successful company and are willing to invest in the direction of radical change, but they are not sure in which direction they should move.

The objective was to increase the effectiveness and efficiency of production system and to design the rational material flows. The analysis of the production program has been made and as product-representative is selected a reservoir for liquid aluminum (Figure 1).

The criteria for selection were that:

- the majority of technologies that are used in all production processes of enterprises is used in the production of the specific product and
- the product is produced in batches.

Fig. 1. Tank and cover before final assembly

Tanks are designed for transportation of liquid aluminum at a temperature of 780° C. Tank has outside dimensions 2050x2100x2100 mm and volume 3.8 m^3, consisting of a total of 312 elements on 83 positions. 214 elements are produced in the company and 98 elements are purchased from suppliers. The annual production counts 25 pieces. For **the zero point of the process** is chosen the moment when all the material and finished components are delivered to the entrance. **Ending point of the process** is the moment when the tank is painted, dried and ready for shipping and delivery. Processing sequence is specified with the technology for producing the tanks and cannot be changed. On-site recording and tank production process documentation showed 40 operations, of which: transport counts 18; processing counts 12, storage counts 4; storing counts 2 and data acquisition 4.

Buildings of companies have been expanded and altered over time. In Figure 2 are identified:

- old hall (OH),
- new hall (NH), divided by walls in four units,
- covered area (CA) which connects two halls,
- space for the input quality control (IQC),
- administrative building (AB),
- small warehouse (SW).

Due to the lack of an internal road (on the company's land) and of the input material storage, after reception and input control, the trucks with the material have to go to the main road again and enter the port for employees directly into the CA. They are blocking the way for at least 3 h while unloading materials. Production equipment of the company includes large and small saw bench, machining equipment (two lathes, milling machines, CNC milling and boring machine), CNC plasma, shears, four rollers, assembly equipment, sandblasting equipment, spray painting equipment and kit for dimensional control and electrical weighbridge.

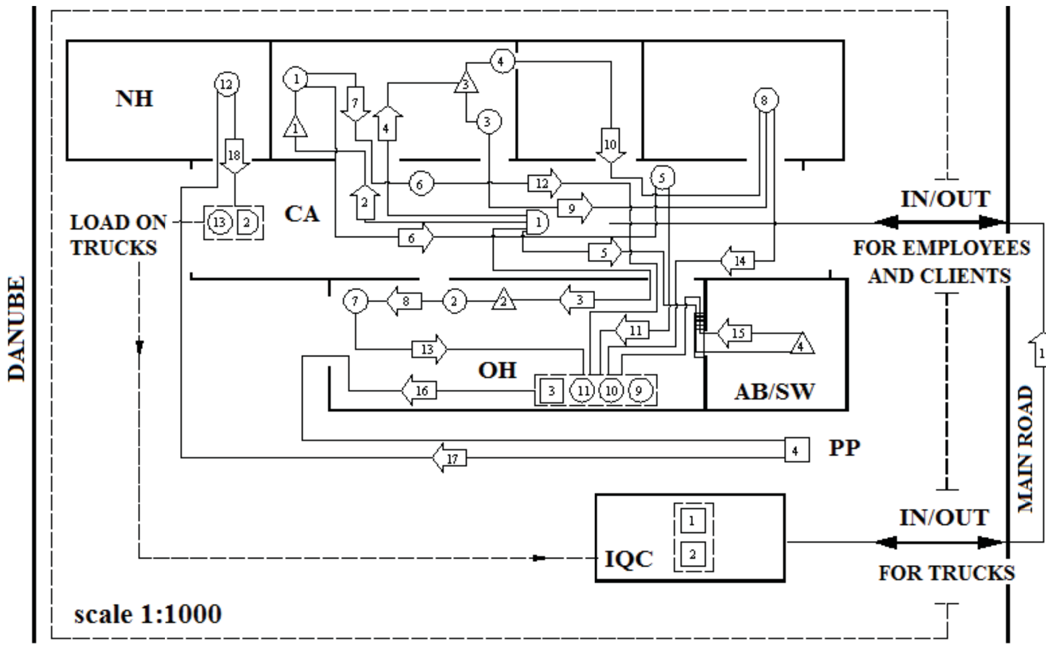

Fig. 2. The existing layout and flow of materials

The equipment was deployed by the order in which it has been purchased over time (Figure 2), without general plan. Location of the pressure probe (PP) is significantly away from the assembly and sanding location. It is proposed that technological process of painting and drying should last 18 h. However, it often happens that the deadlines are breached and the tank does not load at the truck in dried condition. That resulted in complaints from customers and in new expenses, and one of the imperatives of this study was solving that specific problem. The study showed that the identified problems are mainly due to defects in the layout. However, here is not only a question of inadequate distribution of machines, but a complete facility layout that needs to be redesigned. Material handling system is ineffective, inefficient and there is a large amount of work that has accumulated in the process. The initial values of parameters analyzed by this study are:

- number of operations N = 40,
- total length of transportation routes L = 3098 m,
- total duration of transport T_t = 32 h,
- duration of the production process T = 325 h.

3.2. Proposal for optimized facility layout

Optimization involves:

- creating a single production facility (SPF), which can be achieved in terms of construction technique,
- creating three warehouses at the appropriate places: the input storage of materials (ISM), near the location where are the entrance and input control; storage of purchased parts (SPP) next to the assembly location (where these parts and used); and storage of finished products (SFP), at the end of the technological process, with access to the river and the internal road for truck transport. Unloading of material takes place at the most convenient location - at the entrance to ISM, which does not interfere with the production process,
- construction of internal road through the own lot,
- facilitating direct transport to the Danube river,
- relocation of production machinery in the technologically justified locations - a new technological layout.

Various approaches for optimizing technological layout were discussed. Because of the heterogeneous production program and the size of the company, computer integration of all manufacturing (CIM) is not rational [3]. However, the CAD/CAM segments and electronic documents management are present and should be further developed. The application of LEAN approach also would not be adequate [3], because it is primarily intended for the adaptation of mass production. However, the existing production process meets both conditions under which it is best to be organized as a Cellular Manufacturing System (CMS) i.e. conditions under which it is best to apply the idea of group technology [10]:

1. company already has a traditional production with discrete material flow and
2. components of finished products can be grouped into families.

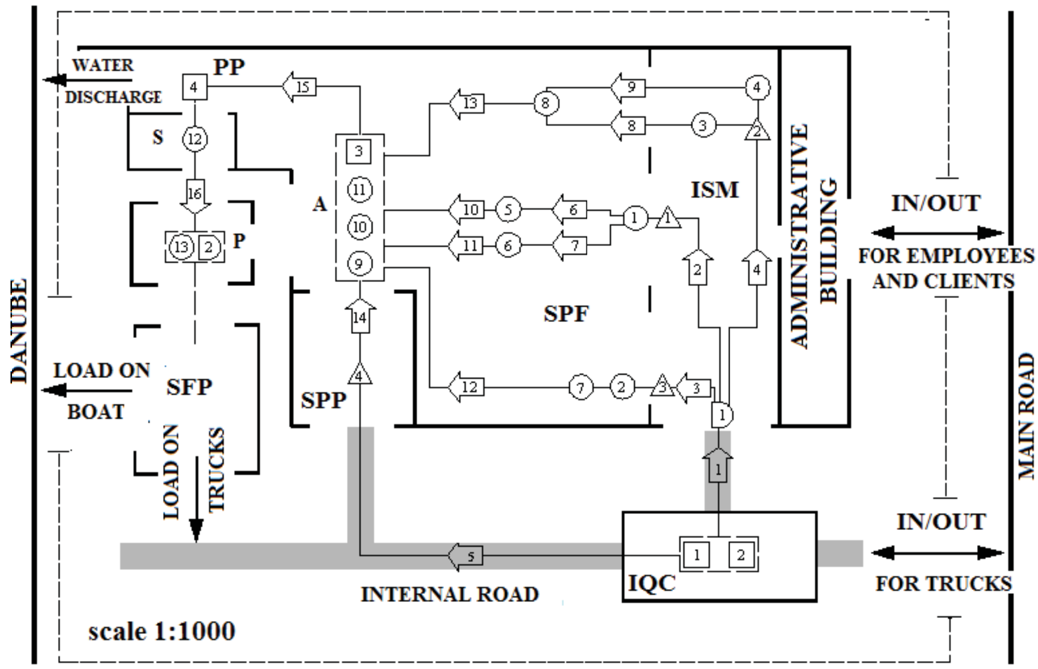

Fig. 3. Proposal of optimized facility layout with new material flow diagram

The largest number of elements is obtained by cutting complex contours out of thick sheets on CNC plasma and by rectifying them on medium and large sized roller (49.4%), followed by machine-processing (13.5%) and, finally, by cutting thin sheets on the shears and rectifying it on the small sized roller (5.7%). Components can be ordered from other manufacturers and 31.4% of those are participating in the assembly. In treating this problem, it was possible to apply Production Flow Analysis (PFA), because none of the anomalies appears which may accompany its application [3]. Each phase of PFA seeks to eliminate delays in the production flow and waste in operations [3]. While designing the layout, *a one-piece flow* technology is applied [2], it is thus achieved a high degree of rationalization. Material flow diagram, shown in Figure 3, which appears from a new facility layout, is much simpler. Three parallel *one-piece-flow* are presented on the diagram, which are used for the processing of grouped components. There are no transport routes crossings or stagnation points. These parallel flows are ending at the assembly (A) location. A new hydrant is envisaged, allowing enough space for the pressure probe (PP) to be located near the assembly (A). Next to this stand the area for sandblasting (S) and the painting (P) area. Table 1 gives a comparative overview of the operations in which a change has been made. Final figures are presented in Table 2. Transport routes are significantly reduced by time and length. This has completely eliminated the acute problem of lack of time to dry tanks. The proposed facility layout enables independent existence of each of the designed one-piece flow, which significantly increases the efficiency of the entire production. Although the facility layout is optimized based on product-representative, it allows the effective production of the entire product range and further growth and development of the company.

Table 1. Overview of optimized operations

Current	New	l (m)	t (h)
1	1	3x15	3x0,1
2 3 4 5 △1 △2 △3 △4	2 3 4 5 △1 △2 △3 △4	302	4
6	6	5x25	1,8
7	7	4x20	1,5
8	disappears		
9	8	2x25	0,5
10	9	20	0,2
11	10	5x50	2,5
12	11	4x50	2
13	12	70	1,5
14	13	2x55	0,8
15	14	4x5	0,2
16	15	25	0,4
17	disappears		
18	16	12	0,3

4. CONCLUSION

When designing a medium or large enterprise, it is possible to choose the most suitable of the so far developed approaches and to organize all production structures on its premises. However, optimization of the current status reached by the company's growth, and changing its type of production is a complex problem. A scientific approach is needed but which is, at the same time, much more flexible and which combines the available options in the best way.

Table 2. Effects of the optimization of the facility layout

Parameter	N	L (m)	T_t (h)	T (h)
State	40	3098	32	325
Proposal	38	1309	16	309
Change	- 2	- 1789	- 16	- 16
Change in %	5	57,75	50	4,92

In general, facility layout optimization belongs to complex engineering and managerial problems, especially if this should be adjusted to optimize business and production structure of a new type of production.From the case study it can be concluded that the scientifically based design principles of production systems can be applied in cases of small-scale production. The realization of this project determined that flow of materials, designed in this way, has proved to have very good results, not only for the product representative, but also in the processing of individual projects that are still dominant in the production program.

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APPLYING LEAN MANAGEMENT USING SOFTWARE IN PETROLEUM MAINTENANCE SERVICES (CASE STUDY APPLIED IN GAS TURBINE MAINTENANCE)

Dr.Eng. Mohamed Kadry Shirazy
Egyptian Maintenance Company

Abstracts . *The use of the lean tools can save time and money by reducing the causes of time losses in maintenance performance, improving Service will cause greater customer satisfaction.*

The three most important requirements for successful Lean system deployment were found to be

- *Management support*
- *Cost of implementation.*
- *Fear of cultural change.*

These three requirements served as challenges for all organizations regardless of size. The benefits of Lean management are great. Organizations reported increased profitability and employee and customer satisfaction associated with Lean implementation. Based on the findings of this study, we can conclude that benefits such as

- *Customer satisfaction.*
- *Increased profitability.*
- *Improved employee job satisfaction.*

There are two kinds of results for this study (process performance and time waste) explained in next section

1. PROCESS PERFORMANCE

After implementation of the lean tools to the dismantling process performance as shown in table (1) and for the Assembly process as shown in table (2) .

1.1. Dismantling process

The dismantling process time saving was summarized as shown in table (1)

Table (1) Turbine Dismantling results

Turbine Dismantling	Mean Time	Planned Time	Time delay
Before	515.8	465	-50.8
After	313	465	152

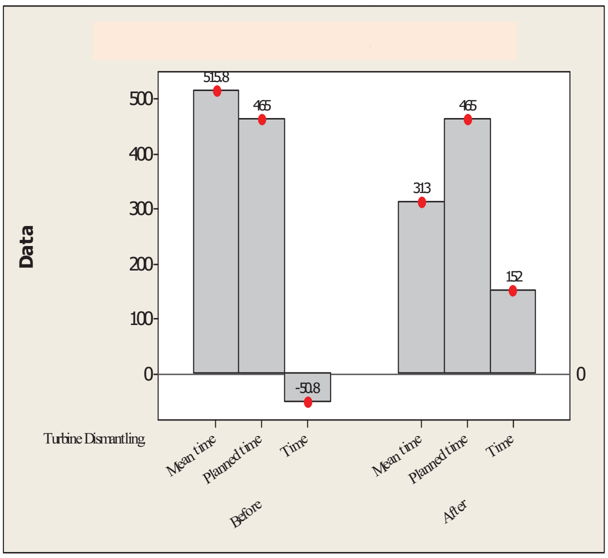

Fig (1) The Dismantling Process Before and after Improvement

The mean time of the dismantling process time has been improved to be 313 Hours instead of 515.8 Hours with saving of 202.8 Hours, which is equal to 8.45 working days. The process effectiveness was 110.9% and was improved to be 67.3 % which mean that after applying the lean tools we saved about 32.7% from the planned time.

1.2. Assembly process

The assembly process time saving was summarized as shown in table (2)

Table (2) Turbine Assembly results

Turbine Assembly	Mean Time	Planned Time	Time Saved
Before	1547.98	824	-723.98
After	699.5	824	124.5

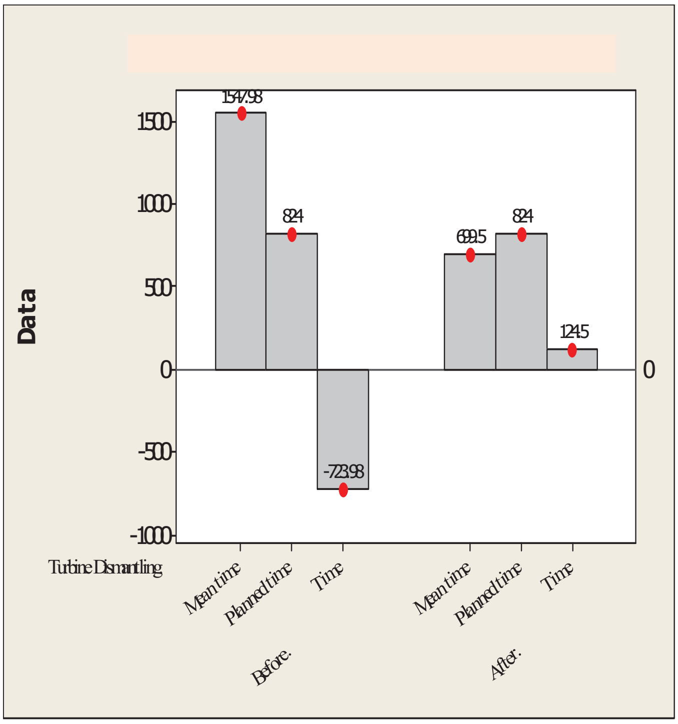

Fig (2) The Assembly Process before and after Improvement

The mean time of the Assembly process time has been improved to be 699.5 Hours instead of 1547.98 Hours with saving of 848.48 Hours, which is equal to 35.35 working days. The process effectiveness was 187.8 % and was improved to be 84.89 % which mean that after applying the lean tools we saved about 15.10 % from the planned time.

2. MAINTENANCE PROCESS PERFORMANCE

The mean of the whole maintenance process was summarized in table (3)

Table (3) Turbine Maintenance Process Results

Maintenance Process	Mean Time	Planned Time	Time Saved
Before	2063.78	1289	-774.78
After	1012.5	1289	276.5

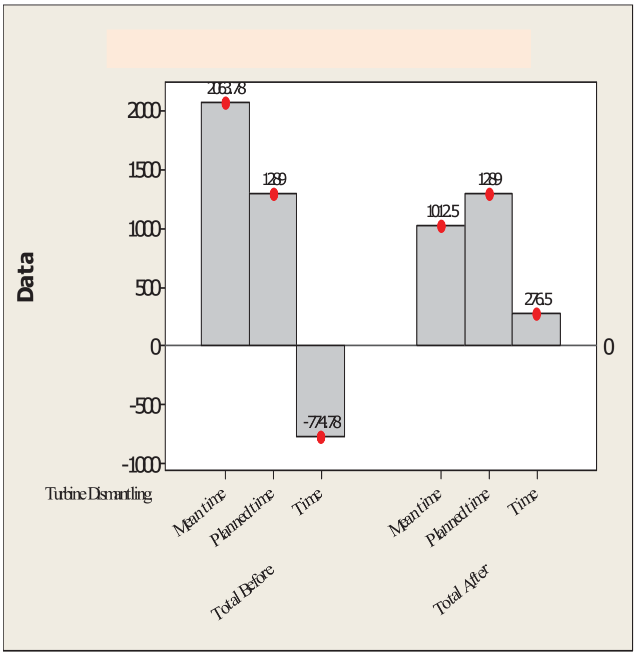

Figure (3) Performance Improvement

The mean time of the Whole maintenance process time has been improved to be 1012.5 Hours instead of 2063.78 Hours with saving of 1051.28 Hours, which is equal to 43.8 working days. The overall maintenance process effectiveness was 160.0 % and improved to be 78.5 % which mean that after applying the lean tools we saved about 21.4 % from the planned time.
From the previous results the researcher can summarize it as:-

1- H0 has been approved from removing the non-added value in the process.
2- H1 has been approved through the software designed to track the time losses in the process.

3. RECOMMENDATIONS

The researcher recommends implementing the suggested preventive actions in the Company (implement process control system) to prevent any possible time losses in the future and sustain the achieved improvements. Also recommends using the waste tracking software in any future maintenance process to track any expected time losses.

4. FUTURE WORK

To generalize the benefits of the previous results, the researcher suggested the study of using of some extra lean tools that may help the reduction of the of more time in the maintenance cycle

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FACTORS INFLUENCING MANAGERIAL DECISION-MAKING IN INDUSTRIAL SYSTEMS

Slavica Mitrović, Jelena Nikolić, Stevan Milisavljević, Ilija Ćosić
Faculty of Technical Sciences Novi Sad

***Abstract**: Given the increasingly complex and intense changes in the business environment, there is a need for changes in the decision-making process. As decision-making is a complex process by itself, in conditions of instability it is determined by a much higher number of factors. It is also much harder to keep its predictability and stability within the boundaries of known managerial mechanisms. Therefore, it is important to identify the external and internal factors that influence the decision-making process, as well as to measure and control these factors. Particularities of managerial decision-making in industrial systems[1] and its compliance with external and internal environment are prerequisites for their successful functioning.*
***Keywords:** managerial decision-making, industrial system [ii] s, factors of influence*

PRELIMINARY SETTINGS

Industrial systems – companies – are organizational units that fulfill their mission in a given environment on the basis of their purpose, operations strategy, levers that drive the employees and standards of behavior in the environment. The main purpose of an industrial system is to supply the market with products and services with the goal to ensure the necessary level of quality of life for the employees, the survival and development of the industrial system, as well as to meet the needs of society in which the given industrial system operates (Zelenović, 2005). Modern industrial systems are complex systems characterized by a wide range of products that are manufactured according to customer (market) needs, operations of international character, the use of expensive and specialized technology and frequent changes in organization, production and management structures. Industrial systems fulfill their mission in complex, unstable and highly uncertain conditions. This requires an active role of management that has the knowledge, desire and power to make good decisions that will improve the work processes in the industrial system. Thus, the need for a decision-making, as pointed out by H. Koontz and H. Weihrich, exists in all types of business and in all industrial systems. Moreover, it can be argued that each employee is required to make decisions needed by his/her job. Decision-making is found in all occupations and at all workplaces. The difference between individual jobs is reflected by the number of required decisions and their importance and role (Weihrich & Koontz, 2007). As opposed to the lowest-level management whose decisions are related to common, operational issues, top management decides on the most important strategic issues. Of course, these are the desirable relations in decision-making by specific levels of management. For industrial systems it is disadvantageous when things go the opposite direction, i.e. that top management is predominantly involved in making operational and routine decisions.

The business world today is in the process of very rapid and numerous changes (globalization of the economy, the swift growth of electronic commerce, the increasing pace of business operations, rapid obsolescence of technological novelties, the rapid expansion of new companies in the global market), which inevitably imposes the need for developing new models and forms of leadership. Therefore, flexible and capable leaders are needed today more than ever. The companies 'ability to survive future surprises largely depends on their leaders' – especially the top management – capability to manage the company as a whole in the face of changes (Mitrovic et al. 2011).

[1] The term "industrial system" is used as a synonym for a company, organization or company as of a business entity that performs a useful social activity.

Given the increasingly complex conditions of operation and the growing uncertainty in recent decades, the importance of high-quality decision-making is confirmed through the emergence of a new profession – a manager, whose key task is to make decisions. In fact, it follows that a good manager is a good decision maker. A reliable way for managers to improve or correct their decision-making is to become familiar with two basic theories: the normative and the descriptive theory of decision-making. Dealing with the ideals and principles of sound and rational decision making, the normative theory emerged in the economy in the mid of the 20th century. In addition to the accurately described behavior of a perfectly rational decision-maker, who is solely concerned with increasing his profits, the normative theory includes a number of decision-making methods. The descriptive theory emerged in the 1970's. Initially, it was related to the normative theory; later it was expanded on the observation, analysis and theoretical interpretation of the actual decision-making procedures.

By planning, organizing, managing and controlling specific resources, the management assists industrial systems in realizing its objectives. However, in order to accomplish any activity, it is necessary to make a decision. Managers need to make functional decisions that are appropriate and qualitative for the given moment and which will improve both the work process and the relationship with the environment.

Decision making is the foundation of management, since managing implies decision-making, which is the manager's most important job. Decision-making is critical to the management, because this is the way for management to actually realize its role. Although decisions in the industrial system are made also by other entities, the most important decisions are still the responsibility of managing bodies (Assembly and Board of Directors) and the management.

In order to be successful, it is important to understand the key dimensions of managerial decision-making, including the following:

- Industrial system, the place of managerial decision-making;
- Levels of management at which decisions are made;
- Managerial abilities and skills;
- The importance of decisions for the future of the organization;
- Rationality, given that managerial decision-making is primarily rational, because it is oriented towards the achievement of the organization's long-term goals;
- Strategy, as an integral part of managerial decision-making, given that it shows when and how to achieve the organization's goals;
- The result, i.e. achieving the organization's objectives;
- Uncertainty as a constantly present factor of managerial decision-making, which can never be removed.

The quality of managerial decision-making is rather dependent on the specific knowledge, abilities and skills related to decision-making, but even more on the manager's general knowledge, culture and education. He must be able to see the whole picture and to look for problems, i.e. to recognize the changes in a timely manner and make decisions. Managerial decision-making is influenced by a number of internal and external factors which will be explained in details in this work.

Many decisions are of poor quality because they are not based on facts, i.e. on complete and reliable information. There are a number of limiting factors for making high-quality functional decisions; three of them are the most important (Petkovic, 2003):

- ➢ Manager (individual limitations)
- ➢ Environment
- ➢ Organizational culture

Any industrial system has its own internal and external limitations. Internal limitations arise from the organization's culture, while external limitations are the result of the organization's environment (Coutler & Robbins, 2005).

THE MANAGER AS AN IMPORTANT DECISION-MAKING FACTOR

Decision-making is one of the most important, if not the most important managerial activity (Mintzberg, 2004). Management theorists and researchers agree that decision-making is one of the most common and most important roles of managers (Greenberg & Baron, 1998). Moreover, the organizational scientist Herbert Simon, who was awarded the Nobel Prize for his work on decision-making, equates the concept of decision-making with management (Simon, 1976).

Individual limitations influence the quality of decisions through factors of cognitive nature. With their abilities, skills and knowledge, managers are the main limiting factor for making effective decisions. They are imperfect makers of decisions for at least two reasons: 1) their limited abilities to gather all relevant information, to assess their importance and process them in an accurate and thorough way; and 2) due to cognitive biases regarding the formulation of problems, i.e. the way they are presented with them and the way of making the decisions, which is often biased when decisions are made on the basis of assessment (heuristics).

In addition to the barriers of cognitive nature, the quality of decisions is influenced also by individual and other limitations, such as ethics and personal moral standards, which are reflected through the integrity of personality and the manager's consistent or inconsistent behavior.

There are different aspects of consideration of the decision makers' personality traits in literature. It is possible to distinguish between irrational decision-maker who makes decisions despite the fear of consequences, creative people who embed some unforeseen and unexpected indicators in their decisions, structures of personalities who fails to make a breakthrough in decision-making from circumstances that are already given.

In psychology, general and relatively permanent features are usually referred to as personality traits. These imply the tendency of a person to behave in the same way in similar situations or in situations that are assessed as similar. Personality traits as permanent tendencies are the most easily observed in the behavior of individuals. They may be more or less generalized, and they include a wider or a narrower range of activities through which they are manifested. They can be reflected in the personality's attitude towards specific phenomena and persons, and can be manifested through a number of activities in different situations. Some personality traits reflect the motives of our behavior, while others point to the ways of behavior. Personality traits may be more or less pronounced; therefore, they are often referred to as dimensions of personality. This dimensionality indicates that one can be more or less attentive, energetic, edgy, and the like.

The structure of personality is mainly considered through the traits of temperament and character.

Temperament traits – refers to the way and type of emotional response and energy characteristics of the individuals' behavior as manifested through the power, speed and duration of response. Temperament is largely determined by hereditary factors, rather than by factors coming from the environment.

Character traits – refer to very broad features of personality, while in their narrower sense these traits refer to the moral-voluntary traits of personality. The character indicates the attitude of personality towards the applicable ethical standards and principles.

In addition to personality traits, the individual's behavior in organizations is influenced also by his biographical characteristics: age, gender, service years.

The age of employees obviously affects their behavior to a certain extent. First of all, it affects the employees' working capacity. On the one hand, aging decreases strength, speed, coordination of movements, concentration, and the like. On the other hand however, age contributes to experience and some routine tasks can be performed much more efficiently than young individuals can do. Also, ages are affecting job satisfaction. According to most researchers, age and job satisfaction related through the "U" type relationship, meaning that young people, as a rule, are highly satisfied with their jobs early in their career, when they still learn, develop, grow; then, in middle ages, when the person reaches its maximum in the work, job satisfaction declines; in the older ages, as the person approaches retirement, this is followed by a renewed growth of job satisfaction (Janićijević, 2008).

Service years imply the time spent by a person in a particular workplace or in a particular organization. As studies have shown, the longer the service years are, the higher is the likelihood that employees will be more productive, more satisfied, and less absent (Robbins, 2003). As for the genders, there are plenty of stereotypical conclusions about the differences between females and males. However, few of these prejudices are confirmed by studies. First of all, gender does not affect job performance and job productivity. In several studies no systematic differences regarding productivity were found between males and females when they were doing the same job. Females were more obeying to authority than males, but males were more aggressive and set higher expectations than females. However, studies have not confirmed the assumption that women leave their job more frequently than males (due to their role in the family), i.e. that their fluctuation is higher than that of the males.

A large number of studies that are based on the features of managers are classified into two categories. The first category consists of studies the authors of which seek to identify the features that make managers different from persons who are not managers. The second group of authors seeks to determine the features that differentiate successful managers from unsuccessful managers. The basic question is the following: what properties are a prerequisite for successful management. Lists of personality traits, as well as criteria for evaluating the success, vary from study to study. For example, the following is perceived as success criteria: the level of leadership, employee satisfaction, organizational success and the like. It is believed that there are a number of features important for the success in management, with the following being particularly emphasized: a high level of energy and high stress-tolerance, self-confidence, emotional stability, orientation toward achievement, need for power which is in a function of the organization's objectives and of the people being managed, a low level of need to care about other people, and internal locus of control. The presence of these features increases the likelihood that the manager will be successful in achieving objectives, but this still does not guarantee success. Also important is the role of the manager's capabilities. The following capabilities are important for managers (Grubić-Nesic, 2005):

- Intelligence
- Imagination
- Divergent thinking
- Logical thinking
- Creativity
- Social intelligence

- Analytical skills
- Verbal comprehension
- Observation.

Capabilities can be defined as the person's mental or physical capacity for performing a task or a job. Intellectual abilities are constituents of general intelligence and cover the following abilities: verbal, numerical, ability to reason, deduct, identify relations, memory, spatial orientation and the ability of perception.

THE ENVIRONMENT AS AN IMPORTANT DECISION-MAKING FACTOR

The environments in which today's industrial systems operate and develop are changing too fast, and the price that is paid for bed decisions increases on a daily basis. Strategic decisions, among other things, require strategic planning, forecasting, risk analysis and management, with the goal of minimizing the price of bad decisions and optimizing investments and the achievement goals (Cosic et al. 2006). In our business environment, there are forces which influence the actions of managers to a large extent. The environment of industrial systems can be divided into specific and general environments. Specific environment includes those external forces that directly and quickly affect the decisions and actions of managers, directly affecting the achievement of the industrial system's objectives. The main forces of this environment are: customers, suppliers and competitors. As though they decisions they can influence the operations of the industrial system, as well as the culture and business environment themselves, these factors have to be given a special attention to prevent them from restricting the decisions and actions of managers. Through its dimensions, organizational culture affects the way in which managers operate, make decisions, plan, organize, lead and control. This culture, particularly if strong, restricts the options of decision-making of managers in all management functions.

The general environment covers broad economic, political/legal, socio-cultural, demographic and global conditions that may endanger the industrial system (Robbins & Coulter, 2005). Changes in any of these areas affect the operations of the industrial system, so managers need to take them into account when making decisions.

Economic criteria: interest rates, inflation, changes in disposable income, market fluctuations all affect the decision-making within the industrial system.

Political/legal conditions: state and local governments affect what industrial systems can and what cannot do, i.e. they restrict them in making decisions. In industrial systems, a considerable time and money are spent on compliance with state regulations. By limiting the choice, these regulations reduce the discretionary power of managers. Managers should be also aware of major political changes in countries where they operate, because these political conditions can affect their decisions and actions.

Socio-cultural conditions: managers have to adapt their practice to changing expectations of society in which they operate. Parallel to the changing social values, customs and tastes, managers also need to change. If an industrial system operates in other countries, managers need to learn about the values and culture of these countries to align their decision-making with the given circumstances.

Demographic conditions: gender, age, education level, type of profession, career movement. Changes in these features may be limiting factors for managers in their decision-making, as well as in the process of planning, organization, management and control.

Technological conditions: technique and technology are areas where changes are the fastest. We live in a time of constant technological change. The whole area of technology and technique radically changes the fundamental ways in which organizations are structured, as well as the managers' behavior and therefore also the decision-making.

ORGANIZATIONAL CULTURE AS IMPORTANT AN DECISION-MAKING FACTOR

Culture is extremely important for management attitudes and practice, as well as for all its relevant aspects that give the overall tone of the totality of relationships that develop in industrial systems and determine the status of their employees. Culture affects the procedure of management, as well as the decision-making in all its functions (Robbins & Coutler, 2005):

There is a view that organizational culture, especially if strong, limits the decision-making options of managers in all management functions. It follows that the main task areas of managers are under the influence of culture in which the managerial job is done. Culture influences all management functions. The influence it exercises on human resource management has particular importance. This influence is reflected in a way that culture affects both the general and strategic approach to human resource management, planning, methods of collecting and selecting, rewarding and motivating, development and education, career, and above all the decision-making process. Cultural values govern the decision-making process, narrowing the circle of alternatives and influencing the choice of decision. In culture of power, managers are prone to make decisions intuitively. They are driven by personal impressions rather than by specific information. In culture of roles, which is typically bureaucratic, managers rely on logic and rationality.

Table 1: Culture and management functions (Robbins & Coutler, 2005):

Planing	- The degree of risk that plans should contain - Do plans need to be made by individuals or teams? - The degree of monitoring the environment in which management will be functioning.
Organisation	- How much autonomy is needed in employee's tasks? - Do tasks need to be performed by individuals or by teams? - The degree of existing interaction between managerial departments.
Leadership	- To what extent are managers interested to meet the employee's needs when increasing the workload? - What leadership styles are considered appropriate? - Do all disagreements – even constructive – need to be eliminated?
Control	- Is there a need to introduce external control or employees should be allowed to control their own actions? - What are the criteria that should be highlighted in the assessment of the employees operation? - What is the consequence of violating the budget?

Decisions are made analytically, on the basis of detailed analysis of possible alternatives and their compatibility with the organization's tradition and culture. In culture of tasks, decisions are made through an analytic process and techniques of formulating a new specific problem. In culture of existence or support, decisions are made quickly and intuitively. Intuitive decision-making is faster and considerably shortens the time required for decision-making. It is the property of young organizations that belong to culture of power or culture of support.

CONCLUDING REMARKS

In this century, the world is characterized (and will be characterized in the future) by constant and quick changes and discontinuities in all dimensions of life. Therefore, change is the only thing which is certain these days. This is the situation also in industrial systems, where these reasons impose the need for willingness to change even in its structure, in order to enable the implementation of possible innovations. Thus, the role of managers is essential, making their proper selection and choice a strategic issue. Leaders and managers need to understand their unique role in the process of implementing changes and need to work together as a team and at the same time to understand the role of employees who should be active during the entire process of implementation of changes (Nikolic, 2010). The consequence is the today's reality that an increasing number of industrial systems, complain about ineffective management, and search for "better and better" managers. Based on all the above, the conclusion is that the management is technology which is a drive of significant changes in attitudes, values, and above all, behavior. The willingness of managers to change is reflected also in how much they constantly change both themselves and the industrial system, which indicates the key relevance of managers. People create industrial systems and manage them. Innovative changes can be initiated, supported and conducted only by managers who have the aptitudes, capacities and power to innovate, all this at all levels of industrial systems rather than just at the level top management. Changes in people include changes in their behavior in order to meet organizational needs. Changes in the individuals occur as a result of their own unconscious activity and under the influence of the environment. Man with his conscious activity is also ready to change his own behavior, beliefs and skills. One of the most important feature of man is his ability to make decisions and thus to change himself and his environment, especially in the present conditions of growing business uncertainty and increased business risk.

In order to be effective and efficient, there should be measurable factors that influence the decision-making process, and they should to be taken into account and need to be managed in industrial systems in volatile economic conditions. On that basis the following should be determined:

- What are the desired dimensions of organizational culture for the given industrial system?
- What are the personality traits a manager should possess?
- What is the knowledge a manager should possess about the economic, legal, social process, within and outside the system?

Managerial decision-making has to be efficient and effective, because only in that way it can ensure the progress and the certain future of the organizations in today's uncertain and turbulent environment. It is the decision-making which differentiates successful and unsuccessful industrial systems (McLaughlin, 2005). Namely, they outperform their competitors when they are better and faster in decision-making and implementing their decisions.

In general, based on all the above, it can be concluded that in these industrial systems, managerial decision-making involves consideration of organizational, managerial and personal prerequisites of measuring their performance in all stages of the decision-making process.

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IMAGE SIZE AND SAMPLE AREAS INTERACTION EFFECTS AT CAN'S SURFACE COMPARISION BASED ON FRACTAL DIMENSION

Bozica Bojovic[1], Bojan Babic[1], Lidija Matija[2], Ivana Mileusnic[2],
[1]University of Belgrade, Faculty of Mechanical Engineering, Department of Production engineering
[2]University of Belgrade, Faculty of Mechanical Engineering, NanoLab

Abstract: *Methods used for fractal dimension calculation demand large image resolution and the adequate sample size, regarding roughness threshold that defines spatial scope for rough surface fractal properties. Imaging devise operators, from the one side, recommend image size and sample area based on experience and expertise, in order to minimize imaging time. From the other side, engineers made decision based on their own requirements. To overcome these problems, in this paper is proposed one-way ANOVA statistical approach for establish significant image size and sample area. Conclusion will enable decision guidelines regarding image size and sample area selection during imaging by scanning microscopes that ever-growing use is inevitable.*

Key Words: *Fractal Dimension, Imaging, Surface roughness, Friction, ANOVA*

1. INTRODUCTION

There are two practical problems that engineers have in a surface imaging in order to characterize machined surface. The first is to determine the values of the surfaces' parameters that will characterize the desired intrinsic property and the second is to minimize time for imaging, regarding image size as well as sample area that have main influence on it. The decision made by engineers is based not only on their own requirements but also on imaging devise operators' experience and expertise.

In the machining field, many of the phenomena that take place during processing are highly complex and interact with a large number of factors, thus fractal dimension has to be used for surface roughness complexity quantification as a ratio of the change in detail to the change in scale. Methods used for fractal dimension calculation demand large image resolution, for example 512x512 pixels. Furthermore, the size of sample previous prepared from machined surface is very important regarding roughness threshold that defines spatial scope for fractal dimension.

To overcome these problems, in this paper is used well known ANOVA test as statistical approach for establish significant image size and sample area. Relationships between various samples taken from same machined surface, as well as from different one, are investigated using Matlab. Presented results will be used for imaging by scanning microscopes that ever-growing use is inevitable. Conclusion enables decision regarding image size and sample area during topography and friction scans.

2. MATERIALS AND METHODS

2.1. Sample Preparation

Mass production of cans in company FMP d.o.o is performed by a sheet feed press CEPEDA (component of automated manufacturing line) by deep drawing. Cans are made of various tin plates, but Double Reduced (DR550) tinplate sheets are used for the experiment, regarding its widespread. Tinplate sheets are made of cold rolled and tin coated steel with high strength and sufficient ductility. This kind of tin plate, before deep drawing, is exposed to lithography and lacquering processes. Samples for the experiment are taken from the cylindrical and bottom part of single can after deep drawing with the ordinary process parameters. After cleaning samples were scanned in NanoLab at University of Belgrade.

2.2. Topography and Friction Scanning

A commercial scanning probe microscope (JSPM 5200, JEOL, Japan) is used for this investigation. Commercial probe produced by MikroMasch, Estonia, CSC37/AlBS for general purpose is used for contact mode scanning. The probe is a three-lever chip that contains long cantilevers with a Single-Crystal Silicon tip that has conical shape. Typical uncoated tip radius is less than 10 nm, height 15-20 µm, full angle cone is less than 40° and the typical force constant is 0.3–0.65 N/m, resulting tip curvature radius is 40nm due 30nm aluminum back coating. All experiments are performed at room temperature. For topography and friction scanning the AFM (Atomic Force Microscopy) operates in constant force mode where the tip is in permanent contact with the sample surface and due to its topography, the cantilever is deflected in the Z-direction. In FFM (Friction Force Microscopy) the torsion of the cantilever due to friction force between tip and sample is detected via photo-diode. AFM and FFM recorded images of samples are analyzed by WinSPM software first.

2.3. Fractal Analyses Method

The images of scanned surface are exported from WinSPM software as an image in tiff format and/or ASCII file. For further fractal analysis ASCII files are imported in Matlab software. The image in tiff format consists of either 256x256 or 128x128 pixels that are identified by their x and y position, with the grey scale function as the z dimension. The ASCII file contains either 65536 five-digit numbers that are modified into 256-by-256 matrices using Matlab custom-made procedure or 16384 numbers modified into 128-by-128 matrices. Such matrix represents an intensity-type image with gray-scale color map, where the range of values is [0, 65535].

The skyscrapers analysis was originally suggested for fractal dimension calculation of digitized mammography [3]. Pixels that constitute an image can be considered as skyscrapers, the height z(x,y), of which is represented by the intensity of the gray. The surface area of the image A, referring to (1), is obtained by measuring the sum of the top squares, which represent skyscrapers' roofs and the sum of the exposed lateral sides of the skyscrapers, according to [3]. The square size ε is presented as 2^n and it increases consecutively (ε=1,2,4,8,16) for 256x256 image size and (ε=1,2,4,8) for 128x128 image size, by adjacent pixel grouping. The gray levels are averaged using Matlab custom-made procedure [1].

$$A(\varepsilon) = \sum \varepsilon^2 + \sum \varepsilon \left[\left| z(x,y) - z(x+1,y) \right| + \left| z(x,y) - z(x,y+1) \right| \right] \quad (1)$$

The surface area A for each of images generated in the previous step is determined referring to (1) and resulting pairs (A,ε) is for images area vs. square size. The dots presented in double-log graph are arranged along the straight line. The linear regression is used for fitting the plot in Curve Fitting Toolbox in Matlab. The fitting process results in linear equation and the slope was determined from it. The fractal dimension D is in relation to the slope, as relation (2) states and D is calculated using custom-made procedure.

$$\log A = (2 - D)\log \varepsilon + c \quad (2)$$

2.4. Independent Samples Analyses

For testing significance and evaluating the differences in means between two and more groups the ANOVA is the most commonly used method. The two-group case can be covered by a t-test. The relation between ANOVA and t-test is given by $F = t^2$ [4]. Theoretically, the t-test and one-way ANOVA assume homogeneity (variance between the groups should be equal) and normal distribution. If the assumptions of homogeneity or normality are violated, ANOVA can be conducted as long as independence isn't violated with equal sized groups. This is the main reason for choosing one-way ANOVA to test differences among two independent groups in this paper, in spite of fact that t-test is suitable for two groups. The future activities will be span to more than two groups and shall justify that method.

The ANOVA produces an F-value, the ratio of the variance calculated among the means to the variance within the samples. If the group means are drawn from the same population, the variance between the group means should be lower than the variance of the samples. The ANOVA returns the p-value under the null hypothesis that all samples in two groups are drawn from populations with the same mean [5]. For one-way ANOVA testing the commercial software Matlab with Statistics Toolbox and procedures are used.

3. RESULTS AND DISCUSSION

The topography images that represent surface roughness distribution gathered from same location but with different areas are given in Fig1-left side for sample No7. and in Fig2-left side for sample No9. In previous work [2] topography images accompany with friction images were consider in order to identify the dominating parameter that affects the change in the friction signal in microscopic domain. The friction signal (recorded in Volt for each pixel) is indicative of the friction force, and therefore the friction images are given in Fig1-right side for sample No7. and in Fig2- right side for sample No9.

In this paper, we calculated fractal dimension as a roughness parameter for topography images sized 256x256 and 128x128 pixels using skyscrapers analysis. In double logarithmic diagram the dots represent images area vs. square size have linear type of appearance. That kind of relationship indicates the existence of power law between the two measures generated from measured surface, which proves the fractal behaviour of surface. The same procedures is apply for friction images in which case fractal dimension express complexity quantification as a ratio of the change in detail to the change in scale consider friction signal surface distribution. Fractal dimension are given in Table 1. The fractal dimension values for topography and friction images characterizes surface of sample No.9 rougher than No.7 and implies that this surface has more irregular friction signal compare to No.7.

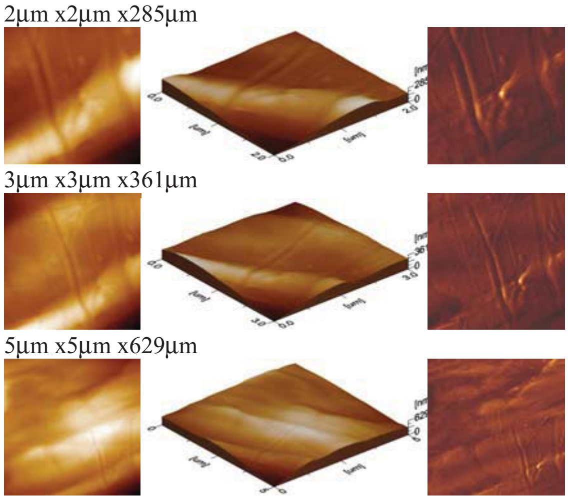

Fig.1. Topography images (left side), 3D images (center) and friction images (right side) gathered from sample No.7 with different scanning areas

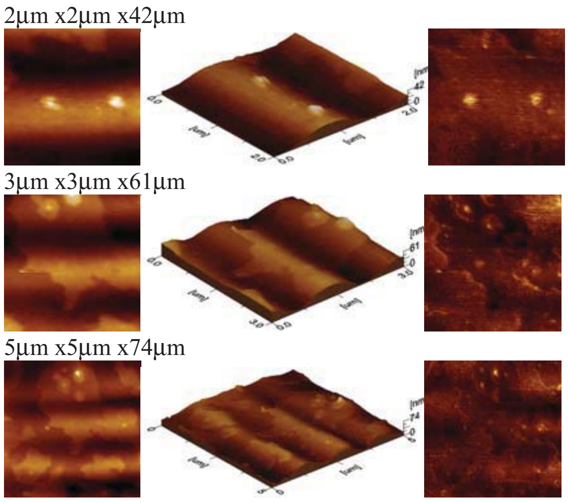

Fig.2. Topography images (left side), 3D images (center) and friction images (right side) gathered from sample No.9 with different scanning areas

In the ANOVA (t-test) analysis, comparisons of means and measures of variation in the groups can be visualized in box plots. In order to test significance of fractal dimension values for different size of images (either topography or friction) one-way ANOVA is perform for 256^2 vs. 128^2 pixels. Results for No.7 are shown in Fig3-left for two groups: the first 'l75' that represent fractal dimensions for topography images with 256^2 pixels and the second 'l74' that represents 128^2. ANOVA results for No.7 friction images are shown in Fig3-right for two groups. The first group 'f75' represent fractal dimensions for 256^2 pixels and the second group 'f74' for 128^2 pixels.

Table1. Samples No.7 and No.9 fractal dimension

Sample No.7 Topography img.				
Img./ Area size		2x2	3x3	5x5
Fract. Dim.	256x256	2.1359	2.1684	2.1928
	128x128	2.1621	2.1991	2.2282
Sample No.7 Friction img.				
Img./ Area size		2x2	3x3	5x5
Fract. Dim.	256x256	2.6578	2.7955	2.8137
	128x128	2.7106	2.8632	2.7837
Sample No.9 Topography img.				
Img./ Area size		2x2	3x3	5x5
Fract. Dim.	256x256	2.2925	2.1128	2.2552
	128x128	2.2035	2.1708	2.3759
Sample No.9 Friction img.				
Img./ Area size		2x2	3x3	5x5
Fract. Dim.	256x256	2.8759	2.7971	2.8447
	128x128	2.7977	2.7611	2.7922

Results of one-way ANOVA for testing of null hypothesis that fractal dimension values for two groups 'l75' and 'l74' belong to the same population are shown at the first column labeled with 'Topography img. 75-74' in Table2. For 'f75' and 'f74' results are in column 'Friction img. 75-74' that corresponds to box plots in Fig3.

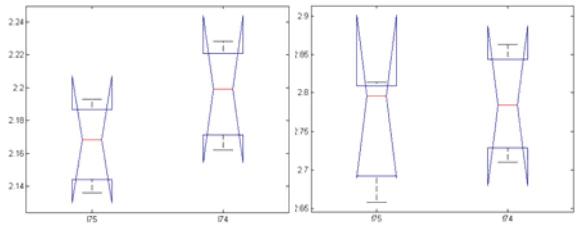

Fig.3. ANOVA box-plot for sample No.7 for topography (left) and friction (right) side, for different image size divided in two groups

High value of p=0.6713 and small value of F=0.21 as ANOVA results from Table2 correspond to testing of null hypothesis that two group of friction images which are scanned for same areas '75-74' with different image size (256 vs. 128), belongs to the same sample. Smaller, but significant value p=0.2894 for 'Topography img. 75-74' confirms that those images belong to the same sample No.7, too.

Table2. ANOVA test results F and t-value

Friction image				
population	75 - 74	95 - 94	95 - 75	94 - 74
F	0.21	4.71	2.37	0.003
p-value	0.6713	0.0959	0.1985	0.9648
Topography image				
population	75 - 74	95 - 94	95 - 75	94 - 74
F	1.49	2.61	9.27	0.08
p-value	0.2894	0.1818	0.0382	0.7957

The second column labeled with '95-94' corresponds to Fig4. There are given ANOVA box-plot for topography (left) and friction (right) images from sample No.9, with labeled groups analog to the designation explained for Fig3. The third and the fourth columns in Table 2. correspond to the Fig5. and Fig6. respectively. These figures are dedicated to combination labeled ‘95-75’ and ’94-74’.

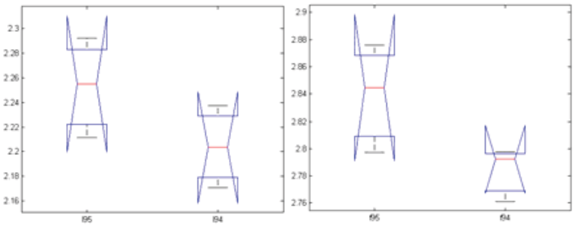

Fig.4. ANOVA box-plot for sample No.9 for topography (left) and friction (right) side, for different image size divided in two groups

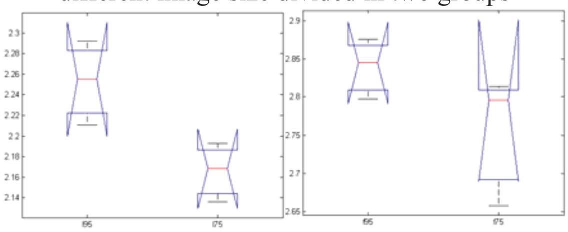

Fig.5. ANOVA box-plot for topography (left) and friction (right) side images sized 256x256 pixels, for sample No.7 and No.9

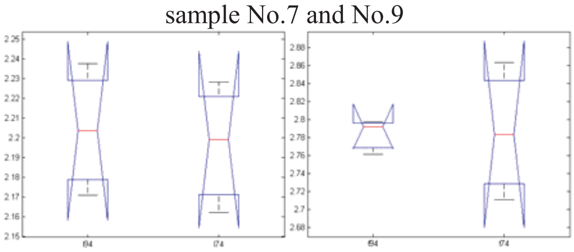

Fig.6. ANOVA box-plot for topography (left) and friction (right) side images sized 128x128 pixels, for sample No.7 and No.9

The box plot of the two group fractal dimensions suggests the size of the F and the p-value. Large differences in the center lines of the boxes correspond to large values of F and correspondingly small values of p as in Fig.4. Especially box plot on right side implies that the friction images didn’t scan from same sample No9. For friction images p-value is equal to 0.0959 and close to probability of having a type one error rate that is 0.05, but as is still higher hypothesis is accepted. Topography images also belong to sample No.9 because p-value is 0.1818.
Since p-values is higher for images with 256^2 pixels than for 128^2, we suggest to use them only for surface comparison. This is based on the first two ANOVA tests. To confirm that topography as well as friction images belong to same sample, we perform another two ANOVA tests. The hypothesis states that groups consist of images size of 256^2 pixels and scanned from sample No.9 and No.7 belong to the same sample. According to p-value that is $p=0.0382<0.05$, we can reject the null hypothesis and cannot assume that the images belong to the same sample. That is correct in case of topography images. In case of friction images, where ANOVA test ($p=0.1985$) accepts hypothesis that is incorrect. That is particularly wrong in case of images with 128^2 pixels, where are high p -values. We conclude that the images with 128^2 pixels cannot be used for surface comparison, based on results of ANOVA tests.

4. CONCLUSION

The samples taken from two different locations on can’s surface are scanned by AFM and FFM. Images are gathered from 3 different area size (5x5,3x3,2x2) and in two different resolutions (256x256,128x128). For fractal dimension calculation that based on “skyscrapers” method and for one-way ANOVA tests were generated custom-made procedure using image processing and statistics toolboxes in Matlab.
First two ANOVA tests suggest that topography and friction images with 256x256 pixels could be used for surface comparison as well as images with 128x128 pixels. The results of another two ANOVA tests confirm previous statement in case of 256^2 pixel sized topography images, but discard it in case of friction ones. Also it is concluded that the topography and friction images with 128^2 pixels cannot be used for surface comparison at all.
This investigation permits selection of 256x256 pixels as image size during friction force scanning and yield to minimum time-consuming measurement process with significant results.

AKNOWLEDGEMENT

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WIND POWER TECHNOLOGY: POSSIBILITIES AND LIMITATIONS

Sonja Josipovic[1], Marko Savanovic[1]
[1]Faculty of Mechanical Engineering, University of Belgrade, Serbia, e-mail: sgrbic@mas.bg.ac.rs

Abstract. Today, energy is a limiting factor for sustainable economic growth and development. Growing environmental problems, uncontrolled spending and waste of limited reserves of fossil fuels, explosive population growth and increasing energy consumption are the main generators of increased production of "*renewable*" energy that is responsible for the progress of the global clean energy sector. Wind energy has recorded a significant growth over the last decade as one of the most economical renewable energy sources.
Key words: *Renewable energy, wind technology, costs, clean energy.*

1. INTRODUCTION

Electricity is the predominant form of energy which can be produced in several alternative ways: hydropower plants, thermal power plants, nuclear power plants, using wind turbines, solar panels etc. Oil and gas have become, over a short period of time, prevalent in global energy consumption, but their limitations pose questions in terms of sufficient supply of energy in the future.[1]

According to the International Energy Agency – an IEA estimation, if current trends continue, by 2020 we will be faced with the following situation: energy consumption will increase by 60% (most of this increase will fall on developing countries), fossil fuels and nuclear energy will retain a dominant share in global energy consumption, much of the population will be faced with a lack of energy and a collective effort to reduce emissions of harmful gases into the atmosphere will not reach the objectives of the Kyoto protocol. In order to overcome problems in the global energy sector, the IEA has defined four pillars of future development that have been accepted by both developed and developing countries. Those pillars are:

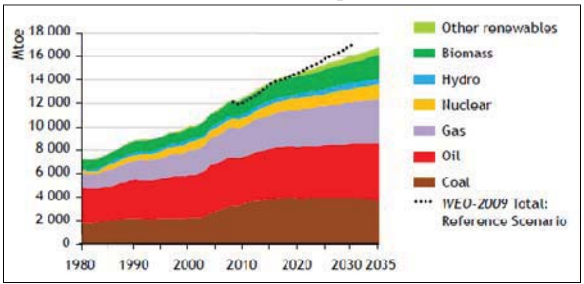
1. Increase in energy from alternative and renewable energy sources;
2. Development of new technologies in the field of alternative and renewable energy sources;
3. Increasing energy efficiency and
4. International cooperation in order to maintain and increase level of energy security.

The **Graph 1** shows the structure of primary energy consumption in the world with a forecast until 2035. Consumption structure is ever changing with the improvement in manufacturing processes, with the application of scientific knowledge, technical and technological improvements and with changes in the efficiency of energy resource utilization. The change in structure indicates turning towards cleaner, renewable energy sources and natural gas. Reduction of oil and coal consumption is a consequence of their negative impact on the environment. The main reason for these changes is the inclusion of ecology and environmental costs in the future world energy development results. Future development will be based on the use of energy sources with a low content of carbon and other harmful substances. Renewable energy sources are exactly this kind of energy. According to forecasts, fossil fuels will continue to play a dominant role in the global energy mix. At the end of 2035 their share will be 74%, which is less compared to 2008 when it was 81%.

[1] In order to increase energy security, the EU is trying to ensure the supply of gas and oil from other parts of the world (because it is over 50% dependent on imports of Russian gas and oil) and to increase the production of “domestic” energy based on renewable energy sources.

The growing energy demand caused by industrialization and enormous growth in population can be met only through diversification of energy sources based on more extensive use of renewable energy.

Graph 1 The structure of primary energy demand in the world from 1860, with a forecast up to 2035



Source: IEA, (2010): „*Wold Energy Outlook 2009*“, p. 54.

2. DESCRIPTION OF THE TECHNOLOGY

Wind energy sector is developing dynamically, shows a strong annual financial turnover and plays a significant role in employment in the world. During the last two decades we have seen a trend of wind generators with higher power, efficiency and effectiveness. As a result of technological improvements, in 25 years the capacity of wind turbines has increased from 50 KW to more than 5 MW. Also, during this period the cost of production was reduced by more than 50%.

Factors that determine the size of wind turbines are:

1. Technical issues related to the physical characteristics of the site;
2. The potential of wind energy;
3. The capacity of local distribution networks and
4. Issues related to landscape, heritage and development plan policies.

The cost structure of wind energy projects consists of:

1. ***Capital costs*** - European wind energy projects are typically financed 10 to 20% from own funding, 80 to 90% with bank loans with tenors of 8 to 12 years.

2. ***Investment costs:***
   - Turbine (ex works)
   - Preparation costs of the project
   - Grid connection
   - Foundation
   - Electric installation
   - Road construction and etc.
3. ***Operation & maintenance costs:***
   - Service and spare parts,
   - Administration,
   - Miscellaneous,
   - Land rent,
   - Insurance,
   - Power from the grid etc.

Annual operation and maintenance costs are often estimated as 2 - 3% of the ex-works cost of wind turbines. The capital costs of wind energy projects are dominated by the cost of the wind turbine itself (ex works). For the 2 MW turbine erected in Europe the turbine's share of the total cost is, on average, around 76%, while grid connection accounts for around 9% and foundation for around 7%. Other cost components, such as control systems and land, account for only a minor share of total costs. Thus a wind turbine is *capital-intensive* compared to conventional fossil fuel technologies, such as a natural gas power plant, where as much as 40-70% of costs are related to fuel and operation & maintenance costs.[2]

Main advantages of using wind energy[3] are threatened by a higher price of wind energy in comparison to the market price of electricity generated by using fossil fuels. In order to overcome this disadvantage, countries use financial and nonfinancial measures to encourage investment in facilities that use wind energy. There are two models for the implementation of financial measures. The first model is based on a certain amount of electricity from wind energy to be purchased during the year (*quota system*). The second model consists of defined purchase prices for electricity from wind energy (**feed-in tariff**). Together with financial measures, non-financial measures such as tax reduction, public-private partnerships etc. are often present.

At the end of 2010 the total installed capacity of wind turbines in the world was 197,039 MW, after 158,908 MW in 2009, 120,291 MW in 2008 and 93,820 MW in 2007. Only in 2010 38 GW of new wind turbines was added worldwide. According to Global Wind Energy Council GWEC estimations, the total installed capacity of wind turbines in the

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[2] Source: EWEA, (2009): „*The Economics of Wind Energy*“, p. 30.

[3] The fuel is free; Abundant and inexhaustible; Clean energy - no resulting carbon dioxide emissions; Provides a hedge against fuel price volatility; Security of supply - avoids reliance on imported fuels; Rapid to install; Provides bulk equivalent to conventional power sources; Land friendly - agricultural / industrial activity can continue around it.

world can meet about 2.5% of global demand for electricity.

In some countries, wind is one of the largest sources of electricity. Denmark is the world leader with 20% share of wind energy in total electricity production. After Denmark, countries with the highest share in the end of 2010 were Portugal (18%), Spain (16%) and Germany (9%).

3. THE POTENTIAL IMPACT OF WIND POWER PLANTS ON THE ENVIRONMENT

Emissions that occur due to the production of electricity using fossil fuels pose a threat to the achievement of sustainable energy development. Wind power plants produce very low emissions throughout their life, but unfortunately they can have some environmental consequences that may reduce their potential. Wind power plant production can lead to direct ***loss or degradation of habitat*** (especially in the swampy area) due to the construction of necessary infrastructure (wind turbines, auxiliary facilities, roads etc.). Also they can ***threaten the safety of birds***:

- Process of construction could result in temporary or permanent relocation of birds from the building and its surroundings;
- Mortality due to collisions;
- Barriers to movement (studies have shown that the response of birds can be different and that is related to the species of birds and /or season).

Table 1 shows the estimation of annual mortality of birds depending on the cause. We may note that the impact of wind turbines on birds, bats and other animals is very low compared to the effects on humans (and other adverse effects).

Table 1 Assessment of bird deaths per year depending on the cause

Causes of mortality of birds	Assessing the annual mortality of birds
The buildings / windows	550 million
A high voltage	130 million
Cats	100 million
Vehicles	80 million
Pesticides	67 million
Wind turbines	28.5 million
Airplanes	25 million

Source: Ericksonn, W., Johnson, G. and Young, D. (2005) http://www.energynews.rs

In addition to these other adverse effects are:

- ***Occurrence of noise*** - There are two distinct noise sources associated with the work of wind turbines: aerodynamic noise caused by the propeller as it moves through the air and mechanical noise generated by the operation of mechanical elements. With better performances of modern wind turbine, mechanical noise is practically gone.
- ***Threat to road and air transport*** - In the construction phase and/or after wind turbines can distract drivers. Although the wind farms are being built in accordance with standard engineering practices, it is recommended to achieve a safe distance from roads and railways, which should be equal to the sum of tower height and length of rotor blades. Also, the location of wind turbines can interfere with communication, navigation and surveillance used in air traffic control and related to the safety of aircraft. In order to achieve safety and efficiency of aircrafts near the airport, the International Civil Aviation Organization – ICAO has defined the airspace above which it is not allowed to set up new facilities. Also, it is necessary to provide adequate empty space between the pillars and cable lines defined by the relevant electric company. For example, in Ireland there is a legal obligation to inform the distributor of electricity about all facilities that are planned to be within 23 meters of any distribution channel.
- ***The effects of shadows*** - Wind farms can drop long shadows when the sun is low in the sky. The effect known as shadow flicker (shadowing) is created when the propeller drops a shadow on the window of a nearby house. The effect has short duration and occurs only in certain circumstances, such as when the sun shines and the angle is low (in the morning and just before dark); a wind farm is located exactly between the sun and the object that drops a shadow and at the same time there is enough wind to ensure the movement of rotor blades.

4. CONCLUSIONS

Rational use of energy, increasing energy efficiency, greater use of renewable energy resources are now key elements of energy policy not only in developed countries but also in other countries of the world. Wind energy recorded a significant growth over the last decade as one of the most economical renewable energy sources. Wind technology has improved substantially. In order to fully use wind energy potential, investments in wind power plants are moving in two directions. The first is finding a less windy place (3.5 - 5 m / sec.) in order to install cheaper wind turbines or turbines with higher unit capacity, so that costs of producing electricity would be more acceptable. And the second, using *off-shore* locations (wind on the sea) that provide greater electricity production but require higher investment costs.

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APPLICATION DOMAINS OF A STOCHASTIC MODEL FOR ESTABLISHING PRODUCTION CYCLE TIME

[1]Klarin Milivoj, [2]Spasojevic Brkic Vesna, [1]Stanisavljev Sanja, [2]Sedmak Tamara
[1] University of Novi Sad, Technical faculty “Mihajlo Pupin”, Republic of Serbia
[2]University of Belgrade, Faculty of Mechanical Engineering, Republic of Serbia

Abstract. *To ensure rational production and adherence to time schedules in production, quality planning of production and corresponding technical-technological calculations are needed to provide machine operating modes and time duration of machine operations as well as the activities in the manufacturing process. This way, they are normed, normalized and standardized, so the elements of production cycle (PC) time can be determined beforehand for machines, mechanization means and manual work. In practice they are not deterministic but stochastic, especially under conditions of small and medium businesses and as such they have to be monitored. Our original stochastic model gives good results under conditions of higher organizational level of production and longer production time duration relative to PC total time. The model can be applied in metalworking large-scale series production, textile industry and assembly processes, as shown by the examples.*

Key Words: *work sampling, production cycle, application*

1.INTRODUCTION

Production cycle is the period from entering a product part or a series of products into manufacturing to their receipt in the warehouse of finished products (or parts). Production cycle is indirectly dependent on the factors of total supply-sales cycle as its part but some elements of cycle time are also mutually influential. When performing the analysis, production cycle is essentially divided into production time – tp and non-production time tnp [2]. Non-production time involves diverse factors of stoppage related directly or indirectly to man’s good or bad attitude towards production. These stoppages, characteristic of small and medium enterprises of metalworking industry, are, as a rule, longer than necessary production times and they are more difficult to shorten. Optimal production cycle is the one that is the shortest for the same product quality and price.

The elements of PC time are possible to monitor using the work sampling method that was first applied by Tippett [1, 5, 6, 7]. However, the original method has a restricted realm of use, and only three elements of PC time were monitored: the machine is in operation, the machine is in preparation, or the machine is idle (+, x, -). Although a technical-technological indicator of machine utilization level, i.e., the time of operation against machine total available time, is a very significant indicator in production and business operations and the stochastic model application itself very simple, it is more important to obtain those levels for the elements of PC time. The PC time involves the time for making a unit or a series of units from putting them in production until their storage, and aside from being significant as a technical indicator, it is important as an economic indicator of freezing current assets, especially raw materials. Consequently, the aim of the paper is to set up a model for stochastic determination of the elements of production cycle time using a modified work sampling method, and it has been experimentally proved in few factories.

2.PREVIOUS RESEARCH

Klarin et al. [4,6] presented a modified work sampling method for establishing the level of capacity utilization and found that the level of capacity utilization as a stochastic variable in work sampling is the model that neatly resolves the problem of determining the total level of capacity with accurate results.

Ilic [2], investigates the dependence of the coefficient of running time on technological time for the line of engine building and assembly (Fig. 1), while Vila [8], analyzes 33 work tasks and obtains the coefficients of running time between 0.9 and 17.7.

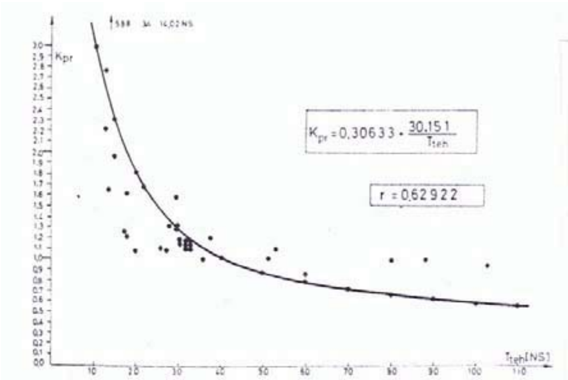

Fig. 1 dependence of the coefficient of running time on technological time for the line of engine building and assembly [2]

Hackstein and Budenbender [3] examined the operational behaviour of flexible manufacturing systems in large-scale series production – case study 1, and the results for the investigation period indicate an average technical availability of 91.1 per cent and an average actual utilization of 84.8 per cent. Technical availability is a sum of non-productive times due to organizational reasons and actual utilization. In this study technical non-productive time was 8.9 per cent and the organizational non-productive time 6.3 per cent of the potential production capacity (Fig. 2).

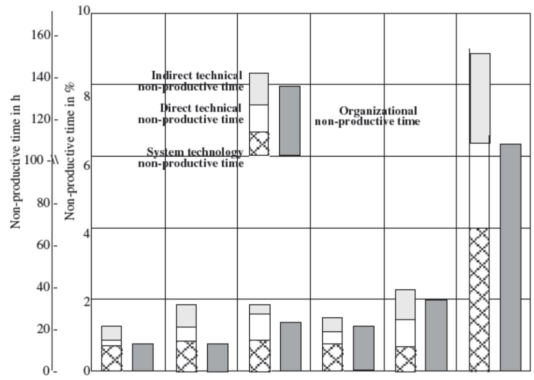

Fig. 2 Technical and organizational components of non-productive times in case study 1 (investigation period 338 h=production capacity 1690 h) [3]

In their second case study, Hackstein and Budenbender [3] investigated the operational behaviour of the flexible manufacturing system in small-scale series production. The results show that an average technical availability for this system was 93.1 per cent, and average actual utilization was 84.9 per cent. Lost production due to technical non-productive times was 6.9 per cent of the potential production capacity, with an equivalent figure of 8.2 per cent for organizational non-productive times (Fig. 3).

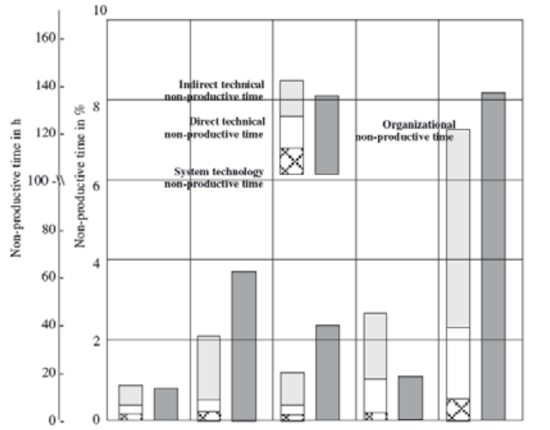

Fig. 3 Technical and organizational components of non-productive times in case study 2 (investigation period 360 h=production capacity 1440 h) [3]

3.THE APPLICATION OF A STOCHASTIC MODEL TO DETERMINE THE ELEMENTS OF PRODUCTION CYCLE TIME

The model was applied in 2011 and involved a larger number of Serbian enterprises. The results obtained for three characteristic enterprises will be presented here.

The first most extensive experiment concerns an enterprise owned by a big German firm engaged in manufacturing car components. Screenings were performed from September 19, 2011 to November 4, 2011. Monitoring included 47 cycles of different series sizes (4 – 10 pieces) and the time duration ranged from the shortest (240 min) to the longest (420 min), with 10 - 30 instantaneous observations. The results are displayed per number of instantaneous observations of working time elements, the percentage of their participation in their total duration and per element of working time, as well as the total average values and standard deviations – SD. There were 932 observations in total, while the total time for all cycles amounts to 15 293 min. The average production cycle time - tpc is 325 min and the average production cycle time per piece tpc is 56.2 min. The results are also presented by diagrams in Figs 5, 6 and 7. The diagram in Fig. 5 shows that the mean level is $\mu tpt = tp/(tpt+tm+tc+ttr+tpk) = 0.7435$, while the control limits amount to $CC = \mu tpt \pm 3 \cdot SD \cdot \mu tpt = 0.7435 \pm 3 x 0.7435 x 0.09735$, AC=0.9606 , BC=0.5264, The mean levels of working time elements μtpt, μtm, μtc, μtr, μpk have relatively stable rates per individual cycle, i.e. when their sum total is higher, the individual levels are higher. The control time level is never higher on account of the machine time level. If we observe μtm within μtp we see that μtm has the highest values compared to the other elements and that its level behaved within the range of normal distribution law, with an approximate mean of μtm=0.244. Levels of cycle

time have normal distribution, since $\chi2=3.070404$ and $\chi12=55.76$, e.g. $\chi2<\chi12$.
It is inferred that to master the process in metalworking industry conditions with a cycle designed for one shift duration and a corresponding series, it is necessary to make approximately 50 daily screenings and 1000 instantaneous observations, and the production cycle time is a stochastic variable that ranges along normal distance. This example shows that the hypothesis that it is possible to apply a work sampling method in monitoring the production cycle has been proved, which represents an original approach to solving this problem.

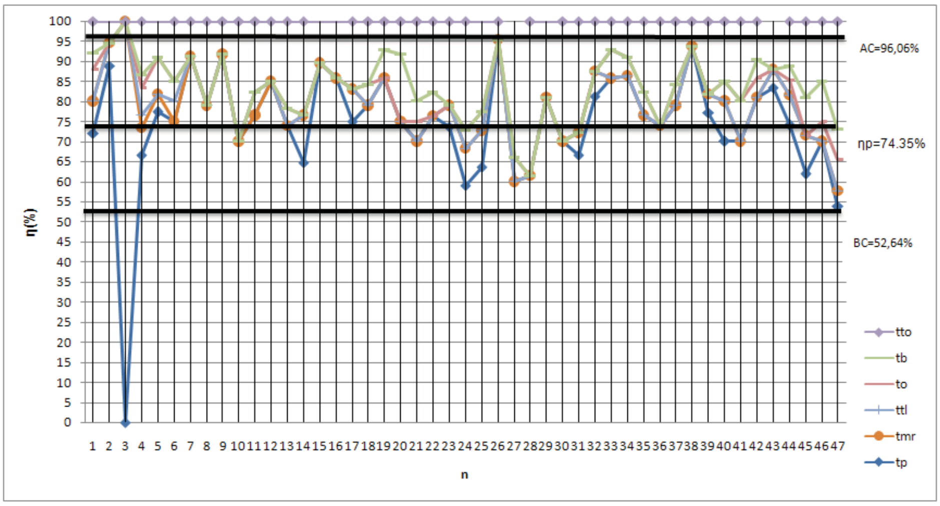

Fig. 5 Diagram showing the levels of cycle time elements for enterprise 1

The second experiment is related to a plant that produces military and firemen clothing. Screenings were carried out from September 27, 2011 to November 13, 2011. Monitoring comprised 26 production cycles of different types of clothing and different series sizes, from 9 – 117 pieces, with time durations from 355 min for the shortest to 3700 min for the longest, while instantaneous observations ranged from 21 – 90. Details can be seen on Figure 6.

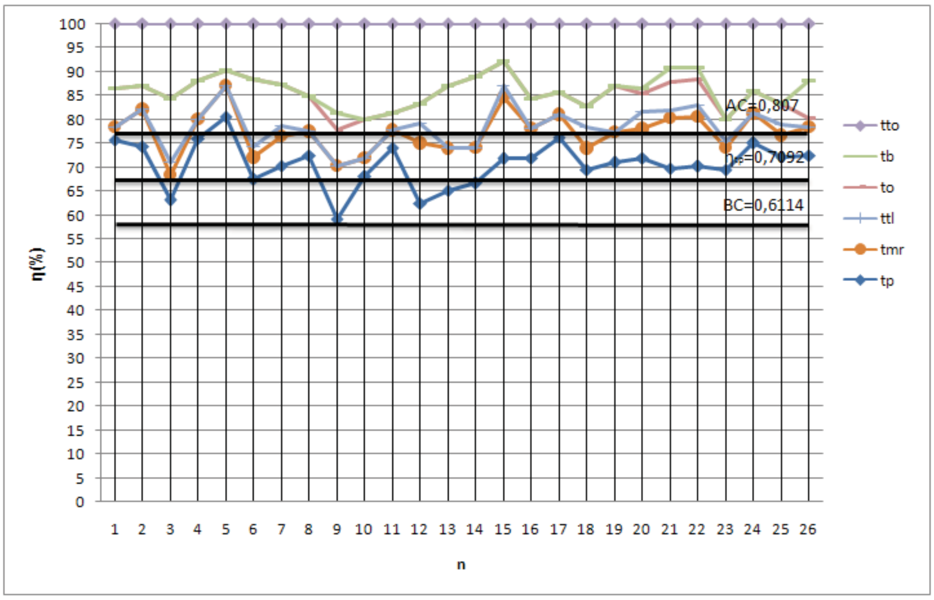

Fig. 6 Diagram showing the levels of cycle time elements for enterprise 2

The third characteristic experiment was carried out in a plant for manufacturing diesel engine parts. Despite being certified for ISO 9000 by RÜVCERT from Austria, the production organizational level is very low. Monitoring involved the production cycle of injectors for high-pressure pumps (Bosch pumps). The screening period was from May 16, 2011 to June 8, 2011 and the results are presented by a diagram in Fig. 7.

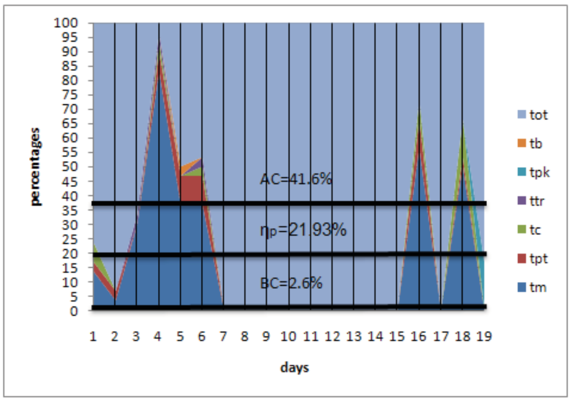

Fig. 7 Diagram showing the levels of cycle time elements for enterprise 3

It is evident from the diagram in Fig. 7 that the control limits range from AC = 0.416 to BC = 0.26, and the mean value of production time is μp3 = 0.2193. Within the control limits, there are only two values of μp for the first and third day of screening making the process unstable. However, irrespective of the given conditions, the diagram provides valuable practical data, so that the production management can make efforts to improve production and shorten the production cycle, for example, by reducing the number of pieces per series.

4.CONCLUSION

On the grounds of previous investigations of PC, it can be concluded that they were largely performed using the method of continuous screening and with a smaller number of working time elements. They were most often conducted in metalworking industry, commonly of a large-scale series production type. Within the framework of this paper a stochastic model for establishing the elements of PC time was applied, and it has been shown that the model is suitable for both large-scale and small-scale metalworking production, as well as for textile industry. The applicability of the method is much better in a higher organizational level of production and higher degree of production time in PC total time.

ACKNOWLEDGEMENT

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INVESTIGATIONS OF TIME AND ECONOMIC DIMENSIONS OF THE COMPLEX PRODUCT PRODUCTION CYCLE

Jelena R. Jovanovic[1], Dragan D. Milanovic[2], Milic Radovic[3], Radisav D. Djukic[1,4]
[1]Technical College of Applied Studies, Cacak, Serbia
[2]Faculty of Mechanical Engineering, University of Belgrade, Serbia
[3]Faculty of Organizational Sciences, University of Belgrade, Serbia
[4]Office of the Manufacturing and Engineering Management, "Sloboda" Co. Cacak, Serbia

Abstract: *The features of contemporary production process of top organization and management methods are grounded on the principles of economies of times and the principles of lean production, a new philosophy of production. Production should be organized according to the push-pull principle, with minimum inventories, manufacturing only what is really necessary, neither too early, nor too late. The paper presents the design procedure and results of investigations on the production cycle of a complex product included in the production program of "Sloboda" – Cacak Co.*
Key words: *complex product, production cycle, design, coefficient of running time, current assets*

1. INTRODUCTION

The achievement of Business and Production System (BPS) is largely dependent of adjusting production to the conditions of demand and application of innovative solutions in the sphere of technology, organization and management. To make the price competitive, the costs of business operations should be reduced, the observed losses should be eliminated or reduced to acceptable levels and resources should be engaged accordingly by using the corresponding management methods. Current assets should be engaged to the maximum in the production process, which is determined by the size of the production series, length of production cycle (PC) time, moment and manner of their engagement. The time and economic dimensions of PC should be mastered, so that the system responds promptly, in real time, no matter whether the orders are small-scale, large-scale, standard or special. Investigations of PCs implies a set of activities that have to define optimum production series, calculations for the amount of components required, cycle design, production preparation and launching, management of production activities, with current assets engagement and the analysis and calculations of the coefficient of material running time.

2. OPTIMUM PRODUCTION SERIES

To manufacture only what can be sold, to consolidate all requirements in a single spot, to enable flexible and economic production in smaller-scale series; all this represents the first and foremost principle of contemporary production. So, a problem is posed of inventing the relations that will enable the calculations of optimal production series, with minimizing total business operating costs. This problem comes to the fore particularly in series production performed in 'Sloboda' Co. Having in mind that the behavior of costs in series production depends on the volume of production (linear, non-linear, independent), the size of production series should be calculated in such a way that the opposite orientation of the nature of costs is optimally harmonized. This means that the optimum series size (***q_0***) is characterized by minimal costs per unit of product. Respecting mentioned constraints, the analytical expression for calculations is defined by the relation (1):

$$q_o = \sqrt{\frac{2\, C_n\, Q}{c_1\, T}} \qquad N = \frac{Q}{q_o} \qquad (1)$$

where:
C_n are total fixed costs required to accomplish the order (Q), c_1 are variable costs per unit of product in unit of time (day), T is period of time required to accomplish the delivery, N is the number of optimum–launched series. On the grounds of data from the Company's annual balance sheet, for the year 2012, corresponding technical documentation and relation (1), the optimum size of the production series was calculated, amounting to 3600 pieces.

3. CALCULATIONS OF THE QUANTITY OF COMPONENTS

The plan of components is the most significant production operational plan. Its creation requires: calculations of optimum production series, drawing of products' hierarchical structure graph (Fig. 1), establishment of inventories in unfinished production (warehouses, work tasks), definition of planned technological waste and inventories at the end of the year for the continuity in the production.

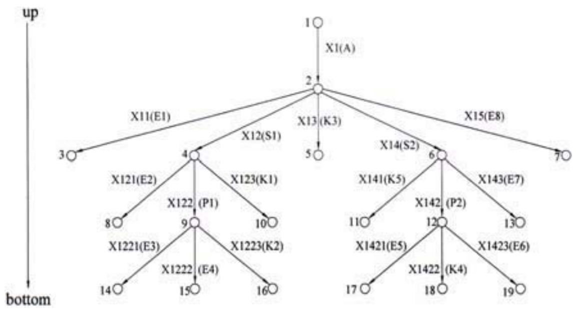

Fig. 1 Graph of products' hierarchical structure

Planned quantities of components (q_{ijk}) can be calculated using the following formulas:

$$x_{ijk} : q_{ijk}^{(1)} = m_{ijk} \cdot Q_i = n_{ijk} \cdot q_{ij} \quad (2)$$

$$x_{ijk} : q_{ijk}^{(2)} = \frac{n_{ijk} \cdot q_{ij}}{1 - \check{S}_{ijk}} = \frac{m_{ijk} \cdot Q_i}{\prod\left(1 - \check{S}_{ijk}\right)} \quad (3)$$

$$x_{ijk} : q_{ijk}^{(3)} = \frac{n_{ijk} \cdot q_{ij} - q_{ijk}^{M}}{1 - \check{S}_{ijk}} - q_{ijk}^{RN} \quad (4)$$

$$x_{ijk} : q_{ijk}^{(4)} = \frac{n_{ijk} \cdot q_{ij} - q_{ijk}^{M}}{1 - \check{S}_{ijk}} - k \cdot q_{ijk}^{RN} \quad (5)$$

where: x_{ijk} is the component designation, q_{ijk} are planned quantities of components, $\check{S}_{ijk}$ is the planned waste, q_{ijk}^{M} are quantities of components in a warehouse, q_{ijk}^{RN} are quantities of components in launched work tasks, k is the coefficient that takes into account work task accomplishment level (per cent), m_i is the quantity of the i-th component in a final article, n_i is the quantity of the i-th component in the first superior level of a hierarchical scheme. For the optimum quantity of 3600 pieces of a complex product, using the corresponding formulas (2) – (5), calculations were made for the quantity of components required for further analysis (Tab. 2).

4. PRODUCTION CYCLE DESIGN

The technological (ideal) PC comprises the time required to perform all operations (t_i) according to the technological procedure on all products of the optimum series ($\boldsymbol{q_0}$). The workpiece movement plays important role in calculating the technological cycle, where movement procedures can be consecutive (6), parallel (7) and combined (8, 9). Combined movements are most commonly encountered in a series production.

$$T_{tu} = q_o \cdot \sum_{i=1}^{m} t_i \quad (6)$$

$$T_{tp} = \sum_{i=1}^{m} t_i + t_{i\,\max}\left(q_o - 1\right) \quad (7)$$

$$T_{tk} = \sum_{i=1}^{m} t_i + \left(q_o - 1\right)\left(\sum_{k} t_k - \sum_{j} t_j\right) \quad (8)$$

$$k : t_{k-1} < t_k \geq t_{k+1} \qquad j : t_{j-1} \geq t_j < t_{j+1} \quad (9)$$

The complexity of a product imposes multi-level approach to the analysis and design of PCs, because production interferes with the assembly of units, sub-units and final article, so that parallel PC proceeding is possible by the stages of manufacturing and assembly. Using above presented considerations, calculations of the PC length for each operation will be made according to formula (10), in compliance with the adopted work organization, while PC for components will be calculated based on a combined workpiece movement applying the relations (11) and (12).

$$\tau(pf)_i = \frac{q_{pf}}{q_{S_i} \cdot S_{n_i} \cdot r_{m_i} \cdot p_{n_i}} \quad (10)$$

$$T_{pf} = \tau_{(pf)1} + (n_{opf} - 1) \cdot \tau + \sum_{p} (\tau_p - \tau_{p-1}) \quad (11)$$

$$p : \tau_p > \tau_{p-1} \quad (12)$$

The designed PC length of a complex product can be determined using a network diagram, a gantogram (Figs 3 and 4) or calculations to define the longest path in a complex-product-structure graph (Fig. 1) in compliance with relation (13):

$$T_{cp} = \max\left\{T_{(i-j)}, (i-j) = 1, l\right\} \quad (13)$$

where: $\tau_{(pf)i}$ is PC length of the i-th operation of the observed production stage by days, pf is the designation of the production stage (component), q_{pf} is planned quantity pf, q_{Si} is the capacity in a shift of the i-th operation, S_{ni} is the number of work shifts during the day on the i-th operation, r_{mi} is the number of workplaces where production of the i-th operation is organized, p_{ni} is norm accomplishment on the i-th operation, T_{pf} is the designed PC length pf, $\tau_{(pf)1}$ is the designed PC length of the first operation of the observed pf, n_{opf} is the number of operations pf (from the technological procedure), p is the designation of the operation that satisfies the condition: $\tau_p > \tau_{p-1}$, T_{cp} is the designed PC length, $T_{(i-j)}$ is the PC length of production stages found on the (i-j)-th path of a complex-product structure (i is the designation of the graph initial node, j is the designation of the graph terminal node), l is the total number of paths in a graph that connect the initial with the terminal nodes, τ is average backup time between operations (compensation for all losses in PC).

5. PRODUCTION CYCLE ANALYSIS AND CALCULATIONS OF THE COEFFICIENT OF RUNNING TIME

Unlike the technological (T_{ci}) and designed PC (T_{copt}) length, the actual (T_{cs}) length, apart from production (technological) time, includes PC non-production time and disruptions that cause losses G_c(Fig. 2). In most cases PC disruptions are the result of inconsistency of production processes, bottlenecks in production, shortage of material, tools and energy, poor organization and handling of workplaces, stoppages due to machine breakdown, tool failure and lack of discipline in workers.

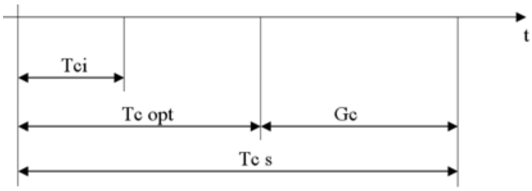

Fig. 2 Production cycle duration

On the grounds of designed operation cycles (T_{cp}) and components involved in a complex product, production documentation was launched. The designed but also subsequently accomplished dates of the initiation and termination of production are recorded in a production date chart, a constituent part of work tasks. These data were used to determine the actual PC lengths (T_{cs}) (Tab. 1) and the coefficients of material running time (K_p) were calculated applying the relation (14).

$$K_p = \frac{T_{cs}}{T_{cp}}, \quad K_p = 1 + \frac{Gc}{T_{cp}} \tag{14}$$

The coefficient of running time indicates how much the actual PC length is longer than the designed one. Table 1 shows the designed and actual PC lengths of all production stages of the analyzed complex product, losses in the cycle and corresponding values of the running time coefficient. On the grounds of the PC designed, T_{cp} = 96 days, and actual, T_{cs} = 122 days, length, the running time coefficient of a complex product K_p = 1.27 was established.

Tab. 1 PC lengths (T_{cp} and T_{cs}), losses in the cycle and coefficient of material running time

T_{cp}, K_p, T_{cs} / production stage		Designed PC length T_{cp} (days)	*Actual PC lengths T_{cs} (days)	Losses in the cycle (%)	Coefficient of running time K_p
1	2	3	4	5 = (4 - 3)/4	6 = 4 / 3
elements	E_1	7	9	22	1.29
	E_2	14	19	26	1.36
	E_3	14	18	22	1.29
	E_4	12	17	29	1.42
	E_5	14	20	30	1.43
	E_6	40	51	22	1.28
	E_7	13	17	24	1.31
	E_8	14	19	26	1.36
sub-assemblies	P_1	17	20	15	1.18
	P_2	16	20	20	1.25
assemblies	SK_1	12	14	14	1.17
	SK_2	24	30	20	1.25
final assembly	A	19	21	10	1.11

Note: T_{cs} value was established on the grounds of production monitoring and analysis of production and plan documentation

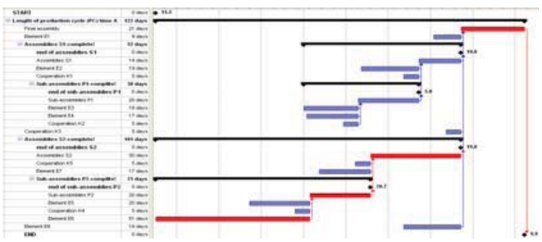

Fig. 3 Gantt diagram – the latest beginning

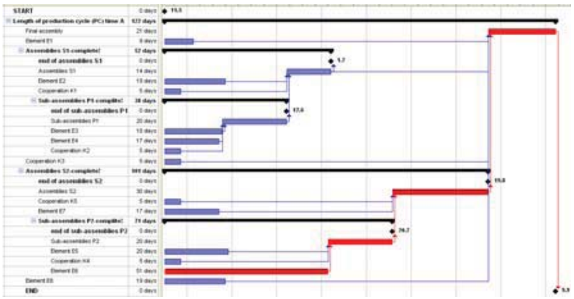

Fig. 4 Gantt diagram – the earliest beginning

6. CURRENT ASSETS ENGAGEMENT

The basic purpose of current assets is to finance the production process, i.e., to settle current obligations, to supply the material and to pay salaries. Unlike fixed assets partially spent in the production process, current assets are a part of business assets that are entirely spent in the production process and their overall value is transferred onto the product. Current assets can be engaged in the production process in a smaller- or larger-scale, depending on the production series size, time period, moment and manner of engagement. Business operating costs (T_p) can be calculated using the formula (15):

$$T_p = T_m + T_r + T_o = T_m + T_r + O \cdot T_p \Rightarrow$$

$$T_p = \frac{T_m + T_r}{1 - O} \tag{15}$$

Other costs (T_o) are divided into variable and constant, relation (16):

$$T_o = O \cdot T_p = T_{ov} + T_{oc} = 0{,}2 \cdot T_o + 0{,}8 \cdot T_o \tag{16}$$

Using previous formula, one can derive the formula for calculating the value of norm-hours for other variable costs ($(VNČ)_{ov}$):

$$T_{ov} = \sum W_{ov_i} \cdot q_i^{(4)} = \sum t_i \cdot q_i^{(4)} \cdot (VNČ)_{ov} \Rightarrow$$

$$W_{ov} = t_i \cdot (VNČ)_{ov} \Rightarrow (VNČ)_{ov} = \frac{T_{ov}}{\sum t_i \cdot q_i^{(4)}} \tag{17}$$

Current assets engaged prior to the beginning of production (point P, Fig. 5) amount to 17 093 264 dinars, relation (18):

$$P = T_{OC} + \sum_i (q_i^{(2)} - q_i^{(4)}) \cdot (W_{r_i} + W_{ov_i}) +$$

$$+ \sum_i (q_i^{(2)} - q_i^{(3)}) \cdot W_{m_i} \tag{18}$$

Current assets engagement depending on the actual PC length will be calculated using the gantograms (Figs 3 and 4) and relation (19).

$$O_{si} = T_{m_i} + a_i \cdot X_i\,, a_i = \frac{T_{r_i} + T_{ov_i}}{T_{cs_i}}, X_i = 1,2,...,T_{cs_i} \tag{19}$$

Results are presented in Tab. 3, correlation coefficient and regression curves are defined by relations (20) and (21), and diagrams of current assets engagement are given in Figs 5 and 6.

Tab. 2 Parameters for determining total and variable business operating costs

Ordinal number	Production stage			$q_i^{(3)}$ (piece)	$q_i^{(4)}$ (piece)	t_i (hourly rates/piece)	$q_i^{(4)} \cdot t_i$ (hourly rates)	W_{m_i} (din/piece)	W_{r_i} (din/piece)	$W_{ov_i} = t_i \cdot (VNČ)_{ov}$ (din/piece)	T_{mi} (din)	T_{ri} (din)	T_{ovi} (din)	T_{vi} (din)
	Mark	n_i	m_i											
1	*2*	*3*	*4*	*5*	*6*	*7*	*8=6*7*	*9*	*10*	*11=7*VNČ*	*12=5*9*	*13=6*10*	*14=6*11*	*15=12+13+14*
1.	A	1	1	2587	3091	0.375	1159.125	320	75	4.875	827840	231825	15068.625	1074733.63
2.	S1	1	1	1553	2571	0.3375	867.7125	60	67.5	4.3875	93180	173542.5	11280.263	278002.76
3.	S2	2	2	3014	5030	0.475	2389.25	276	95	6.175	831864	477850	31060.250	1340774.25
4.	P1	1	1	536	2112	0.425	897.6	180	85	5.525	96480	179520	11668.800	287668.80
5.	P2	2	4	1850	8023	0.45	3610.35	200	90	5.85	370000	722070	46934.550	1139004.55
6.	E1	0.2	0.2	320	526	0.275	144.65	15.75	55	3.575	5040	28930	1880.450	35850.45
7.	E2	3	3	1608	6335	0.125	791.875	94	25	1.625	151152	158375	10294.375	319821.38
8.	K1	1	1	1553	2571	0	0	0	0	0	0	0	0.000	0.00
9.	E3	4	4	0	6287	0.1375	864.4625	6.6	27.5	1.7875	0	172892.5	11238.013	184130.51
10.	E4	3	3	0	5004	0.051	255.204	25.5	10.2	0.663	0	51040.8	3317.652	54358.45
11.	K2	1	1	536	2112	0	0	0	0	0	0	0	0.000	0.00
12.	K3	1	1	2587	3091	0	0	0	0	0	0	0	0.000	0.00
13.	E5	0.04	0.16	0	229	5	1145	175.4	1000	65	0	229000	14885.000	243885.00
14.	K4	2	8	0	16046	0	0	0	0	0	0	0	0.000	0.00
15.	E6	7	28	0	41953	0.061	2559.133	42	12.2	0.793	0	511826.6	33268.729	545095.33
16.	K5	3	6	9042	15090	0	0	0	0	0	0	0	0.000	0.00
17.	E7	2	4	1900	8116	0.1125	913.05	117	22.5	1.4625	222300	182610	11869.650	416779.65
18.	E8	0.05	0.05	76	126	10.5	1323	1967.4	2100	136.5	149522.4	264600	17199.000	431321.40
TOTAL:						8.5035	16920.41	4070	1701	111	2747378	3384082	219965	6351426

Tab. 3 Dynamics and amount of current assets engagement in the latest and earliest beginning

Or. nu.	Day	The latest beginning		The earliest beginning	
		Current assets (Os)	Cumulative Os	Current assets (Os)	Cumulative Os
1	*2*	*3*	*4*	*5*	*6*
1.	0	17093264.4	17093264.4	17621278.8	17621278.8
2.	15	160322.2	17253586.5	1102684.4	18723963.2
3.	31	171010.3	17424596.8	607533.2	19331496.4
4.	38	160176.8	17584773.6	234913.1	19566409.5
5.	49	251706.3	17836479.9	262787.5	19829196.9
6.	51	439421.3	18275901.2	417779.5	20246976.5
7.	60	757835.2	19033736.4	359253.7	20606230.1
8.	71	1787147.2	20820883.6	1254816.5	21861046.6
9.	82	538927.4	21359811.0	186600.4	22047647.1
10.	92	574364.0	21934175.0	169636.8	22217283.8
11.	101	1263621.9	23197796.9	980513.1	23197796.9
12.	111	117568.4	23315365.3	117568.4	23315365.3
13.	122	129325.2	23444690.5	129325.2	23444690.5

$$Os(t) = 1.71753 \cdot 10^7 - 11185.1 \cdot t + 70.5965 \cdot 10^2 + 18.0496 \cdot 10^3 - 0.118619 \cdot 10^4, \quad R = 0.994 \quad (20)$$

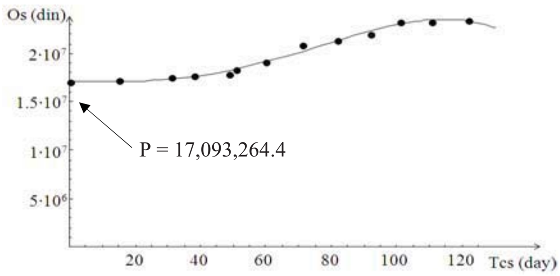

Fig. 5 Diagram of current assets engagement (O_s) as a function of time (T_{cs}), the latest beginning

$$Os(t) = 1.76848 \cdot 10^7 + 71953.6 \cdot t - 1097.54 \cdot 10^2 + 17.1497 \cdot 10^3 - 0.0806001 \cdot 10^4, \quad R = 0.993 \quad (21)$$

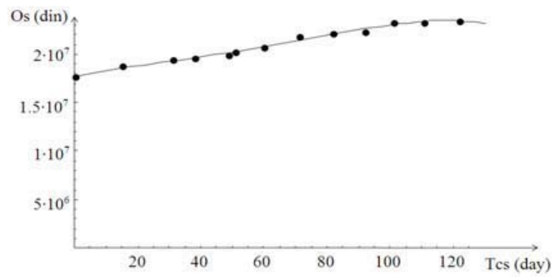

Fig. 6 Diagram of current assets engagement (O_s) as a function of time (T_{cs}), the earliest beginning

7. CONCLUSION

Respecting technical, technological, production and plan documentation and graph theory the paper describes the hierarchical structure of a complex product (Fig. 1). The oriented graph represents a basis for applying the algorithm that synthesizes the processes of optimization, planning, designing and analysis of PC of a complex product and components it is made up of. The systems for weaponry and military equipment production have a specific position and role in the economic environment of the Republic of Serbia. Threats to survival, uncertain trends of changes in the environment, a host of constraints, globalization of business operations and impact of diverse markets impose to 'Sloboda' – Cacak Co. two key dimensions of the strategy: forecasting and risking. Viewed within this context, the principle of economies of times in the manufacturing domain requires thorough investigation and mastering of time and economic dimensions of PCs. The coefficient of time of a complex product is at the satisfactory level (1.27) having in mind the designed and actual PC length (96 and 122 days). Taking into account the scale of uncompleted production, this coefficient value was expected to be lower. The diagrams of assets engagement for two diametrically opposed manners of production organization (Figs 3 and 4) are similar, which indicates a great value of inventories in unfinished production process (point P, Fig. 5) amounting to 73%.

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ORGANIZATIONAL STRUCTURE FACTORS

Zoran dr Radojević[1], Miroslav dr Radojević[1], Darko ms Radojević[2], Ivan Radojević[3]
[1]Faculty of Org. Sciences, Belgrade, Jove Ilića 154, zovime1@gmail.com
[2]Insurance Company, Belgrade, Makedonska 4, zovime1@gmail.com
[3]eng., IS-TRAVEL, Belgrade, zovime1@gmail.com

Abstract: *Each organizational structure has its own factors, which are different and express themselves through different sectors. This applies to: technology, strategy, location and environment, organizational culture, size and age of the production / service systems.*
Keywords: *factor, organization, structure, systems, sector*

1. INTRODUCTION

Factor is a Latin word which means: make, do, doer or actor. It can be defined as the number that is multiplied.

Factors of organizational structures are different and depend on the activity in the sector of the economy. Each organization (utility) system has its own characteristics which are expressed through specific sectors. These sectors depend on the number of competitors and changes taking place within the organizational structuring, which provides stability and progress in relation to the overall environment. Certainly, organizational structure depends on several sectors operating within the entire production/service systems.

The above mentioned factors of organizational structure will be shown separately, their task will be to show their full impact on the organization of production /service system.

2. TECHNOLOGY

Technology is a word of Greek origin and it means learning about the processes by which materials are transformed. Many authors in the literature define technology in a different way. "Technology is the science of sizes and crafts as well as the scientific view of human activity with the purpose of processing of natural products (raw materials) for human consumption. [4]

Technology is the technology applied in production / services. Professor Kalajić said, "The technology is applied, scientific and technical discipline which studies the human activities compatible with the laws of natural science and economic expediency" [4]

By JONES, G. the "organizational theory" (2004) defines technology as "a combination of relevant knowledge, skills, and technical equipment and machinery necessary for people to transform raw materials into useful products and services." [2] We can say that the transformation of raw materials, where a certain amount of financial resources, creating new products or services are performed, where we create new financial resources to meet the demands of people and increase and improve living standards and enable the development of production /service systems.

Technology as applied science technique is one of the most important, both in manufacturing and in services. As each product to be produced has its own technology, it means that technology is one of the most important sets of activities that are used in production/services. Each technology has its own characteristics, which means that any product or "gamma" product has its own technology.

Technology is improving on a daily basis, which means that the duration of the production / service decreases, i.e. an existing technology is upgraded, which is the goal of every production / services. The technology is usually considered within the overall business operation. One possible approach is to observe the technology in three key areas, namely:

- product technology,
- process technology,
- information technology.

"By separating technology into three key areas, attention is directed to specific areas critical to understanding and addressing the management of technology in the production / service system". [2]

2.1. Product/service technology

The product/service is a requirement of customer demand, and it can be said that it is the output of the manufacturing system, which is determined: quantity, quality, time and cost.

Shape of the product is formed through the design, which is implemented based on market demand. Products in their composition and shape can be: simple, compound and medium complex. "Simple product is the product that consists only of one element (fork, spoon, the court, plate, pins, pin, etc..), which means that the same product can not be disassembled and used as such until it is worn (depleted), and then thrown as waste material. Medium complex product consists of up to 30 elements (knife handles and blades, the pen cartridges, mechanism and mine, the eyewear lenses, frames and handles, etc..).

A complex product is composed of elements the number of which s greater than 30 (tractor, which consists of several thousand elements, lift, car, truck, etc..). [4]

Technology products are exploited everyday. Today's customer requires a lengthy and high-quality product, which will exploit the long-term (used). If the manufacturers adheres to customers' requirements, then it would satisfy all customer requirements. For this reason, consumer goods are produced for a short period of time, the producers would have continued production.

Products/services are sold on the market and basically represent potential sales. "The potential sale is part of the market potential that the organization can not cover the sale of their products/services." [1]

Anyone interested in the manufactured product can be considered as a potential buyer. "A potential buyer is a person who is in need, willing and able to participate in the exchange value of the particular organization." [1]

Except a potential buyer, we can say that the potential market is formed. "The potential market of customers, consumers and users are individuals who want and can or will in the near future or now be able to buy a particular product/service." This figure indicates the maximum possibilities of the manufacturer sells its products in a certain period in the future and the particular market under the influence of strong competition. Potential markets include: the existing market, new market and the so-called market "relative unconsumers" [1]

2.2. Process technology

The technological process is part of the production process, which refers to the shaping of the workpiece, which is realized in the defined productive workplaces.

Shaping the work is accomplished through a series of interrelated activities, whose task is the transformation of inputs into defined work. This is achieved thanks to the technical requirements defined by documentation.

The transformation of the technological process where raw materials/material transformed into product/service is provided on the machines or devices as defined by the technological process which is defined in technological preparation of production. The technological process can be divided into several smaller technology and organization defined entities: surgery, surgery (complex group), passing, movement, tools, extra accessories.

Each production consists of several specific technology flows (single output), which is characterized by high costs and great flexibility. High costs of production are the result of preparation; a great flexibility is the ability to customize each product to customer requirements. This technology is complex because it doesn't allows standardization of the working operations, so it causes the expencive production.

Process manufacturing uses the most sophisticated technological process which is fully automated with few employees. The man just follows the technological process, manages and controls. Production costs are minimal and the maximal productivity and standardization.

"Research has shown that there is no official correlation parameter type of technology and organizational structure in successful companies". [2]

Modern manufacturing/service operations are characterized by variability. In the high variability of the work problems are expected to be solved on the fly, which requires full operational autonomy. Low variability of operation favors specialization and standardization process.

For simple operations expertise and skills are not necessary to be analyzed, but requires professional specialization and centralization. For complex operations requires necessary expertise is highly difficult subject of analysis, structures of authority must follow knowledge, while appearing high vertical and horizontal decentralization.

Table 1.1 Characteristics of technology types [2]

	UNIT PRODUCTION	MASS PRODUCTION	PROCESS PRODUCTION
TECHNOLOGICAL COMPLEXITY	LOW	MEDIUM	HIGH
PRODUCTION COSTS	HIGH	MEDIUM	LOW
FLEXIBILITY	HIGH	MEDIUM	LOW
NO OF CHIERARCHICAL LEVELS	3	4	6
RANGE OF GEN.MANAGER CONTROL	4	7	10
RANGE OF FIRST LINE DIRECTORS CONTROL	23	48	15
THE RATIO OF MANAGERS TOWARDS NONMANAGERS	1:23	1:16	1:8
TYPE OF STRUCTURE	ORGANIC	MECANICAL	ORGANIC

(resourcer: Adopted according to JONES, G. (2004), Organizational Theory and Design, Addison Wesley, New York)

2.3. Information technologies

Each technological process has its own information system. The most common are carriers of the documentation system. The information system of each subsystem is a technological solution with the task of carrying the most important information, enabling the product to be formed on the basis of technical documentation. This system documents each operations. All documents are carriers of certain information and it is therefore important to define their way, because then we effectively acting on the production process. Certainly we can not list all the documents, for each specific furniture has a specific document.

The most important factors in preparing technical documentation are:

- create a high quality specification of reproductive material from cutting plan, where the tendency to waste material should be as close to zero (it is best not to waste),
- make a technological process and production elements, subassemblies, assemblies and complete products, whose costs are minimal, which means that all components of the technological process must be optimized (operating time workers, the degree of capacity utilization of machines, devices and equipment, as many special tools and supporting equipment that will quickly pay and whose participation in the cost of products to be optimal and minimum).

Characteristically, there is a database (of all the existing machines, devices and equipment), which has a production system, as well as data collected from the same or similar treatment that are used in the world, and that means that has two data banks (and their own world), used by all employees in the technological preparation of production. All are inter-connected telecommunications, so that they can quickly and efficiently communicate and share information. Each employee has their own software on which it performs its technological tasks.

3. OTHER FACTORS

The other factors will be explained briefly: "**The strategy** is a coordinated decision about how to achieve business goals. It is oriented to the source areas of business activity and the allocation of company resources to create competitive advantage in the future. "

"**The location of the environment** is the availability of the department which can act decisively to business success, and devotes considerable attention precisely to the best or optimal future of the company so as to implement new ideas."

"**Organizational culture** has developed a set of shared attitudes, beliefs and assumptions of organization members who directs their behavior during operation, and establishing relationships within and outside the organization."

"**The size and age** of the production/service systems are important factors of organizational restructuring. Certain size and age of the system leads to the formation of the system life cycle. [4]

4. CONCLUSION

This work presents all the factors of organizational structure, with special emphasis on technology. We believe that technology is one of the most important factors, and should be treated separately. This does not mean that other factors should be disregarded, because they should be examined in detail, but we in this paper were not able to display all the detail due to the length of the text and briefness of the mere presentation.

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IDENTIFICATIONS OF POOLS AND LANES IN BPMN BY TEXTUAL ANALYSIS – PERFORMANCE MEASUREMENT CASE

Nenad Marković
Belgrade Business School, Beograd, Kraljice Marije 73

Abstract: *Important initiatives in the companies (definition and implementation of strategies, using business performance measuring system) require clearly defined processes. To develop a strategy, managers must work through each activity contained within the process model, from the high level abstract elements through to the detailed operational analysis to support the strategy statements. Identification of participants is the first step in Business Process Modeling Notation (BPMN). Here, for that purpose, we used Thematic coding, introduced by Flick. More precisely, identifications of participants are done by identification of pools and lanes. The area, where processes are examined is one modification of BSC approach. This is BSC paradigm modification which is shift from reengineering to the process of continual improvements. Analyzing text from relevant literature, which deals with the BSC, we can find many synonymous, incompleteness, and poorly defined processes.*

Key words: *Performance Measurement Systems, Balanced Scorecard, Business Process Modeling Notation, Identification of participants*

1. INTRODUCTION

In the late 80`s the limits of traditional ways of business performances measurement were generally known and researchers have started to consider the introduction of new measures and integrated business Performance Measurement Systems (PMS). Afterwards, in the beginning of 90, appeared many wider conceptual frames of performance measurement (*Balanced Scorecard* - BSC, The Performance Prism, and Monitor of Intangible Resources). Those new frameworks have often emphasized non-financial, external and future performances [1-4], intending to support proactive management style. New frameworks for Performance Measurement (PM) are followed by the development of management process especially designed to provide managers with tools for development and redesign of current PMS [3]. Changes that occurred during the *PM revolution* [4] can be summarized in five most significant elements: focus, dimensions, drivers, goals and benefits. Over years, the result of these changes became substitution of traditional with balanced performance measurement, with existing tendencies to complete Corporate PM (CPM).

Majority of PMS approaches [5, 6] are consistent with other initiatives in many companies, such as: cross-functional integration, constant improvement of process, new ways of partnership with customers and suppliers, and emphasis of the team role, over the role of individuals. In that sense, BSC can be adjusted into the philosophy of the quality management, including some of the Business Excellence principles [5-6].

This paper attempts to present parts of the PMS processes using BPMN (Business Process Modeling Notation) notation. The first step (processed here) is determination of the participants. By analyzing the relevant literature participants (*pools and swimlines*) are defined.

2. STRATEGY AND PERFORMANCE MEASUREMENT

The relation between the strategy and PMS is mainly regarded in two ways [7]. The first one is *linear deterministic approach,* based on the assumption that management can rationally set the goals of the organization’s future, so that performances can be measured based upon fulfillment of these goals. As a rule, these kinds of approaches were explained through the methodologies that follow trajectories: *vision, mission, strategy, objectives, targets and performance measurement*. BSC (e.g.) follows the trajectory consisting of: mission, key values, vision,

strategy, ScoreCard, strategic initiatives, individual's goals and strategic outcomes [6 -8].
The second paradigm of creation and implementation of strategy is *cybernetic* or *systematic*. Related to that, performance measurement could be based on the feedback. Organization will use performance measurements to apprehend its own activities and possibilities, and to understand the nature and the condition of relations that prevail in its environment. Performance measurement can be designed with an aim not only to inform on the previously set goals, but also to present the set of inputs into the strategic process on capabilities and options of the organization.

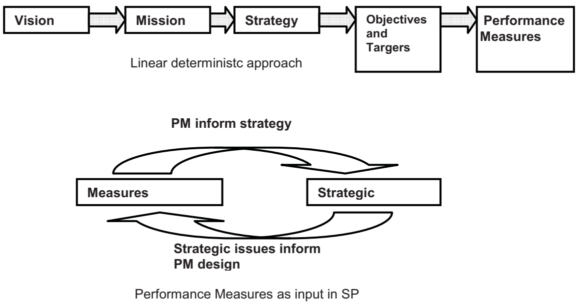

Figure 1. Two paradigms of PMS (Hoverstadt, 2006 - adapted)

Munive-Hernandez et al. (2004) have explored, modeling of the strategy management process, using IDEF0. *The resulting hierarchical model comprises 134 activities over five hierarchical levels (or sub-models) in which each activity can be supported by documentation in the form of word documents, pro formas, spreadsheets and hot links to a company intranet* [9, p708].
This paper discussed proposed modification of BSC approach which will be positioned between two specified paradigms, without much digressing from primary BSC approach. To be more precise, suggested approach shall be moved towards Continual Improvements (CI) [8]. On the other side, we trying to define the primarily steps of the process of defining a BSC modified solution. BMMN will be used as an attempt to describe the processes in the construction of the BSC in the company.

3. THE STAGES OF PROPOSED BSC MODIFICATION

The first stage (Table 1.) will include identification and designation of business goals of highest priority, in sense of focusing efforts to improvements and elimination of communication problems. It is followed by choosing of priority goals and by collecting proposals for amelioration. In the second stage, the construction and usage of PM will help in assessment of successes in efforts for improvements and it would supervise progress towards designated goals. Regular revision of performance indicators data may give early warning on potential problems and provide that measure remains relevant. It can also result in updating existing and in removing of inadequate or outdated measures. Third stage will deal with IT support to the PMS and to management processes.

Table 1. The stages and Steps in the Proposed Approach

The first, *strategic-stage*, consists of the following steps:
1. Purpose and need for PMS
2. Determination of participants and training
3. Evaluation of existing PMS and criterions in the organization
4. Determinants- vision and strategy, goals, key areas of performances, strategic maps. Identification of current business goals.
5. Selection of priority goals. Choosing of several tenable goals for direct action. Collecting proposals for improvements; selection of adequate improvements.
The second – *PM stage* consists of:
6. Construction: KPI and belonging data, procedures in PMS, validity of system.
7. Identification of appropriate system for data collection. Integration of PMS segments into the organization's management system.
8. Implementation of selected ameliorations; communication of data toward employees; reporting on progress in accordance with expected levels of performances.
9. Review of progress according to expected levels of performances; giving appraisal of the success of improvements; revising the convenience of performance measurements; feedback actions.
The third – *IT stage* consists of:
10. IT definition of KPI and identification of data sources
11. Procedures for data collection
12. Creating database on KPI
13. Procedures for data analysis
14. Procedures for communication of results
15. Procedures for usage of results

4. BUSINESS PROCESSES AND BPMN

A Business Process (BP) is a set of one or more linked activities executed following a predefined order which collectively realize a business objective or policy goal, normally within the context of an organizational structure defining functional roles or relationships [10, p10]. A process can be entirely contained within a single organizational unit as well as it can span several different organizations. Business process collaboration across enterprise boundaries is a complex task due to the lack of a unique semantics for the terminology of their BP models and to the use of various standards in BP modeling and execution [11]. Business Process Management (BPM) provides governance of a business's process environment to improve agility and operational performance.
Business Process Modeling is a method for improving organizational efficiency and quality. Its beginnings were in capital/profit-led business, but

the methodology is applicable to any organized activity. The increasing transparency and accountability of all organizations, including public service and government, together with the modern complexity, penetration and importance of ITC (information and communications technology), for even very small organizations nowadays, has tended to heighten demand for process improvement everywhere [11].
Since both Business Process Modeling and Business Process Management share the same acronym (BPM), these activities are sometimes confused with each other. Business Process Modeling is the activity of representing processes of an enterprise, so that the current - *as is* process may be analyzed and improved in future - *to be* [11]. Business Process Modeling is typically performed by business analysts and managers who are trying to improve process efficiency and quality. The term „Business Process Modeling" was coined in the 1960s in the field of systems engineering. In the 1990s companies started to substitute terms like „procedures" or „functions" with the terms „processes" and „workflows".
Thematic coding, introduced by Flick [12], is useful tool for analyzing interview with company's management. Here, as qualified examples, the themes were derived from the conceptual model of integrated PM development [13]. The purpose of this was to enable the identification of the PM.

> *When we receive an order we quote a delivery date. The customer gives a date that they would like it by and we give a realistic date that might be better or it might be worse. Then when we don't reach that delivery date we have statistics that tell us how efficient we have been. So we can say "well 10% of what we have done has been delivered late". Then we can look back and see what the cause was. Design new processes so it doesn't happen again. That works best and that is as and when – that is not taken every month [13, p75].*

From this parts of after interview, M. Hudson [13] was identified tree PM`s: *lead times, effectiveness and feedback.*
Thematic coding will be used, in below, in the literature analysis following Chinosi rules [11] made for BPMN development. Main phase (i): *Conceptual Modeling* consists of:
Rule 1.1: *Identification of participants.* Participants are all the actors, or services, involved in the process. Participants (roles) perform activities. They are represented in BPMN with swimlanes.
Rule 1.2: *Identification of activities*. Activities must be identified for each of participants. If activity has a simple structure it can be represented with a task, otherwise if it is a complex action, it can be represented as sub processes.
Rule 1.3: *Identification of events*. An event affects the flow of a process. It could be Start Events, End Events or Intermediate Events (when they occur between the start and the end of a process).
Rule 1.4: *Identification of choices*. Choices in BPMN are represented by Gateways. Gateways affect the flow of the process on different paths. It is possible to identify choices every time a single flow could be splitted in more than one different path. Choices are conditional expressions, like, *if. then else*, *while, otherwise*.
Rule 1.5: *Relationships*. Relationships could be: sequence and message flows. Sequence flows is order given by the process specifications, connect all the activities, events and gateways, beginning from Start and finishing with the end events. Message flows are information exchanged between participants.
Rule 1.6: Documentation of the processes. Adding of BPMN artifacts.
The subsequent main phases are: (ii) *Logical modeling* – it presents refinement rules to improve the business process diagram. (iii) *Physical modeling* – putting second phase output into a physical format (BPEL).

Table 2. *Participants* in BSC implementation

	Kaplan and Norton (1996)	Niven (2006)	Markovic (2008)
Roles/Participants		Executive sponsor	Executive sponsor
	Architect (Project leader or Consultant)	BSC champion	BSC Consultant
	Senior management team (Client, Key senior management executives, Top management team)	Team members	Senior management team
	- four subgroup for perspectives		
	- larger number of middle managers	Organizational change experts	

This paper deals with analysis of text given in the seminal book of Kaplan & Norton [6] relating to the participants in the process of implementation of BSC.

> *The architect will own and maintains the framework, philosophy, and methodology for designing and developing the scorecard. Of course, any good architect requires a client, which in this case is the senior management team. ... since the client will assume ultimate ownership of the scorecard and will lead the management processes associated with using it* [6, p299].

The <u>*architect*</u> *must, in consultation with the* <u>*senior executive team,*</u> *define the business unit for which a top-level scorecard is appropriate* [6, p300].
The <u>*architect*</u> *prepares background material on BSC as well as internal documents on the company ... this material is supplied to each* <u>*senior manager*</u> *in the business unit -typically between 6 and 12 executives....* [6, p303].
The <u>*architect*</u>*`s (and* <u>*consultants*</u>*) involvements is heavy at the front end of this time table, ...* [6, p303].
By the end of the workshop, the <u>*executive team*</u> *will have identified three to four strategic objectives for each perspective,* [6, p306].

In the same way are analyzed Niven [14] and Markovic [8] – Table 2. Role-participants, arising from Chinosi Rule 1.1 (*Thematic coding)* analysis, are presented in Figure 2.

		Swimlines
Executive sponsor		
BSC architect		
BSC team	**Key senior management executives**	
	Subgroup (four) for perspectives	
	Middle managers	
Organizational change experts		

Figure 2. BPMN Swimlines in BSC case

5. CONCLUSION

Using concept of thematic coding could be very useful in the processes of analysis of interviews. In this paper, the concept has been applied to the analysis of texts from the relevant literature dealing with the implementation of the BSC (and BSC modification). An attempt was made to define the initial step in the process approach to development and implementation of PMS. During modeling the process, we should identify the participants, activities, events, choices and other attributes. Here, (first step) it is shown in the modeling processes of development and implementation of BSC.

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PRODUCT DESIGN FACTORS FOR EFFICIENT INDUSTRY

Svetomir Simonović
Ph.D., Technical College, Visoka tehnička škola, Bulevar Zorana Đinđića 152a, 11070 Novi Beograd,
e-mail:svetomir@sezampro.rs

Abstract: *Excessive products variety is detrimental to productivity because it tends to introduce high production operations variety and consequentlu high production costs. Global technical regulations such as that of European "New approach" tend to reduce excessive product variety by introducing harmonized technical legislation. On the other hand intentionally high product variety can be beneficial for market share of a company because it renders more choices to customers.*
Mixed model production oriented product design embodied in modular design and design for group technology enables high product variety at low production cost. Design for simplification and design for ease of auotmations are product design techniques that enable further improvement of production efficiency.
Key words: *Harmonization, design for mixed production*

1. INTRODUCTION

As is well known mass production is inherently inflexible in the sense that switchover to another product or variant of product takes long production machinery set-up time. So it is, in principle, detrimental for production efficiency to simultaneously produce few products in the same production shop.

Various technical legislations of EU member's countries concerning design of machinery tends to impose different design parameters to the mechanical equipment of the same kind. It tends to confine a Manufacturer to produce only for local legislation area in order to evade costs of designing and producing more variants of the same product. In order to reconcile various national technical regulations European Union has adopted regulatory technique called "**New approach"** and so it opened a possibility for manufacturers to produce their equipment with less variety that is to have much longer production runs.

On the other hand it is vital for producers to offer more variants of its mass produced products at affordable prizes and so to attract customers by opportunity to choose. It is possible for manufacturers to attain by applying mixed model production**. Mixed model production** is a concept relating to manufacturing and assembling a variety of products in the same plant simultaneously. Mixed model production should be distinguished from **multi-model production** where a variety of products are produced in the same plant, but not simultaneously. Mixed model production can be achieved only if set-up times for individual models are extremely small, and that is only possible if design of products under consideration is such that minimize **operations variety**.

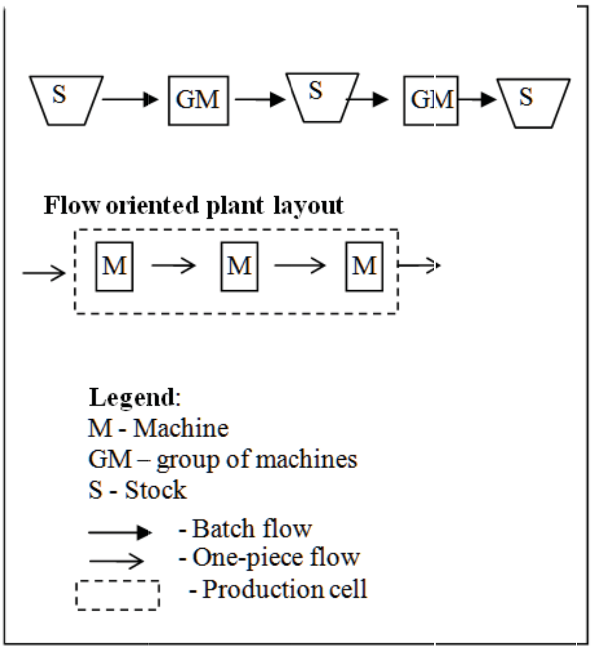

Fig. 1 Operation oriented plant

Design techniques for minimization of operations variety can be modular design and design for group technology. Also special design of jigs and fixtures is applied in order to achieve simple and therefore fast and inexpensive production equipment set-ups and product changeover.

On the other hand low operation variety enables flow oriented plant layouts that minimize lead times and inventories between operations.

Picture above renders schematic representations of classical – operation oriented and modern flow oriented plant layout.

Operation oriented means that production lot as a whole is submitted to particular machining operation and not moved to another machining operation before last item in the lot is processed.

Flow oriented means that one or few pieces of products are submitted to certain machining operations succession, that is number of items in lot is one or few.

Operation oriented plant layout consists of groups of similar machines with stocks between them. It is characterized by long lead times, long setup times and, as consequence, long production runs and inflexibility.

Flow oriented plant layout consists of groups of dissimilar machines so that each group of machines correspond to certain type of production process. There are no stocks between machines and machines are lined according to the operations schedule. It is characterized by short lead times, short setup times and, as consequence, short production runs and high flexibility.

Mixed model assembly can be very beneficial, particularly in an environment where customers expect rapid turnaround of orders and when ability to respond quickly is critical [3].

Design for simplification strives to reduce time of manufacturing and assembly by taking into consideration influence of product design characteristics on production and assembly productivity. Design for ease of automation takes in consideration product design characteristics that enable more efficient automatisation of production and assembly.

In the following text mentioned techniques will be elaborated.

2. NEW APPROACH

The creation of a single European market by 31 December 1992 could not have been attained without a new regulatory technique that reduces unnecessary product variety by setting down only the general essential design requirements that must be fulfilled by products placed on EU market.

A new regulatory technique and strategy was laid down
by the Council Resolution of 1985 on the New Approach to technical harmonization and standardization, which established the following principles [1,2]:

- Legislative harmonization is limited to essential requirements that products placed on the Community market must meet, if they are to benefit from free movement within the European Union.
- The technical specifications of products meeting the essential requirements set out in the directives are laid down in harmonized standards.
- Application of harmonized or other standards remains voluntary, and the manufacturer may always apply other technical specifications to meet the requirements.
- Products manufactured in compliance with harmonized standards benefit from a presumption of conformity with the corresponding essential requirements

Harmonized standards are European standards, which are adopted by European standards organizations, prepared in accordance with the General Guidelines agreed between the Commission and the European standards organizations, and follow a mandate issued by the Commission after consultation with the Member States.

So, designing products in accordance with European harmonized standard means long run production that matches whole European Union market and accordingly much lover production cost per unit of product.

3. MODULAR DESIGN

Architecture of the product is the physical structure of the product. It is defined by the arrangement of its constituents and by the way how its constituents interact between themselves with respect to the main function of the product.

There are two architectural philosophies, modular and integral. A modular philosophy puts a limited number of functions in each product constituent, and interaction between constituents are well defined and are generally fundamental to the primary function of the product. In integral philosophy one function is incorporated into several constituents, while a single constituent incorporated several functions. The interactions between constituents are ill-defined and have little to do with the functions.

World Class Companies design their products in modular fashion for several reasons. Modularity makes it easier to change a product without having to redo much or the entire product. The product can be upgraded by replacing module or by adding to. Parts that wear out more quickly can be easily replaced.

Modular design mediates the desires of customers for product variety with the desire of manufacturer and retailers for simplicity by incorporating variety into a limited numbers of modules. In these way designers reduces manufacturing cost and inventory. Risky technologies can be concentrated in one or few

modules. Standard modules can be introduced that are not seen by customer providing similar benefits.
System architecture for modular design ought to be thought out with great details at the outset of the project by the cross-functional team that should involve also external suppliers design staff. Their architectural decision establishes a product platform that may become basis for entire family of products. Successive innovations may each be concentrated in one or another module, thereby facilitating continuous product innovations at low incremental development and manufacturing cost. Interfaces should be robust, standardized and early defined so that detail design of modules can be developed within those interface parameters [3,9].

4. DESIGN FOR GROUP TECHNOLOGY

In flow oriented production systems each production cell corresponds to a particular family of products that can be produced in that cell. In this respect there are two main use of Group technology:

- Group technology is used to define families of products and components which can be manufactured in well-defined production cells.
- Group technology is used to reduce unnecessary variety and redundance in product design.

In Group technology production items are grouped into families on the basis of such characteristic as part shapes, part finishes, materials, tolerances which all results in certain kind of succession of production operations.
Each part family is represented by master part. Products are designed so that their features can be matched to respective features of a master part, that is to a product family.
As a part of designing for Group Technology there is also design of jig and fixtures for group technology. Every machine in production cell must have a jig or fixture that enable swift changeover from a currently produced part in family to production of another part of the same family, thereby enabling one-piece flow of different parts through a production cell [3,4].

5. DESIGN FOR SIMPLIFICATION

Design for simplification strives to design products which are relatively simple to manufacture and assemble. New product design should, as far as possible, include off the shelf items, standard items or component that are possible to make with a minimum of experimental tooling. Product features such as part tolerances, surface finish requirements, etc., should be resolved with respect to the consequences of the unnecessary embellishment on the durability of production process and thereby on the production costs. Designers, added by their team members, must be familiar enough with manufacturing alternatives, capabilities and limitations so that they do not unknowingly make choices that are unnecessary difficult, impossible, costly, and time consuming to manufacture. Design for ease of assembly is recommended in which a parts are assembled by adding them from the top, and the product never has to be turned over, parts should be designed to be self aligning, require no tools for assembly, are secured immediately upon insertion, and do not need to be oriented. Whether for automated or hands assembly, fasteners (screws, pulleys, cotter-pins, etc.) are to be avoided as much as possible. Subassemblies should be designed as modules having testable functions. In that way design, quality assurance and assembly should be integrated [5,6]. There are also issues of access to fasteners and lubrication points, access to certain points of surfaces for sake of testing, location points for accurately holding components and subassemblies, standardization of subassemblies for multiple models, and reduction of number of times the parts and subassembly must be turned over during assembly [7].

6. DESIGN FOR EASE OF AUTOMATION

Design for ease of automation relates to the design characteristics that will, for example, in the case of assembled components, help to simplify automatic part feeding, orienting and assembly operations. In the case of assembled components it is important to design products to be assembled from the top down and to avoid forcing machines to assemble from the side and particularly from the bottom. The ideal assembly procedure should be performed on one face of the part, with straight vertical motions and keeping the number of faces to be worked on to a minimum.
Until the early 1980s the application of robots in industry had been confined to relatively simple tasks: machine loading and unloading, spot and arc welding, spray painting, etc. Relatively few applications in assembly were realized. Manufacturing system designers adopted two main approaches to assembly automation: the development of advanced assembly robots and redesign of products, components, etc. for robots based assembly. The first approach involves the development of universal grippers and intelligent, sensor based robots with sufficient accuracy, speed and repeatability, and which are capable of being programmed in task oriented languages. This approach tends to mimic the flexibility and capability of human arm and hand. The second approach seems to be more successful in practice because the product designing for ease of automation reduces assembly to series of pick- and- place operations, thereby eliminating the need for more sophisticated robot. This results in manufacturing costs savings and increases the probability of financially justified robotic assembly [8.9].

7. CONCLUSION

Product design aspects that are most influential to the industrial efficiency are: (1) global technical harmonization that reduces excessive variety of products and enables super long run production (2) Design techniques for minimization of operations variety such as modular design and design for group technology that enables production of various products in the same production run and (3*)* design for simplification and design for ease of automations aimed to reduce costs of particular production and assembly operations.

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IMPLEMENTING KAIZEN APPROACH FOR QUALITY OF E-LEARNING

Eiman A.El Wazzan[1], Dr.Maged Farouk[2], Prof.Dr. Ahmed El Kashlan[3]
[1]Bibliotheca Alexandrina, Egypt.
[2]Alexandria University, Faculty of commerce, Alexandria,Egypt.
[3]Productivity and Quality Institute, Academy for Science and Technology, P.O. Box 1029, Alexandria, Egypt.e-mail: kashlan@aast.edu (Corresponding Author).

Abstract: *E-learning models are valuable aids to develop frameworks to designer in the world of e-learning address the concerns of the learner and the challenges presented by the technology so that pedagogy and e-learning can take place effectively. These models provide useful tools for evaluating existing e-learning initiatives or determining critical success factors. The present paper reviews a number of paradigms for identifying and evaluating the quality of online learning programs. As quality is a concern of all stakeholders, a proposed model is presented based on implementing "Kaizen" concept for continuous improvement of e-learning effectiveness, administrative, and technical support ,an issue was rarely applied in education. In addition the paper focuses on the importance of adopting a quality concept in implementing e-learning courses, more specifically to reveal the significance of using "Kaizen" concept for improving e-learning processes. The proposed model enables practitioners to make decisions concerning online learning in a principled way based on IMAI cycle.*

Keywords: *quality assurance, kaizen, e-learning models, continuous improvement, quality control and management.*

INTRODUCTION

The primary focus of this paper ison e-learning improvement by proposing a model based on the quality, skill and cooperation of the instructor and students. E-learning began a long time ago, but it was slowly lengthy process. Today networks are common and most countries would have access to the internet and the World Wide Web (www). Nevertheless it is still far from using these technologies for effective learning. E-learning is often synonymous with online learning, itrefers to methods of learning that uses electronic instructional content delivered via the internet. Many e-learning initiatives have been justified on the assumption that information and communication technology (ICT) could improve the quality of learning while at the same time improving access to education at reduced costs. Developing an e-learning strategy is essential in setting a course that will enable a university, faculty or department to achieve its goal(s). Without a strategic plan, short term measurement of costs and return on investment may reduce the longer term benefits of e-learning as a means of producing knowledge workers. Kaizen is a philosophy of continual improvement, emphasizing employee participation, in which every process is continuously evaluated to be optimized or improved in terms of time, resources, quality, and other aspects relevant to the educational process [1]. The concept has been applied for improving productivity of manufacturing processes, logistics and management, health care activities, but rarely in education.Face-to-face instruction delivery pattern includes those courses in which a part of the contentfrom zero to 29 percent is delivered online; this category includes both traditional and web facilitated courses. Blended and sometimes called hybrid and integrative instructiondelivery pattern is defined as having between30 percent to 80 percent of the course content delivered online.Online course is where no face-to-face meetings. Online learning has become a popular and effective alternative to the traditional face-to-face education system. It may be used to supplement either traditional education, or it may be a complete replacement of traditional education. As the number of online education programs grows, defining educational quality in such a mode becomes increasingly important task. There is no simple definition of quality in e-learning programs. The most important criteria for evaluating quality in e-learning are that it should function technically without problems across all users,and clearly explicit pedagogical design principles appropriate to learner needs and context [2]. Some of the obstacles facing learners are the preparation time required, lack of support for technical problems and course development. There can be no improvement if there are no standards. Many existing quality standards for the design of online courses are available. In 2005, the quality standard for learning, education, and training ISO/IEC 19796-1 was published, later in 2009 the ISO/IEC 19796-3standarad was published, both standards were the first international standards in e-Learning domain. The quality standard ISO/IEC 19796 is a general framework to describe and develop quality assurance for educational organizations, and provides an overall framework which can be used for introducing quality approaches for both provider and users organizations presenting e-learning. The standard makes it easier to compare and evaluate the quality of e-learning relative to different initiatives [3]. The next section presents some e-learning models that the proposed e-learning model is based on. In the third section the modeland a brief description of the main foundation phases is discussed. Finally the paper is concluded with sample references.

E-LEARNING MODELS

There are really no standard models for e-learning, only enhancements of models of learning[4]. Various models with varying degrees of complexity for e-learning were derived in the literature, the model help the implementation of quality and sustainable e-learning programs [5]. This requires an understanding of the impact of information and communication technology (ICT) on the education quality landscape and on current teaching and learning practices.In addition models are useful in identifying internal and external environmental factors that affect the desired future outcomes of university, faculty or department and identify critical success factors [6]
A proposed model is presented and derived from the following models

1-Anderson's model of online learning [7]
The model is based on the iterative triad (interactive possibilities among students, teachers,andcontent). The model describes the types of communication and interaction which produce multiple types of learning in an online fashion.

2-Atkin's minimal model of learning
The model consists of two sets of three spheres (Design-Produce-Evaluate) to describe the performance cycle and its relation to (Learn-Perform-Value) to describe learning cycle, it reveals that processes are often overlap and interdependent The objective of the proposed model is to improve learning [7].

3-Clark's model of instructional system design [8]
The model uses the familiar (analysis, design, development, implementation, evaluation) design sequence (ADDIE). Where needs assessment, task analysis, learning objectives, and assessment are under the umbrella of analysis and design. Development is concerned with revision, improvement. Implementation and evaluation performs the feedback process.

THE PROPOSED E-LEARNING MODEL[9]

The proposed model of e-learning is based on IMAI cycle SDCA, (Standard, Do, Check, Act) [1],where a continuous optimization in small steps is realized. The guidelines for achieving quality assurance principles are learning effectiveness and new knowledge, faculty "employee" satisfaction, student "customer" satisfaction and loyalty, and competitive intelligence. The model is extracted from a PhD dissertation [9].

A brief description of the proposed model components includes the following foundation phases:-

(A) **Admission/management phase**
Any e- learning programs offered by an institution must be appropriately integrated into the institution's administrative structures**,** the phase includes:-
(i)supporting the research and development of emerging technology in online education.
(ii) providing students with adequate information and support to be successful.
(iii) providing contact information and questions and concerns clearly posted with indications of the expected response time.

(B) **Learning management systemphase**, the phase includes:-
(i)faculty are supported in the transition from class room teaching to online instruction and receive feedback during the process, including access to pedagogical and technical resources.
(ii) faculty are able to meet the diverse needs of students.
(iii)Instructors who teach at a distance must be appropriately oriented and trained in the effective use of technology to ensure a high level of student motivation and quality of instruction.
(iv) students assessment is related to learning outcomes.
(v) studentsinquires are usually responded to within 24-48 hours. This is stated in the course policies.

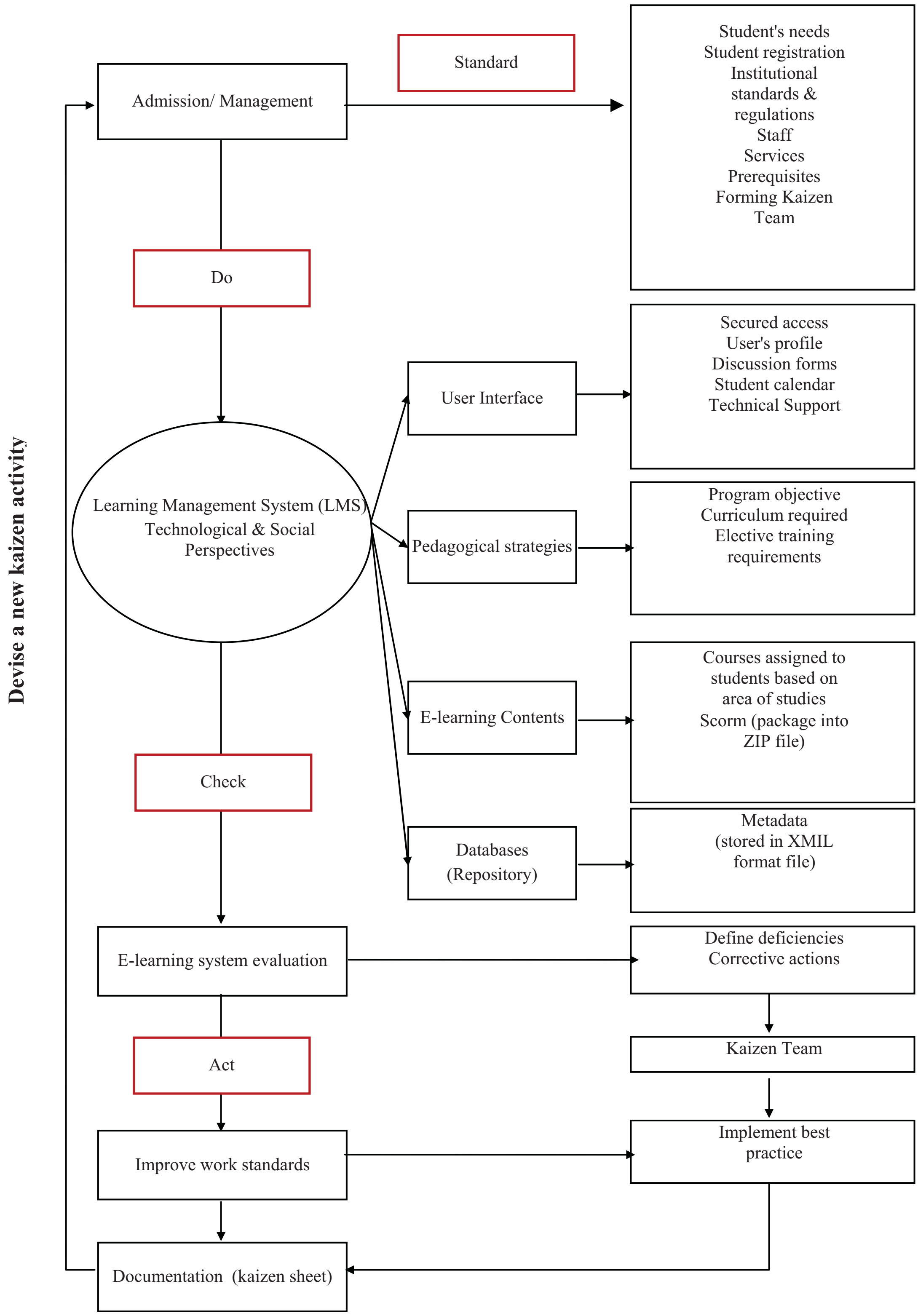

Figure 1: E-learning processes using Kaizen approach

(C) **Check phase**, the phase includes:-

(i) the course objectives and intended learning outcomes (ILO's) are clearly articulated and the online course design reflects these.

(ii) the intended learning outcomes (ILO's) are reviewed regularly to ensure clarity, utility, and appropriateness.

(iii) course materials provided to students support fulfillment of course objectives.

(iv) measurement and accountability system are embedded into programs and courses.

(D) **Act phase**, the phase includes:-

(i)the course's educational effectiveness and learning process is assessed through an evaluation process that uses several methods and applies specific standards.

(ii) the online program is reviewed and accredited regularly by a professional regional and national accrediting organizations association.

(iii) learning environments include problem-based as well as knowledge-based learning.

Cooperative teams have been used across all model phases to promote ideas to aid in creating flexible learning environment and achieving small effective incremental changes.

The expected outcomes describe how to engage the learner in meaningful task, give rapid feedback, encourage reflection through KAIZEN team to tutor and peers.

CONCLUSION

Quality is easy to state but more difficult to quantify. The main objective of the present paper is to present an effective model as a foundation which will guide staff members as they plan and administer quality online education for e-learning. The model is based on "kaizen" concept for continuous improvement for the better of the learning process, adopting the SDCA cycle change for the better. In" kaizen" every process is standardized after its improvement before it is released. All learning processes need to be improved before results can be improved. It is expected from the proposed model that it enables practitioners to make decisions concerning online learning in a principled way based on IMAI cycle.

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ANALYSIS OF THE REASONS OF INFLEXIBILITY OF OUR COMPANIES AS A SUPPORT TO TQM IMPLEMENTATION

Ljiljana Pecić
Higher Technical School of Professional Studies Trstenik, ljpecic72@gmail.com

***Abstract**: In order to successfully manage organizations in era of dramatic change, is no longer enough to master the classic management process, it is necessary to master the process of total quality management and reengineering as its business reengineering. The situation, in which our companies operate, is loaded with a very complex mix of factors or reasons that obstruct them in the exercise of greater market flexibility. The aim of this paper is to present research results and consideration of these reasons.*
***Keywords**: reengineering company, inflexibility, TQM,*

1. INTRODUCTION

In developed economies, due to their development specificity and character, a scientific opinion about the performance of business process re-engineering company is crystallized and with them is mainly covered the question of necessity of performing re-engineering companies. However, under conditions of underdeveloped countries is not quite so. It is said that reengineering is the radical improvement of one or more processes that need to start from the beginning. And what is the beginning for the company in a developed economy, and what for company in the underdeveloped, especially in the economy in transition? It is obvious that between them is a big difference. Companies in developed economies, where market rules are the only regulator of enterprise, where the technical and technological development is constantly carried out, beginning for performing re-engineering is different from the beginning in companies in developing and transit economies, especially where such characteristics in the past was none and which today still does not exist, and as things stand, they will almost never be.

In developed economies, radically improving the competitive capacity of businesses is mainly implemented through the activities of radical business process improvement, and here and in many similar economies of the world requires a radical improvement of the total process-organized company, not just their individual processes. Partly this is due to the fact that in many companies in underdeveloped economics some of the necessary processes exist, some are incorrectly placed and some because of the present of individual weaknesses or deficiencies of other processes, do not give satisfactory results.

This work is created as a part of making the company re-engineering methodology, which would be applicable in terms of business of our company, and to survey the situation that is present in our companies.

2. FIELDS OF RESEARCH IDENTIFICATION AND OBSERVATIONS PREVIOUS RESULTS

In the period of rapid economic and technological changes, political turmoil and global threats to the life on Earth survival, no one can successfully manage companies just because someone thinks that he is clever. To be successful in managing organizations in an era of dramatic change, is no longer enough to master the classic management process, but it is necessary to master the process of total quality management and reengineering as reengineering its business.

In organizational theory, it is known that classical management is based on the processes: *planning* (setting goals, determining how to achieve the objectives, the allocation of necessary resources), *organization* (division of labor, delegation of authority, coordination), *management* (supervision, motivation, reward and punishment, training and training, conflict resolution) and *control* (selection of specific parameters, monitoring results,
Comparing planned and achieved corrective action).

The process of total quality management, is however, unless specified, and with upgrading the best features of previous management modern approach, based on the total process approach and continuous improvement companies in small steps (progressive and evolutionary changes, with the involvement of all employees), as long as possible so and after that on performing the radical transformation of enterprises into a new basic organizational state with a new total process organizing with a tendency to achieve a new Total Quality Management or new TQM.

William Deming, one of the founders of modern quality management movement, claims that 85% of problems related with the quality, the result of the quality of business processes rather than individual mistakes. When moves to establish a quality management is made, emphasis is moved shifted from finding errors in testing and improving business processes that enable the creation of defects, in order to experience problems, disable it before.

2.1 GOOD PRACTICE IDENTIFICATION IN TERMS OF MANAGING COMPANY FOR THE LONGER TERM

Dealing with ongoing or acute problems is the overwhelming preoccupation of managers in most companies today. Overcoming the problems associated with present and immediate future relates most of the time and energy managers in most companies. According to lot of studies, most managers energetically recognize that their ability to predict the future of the company is now very limited. In their opinion, except for death and taxes, only predictable today is that requirements for the successful operations are continuously changing. This is true even for company’s most bureaucratic mature and stable environments.

Nowadays, companies are faced with changes in: its operations, markets, competition, regulatory policies, the present technology, availability of personnel - and their own business strategy. These changes are an inevitable result of his among actions with the environment, which is becoming more dynamic.

All these kinds of changes that occur in the company and around it, needs its organizational adaptation. For example, if the personnel market supply is changed over time, the company must change its criteria for selection of staff or to make other adjustments to make new employees introduced into the mode of their needs. New competitors may occur with new products, which require extensive involvement on the products development or services and the appropriate organizational setup for such an effort support. Transactions in a growing company require certain major adjustments in all aspects of the organization (1, p.16).

The company inability to anticipate the need for change and to effectively adapt to change its business or its organization, causing problems. These problems sometimes take the form of poor cooperation and coordination; they can have the effect of high stress and downs and had the appearance of irresponsibility. The occurrence of such problems always affects company business results - targets are not achieved, and costs increase.

Bearing in mind that changes in the environment are inevitable and easily produce problems in business, a very important characteristic of effective company, from long-term point of view speaking (from seven to ten years) is that it has the ability to predict upcoming changes in the environment and according to them company is promptly set to appropriate organization. The ability to predict upcoming changes in the environment can help to prevent weakening of business enterprises due to the presence of the organizational unsets, and timely organizational customizing helps the company to avoid the problems that upcoming changes in the environment can cause. Over time the ability to avoid weakening the business can mark the difference between success and failure of a company.

According to the access to some research, it can be point on features of behavior that contributes to long-term perspective in particular companies. These characteristics are:

- Changes in operations are anticipated and quickly recognize
- Adequate response is achieved quickly and
- Necessary response are executing with minimal costs.

This behavior is possible if the company has radically modern managers who are skilled in conducting business and organizational analysis, and if they have employees with the capabilities to quickly adapt to changes. Informal relationships among employees of such companies are based on trust, open communication and respect the opinions of others. Their formal structure involves the effective integration mechanisms, sensitive and well-designed systems of measurement and reward systems that encourage customization and the selection and development systems that support all the other essentials stated in Table 1.

The company with the characteristics presented in Table 1 can successfully respond to the growth, to changes in its business environment, to management change and everything else that is threatening his business success. The ability to customize allows him to pursue a change in order to correct business and it will survive and even thrive in crisis circumstances over time.

However, very few companies or nonprofit institution has an organization with characteristics presented in Table 1. This fact is emphasized by many researchers in the last ten years and serious concern were expressed because of strong presence of a condition called "bureaucratic decay" (1, p. 20). We all pay a heavy price, they say, to a tall, bureaucratic, inflexible companies that do not feel the needs of their employees, which ignore wishes of their customers and avoid the observance of social obligations and responsibilities.

Available information suggests that, although most of today's companies can not be called adaptable, lot of managers emphasize the need to adjust the benefits. In surveys in which they participated, managers clearly point to the "ideally" like to them, the company has the characteristics shown in Table 1, but also point out that their company does not have enough, or only some of these characteristics.

EMPLOYEES: - The company is characterized with more than good leadership skills. - Managers are skilled in performing organizational analysis and well-know and understand the process of performing organizational development. - Most of the employees and the government are with easily adaptable skills outside their narrow specialties. - Employees have the objectivity in expectations what they can get and what they need to provide to the company in the foreseeable future.
INFORMAL RELATIONS: - There is a high level of trust between employees and managers. - Information flow is a free and very small deviation between individual organizational units. - Staff at all positions of responsibility is a tolerant, ready to hear suggestions and comments no matter from which they come to them and to act constructively.
THE FORMAL STRUCTURE: – The organizational structure includes high-quality integration mechanisms for responding to the current situation and does not rely on rigid rules and procedures. – The system of measurement consistently collects and disseminates all relevant data and information around the company, the engagement and achievements in it and the changes that are occurring relevant factors. – The system of compensation encourages employees to realize the necessary changes and participate in their implementation. – System selection and personnel development are designed to create high educated managers and employees and to encourage the achievement of established informal relationships.

Table 1. Summary characteristics of high effective companies from long-term aspect

3. IDENTIFICATION AND ANALYSIS OF IDENTIFIED FACTORS AFFECTING THE FLEXIBILITY OF OUR COMPANY

Identification of the reasons that affect the rigidity of the company was built on the basis of monitoring results done over the years for our business.

Recorded a number of reasons, but there is at least five reasons for inflexibility and shortsightedness of most companies today.

The first and most important reason is related to the resources needed for investment. The creation of highly customizable organization takes time, energy and money. In the case of companies that have started to weaken, making the flexible organization in its early history is probably required:

- Recruitment, training and assimilation of the management team both strategic and tactical.
- Selection and training of other employees.
- The concentration of efforts of managers to develop integration mechanisms, measurement systems and the like.
- Develop and maintain a good, informal relationship between managers and employees.

Particular company may not have funds to invest in development. Or it was not aware that it is really is needed. If it was any attempt to do something, perhaps, there has to be some reason for which it had to give up.

The second reason for unsuitable and bureaucratic behavior of today's companies is that their management was not able to realize the characteristics of the organization which are effective in the long run. The companies mainly invest in current operations, but not into the development of adaptive human systems. Manager education together with work is usually focused to solve current problems, not to achieve flexible organization. The characteristics exercise according to Table 1 requires skills that need to be continuously develop and nurture.

The third reason for the existence of rigidity companies today, is obviously present gain from present state of the organization. Management that created the existing unsuitable organization is completely engaged with it and enjoys the way he leads the company. The question is, would it be interested to invest funds in development of management team or to create a new team, even if this would not cost the company. If you created the ambient that the company's shareholders are satisfied with the way of running the business, the involvement of a large part of employees' earnings in dividends or other of their use, management has become favored in the company. If he had worked to reduce the dividend because investment in something that is intangible, to shareholders such as flexibility, it would have been removed.

The fourth reason for the inflexible behavior of enterprises is also evident in the case of depreciation. Once when company reaches a certain size, if did not at least evolved somewhat flexible human organization, the subsequent launch of resolving defects becomes very questionable, without investing significant resources. It takes a very pronounced effort to overcome "organizational entropy" which makes the company inflexible and rigid.

The fifth reason why most companies do not have organizational characteristics that are contained in Table 1, is that their management has dedications which have not acknowledged the need to possess such characteristics, because they are considered unnecessary. By its predictions, management estimates which adaptability will be needed for their business. Compared to that, management directs investment funds needed to be achieved the desired flexibility. If a company is growing rapidly or is in an unstable market, and management expects rapid continue changes in business, it will plan a significant investment of resources in achieving flexible humane organization. However, if a company is not growing, if is not in a volatile market, and if management believes that the future of the company will not suffer any significant impact on its behavior, management will plan a small investment in achieving changes.

4. CONCLUSION

Exercising an enterprise transformation in companies in developing economies is very problematic because it is needed to radically change a lot of things in the manner of conducting business. Usually, in a company there are almost no conditions for conducting those needs. There is a wrong practice of business: there is no adequate knowledge for different company's behavior, there is no adequate scientific support for implementation necessary undertaking in current business environment, there are no corresponding investment capabilities for large development projects implementation and there is a very rigid attitude from collective enterprises about bringing changes on, especially radical. And, with such a accompanying condition lot of our companies are in early nineties, entered the exercise of applying the standards ISO 9000. And because lot of them did not take into account the need for substantial changes, but only the formal fulfillment of standard requirements, such attempts failed or were formally succeeded, from which there were no special benefits. For this reason, it should now be entering radically new ventures, such as re-engineering companies.

The methodology that we propose will be discussed in a forthcoming work and facts which we summarize through this work is that the effects that prevent a company to develop a high level of adaptation are very complex. Impacts that can successfully push the company into stagnation and serious difficulties are also numerous. Therefore, it is clear that there is a need for successful performance of the hardest task of any management - to create an organization that has the necessary flexibility to achieve satisfactory efficiency and effectiveness in the long run.

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NOTE ON FOUR LEVEL TAGUCHI'S OA WITH ROLE OF LATIN SQUARES FOR THEIR CONSTRUCTION

Zorica A Veljković[1], Slobodan Radojević[1]
[1]Assistant Professor, Faculty of Mechanical Engineering, Belgrade, zveljkovic@mas.bg.ac.rs
[2]Associate Professor, Faculty of Mechanical Engineering, Belgrade, sradojevic@mas.bg.ac.rs

Abstract. *Orthogonal arrays for four level factors are in common use in practice. Paper discusses use of Latin squares for construction of orthogonal arrays for four level factorials. Using Taguchi's OA* $L_{16}(4^5)$ *it was proved that results are the same for closed (Taguchi's) and open (traditional) factorial designs. In addition, it is shown that choice of different standard Latin squares for construction of orthogonal array leads to different experimental results. This poses a question of criteria for decision what standard Latin square to select in order to construct orthogonal array that will result with authentic experimental results. This can be problem with orthogonal arrays that are not developed, for example in cases for factors with six, eight, nine or ten levels.*

Key words: *Four level factorial design, Latin square, Taguchi, Traditional factorial design, Orthogonal array*

INTRODUCTION

Common use in traditional DOE (design of experiments) of factorial designs is two level factorials. Only for them matrix tables are developed. Factorials for higher levels are rarely used with recommendation for other methods (response surface, center points, center composite designs etc. (Montgomery 2008)).

For factorials with more than two levels and prime number as a number of levels, Yates algorithm is developed (Montgomery 2008, Fisher, Yates 1935). This algorithm identifies all effects in factorial design, but it is complicate for usage. That means that in traditional approach matrix form for factorial design exists only for two-level factorials.

On the other side, Taguchi developed orthogonal arrays - OA for two, three, four and five level factors (Taguchi 1991). Those OA's are in their structure full factorial designs (closed factorial designs). In addition, they can be transformed in traditional factorial designs (open factorial designs) (Veljkovic 2005). Simplicity of use Taguchi's OA resulted in their widespread application in practice and experimentation.

This paper considers four levels OA. Despite critique they are widely in practical use in various fields of experimentation especially in engineering, technology and chemistry (Mehdinia, et.al. 2012, Nematollahzadeh, et.al. 2011, Cheng, et.al. 2007, Datta, et.al. 2008, Sanjari et. al. 2009)

ROLE OF LATIN SQUARES FOR CONSTRUCTION OF OA

For construction of OA Taguchi, recommend Latin squares - LS (Tagichi 1991). OA are obtained by combining orthogonal standard Latin squares and their derivates (Huynh 2008).

In case $L_{2^s}\left(2^s\right)$ it is possible to use only one existing LS. For $L_{3^s}\left(3^s\right)$ OA Taguchi uses only one existing standard LS (Federer 1974) and one of 12 possible modifications. For both OA types it is easy to prove that they are by structure closed OA. Case of four levels OA will be further discussed in this paper. Taguchi's choice of five level factorials could be proved by Yates algorithm.

CONSTRUCTION OF FOUR LEVEL OA

Construction of four levels OA will be demonstrated on example of $L_{16}\left(4^5\right)$, due the size of design. Construction of four levels OA needs three LS dimensions 4×4. There are four standard 4×4 LS (Federer 1974). For every standard LS, there exists $4!(4-1)!=144$ possible combination of replication. Therefore, there are 576 possible LS, with 572 nonstandard. From these four LS Taguchi uses standard design shown in Table 1, as a primary

Table 1. *Primary LS for construction of OA*

I_1		A			
		1	**2**	**3**	**4**
B	**1**	1	2	3	4
	2	2	1	4	3
	3	3	4	1	2
	4	4	3	2	1

Secondary and tertiary LS for construction of OA are nonstandard and are shown at Table 2. All three used LS are the same for four level OA's. Taguchi also suggests alternative LS for construction of four levels OA's, with same primary and commutated secondary and tertiary LS.

Table 2.

II_1		A			
		1	**2**	**3**	**4**
B	**1**	1	3	4	2
	2	2	4	3	1
	3	3	1	2	4
	4	4	2	1	3

III_1		A			
		1	**2**	**3**	**4**
B	**1**	1	4	2	3
	2	2	3	1	4
	3	3	2	4	1
	4	4	1	3	2

Use LS (Table 1, 2) for construction of OA is shown at Table 3.

Table 3. $L_{16}\left(4^5\right)$ *OA with allocation of factorial effects for closed and open designs*

closed (c) / open (o)	A / B	B / A	AB / AB	AB_2 / AB_3	AB_3 / AB_2	$\sum_{k=1}^{n} y_{ijk}$	1	...	n
	1	2	3	4	5				
1	1	1	1	1	1	y_{11}	y_{111}	...	y_{11n}
2	1	2	2	2	2	y_{12}			
3	1	3	3	3	3	y_{13}			
4	1	4	4	4	4	y_{14}			
5	2	1	2	3	4	y_{21}	...	...	...
6	2	2	1	4	3	y_{22}			
7	2	3	4	1	2	y_{23}			
8	2	4	3	2	1	y_{24}			
9	3	1	3	4	2	y_{31}			
10	3	2	4	3	1	y_{32}			
11	3	3	1	2	4	y_{33}			
12	3	4	2	1	3	y_{34}			
13	4	1	4	2	3	y_{41}			
14	4	2	3	1	4	y_{42}			
15	4	3	2	4	1	y_{43}	...	...	...
16	4	4	1	3	2	y_{44}	y_{441}	...	y_{44n}

Taguchi's four levels OA are closed factorial designs. It is possible to developed correspond open OA for traditional DOE approach. In this case, allocation of factorial effects in design is different. Since $L_{16}\left(4^5\right)$ is the smallest OA, it is also full factorial design. In cases of largest OA for four level factorials, columns in OA could be assigned effects for adequate full factorial designs. This enables easy use of this design in practical experimentation (Table 3).

ANALYSIS OF EXPERIMENTAL RESULTS

Analysis of factorial effect will be representing by calculation of sum of squares. Consequent analysis of variance is unnecessary.

For closed factorial designs (original Taguchi's OA) sum of squares are

$$SS_T = SS_A + SS_B + SS_{AB} + SS_e$$

with

$$SS_T = \sum_{i=1}^{16}\sum_{j=1}^{5}\sum_{k=1}^{n} y_{ijk}^2 - \frac{T^2}{N},$$

$$y_{ij} = \sum_{k}^{n} y_{ijk},$$

$$T = \sum_{i=1}^{16}\sum_{j=1}^{5}\sum_{k=1}^{n} y_{ijk},$$

$$N = 16 \cdot n$$

$SS_{A_o} = SS_{B_c}$ and $SS_{B_c} = SS_{A_O}$

Interaction AB has three partitions, resulting with need for three columns for them. Therefore interaction and its partitions, based on calculation from columns in OA are

$$SS_{AB_c} = SS_{AB_c} + SS_{AB_c^2} + SS_{AB_c^3},$$

with

$$SS_{AB_c} = \frac{\left(AB_c\right)_{(1)}^2 + \left(AB_c\right)_{(2)}^2 + \left(AB_c\right)_{(3)}^2 + \left(AB_c\right)_{(4)}^2}{3n} - \frac{T^2}{9n} = $$
$$= SS_{AB_o}$$

$$SS_{AB_c^2} = \frac{\left(AB_c^2\right)_{(1)}^2 + \left(AB_c^2\right)_{(2)}^2 + \left(AB_c^2\right)_{(3)}^2 + \left(AB_c^2\right)_{(4)}^2}{3n} - \frac{T^2}{9n} = $$
$$= SS_{AB_o^3}$$

$$SS_{AB_c^3} = \frac{\left(AB_c^3\right)_{(1)}^2 + \left(AB_c^3\right)_{(2)}^2 + \left(AB_c^3\right)_{(3)}^2 + \left(AB_c^3\right)_{(4)}^2}{3n} - \frac{T^2}{9n} = $$
$$= SS_{AB_o^2}$$

where

$$\left(AB_c\right)^2_{(1)} = \left(y_{11} + y_{22} + y_{33} + y_{11}\right)^2 = \left(AB_o\right)^2_{(2)}$$

$$\left(AB_c\right)^2_{(2)} = \left(y_{12} + y_{21} + y_{34} + y_{43}\right)^2 = \left(AB_o\right)^2_{(2)} = = \left(y_{21} + y_{12} + y_{43} + y_{34}\right)^2$$

etc.

Therefore for interaction

$$SS_{AB_c} = SS_{AB_c} + SS_{AB_c^2} + SS_{AB_c^3} = SS_{AB_o} + SS_{AB_o^3} + SS_{AB_o^2} = SS_{AB_o}$$

That demonstrate that results of experiments are the same for both types of designs, since partitions of interaction doesen't have phisical meaning.

ALTERNATE CHOICE OF LS

Question is: What will be with results of experiment if some other standard LS is chosen for primary LS in construction of OA?

For example, let primary LS be one reccomended by Montgomery (2008). Secondary and terciary LS are obtained on the same way as in LS that Taguchi uses. System of LS for for design of OA is shown at Tables 4, while adeqate OA is represented at Table 5.

Table 3. *Alternate system of LS for construction of OA*

I_2		A			
		1	**2**	**3**	**4**
B	**1**	1	2	3	4
	2	2	3	4	1
	3	3	4	1	2
	4	4	1	2	3

II_2		A			
		1	**2**	**3**	**4**
B	**1**	1	3	4	2
	2	2	4	1	3
	3	3	1	2	4
	4	4	2	3	1

III_2		A			
		1	**2**	**3**	**4**
B	**1**	1	4	2	3
	2	2	1	3	4
	3	3	2	4	1
	4	4	3	1	2

Table 4. *OA constructed with alternate LS*

closed (c)	**A**	**B**	**AB**	**AB2**	**AB3**	$\sum_{k=1}^{n} y_{ijk}$			
open (o)	**B**	**A**	**AB**	**AB3**	**AB2**				
	1	*2*	*3*	*4*	*5*		*1*	...	*n*
1	1	1	1	1	1	y_{11}	y_{111}	...	y_{11n}
2	1	2	2	2	2	y_{12}			
3	1	3	3	3	3	y_{13}			
4	1	4	4	4	4	y_{14}			
5	2	1	2	3	4	y_{21}	...	...	...
6	2	2	3	4	1	y_{22}			
7	2	3	4	1	2	y_{23}			
8	2	4	1	2	3	y_{24}			
9	3	1	3	4	2	y_{31}			
10	3	2	4	1	3	y_{32}			
11	3	3	1	2	4	y_{33}			
12	3	4	2	3	1	y_{34}			
13	4	1	4	2	3	y_{41}			
14	4	2	1	3	4	y_{42}			
15	4	3	2	4	1	y_{43}	...	...	...
16	4	4	3	1	2	y_{44}	y_{441}	...	y_{44n}

Since columns for main effects are the same, only sum of sqares for interactions are calculated with following results for first partition of interaction

$$SS_{AB_2} = \frac{\left(y_{11} + y_{24} + y_{33} + y_{42}\right)^2_{(1)} + \left(y_{12} + y_{21} + y_{34} + y_{43}\right)^2_{(2)} +}{3n} + \\ + \frac{\left(y_{13} + y_{22} + y_{31} + y_{44}\right)^2_{(3)} + \left(y_{14} + y_{23} + y_{32} + y_{41}\right)^2_{(4)}}{3n} - \frac{T^2}{9n} \neq \\ \neq \frac{\left(y_{11} + y_{22} + y_{33} + y_{44}\right)^2_{(1)} + \left(y_{12} + y_{21} + y_{34} + y_{43}\right)^2_{(2)} +}{3n} + \\ + \frac{\left(y_{13} + y_{24} + y_{31} + y_{42}\right)^2_{(3)} + \left(y_{14} + y_{23} + y_{32} + y_{41}\right)^2_{(4)}}{3n} - \frac{T^2}{9n} = SS_{AB}$$

Also $SS_{AB_2} \neq SS_{AB^2} \neq SS_{AB^3}$.

That means the results for influence of interactions are different, depending of choice of LS.

CONCLUSIONS

For construction of Orthogonal arrays by Latin squares for four level factors there exists problem of choosing adequate standard Latin square as an primary. Different choice of Latin squares leads to different results for interactions. In case of four level factorials, existing orthogonal arrays can be used as criteria.

In cases of two and tree level factorial designs use of Latin squares for construction of orthogonal arrays also do not represent a problem, since for them exists only one standard Latin square. Adequate Latin squares for construction of orthogonal arrays can be derived from results obtained by Yates algorithm when level of factors is prime number.

In other cases, such as factors on six, eight, nine or ten levels, there exists a problem of choice of criteria for picking up standard Latin square that will lead to accurate experimental results. Extent of the problem could be illustrated by six level factorials. In this case there exists 9408 standard Latin squares and 818 841 792 nonstandard Latin squares.

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ANALYSIS RESULTS OF SIMULATION FOR PARAMETERS INFLUENCING GEOMETRIC DEVIATIONS IN PLASTIC INJECTION MOLDING

Z. A.Veljković[1], D. Ćurić[2], J. Duhovnik[3]
[1]Faculty of Mechanical Engineering, University of Belgrade, Serbia, zveljkovic@mas.bg.ac.rs
[2]Foundary "Novi život", Zenica, Bosnia and Herzegovina, d.curic@bih.net.ba
[3]Faculty of Mechanical Engineering, University of Ljubljana, Slovenia, duhovnik@lecad.fs.uni-lj.si

Abstract. *Paper discusses identification of parameters that influence plastic injection modeling by simulation on the example of the parts for wall cassette for optical fibers splitter. Simulation was based on Taguchi's orthogonal array $L_8(2^7)$. Two types of analysis of results - Taguchi's and Lenth analysis presented different results. Furthermore, both results significantly differ from results obtained by real experimentation. Conclusion is that for more accurate identification of parameters that influence geometric deviations plastic injection molding for production environment real experimentation is recommended, whenever it is possible.*
Keywords: *Plastic injection molding, simulation, Taguchi's orthogonal array, Lenth method, wall cassette for optical fibers splitter*

I. INTRODUCTION

One of the insufficiently explored problems is the parameters that influence geometric deformations in plastic injection molding. Two most common geometric deviations that occur are shrinkage and warpage. If the shrinkage is evenly distributed that results in geometric reduction of part dimensions without change in form. Warpage occurs in cases on uneven shrinkage in one or more part coordinates. Unequal part shrinkage causes inner tensile strains. Depending on the tenseness of the part, thus strains could result in part deformations and change of shapes. In extreme cases, part can be broken. That presents one in the largest problems in PIM to achieve dimensions within tolerance limits of products.

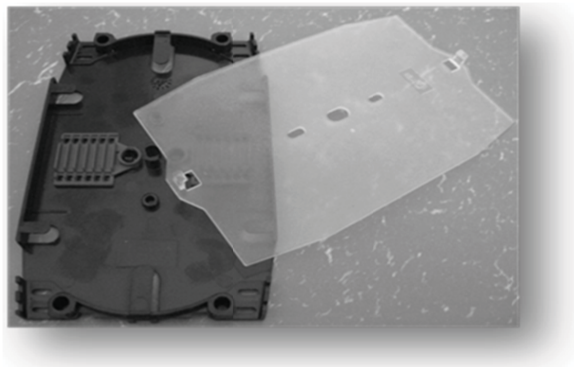
Simulation as a method is commonly used for examination of parameters influencing geometric deformations in PIM, with addition of different techniques of analysis data such as design of experiments, Taguchi methods, finite elements, neural networks, etc. (Busick et.al. 2009, Yin, et.al. 2011, Ozcelik, Sonat 2009, Farchi et. al. 2011). Other authors prefer real experimentation using Taguchi methods, DOE, ANOVA or numerical analysis (Ozvelik, Erazurumlu 2006a, Choi, Im 1999, Erazurmulu, Ozcelik 2006b, Tang, et.al. 2007).

Examined influential parameters vary for different papers. Hence, it was not possible to draw conclusions about influential parameters since choice of factors are limited on production specific parts described in papers. Therefore, it can be concluded that this area is still insufficiently investigated and the real result could be expected in the future researches.

II. RESEARCH BACKGROUND

It is common knowledge that shrinkage and consequently warpage is caused primary by production conditions. That means that final shrinkage and warpage is the complex function of process parameters and machine settings, as well as characteristics and capability of equipment.

Experimentation was conducted on plastic wall cassette for optical fibers splitter that is in use in telecommunication (Picture 1). It consists from three parts - housing, cover and splice tray. All parts are produced by plastic injection molding. Two types of experimentation were conducted simulation and real experiment.



Picture 1. *Wall cassette for optical fibers splitter*

Housing is produced from Cycoloy, PC/ABC, Grade C2800, with weight 26 g, and dimensions 142×92×9 mm. Cover weight 21g, with dimensions 151×92×1.6 mm from Terluran GP35, Natur. Splice tray weight 1.2g, with dimensions 33×26×4.8 mm from ABS, grade TR557.

III. EXPERIMENTAL SETUP

During experimentation two types of experiments are conducted, real experiment, with three level factors and simulation. This paper discusses results obtained by simulation. Simulation is conducted using Moldflow Plastic Insight 2010. Moldflow have restrictions for three level factor experiments that could not have been overcome. Therefore, simulation is conducted for two level factors. Examined factors or parameters and their values, which could have influence on geometrical deviation of molded plastic, for simulation are shown at Table 1.

Table 1. *Factors (parameters) and their levels for simulation*

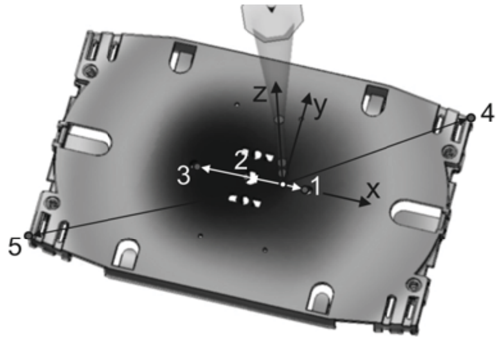
experimental factors			simulation	
annotation	**name**	**unit**	**low**	**high**
TMP	Temperature of Molded Plastic	°C	220	260
IT	Injection Time	s	0.8	1.2
CT	Cooling Time	s	15	40
HP	Holding Pressure	bar	40	70
HPT	Holding Pressure Time	s	3	5

Taguchi's orthogonal array $L_8(2^7)$ was used for experimental setup. Allocations of factors in simulation are presented at Table 2.

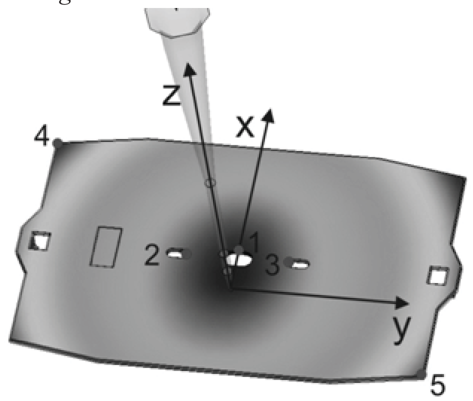
Table 2. *Allocation of parameters in simulation*

effect	**HP**	**IT**	**CT**	**TMP**	**HPT**	**e_1**	**e_2**
column	1	2	3	4	5	6	7

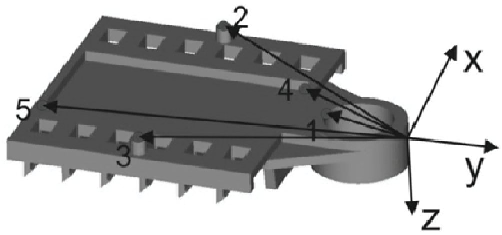
Columns 6 and 7 are used as an error columns e_1 and e_2. For each part deviations are measured in five points (Picture 2 (a)-(c))



(a) Housing



(b) Cover



(c) Splice tray

Picture 2. *Measurement points for deviations for wall cassette for optical fibers splitter parts*

IV. EXPERIMENTAL RESULTS

In this paper only results for nearest and futherest point from injection point are presented, with assumption that they are most important areas where molding process could affect on geometry of the part. Program used for simulation (Moldflow) did not have module for design of experiments. Therefore, only one measurement is obtained, resulting with unreplicated experiment. One of the possible solutions was use of

Taguchi's error columns and pooled error method to estimate influential parameters.
Results obtained using only error columns indicate that important parameters in injection point are Temperature of molded plastic for cover with statistical significance $(p<0.05)$, Holding pressure, Temperature of molded plastic and Holding pressure time with high statistical significance $(p<0.01)$ for housing, and no influential parameters for splice tray.
In furtherest measurement point results indicate that only in housing exists influence of measured parameters. Holding pressure, Temperature of molded plastic and Holding pressure time with high statistical significance $(p<0.01)$.
Results obtained by pooling error method present for injection point Temperature of molded plastic for cover as a highly significant parameter $(p<0.01)$, Holding pressure, Temperature of molded plastic and Holding pressure time with high statistical significance $(p<0.01)$, for housing. Temperature of molded plastic has statistical significance for splice tray $(p<0.05)$.
In furtherest point, pooled error method results with statistical significance $(p<0.05)$ of Holding pressure for cover. In the case of housing, highly significant parameters $(p<0.01)$ are Holding pressure, Temperature of molded plastic and Holding pressure time, while Injection time have statistical significant $(p<0.05)$ influence. For splice tray Holding pressure have significant statistical influence $(p<0.05)$ in the point furtherest from injection point.
Results of simulation obtained by those two methods significantly differ from results obtained by real experimentation. Therefore, those results are analyzed by one of the methods for unreplicated factorial designs in traditional DOE approach.

V. ANALYSIS OF RESULTS USING LENTH METHOD FOR UNREPLICATED FACTORIAL DESIGNS

There exist various methods for analysis of unreplicated factorial experiments (Hamada, Wu 1998). Most common is Daniel plot. Since method is graphical, conclusions could be biased. Therefore for analysis of unreplicated experiments is chosen Lenth method because it is simplicity and reliability.
For Lenth method (Lenth 1989) if $c_1,\ldots,c_7$ corresponding estimates of contrasts $k_1,\ldots,k_7$ obtained from design matrix with assumption that they are independent realization of random variables $\mathrm{N}\left(k_i,\sigma^2\right)$ let $s_0 = 1.5\times \underbrace{median}_{i}\left|c_i\right|$.

Then pseudo standard error (*PSE*) is

$$PSE = 1.5\times \underbrace{median}_{|c_i|<2.5s_0}\left|c_i\right|$$

From *PSE* it is possible to obtain margin of error *ME* for c_i, with 95% of confidence, i.e.

$$ME = t_{0.975,d}\times PSE\ ,$$

where $t_{0.975,d} = 3.76$, from recommended table (Lenth 1989).

If contrasts estimate exceeds *ME*, there is statistically significant influence of parameter defined by that contrast.

In addition, to achieve estimate of high statistically significant influence of parameter, Lenth recommends simultaneous margin of error *SME* by

$$SME = t_{\gamma,d}\times PSE\ .$$

From recommended table (Lenth 1989) $t_{\gamma,d} = 9.01$

V.1 Analysis by Lenth method for injection point

Results obtained for injection point for respective parts of wall cassette for optical fibers splitter are shown at Table 3.

Table 3. *Results for Lenth method for respective parts in injection point*

	housing	cover	splice tray
s_0	0.0075	0.015	0.00375
$2.5s_0$	0.01875	0.0375	0.009375
PSE	0.0075	0.01125	0.00375
ME	0.0282	0.0423	0.0141
SME	0.067575	0.101363	0.033788

Highest values of contrast estimates for housing are 0.025 for Injection time and Holding pressure time, for cover this is Temperature of molded plastic with 0.04 value of contrast estimate. For splice tray highest contrast, estimates are 0.0125 for Injection time and Temperature of molded plastic.
Neither of the values of contrasts estimates regarding examined parameters does not exceed either value of *SME* or *ME*. Therefore, conclusion could be drawn that neither parameter has significant influence in injection point, for all parts of wall cassette for optical fibers splitter.

V.2 Analysis by Lenth method for point furtherest from injection point

Results obtained for points furtherest from injection point for respective parts of wall cassette for optical fibers splitter are shown at Table 4.

Table 4. *Results for Lenth method for respective parts in furtherest points*

	housing	cover	splice tray
s_0	0.0675	0.0675	0.01875
$2.5s_0$	0.16875	0.16875	0.046875
PSE	0.0675	0.0675	0.01125
ME	0.2538	0.2538	0.0423
SME	0.608175	0.608175	0.101363

In furtherest point from injection point, highest values of contrast estimates for housing is 0.1625 for Injection time, for cover this is Holding pressure with 0.15 value of contrast estimate. For splice tray, highest contrast estimates are 0.055 for Injection time and 0.0575 for Holding pressure.

Neither of the values of contrasts estimates regarding examined parameters for housing and cover does not exceed either value of *ME* or *SME*. In the case of splice tray, Injection Time and Holding pressure are higher of value of *ME*, which mean that they are possibly influential parameters with statistically significant influence, but not with high statistically significant influence.

VI CONCLUSIONS

Based of analysis of results of simulation for plastic injection molding for three parts of wall cassette for optical fibers splitter following conclusions are:

1. It is confirmed that Taguchi's analysis (with and without pooling error) is unreliable for unreplicated experiments (Veljković, Radojević 2002).
2. Alternative analysis by Lenth method for unreplicated analysis leads to results that are significantly different either from results obtained by Taguchi's analysis or by real experimentation.
3. Results obtained by Lenth method indicate that simulation is inadequate technique to identify parameters that influence geometric deformations in plastic injection molding that is conducted in real production environment.
4. For identification of parameters influencing geometric deformation in production real experimentation should be used.

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CRANE CABINS WITH INTEGRATED VISUAL SYSTEMS FOR THE DETECTION AND INTERPRETATION OF ENVIRONMENT - ECONOMIC APPRAISAL

Dondur Nikola[1], Spasojevic Brkic Vesna[1], Brkic Aleksandar[1]
[1]Faculty of Mechanical Engineering, University of Belgrade, Serbia

Abstract. This paper analyses the economic feasibility of production and use of the new generation crane cabins of considerably lighter weight and stiff structure whose interior space necessary for the operator will be developed by using the methods of physical, cognitive and organizational ergonomics with the solved problem of visibility and which will allow higher productivity due to reduction of physical and psychological stress of the operator, as well as greater safety and security due to the integrated visual system. It is proved that the total economic benefit of the exploitation of the cabin in the overall exploitation period is significantly higher than the purchase price of the cabin, as well as that the internal rate of return is above the relevant average weighted interest rate and the payback period is less than three years. The analysed project of production and use of crane cabins with integrated visual systems for the detection and interpretation of environment is the project with low economic risk.

Key words: Economic feasibility, crane cabin..

1. INTRODUCTION

As a result of the complicated and constantly changing nature of industrial and construction work, there are very high injury and fatality rates, where cranes contribute to as many as one-third of all fatalities and injuries resulting in permanent disability [1]. The Crane and Hoist Safety report - OSHA reported a death rate of 1.4 deaths per 1000 operators [4]. Human error is the cause of almost 60% of lifting operation related accidents [1]. It is not surprising since crane operators still work in ergonomically unadjusted surrounding with very high visual tension in stressful working conditions due to both physical stress (shocks, vibrations and accelerations), and psychological stress (the sway of the load, extremely low visibility of cranes, etc.). Additionally, the ever growing competitiveness in the international and/or national market makes further improvement in the management, effectiveness and efficiency of crane operations and crane systems absolutely essential. According to previous research results [1],[4].[6] a new solution for crane cabins is needed to solve the aforementioned problems is needed. The goal is to develop crane cabin as ergonomically adjusted, light weight and integrated visual systems for the detection and interpretation of environment.

2. TECHNICAL DESCRIPTION AND FEASIBILITY

We propose the following: 1) To develop smaller and lighter ergonomically adjusted crane cabins with appropriate safety features using physical, cognitive and organizational ergonomics and modelling, and static and dynamic calculations using the finite element method; 2) To develop well designed integrated visual systems for the detection and interpretation of environment which will solve the operator's visibility problems; 3) To develop a simulation crane cabin, based on Virtual Reality technology, to replicate a real crane cabin together with the instrumentation and control of crane operations for the purposes of training and enhancing the cognitive abilities necessary for the effective and efficient use of integrated vision systems, and 4) To develop a prototype remote control for cranes which will include a remote control console and associated tracking (sensory) and management information systems. The main innovative idea behind this project consists of synergetic contributions from the following entities as the main fields of development: a) The development of a model with the minimal dimensions of the cabin where the operator will be accommodated in an ergonomically adjusted way based on an anthropometric study; b) The development of a model for the cabin interior including well-designed controls and the control station layout according to the principles of ergonomics and biomechanics which will ensure good safety features, c) The further optimization of the cabin by designing a light weight cab supporting structure with the application of the finite element method (FEM) for the analysis of load distribution, membrane and bending stresses, strain energy and the distribution of kinetic and potential energy to groups of elements of cab structure; d) The development of integrated visual systems for the detection and interpretation of environment which will solve visibility problems; e) A Virtual Reality based simulation cabin, and f) A crane remote control prototype setup. The benefits of this project lie in offering solutions to the following problems: (i) lower productivity due to human-machine interface problems; (ii) large financial and other losses resulting from the direct and indirect costs of the accidents caused;(iii) damage to the materials as well as to the material handling equipment; (iv) the unnecessary cost of frequent repairs and consequent loss of production; (v) disturbance in material handling schedules and (vi) an increased work-load on the other equipment and their consequent quicker downtime and break down.

3. ECONOMIC APPRAISAL METHODOLOGY

According to the Global Cranes, Lifting and Handling Equipment – Market Opportunities and Business Environment, Analyses and Forecasts to 2015 document produced by World Market Intelligence during the period 2006-2010, the consumption value of the global crane, lifting and handling equipment market grew at a CAGR of 2.76%. After witnessing a year of production and consumption decline due to low demand, the market recovered in 2010 to record production growth of 5.9% and consumption growth of 4.7%. Whilst South America experienced the fastest growth in consumption value during the review period, Asia-Pacific and Europe made the highest contributions to market consumption value in 2010. In terms of construction equipment from emerging nations to support infrastructural and mining investments, global cranes, lifting and handling equipment consumption is expected to record a CAGR of 10.75% in the forecast period - 2015. The European market has experienced a constant and the largest growth, amounting to 46% in 2000, in contrast to 15% in America and 11% in the rest of the world. A European crane cabins market is envisaged in this project as this is the area with the lowest transportation costs, thus the highest market growth is expected in this region.

For the assessment of economic feasibility of development, production and use of crane cabins, in practice the most commonly used approach is cost-benefit (CB) framework. Economic feasibility assessment through the cost-benefit framework can generally be used in the two assumed scenarios:

- development, production and sale of a new generation of crane cabins (producer point of view)
- use /purchase of the above type of crane cabins by the crane owners /lessors .

Economic and financial feasibility in the first assumed scenario foresees defining the standard parameters of the assessment from the aspect of a cabin producer (owner of the crane cabin factory, shareholders, potential creditors) and the overall economy [3]. This approach requires developing complete tables of financial and economic flows, necessary for the calculation of the selection criteria (FNPV, FIRR, ENPV, EIRR, pay-back period, BCR).

The second approach refers to an assessment of economic feasibility of investing into acquisition of a new generation of crane cabins and/or comparison of such investments (initial investment costs) and discounted additional effects (savings) in the crane exploitation over the entire (remaining) lifetime. Thus developed net flow serves as a basis for developing the quantitative parameters for the justification of investment and/or purchase of the new generation crane cabins from the aspect of the crane owner or user and from the aspect of the entire economy (NPV, IRR, BCR, pay-back period). For creating an economic net flow related to a new crane cabin, it is necessary to identify and quantify relevant costs and effects. [7].

Costs

In the standard terminology that refers to project analysis, acquisition (purchase price) of the new generation of crane cabin can be seen as an initial investment cost. In the competitive circumstances, purchase price is nearly equal to the marginal production cost, increased by transport, insurance and trade margin. The cost of manufacturing a cabin should include materials, labour and energy costs, as well as a portion of dependent fixed costs. In addition to the costs included in the purchase price (I_0), it is necessary to assemble and test the crane cabin, ensure training for a crane operator, but also disassemble the existing cabin if it is already existed on the crane (I_1). Initial investment costs, required for the economic assessment of the project of using the new generation crane cabins, would represent a sum of the above-mentioned costs ($I_0 + I_1$).

Benefits

The exploitation of the new generation of crane cabins has direct and indirect positive effects from the aspect of the owner or user of the crane, but also positive effects on the overall economy. Direct positive effects from the point of view of the crane owner are primarily appeared through increase in productivity of the crane use. The cabin with integrated visual systems for the detection and interpretation of environment allows the crane operator to perform work operations faster. Savings of time at one duty allows the crane owner to engage the crane at another job without any additional exploitation costs. Reduction of the annual crane exploitation costs due to the assembly of the new crane cabin, which allows saving of time in performing work operations (Δt) represents benefit from the aspect of the crane owner. As the exploitation costs depend on the time of the crane operation (t), for the calculation purposes the positive effect for the crane owner represents a product of the sum of all exploitation costs and weight of the average time saving in performing operations ($\sum CE_t \cdot \rho_t$).

The annual crane exploitation costs can be decomposed to the costs of depreciation (capital recovery), costs of maintenance and repairs, as well as insurance and registration costs. Formally, these costs can be presented as follows:

$$\sum CE_t = PC * PMT_n^i + MC_t + RC_t + IC_t \qquad (1)$$

where PC represents a purchase value of the crane, PMT_n^i stands for capital recovery factor for the specific exploitation lifespan of the crane (n) and interest rate (i). Depreciation of the crane is observed as depreciation of debt and/or future value of equal annual repayments of the amount invested in the purchase of the crane.

Weight of the average time saving is determined as a relative ratio of the sum of differences in time of the operations performed by the crane without the new generation cabin and the time of operations with the new cabin and the total time of operations without the cabin with the integrated visual crane management system:

$$\rho_t = \frac{\sum_j^N (T_j^1 - T_j^2)}{\sum_j^N T_j^1} \qquad (2)$$

where ρ_t represents weight of the average reduction in time of operation of the crane with the new cabin, T_j^1 time of operation (j) without the cabin with the integrated visual system for detection and T_j^2 stands for time of operation (j) with the new generation crane cabin.

The following direct benefit of installing the new generation crane cabins is reduction in labour costs. If we assume that the number of workers and labour cost per hour remain the same, operation time reduction allows the worker to perform in such time reduction an additional work that is beneficial for the crane owner. Accordingly, time reduction of the operations (ρ_t) which the crane achieves due to the use of the new generation cabins represents a weight for calculation of the annual savings in labour costs (LSC_t) as a product of the number of workers, cost of labour per hour and number of working hours of the crane:

$$LSC_t = n * h_t * w_h * \rho_t \qquad (3)$$

where LSC_t represents savings of labour costs in a year (t), n stands for a number of crane operators, h_t number of effective working hours of the crane in a year (t), w_h average value of the working hour and ρ_t is a weight of average savings of time of the crane operation in a year (t).

By installing the new generation crane cabin, incidence of professional diseases and injuries of crane operators is reduced. This positive effect can be quantified through reduction of number of working hours which the crane operator spends on a sick leave, during which period a new worker must be hired. This saving can be quantified as a product of the number of workers, number of hours lost due to the crane operator's absence, labour cost per hour and average weight of time reduction of the crane operations:

$$LSDC_t = n * Dh_t * w_h * \rho_t \qquad (4)$$

where $LSDC_t$ represents annual savings in labour costs while the crane operator is on a sick leave, *n* a number of crane operators, Dh_t number of working hours lost due to sick leaves, w_t represents a cost of the working hour and ρ_t weight of average time saving of the crane operation in a year (t).

Thanks to a better visibility, the use of the new crane cabin reduces a number of breakdowns and slows down wear and tear of the crane mobile parts and/or reduces the costs of crane maintenance and repairs. This positive effect is determined as a product of the crane value and difference in the relative annual maintenance and repair costs:

$$MRSC_t = PC * \left[\frac{MRC_t^1}{PC} - \frac{MRC_t^2}{PC} \right] \quad (5)$$

where $MRSC_t$ represents savings on the annual costs for maintenance and repairs of the crane, PC is a purchase value of the crane, MRC_t^1 is the value of the annual costs for maintenance and repairs of the crane without crane cabin with visual system and MRC_t^2 is a value of the annual costs for maintenance and repairs of the crane with the new generation crane cabin.

Through a more efficient use of the crane, the new generation crane cabin is supposed to exend the assumed crane exploitation lifespan. Extension of the crane exploitation lifespan brings additional benefits through reduction of annual depreciation (recapitalisation) costs of the crane which is quantitatively determined as the difference between recapitalised annual write-offs and the lifetime of the crane (n) without the new generation crane cabin and recapitalised annual write-offs with the extended crane exploitation lifespan (n+m):

$$ELSC_t = PC * PMT_n^i - PC * PMT_{n+m}^i \quad (7)$$

where $ELSC_t$ represents annual savings on depreciation write-offs, PC purchase value of the crane, PMT_n^i capital recovery factor with the assumed exploitation lifespan without the new crane cabin *(n)* with appropriate interest rate *(i)*, whereas PMT_{n+m}^i represents a capital recovery factor with the extended exploitation lifespan *(n+m)* due to the use of the new crane cabin with appropriate interest rate *(i)* .

Economic appraisal criteria

For the assessment of economic feasibility of the crane cabin with integrated visual systems for the detection and interpretation of environment, the following standard cost benefit criteria are defined: net present value, internal rate of return, cost - benefit ratio and payback period on investment. Net present value (NPV) of an investment in the new generation crane cabin represents the difference between the sum of initial investment costs and the sum of discounted savings over the entire lifetime of the crane, whereby such savings are resulting from the use of the new crane cabin:

$$NPV = -(I_0 + I_1) + \sum_t^{n+m} \frac{(CE_t + LSC_t + LSDC_t + MRSC_t + ELSC_t)}{(1+i)^t} \quad (8)$$

where NPV represents net present value of savings on costs of the crane exploitation achieved by the crane cabin with the integrated visual system over the crane lifetime $(n+m)$ and *(i)* represents relevant discount rate. Based on this criterion, use of the new crane cabin is acceptable if the net present value is positive.

Internal rate of return (IRR) of the investment in acquisition of the new crane cabin is the value of discount rate which equalize the difference of the initial purchase costs of the new crane cabin and the present value of the total savings in operating costs with zero. For a project to be economically justified, this rate should be above the average weighted interest rate. [2],[5].

Cost benefit ratio is a quotient of the total net savings of the crane exploitation and the purchase costs, assembly costs and training costs for the work in that cabin. According to this criterion, purchase of the crane cabin will be economically acceptable if this ratio is greater than one.

4. ECONOMIC APPRAISAL RESULTS

For the assessment of the economic feasibility of the new generation crane cabin purchase, we used the data referring to the bridge crane cabin. Table 1. provides the estimated data and, by using equtions from (1) to (7), calculated values referring to the costs of purchase and savings during the exploitation of the new crane cabin.

Table 1. Economic cost - benefit appraisal inputs

Variables	**Values (Euros, %,)**
Costs	
• Cabin manufacturing costs (costs of materials, labour, energy - I_0)	20000 Eur
• Costs of assembly, testing, crane operator training and disassembly of the existing cabin if it is already fitted on the crane (I_1)	1500 Eur
Benefits (Savings)	
• Savings in time of operations /cycle reduction / (ρ_t)	10 % (8-12%)
• Purchase price of the crane	268000 Eur (20000-500000)
• Annual savings on labour costs (LSC_t) .	1440 Eur
• Annual savings due to reduced incidence of professional diseases and injuries of crane operators (LSC_t)	400 Eur
• Reduction of the crane maintenance and repair costs $(LSDC_t)$	4025 Eur
• Savings due to the extended exploitation lifespan (from 15 to 18 years) $(ELSC_t)$	1828 Eur

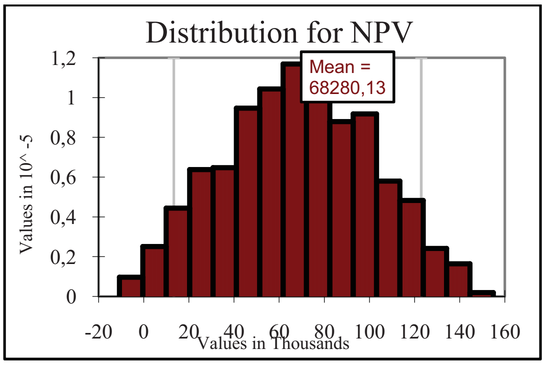
By using the expression (8), we estimated empirically net present value of the net effect of the purchase and use of the new generation crane cabin. Net present value as a synthetic measure of absolute economic viability is in the first step calculated on the basis of the best estimates values of variables. Those values are given in Table 1. Net present value is, at the discount rate of 10%, Eur 68350. The total economic benefit of the exploitation of the cabin in the overall exploitation period is higher than the purchase price of the cabin and according to this criterion, the project of installing the new generation cabin is economically viable. Internal rate of return as a relative measure of economic acceptability of the purchase and exploitation of the new crane cabin is significantly above the relevant average weighted interest rate and is equal to 34.30%, which implies high economic profitability of the investment. Annual savings which are made in the operation of the crane managed from the new generation cabin are Eur 13770 which shows that the payback period is slightly less than three years. As these are estimated input values applied in the calculation of the relevant criteria for the assessment of acceptability, we used sensitivity and risk analysis to test the robustness of the obtained results.

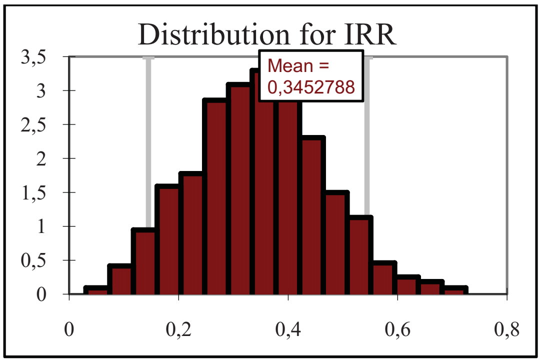
Table 2. Sensitivity analysis

	NPV		IRR(%)	
Change (%)	+10	-10	+10	-10
Purchase value of the crane	77415	59273	37.31	31.26
Cabin price	64708	71980	31.11	38.17
Dh (savings in working hours)	68648	68040	34.4	34.19

Sensitivity analysis shows relative stability of results as the change of the selected critical variables in the range (±10%) does not significantly influence the value of the criteria for the assessment of the economic viability of purchase and use of the new generation crane cabin. In risk analysis, we modelled five critical uncertain variables (cycle reduction, purchase price of the crane, cabin price, price of the working hour of a crane operator, number of working hours lost due to sick leaves and crane maintenance costs) by triangle probability distribution. Figure 1. gives an overview of simulation results (Hypercube sampling).

Fig. 1. Distribution of the results





Net present value varies in the range from -16123,6 Eur to 162144 Eur and the internal rate of return ranges from 3% to 72.4%. Probabilities for negative net present values and for internal rates of return below average weighted reference interest rate (10%) are very low. The results of the analysis show that the project of purchase and use of the crane cabin with integrated visual systems for the detection and interpretation of environment is the project with low economic risk.

5. CONCLUSION

Techno-economic analysis of the project shows that the total economic benefit in the overall exploitation period is significantly higher than the purchase price of the cabin and according to this criterion the project of installing the new generation cabin is economically viable. Internal rate of return is above the average weighted interest rate, which implies high economic profitability of the investment. Annual savings made in the operation of the crane which is managed from the new generation cabin have the payback period of less than 3 years. The analyzed project of production and use of crane cabins with integrated visual systems for the detection and interpretation of environment is the project with low economic risk.

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ALLOCATIVE EFFICIENCY AND QM FACTORS COVARIATE IN SERBIAN INDUSTRY

Spasojevic Brkic V., Pokrajac S., Dondur N., Josipovic S.
University of Belgrade
Faculty of Mechanical Engineering
Kraljice Marije 16
11000 Belgrade
Serbia
e-mail: vspasojevic@mas.bg.ac.rs

Abstract.
Trends of allocative efficiency and covariate of firm size and efficiency of quality management(QM) factors in the Serbian industry were tested on the unbalanced panel sample of 48 industrial firms from 12 industrial sectors in the period 2004-2009. The obtained results show that 10 of 12 sectors have a positive covariate of participation in the output market and multi-factor productivity. Covariates of firm size and efficiency of all QM factors record the same direction in the chemicals sector (positive) and motor vehicles (negative), which means that in those two sectors larger companies had above-average and/or below-average efficient TQM. The same (positive) trend of allocative efficiency and covariates of all QM factors was recorded in manufacture of chemical industry.

1. INTRODUCTION

The more recent literature brings a limited number of studies which analyse the relationship between firm performances and quality management. [1], [3], [11]. Results are mixed and often do not support the hypothesis on positive correlation between productivity and efficiency of some critical QM factors [9]. Reallocation of resources significantly influences the level of aggregate productivity of industry from less productive to more productive firms.

In this type of studies, aggregate industry productivity is determined as weighted average of firm level total (multi-factor) productivity with market share in industry output as a weight. This method of defining productivity allows decomposition of industry productivity on average productivity and covariate part as sum of cross product of firm size and firm productivity. Such decomposition gives insight into correlation of firm size (market share) and firm level productivity. If the sum of cross product positive industry productivity is improved, the sector resources are allocated towards more productive firms and industry is allocative efficient.

Concurrently, deregulation and market liberalisation may have positive impact on QM practice as companies are trying, in the conditions of increased competition, to have more effective QM. Therefore, thanks to reallocation of resources, more productive firms can be expected to grow bigger and at the same time have more effective QM. Average QM efficiency may be, similarly to productivity, decomposed to average efficiency of critical QM factors and a sum of cross product of firm size and firm QM effectiveness (QM factors covariate). If a covariate is positive, QM effectiveness of the industry is improved. The aim of this research is to examine the trend of allocative efficiency and QM factors covariate.

2. METHODOLOGY

Allocative efficiency

Market reallocation of resources represents one of key channels for identifying the change in productivity at the level of an industry. [4],[5],[7]. Aggregate multi-factor productivity in industry is average weighted productivity of firms, whereby a weight is share of a firm in the output market:

$$MFP_{t,j} = \sum_{i}^{N} \theta_{i,j,t} * MFP_{i,j,t} \quad (1)$$

where $MFP_{t,j}$ represents aggregate productivity in industry (j) in time (t), $(\theta_{i,j,t})$ is market share of plant (i), in industry (j) in time (t), $MFP_{i,j,t}$ firm level productivity and N represents a number of firms in the sector (j).

Industry productivity may vary through changes in allocation of productivity and market share reallocation between incumbent (surviving) firms, but also through contributions entering and exiting firms [8]. Contribution of resource reallocation to the change in aggregate productivity can be captured through decomposition of productivity of industry to the product of the deviation of market share of plant from the average market share and firm productivity from average unweighted productivity at the level of the industry:

$$MFP_{t,j} = \sum_{i}^{N} (\bar{\theta}_{j,t} + \Delta\theta_{i,j,t})(\overline{MFP}_{j,t} + \Delta MFP_{i,j.t}) \quad (2)$$

or

$$MFP_{t,j} = N_{t,j}\, \bar{\theta}_{j,t}\, \overline{MFP}_{j,t} + \sum_{i}^{N} \Delta\theta_{i,j,t} \Delta MFP_{i,j,t} = \overline{MFP}_{j,t} + \sum_{i}^{N} \Delta\theta_{i,j.t} \Delta MFP_{i,j,t} \quad (3)$$

where $\overline{MFP}_{j,t}$ represents average unweighted productivity, $\bar{\theta}_{j,t}$ average unweighted sales participation, $\Delta\theta_{i,j,t}$ difference between participation in company sales $\theta_{i,j,t}$ and average sales participation $\bar{\theta}_{j,t}$ and $\Delta MFP_{i,j.t}$ difference between company productivity $MFP_{i,j,t}$ and average productivity at the level of the industry $\overline{MFP}_{j,t}$. Sum of cross product $\sum_{i}^{N} \Delta\theta_{i,j.t} \Delta MFP_{i,j,t}$ represents productivity covariate (covprod) and contains contribution of resource reallocation to the change in aggregate productivity.

If it is positive, industry has a positive allocative efficiency where resources in the industry follow more productive incumbent (surviving) firms.

QM factors covariate

The covariate of efficiency of QM and firm size comes down to a question whether firms with above-average scale of dimensions of the specific critical QM factor have bigger output market participation.

QM efficiency is measured as an average value of the dimension scale for specific critical QM factor. Efficiency of the specific QM factor at the industry level is a weighted average of firm-level efficiency (scale of QM factor at firm level) with market share of industry as weights:

$$QM^{n}_{t,j} = \sum_{i}^{N} \theta_{i,j,t} * QM^{n}_{i,j,t} \quad (4)$$

where $QM^{n}_{t,j}$ represents a weighted scale of the factor (n), sector (j) in time (t), $(\theta_{i,j,t})$ represents a market share of the firm (i), in the market of the sector (j) and time (t), $QM^{n}_{i,j,t}$ scale of the factor (n) of the firm (i) sector (j) in time (t) and N represents a number of firms in the sector (j). Weighted efficiency of the specific QM factor in the sector (j) can be decomposed to average unweighted efficiency of factor (n) and the sum of cross product deviation of firm size (i) and efficiency (scale) of the factor (n) in a firm (i):

$$QM^n_{j,t} = \overline{QM^n_{j,t}} + \sum_{i}^{N} (\theta_{i,j,t} - \bar{\theta}_{j,t}) * (QM^n_{i,j,t} - \overline{QM^n_{j,t}}) \qquad (5)$$

where $\overline{QM^n_{j,t}}$ represents average unweighted efficiency of factor (n), sector (j) in time (t), whereas $\bar{\theta}_{j,t}$ represents average unweighted market share as a measure of average size of a company in the sector (j) in time (t).

If covariate of QM factor (QM cov) and firm size is positive, efficiency of QM factor at the industry level increases. Companies with higher market share (larger companies) had in the observed time a more efficient QM factor.

Analysis procedure and results

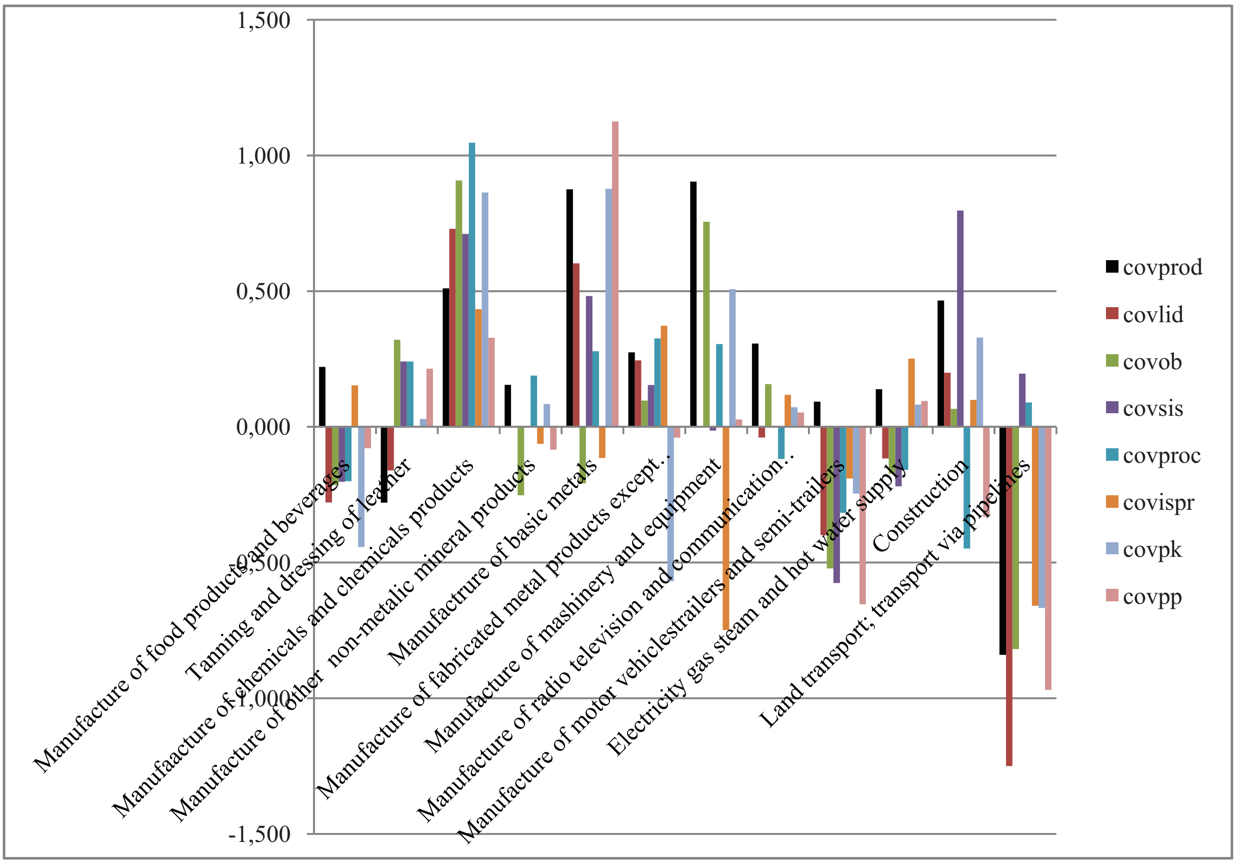
The sample is a stratified random sample drawn from the population of Serbian industrial firms certified according to ISO 9000. The information referring to the determination of MFP and efficiency of QM factor cover the period 2004-2009. The information on company productivity comes from the official financial reports and information about QM practice comes from a questionnaire. Quality management elements or critical QM factors, as the components that will lead to the successful application of the QM concept, were considered for the first time by [2] and the number of available works reported to date is not negligible. Following an analysis of frequency incidence in available literature the QM critical factors shown in Table 1. can be segregated. The research instrument proposed initially contains 7 factors with 31 dimensions (Table 1.), which is substantially the lowest of all offered to date. Using recommendations by [13] to recode 25 – 50% of the questions (posed in reverse order relative to other questions), 45.88% of the questions were recorded. All questions had a five-level Likert scale. The majority of questions in the research instrument were taken from or designed using previous research (which is of critical importance in research of this kind as stated in [12]).

CRITICAL QM FACTORS	DIMENSIONS FOR CRITICAL QM FACTORS
Leadership and management support for quality program (LID)	L2: Care of Department manager for quality L3: Efforts of company management to improve quality L4: Goal setting and quality policy L5: Establishing regulation for quality
Training and involvement of employees (OB)	OB2: Employees training as priority of the company OB3: Existence of financial resources for employees training OB4: Employees training to apply methods and techniques (tools) for quality improvement
Systemic approach and documentary evidence for quality system (SIST)	SIST1: Availability of data on quality to each employee SIST2: Analysis of collected data on quality in order to improve it SIST3: Existence of Department of quality SIST4: Possession of documents for quality system
Process approach (PROC)	PROC1: Differentiation and description of each process in the company PROC2: Continuous monitoring of key processes in the company and their improvement PROC3: Determination of quality measure for each process in the company PROC4: Participation of machine operator in maintenance
Beneficial interaction with suppliers (ISP)	ISP1: Relying upon a small number of reliable suppliers ISP2: Selection of certified suppliers ISP3: Participation of supplier in program development ISP4: Participation in employees training in quality field at supplier's firm

Permanent quality improvement (PK)	PK1: Permanent tendency to eliminate internal process leading to waste of time or money PK3: Application of advanced IT to better analyze data and determining priorities to improve quality PK4: Revision of documents for quality system if necessary PK5: Application of methods and techniques to improve quality
Product design according to user demands (PP)	PP1: Coordination of employees from different organizational units in product development process PP2: New product quality as priority in its design and manufacture PP3: Analysis of possibility for manufacture and cooperation in product development

Table 1. The dimensions of critical QM factors after factor and reliability analysis [9]

The information from financial statements is used for the determination of MFP at the industry level through neoclassical production function, whereby LP algorithm is applied in order to avoid simultaneity. [10]. The data due to QM practice were exposed to factorial analysis to ensure that they constituted reliable indicators of QM constructs. [9]. Based on the determined MFP and selected reliable QM factors by applying algorithms (2),(3),(4) and (5), allocative efficiency and QM covariate of all 12 industrial sectors were determined.



The results show that 10 of 12 sectors have positive covariate of output market participation and multi-factor productivity and in those sectors market allocates most resources towards companies with factor productivity above average productivity of the sector. Allocative efficiency in these sectors is increasing in the observed period. Covariates of firm size and efficiency of all QM factors show the same trend in the sector of chemical industry (positive) and motor vehicles (negative), which means that in these two sectors larger companies had QM efficiency above average. In other sectors, the trends of covariate of firm size and scale of QM factor are different. In food-manufacturing industry, an increase of quality with negative covariate is visible, which means that larger companies had efficiency of quality increase below sector average. Training of employees has positive covariate in leather sector, while it is negative in non-metal industry. Metal sector shows a positive covariate of product design, while the sector of machine manufacturing has positive covariate of training and negative covariate of quality improvement. In the production of TV sets, values of covariate are very low. In the electrical sector, there is a positive covariate of suppliers, whereas in the construction sector a positive covariate of systemic approach should be noted. In the transport sector, there is a very negative covariate of leadership.

If a covariate of firm size and efficiency of all analysed QM factors and a covariate of firm size and MFP are observed only in the sector of manufacture of chemicals and chemical products, the same trends are recorded. It is only in that sector that larger firms record a higher factor productivity and more efficient TQM as well.

3. CONCLUSIONS

The chemical industry's predominant use of batch manufacturing processes is in sharp contrast to the use of assembly line production in automotive or computer industries, so it can be expected that these differences influence the relationship between QM implementation [6]. According to the same authors the strongest contributor to variation in total effects of QM across groups was industry type, followed by size and then QM duration. Typical risks associated with the work in chemical industry require high level of organisation, documented, transparent and effective management systems and therefore, greater attention is given to the standardisation of various management systems. On the other hand, motor vehicles industry in Serbia is in most cases only learning about ISO/TS 16949: 2009, whereby larger manufacturers are for many years in the phase of restructuring and production programme adjustment.

Therefore, our result is expected. Work thus offers managers the possibility to allocate available resources subject to the type of industry and size of the company. An important result of this research is also a fact that majority of the sectors have positive covariate of output market participation and multi-factor productivity so that in those sectors the market directs most of the resources towards companies that have factor productivity above average productivity of the relevant industrial sector.

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MULTICRITERIA ANALYSIS OF CHOICE OF AUTOMOBILE BY TOPSIS METHOD

M.Sc. Željko Stojanović[1], Ph.D. Milivoj Klarin[2], M.Sc. Sanja Stanisavljev[2]. Ph.D.Zvonko Sajfert[2]
[1]Partizanska 34/e, 23208 Elemir
[2]Technical faculty »Mihajlo Pupin« in Zrenjanin

Abstract. *The paper discussed hipothetical case of problem choosing a new automobile. In multicriteria deciding about the selection of a new automobile, used multicriteria analysis method, ie. TOPSIS method, where was realization rating the obtained results and on the basic of that was made the decision about choice of automobile. Accent was placed on basic theoretical assumptions of decisions problems, with special emphasis on multicriteria decision making. Having in mind that these problems here not sufficiently represented in practice, the main aim of this paper was to closer clarify the role and importance of multicriteria analysis method, through ilustration of the application of TOPSIS method on hipothetical example choice of automobile, as well as to indicate on the other methods of multicriteria analysis which can be applied in a practical environment for the consider and eliminating the dilemma and indecision of the decision maker or to purchase most costeffective products.*

Key Words: *decision making, TOPSIS, automobile*

1. INTRODUCTION

Decision making is a part of everyday life, and is old as a mankind. However, not until in recent decades has developed separate scientific discipline which deals problems of decision making. That is the theory of decision making. Decision theory as science exist relatively short, bat during that time is developed a large number of methods and models which help in decision making. Decision making is a process which is constantly occurs everywhere and by all. Is part of the everyday life of people: making decisions about today's lunch meny, the purchase of toys, about place of summer vacation, the choice of kindergarten, about purchasing house and automobile, choice of school and college. It brings also decision of the entry in marriage. In all the approaches which are present in modern management theory, the deciding means rational choice of one, from the set of available alternatives. When making decisions oftentimes sets a question of the best choice. Before the multicriteria analysis was developed, problems of selection and ranking of various decisions were usually reduced to a single criterion optimization tasks. Descriptive definition of the criterion as follows: „The criterion is a measure by which some decisions are evaluates with the same point of view". When it comes to selection of alternatives based on a single criterion, then it easy to find the best alternative by choose alternative which gives extremum optimality criterion. However, in practice most often encountered tasks where alternatives should be evaluated according to several criterion, which makes the problem much more complex. Most practical problems require that the decision implement based on more criterion, which causes the developed a numerous methods of multicriteria decision making. For all of them is characterized that containing specific subjectivity. This subjectivity are particulary expressed in the process of assigning weight coeficient for the criteria identified in a given model. The presence of different criterion, some of which should be maximized and some minimized, means that the decisions making in conflicting conditions and that they must be applied instruments which are more flexible than the stricting mathematical techniques related to the clean optimization. For such tasks have been developed a special techniques of analysis and solving between which the most significiant: PROMETHEE (Brans et al, 1986), ELECTRE (Roy, 1968), AHP (Saaty, 1980), TOPSIS (Hwang and Yoon, 1981) and CP (Zeleny, 1982). All belong to the soft methods of optimization because are used heuristic parameters, measure distances and scales of values. Some have multiple versions (eg. ELECTRE I, II, III and IV or PROMETHEE 1 and 2) and in practice often same time using several methods to ensure control consistency decision.

The aim of this paper is to contribute to a better understanding of the role and importance of methods of multicriteria analysis through illustration application TOPSIS methods on hipothetical case of choice of automobile.

2. WHICH ARE METHODOLOGICAL FOUNDATION OF TOPSIS METHOD?

The Multiple Attribute Decision Making (MADM) techniques which are used in diverse fields such as engineering, economics, management science, transportation planning and etc, deal with candidate priority alternatives with respect to various attributes. [7]

Multi-criteria decision making has been one of the fastest growing areas during the last decades depending on the changings in the business sector. Decision maker(s) need a decision aid to decide between the alternatives and mainly excel less preferrable alternatives fast. With the help of computers the decision making methods have found great acceptance in all areas of the decision making processes. Since multicriteria decision making (MCDM) has found acceptance in areas of operation research and management science, the discipline has created several methodologies.

TOPSIS (**T**echnique for **O**rder **P**reference by **S**imilarity to **I**deal **S**olution) method is a popular approach to MADM and has been widely used in the literature. TOPSIS was first developed by Hwang and Yoon for solving a MADM problem.

The principle behind TOPSIS is simple: the chosen alternative should be as close to the ideal solution as possible and as far from the negativeideal solution as possible. The ideal solution is formed as a composite of the best performance values exhibited (in the decision matrix) by any alternative for each attribute. The negative-ideal solution is the composite of the worst performance values. Proximity to each of these performance poles is measured in the Euclidean sense (e.g., square root of the sum of the squared distances along each axis in the "attribute space"), with optional weighting of each attribute. [9]

In cases where real problems are to be solved, the managers often have to make a decision by choosing one out of many alternative solutions based on several decisionmaking criteria of opposite or partially opposite characteristics. TOPSYS method determines the similarity to ideal solution. [10] Therefore, it introduces the criteria space in which every alternative A_i is represented by a point in the n-dimensional criteria space and coordinates of those points are attribute values of decision-making matrix V. Next step is determining of ideal and anti-ideal points and finding the alternative with the closest Euclidean distance from the ideal point, but at the same time, the farthest Euclidean distance from the antiideal point.

Picture 1 represents the example of twodimensional criteria space in which every alternative A_i possesses the coordinates which are equal to normalized values of the assigned attributes multiplied by normalized weight coefficients, coordinates of ideal A^* and anti-ideal point A^-, as well as the Euclidean alternative distances from the ideal and anti-ideal point.

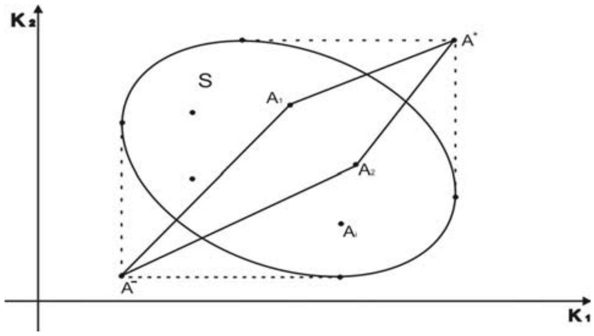

Figure 1-Euclidean alternative distances from the ideal and anti-ideal point [10]

It is also assumed that attributes expressed by linguistic terms have been quantified, as well as that benefits of each individual criterion have been determined and that relative criteria weights w_j have also been defined.

3. DEFINING THE CRITERIA FOR CHOICE OF AUTOMOBILE

The process of design making represent choice of one from set of available alternatives which to the fullest possible extent fulfills the given criteria. Multicriteria decision making process can be represented by the following stages:

1. Identification and formulation of the problem.
2. Forming model of decision making.
3. Use of method of multicriteria decision making.
4. The choice of the most acceptable alternative.

In the first two phases of the process defined the objectives which want to realize by choices, the attributes (criteria) based on which will be observe evaluating of alternatives, determine the weight (importance) of attributes and a set of available alternatives from which the choose the best. After that, the decision maker observe the evaluation of available alternatives in regard selected attributes. In order to perform the choice of automobile, it is necessary to define criteria. In this case, the choice was performed based on five atributes (criteria):

A_1-Car price (€) (the minimum request).
A_2-The fuel consumption (l) (the minimum request).
A_3-Comfort (qualitative evaluation).
A_4-Reliabiliti (qualitative evaluation).
A_5-The advantages of service and maintenance (qualitative evaluation).

When choosing a car, there may be some other criteria, such as: maximum speed, handling-maneuverability, possibility of load, visibility the road, additional equipment, length of the warranty period, luggage capacity etc., but some are in this case the authors of this paper estimatet that interest to them previously specified criteria.

4. ILUSTRATIVE EXAMPLE

In order to choice the optimal automobile, the authors was performed the ranking on the basis of criteria specified in the third part of the paper. The data which are relating to the four alternatives are presented in the initial decision-making matrix. TOPSIS method was applied with the objective of choice most profitable investment in the new automobile. When buying a automobile, the decision maker (automobile bayer) chooses between four actions:

a_1-Opel Meriva 1,4 16 V Enjoy.
a_2-Hyundai i30 1,4 DOHC GLS Imagine.
a_3-Opel Astra GTC.
a_4-Peugeot 407 1,8 SR.

Ratings (quantitative and qualitative) of all actions to all the criteria are given in the initial matrix of decision-making:

O=

	A_1	A_2	A_3	A_4	A_5
a_1	15840	8	Good	Good	Average
a_2	14490	5,7	V. high	Average	Average
a_3	15999	4,8	V. high	High	Average
a_4	21890	8	Good	V. high	V. high

Initial decision matrix are ompleately quantify over linear scale which usually has a value of 0 to 10 where 0 is award to lowest level, and 10 to highest which can be realized. Quantified decision matrix has the folowing values:

O=

	$A_1\ [10^3]$	A_2	A_3	A_4	A_5
a_1	15,84	8	7	7	5
a_2	14,49	5,7	9	5	5
a_3	15,99	4,8	9	7	5
a_4	21,89	8	7	9	9

In the first step are performed determine the normalized decision matrix by which every element of the vector-column from the decision matrix divided with its norm. For the analyzed example, the normalized decision matrix has the following values:

N=

	A_1	A_2	A_3	A_4	A_5
a_1	0,5419	0,4094	0,4341	0,4901	0,4003
a_2	0,5809	0,5792	0,5581	0,3500	0,4003
a_3	0,5376	0,6456	0,5581	0,4901	0,4003
a_4	0,3669	0,4094	0,4901	0,6301	0,7205

Application of the second step of TOPSIS method determines weighted normalized decision matrix V. In this step, the authors are define the weight of all criteria as follows:

$$W=\begin{bmatrix} w_1=0,15 & 0 & 0 & 0 & 0 \\ 0 & w_2=0,2 & 0 & 0 & 0 \\ 0 & 0 & w_3=0,1 & 0 & 0 \\ 0 & 0 & 0 & w_4=0,35 & 0 \\ 0 & 0 & 0 & 0 & w_5=0,2 \end{bmatrix}$$

Per TOPSIS method, the action can be ranked in complete order according to size C_i^*. The first rank has action with the highest value C_i^* and so on. The result of ranking actions achieved by applying TOPSIS method are given in below. In given example, ratings of actions are as follows:

1. rang: akcija a_4.
2. rang: akcija a_3.
3. rang: akcija a_1.
4. rang: akcija a_2.

5. CONCLUDING REMARKS AND FINAL DECISION

As aid in the summary of the paper, multicriteria analysis methods are not enough represented in local practice, which influenced on the choice of topic of this paper.

If we bear in mind that in forming an initial matrix of decision making, proper positioning and using of realistic conditions, realistic actions and criteria and realistic evaluating, enables larger, more creatively and systematic inclusion of a decision maker in the process of making optimal decisions, obtain reliable results, facilitates work and saves time, then, according to the authors of this paper, the importance of discused topics not need additional argument.

TOPSIS method is one of the best known and most widely used methods in multicriteria decision making. The paper presents the basic theoretical postulates, and the application itself ilustrated on the hipothetical case of problems choice of automobile.

On the basis of set objective of work and defined the content of research as well as on the basis of the processed literature data, it can be concluded that the multicriteria analysis can be succesfully applied in solving the problem of choice automobile. This was indicated and an example which is solved by TOPSIS method. On this way achieves more objective perception the problem and its efficient resolving.

It should be emphasize that it is possible to change the criteria and their importance (weight) depending on specific conditions.

Based on the results of calculation, it can be seen that the action a4 (which has the highest relative closeness to ideal solution) avarded to first place (rank), the action a3, which the relative closeness of the ideal solution is slightly lower, the second place and so on.

On the basis of the final results and ranking of actions, can be concluded that the most favorable action is a4, apropos automobile brend Peugeot 407 1.8 SR.

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INFORMATION SYSTEM AND MACROORGANIZATIONAL STRUCTURINGAS A FOUNDATION AND MAIN CONTSRAINT FOR QMS

Jelena Lazić[1], Janko M. Cvijanović[1], Isidora Ljumović[1]
[1]Economics institute, Belgrade

Abstract: *This issue deals with contradictory impact of information's system and macroorganization structure on QMS. Macroorganizational structure (especially some of its elements, e.g. the time-span of discretion) is important frame for organization of business information system, and information system is supporting structure for QMS. In practice, because of strong and complex feedback between all three block, information system and macrostructure immerge also as an important constraint for QMS.*
Key words: *macrosturcturing, time-span of discretion, QMS*

INTRODUCTION

The most of the crucial development factors in developmentally successful enterprises are of organizational provenance. All growth and developmental activities of the enterprise are incorporated into the organizational environment and their commercial results depend in large measure on organizational support provided to developmental activities. Any discrepancy between the organizational structure and management and developmental activities may even prevent the realization of the best, innovative and developmental ideas. The growth and development of the enterprise rank among the very important preconditions for achieving its desirable future. At the same time, it is impossible to speak about the planned future of the enterprise outside its organizational context. Here we think especially of the organizational structure of the enterprise which, in essence, provides the frozen picture of all main flows within it. In this paper, we will analyze the possible influence (advantages and threats) of changes in some basic theoretical assumptions of organization (we will analyze only four paradigms of organization theory, whose validity has been disputed in some way) on the selection and implementation of technical and technological innovations or, in other words, on the development of the enterprise.

Business organization can be defined as the way of suitable differentiation and appropriate coordination of tasks. This is, in fact, a more precise definition of organizational structure, rather than of organization itself. An organization most often appears simultaneously as purpose, means, activity, and result, thus blurring the Hoffman boundaries between individual organizational categories, especially those between the structure and functioning of an organization. Second only to labor and capital, organization is probably the third most influential production factor and an influential element, interacting with other situational factors (e.g. age, size, technology) and structural dimensions.

What is certainly changing in the nature of hierarchy is the need for its selective application at specified levels and within specified business functions. Although the line dimension is the essential source of and support to any hierarchy (including a group – team one), in specified functions, especially in development, authority is based only in part on the line dimension (so-called position authority). The other part must be deserved (knowledge and performance authority), so that the group or, better said, the development team can produce the best possible results. Consequently, innovations and development do not dispute hierarchy as a natural phenomenon, but only call for its more subtle and more efficient application.

Enterprises have officially become companies (corporations, etc.) and companies do not belong to any individual; only an individual can belong to a company. Consequently, the stakeholder concept has imposed numerous legal and legitimate restrictions, which are slowly replacing the old ownership concept with the company one. The change of this paradigm change crucial dimensions in QMS and is useful for innovations and development, since those who make decisions on carrying out development projects (which are risky, as a rule) are not additionally restricted by ownership, while decisions are made mostly on the basis of analyses and conclusions made by internal or external expert analysts.

THE TIME-SPAN OF DISCRETION AND THE SPAN OF MANAGEMENT AS CONSTRAINTS OF QMS

Every job in an enterprise has (see /1/) two dimensions: (1) the prescribed job content (with the detailed instructions, standards relating to inputs, outputs, processes, required knowledge, etc. and with the cost and expenditure formatives) and (2) discretionary job content (within which an employee or executive reacts freely to the current situation and makes an appropriate decision autonomously). The prescribed job content relieves the employee from his responsibility for all unforeseen events and situations, while the discretionary job content anticipates personal relationship and responsibility for actions taken, which should be based on the employee's greater knowledge and greater interest in his job and job performance.

The time-span of discretion is the period within which the subordinate makes a decision freely (i.e. at his discretion) within the aims, authorities, rights, obligations and tasks assigned to him by his superior. As a rule, that is the period during which the effects of a decision made or action taken manifest themselves. The longer the period of free (discretionary) decision-making, the wider the scope for free action, the more generalized the operating instructions and the less defined the jobs. In addition, an increase in the time-span of discretion increases the possibility that the decision-maker's interests would be taken into account to a greater extent. The time-span of discretion determines, in large measure, the depth of hierarchy to which the level of decision-making can be lowered. In fact, the quality of this process is also improved if one is better acquainted with the qualities and shortcomings of subordinates, due to which time-spans of discretion for different employees at the same hierarchical level may be different.

The positions with a long span of discretion are open positions, since the dynamics and contents of the relevant jobs are defined only provisionally. The positions with itemized and clearly defined jobs are partly closed and their efficiency changes at short time intervals (within the time span of discretion). In fact, it varies only with the efficiency of the relevant employee, since all other position factors are stabilized and under control. The time span of discretion of the enterprise manager is measured in months, as well as in years, while the time span for the employees who perform simple jobs is frequently measures in minutes.

To be able to perceive the real length of the time span of discretion, one must be well acquainted with the technology and content of the business process, corporate culture of the enterprise, system of control and management and the profile of the employee at the workplace (since the time of decision-making, that is, hesitancy, is also included in the time span of discretion). Here we think especially of the objective length of the time span of discretion, although that value should be also moderately adjusted by subjective factors which increase or decrease that value. Naturally, in the process of organizational structuring, the time-span value is rarely numerically explicated, but it is a conscious or subconscious factor that must always be taken into account by the organization designer.

The definition of the time span of discretion shows clearly that the subordinate's time span of discretion is the longest time interval during which the superior can be sure that the negative consequences of the subordinate's suboptimal or bad discretionary decisions will not be manifested. This means that the time span of discretion defines the longest interval between controls, frequency and the duration of control over the subordinates by their superiors and (in view of constant working time) the greatest possible number of direct subordinates.

According to /2/, it is actually the question of decentralized decision-making, whose optimal measure, in essence, originates from the time-span of discretion as well. First of all, decentralization must be distinguished from divisionalization. Namely, in the case of decentralization it is the question of extending decision-making rights to a lower hierarchical level (consequently, this refers to decision-making at one hierarchical level in general, or at that workplace). In the case of divisionalization, the subject criterion is applicable and this means that one (usually limited) part of responsibility for decision-making is transferred to all hierarchical level of the organizational entity that has been formed according to the subject principle.

In the light of QMS, as already mentioned, by decentralizing decision-making, one deliberately assumes the risk of having a limited number of errors in decision-making at a lower level. The three most important criteria for determining the degree of decentralization are: (1) the superior's conviction in the competence of his subordinate; (2) availability of adequate and reliable information required for decision-making at the lower level to which decision-making rights have been extended (in other words, decisions should not be made at the level being below the level of information required for decision-making), and (3) a wrong decision must not jeopardize other organizational entities, especially those at a higher hierarchical level. The problem of decentralization (see /3/) is especially dealt with in the theory and practice of managing large organizational systems (large enterprises, economies, states), where the modalities of decentralization are primarily related to different dimensions of the (organizational) system.

The span of management (which is often called the span of control) is the number of subordinates of one superior. For a real hierarchy (i.e. for a given number of employees), the span of control is an independent variable and the number of hierarchical levels a dependent variable. In practice, the span of control is not constant throughout the hierarchy. Since the time-span of discretion is larger at the top of hierarchy, it is logical that the span of control is smaller at the top of hierarchy and the largest at the bottom. In essence, research on an optimal or adequate span of control is confined to the determination of the time-span of discretion, although many of them are not aware of that fact.

To use the span of control in the design of organizational structure it is necessary to bear in mind the following facts, which are logical and known, but are easily overlooked in organizational structuring. First of all, by its nature (and definition), the span of management is greater than zero by a whole number. This means that it is pointless to determine the average span of management. In fact, the average span of control represents the reciprocal value of management intensity, which is of no use in practice, because it is impossible to manage a fractional number of subordinates.

In practice, the span of management changes along the depth of the hierarchy, as well as across its levels. Thus, it is possible to speak only about the span of management at a specified level, or in the overall hierarchy. This property of the span of control means that it can be used as an independent variable in the design of organizational structure only if it is constant throughout the hierarchy. This is an ideal case which is used in the preliminary design of organizational structure. For a given total number of employees and the (tentatively) adopted constant span of control (it is usually 3), individual levels of management and their total are determined. Thereafter, this preliminary design is tested against the Jaques constraints with respect to the number of hierarchical levels, in particular, and then is adjusted in accordance with the specific requirements of the business process in question, at specified hierarchical levels, while at the same time taking into account the specific characteristics of organizational culture, information system, dominant technology, etc.

When opting for the initial constant span of control we actually opt for a greater or lesser number of hierarchical levels, with slower or faster information flows along the height of the hierarchy. For low management intensity, that is, for a large span of control, the pyramid is lower and the flow of vertical information is faster. In that case, however, we enter the zone of a larger time-span of discretion, which is not acceptable for all business processes and activities. Within the initial solution, by a detailed analysis we obtain the final value of the span of management at each point of hierarchy ramification. That value is determined by a great number of factors, such as: the complexity and diversity of decisions that should be made at that level; frequency of the problems on which decisions are made; homogeneity of business activities; specifics of the production program; specifics of locations; technological complexity and up datedness; the degree of interaction between the activities that should be controlled; knowledge and skills of all employees; communication accessibility of subordinates, superiors and managers at the same hierarchical level, etc.

Organization theorists, researchers and managers are unable to give a recipe for the design of organizational structure (the so-called normative approach to the design of organizational structure is evidently limited), because theoretical knowledge and empirical experience are evidently still very limited in scope relative to the complexity of the structuring problem and an increasing number of variables and factors, which certainly exert influence on business processes and the supporting organizational structure.

In any case, in practice, the partial improvement and adjustment of organizational structure are more frequent (although this option is not recommended, because it usually causes new, even greater problems). This also applies to intervention in the field of control and management, which is a better option despite its limited scope because, in principle, structural problems are solved only by structural changes (a benefit can be derived only if intervention is aimed at harmonizing the practice of control and management and the existing organizational structure).

In our consulting practice, the most frequent problems - which are associated with the organizational structure or collision between structure and functioning in the minds of the employed in an enterprise - are as follows: (a) undefined or obsolete corporate aims; (b) unclear assignment of competences to organizational entities (so that nobody performs that job); (c) unnecessary complexity of the decision-making complex procedure; (d) unclear situation about the superior-subordinate relationship in some organizational configurations (say, design and division managers in the event of a dispute, when a matrix configuration is in question); (e) excessive paper work; (f) professional over-dimension of some employees; (g) redundancy of levels of management (operationally justified and/or necessary yet not articulated structurally), and (h) the lack of a long-term plan of business changes and the appropriate structural adjustment of an organization.

The use of the span of management in the design of organizational structure is necessary and useful but, unfortunately, its effect is limited. It can be recommended that the span of control should be used only in the preliminary design of macroorganizational structure, after which the span of control along the depth of the hierarchy and across the levels of management should be precisely defined.

CONCLUSION

Direct harmonization of business operations is defined by the organizational form (line and/or team), while indirect harmonization is defined by the organizational model, which is actually a combination of the vertically (hierarchically) oriented organizational forms and/or horizontal (equiordinarilly) oriented organizational forms. For differentiation and integration of business operations there are only two criteria (similarity and conditionality), which are applied to objects (products), processes (functions) and location (in a geographical sense). The obtained organizational structure can have (depending on the specificity of the tasks and selected concept of management) a different number of hierarchical levels, different management intensities and other quantitative differences in the organizational articulation of business operations. All mentioned elements of organizational structuring and harmonization provide a basis for the efficient growth and development of the enterprise and its preparation to face the unavoidable crises in that process.

And, finally, structure implies, by definition, certain basic, dominant and permanent mechanism of behavior harmonization and of integration of the business of the company, both direct (through the chosen form), and indirect (through the chosen model). Additional and periodical harmonization, accomplished with soft structures, is significantly dependent on the basic, firm, macroorganizational structure, and relies on it, especially in the stage of carrying out the constructed harmonization, that is in the stage of its being accepted.

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(SEMI)PRODUCT NONCONFORMITY COST MANAGEMENT IN PRODUCTION PROCESSES

Igor Nikodijević[1)], Dragan Milivojević[2)], Vitomir Bošković[3)]
[1)]MSc, Financial Manager, IPM AD, Beograd, e-mail: igor.nikodijevic@ipm-factory.rs
[2)]BA in Econ., General Manager, IPM AD, Beograd, e-mail: dragan.milivojevic@itm.rs
[3)]Mechanical engineer, Quality Manager , IPM AD, e-mail: ipm.kontrola@ipm-factory.rs

***Abstract**: Cost Management, as part of the overall business performance management process, includes optimization of all operating costs in particular the unnecessary or unwanted costs covering nonconformity costs too. Nonconformity costs arise due to loss at the quality level in the process of manufacturing (semi)products. The past experience shows that it is not easy to encompass and quantify all nonconformity costs as some of them are often hidden. To have as realistic as possible cost determination for (semi)products which fail to meet the requirements defined, it is necessary that such costs should be projected, monitored and analysed in order to timely identify causes for their occurrence or to take preventive or corrective actions aimed at their rationalization. Growth of nonconformity costs above the projected amount directly adds to the increase in production cost of (semi)products, and at the same time the increase in total costs. However, by the application of efficient nonconformity cost management, particularly in the circumstances of crisis when available opportunities to increase revenues are limited and exhausted, companies may act in the direction of enhancing their own cost-effectiveness, profitability and productivity.*

It is author's wish that this paper should not only attract the attention of as wide as possible scientific and expert public with its topics, content and structure, but to stress the importance of practical approach in perceiving the topics discussed.

***Key words:** nonconformity costs, quality costs, production process, (semi)product.*

1. INTRODUCTION

Quality management concept has its widest application in mass production containing cyclic repetition of production operations under controlled conditions. If any production process stages of a (semi)product do not run according to predefined rules, the result is poor quality, that is, non-conformity. Non-conformity can be simply defined as a failure to meet defined requirements. To achieve a projected quality level of a (semi)product, it is necessary that the company management should master the knowledge and abilities to timely recognise an occurrence of non-conformity, and then define and take set corrective actions to remove such non-conformity. As every stated activity requires additional investments, where their amounts directly depend on the time of detecting non-conformity, efficient non-conformity cost management seems to be the only rational strategic option.

2. QUALITY COST STRUCTURE

Quality costs, as an integral part of overall costs, are a significant item in their structure as they have a tendency of continued growth due to ever-increasing market requirements for quality. From the producer's aspect, the (semi)product quality should be analysed in connection to costs necessary for achieving a satisfactory quality level. Namely, the costs of introducing and operating the quality system temporarily increase quality costs, that is, conformity costs. However, in the long run, consistent application of the quality system has direct influence on reducing the number of errors occurring in the production process, resulting in nonconformity costs starting to decrease. In the course of time, at one point, the savings achieved in nonconformity costs start to exceed the amounts of costs generated by introducing and operating the quality system so that overall quality costs start to fall.

That is why we can say that quality costs are a measure of the QUALITY SYSTEM efficiency. In addition, decreased quality costs are not the main objective of the quality system, but one of its major functions. According to the needs of our analysis and overview of quality costs and accepting the fact that their structure is highly complex, we have divided quality costs into:

1. conformity costs and
2. nonconformity costs

2.1 CONFORMITY COSTS

All quality costs incurred for a (semi)product to meet a set (defined) quality level are called conformity costs. They are a financial measure of quality performance. Conformity costs can be:

- prevention costs and
- control costs

2.2 NONCONFORMITY COSTS

The production of faulty (semi)products results in losses at the quality level causing extra costs called nonconformity costs. The production of faulty (semi)products arises due to inadequate projection or insufficient utilization of available capacities in processes and activities. Nonconformity costs sum up all producers' costs arising due to faults in their current production processes, and depending on where they can occur we make difference between:

- internal nonconformity costs and
- external nonconformity costs

The said classification of nonconformity costs, to be worked out in detail in this paper, is shown in fig. 1.

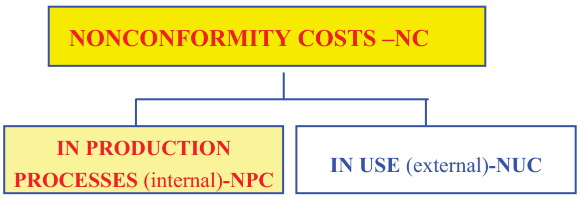


Fig 1. Nonconformity cost structure

2.2.1 Internal nonconformity costs (NPC)

Internal nonconformity costs or nonconformity process costs (NPC) arise prior to delivery of (semi)products to users. They can be calculated by applying the following formula:

$$NPC = MNC + MC + RC$$

where: *MNC –manufacturing nonconformity costs*
MC –material costs
RC – rework costs due to nonconformity

Manufacturing nonconformity costs (MNC) are quality losses arising in the course of manufacturing when a production process results in nonconforming (semi) products. They can be roughly categorised and monitored depending on causes of their occurrence. They are calculated as a sum of costs of all determined causes by applying the following formula:

$$\underline{NMC = FM+FPO+FCO}$$

where: *FM – faulty material*
FPO – faulty previous operation
NTO – faulty current operation

Material costs (MC) include the value of material used for manufacturing (semi)products subject to fault (nonconformity).

Rework costs due to nonconformity (RC) are extra costs incurred in the process of correcting nonconforming (semi)products or due to temporary introducing new operations (machine replacement, material replacement, etc.).

2.2.2 External nonconformity costs (NUC)

External nonconformity costs (NUC) arise due to nonconformity during the use of (semi)products by users. These costs can be classified as:

- costs of advertised (semi) products
- costs of servicing within the warranty
- costs of repairing returned products

3. COST MONITORING AND ANALYSIS

Nonconformity cost monitoring and analysis is aimed at creating a quality information base for the top management to act in the direction of taking adequate corrective actions, tasked to efficiently reduce nonconformities. This goal can be achieved by identifying causes of nonconformity (employee, machine, tool, material, documentation) and locating the point where they arise (organizational unit).

3.1 Nonconformity cost monitoring

Monitoring of nonconformity cost trends is done by technological unit, (semi)product or production operation by looking into their growing or declining trends in observed time periods. At the same time, the occurrence trends are monitored for causes of nonconformity.

3.2 Nonconformity cost analysis

Nonconformity cost analysis determines the causes of their occurrence. Based on the obtained results of the analysis, through the functions of management and control, certain corrective actions are defined to be implemented in order to reduce nonconformity costs. As many undertaken activities are often left without desired effects or require a long-time review and determination of causes of nonconformity, it is very important to apply quick and simple analytical methods well-proved in practice, by means of which one can easily and efficiently determine the cause of error adding to the occurrence of nonconformity. There are many factors that can bring about an occurrence of error. However, all factors are not of the same importance for the effects we want to achieve, so it is necessary that we address our actions towards a lower number of more important factors in order to have better effects of corrective actions taken.

In practice, there are two analytical methods most often used: Pareto and Ishikawa.

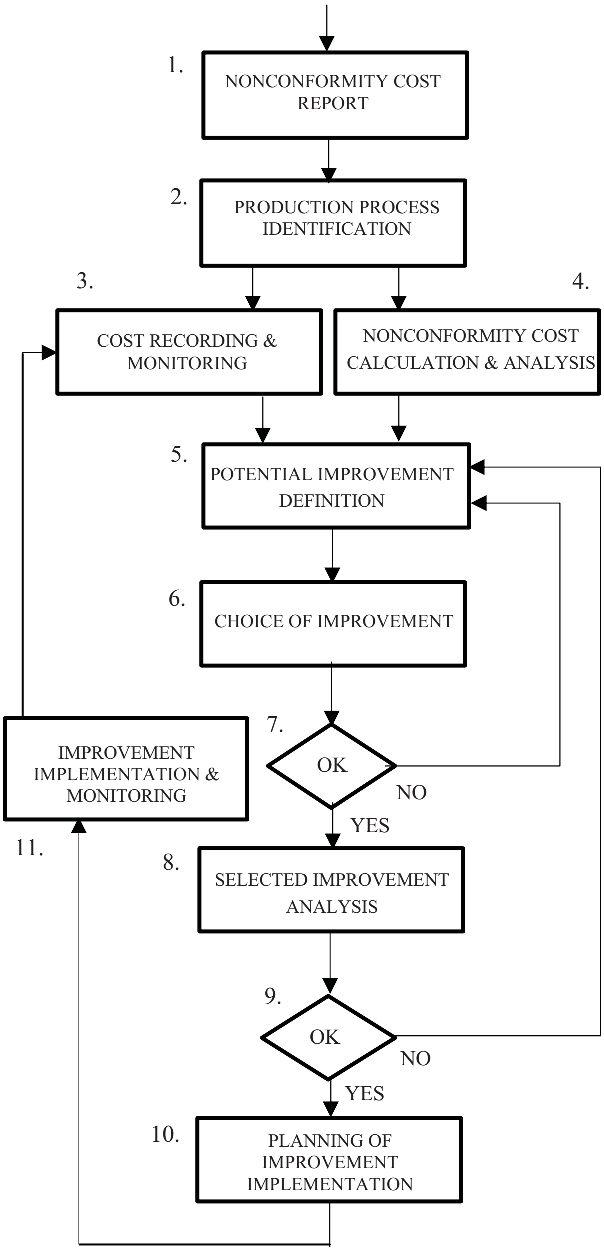


Fig 2. Nonconformity cost management algorithm

To have quality monitoring and analysis of nonconformity costs, that is, to have quality management over them, it is necessary that certain activities should be taken, whose flow is shown in fig. 2 algorithm. The start of this activity requires that "COST REPORT" form should be applied including a record of data on the error that caused the nonconformity. Based on the "COST REPORT", production process identification is performed as well as actual cost analysis, followed by defining, analysing, selecting, implementing and monitoring selected improvements.

4. COST CALCULATION

Nonconformity cost calculation provides information about their measurable values. The application of nonconformity cost calculation depends on specific needs of each organization, but generally speaking, most benefits come from collecting information to serve as an input for nonconformity cost management. The inputs serving as the base for nonconformity cost calculation are:

Allowed costs. In production processes, during the manufacturing of (semi) products, the occurrence of certain nonconformity costs should be expected as they cannot be avoided. These costs are usually called allowed nonconformity costs (AC). They are planned prior to starting a production process, stated in percentages, and their amount depends on the type of production process, manufacturing procedure, processing technology, mechanical wear and tear, etc.

Material. In case of scrap due to inadequate material (inadequate composition, tolerance, size, etc.), cost calculation is done by taking the actual value of material loss (the value is converted in quota hours [QH]), while in case of rework, the calculated value is only that of excessively consumed material. In case of complaint and its resolution, the cost calculation result is equal either to the selling value of finished part being replaced or to the value of material used for the replacement operation.

Work. It is very often the case that scrap can be caused due to the employee negligence or misconduct at work place. Then, the obtained result of nonconformity cost calculation is equal either to the value of work contained in the scrapped unit of such (semi)product or the value of performed work required for its rework/intervention within the warranty.

Nonconformity cost calculation procedure is done by summing up all nonconformity costs by all types in cost structure. In that way, an aggregate cost is obtained which is total nonconformity cost (ΣNC).

5. NMC CALCULATION AND ANALYSIS CASE STUDY

There is a specific case shown below about the calculation and analysis of nonconformity costs during manufacturing (MNC) in the production company IPM AD Beograd (Tables A, B and C).

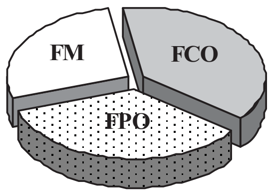
- Table **A** shows nonconformity costs (MNC) by cause of nonconformity (FM, FPO and FCO), as well as their relation to the actual production (AP) and allowed costs (AC).
- Table **B** shows the shares of nonconformity causes (FM, FPO and FCO) in total nonconformity costs during manufacturing (NMC) for 2011.

OVERVIEW OF MANUFACTURING NONCONFORMITY COSTS (MNC) FOR 2011									TABLE A
Quarter	*Actual production* (AP) [QH]	*Allowed nonconformity costs* (AC)		*Manufacturing nonconformity costs* (MNC) [QH]			*2011*		
		[QH]	[%]	*Faulty material* (FM)	*Faulty previous operation* (FPO)	*Faulty current operation* (FCO)	Σ MNC [QH]	Σ MNC [%]	MNC/AC [%]
1	2	3	4	5	6	7	8 (5+6+7)	9 (8: 2)	10 (8: 3)
QUARTER 1	81585	2094,19	2,56	316,20	532,06	463,14	1311,40	1,607	62,60
QUARTER 2	88024	2122,94	2,41	336,58	540,94	462,65	1340,17	1,522	63,10
QUARTER 3	90105	2001,82	2,22	432,74	444,56	431,79	1309,09	1,452	65,30
QUARTER 4	107281	2308,01	2,15	458,08	465,74	710,40	1634,22	1,523	70,80
Σ (I+II+III+IV)	**366995**	**8526,96**	**2,32**	**1543,60**	**1983,30**	**2067,98**	**5594,88**	**1,524**	**65,60**

- Table **C** shows manufacturing nonconformity costs MNC (in QH and %), and their relations to actual production for a three-year period (2009, 2010 and 2011).

SHARES OF CAUSES OF NONCONFORMITY DURING MANUFACTURING (FM, FPO & FCO) IN TOTAL MANUFACTURING NONCONFORMITY COSTS MNC FOR 2011 — TABLE B

ΣMNC =5594,88 [QH] **(100%)**



FCO – nonconformity costs due to faulty current operation **(36,96%)**

FPO – nonconformity costs due to faulty previous operation **(35,45%)**

FM – nonconformity costs due to faulty material **(27,59%)**

Based on the calculated amounts of nonconformity costs (MNC) in production processes of IPM AD Beograd, one can conclude that the share of total nonconformity costs in production value is favourable, and that their downfall trend continues when compared with the previous observed periods.

Note: For easier monitoring and comparison with previous periods, the values of nonconformity manufacturing costs are stated in quota hours [QH].

OVERVIEW OF MANUFACTURING NONCONFORMITY COSTS (MNC) [%] VS. ACTUAL PRODUCTION FOR 2009, 2010 AND 2011									TABLE C
Year	*Actual production* [QH]	Manufacturing nonconformity costs (MNC)							
		FM		**FPO**		**FCO**		**Σ MNC**	
		[QH]	[%]	[QH]	[%]	[QH]	[%]	[QH]	[%]
1	2	3	4 (3:2)	5	6 (5:2)	7	8 (7:2)	9	10 (9:2)
2009	342373	1782,91	0,521	2564,62	0,749	3025,18	0,883	7372,71	2,153
2010	330933	1339,10	0,405	1956,70	0,591	1913,10	0,578	5208,90	1,574
2011	366995	1543,60	0,421	1983,30	0,540	2067,98	0,563	5594,88	1,524

6. CONCLUSION

Efficient nonconformity cost management means that quality costs of (semi)products should be continually monitored, analysed and planned in order to conduct an adequate quality policy. Namely, the occurrence of nonconformity costs (scrap and rework) increases total costs, and consequently the unit cost per product which has negative impact on competitiveness and selling opportunities for such (semi)product in the market. It is for these reasons that the top management most often directs their actions towards nonconformity cost rationalisation and higher operational efficiency in order to create conditions for growth of the company's total revenues and profitability.

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DIFFERENCES BETWEEN VERIFICATION AND VALIDATION FROM QUALITY PERSPECTIVE

Branislav Tomic
Senior Quality Coordinator, Bombardier Aerospace, Toronto, Canada

Summary: *Looking at glance, the one can say that there is no big difference between verification and validation processes. Even worse, sometimes these processes are used interchangeably for the same meaning without real understanding what they represent. This is the result of not knowing what these processes intend to do, from which perspective and to which extend. This article has intention to clarify the meaning, purpose, and final outcome of these processes. Verification and validation are often mentioned in different quality standards and their definitions can be easily obtained. What is not easily accessible are their purpose and detailed explanation. This article has intent also to highlight the most important differences between verification and validation processes.*

Key Words: *Quality, Verification, Validation, Process, System*

1. INTRODUCTION

Verification and validation are independent processes that are used together for checking that a product, service, product or system meets requirements and specifications and that it fulfills its intended purpose. Verification and validation are critical components of a quality management system and can be found in any quality standard such as, for example ISO 9000.

Verification is a process of confirmation, through the provision of objective evidence that specified requirements have been fulfilled (ISO 9000:2005, 2005). Whenever specified requirements have been met, a verified status is achieved. There are many ways to verify that requirements have been met. For example, different test can be performed, demonstrations, alternative calculations, comparison to a new design specification with a proven design specification, or the simple inspection can be carried out as well.

Validation is a process as well. It uses objective evidence to confirm that the requirements which define an intended use or application have been met (ISO 9000:2005, 2005). Whenever all requirements have been met, a validated status is achieved. The process of validation can be carried out under realistic use conditions or within a simulated use environment.

Verification has to be done between phases of the development to guarantee that the output from each phase met the input requirements from that phase, as well as the final stage of product / service development. Validation has to be done to guarantee that the final product meets the customer needs. In this case, the word "customer" means all the stakeholders not only the actual customers themselves.

Verification ensures the product is designed to deliver all functionality to the customer; it typically involves reviews and meetings to evaluate documents, plans, code, requirements and specifications; this can be done with checklists, issues lists, and walkthroughs and inspection meetings.

Validation ensures that functionality, as defined in requirements, is the intended behavior of the product or service; validation typically involves actual testing and takes place after verifications are completed.

Customers wishes and desires translated into customer requirements are primary features when is needed to properly define and explain verification and validation processes. What customers want is input to the system / process and what customers get is output from the system / process.

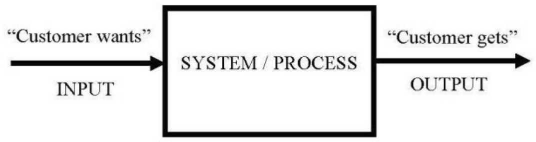

Figure 1. Elementary process / system

In simple equation, where customer satisfaction means quotient between what customers get and what customers want, it is easy to distinguish between verification and validation process.
What customers gets, is output from the system, the final product or services that has been checked that it conforms to defined standards or requirements, or in other words - being verified. These activities are formal and have been done through different quality control / assurance steps. It is relatively easy to perform these steps since the final result will be easy to interpret – quantitatively and qualitatively. What customers want, is the input to the system, the initial list of wishes and desires that need to be translated into technical requirements which serve the purpose of guidance to the provider how to satisfy the customer. These qualitative data is not easy to transfer into technical aspects, first of all because they are not explicit; they have to be questioned, observed, anticipated and projected. Since they are complex and diverse in nature, it is not easy to capture all of them neither to their full extend. Because of all this factors, this process step seems to be the critical and the most important one in the system. Validation process, performed by customer through intended use of the product / service, will conform how precisely and accurately this process has been performed.

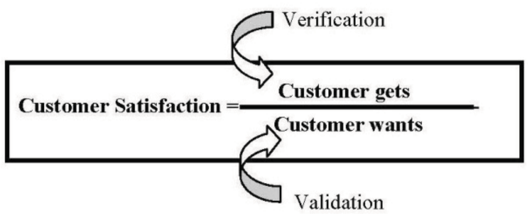

Figure 2. Customer Satisfaction Formula

2. VERIFICATION

Verification is intended to check that a product, service, process or system (or portion thereof, or set thereof) meets a set of initial design requirements, specifications, and regulations. Verification process therefore ensures that the product / service is designed to deliver all functionality to the customer / final user / stakeholder.
Verification process verifies that designed product / service conforms to prescribed requirements. Quality definition – "conformance to requirements" which is coming from Crosby (1979), implies that every product or service has a requirement - a description of what the customer needs translated into technical documentation. When a particular product or service meets that requirement, it has achieved quality, provided that the requirement accurately describes what the customers actually need (validation). According to Crosby (1979) "zero defects" is a part of Quality Improvement philosophy which also highlights that the only performance measurement is the cost of quality and that quality means conformance not elegance.
Verification process relies on the fact that all customer wishes and desires are properly defined into customer requirements and thereafter precisely and accurately translated into system's specifications. Even small deviation and discrepancy in this stage can cause big gap between desired item and final product / service. Since verification process cannot verify directly customer requirements but only indirectly through comparison of final product / service in the light of system specifications (standards, drawings, technical documents, procedures, etc.), verification process remain limited in the scope of total assessment of customer requirements and overall quality.

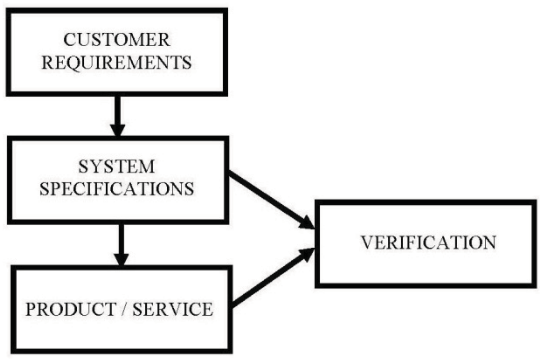

Figure 3. Verification Process

Verification process includes controls such as product inspection, where every product is examined visually or dimensionally using metrology, and often tested for different features. The quality of the outputs is at risk if any of these three aspects is deficient in any way. Verification process is quantitative – it can be expressed in certain units and be understood easily. Both Quality Control and Quality Assurance attempt to provide sufficient controls that output from the process doesn't deviate from its input.
Verification process is exclusively performed by manufacturer. For his / her perspective any gap between required level of quality standard and achieved level of quality can be considered as poor quality. That poor quality is detected by verification process. Any discrepancy between required and achieved level of quality of final product / service

represents the problem of unachieved quality. Therefore verification process is highlighting unachieved quality due to poor translation of customer requirements or incapable process to achieve those requirements. In any case, customer / final user / stakeholder will receive the quality level of the final product / service that is below expectations and consequently customer satisfaction will indisputably drop.

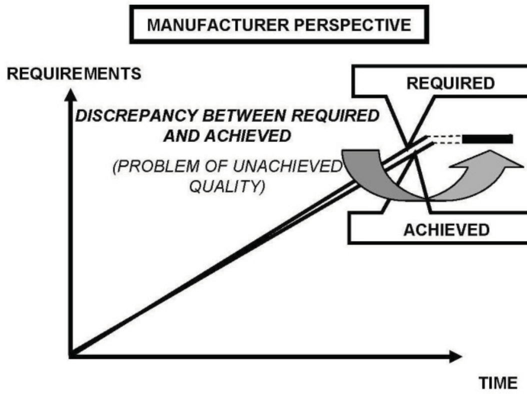

Figure 4. Verification – Manufacturer Perspective

3. VALIDATION

Validation is intended to evaluate that a product, service, process or system (or portion thereof, or set thereof) meets a set of initial stipulated requirements, specifications, and regulations. Validation process therefore ensures that the functionality of the product / service as defined in requirements is the intended behavior of the product / service delivered to the customer / final user / stakeholder.

Validation typically takes place after verifications are completed.

Validation process assesses fitness for use of the final product / service. Validation process is similar to Juran's (Juran and Godfrey, 1998) definition of quality. Juran defines quality as fitness for use (Fitness is defined by the customer) in terms of design, conformance, availability, safety, and field use. Thus, his concept more closely incorporates the viewpoint of customer. He is prepared to measure everything and relies on systems and problem-solving techniques. He focuses on top-down management and technical methods rather than worker pride and satisfaction.

Fitness for use in other words means the effectiveness of a design, manufacturing method, and support process employed in delivering a good, system, or service that fits a customer's defined purpose, under anticipated or specified operational conditions.

Validation process compares and assesses customer wishes and desires to the final product / service. Validation process is somehow subjective and qualitative and therefore it is difficult to be easily understood and recognized. Since not only facts are involved but emotions as well, validation process becomes very complex and very often ambiguous. However, the key performance indicators can detect the weak areas and serve the purpose of signs for improvement. The fact that something is done according to precisely and accurately defined customer requirements doesn't assure that customer / final user / stakeholder will like it and be satisfied with it. Intuitive, creative and innovative approach to design in combination with capture of all customer wishes and desires translated into customer requirements and anticipation of possible features that may delight the customer / final user / stakeholder, seems to be the only way to increase the results of validation. Validation process compares customer requirements and final product / service without checking the processes that lead from customer requirements to the final product / service. Validation process is integral comparison process since it compares what is needed to the actual. Its deficiency is very general perspective which doesn't take into account important steps that make this intended process possible.

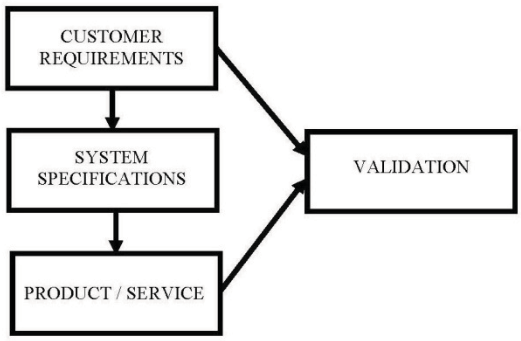

Figure 5. Validation process

Validation process includes perceptive measures that often cannot be quantitatively expressed. Practical use of the final product or provided service are the best stage when all features can be properly evaluated against the customers' practical needs and therefore be a direct measure of intended quality. Validation process is frequently qualitative – it can not be expressed in certain units and be understood easily. Quality Improvements in the organizations on continual basis should be the best way to gradually approach targeted customer requirements.

Validation process is exclusively performed by customer. For his / her perspective any gap between desired and received level of quality can be considered as poor quality. That poor quality is detected by validation process. Any discrepancy between desired and received level of quality of final product / service represents the problem of not properly defined quality. Therefore validation process is highlighting not properly defined quality due to primarily poor translation of customer requirements and secondly incapable process to

achieve those requirements. In any case, like previously stated, customer / final user / stakeholder will receive the quality level of the final product / service that is below expectations and consequently customer satisfaction will indisputably drop which can cause long term negative effects.
Validation is more important than verification because it confirms that intended quality has satisfied its purpose or not. The fact that this process is performed by customer / final user / stakeholder makes validation indisputable when comes to overall quality of the final product / service.

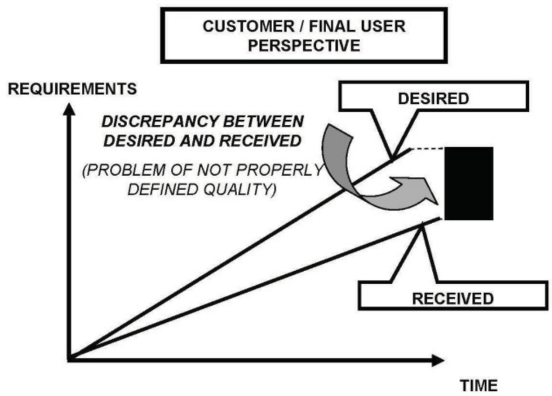

Figure 6. Validation – Customer / Final User Perspective

4. CONCLUSION

Verification takes place before validation, and not vice versa. Verification evaluates documents, plans, code, requirements, specifications, and product itself. Validation, on the other hand, evaluates the itended functionality of the product.
The final product / service can be verified that they conform and confirm to specified requirements, but that doesn't mean they are perfect..
How something can possibly be verified as meeting customer specifications and still not be what the customer wants? It seems illogical, and yet the truth is that it can and does occur very often.
In the same way, an organization can produce a product that is not what the customer intended or expected. This could be due to inadequate or ambiguous specifications. It could also result from variables in process or materials that have an adverse or unanticipated effect on the final output.
Some of these variables can probably be caught using several planning tools. Ensuring complete understanding of customer specifications, asking questions, and requiring more details can help mitigate these surprise outcomes. Certain processes also serve to broaden individuals' perspectives of potential problems.
However, even with robust processes in place and utilization of effective prevention tools, it's still possible to have unanticipated consequences. That is what justifies validation process. Like a final check and evaluation, all problems that couldn't be caught during previous actions will show up and be identified. This process, even it's painful for the provider, can serve the purpose of trigger for continual improvements which should be the core strategy for every company.
On the end, verification checks whether the design or final product / service meets the original specifications.
Validation checks whether the final product / service works (does it do what it's supposed to as it is supposed to do it).
Both processes are extremely important, and they represent the different ways of looking at product / service..

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THE KEY CHARACTERISTICS OF MEASUREMENT SYSTEM ANALYSIS

Branislav Tomic
Senior Quality Coordinator, Bombardier Aerospace, Toronto, Canada

Summary: *Measurement System Analysis is vital aspect in today's business of making decisions. The process of determination how measurements are good or bad, is crucial to the subjects that are in positions to manage certain projects. Measurement System Analysis is statistical calculation of performed measurements and explicitly shows the error; the variation that occurs during measurement process. This article has intention to highlight the key characteristics of Measurement System Analysis.*
Key Words: *Measurement System Analysis, Variation, Process*

1. INTRODUCTION

Measurement Data are used more often and in more ways than ever before. For instance, the decision to adjust a manufacturing process or not is now commonly based on measurement data. Measurement Data, or some statistics calculated from them, are usually compared with statistical control limits for the process, and if the comparison indicates that the process is out of statistical control, than an adjustment of some kind is required to be made. Otherwise, the process is allowed to run without adjustments. Another use of measurement data is to determine if a significant relationship exists between two or more variables.

Studies that explore such relationships are examples of what Deming called analytic studies. In general, an analytic study is one that increases knowledge about the system of causes that affect the process. Analytic studies are among the most important uses of measurement data because they lead ultimately to better understanding of processes.

The benefit of using a data-based procedure is largely determined by the quality of the measurement data used. If the data quality is low, the benefit of the procedure is likely to be low. Similarly, if the quality of the data is high, the benefit is likely to be high also.

To ensure that the benefit derived from using measurement data is great enough to warrant the cost of obtaining it, Attention needs to be focused on the quality of the data.

2. MEASUREMENT SYSTEM ANALYSIS

The manufacturing environment, by its very nature, relies on two types of measurements to verify quality and to quantify performance:

(1) measurement of its products, and

(2) measurement of its processes.

Therefore, product evaluation and process improvement require accurate and precise measurement techniques. Due to the fact that all measurements contain error, and in keeping with the basic mathematical expression:

Observed value =
True value + Measurement Error

Understanding and managing "measurement error," is generally called Measurement Systems Analysis (MSA), is an extremely important function in process improvement (Montgomery, 2005).

MSA is a comprehensive set of tools for the measurement, acceptance, and analysis of data and errors, and includes such topics as statistical process control, capability analysis, and gauge repeatability and reproducibility, among others (Besterfield, 2004). MSA recognizes that measurements are made on both simple and complex products, using both physical devices and visual inspection devices that rely heavily on human judgment of product attributes (Smith et al, 2007).

Despite the comprehensive approach of MSA, and the documented importance of gauge control (Besterfield, 2004), experts throughout the

manufacturing industry express concerns about the reliability of measurements used in decision. When data quality is low, the benefit of the measurement system is also low, likewise when the data quality is high, the benefit is high (AIAG, 2002).
The effectiveness of a measurement system depends upon accurate gauges and proper gauge use. Common measuring devices are of particular concern when used incorrectly (Hewson at al., 1996). Measuring equipment and processes must be well controlled and suitable to their application in order to assure accurate data collection (Little, 2001).
According to the MSA Reference Manual, MSA defines data quality and error in terms of "bias," "reproducibility," "reliability," and "stability" (AIAG, 2002). Further, MSA provides procedures to measure each term, however the phrase gauge Repeatability and Reproducibility Studies (R&R) has come to incorporate the procedures recommended for measurement of "bias," "reproducibility," and "reliability" (Foster, 2006).
Following the definitions of MSA, bias is the "systematic error" in a measurement, sometimes called the "accuracy" of a measurement. Repeatability is "within operator" (one appraiser, one instrument) error, usually traced to the gauge itself, and is best considered to be "random error." Reproducibility is "between operator" (many appraisers, one instrument) error, and is usually traced to differences among the operators who obtain different measurements while using the same gauge (Montgomery, 2005).
Measurement is an integral part of the evaluation, maintenance, and improvement of a product or service. There is a tendency, however, to focus on the product or service indicators rather than how the indicators are measured. Just like the indicators, the measurement system should be evaluated, maintained, and improved.
Total variation is the sum of the process variation plus the measurement variation:

$$\sigma^2_{Total} = \sigma^2_{Process} + \sigma^2_{Measurement}$$

As the process capability improves, the ability to make further process improvements becomes increasingly challenging, if not impossible, due to limitations in the measurement system. Figure 2 shows a normal curve which represents the total variation. The black normal curve represents the variation due to measurement. When variability is removed, the measurement variability accounts for a higher percentage of the total remaining variability. The measurement system must remain sensitive enough to be used to measure the process. In short, improved measurement capability must accompany improved process capability in order for the measurement system to be useful in the evaluation, improvement, and maintenance of the process.

Every observation of a process contains both actual process variation and measurement variation (Figure 2). In the case of measurement systems, the sources are:

- The gage
- The operator
- The variation within the sample

Gage variability can be broken into additional components, such as:

- Calibration (Is the gage accurate?)
- Stability (Does the gage change over time?)
- Repeatability (Is there variation of the gage when used by one operator in brief time interval?)
- Linearity (Is the gage more accurate at low values than high values and vice versa?)

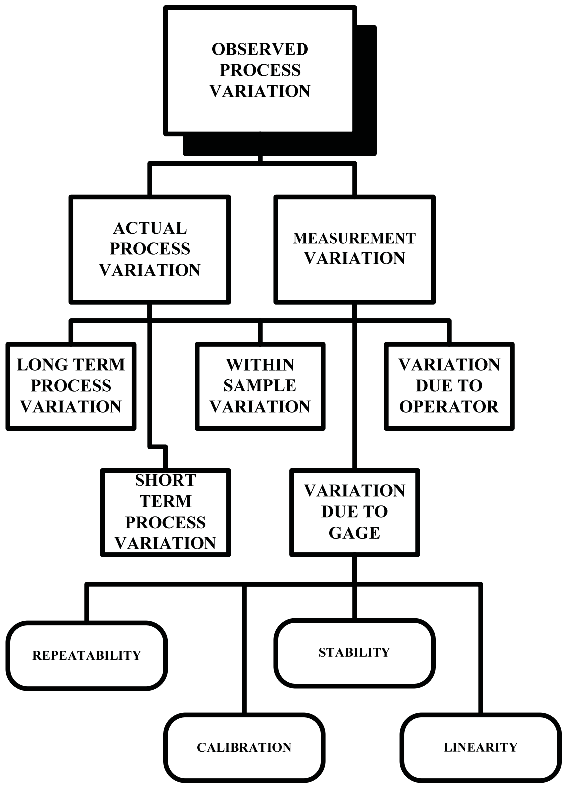

Figure 1. Possible Sources of Process Variation

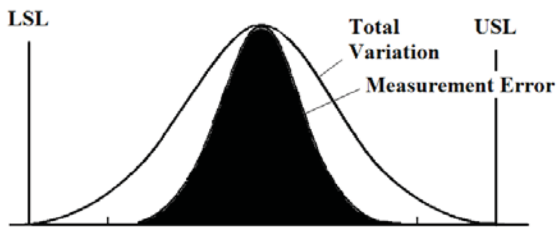

Figure 2. Total Variation Distribution as Sum of Process Distribution and Measurement Distribution

A measurement system may be treated like a process (Taylor, 1991). As such, the tools of statistical process control (SPC) may be applied in order to evaluate, maintain and improve a measurement system. In SPC terms, a process must be stable and capable.

Stability refers to consistency over time. In measurement terms, stability is referred to as reproducibility. In other words, the measurement system must be robust to different operators and environmental conditions across the range of possible values which may be measured.

Capability refers to the measurement systems' ability to produce precise and accurate results. In measurement terms precision refers to repeatability. Repeatability is addressed by studying the measurements obtained by one operator taking repeated measurements from one "unit" using the same instrument. If the unit being measured has a standard value, the accuracy of the measurement may also be evaluated. The difference between the standard value and the measured value is called the bias. Accuracy is improved as the bias decreases. Precision and accuracy can be used to determine measurement sensitivity.

Assessing the precision of a measurement system is a vital step that should be carried out before any design or process improvement effort. The method most commonly used to do this is a gauge repeatability and reproducibility study, which aims to answer two main questions: How much of the total observed variability is due to real part-to-part variation and how much is due to random measurement error and secondly, what is the breakdown of the measurement variation and how much is due to repeatability versus reproducibility?

Repeatability is the extent to which measurement values are equal if measurements are repeated by the same appraiser, and reproducibility is the extent to which measurement values are equal if measurements are done by different appraisers. In a standard gauge R&R study a number of appraisers measure a sample of parts several times. The results are analyzed using the random effects analysis of variance (ANOVA). The error variance represents the repeatability and the variance between appraisers the reproducibility. There are many relevant situations in which the standard gauge R&R study described above is not applicable. For instance, if the true value of the measured characteristic of a particular part is not constant for each measurement, the error variance will not purely be caused by measurement error but partly by variation in the true value of that characteristic, and therefore the measurement error will be overestimated. Or in case each part cannot be measured more than once by each operator, the error is confounded with the part-appraiser interaction effect. Consequently, the standard gauge R&R study as described by AIAG (2002), assumes that for each part the true value of the measured quantity is constant over time, is not affected by the measurement, and can be measured at least twice by each appraiser under identical circumstances.

Some terms used in this paper refer to the following:

Accuracy represents the closeness to the true value, or to accepted reference value, the effect of location and width errors.

Precision represents the closeness of repeated readings to each other; a random error component of the measurement system

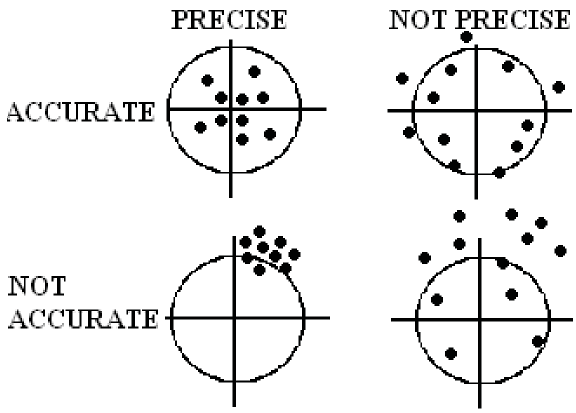

Figure 3. Difference between Precision and Accuracy

Bias represents the difference between the observed average of measurements and the reference value, systematic error component of the measurement system.

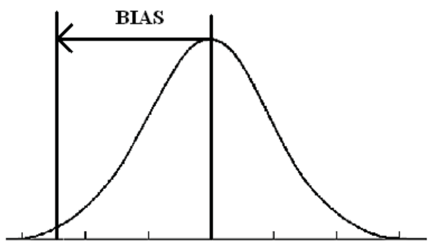

Figure 4. Bias – Difference between observed average and reference value

Stability represents the change in bias over time, drift, or meaning that stable measurement process is in statistical control with respect to location.

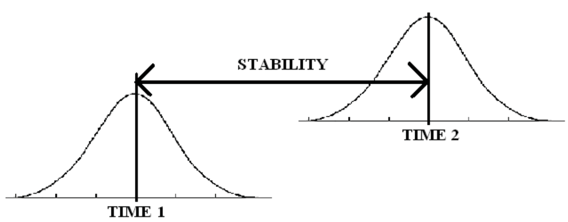

Figure 5. Stability – Change in Bias over time

Linearity represents the change in bias over the normal operating range, the correlation of multiple and independent bias errors over the operating range, or systematic error component of the measurement system.

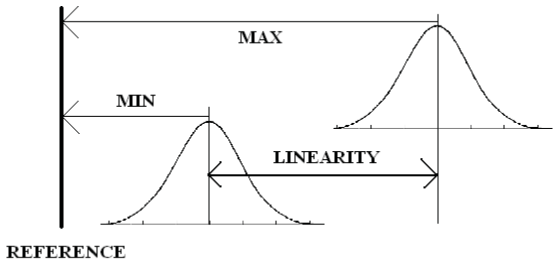

Figure 6. Linearity – Consistency over the measurement range

Repeatability represents the variation in measurements obtained with one measuring instrument when used several times by an appraiser while measuring the identical characteristic on the same part, than the variation in successive (short term) trials under fixed and defined conditions of measurement - commonly referred as equipment variation, instrument (gage) capability or potential within-system variation.

Reproducibility represents the variation in the average of the measurements made by different appraisers using the same gage when measuring a characteristic on one part, where for product and process qualification, error may be appraiser, environment (time), or method. This item is commonly referred to appraiser variation or between-system (conditions) variation.

4. CONCLUSION

A measurement process can be thought of as a well-run production process in which measurements are the output. The goodness of measurements is the issue, and goodness is characterized in terms of the errors that affect the measurements. The goodness of measurements is quantified in terms of: Bias, Short-term variability or instrument precision, Day-to-day or long-term variability, and Uncertainty. The continuation of goodness is guaranteed by a statistical control program that controls both: Short-term variability or instrument precision, Long-term variability which controls bias and day-to-day variability of the process. The importance of good Measurement System Analysis lays into statistical determination "how measurements are good or bad". With this in mind, it's easier to make certain decisions, especially those that require this type of inputs. On the end, the common known axiom - "What can't be measured can't be managed", seems to be the final message of this article.

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THE INTEGRAL VERSION OF SIX SIGMA METHODOLOGY

Branislav Tomic
Senior Quality Coordinator, Bombardier Aerospace, Toronto, Canada

Summary: *The Integral Version of Six Sigma Methodology encompasses four stages and eight phases that provide structured, very precise and accurate sequence of steps that lead to successful process, system or business results. Moreover, there is no more powerful methodology that effectively provides financial results. This article has intent to highlight and briefly explain the most important steps in the Integral Version of Six Sigma Methodology.*
Key Words: *Six Sigma, Integral Version, Methodology*

1. INTRODUCTION

Six Sigma at many organizations simply means a measure of quality that strives for near perfection. Six Sigma is a highly disciplined, data-driven approach and methodology for eliminating defects (driving toward six standard deviations between the mean and the nearest specification limit) in any process – from manufacturing to transactional and from product to service.

According to Harry and Shroeder (2000) Six Sigma is the most powerful breakthrough management methodology that has ever existed. Six Sigma is business process that allows companies to drastically improve their bottom line by designing and monitoring everyday business activities in ways that minimize waste and resources while increasing customer satisfaction. It provides specific methods to re-create the process so that defects and errors never arise in the first place. It is also produces superior financial results, using business strategies that not only revive companies but help them to move forward better than their competitors in terms of market share and profitability.

The Six Sigma breakthrough strategy is a disciplined method of using extremely rigorous data-gathering and statistical analysis to pinpoint sources of errors and ways of eliminating them. Six Sigma’s heavy reliance on performance metrics coupled with statistical analysis eliminates the imperfections found in quality programs. Quality-improvement projects using six sigma are chosen as a result of customer feedback and potential cost savings, not fuzzy notions of continual improvement. Improvements that have the largest customer impact and the biggest impact on revenues are given the highest priority. In other words, six sigma focuses first and foremost on the improvements that have the biggest impact on the business itself (Harry and Shroeder, 2000).

Six sigma brings new definition of quality: Quality is the state in which value entitlement is realized for the customer and provider in every aspect of their business relationship (Harry and Shroeder, 2000).

Six sigma bears in its name a statistical term that measures how far a given process deviates from perfection. The central idea behind Six Sigma is to measure how many "defects" there are in a process, and how to eliminate them and get as close to "zero defects" as possible. To achieve Six Sigma Quality, a process must produce no more than 3.4 defects per million opportunities. An "opportunity" is defined as a chance for nonconformance, or not meeting the required specifications. This means the process needs to be nearly flawless in executing the key results. At its core, Six Sigma revolves around a few key concepts. Critical to Quality (CTQ) is one of the crucial concepts. Critical to Quality defines attributes most important to the customer.

2. THE INTEGRAL VERSION OF SIX SIGMA

Six Sigma methodology is about creating a value. Once the sources of variations in the process(es) or system(s) are identified, through structured sequence of steps that variation is reduced. Reduced variation automatically produce stable and cable process which outputs are conforming items. When producing conforming items, the nonconformities are eliminated. When nonconformities or defects are eliminated from process(es) or system(s) the overall costs are decreased. When overall costs are decreased, the value is created. This is basically the chain reaction of the Six Sigma methodology.

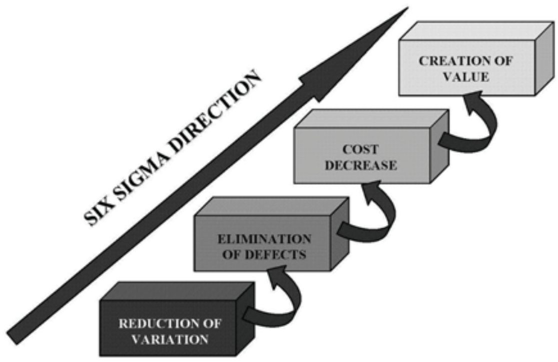

Figure 1. Six Sigma Process

The most important feature of Six Sigma methodology is Critical to Quality (CTQ) which is used to decompose broad customer requirements into more easily quantified requirements.
CTQs are the key measurable characteristics of a product or process whose performance standards or specification limits must be met in order to satisfy the customer. They align improvement or design efforts with customer requirements. CTQs represent the product or service characteristics that are defined by the customer (internal or external). They may include the upper and lower specification limits or any other factors related to the product or service. A CTQ usually must be interpreted from a qualitative customer statement to an actionable, quantitative business specification. CTQs are the internal critical quality parameters that relate to the wants and needs of the customer / final user.

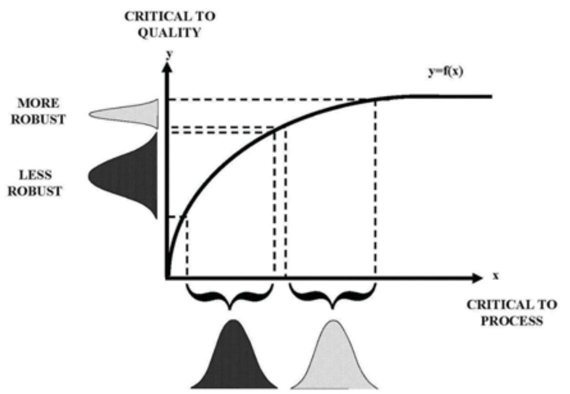

Figure 2. Critical to Quality (CTQ) Process

There are eight fundamental steps or stages involved in applying the Breakthrough Strategy to achieve Six Sigma performance in a process, system, or company. These eight steps are: Recognize Define, Measure, Analyze, Improve, Control, Standardize, and Integrate. Each phase is designed to ensure:

(1) that companies apply the Breakthrough Strategy in a methodical and disciplined way;
(2) that Six Sigma project are correctly defined and executed; and
(3) that the results of these projects are incorporated into running the day-to-day business.

The eight primary components of the Breakthrough Strategy fall into one of four categories. The Recognize and Define phases fall under the category of Identification, where companies begin to understand the fundamental concepts of Six Sigma and get sense of the Breakthrough Strategy as a problem-solving methodology with unique set of tools. Managers and employees begin to question inputs – the processes that go into creating a product or service – rather than simply inspecting the final product or service that is delivered to the customer / final user. Management can than create opportunities and an environment for change. In the Define phase, certain Six Sigma projects can be identified based on product an process benchmarking. The Measure and Analyze phases fall under the category of Characterization, where Critical-to-Quality (CTQ) characteristics in the process are measured and described. The Improve and Control phases fall under Optimization, because these two phases maximize and maintain the enhanced process capability. And finally, the Standardize and Integrate phases are part of Institutionalization, where the results of applying the entire Breakthrough Strategy are woven into the corporation's culture (Harry and Shroeder, 2000).

THE INTEGRAL SIX SIGMA ROADMAP			
BREAKTHROUGH STRATEGY	STAGE	PHASE	OBJECTIVE
	Identification	***R****ecognize* ***D****efine*	Identify key business issues
	Characterization	***M****easure* ***A****nalyze*	Understand current performance level
	Optimization	***I****mprove* ***C****ontrol*	Achieve breakthrough improvement
	Institutionalization	***S****tandardize* ***I****ntegrate*	Transform how day-to-day business is conducted

Table 1. The Integral Six Sigma Roadmap (Harry and Shroeder, 2000).

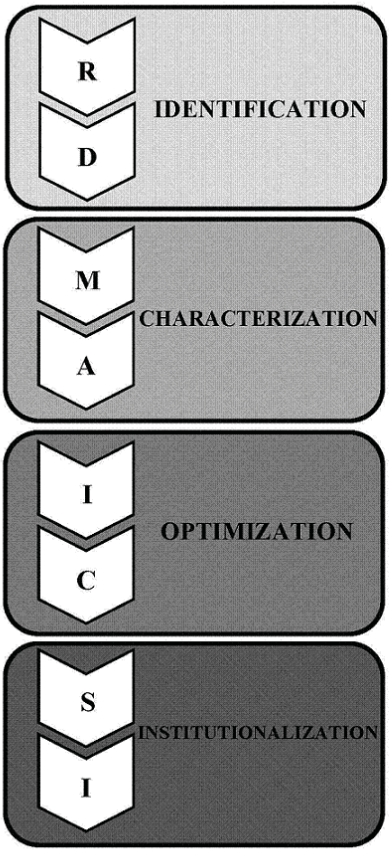

Figure 3. RDMAICSI – Six Sigma

2.1. Identification Stage
Business growth depends on how well companies meet customer expectations in terms of quality, price, and delivery. Their ability to satisfy these needs with a known degree of certainty is controlled by process capability, and the amount of variation in their processes which can be any kind of processes, ranging from administrative to service to sales to manufacturing. Variation has a direct impact on business results in terms of costs, cycle time, and the number of defects that affect customer satisfaction. Identification allows companies to recognize how their processes affect profitability and then define what the Critical-to-Business processes are. Recognize stands for a breakthrough in one's attitude, or a certainty that some improvements should be triggered (Harry and Shroeder, 2000). This kind of recognition is the start of sensing a crisis.

2.2. Characterization Stage
Characterization assesses where a process is at the time it is measured and helps to point to the goals a company should aspire to achieve. It establishes a baseline, or benchmark, and provides a starting point for measuring improvements. Following the Measure and Analyze phases that make up characterization, an action plan is created to close the gap between how things currently work and how the company would like them to work in order to meet company's goals for a particular product or service. In characterization, one or more of the product's key characteristics are selected and detailed description of every step in the process is created. Than certain measurement have been performed, result have been recorded, and short-term and long-term process capability is estimated (Harry and Shroeder, 2000).

2.3. Optimization Stage
Optimization identifies what steps need to be taken to improve a process and reduce the major sources of variation. The key process variables are identified through statistically designed experiments; these data is than used to establish which "knobs" must be adjusted to improve the process. Optimization looks at a large number of variables in order to determine the "vital few" variables that have the greatest impact. Using various analyses, it is determined which variables have the most leverage or exert the most influence. The final goal of optimization in the Breakthrough Strategy is to use the knowledge gained to improve and control a process. Results may be used to develop better process limits, modify how certain steps of the process are performed, or to choose better materials and equipment. In a nutshell, optimization improves and controls the key variables that exert the greatest influence on a product's key characteristics. This provides the organization with an array of improvements that ultimately improve profitability and customer satisfaction, as well as increase shareholder value (Harry and Shroeder, 2000).

2.4. Institutionalization Stage
The Standardize and Integrate phases that make up Institutionalization address the integration of Six Sigma into the way the business is managed on daily basis. Six Sigma involves more than just focusing on each phase of project completion. It also offers a way to step back and look how the collective results of smaller projects affect the large, high-level processes that run the day-to-day business. As companies learn what kind of measures and metrics are needed to drive improvement, these insights have to be integrated into management's thinking and intellectual capital. The Standardize phase ties together the many Six Sigma projects within a business and works to identify the best practices and to standardize those practices within and across the businesses. As companies improve the performance of various processes, they should standardize the way those processes are run and managed. Standardization allows companies to design their processes to work more effectively by using existing processes, components, methods, and materials that have already been optimized and that have proven their success. The Integrate phase modifies the organization's management processes by taking advantage of the best practices identified through

Six Sigma projects to support overall Six Sigma philosophy (Harry and Shroeder, 2000).

4. CONCLUSION

The success of any Six Sigma initiative is largely driven by the following factors: Does company's leadership understand and are they completely behind implementing Six Sigma? Is company open and ready to change? Is company hungry to learn? Is company anxious to move quickly on a proven idea? Is company willing to commit resources – people and money – to implement this initiative? Is organization and its people ready and able to re-create its values so that there are no roadblocks to achieving the vision of Six Sigma?

Traditionally, organizations compare current performance with past performance, not with what might have been or what is yet to be. Six Sigma tears down the structures that protecting the existing systems. The Breakthrough Strategy gives organizations a road map to business situations not yet on the horizon or issues that are so unprecedented that there is no time to learn by trial and error. People can't change unless they are made aware of their current reality. Awareness of this reality comes through the accumulation of unquestionable evidence known as data. New measurements create new data, and new data (when properly analyzed and interpreted) lead to new knowledge. In turn, new knowledge leads to new beliefs, and new beliefs lead to new values. New values, when cultivated through success and properly reinforced, create passion. And passion is the root of profound change (Harry and Shroeder, 2000).

The Integral version of Six Sigma places a clear focus on achieving measurable and quantifiable financial returns to the bottom-line of an organization, unprecedented importance on strong and passionate leadership and the support required for its successful deployment, it integrates the human elements, utilizes the tools and techniques for fixing problems in business processes in a sequential and disciplined fashion, emphasizes the importance of data and decision making based on facts and data utilizes the concept of statistical thinking and encourages the application of well proven statistical tools and techniques for defect reduction through process variability reduction methods (Fiju, 2004), it considers the optimal expenditure of resources, and creates value for the customer.

All quality improvement occurs on a project-by-project basis and there is no other way (Juran J., 1964). This statement can be considered an essential element in the foundation of the integral Six Sigma Methodology. Finances spent on Integral Six Sigma projects should not be considered as cost; they rather be considered as investment due to their long-term effects (Bisgaard and Freiesleben, 2004).

The integral version of Six Sigma methodology is very important because it provides structured sequence of steps that need to be taken in order to successfully accomplish any business or system or process related task.

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INTEGRATED MANAGEMENT SYSTEM AND PERFORMANCE

Tanja Milanović[1], Snežana Knežević[2], Zoran Milanović[3],
[1]PRO-QUALITY, Consulting Agency, Belgrade, Serbia
milanovic.tanja@open.telekom.rs
[2] Railway Technical School, Belgrade, Serbia;
sknezevic1604@gmail.com
[3]The Academy of Criminalistic and Police Studies, Belgrade, Serbia; zoran.milanovic@kpa.edu.rs

Abstract: *Some further research has been requested by unresolved issue of relationship between Quality Management and Business Performance. The contemporary trend of integration of different management systems moreover emphasizes this issue. With basic assumption that integration generates benefits, a study of relationship between Integrated Management System (IMS) and Business Performances has been carried out. Being chosen as a framework for performance measurement, Balanced Scorecard implies financial perspective, customer perspective, internal processes perspective (operating perspective) and development perspective measurements. Results reveal significant, but moderate relationship, partially due to the young IMS and in some extent caused by motives for implementation, as we concluded.*

Key words: *Integrated Management System, Business Performance, Balanced Scorecard*

1. INTRODUCTION

A contemporary business condition deletes a permanent dilemma "Is management a science or a skill." When managing organizations today, management is less a skill and more science pronounced in the selection and application of appropriate management system. One of the key management activities is aiming, creating and maintaining harmony between strategic organization objectives and resource and changing market opportunities [1]. The solution to this problem is offered through the integration of different management systems, established pursuant the requirements specified by international standards.

Considering that certification today is widely accepted as "business passport" [2] and "quality badge" [3], the growing trend in the number of certified organizations is quite understandable. With nearly 1.5 million certificates in 178 countries [4], ISO standards have become a global phenomenon, although the question of their effect on business performance is still open due to the fact that in many organizations implementation of standard did not lead to performance improvement.

The results of ISO 9000 exploration further emphasize the discrepancy between the popularity of standards and lack of positive effects of its application. The contradictory results lead to one general conclusion - a causal link between standards implementation and improved performance has not been proven. So, the aim of this study is to establish the relationship between the implementation of Integrated Management System (IMS) and the business performance of the organization.

2. LITERATURE REVIEW AND HIPOTHESIS FORMULATION

The main reason for the integration of different management systems in the literature was emphasized through a number of benefits (Table 1) which can be classified into three categories: operative, financial and market benefits. Authors [5], among other things, suggest that IMS leads to improvement of overall organization performance. In [6] and [7], IMS is considered as a means for sustainable development.

Based on the studies specified in Table 1, the main hypothesis is developed:

H1: System-structuring and process-implementation of IMS directly and positively affect business performance.

There is no universal frame for performance measurement. Different authors measure them in different ways. Performance measurement chosen in this research was Balanced Scorecard (BSC), which includes the financial perspective, internal process perspective, development perspective and customer perspective.

Table 1. The benefits of IMS implementation

Benefits		Literature review
Reducing documentation	Eliminating of documentation duplication	Douglas, Glen, [8] McDonald et al. [5] Zutshl, Sohal, [9]
Customer requirements	Business necessity	McDonald et al. [5]
	Increased customer satisfaction	Douglas, Glen, [8] Zutshl, Sohal, [9]
Cost reduction	Cost reduction in manufacturing, business	Jorgensen et al. [10] Wrignt, [11] Douglas, Glen, [8] Zeng et al. [12] Zutshl, Sohal, [9] McDonald et al. [5]
Operational benefits	Operational improvements	Fresner, Engelhardt [6] Holdsworth, [13] Jorgensen et al. [10] McDonald et al. [5]
	Simplified system	Douglas, Glen, [8] Zutshl, Sohal, [9]
	Saving time	Zutshl, Sohal, [9]
	Synergistic effect between systems	Rocha et al. [7]
	Merge internal audit	Salomone [14]
	Unique employee training	Salomone [14]
	Joint framework for continuous improvement	McDonald et al. [5]
	Improvement of overall organizational performance	McDonald et al. [5]
Allocation and utilization of Resources. Other benefits	Better allocation of resources	Zeng et al. [12]
	Employee protection	Salomone [14]
	Better utilization of resources	Rocha et al. [7]
	Strategic planning	Zutshl, Sohal, [9]
	Holistic approach	Zutshl, Sohal, [9]
	Improving of interdepartmental communication	Douglas, Glen, [8] Wrignt, [11] Zutshl, Sohal, [9]
	Better definition of responsibilities	Salomone [14]
	A means for sustainable development	Fresner, Engelhardt [6] Rocha et al. [7]

Although the BSC performance measurement framework is often criticized as too easy and inconsistent, it was chosen in this research for reasons, as follows: it is a methodology that mission, vision and strategy translates into an understandable set of measures providing the framework for implementing strategies; BSC is used to transform the organizational strategic objectives in the performance indicators; BSC is suitable for application due to its rationality and profitability by tracking the optimal number of key characteristics whose selection emerged from the vision and strategy of the organization [15].

3. METHODOLOGY

3.1. Instrument development

For testing the hypotheses, an original measurement instrument was developed. The measurement of system and process applications of IMS throughout the organization was conducted with the following constructs:

System approach (SA) - a construct measure whether the structural entities required by IMS are established, processes identified, linked and aligned with the requirements of integrated management systems and whether the mission, vision, policies and strategies are presented throughout the organization in a clear and transparent manner.

Process approach (PA) - construct is designed to measure whether all identified processes are described in the procedures, monitored, measured and improved.

Continuous improvement (CI) - construct measures of whether the product/service is permanently improving, priorities for improvement are identified and to what extent advanced information technologies are used for analysis.

Business performance is measured by the following constructs:

Financial perspective (FP) – construct measures revenue growth, profits, total revenues per employee and productivity.

Customer perspective (CP) – construct measures the degree of fulfillment of customer requirements, availability of products/services, a way for solving problems and the existence of a database for tracking customer relationships.

Internal processes perspective (IP)– construct measures the proportion of non-compliant products/ services relative to the total volume of products/ services, the cost of the warranty in relation to sales, cost of quality in relation to total revenue and cost of advanced information technology.

Development perspective (DP) – construct measures the investment in research and development, capacity expansion, developing new and improving existing products/ services, new markets, increase in number of employees.

The final measuring instrument consists of 29 items. All constructs are measured with five-point scale except the construct **operational performance** in items related to cost. For their evaluation, certain responses were offered and during processing converted into Likert scale. The criterion for evaluation was: 1 - absolutely disagree with the statement, 2 - disagree with the statement, 3 - partially agree with the statement, 4 - agree with the statement, 5 - strongly agree with the statement. Measuring instrument - the questionnaire is designed as client-oriented Web applications and as such is distributed to the respondents. The collected data are poured in MySQL database

3.2 Sample

Proposed hypotheses were tested on a sample of Serbian companies. According to the Republic Bureau of Statistics and Serbian Chamber of Commerce, Republic of Serbia has 293 IMS certified subjects, as of February 2012. After consulting the database of the Agency for Business Registers, 180 companies have been selected for survey. Selected companies were contacted by phone and, with short explanation of the goal, they were asked to participate in research. Those who gave consent were sent an e-mail with a brief explanation of procedure and the site address which contained a survey. A total 60 responses were obtained. The sample consists of 40% small, 31% medium and 28% large companies.

4. RESULTS

The data collected from the survey of the Serbian companies were analysed by descriptive statistics, reliability analyses, criterion-related validity (correlation analysis) and construct validity (factor analysis). The results of descriptive statistics are given in Table 2.

Reliability analyses indicate the improvemet of scale after dropping items, as folowing: CI3– review documentation in accordance with the needs and PK5-level of customer satisfaction. **Criterion-related validity** is measured through correlation coefficient of seven factors of quality management and performance. Correlation analysis is shown in Table 3. Most of the relations (15) was statistically significant (p<0.01 or p<0.05). Six correlations were not statistically significant. Therefore, criteria-related validity is accepted.

Table 1. Factor analysis

	F 1	*variance explained*	*% of variance*	*Eigenvalue*
SA	0.752–0.855	2.468	61.691	2.468
PA	0.704–0.790	2.295	57.364	2.295
CI	0.808–0.832	1.619	53.953	1.619
FP	0.848–0.930	3.081	77.037	3.081
IP	0.747–0.784	2.344	58.588	2.344
DP	0.768–0.816	2.991	59.826	2.991

CP	*component*	
	F1	*F2*
CP1	0.631	-0.575
CP2	0.691	-0.487
CP3	0.721	0.275
CP4	0.672	0.399
Variance explained	1.987	1.192
% of variance	39.741	23.843
Eigen value	1.987	1.192

Construct validity is calculated through a factor analysis for each of the constructs. Factor analysis implies that Customer focus is not one-factor, so deeper analyses is required. Items loading, Eigenvalue and percentage of variance explained by F1 is shown in Table 4.

The results of obtained analysis indicate that the reliability and validity of the construct improved by omitting a number of items (dimensions of the construct). The initial measuring instrument of 29 items is reduced to 27 items.

Table 2. Descriptive and reliability analyses

Construct	mean	SD	α after dropping		α
SA	4.38	0.69	SA1 SA2 SA3 SA4	0.745 0.759 0.688 0.760	0.790
PA	4.27	0.74	PA1 PA2 PA3 PA4	0.696 0.728 0.656 0.669	0.749
CI	4.2	0.89	CI1 CI2 CI3	0.362 0.287 0.637	~~0.549~~ 0.637
FP	3.52	0.81	FP1 FP2 FP3 FP4	0.886 0.839 0.870 0.887	0.900
CP	4.21	0.72	CP1 CP2 CP3 CP4 CP5	0.561 0.512 0.512 0.532 0.630	~~0.607~~ 0.630
IP	4.37	0.37	IP1 IP2 IP3 IP4	0.701 0.719 0.715 0.693	0.763
DP	3.49	1.17	DP1 DP2 DP3 DP4 DP5	0.792 0.766 0.809 0.777 0.789	0.822

Table 3. Correlation analysis

	SA	PA	CI	FP	CP	IP	DP
SA	1						
PA	0,427 0,001	1					
CI	0,406 0,001	0,467 0,000	1				
FP	0,312 0,015	0,286 0,027	0,251 0,053	1			
CP	0,450 0,000	0,400 0,002	0,585 0,000	0,297 0,21	1		
IP	0,415 0,001	0,037 0,778	0,196 0,134	0,205 0,116	0,306 0,018	1	
DP	0,414 0,001	0,374 0,003	0,503 0,000	0,757 0,000	0,505 0,000	0,086 0,515	1

5. DISCUSSION AND CONCLUSION

The application of IMS observed through variables **system approach**, **process approach** and **continuous improvement**, is highly evaluated. Although the average length of application is two years, such high score IMS can be explained with the long previous implementation of QMS (Quality Management System according to ISO 9001), which most organizations used as a basis for other management systems integration. According to [16] in Serbian context, earlier adopters of ISO 9000 have higher level of QMS practice and, consequently, better performances.

The general view of organizations is a rising trend of business performance, while greatest improvement is shown in internal processes perspective. Also, the customer perspective shows an awareness of the importance of customers whose desires and needs are taken into account. Financial performance showed a slight stagnation. Development perspective has the lowest mean value, with contradictory results that investment in developing new products and new markets is growing while, on the other hand, the number of employee's is decreasing.

Low levels of financial and development performance can be explained by the transition process which carries a range of negative effects that are reflected in the orientation of Serbian enterprises towards the achievement of results, while the perspective of an individual (employee), currently is marginalized. In addition, we must not neglect the impact of the global economic crisis.

The correlation matrix (Table 3.) shows the impact of IMS on business performance, although not in the expected extent. Most of the correlations are significant; however, their strength is moderate. Such result may rather be a reflection of the motives for certification, then incoherence of IMS with business performances. Organizations with certification as primary goal (for receiving tenders, for example) achieve lower benefits, as opposed to organizations which the motive for IMS implementation seeks in development or some other internal purposes.

Considering the length of IMS applications and obtained results and with the implications resulting from a literature review, it would be very useful to repeat the study for three years. One could argue that this research is premature; however, it is useful. The results indicate the existence of causality between the IMS and business performance. With the maturing of IMS and with expansion of its application, it would be possible to obtain more precise results. Absence of previously mentioned conditions is, therefore, a major limitation of this study.

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RESEARCH OF THE CHANGE RATE OF UNCOMPENSATED CENTRIFUGAL ACCELERATION IN SPECIFIC POINTS OF SOME TYPES OF TRANSITION CURVES

Nikolay Arnaudov[1], Maya Ivanova[2]
[1]MSc-Eng., University of Transport ”Todor Kableshkov”, 158 Geo Milev Street, Sofia, 1574, Bulgaria, nikiarbg@mail.bg
[2]Assoc. Prof., University of Transport ”Todor Kableshkov”, 158 Geo Milev Stret, Sofia, Bulgaria, 1574, mai_5e@abv.bg

Abstract: *Research of the change rate of uncompensated centrifugal acceleration of some types of transition curves has been made. And for that matter linear approximations and calculus methods have been used. The results have been compared with the limit values in the Bulgarian Regulations.*
Key Words: *uncompensated centrifugal acceleration, transition curve, centripetal acceleration, ramp of cant*

INTRODUCTION

The uncompensated centrifugal acceleration, caused by the centrifugal force, has the biggest dynamic impact on safety, security and comfort of the passengers during the movement of train along the circle and transition curve. Because of that there is a need to reduce the effect of this acceleration. One way is to make cant - difference in elevation (height) between the inner and outer rail, but here appears new force – centripetal force, caused by the inclination of wagon to the center of the curve. This force in some cases has also unfavourable effect – in case of emergency if the train stops in the circle curve.

The researches of the impact of the uncompensated centrifugal acceleration on passengers show that values from $\alpha_{н}$=0,15 m/s^2 can hardly be felt. Up to this value of the acceleration the trains are moving tranquilly, the passengers are quite comfortable the goods are lying steadily and the rails are wearing out evenly. By increase of the lateral accelerations to $\alpha_{н}$ =0,31 m/s^2 the passengers are beginning to feel some discomfort, but the movement of the train is still steady according to all indicators. When the lateral acceleration is reaching from 0,6 to 0,7 m/s^2 the movement of the train becomes unsteady, the goods are beginning to come out of their places, the rails are being loaded unevenly and therefore they are being wearied out unevenly. The passengers are loosing their feel for comfort and become nervous, although the safety movement of the train is not yet in danger. By lateral accelerations with measures 1,3 – 1,4 m/s^2, the movement of the train become critical, the goods are beginning to glide, the movement is extremely unstable, the wearing out of the rails reaches a magnitude, that the rails might get destroyed or other elements of the superstructure can be damaged or even it may comes to accidents with serious consequences.

According to the Bulgarian Regulation №55 for design and building of rail ways, stations, crossings and other elements of the rail road infrastructure, in Bulgaria is admitted 0,65 m/s^2 as the maximal value of the centrifugal acceleration and the maximal centripetal acceleration by emergency train stop in curve between two stations or in station in curve without pat form - 0,98 m/s^2 by maximal admitted cant 150 mm (railroads first and second category) and 1,05 m/s^2 by cant of 160 mm (speedways). These limitary values will be further used for comparison of the results.

As we know the uncompensated centrifugal acceleration in circular curve can be estimated with the following formula:

$$\alpha_{н} = \frac{V^2}{13.R} - \frac{h}{153}, \text{ (m/s}^2\text{)} \qquad (1)$$

where

V is the speed of the train in km/h;

R is the radius of the circular curve in m;

h is the cant (superelevation between the two rails) in mm;

In the transition curve the radius and the cant are changing constantly. According to Bulgarian Regulation №55, the ramp of the cants gradually change is a straight with a slope $K=10.V_{max}$. By new road design the beginning of the ramp is identical with the transition curve begin (TCB or НПК, fig. 2) and the end of the ramp is identical with the transition curve end (TCE or КПК). Therefore when the cant and the length of the transition curve are calculated in advance through linear interpolation, the value of the cant in random point of the transition curve can be estimated.

The radius in the transition curve is changing its value from $\rho=\infty$ in TCB to $\rho=R$ in TCE. In the interval from TCB to TCE ρ is changing from $+\infty$ to R constantly, lightly and monotonously. The radius in one random point of the transition curve can be estimated through linear approximation and calculus method. After the estimation of the unknown values through the formula (1) the uncompensated centrifugal acceleration can be calculated for a random point of the transition curve.

In this comparative analysis it will be considered different types of transition curves: cubic parabola, clothoide, Blos's curve and two variants of Schramm's curve in speed interval from 100 to 200 km/h. For the purpose to be shown the most unfavorable results, it will be worked here with the minimal admitted radiuses according to Bulgarian Regulation №55 for relevant speeds: for 100km/h the rate of the minimal radius R is 500 m, for 130 km/h R=800m, for 160 km/h R=1500m and for 200km/h R=2500m.

In the beginning and only for the needs of the comparative analysis it will be considered one more unfavorable case for the speed of 200km/h and R=2000m (in this case it becomes maximal length of the transition curve and maximal cant of 160mm). For the need of easiest calculating it was compounded an MS Office Excel algorithm and the results are shown in the next *table 1* below.

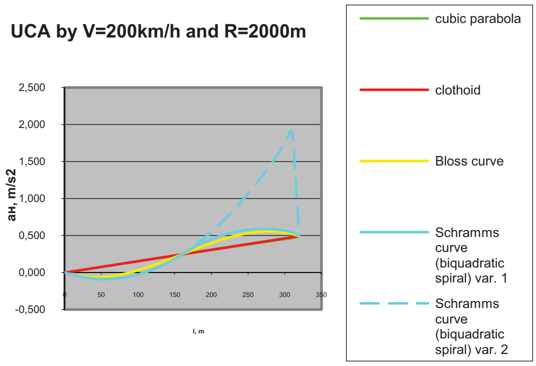

Fig. 1

The table makes it visible, that the change of the lateral uncompensated centrifugal acceleration (UCA) by cubic parabola and clothoide is linear along the length of the transition curve and it reaches its maximal rate in the circular curve, which in this case is 0,49 m/s^2 , while the graph data of these two types of transition curves are almost completely identical. Therefore for the Bulgarian conditions, even by this most unfavorable case (from the view point of the transition curve's length), the two types of transition curves have identical, even almost completely identical geometric as well as dynamic characteristics. In contrast to them, by the other two types of transition curves, the situation is different. As it is shown on the *table 1*, the Blos's curve and the first variant of the Schramm's curve have curvilinear graph data of change of the accelerations. And there are extremum points of the two curves, which positive values exceed the value of the acceleration in the circular curve. This is due to the fact, that the ramp of the cant is rectilinear. If the ramp of the cant were realized according to the theory, shown here in the fig. 2 below, with a type, similar to the lineament of the graph data of the two curves, then they would have a linear change of the increase of the acceleration or again a curvilinear change, but with much smaller extremum points.

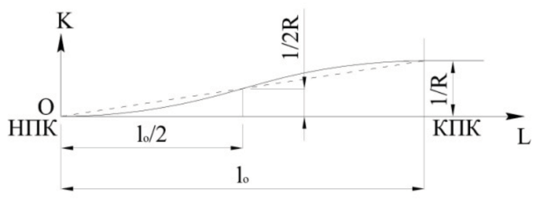

Fig. 2

Also it is evident, that in the first section of the transition curve the centrifugal acceleration has negative values, which means that a centripetal acceleration appears. This is again due to the rectilinear lineament of the ramp of the cant, because the curvature of these two types of transition curves is changing slowly than the increase of the ramp of the cant (the more the equation of the transition curve is involving higher power, the more the transition curve in its first section is getting near to a straight line) and actually the acceleration by taking up the outside wheel in this section is higher than the centrifugal acceleration.

In geometrical way variant 2 of the Schramm's curve was estimated as the coordinates of detailed points were calculated with the formulas for the first half of the curve, but along the whole length of the transition curve. The result is a type of a curve, which has a first section with smaller curvature in comparison with a cubic parabola and clothoide, but in the transition curve end /TCE/ it has an equal offset - *p* with them (in contrast to the Blos's curve and variant 1 of the Schramm's curve, by which the movement aside is smaller.) The answer of the question, if such type of a curve is usable in the railways as a transition curve, gives us figure (1). There is clearly shown, that in the second section of the transition curve the lateral uncompensated centrifugal accelerations are increasing to such an extent, that exceed the admissible levels quite a lot (0,65 m/s^2), after that in the TCE follows a sudden dynamic hit in order to reach their values in the circular curve. This result presents, that in order to compensate the first straighter in geometrical sense section of the transition curve, in the end section the radius intensive decreases and reaches values smaller than the radius in the circular curve, which is presented below in the *table 1* with the calculations as follows:

Table 1.

$\alpha_н$	h	R	Δ y	Δ x	dy/dx	Δ m	Δ x'	d^2y/dx^2
0.000	0	∞						
-0.03	5	877714.29	0.000	10.000	6.51042E-06	0.0000113932	10	1.13932E-06
-0.05	10	245760.00	0.000	10.000	3.25521E-05	4.06901E-05	10	4.06901E-06
-0.07	15	111709.09	0.001	10.000	9.76563E-05	8.95182E-05	10	8.95182E-06
-0.08	20	63340.20	0.001	10.000	0.000221354	0.000157878	10	1.57878E-05
-0.09	25	40688.74	0.003	10.000	0.000423177	0.000245768	10	2.45768E-05
-0.09	30	28313.36	0.005	10.000	0.000722656	0.00035319	10	3.5319E-05
-0.08	35	20827.10	0.009	10.000	0.001139324	0.000480144	10	4.80145E-05
-0.07	39.999	15958.42	0.014	10.000	0.001692711	0.00062663	10	6.26631E-05
-0.05	44.999	12615.98	0.020	10.000	0.002402351	0.00079265	10	7.92653E-05
-0.03	49.999	10222.90	0.028	10.000	0.00328778	0.000978206	9.99	9.78212E-05
0.005	54.999	8451.08	0.038	10.000	0.004368534	0.001183302	9.99	0.000118331
0.041	59.999	7102.77	0.050	10.000	0.005664158	0.001407946	9.99	0.000140797
0.083	64.999	6053.04	0.064	10.000	0.007194205	0.001652147	9.99	0.000165219
0.132	69.99	5219.83	0.080	10.000	0.00897824	0.001915923	9.99	0.0001916
0.186	74.099	4547.46	0.099	10.000	0.01103585	0.002199297	9.99	0.000219943
0.247	79.998	3997.03	0.121	9.999	0.013386651	0.002502304	9.99	0.000250253
0.313	84.998	3540.74	0.146	9.999	0.016050297	0.002824989	9.99	0.000282536
0.386	89.997	3158.28	0.175	9.998	0.019046502	0.00316742	9.99	0.0003168
0.465	94.996	2834.53	0.206	9.998	0.022395052	0.003529681	9.99	0.000353057
0.549	99.995	2558.05	0.242	9.997	0.026115837	0.003911888	9.99	0.000391323
0.64	104.99	2320.04	0.281	9.996	0.030228876	0.00431419	9.99	0.000431617
0.737	109.99	2113.68	0.324	9.995	0.034754361	0.004736778	9.99	0.000473965
0.84	114.98	1933.58	0.371	9.993	0.039712698	0.005179895	9.99	0.0005184
0.949	119.98	1775.44	0.423	9.991	0.045124569	0.005643847	9.98	0.000564962
1.064	124.97	1635.82	0.479	9.989	0.051010999	0.006129013	9.9	0.000613701
1.186	129.96	1511.92	0.540	9.985	0.057393436	0.006635862	9.98	0.000664682
1.313	134.96	1401.44	0.606	9.982	0.064293852	0.00716497	9.97	0.000717981
1.448	139.94	1302.49	0.677	9.977	0.071734855	0.007717036	9.97	0.000773692
1.588	144.93	1213.51	0.754	9.972	0.079739826	0.008292905	9.96	0.000831928
1.735	149.91	1133.17	0.836	9.965	0.088333075	0.008893593	9.96	0.000892827
1.889	154.89	1060.38	0.924	9.957	0.09754003	0.009520317	9.95	0.000956553
0.493	160	2000	1.018	9.948				

This is inadmissible and leads to dynamic break in the transition curve end (TCE), which is in breach of the theory for the transition curves and also in breach of the rules for fluent and safety movement of the trains. This type of transition curve can't be used in the railways and therefore it will not be considered further. Now the above described worst case scenario will be respectively elaborated. And the results are presented in fig. 3 for an admissible speed V = 200 km/h and radius R=2500 m:

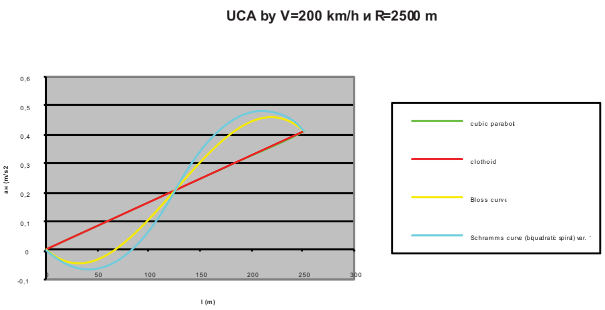

Fig. 3

Fig. 3 presents, that the values of the accelerations are in the admissible limits. The graph data for the change of the uncompensated centrifugal acceleration are analogous to the first case for the different types of transition curves.

The results are presented in fig. 4 for an admissible speed V = 160 km/h and a minimal admissible radius R=1500 m:

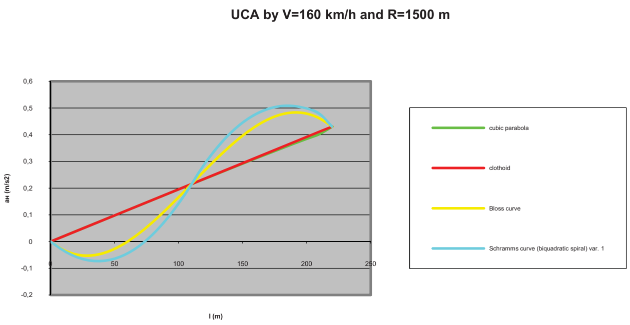

Fig. 4

And also here it is presented, that the type of graph data are analogous to the above two cases and the difference is only in the size of the extremum values of the Blos's curve and the Schramm's curve and also in the size of the acceleration in the transition curve. In analogous way the results for the two other cases are estimated – V= 100 km/h and R=500 m and V=130 km/h and R=800 m.

Fig. 5 presents the change of the maximum, middle and minimal values of the uncompensated centrifugal acceleration for the various minimal admissible values in the speed range 100 – 200 km/h.

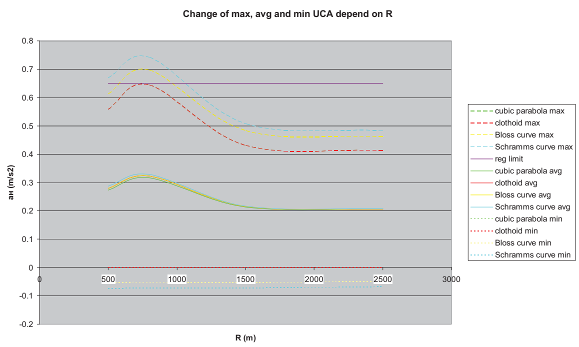

Fig. 5

Fig. 5 shows, that the most unfavorable case is estimated by radius R=800m and speed V=130 km/h. Here in the transition curve end (TCE) α_H =0,6446 m/s^2 whereas by the Blos's curve and the Schramm's curve there is even an exceeding of the admissible value in the extremum point. The minimal values of the two types of transition curves are in the limit values of the admissible maximal centripetal acceleration. It will be more acceptable by a railway design with this project speed to avoid working with the minimal admissible radius.

The Schramm's curve has also such exceeding of the admissible value for radius R=500 m and speed V=100km/h, while the Blos's curve is situated in the limit. By higher speeds and radiuses the maximal values for each of the four types of transition curves are in the admissible limits.

CONCLUSIONS

In the speed range 100-200 km/h according to the rules of Bulgarian regulation №55, in dynamical and geometrical way the most appropriate for use are the cubic parabola and the clothoide as the differences with regard to the geometry and the arising dynamic forces of the cubic parabola and the clothoide (which increase linear till their maximal value in the transition curve end) are unsubstantially small. By the Blos's curve and the Schramm's curve the acceleration along the length of the transition curve are changing non-linear. Positive extremum values (higher values than these in the circular curve) and negative extremum values (centripetal acceleration) are estimated, which are due to the rectilinear lineament of the ramp of the cant. Variant 2 of the Schramm's curve, which has an offset equal with the cubic parabola and clothoide, is inapplicable for use in railway and in road design as a transition curve, because of violating the rules for smoothness and undisruptability of movement and there is an dynamic break in the transition curve end.

By project speeds up to 130 km/h it is recommended to avoid using the minimal admissible radius R=800 m because of the fact that in this case it is reaching the limited value of the uncompensated centrifugal acceleration by clothoide and cubic parabola. And by Blos's curve and the Schramm`s curve it is even over the limit whereby the purpose of the design of high speed railways is for the uncompensated centrifugal acceleration not to exceed 0,5 m/s^2.

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USING LINEAR PROGRAMMING IN OPTIMAL CHARGE MODELING FOR PYROMETALLURGICAL COPPER PRODUCTION

Ivan Mihajlović, Nada Štrbac, Ivan Jovanović, Živan Živković, Predrag Đorđević
University of Belgrade – Technical faculty in Bor, Management department

ABSTRACT. *This paper presents the results of linear programming (LP) procedure applied on the blending problem. The main aim of the study was to develop the procedure for determining the optimal mix of different copper concentrates which could be treated in pyrometallurgical copper production without* SO_2 *and heavy metal emission (in the* PM_{10} *form) above the internationally prescribed limiting values. This research is the part of the project: Developing technological processes for nonstandard copper concentrates processing with the aim to decrease pollutants emission. The project is financially supported by the Serbian Ministry of Science and Education. One of direct benefits of the model developed in this paper is the possibility to asses the potential of utilizing different copper containing raw materials in copper extraction, according to their composition.*

Keywords: *Linear programming, modeling, blending problem, copper.*

INTRODUCTION

During the last 50 years, pyrometalurgical technology for copper production was extremely modernized. Starting point was the classical process of copper concentrate oxidative roasting followed by subsequent smelting in the reverberatory furnace. The product of smelting – copper matte is subsequently submitted for further purification in the converters. Besides this main product, two most important by products of this technology are the smelting slag and the off gases generating during the process. Smelting slag, containing up to 0.6% of copper, is either deposited on the waste yards (in most cases) or further processed to extract remaining copper (not that often). Off gases of the copper extraction process contain certain amount of SO_2, considering that starting copper concentrates are composites of sulfide minerals. These gases are submitted to dust removal and to sulfuric acid production, considering high SO_2 content. Until 1970 this, this was the main technological process for copper production. Having in mind high energy requirements, low copper utilization, large amount of waste materials and insufficient environment protection, this process is extensively replaced with new technologies such are: Outokumpu flash furnace, Ausmelt technology, Noranda reactor, Mitsubishi smelting concept, El Teniente converter, etc [1,2]. The only remaining reverberatory furnace is the one which is still in use in Mining and Metallurgy Complex in Bor (RTB Bor), Serbia.

New technologies for copper production are with largely increased copper utilization. On the other hand in most new technologies for copper extraction, copper content in the slag is increased reaching up to 6%. This requires additional unit for slag treatment and extraction of copper carried with this waste material. Even with additional units for copper extraction from the slag, energy requirements are much less compared to the traditional reverberatory furnace. From that reason even the last company which operates reverberatory furnace is in the project of replacing the old furnace with Outokumpu flash technology. However, even the new technology for copper extraction does have some constraints considering the content of the highly toxic materials in the starting materials which can be used for the copper extraction, e.g. copper concentrates.

Highly toxic materials potentially present in the copper concentrates, such are: Ni, As, Cd, Hg, Pb, Zn and other metallic impurities, if present in increased content, can leave the process in the form of fumes or particle meter (PM_{10} or $PM_{2.5}$), carried by the off gas. New technologies of copper extraction increased overall copper production in the world, leading to intensive consumption of pure row materials for the production. Remaining row materials are usually with the high contents of some of the toxic impurities. The situation is the same with remaining ore bodies in the Bor copper mine. Some of the remaining ore bodies

are rich in copper content; however the content of impurities – especially arsenic – is usually very high.
The reason for conduction the research presented in this paper is in attempt to analyze the possibility of forming the mixture of concentrates of high purity with small ratio of these containing increased content of toxic impurities, which will result in off gasses emission below the prescribed upper levels, defined by the World Health Organization [3] and the EU regulative [4].

ENVIRONMENTAL ISSUE

Besides the copper minerals, ore bodies in Bor copper mine, contain the minerals of *Se*, *Bi*, *Cr*, *Cl*, *Sb*, *Cd*, *As*, *Zn*, *Pb*, *S*, *Ni*, *Fe*, *and Hg*, which partially remain in the final copper concentrate even after flotation separation process. Largest problem is with the sulfide copper minerals containing arsenic, which are transferred in the copper concentrates entirely, being impossible to separate them from the other sulfidic copper bearing minerals [5]. At the increased temperatures of copper extraction in the pyrometallurgical processes, heavy metal sulfidic minerals are oxidized or sublimated, leaving the smelting unit as fumes or in the PM form [6]. Modern copper smelters are equipped with contemporary facilities for PM removal from the off gases, as well as for high SO_2 utilization. However, even such facilities are presenting the largest environmental polluters in the regions in which they operate [7].
Copper smelters using the outdated technologies, or smelting the low quality concentrates, are emitting the PM_{10} and the SO_2 highly above the prescribed limits, which is presenting serious hazard for people's health [8]. This is the reason why The World Health Organization [3] prescribed the limiting values of SO_2, PM_{10} and heavy metals in the air surrounding such industrial facilities. EU is also limiting the content of such pollutants in the ambient air [4, 8], with the regulations that are obligatory for the companies. However, world metal market is overloaded with the copper concentrates containing high content of impurities which will for certain result in increased PM_{10} and heavy metals emission in the air, above prescribed limits, after pyrometallurgical treatment, even in facilities operating new technological processes. The reason is laying in the fact that most of the common copper mines have almost depleted their high purity raw materials ore bodies. Remaining ones are on the outskirts of the ore veins and as such usually containing increased content of impurities which cannot be completely eliminated during the flotation separation of copper concentrates. Also, there are large reserves of enargitic copper ores in some parts in the world, which besides being rich in copper, gold and silver, usually contain increased amount of arsenic in the enargite mineral form (Cu_3AsS_4).

POSSIBLE SOLUTION: OPTIMAL CHARGE BLENDING PROCEDURE

The presence of useful (Cu, Au, Ag) and unwanted elements (As, Hg, Zn, Pb, Cd, Ni, …) in the copper concentrates is largely influencing its value which is formed on the Worlds Metal Market [9], according to the demand and supply principle. The system for concentrate price development does contain "bonuses" for the high content of useful compounds, and also there are any "penalties" for the unwanted ones. Sulfur in the concentrate can be regarded both as useful and the unwanted element. However, usually there isn't any limit of the unwanted materials content in the concentrate, above which it will be considered as high toxicity material which cannot be offered on the worlds metal marked. This is the reason why even extremely "dirty" concentrates can arrive to some of the smelter plants, being purchased for low price.
This paper is trying to approach this problem from the different aspect. In this paper the model of optimal charge blending is developed and described. This model is analyzing the possibilities to mix copper concentrates with different level of purity in such manner to obtain the pyrometallurgical charge which can be safely processed without any environmental hazard. Contents of the impurities in the concentrates, above which its emission in the off gases will be above the prescribed limits, were considered as the constraints of the model. The problem is basically considering the amount of different types of concentrates which can be mixed in the charge, for producing of quality copper mate, with optimal raw materials purchasing cost and under the prescribed environmental limitations.
In the contemporary literature, the blending procedure for optimization the copper concentrates charge, to be used in pyrometallurgical copper production, is not described at all. There are some papers described blending problem in the oil industry [10], papers dealing with optimal mixtures in coal preparation to be used for thermoelectric power plants [11] and in fertilizers production [12].
This way the idea to apply the linear programming methodology, in solving the charge blending problem, for the copper production can be regarded as the new approach.
The blending problem solving, described in this paper, is based on linear programming (LP) approach. Linear programming is the part of the operations research aiming to determine the extreme of the linear function, depending on more then one variables. The constraints are including nonnegative behavior of the independent variables and certain limiting values in the form of equalities or non equalities.

METHODOLOGY

The main goal of this paper was to develop and to apply the model of multiple criterion optimization of the copper concentrate charge, containing different starting raw materials, which will allow their treatment under the conditions of pyrometallurgical copper extraction with the amount of SO_2 and PM_{10} emission under the proscribed limiting values.

Developed model would also be the tool to test the potential utilization of some nonstandard materials containing high copper content, unfortunately followed by high amount of toxic impurities (such are enargite ores and concentrates).

For such optimization, a primal-dual simplex algorithm of interior point was developed using the MATHEMATICA software application.

For those nonstandard materials which are found to be untreatable pyrometallurgicaly under any circumstances, alternative technological pretreatment for impurities reduction will be subsequently developed in the frame of this project.

Table 1. Share percentage of P_j in K_i and allowable limits in the concentrates

Products	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}
Chemical symbol	*Cu*	*Bi*	*As*	*S*	*Pb*	*Zn*	*Cd*	*Se*	*Hg*	*Sb*	*Ni*	*Ag*	*Au*	Miscella-neous
Unit	%	%	%	%	%	%	%	%	%	%	%	%	%	%
K_1	23.400	0	0.0030	29.480	0.0050	0	0.0004	0	0.00001	0.0050	0.0040	0	0	47.103
K_2	13.630	0	0.0310	33.290	0.1400	0	0.0030	0	0.00002	0.0050	0.0170	0	0	52.884
K_3	11.760	0	0.1100	14.500	0.1000	0	0.0004	0	0.00003	0.0050	0.0150	0	0	73.510
K_4	7.800	0	0.0075	61.790	0.0700	0	0.0025	0	0.00010	0.0050	0.0035	0	0	30.321
K_5	16.131	0.0202	0.0030	40.343	0.0101	0.0485	0.0025	0.0092	0.00003	0.0051	0.0020	0.001420	0.000280	43.424
K_6	15.493	0.0274	0.0038	24.870	0.0443	0.1266	0.0026	0.0117	0,00002	0.0053	0.0084	0.003150	0.000400	59.403
K_7	26.250	0.0030	10.340	19.480	0.0054	0.1500	0	0	0	0.0400	0.0100	0.000000	0.000064	43.722
Standard	21-25	0.05	0.2	32	2	3	0.01	0.02	0.0005	0.3	0.1	0.015	0.001	/
Criterion	min-max	max	max	min	max	max	max	max	max	max	max	min	min	/

Table 2.Obtained experimental results

% Cu In the charge	**Limitations**	K_1	K_2	K_3	K_4	K_5	K_6	K_7
18	*Cu*	0.173	0.173	0,135	0	0.173	0.173	0.173
	Cu+S	0.182	0.182	0.009	0.081	0.182	0.182	0.182
	Cu+As	0.429	0	0.142	0	0	0.429	0
	Cu+S+As	0.490	0	0.059	0.147	0	0.304	0
	Cu+S+all impurities	0.435	0	0	0.152	0.400	0,013	0
19	*Cu*	0.201	0.196	0	0	0.201	0.201	0.201
	Cu+S	0.223	0.005	0	0.103	0.223	0.223	0.223
	Cu+As	0.409	0	0	0	0.409	0.182	0
	Cu+S+As	0.562	0	0	0.124	0	0.315	0
	Cu+S+all impurities	0.481	0.159	0	0	0	0.361	0
20	*Cu*	0.238	0.048	0	0	0.238	0.238	0.238
	Cu+S	0.268	0	0	0.086	0.268	0.110	0.268
	Cu+As	0.510	0	0	0	0.469	0	0.021
	Cu+S+As	0.546	0	0	0.027	0.317	0.11	0
	*Cu+*S*+all impurities*	0.676	0.115	0	0.081	0	0.128	0
21	*Cu*	0.286	0	0	0	0.286	0.142	0.286
	Cu+S	0.322	0	0	0.087	0.270	0	0.322
	Cu+As	0.671	0	0	0	0.329	0	0
	Cu+S+As	0.575	0	0	0	0.420	0.005	0
	Cu+S+all impurities	0.826	0	0	0.157	0	0	0.017
22	*Cu*	0.348	0	0	0	0	0.303	0.349
	Cu+S	0.800	0	0	0.104	0	0	0.096
	Cu+As	0.820	0	0	0	0	0.180	0
	Cu+S+As	0.870	0	0	0.052	0.078	0	0
	Cu+S+all impurities	0.855	0	0	0.051	0.085	0	0.009
23	*Cu*	0.402	0	0	0	0	0.196	0.402
	Cu+S	0	0	0	0	0	0	0
	Cu+As	0.943	0	0	0	0	0.057	0
	Cu+S+As	0	0	0	0	0	0	0
	*Cu+*S*+all impurities*	0	0	0	0	0	0	0
24	*Cu*	0.457	0	0	0	0	0.086	0.457
	Cu+S	0	0	0	0	0	0	0
	Cu+As	0	0	0	0	0	0	0
	Cu+S+As	0	0	0	0	0	0	0
	Cu+S+all impurities	0	0	0	0	0	0	0
25	*Cu*	0.432	0	0	0	0	0	0.561
	Cu+S	0	0	0	0	0	0	0
	Cu+As	0	0	0	0	0	0	0
	Cu+S+As	0	0	0	0	0	0	0
	Cu+S+all impurities	0	0	0	0	0	0	0

RESULTS AND DISCUSSIONS

Copper concentrates available for this research, were denoted with following abbreviations: K_1 – Veliki Krivelj (Bor ore body) 1; K_2 – Majdanpek 1 (Bor ore body); K_3 – Bor (Bor ore body); K_4 – Argani-Turkey (imported); K_5 – Veliki Krivelj 2 (Bor ore body); K_6 – Majdanpek (Bor ore body) 2; K_7 – Rudno telo "*H*" (Bor ore body – nonstandard raw material containing high impurities content).

Results of the chemical analysis of the concentrates, with the limiting upper and lower extremes are presented in the Table 1 and indicated with the indexes P_1 to P_{13}.

Model implementation was performed in the programming environment of MATHEMATICA software package, using the standard maximize function. Numerical experiments were performed for copper content in the final charge ranging from 18% to 25%. Total number of 5 different experimental presents was developed, with the following limitation of different copper charge constituents:

1. Only the copper content is limited;
2. Copper and sulfur content are both limited;
3. Copper and arsenic content are limited;
4. Limitation of Cu + S + As content
5. Limitation of Cu + S + content of all present impurities.

Obtained numerical results are presented in Table 2. The ratios of different concentrates which can be included in the copper charge mix, without increased environmental hazard, are presented in the columns K_1 to K_7.

According to the results presented in Table 2, copper concentrate K_1 is the best constituent of all potential charges, considering all five defined limitations, because of its high Cu and low impurities content. Imported concentrate K_4, has low Cu level, however, it can be the part of mixtures (up to 23% Cu) based on its high sulfur content, because the sulfur is considered as a fuel for the process. Non standard material (K_7), is high in copper content. However, its high arsenic content is limiting its mixing potential, according to constraints 3 - 5. Only scenarios in which this material could be used in pyrometallurgical copper production are those with its ratio ranging from 0.01 to 0.04, regarding its high arsenic content.

Another important conclusion, resulting from the obtained model, is the fact that environmentally acceptable mixture can be made of such starting concentrates, to the limit of 22% Cu in the final charge. Higher Cu contents would lead to increased emission of the impurities.

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MODELING THE PROCESS OF COPPER EXTRACTION FROM THE NONSTANDARD RAW MATERIALS USING FACTORIAL EXPERIMENTAL DESIGN

Nada Štrbac, Ivan Mihajlović, Aleksandra Mitovski, Živan Živković, Đorđe Nikolić
University of Belgrade – Technical faculty in Bor, Management department

ABSTRACT. *During the long period of copper ore excavation, ore bodies reach in copper with low level of toxic impurities are usually completely consumed all over the world. Remaining raw materials are usually on the outskirts of already exploited ore bodies. Some still contain high copper content, unfortunately accompanied with other heavy metals minerals. These minerals usually contain high percentage of toxic elements such as Fe, Zn, Sn, Sb, Pb, Hg, Cd and As. If processing such materials in classical pyrometallurgical treatment, it would lead to release of toxic materials in water, air and soil. The release of heavy metals into the water and soil is always resulting in a number of environmental problems. The release in air is even larger problem, because of its impact on huge area surrounding the industry. On the other hand, amount of copper in this raw material is high enough to be economically utilized using adequate leaching methods. In this study, the leaching characteristics of enargite raw material, from the Bor Copper Mine, Serbia have been investigated for potential copper extraction. The aim of this study was to perform a laboratory investigation to assess the feasibility of extraction or copper from such raw material containing increased content of arsenic.*

Keywords: *Factorial experimental design, Copper extraction, MLRA, mathematical modeling.*

INTRODUCTION

Arsenic is present in the earth's crust in the concentrations of 4.8 ± 0.5 $\mu g\ g^{-1}$ in the natural form [1]. The sources of arsenic in the industrial area are natural and anthropogenic [2] and it can be found in soil, water and atmospheric dust. Among the biggest anthropogenic sources of arsenic are copper smelter plants which are considered the main environmental pollutants all over the world: Chile, USA, Sweden, Spain, Russia, Australia and Serbia [3].

Arsenic is one of the most common toxic impurities found in copper concentrates. The main As-containing mineral species, which can be found in the copper concentrates obtained from the Bor (Serbia) ore deposits, are enargite (Cu_3AsS_4) and luzonite (Cu_3AsS_4), while realgar (As_4S_4) and arsenopyrite (FeAsS) are present in lesser amounts. Unfortunately, the prevalence of enargite among the copper-bearing minerals and as a result the relatively high arsenic content in the concentrates substantially reduces their economic value, owing to the hazardous emissions generated from pyrometallurgical processing [4].

Because of this fact and difficulties in controlling arsenic in such industrial process, the amount of arsenic released during the process of arsenic bearing concentrate roasting, prior to smelting operation, is very high. Arsenic, as well as its oxides, are highly evaporative and leaves reactor as the off-gas constituents. Thus, in unfavorable metal market conditions, direct roasting of such concentrates is not an economical option because gas cleaning facilities required are too expensive.

In order to minimize the problems associated with the processing of these very hazardous materials, the arsenic content in copper concentrates must be reduced to low levels (usually less than 0.5% As). Such levels are difficult to obtain by differential flotation procedure of the ore from some sulfide deposits [5]. On the other hand, in 2001 the World Health Organization (WHO) published the second edition of Air Quality Guidelines for Europe in which it was explained that value of arsenic in the air above 1.5×10^{-3} $\mu g\ m^{-3}$ presents high risk for human life [6]. Typical contents of arsenic in European regions are in the range from 0.2 to 1.5 ng m^{-3} in rural areas; 0.5 to 3 ng m^{-3} in urban areas and up to 50 ng m^{-3} in industrial zones [3,7], including the zone in the vicinity of the copper smelter plant in Bor (Serbia).

The real problem that needs to be solved is how to minimize the concentration of arsenic emitted from the copper smelter plant, if planning to use the raw materials which besides being rich in copper do have increased arsenic content. In an attempt to solve this problem, we have explored the possibility of hydrometallurgical treatment of the copper concentrates with the purpose to dissolve the arsenic prior to the pyrometallurgical processing.

Two techniques for arsenic removal from enargite are present in the literature [8]:

1) Alkaline leaching of energite concentrates using sodium sulfide solutions after mechanical activation via fine grinding
2) Leaching of natural enargite crystals with sodium hypochlorite under alkaline oxidizing conditions with enargite converted into crystalline CuO and the arsenic solubility forming (AsO_4^{3-}).

Authors of this paper decided to evaluate the possibility of applying the second method, because it is attractive in terms of its potential application on a commercial scale and previous investigations of this matter.

The technique that was used for obtaining the optimal conditions for the future technical approach to this problem was mathematical modeling, based on the factorial experimental design.

ENVIRONMENTAL ISSUE

Besides the copper minerals, some ore bodies in Bor copper mine, contain the minerals of *Se*, *Bi*, *Cr*, *Sb*, *Cd*, *As*, *Zn*, *Pb*, *S*, *Ni*, *Fe*, and *Hg*, which partially remain in the final copper concentrate even after flotation separation process. Largest problem is with the sulfide copper minerals containing arsenic, which are transferred in the copper concentrates entirely, being impossible to separate them from the other sulfidic copper bearing minerals [4]. At the increased temperatures of copper extraction in the pyrometallurgical processes, heavy metal sulfidic minerals are oxidized or sublimated, leaving the smelting unit as fumes or in the PM form [9]. Modern copper smelters are equipped with contemporary facilities for PM removal from the off gases, as well as for high SO_2 utilization. However, even such facilities are presenting the largest environmental polluters in the regions in which they operate [10]. Copper smelters using the outdated technologies, or smelting the low quality concentrates, are emitting the PM_{10} and the SO_2 highly above the prescribed limits, which is presenting serious hazard for people's health [6,7].

This is why the investigation presented in this paper was based on non standard raw material obtained from the Bor copper mine (ore body H), containing 26.25% Cu and 19.48% S, accompanied with the 10.34% As. With such high arsenic content, this material shouldn't be treated for copper extraction pyrometallurgicaly, under any circumstances.

POSSIBLE SOLUTION

As already indicated, the possible solution to this environmental problem is leaching of natural enargite crystals with sodium hypochlorite under alkaline oxidizing conditions with enargite converted into crystalline CuO and the arsenic solubility forming (AsO_4^{3-}). To obtain the optimal conditions for this procedure, factorial experimental design was used as the starting point, based on experimental conditions ranges obtained from the contemporary literature.

Leaching of enargite samples was conducted in a 1 dm^3 three-neck tank with condenser, mechanical stirrer and ultra-thermometer. The leaching kinetic experiments were performed at different hypochlorite concentration (X_1), with different solid to liquid ratios (X_2). Leaching solution was mechanically stirred at different rates (X_3). Leaching temperatures were in the range: 25-60^{O}C (X_4), and time intervals up to 120 minutes (X_5).

The progress of the reaction was determined by analyzing arsenic in the obtained leaching solution using inductively coupled plasma emission spectroscopy. According to the reaction stoichiometry, the fraction of the enargite reacted was determined as a function of arsenic extracted (Y).

EXPERIMENTAL DESIGN METHODOLOGY

To obtain a reliable statistical model, prior knowledge of the investigated procedure is generally required. The three steps used in the experimental design include statistical design of experiments, estimation of coefficients through a mathematical model with response prediction, and statistical analysis [11].

Today, the most widely used experimental design to estimate main effects as well as interaction effects is the 2^n factorial design, where each variable (X_i; i = 1 ÷ n) is investigated at minimum two levels [12,13]. As the number of factors (n) increases, the number of runs for a complete replicate of the design also increases rapidly. Modeling can be performed using the first order model, defined by the equation:

$$y = b_o + \sum_{i=1}^{n} b_i x_i + \sum_{i=1}^{n}\sum_{j>1}^{n} b_{ij} x_i x_j \qquad (1)$$

Or the second order model, which is:

$$y = b_o + \sum_{i=1}^{n} b_i x_i + \sum_{i=1}^{n} b_{ii}(x_i^2 - \overline{x_i^2}) + \sum_{i=1}^{n}\sum_{j>1}^{n} b_{ij} x_i x_j \qquad (2)$$

Where: $$\overline{X_i^2} = \frac{1}{N}\sum_{i=1}^{N} x_i^2 \qquad (3)$$

Where N is the total number of experiments, including the holdout cases.
This way, with following approximation:

$$b_o' = b_o - \sum_{i=1}^{n} b_{ii}\overline{x_i^2} \quad (4)$$

The second order model can be presented as:

$$y = b_o' + \sum_{i=1}^{n} b_i x_i + \sum_{i=1}^{n} b_{ii} x_i^2 + \sum_{i=1}^{n}\sum_{j>1}^{n} b_{ij} x_i x_j \quad (5)$$

RESULTS AND DISCUSSIONS

Both, first and the second order model were used to fit the experimental data obtained. With five factors (X_1 to X_5), and three factor levels, SPSS software (SPSS v. 18) resulted with the factorial experimental design that requires 16 runs. Six holdout cases were added to the experimental plan to estimate pure experimental errors (Table 1). The experiments were run in random order to avoid systematic errors. After conducting all 22 experiments, results of copper extraction were included in the database as the output variable - Y (Table 1). Using the Multiple Linear Regression Analysis (MLRA), on the results presented in Table 1, the first order model (Equation 1) was obtained.
Based on these results, the following final first order model equation is resulting from the regression analysis:

$$Y = 2.749+106.465 \cdot X_1-210.109 \cdot X_2-0.045 \cdot X_3+ 2.352 \cdot X_4+0.828 \cdot X_5+279.439 \cdot X_1 \cdot X_2+0.172 \cdot X_1 \cdot X_3- 6.615 \cdot X_1 \cdot X_4+ 0.075 \cdot X_1 \cdot X_5+ 0.135 \cdot X_2 \cdot X_3+ 3.187 \cdot X_2 \cdot X_4-0.277 \cdot X_2 \cdot X_5-0.001 \cdot X_3 \cdot X_5-0.010 \cdot X_4 \cdot X_5 \quad (6)$$

Coefficient of determination of the final first order model is $R^2 = 0.85$, as indicated in Figure 1. This coefficient is the squared value of the multiple correlation coefficients, which presents the linear correlation between the observed and model predicted values of the dependent variable. Its large value indicates a strong relationship.
Considering that obtained coefficient of determination, representing the first order model, was not adequately high, it was decided to perform further modeling using the second order model defined by equation 5. The final second order model equation obtained using stepwise method, in six iterations, is as follows:

$$Y = -130.414 + 8.105 \cdot X_4 + 0.444 \cdot X_5 - 0.073 \cdot (X_4)^2 + 0.093 \cdot X_1 \cdot X_3 - 0.599 \cdot X_2 \cdot X_4 - 0.006 \cdot X_4 \cdot X_5 \quad (6)$$

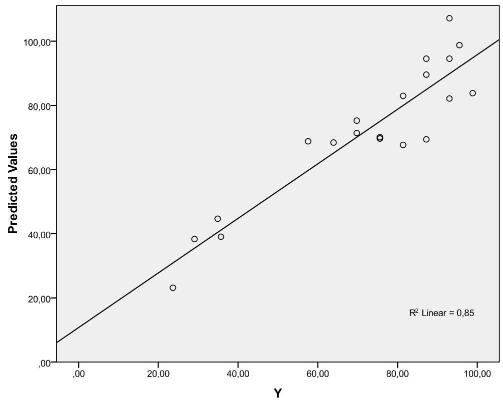

Figure 1. Correlation between experimentally determined and first order model predicted values of the copper extraction from the flotation waste

Only the variables with the significant level ($p<0.05$), remained in the final model equation. The accuracy of obtained model is presented in the Figure 2.
Using the final second order model (Equation 6), which predicts the amount of copper extraction accurately enough ($R^2 = 0.931$), it is possible to determine optimal conditions for operations management of the process, since the model fit the experimental results well enough. Optimization consists of finding the whole of the values of the operational variables which involves an optimal arsenic removal from the starting raw material. The optimal arsenic removal obtained by the model reaches 97.93%, this result closely agrees with the absorption yield of 98.84 % obtained by the experiment (in run 18).

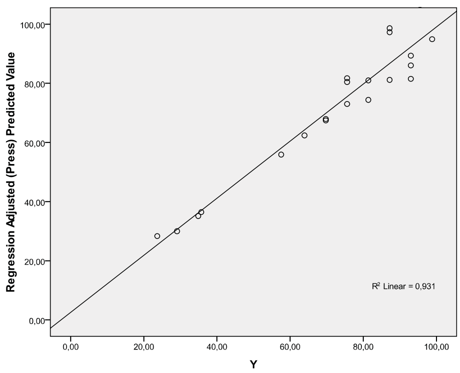

Figure 2. Correlation between experimentally determined and second order model predicted values of the copper extraction from the flotation waste

Table 1. Experimental design and arsenic leaching yield

No	X_1 - M_{NaClO}_	X_2 - Solid phase, g	X_3 - Stirring speed, min^{-1}	X_4 - Temperature, ºC	X_5 - Time, min	Y - Arsenic removal, %
1	0.18	0.3	100	25	20	30.05
2	0.42	0.3	600	25	60	63.95
3	0.18	0.3	100	40	120	87.21
4	0.3	0.3	300	60	20	87.21
5	0.3	0.3	600	40	20	93.02
6	0.18	0.3	100	25	20	29.07
7	0.42	0.5	100	60	20	81.39
8	0.18	0.5	300	40	60	87.21
9	0.42	0.7	100	40	20	69.77
10	0.42	0.3	300	25	120	69.77
11	0.18	0.5	600	25	20	34.88
12	0.18	0.7	300	25	20	23.67
13	0.18	0.7	600	60	120	93.02
14	0.3	0.5	100	25	120	57.56
15	0.3	0.7	100	25	60	35.71
16	0.18	0.3	100	60	60	93.02
17	0.3	0.5	100	40	60	75.58
18	0.3	0.3	100	40	120	98.84
19	0.42	0.5	100	40	60	75.58
20	0.18	0.3	100	40	20	81.39
21	0.42	0.7	600	25	120	75.58
22	0.42	0.7	600	60	120	95.51

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COMBINATION OF KNOWLEDGE IN THE SYSTEM SUPPLIERS - MSP - CUSTOMERS IN THE TRANSITIONAL ECONOMY ENVIROMENT IN SERBIA

Marija Savić, Predrag Djordjević, Djordje Nikolić, Ivan Mihajlović, Živan Živković
University of Belgrade, Technical Faculty in Bor, Serbia

Abstract. *The paper presents the results of research of the combination of knowledge in the system: suppliers - SMEs - consumers in case of SMEs in Eastern Serbia. A theoretical model of a combination of knowledge was established in the investigated system. By using the statistical analysis of the results a satisfactory statistical significance of acquired results was determined, which allowed the testing of the defined model using LISREL software package. The results show the importance of the established hypotheses for the impact of the cooperation with suppliers on a combination of knowledge, as well as the combination of knowledge of customers and suppliers on the creation of the new knowledge in SMEs. The hypothesis about the positive influence of the sharing of knowledge with customers on the combination of the knowledge in SMEs has not been proven. These facts suggest that SMEs in Serbia do not collaborate with their customers. The cause of such a situation is the lack of system quality (SQ) in the SME sector in Serbia, as well as not applying the principles of TQM practices, which provides the best explanation of the short life cycle of SMEs in Serbia and the inability of their internationalization.*
Keywords: *SMEs, customers, suppliers, knowledge combination, LISREL*

INTRODUCTION

The concept of small and medium enterprises (SMEs) is particularly developed in the U.S., and has recently been experiencing an expansion in Europe (Acs et al, 2003).The development of SMEs in Europe is slower because of the barriers in the process of starting a new business and the fear of failure (Audretsch and Thuric, 2000; Moen, 2002). SMEs in developed economies are complementary to large companies, which provides them with safety in their work, growth and development (Audretsch and Thurik, 2000 Dyer and Nobeoka, 2000). In transition economies in post-communist countries (countries of the former USSR, the countries of the former Warsaw Pact, countries that emerged from the disintegration of Yugoslavia....) there is a great desire, among entrepreneurs, to create their own businesses and to start new SMEs, but many attempts have been unsuccessful. Unsuccessful attempts were usually caused by a lack of knowledge of entrepreneurs, who gained their experience in the state-owned companies. In the educational systems in these countries, until recently, there were no elements pertinent to the field of private enterprise, therefore the knowledge to start and run a private business was obviously lacking among entrepreneurs (Benzing, et.al., 2005; Chu, et.al., 2007; Benzing, et.al., 2009).

In Serbia, which has been going through the transitional process for a long period of time, the expansion of the starting SMEs actually takes place after the year 2000. The motivation for the creation and development of SMEs is growing during 2009 and onwards, due to the global economic crisis and high unemployment. In such conditions, the survival of SMEs during the period of economic crisis is becoming more difficult, which causes many SMEs to fail. Development Strategy for SMEs can be defined as the creation of knowledge and the concepts of utilizations and adaptation of knowledge artifacts (knowledge artifact) which are necessary for the key elements of the SMEs functioning (Jarzabkowski and Wilson, 2006). Many studies show that the knowledge is transferable in certain organizational systems such as TQM (Molina, et. al., 2007.)

According to the theory of entrepreneurship, SMEs innovative behavior is conditioned by a combination of knowledge that is widespread, which means that different individuals know different things (Tolstoy, 2009).Science has established networks of knowledge (Blomstermo, et.al., 2004) through the various concepts, such as learning through a network, relationship memory (Cagerra-Navarro, 2007) and even the memory network (Soda, et.al., 2004.,)Within the concept of entrepreneurial activities, innovative behavior is caused by a combination of knowledge which can be created within the concept of knowledge networks of SMEs with their customers and suppliers (Street and Cameron, 2007), which in many cases can lead to the creation of the new knowledge (Soda et. al., 2004.) In terms of globalization of the market, many SMEs become more international (Zahra, et.al., 2003; Moen 2002; Acs, et.al., 2003) and the terms of the concept of creating a network of development produce good results, leading to the emergence of entrepreneurial firms with high technological performance as a consequence of the accumulation of knowledge in the process of combining knowledge (Tolstoy, 2009).

The system suppliers - SMEs - customers, if the activity of SMEs is internationalized, creates good opportunities for the creation of a network of different knowledge whose combination can create a new knowledge which presents a basis for growth and development of SMEs (Street and Cameron, 2007). In terms of transitional economy in Serbia, with high entropy in the system suppliers - SMEs - customers, the creation of the new knowledge, by combining existing knowledge in certain areas of the defined system, can be a good starting point for improving the performance of SMEs in Serbia.

THEORETICAL BACKGROUND AND HYPOTHESES

Many SMEs have a problem with limited resources, which limits their business activity on the market, where they operate in one way in activities on domestic market, and in different way in the process of internationalization of business. Very often the missing resources cannot be provided through the proprietary possession, therefore SMEs become dependent on the resources they utilize from the network with customers and suppliers (Zahara, et.al., 2003.) In accordance with the substantive arguments of this study, SMEs are dependent on the knowledge network of clients and the knowledge networks of suppliers, because these categories provide different knowledge which is the instrument for combining the knowledge (Uzzi and Lancester, 2003). Knowledge derived from these networks, in the case of SMEs, may consist mainly of market knowledge (consumer preferences, market conditions) and technological innovation (Thorpe, et al, 2005).

Market knowledge is usually associated with a network of consumers, but may be associated with the network of suppliers. Technological knowledge is usually associated with a network of suppliers, but may be also connected to the network of consumers. Knowledge within the networks of SMEs with customers and suppliers can be acquired by reacting to exogenous situations, as well as through conscious and planned efforts by SMEs (Tolstoy, 2009). Modern SMEs should be actively operating in the network capabilities of customers and suppliers, which implies that they must work to change the existing combination of knowledge and to find new ones. These findings enable definition of the following hypotheses:

H_1 Supplier knowledge positively affects the combination of the knowledge in SMEs.
H_2 Customer knowledge positively affects the combination of the knowledge in SMEs.

Research suggests that knowledge-based view serves as an important tool for understanding the spread of entrepreneurial firms (Rialp, et.al., 2005.) Current knowledge is not sufficient and requires constant accumulation regardless of whether SME operates at the local level or the international level (Knight and Cavusgil, 2004).Therefore, SME performance depends on its ability to create knowledge, to combine it order to achieve the objectives required by the market (Zahara, et.al., 2003). It was determined that the business opportunities are improving more rapidly and developing more innovatively with the knowledge that is being actively developed as opposed to the knowledge gained by experience over time (Crick and Jones, 2000).Activities that take place through a combination of knowledge adjusted dynamics of the SMEs with the dynamics of the market. Therefore, the combination of knowledge will enhance the accumulation of knowledge which will enhance the performance of SMEs. These facts allow the definition of the following hypotheses:

H_3 Combining knowledge of suppliers and customers has a positive impact on the creation of the knowledge in the SMEs.

Based on the defined hypothesis it is possible to define a theoretical model of a combination of knowledge in the system suppliers-SME-customers to increase the knowledge, in order to increase the performance of SMEs, Figure 1.

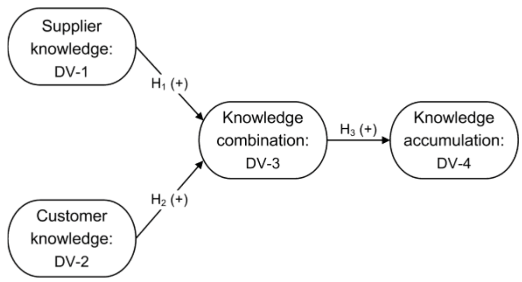

Figure 1. The theoretical model of the combination of knowledge in the system: suppliers - SMEs – customers

DISCUSSION OF RESULTS

The studies presented in this paper were carried out through a questionnaire given in Appendix A (Tolstoy, 2009). Studies were conducted in the Eastern Serbia in a total of 536 SMEs, by surveying entrepreneurs during the visit to their firms. The questionnaire was administered in a way that the interviewer conducted an interview with the entrepreneur. The questionnaire has four groups of dependent variables (DV) supplier knowledge (DV-1), customer knowledge (DV-2), knowledge combination (DV-3) and the creation of knowledge (DV-4), within which 10 independent variables are contained.

The demographic structure of the sample is as follows: with the sample of entrepreneurs, in the most devastated part of Serbia, 71% were men and 29% were women entrepreneurs. Most of the SMEs were as follows: 75% had up to 10 employees, 22% had 10-30 employees and 3% had 50-250 employees. Time from starting a business: 11% up to 1 year; 18% 1-3 years; 25% 3-5 years; 24% 5 – 10 years and 22% over 10 years. Investigated SMEs belong to the sector of: agriculture - 11%; transport - 24%; industry - 5%; tourism - 7%; service sector - 45% and healtservice - 8%. Demographic characteristics of the sample indicate that the dominant structure in the SMEs belongs to the service sector, the existence of most companies was noted to be up to five years and that the dominant structure of entrepreneurs male.

Likert's five-point scale (1 - completely disagree, 2 - disagree, 3 - undecided, 4 - agree and 5 - completely agree) was used for testing, with results presented in this paper. This methodology has been used in numerous previous studies (Molina et.al., 2007; Kale et.al., 2000; Kaynak, 2003; Tari et.al., 2007), which justifies the validity of the utilized methodology.

A statistical analysis of the results obtained in our research and validation of theoretical models defined in Figure 1. were performed by using the software packages SPSS v18 and LISREL (Linear Structural Relationship) v16. For the empirical validation of the hypothetical model, Figure 1., a SEM (Structural Equation Modeling) methodology was used in this paper Bou-Luslar et.al., 2009). In the statistical analysis of the validation of the defined models, firstly one-dimensionality was confirmed, using factor analysis (PCA), across all 10 groups of latent variables in the considered model. The values obtained by factor analysis are shown in Table 1. To ensure the reliability and validity of the research model a control measurement model was defined on which confirmatory factor analysis (CFA) was performed. CFA analysis confirmed the good fit of the control model, which practically verifies that 10 defined variables describe, in a reliable way, the four latent class variables, defined in the research model, Figure 1.

Consistency of variables, defined in the framework of latent classes in the investigated model, was measured by the size of the Crombach's alpha (Crombach, 1951). Acquired values of the Crombach's alpha > 0.7, Table 1, show good consistency of certain variables within the four defined latent groups of variables in the investigated models. Crombac'h alpha value for the whole population is 0.98, so the obtained data can be considered reliable for the testing of the proposed model (Bou-Luslar, et.al., 2009.)

Table 1. The results of the factor analysis and CFA analysis of the investigated model

Groups of questions	Considered variable	Factor analysis (EFA)		Confirmatory factor analysis (CFA)		
		PCA		Reliability	Convergent validity	
		% of variance explained by one-dimensional factor	Factor loading	Cronbach`s alpha	Factor loading	t - statistics
Supplier knowledge: ZV-1	L1 L2	67.343	0.911 0.804	0.891	0.830 0.703	4.13* 8.19*
Client knowledge: DV-2	L1 L2	82.392	0.861 0.906	0.942	0.836 0.932	6..56* 6.14*
Knowledge combination: DV - 3	L1 L2 L3 L4	49.937	0.718 0.842 0.872 0.975	0.956	0.631 0.775 0.769 0.845	6.53* 4.04* 5.10* 6.74*
Knowledge creation DV - 4	L1 L2	89.236	0.881 0.801	0.956	0.887 0.775	8.02* 4.75*

* $p < 0.05$

The values of the t-tests are used to test the hypothesis that the sample does not differ from the population, which shows the tendency of the normal Gaussian distribution; t values should be greater than 2. Results obtained in Table 1 show that in all cases t - values are greater than 2, with the significance

level of $p < 0.05$, which indicates that values in the tested model, are statistically reliable (Ho, 2006).
To study the discriminant validity of various groups of questions the Structural Equation Modeling (SEM) was performed, by comparing pairs of latent class-defined questions on the principle of two by two. Table 2 shows the results of discriminative validity and the correlation between the four groups of questions.
Positive values of Pearson's coefficient were obtained with statistical significance of $p < 0.05$, which indicates that the correlation of random pairs of groups of latent variables are true (Moris, et.al., 2002).

Table 2. Analysis of the discriminant validity - correlation of the latent class-defined questions.

Groups of variables	DV- 1	DV- 2	DV- 3	DV-4
DV – 1	1			
DV – 2	0.39*	1		
DV – 3	**0.14***	**0.44***	1	
DV – 4	0.31*	0.33*	**0.12***	1

* $p < 0.05$

Correlations between pairs of latent classes of variables, associated to the defined model, Figure 1. have values of Pearson's coefficients generally above 0.12 (coefficients marked bold in Table 2). The highest value of correlation exists between knowledge of suppliers and knowledge combinations (0.44 with $p < 0.05$), indicating that entrepreneurs perceive the dominant influence on customer knowledge on the knowledge combination in SMEs. The lowest correlation with the value of Pearson's coefficient of 0.12 with $p < 0.05$ refers to the influence of a combination of knowledge of customers and suppliers on the creation of the new knowledge, indicating a poorly developed mechanisms for combining knowledge with the goal to create new knowledge in terms of SMEs operation under the conditions of transitional economy in Serbia.
To test the validity of the model defined in Figure 1. software package LISREL v16 was used for statistical data analysis, considering that the statistical reliability of the data for the model validation is satisfactory.
Firstly, the values of indicators were determined, which determine whether the proposed model adequately fits the input data. The results of the analyzed fitting indicators are shown in Table 3.
Goodness-of-fit index (GFI) is the extent to which the model is applicable in comparison with the case where a model does not exist. Good fitting is indicated with GFI value above 0.90 (Molina, 2007). In this case the value of GFI of 0.96 is above the threshold.

Table 3. Summary values for the fitting indicators

Indicators of the fitting statistics	Values obtained in the model	Recommended values
X2/d.f.	59.97/31 = 1.93	< 3.0
RMSEA	0.081	0.08 – 1.0
GFI	0.96	> 0.9
NFI	0.92	> 0.9
CFI	0.92	> 0.9
IFI	0.93	> 0.9
RFI	0.92	> 0.9

V Indicator Root Mean Square Error of Approximation (RMSE) shows the errors that occur during the approximate connection of populations. Good value of the RMSA indicators is within the limits of 0.08 – 0.10. The obtained value of this indicator 0.081 shows, together with the GFI indicator, a satisfactory coincidence.
In addition to GFI and RMSA indicators for assessing the quality of fitting the following indicators are also being used: Normed fit index (NFI), Comparative fit index (CFI), Incremental Fit Index (IFI) Relative Fit Index (RFI). Following values were obtained in the tested model : 0.92, 0.92, 0.93 and 0.92, respectively. The values were above 0.9 therefore they can be regarded as absolutely satisfactory. Also, an indicator of Minimum Fit Function Chi-Square/Degre of Frededom X2/d.f. should be considered, which in this case has a value of 1.93, where the required value should be less than 3.
The obtained values of the considered fitting indicators of indicate a satisfactory level of fitting in the suggested model which suggests that the regression coefficients of the paths can be calculated in the defined theoretical model in Figure 1.
By using LISREL v16 the path-regression coefficients were determined (correlations between the latent class variables defined in the model which is shown in Figure 1) and the obtained results are shown in Figure 2. The results in Figure 2. indicate that the hypotheses H_1 and H_3 in the defined model have positive values of path coefficients with the values for t above 2 and the statistical significance of $p < 0.05$, indicating that these hypotheses are confirmed. The obtained value of - 0.10 for the path coefficient of the H_3 hypothesis is negative and t = - 0.29, indicating that H_3 is not proven.

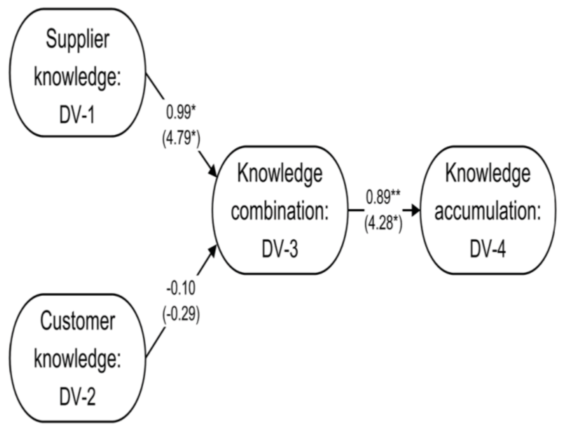

Fig.2. Structural model of the combination of knowledge in the system: suppliers - SMEs – customers in Serbia
(t - values in parenthesis)
Level of significance: * < 0.05

CONCLUSION

Bearing in mind the proposed hypothetical model of knowledge creation by combining knowledge in the system suppliers - SME - customers in SMEs in the transition economy in Serbia, Figure 1., and obtained results in Figure 2., hypothesis H_1 and H_2 were confirmed while the hypothesis H3 is not confirmed. Hence, it was confirmed that knowledge has a positive effect on the combination of entrepreneurial skills of a company, as well as on developing the dependence on supplier knowledge networks which have a positive effect on the entrepreneurial combining of knowledge of firms and the creation of new knowledge, which in accordance with the results of the investigation of SMEs in Sweden (Tolstoy, 2009).

Our research has shown that information obtained from clients do not have a positive effect on the combinations of entrepreneurial firms knowledge, which means that manufacturers do not rely on knowledge of clients (consumers) because it does not contribute to new knowledge in entrepreneurial firms.

This result can be explained by under-developed marketing function in the investigated SMEs in Serbia, which indicates a low level of compliance with the requirements of clients, including the lack of TQM practices in investigated SMEs. Transitional conditions in Serbia: the reforms, restructuring, price liberalization, the establishment of a strong private sector and the fulfillment of the EU requests, still holds Serbian borders closed for major business projects, which is slowing down the internationalization of Serbian SMEs.

Due to the confusing situation in the market customers have lost their vision of what they want in the market, and suppliers use this as an opportunity to sell to the market what they have, by providing favorable terms of payment of purchased goods. Most entrepreneurs are determined to purchase goods offered by suppliers, while not being informed if customers have a demand for it or not. Due to the organizational and business culture in Serbia overloaded with transitional restrictions, client's culture, and primarily due to a lack of quality standards, most of the SMEs are confident that they will sell on the Serbian market whatever they offer.

APPENDIX A

QUESTIONNAIRE

DV-1 (Supplier knowledge)
1. Your relationships with key suppliers depend on information, knowledge and experience you acquire from them.
2. Your relationships with other suppliers in the market depend on information, knowledge and experience you acquire from them.

DV - 2 (Client knowledge)
1. Your relationships with key clients depend on information, knowledge and experience you get from them.
2. Your relationships with other clients in the market depend on information, knowledge and experience you get from them.

DV-3 (combination of knowledge)
1. Business partners (customers and suppliers) are a source of information, knowledge and experience to you.
2. The relationship with your business partners (customers and suppliers) is characterized by mutual adjustments
3. The relationship with your business partners (customers and suppliers) is characterized by an exchange of information, knowledge and experience.
4. How familiar are you with the business partner’s (customers and suppliers) information, knowledge and experience?

DV-4 (Knowledge creation)
1. The relationship with your business partners (customers and suppliers) result in the creation of new products/new services.
2. The relationship with your business partners (customers and suppliers) result in new procedures, practices of the organizational details etc. in your company.

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A FORECASTING MODEL FOR EMERGING TECHNOLOGIES – CASE OF INTERNET DIFFUSION IN SERBIA

Dr Djordje Mitrovic[1], prof. dr Slobodan Pokrajac[2]
[1]University of Belgrade, Faculty of Economics
[2]University of Belgrade, Faculty of Mechanical Engineering

Abstract: *Forecasting is one of the cornerstones of research in industrial engineering. It delivers information required for planning projects as the design of products, the development of production processes or introducinga new technology. The most important role of technological forecasting models is to reveal in advance the possible adoption rates of anew technology, the moment of inflection point and maximum rate of penetration. This paper researches several technology and innovation diffusion models to find the best fit model for forecasting Internet diffusion and adoption in Serbia. Models are analyzed and compared on the basis of values for a number of internet users in Serbia during the period 1997-2011. Such analysis provides a very useful tool for industrial engineers to predict the diffusion and adoption shapes of new similar technologies in Serbia and to understand how to make good decisions related to staffing needs, production levels, resources mobilizing plan, organizational changes etc.*

Key words:*industrial engineering; forecasting; Internet diffusion; technology diffusion model; logistic models; Gompertz model*

INTRODUCTION

Industrial engineering (IE) as research discipline needs to deal with designing, development, enhancement, application and evaluation of integrated systems of people, financial, material and energetic resources, technologies, information, knowledge and different types of know-how in order to determine, forecast and evaluate the results of these systems. In practical terms, the main task of IE as scientific system, consisted from physical, mathematical and economics sciences is to find optimization parameters for production, service or financial service activities in order to increase efficiency and saving of time, financial, labor and other resources. Using different types of mathematical models and computer simulation industrial engineers make analysis, forecasting, estimating and optimization of number of different system's elements – information regarding the design of new products, methods of development of production processes or when and how to introduce new technology.

Having in mind that such concept of IE for the most part depends on development of information and communication technologies (ICT), this paper attempts to reveal (1) what level of ICT penetration exists in Serbia, (2) possible future adoption rates of the new technologies, (3) the moment of inflection point and (4) maximum rate of penetration. Such analysis provides a very useful tool for industrial engineers to predict the diffusion and adoption shapes of new similar technologies in Serbia and to understand how to make good decisions related to staffing needs, production levels, resources mobilizing plan, organizational changes etc.

To answer these questions, in this paper we deal with several technology and innovation diffusion models to find the best fit model for forecasting ICT diffusion and adoption in Serbia. Unfortunately, time series data about the Internet and computer software decision tools packets usedin companies are not long enough. Because of that, models are analyzed and compared on the basis of values for number of internet users in Serbia during the period 1997-2011.

The paper is organized as follows. After introduction, we shortly discuss relevant literature. In next section, theoretical background of four forecasting models will be presented: Bass model, exponential model, logistic model and Gompertz model. Next two sections are dedicated to model parameters estimationand results discussion. IE

LITERATURE REVIEW

For the most part of literature, ICT diffusion is analyzed and forecasted through several innovation diffusion models. The most known diffusion models are Bass model (Bass, 1969), the logistic family models,Fisher-Pry model (Bhargava, 1995)Gompertz model(Rai, Ravichandran&Samaddar, 1998) and flexible logistic models - FLOG model and Box-Cox model (Bewley&Fiebig, 1988). All of these models have as a result S-shaped curve showing technology diffusion and adoption among population or companies in the country. One of practical implementations of these models on mobile telephony diffusion can be found in Michalakelis, Varoutas&Sphicopoulos, (2008).A very interesting research on a sample of 214 countries made in Andres, Cuberes, Diouf and Serebrisky, (2010) is confirming that in almost all countries new technology diffusion processes follow S-shaped growth curve.

The best critical review of different innovation diffusion models is given in Peres, Muller &Mahajan, (2010). Based on their research we can conclude that the development of new, more complex types of product categories requires from industrial engineers permanent revisiting and adaption of diffusion models they are using for data forecasting. According to this, McDade, Oliva& Tomas, (2010) examines forecasting accuracy when applying macro-level diffusion models to high-tech product innovations among organizational adopters. They emphasize that industrial engineers must be very careful when choosing existing, previously mentioned models for forecasting diffusion of new high-tech products. Every model needs to be adjusted to a concrete type of technology, because „a model developed for one purpose can't be automatically applied to another."

FORECASTING MODELS

Without going in deep mathematical explanations of each proposed model, we will present only basic models formulation and their parameters description. The most part of diffusion modelsare developed on the base of Bass model. This model is described by

$$A(t) = M\frac{1-e^{-(p+q)t}}{1+\frac{q}{p}e^{-(p+q)t}}, \quad (1)$$

where*A(t)* is cumulative adoption in time period t, *M* is the ultimate number of adopters (saturation level), p is coefficient of innovation and q is coefficient of imitation.The inflection point (time period when the diffusion growth rate is maximal) is defined as

implications and directions for future research are given in the last part of the paper – Conclusion.

$$t^* = \frac{1}{p+q}\ln\left(\frac{q}{p}\right). \quad (2)$$

The second model analyzed in the paper is exponential model derived from Bass model when it is assumed that q is 0, i.e. when diffusion process is driven only by innovation:

$$A(t) = be^{at}, \quad (3)$$

where$a$ is the rate of technology diffusion, and parameter b shows the position of S-shaped curve on the time axe.

On the other hand, when in Bass model parameter p is equal to 0, the technology diffusion is driven only by imitation. This is logistic model described by mathematical formulation

$$A(t) = \frac{M}{1+be^{-at}}, \quad (4)$$

where$a$ is imitation coefficient, while parameter b as in previous model shows the position of S-shaped curve on the time axe.

The last model used in this paper for forecasting internet diffusion in Serbia is Gompertz model, described as follows.

$$A(t) = Me^{-be^{-at}}. \quad (5)$$

Parameter a is again the imitation coefficient, and b shows the position of S-shaped curve on the time axe. The difference between these two last models is in the time period when theinflection point is expected to appear. The inflection point for these two models is defined as

$$t^* = \frac{\ln(b)}{a}. \quad (6)$$

According to (Rai,Ravichandran&Samaddar, 1998) the inflection point in logistic model is at half of saturation level – A(t)=M/2, while in Gompertz model maximum diffusion growth rate is at approximately 37% of the saturation level - A(t)=M/e. It means that logistic model shapes symmetric S-curve, while in Gompertz model it is asymmetric.

We mentioned earlier FLOG and Box-Cox models. The inflection point in these models is not constrainedin advanced by degree of symmetry as in previous two models. But, flexible logistic models are not in the scope of this paper.

PARAMETERS ESTIMATION

After theoretical explanation of different model for possible forecasting of emerging technologies diffusion, we will estimate the main parameters. Data used in the paper take in account the period from 1997-2011. The Internet appeared in Serbia in 1996, but it will not take into consideration this year because of lack of data. Source of data was Statistical Office of Republic of Serbia (SORS), International Telecommunication Union (ITU) and some author's own calculations for starting year of internet using in Serbia.

We will use this original internet diffusion data to find, between four previously described models, best model for estimating future internet diffusion in Serbia. Data for period 1997-2011 (15 years) is usedfor model fitting,while data for 2012-2014 (3 years) is usedfor predicting.

In this research SPSS software is used to fit the original data and to estimate the main parameters of the model. Parameters for all four models are estimated by nonlinear least squares regression.

According to SORS, by the end of 2010 total population aged 16-74 was 5.543.556 habitants. This number is used for initial value of parameter M, i.e. as saturation level for internet diffusion.

The results of parameter estimation for each model are shown in table 1.

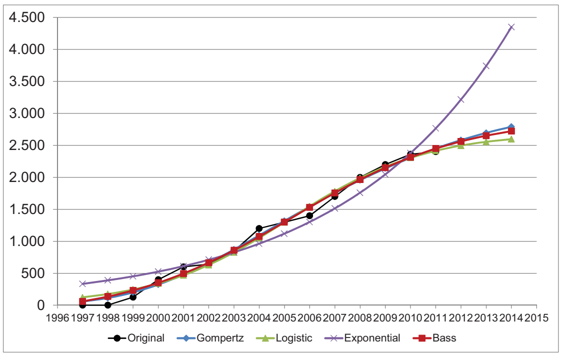
Table 1. Model parameter estimation

Parameter	Model			
	Bass	Exponential	Logistic	Gompertz
M	2949,708	-	2696,946	3325,735
a	-	0,151	0,370	0,185
b	-	287,933	30,255	4,886
p	0,018	-	-	-
q	0,276	-	-	-
Inflection point (t*)	9,29	-	9,22	8,57
Max. penetration rate	53,21%	-	48,65%	59,99%

According to model results, inflection point is approximately about time period t=9 (it is year 2005). It means that from 2005 the number of internet users in Serbiachanges/moves/growsat decreasing rate. Original data confirmed that assumption. Prediction of Logistic model is pessimistic – maximal internet penetration rate will be 48,65%, i.e. saturation level for this technology will be 2,697 million of users. Gompertz model is the most optimistic with prediction that internet technology will be adopted by almost 60% of total population aged 16-74.

The estimation of Gompertz model for internet penetration in Serbia in 2014 is approximately 50,36% (49,08% in Bass model). For example, logistic model, as more pessimistic, predicts that in 2014 46,5% of population aged 16-74 will use the Internet.The calculated parameters for Bass model (p=0,018 and q=0,276) show that in Serbia the majority of population – new users of internet are in most cases imitators.The numerical values for original and projection data for each model are shown graphically in Figure 1.

Figure 1. Estimating a forecasting internet diffusion in Serbia



MODEL FORECASTING PERFORMANCE

In order to estimate appropriateness for these four models, or its forecasting ability, we use 6 indicators: coefficient of multiple determination (R^2), adjusted coefficient of multiple determination (Ra^2), standard error of estimation (SEE), Durbin-Watson statistics, Shapiro-Wilks statistics, Runs test, mean squared error (MSE), mean absolute error (MAE), mean absolute percentage error (MAPE), mean error (ME) and mean percentage error (MPE).

In Table 2 values for “goodness of fit” indicatorsare presented.

Table 2. Statistical measures of model precision

Fit Indicator	Model			
	Bass	Exponential	Logistic	Gompertz
Observations #	15	15	15	15
R^2	0,99694	0,97518	0,99550	0,99699
R^2a	0,99101	0,92705	0,98678	0,99116
SEE	87,16176	238,59619	105,72486	86,42813
Durbin-Watson	1,38742	0,40262	1,00091	1,43079
Shapiro-Wilks	0,69500	0,07588	0,46306	0,60809
Runs test	0,60270	0,13052	0,13052	0,69505
MSE	6077,73764	49337,72399	8942,19618	5975,85748
MAE	65,69422	184,11683	74,85288	68,48843
MAPE	9,67131	40,85399	16,13385	8,67730
ME	-10,64446	-35,13479	-12,71233	-6,67021
MPE	-9,60964	-40,75661	-16,05797	-8,60330

First, all models have satisfactory values calculated for coefficient of multiple determination (R^2) and adjusted coefficient of multiple determination (Ra^2).

In literature MAPE is emphasized as one of the most appropriate indicators for estimating “goodness” of fitfor forecasting models. Gompertz and Bass model achieves much better MAPE values than the other two models. Exponential model can be rejected even after graphic analysis shown in Figure 1, because the projected data are very far from original data.

Durbin-Watson statistic reveals that Gompertz model has the smallest autocorrelation and consequently the results of regression analysis for this model are more reliable.

The main characteristic for all models is also that it does not fit well in the initial phase of internet introduction, especially in 1997 and 1998. Nevertheless, values for almost all "goodness of fit" indicators analyzed in this paper show that Bass and Gompertz model can be a useful tool for prediction of internet diffusion in Serbia, much better than exponential or logistic models.

CONCLUSION

We can conclude that three out of four presented models (Bass, logistic and Gompertz model) can adequately describe the internet diffusion process in Serbia and consequently the diffusion of new similar technologies important for IE. Analysis made in this paper can help industrial engineers to rank description models for internet and similar ICT diffusion forecasting in Serbia, according to the values of "goodness of fit" statistics and their data approximation precision compared to original data set.

Technology forecasting, as part of IE planning, has to answer different questions related not only to using ICT as IE decision support tool, but also related to ICT market development in Serbia as end-user market. Planning and decision process in IE depends on the ability and precision of forecast model to predict, for example, if the market is ready or not for a new technology, how close an existing technology is tothe end of its life, if new technologies are still in their early stages, what possible adoption rates of the new technology are, etc. Based on the information gained from forecast models industrial engineers make decisions regarding the design of new products, methods of development of production processes or when and how to introduce a new technology, product or services.With the help of these models industrial engineers can more easily understand how to make good decisions related to staffing needs, production levels, resources mobilizing plan, organizational changes etc.

This research confirmed that internet adoption in Serbia has already achieved an inflection point and that number of internet users now is growing on decreasing rate. According to official data for the last several years, a similar situation is with ICT use in firms where IE need to be applied. It means that it is time for introducing more sophisticated ICT on the Serbian market as WIMAX or 4G with further pushing to faster adoption of internet broadband technologies, as technologically superior ICT basement for IE. In that case, the crucial factor of new ICT adoption will be the initial users – innovators, who determine how fast and in which level will technology diffusion go.

But, this research and analyzed models cannotdescribeand predict thepurpose of ICT technologies used by the end-user (individuals or firms). We can assume that more ICT use in firms means stronger IE decision support, but models cannot predict if adequate ICT would be engaged or not in Serbian firms. In further research, this qualitative analysis has to be complementary to mathematical and statistical analysis of possible technology forecasting models. Also, to reconfirm ICT forecasting precision of models analyzed in this paper it will be very useful in further research to add FLOG model and Box-Cox model to the analysis and to analyze the diffusion of mobile telephony, broadband internet and ICT use in firms in Serbia. The last mentioned is the most important from IE point of view.

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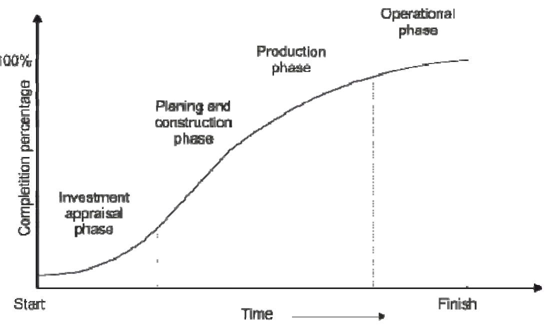
USING ARIMA MODELS FOR TURNOVER PREDICTION IN INVESTMENT PROJECT APPRAISAL

Zoran Petrović[1], Uglješa Bugarić[2], Dušan Petrović[2]
[1] Dipl. Ing, Tecon Sistem d.o.o, [2]Associate Professor, University of Belgrade, Faculty of Mechanical Engineering

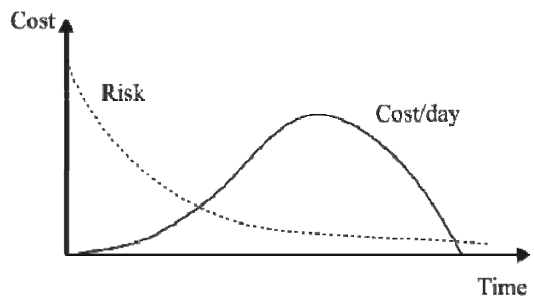
Abstract. *In the contemporary investment project analyses, most critical point is how to estimate daily turnover of production, or service, based system. In order to make prediction, for investment in certain type of equipment more accurate, daily turnover in the system for automated car wash was observed, along with weather conditions. According to observation, ARIMA model for daily turnover and weather condition is created, according to Box-Jenkins procedure. Conclusion was made that daily turnover can be analytically expressed through daily weather conditions.*
Validity of observation is checked on second system that is installed in different town in Serbia. According to compared results, conclusion was made that ARIMA model of system daily turnover, predicted by dependent variable, can be generally used as good predictor in investment analyses, or selective criteria for investment decisions.
Key words: *ARIMA, Box-Jenkins, investment analyses, turnover prediction*

1. INTRODUCTION

Life cycle of project is determined by, at least four phases. In the first phase, also called initial phase, feasibility study is performed and decision for continuing or cancelation of the project, (if not feasible), is made. In the production systems if project is evaluated as feasible, other phases can be carried out (planning and construction, production and final operational phase), **Picture 1.**
From the **Picture 1**, it is hard to conclude that first phase of the project is most important one. Conclusions from the first phase will have vital influence to the project successful finishing [2].
Considering risk distribution across project life cycle, beginning of the project is bearing most of the risk, since in the beginning number of available information is relatively small.



Picture 1 Project cycle phases [1]



Picture 2 Diagram of project life cycle considering project expenditure and risk [3]

Usually, in investment analyses average daily turnover, measured on existing system is used to estimate turnover for system that is analyzed from the point of investment appraisal. Problem in such approximation is that fluctuation of average daily turnover of the system that is analyzed as potential

investment, can differ significantly from any other, previously installed system.
In order to predict daily turnover, two variables were measured on existing system. First variable is Daily turnover and second one is Daily weather condition.

2. HYPOTHESIS

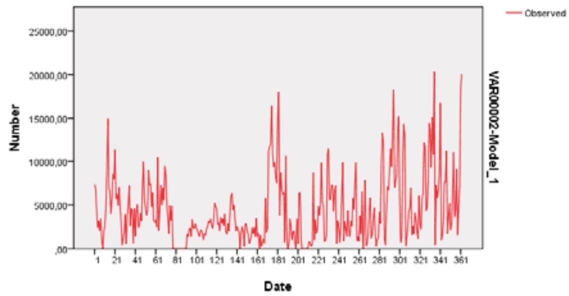
Hypothesis 1.: H0: Daily turnover is dependent from Daily weather condition.
Hypothesis 2.: H0: Measure of dependence can be expressed in analytical form.
Hypothesis 3.: H0: Daily weather condition can be used as predictor for estimation of daily turnover in investment analyses.

3. METHODOLOGY

Automated car wash was observed in such way that daily records of turnovers and weather conditions were registered in research protocol. Case study was created from daily records taken from 25.05.2009. until 21.5.2010. During mentioned time 362 data records were taken.
From research protocol two variables were created – Daily turnover and Daily weather condition. Daily turnovers are represented as values in RSD and Daily weather
conditions are represented as one of four different, weather conditions. If weather during most of the day was sunny, number 1 was assigned for Daily weather condition. If weather during most of the day was cloudy, number 2 was assigned. To mostly cloudy with rainy period was assigned number 3 and to the rainy, or snowy, day was assigned number 4.
Variables defined in research were modeled as ARIMA time series according to Box-Jenkins modeling strategy [4]. Such variables are used for forecasting of turnover on the system [5]. All calculations were done in statistical software IBM SPSS Statistics 20.
Dependency between those variables was examined in order to check if daily turnover depends from daily weather condition. In the results, after confirmation of the **Hypothesis 1**, analytical model of dependency was created and **Hypothesis 2** was confirmed.
For confirming **Hypothesis 3**, new system in different town was observed. Observation period was defined as 100 days, on which both variables (Daily turnovers and Daily weather conditions) were recorded and registered in research protocol. Based on the analytic expression of the dependency between variables in first case, daily turnover on second system was modeled, using daily weather conditions as predictor.
Data for both variables were tested against Hypothesis that they can fit to the Normal distribution. Goodness of fit for both variables was tested with Kolmogorov-Smirnov test, with significance level α=0,05.
Students T test was used in order to test both variables against **Hypothesis 3**, that there is no significant differences between distribution of two samples.

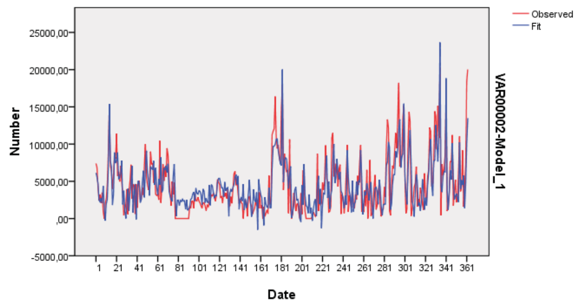
4. RESULTS

According to proposed methodology time series of daily turnover is given on the **Picture 3**:



Picture 3 Observed daily turnover

Time series of measured data compared to time series of modeled data using ARIMA methodology is given on the **Picture 4.**



Picture 4 Observed and modeled daily turnover

According to the calculated data best fitted model that describes analytical relationship between Daily turnover and Daily weather condition was: ARIMA (1,0,14). Parameters of ARIMA (1,0,14) model are given in the **Table 1.**
Analytical expression for relationship between variables is given as:

$$Day_n = 8447,649 + 0,696\ Day_{n-1} - $$
$$-0,296 \sum_{k=n-13}^{n} \frac{Day_k}{n-1} - 1789,317\ W_c$$

where:

$\sum_{k=n-13}^{n} \frac{Day_k}{n-1}$ is average turnover for past 14 days.

n is number of observation $n \geq 14$.

Wc is daily weather condition on observed day as categorical variable that can take value 1-4.

Table 1. ARIMA model paramters

ARIMA Model Parameters								
					Estimate	SE	t	Sig.
VA02-Model_1	VAR02	No Transf.	Constant		8447,649	557,341	15,157	,000
			AR	Lag 1	,696	,041	17,070	,000
			MA	Lag 14	-,265	,055	-5,431	,000
	VAR01	No Transf.	Num.	Lag 0	-1789,317	115,705	-15,464	,000

According to Ljung-Box procedure, statistical model is good fitted to observed data. Significance of the test was 0,081, so difference between fitted and measured values are not statistically significant. Values of the Ljung –Box test for goodness of fit are given in the **Table 2**.

Table 2. Model goodnes of fit

Model	Number of Predictors	Model Fit statistics	Ljung-Box Q(18)			Number of Outliers
		Stationary R-squared	Statistics	DF	Sig.	R-squared
VAR02-Model_1	1	,609	23,158	15	,081	6

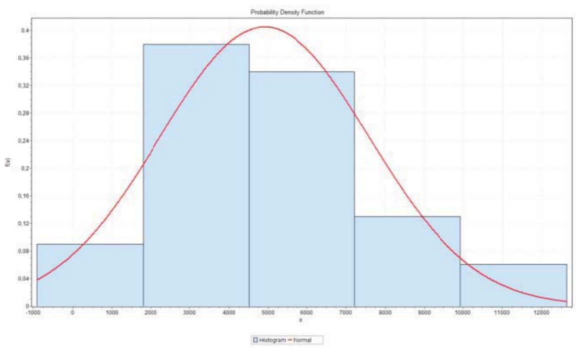
Table 3. Extreme values (outliers)

			Estimate	SE	t	Sig.
VAR02-Model_1	14	Additive	7889,826	2094,530	3,767	,000
	182	Additive	10126,487	1996,093	5,073	,000
	300	Additive	10890,786	2045,844	5,323	,000
	335	Additive	13578,128	2011,825	6,749	,000
	341	Additive	10432,565	2030,952	5,137	,000

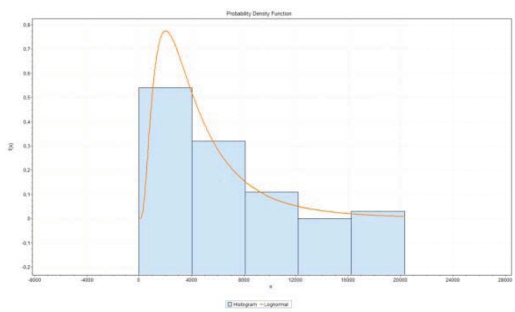
Number of extreme cases (outliers) is 6, which is less than 2%, of all observed cases. Extreme values (outliers) are given in the **Table 3.**

In order to validate results, newly installed system was observed in different town. Average turnover form first model was used as starting value for modeling. Rest of time series was modeled from analytical expression for relationship between variables, based on weather variable that was recorded on the system, as predictor. Data sets from observed real system were tested against Hypothesis that they can be described with Normal distribution. Data sets from model, were tested against Hypothesis that they can be described with Log Normal distribution.

In the first case results are distributed according to Normal distribution N (2671,4912) and in the second, results were distributed according to Log Normal distribution LogN (0.77,8.2). Histograms for both variables are presented on **Pictures 5** and **6**.



Picture 5 Histogram of data observed from real system



Picture 6 Histogram of data predicted with ARIMA model

Goodness of fit was tested with Kolmogorov-Smirnov test, for same significance level $\alpha=0,05$.
In the first case, where data on real system were tested against Hypothesis of Normal distribution, critical value for Kolmogorov –Smirnov test was 0,13403 for 100 recorder data sets and value of the test was 0,086.
In the second case, where modeled data were tested against Hypothesis of Log Normal distribution, critical value for Kolmogorov –Smirnov test was 0,13403 for 100 recorder data sets and value of the test was 0,078.
Student's T test was accomplished in order to test **Hypothesis 3,** that there is no significant difference between means on two independent samples.
According to calculated values of Student's T test, for significance level of $\alpha = 0,05$ and degrees of freedom df=198, value of the test was t=0,553. There is no significant difference between means on two variables.

5. DISCUSION

Hypothesis 1 was tested and results confirmed stated Hypothesis that variable Daily turnover can be predicted by variable Daily weather condition. From the model fit it can be seen that goodness of the fit is 60,9%, which is considered as good model fit [6].
Number of outliers in fitted model was significantly small (below 2%), which also indicates goodness of the fit.
Hypothesis 2 was also confirmed. Analytical formulation of dependency was made, which also established mathematical model for next Hypothesis.
Hypothesis 3 was also confirmed. Based on proposed methodology, record sets of measurements from real system and record sets from modeled values were analyzed. Measured values were fitted to Normal distribution and modeled values were fitted to Log Normal distribution. Reason for this is in the fact that modeled values are dependent from previous record sets, so sudden changes from one weather condition to completely opposite one (from sunny weather to snow for example) can't be described completely by model.
Never the less model is in the end, for mentioned number of record sets giving good predictive results, with no statistically significant differences between two samples.

6. CONCLUSION

As described in the paper Daily turnover of automated car wash system depends from observed variable Daily weather condition. Measure of this dependence is calculated through ARIMA time series model. Results from modeling were compared to observed values got from another system. According to these results there is no statistically significant difference between two data sets, which implies that proposed ARIMA method can be used for prediction of daily turnover of car wash facilities. Similar model can be used for estimation of daily turnover in other industry fields.
Future analyses will be in the direction of finding one or more variables that can be used for prediction of daily turnovers in other technical systems and comparing results with one published in this paper.

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THE ROLE OF INFORMATION SYSTEMS IN DECISION-MAKING

Mirjana Misita[1], Nebojša Lapčević[2], Danijela Tadić[3]
[1]Faculty of Mechanical Engineering, University of Belgrade
[2]Production Manager, Metalika-Volf, Vojka
[3]Technical Faculty, University of Kragujevac

Abstract: *Decisions made by managers are often based on reports obtained on request from the electronic database companies. Information contained in the database are not always accurate. In this paper we describe the relationship between information systems, data formats, and their influence on decision making.*
Keywords: *information systems, decision making, errors in the database*

1. INTRODUCTION

Information systems in business relations have an irreplaceable role. It is inconceivable that the world today without the information systems function.
The information system is a set of elements or components that are interrelated that collect (input), process (the process), and the general store (output) data and information and provides a corrective response (feedback mechanism) to achieve the goal. [1].
The special role of information systems have in making decisions. Here we primarily think of decision making in business and manufacturing environment. This environment significantly affects the lives of people so that decisions have implicitly human role. Managers are people who make decisions and because of their great responsibility to make the right decision. That decision is usually based on the information gathered largely from the information systems that the organization eg. The company owns. All of the information system must be accurate because it implies the right decision.
We try to describe some of observations and experiences gained by using several ERP information systems to monitor production and to the MAX Ikarbus-in, in ISSUP Minel GE, Minel Compass in GE, the Metalika Metalika-Volf and thus closer to the problems that occur in the ERP information system.
These companies as customers have the most public companies, which means that they are subject to public procurement, and that there are two ways through tenders and procurement through small purchases.

Figure 1. Shows a complete ERP system on an enterprise consists of the following modules: Inventories, Production, Accounting, Personnel, Delivery, Business obeveštavanje, Sales, Design, Production Planning, Procurement

Common to all public procurement is the highest score in the evaluation of the tender carries the price and delivery time, so that these two decisions on the price and delivery time are becoming the two most important decisions for both managers and the company.
Information on price and delivery period, the manager receives from the system upon request. These data represent the Cp-production cost and time for the product, the value below which the manager should not go, although it does occur but that it belongs to the company policy.
Due to fierce competition in all markets there was a shooting down the price and the maximum shortening deadlines. This caused the shortening of production times, requires the suppliers to lower the prices of goods, and sometimes even change the technological process (investoranjem in new technology) and closing companies that could not respond to market demands.

If you have a complex product such as a bus which has about 10,000 parts or pantograph for a locomotive or tram around 200 parts need for quality information system is more than necessary.
Common to all information systems, ERP systems, which have complex production processes and products that is very difficult to select some software on the market that will meet all the needs of companies. Each company has a system for himself with his virtues, flaws, strengths and limitations. However, software vendors are willing to not knowing the needs of companies that promise to the necessary alignment with the needs of software companies to reach a common solution at the same time offering him a very attractive price.
After purchasing the necessary hardware (computers and networks), training and familiarization with the software as well as the harmonization of the previous database or create a new case that is not compatible. manual data entry, it starts using the application in real time. Then begin to make unplanned costs, additional training and additional modules to be programmed to make the software work in real life. The General Manager then realizes that he must set aside their best employees, best paid, to work with consultants from the company that sold them sotver to transfer their knowledge to them that they would transfer their developers to create a module that they need. Here there is one kind of animosity between employees and consultants of the company. Employees feel that they lose time because they separate from their core business and argue that consultants do not do anything but just take the per diem and consultants say they are not well explained to employees what they want and not make the module as they should. Employees feel that they do not need their former way of adapting the software, and consultants believe that this is inevitable.
This usually takes about 2 years and when it comes to life mainly supply module, financial accounting module, and module sales staff because these modules are defined by law (almost the same in all companies), while the project module almost never comes to life, and the production is achieved mostly in the area of the launch and records of work orders ie. through the preparation of the production module. Sales Module is used mostly in the area of printing the report, ie. Printing invoices and delivery notes. Production planning is not used because it usually produces a known customer acquisition module is used only in the records of goods supplied and otvararanje input module supplies. Inventory module is used only as an electronic version of warehouse management cards, and business intelligence module is usually not used because Sam is not able to in a qualitative way, the processing data in the database.
Finally, general manager understands that in addition to the direct costs of investment in IS has a huge number of paid hours of their employees are not rare and overtime, giving up on further investments in information systems, so the IS is left alone with people who are directly responsible to take care of him : IS administrators and employees who IS necessary for daily operation. IS left without the support of the general manager who realizes that he has benefited from data received from him, but justified by the fact that it did shift the segment condition and value stocks.
However, companies that achieve significant profit and whose employees and general manager, understand the necessity of a good quality IS break after a year of collaboration with existing IS and seller accept a real loss of the failed investment, create your IT service which employs developers and a local developer with a house that will help developers and employees of the company to make ERP software for production monitoring to meet the demands and needs of the enterprise. Often it happens that there are two different IS related to certain interface, each working in a particular segment of the company.
It should be noted that It is necessary care-IS set in the range of quality products for only the continuous improvement of IS can provide accurate and quality data.
To achieve high quality and accurate information to the database must be:
- User frendly,
- Up to date,
- All the elements to enter the base, and all the attributes to be entered correctly,
- All parts and related products uniquely coded,
User frendly - to monitor trends in the production company and recognized for their employees.
When it says up to date means that all elements are defined with the price of raw materials, the possibility of procurement of raw materials and its alternatives in the market and their delivery time, ie. associated with the base of suppliers.
All the elements that enter the base. technology of products consists entered completely with time manufacturing. Correctly enter the elements means that a person who enters the data into the database is able to recognize the goods specified on the invoice of the supplier and its attributes and according to established rules for the opening of a base ident at the base or recognize it if it exists.
Very often it happens that some sub-assemblies are connected in the circuit so that they are not taken into calculation, or you happen to have some part of the two codes.

2. USEFUL INFORMATION

To ensure that the information would be useful information to managers must have the characteristics shown in table 1.

Table 1 Characteristics of IS [1]

Characteristics	Definitions
Availability	The availability of information should be accessible to authorized users so that they can get them in the right format at the right time when there is a need
Accuracy	Accuracy means that information without error. In some cases, inaccurate information is created because the incorrect data entered into the transformation process. In the jargon this is called "garbage in, garbage out" [GIGO].
Complexity	Complexity of information containing all relevant facts. For example. Report on investments do not include also all the relevant costs.
Cost	Cost information should be relatively economical to process their application. Managers who make decisions need to balance the value of that information and they are received.
Flexibility	The flexibility of information can be used in different purposes. For example. how much stock on a certain part of the state can use for sales presentations, samples to give the customer free of charge, to the production manager could plan more inventory, and financial executors to provide more money to be invest in production stock.
Relevance	Relevance is important for decision making, for example. producers in the old chip prices may fall, and therefore not relevant to producers.
Reliability	Reliable information to believe. In many cases, the reliability of the information depends on the reliability of methods for data collection. At other levels, depending on the reliability of information sources. For example. Gossip from unknown sources that the jump in oil prices are unreliable.
Safety	Information should be protected from access by unauthorized users.
Simplicity	Ease of information should be simple, not too complex. Detailed information is not necessary. In fact, too much information may cause the manager can not determine what is really important.
At the time	Information is delivered to time when necessary. Knowledge of the time last week does not help us to decide how to wear today.
Probity	Information should be probity. This mean we can check whether they are correct, often must check multiple sources for the correctness of the same information.

3. VALUE OF INFORMATION

The value of information is directly directly associated with providing assistance to managers who must make decisions and achieve their goal. Useful information can help people more efficiently and effectively achieve the goal. For example. predict market demand for new product and if use this information to develop new products and the company earns a profit of 10,000 euros, the value of this information, the company will be 10 000 less the cost of information. Any information is worthwhile if it thanks to realize a direct profit, eg by reducing costs. in production or in spending enegrije, energy, povećna productivity, or point to new markets.

4. EXAMPLES OF ERRORS IN THE DESIGN OF DECISION AFFECTING DEVELOPED ON THE BASIS OF THE IS

This is an example of the electronic design of nuclear power plants by using PDMS (Plant Design Management System) and errors that arise in designing 3D models (modeling) and IS, which is formed during design.

Table 2. Errors in the 3D modeling, example

	∑	Tubes with a large bore tube wrongly classified as a small bore tubes with a small bore	Tube wrongly classified as a large bore	Pipes with Dn = 0
The total number of tubes	22041			
The total number of tubes with a nominal diameter Dn> 50	6397	43		85
The total number of tubes with small nominal diameter DN <50	15644		1870	629

This is an example of a French company since it is not doing complex projects in Serbia. The company has the following project sections:

- Electricity team - electrical networks
- Team HVAC - Heating, ventilation and air conditioning
- Civil team - a team building facilities
- Layout team - co-ordination between the teams, heat exchangers, pumps, fixtures and equipment in the project
- Piping team - distribution pipes in the area

1) Errors in the 3D model when designing piping (Piping), which is divided into the Great bore tubes and pipes with a small hole and the value of Dn = 0 (table 2). Errors that occur during the categorization of pipe. Such errors lead to a defective documentation, laying pipes in the wrong place, system instability due to inadequate pipe supports. When Dn = 0 the whole system is faulty and

requires re-planning (MTO-Material take-off and BoQ Bill of quantity).
2) Errors that occur when errors in determining the material has not prescribed the proper material.
The material properties give information about the type of materials to be used in the construction of concrete or steel structures. This information indicates the class of concrete quality, radiation exposure, mechanical properties, etc.. Information about the characteristics of steel materials appear so. "Steel Grade" table.
Automatic detection and evaluation in 3D modeling is not possible because the criteria that determine the material are strictly engineering. But the more important that these values are defined.

The total number of carrier material properties in the 3D model	Material is not specified	The material has not changed with the change of catalog
25442	692	13

These errors directly affect the MTO and the increase in construction costs as well as the work on time. These errors can easily identify and remove the 3D model, but if not timely removed a major problem in the project.
3) Errors caused by poor management decisions, such as the decision to prepare a catalog of building components and materajala at the same time with the design of buildings.
a) Using parts (parts, floors, concrete sections, etc..) from outdated or incorrect catalog.
b) Using parts from the correct directory, but the revision of outdated catalogs.

The total number of installed parts	Parts taken from the wrong or outdated parts catalogs	Taken from the catalog of a good review but outdated
87241	973	6564

4) Errors resulting from poor IS design elements.

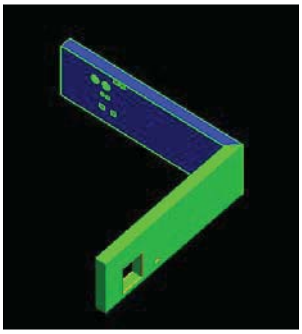

Figure 1. Example of poor design in IS

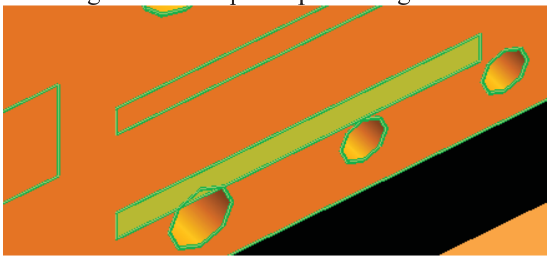

Figure 2. Example of poor design in IS

In this figure, "clash checker" ignores edges that are cut and reported the collision between the elements, although it is obvious that there is no collision between them. This error is sometimes ignored, but the art that is derived from the 3D model can lead to misunderstanding.
Plate anchors if poorly positioned collisions with holes designed for the pipe. As seen from the example of the observed errors are not significant individually, but because of the environment, influence and a large number of positions in the project and their number is important so that managers can lead to the wrong choice. When jobs are valuable hundreds of millions leads to the clear conclusion that the importance of data obtained from the IS to be accurate.

5. CONCLUSION

The paper emphasizes the importance of IS managerial decision-making. Therefore, the consequences of inadequate implementation of IS managerial decision-making may be large.
Manufacturing practices indicated to us the most common mistakes that have occurred during the inadequate use of ERP on decisions that followed erroneously interpreted the data from the IS. The paper aims to show managers that decisions are based on data from the IS depends on good knowledge of IS, timeliness of data and accurate interpretations of the manufacturing process when designing for a specific company.

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IMPROVING THE ENERGY EFFICIENCY OF THE HEATING PLANT "TECHNICAL FACULTIES": A CASE STUDY

Ph.D. Dragoljub Zivkovic, Ph.D. Pedja Milosavljevic, M.Sc.Milena Todorovic, M.Sc.Dragan Pavlovic
University of Nis, Faculty of Mechanical Engineering, Aleksandra Medvedeva 14,18000 Nis, Serbia;
draganpavlovic10369@gmail.com

***Abstract**: This paper presents the analysis of the current state of the energy supplying system of the heating plant "Technical faculties" by using modern quality tools (Statistical Process Control – SPC and ISHIKAWA diagram). The analysis of the current state points out the problems and needs for modernization, reconstruction and increase in the energy efficiency of the heating plant. The expected effects of the system modernization are reflected in securing the supply of thermal energy, high efficiency, reduced energy consumption and primary energy losses and reduced emission of gases. All this clearly shows the justification of investment in the modernization of the district heating system in the heating plant "Technical faculties".*

***Key Words**: district heating, SPC analysis, ISHIKAWA diagram, automatic regulation, modernization*

1. IINTRODUCTION

The heating plant "Technical faculties" in Niš, with the total capacity of 25.7 MW, represents a very important heating unit of the city of Niš. The heating plant is not a part of the Public Utility Company "Heating plant of Niš", but it is an individual unit, responsible for supplying thermal energy to the residential area, technical faculties and secondary schools. The improvement of the energy efficiency of the heating plant "Technical faculties" represents the topic of this paper. To ensure safety in the delivery of thermal energy, reduce energy consumption and losses of primary energy, and reduce greenhouse gas emissions, quality tools (SPC and ISHIKAWA) and 6S methods are applied to the process in the heating plant. Based on the results, proposed improvements are defined, which would have a great effect on the heating plant efficiency and increase its competitiveness in heat supplying.

2. DESCRIPTION OF THE HEATING PROCESS

Three boilers are installed for the preparation of hot water at the temperature level of 130/70ºC in the boiler room of the heating plant. Natural gas is used as the primary fuel and as an alternative – fuel oil, which is used in the case of failure or lack of gas at the gas installation.

From the heating plant there are 4 distributors or routes of heating systems, which represent four groups of consumers:

- Schools (Secondary school of electrical engineering "N. Tesla", Secondary school of civil engineering, Technical school "February 12", and Technical College of Professional Studies);
- Faculty of Electronic Engineering (including student dormitory and restaurant "Index");
- Residential area "S. Sinđelić" (5 substations in total);
- Faculty of Mechanical Engineering and Faculty of Civil Engineering.

Except the residential area and the dorm, which are daily supplied with thermal energy, schools and faculties are heated only on working days and only during the working hours.

This heating plant has 6 employees: 3 boiler plant operators (responsible for handling of boiler room and monitoring of automatic system SCADA), 2 installers (responsible for the maintenance of installations) and head chief of the heating plant. The working hours are organized in two shifts, excepts in very cold weather conditions when they are organized in three shifts in order to monitor the plant when it operates at full capacity.

A heat substation, a heat source and district heating networks, represent basic system elements of the district heating system. The heat substation is designed for regulated distribution of heating energy from the primary network of the district system to the secondary network of house installations (radiators or air heating), or preparation of sanitary hot water. Water temperature regulation in the secondary network of the heating substations is performed depending on the ambient air temperature. The main goal of the regulation is to achieve the desired room temperature [1].

To provide high-quality supply of heating energy together with a cost-effective mode of heating production in the heating plant, it is necessary to provide a suitable method of regulation. Satisfying these requirements is only possible by using a system of automatic control. This means that proper equipment is needed. Depending on where it is installed, the place where it is positioned, one can differentiate between central, group, local and individual control [2].

Automatic control has a task to regulate the temperature in the room directly by water regulation in the feedline supply of the secondary circuit. The central computer in the lab is connected to the controller in the heating substation by wired connection (or GPRS) via the central controller in the boiler room, which represents the local regulation, and which provides data in both directions: from the system to the operator and vice versa. An overview of system parameters is enabled, as well as their remote control. Furthermore, the operator of the system of central control has access to the current state of the electrical drive, as well as the possibility of issuing unconditional commands to all electric actuators (switching on, switching off, opening and closing of valves).

This paper reviews the data taken from the central SCADA computer in the boiler room that supplies the school heating system.

3. STATISTICAL PROCESS CONTROL ANALYSIS – SPC ANALYSIS

Using the modern methods for statistical monitoring and process control provides an insight into the current state of the system, a variation of the system and monitoring of parameters that affect the process. In further analysis of water temperatures, monitoring was used in the substation SPC analysis, at different time intervals in order to obtain an insight into the temperature variations [3], [4]. Software SPC.Net, developed by the CIM Group company was used to conduct the SPC analysis.

The boilers start every day at 5:00, except in the transitional regimes when they start around 5:45. The operators start up boilers manually, while the rest of the process is carried out automatically. Figure 1 shows the SPC diagram of feedwater temperature in the boiler at 6:00 during January. Control points are days in January and each day at 6:00 the temperature of the boiler feedwater is measured.

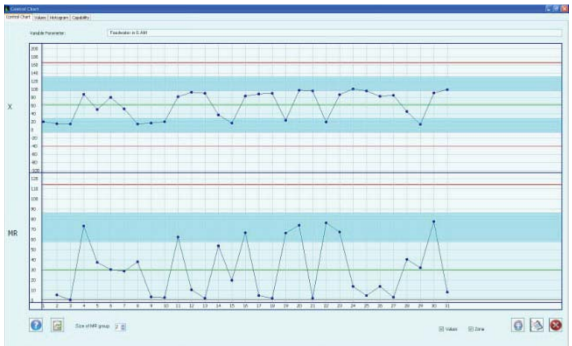


Figure 1 - SPC diagram of feedwater temperature at 6:00 - January 2012

Based on the SPC diagram, it can be concluded that feedwater temperature on the working days is 95-100 ºC, while at the weekends or non-working days this substation is turned off and the system works with minimum values that prevent freezing of the water in the system. It can also be noticed, based on the available data, that the boilers are not started every day at 5:00, but sometimes later, which causes the feedwater temperature to reach its set value around 7:00 to 8:00.

Figure 2 shows the SPC diagram of feedwater temperature for every day at 14:00 in January.

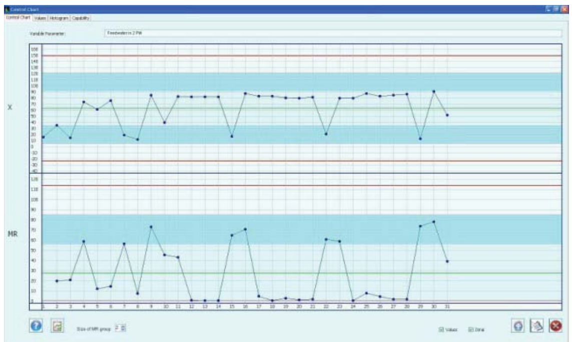


Figure 2 – SPC diagram of feedwater temperature at 14:00 – January 2012

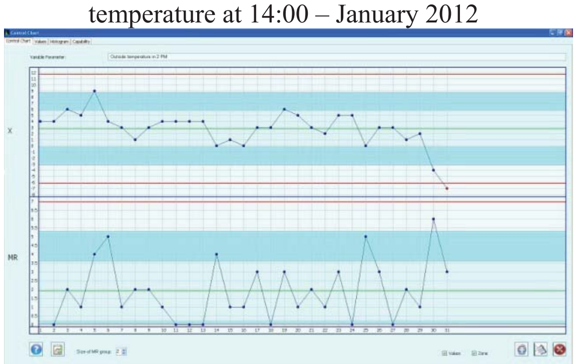


Figure 3 – SPC diagram of the external temperature at 14:00 – January 2012

Figure 3 shows the values of the external temperature, also for each day at 14:00 in January.

Control points are days in January and each day at 14:00 the boiler feedwater temperature is measured.
It can also be noticed that on working days the feedwater temperature reaches the value of around 90 ºC, while at the weekends or non-working days this substation is turned off. The above time represents the warmest time of the day and time when boilers operate in a steady operating mode. It can be also notices, via the sliding diagram for the primary circuit, that the temperature of boiler feedwater increases with the lower ambient temperature.
As the coldest day during January, the January 31 was suitable for monitoring the feedwater temperature of the heating plant (Figure 4).

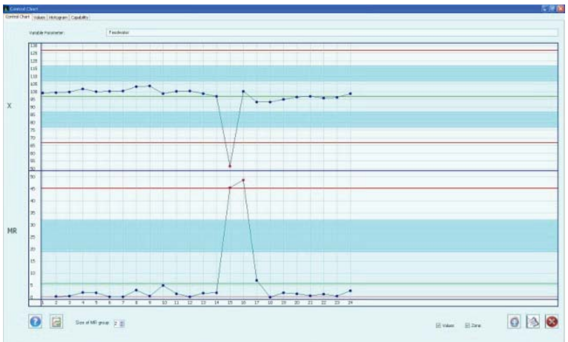


Figure 4 – SPC diagram of feedwater temperature for 31.01.2012.

In the periods of the coldest days, the boiler plant worked in three shifts and continuously without stopping the boilers. From the diagram it can be noticed that the boilers were working at full capacity and with feedwater temperature of above 100 ºC. The observed deviation at 15:00 can be explained as a measurement error or an interruption in communication, because it did not affect the further course of the process, which can be seen from the feedwater temperature at 16:00 which is 100 ºC. Based on the SPC analysis it can be concluded that the process is stable and without significant variations.

4. ISHIKAWA ANALYSIS

Ishikawa diagram is a tool that helps in identification, sorting, and displaying of possible causes of a specific problem or quality characteristics and aspects. The diagram graphically shows the relation between a specific consequence and all factors that influence that consequence [5].
In this case, the considered consequence is **Low efficiency and primary energy loss**. Software **Ishikawa .Net**, developed by the CIM Group company, was used for creating the Ishikawa diagram (Figures 5 and 6).

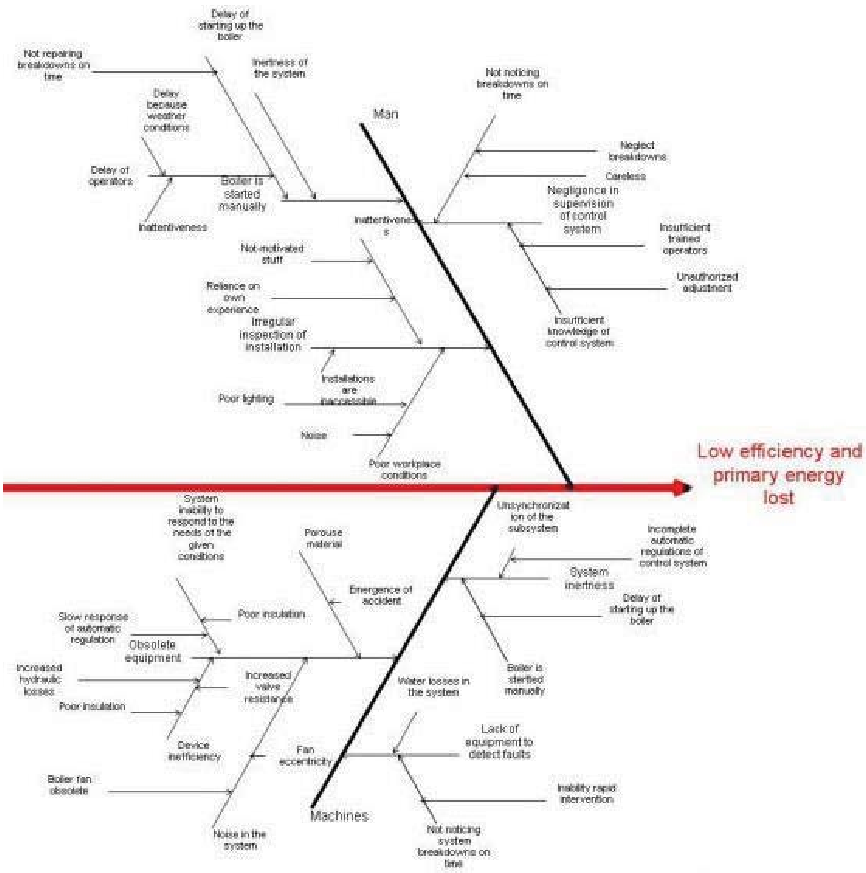


Figure 5– Categories Man and Machine

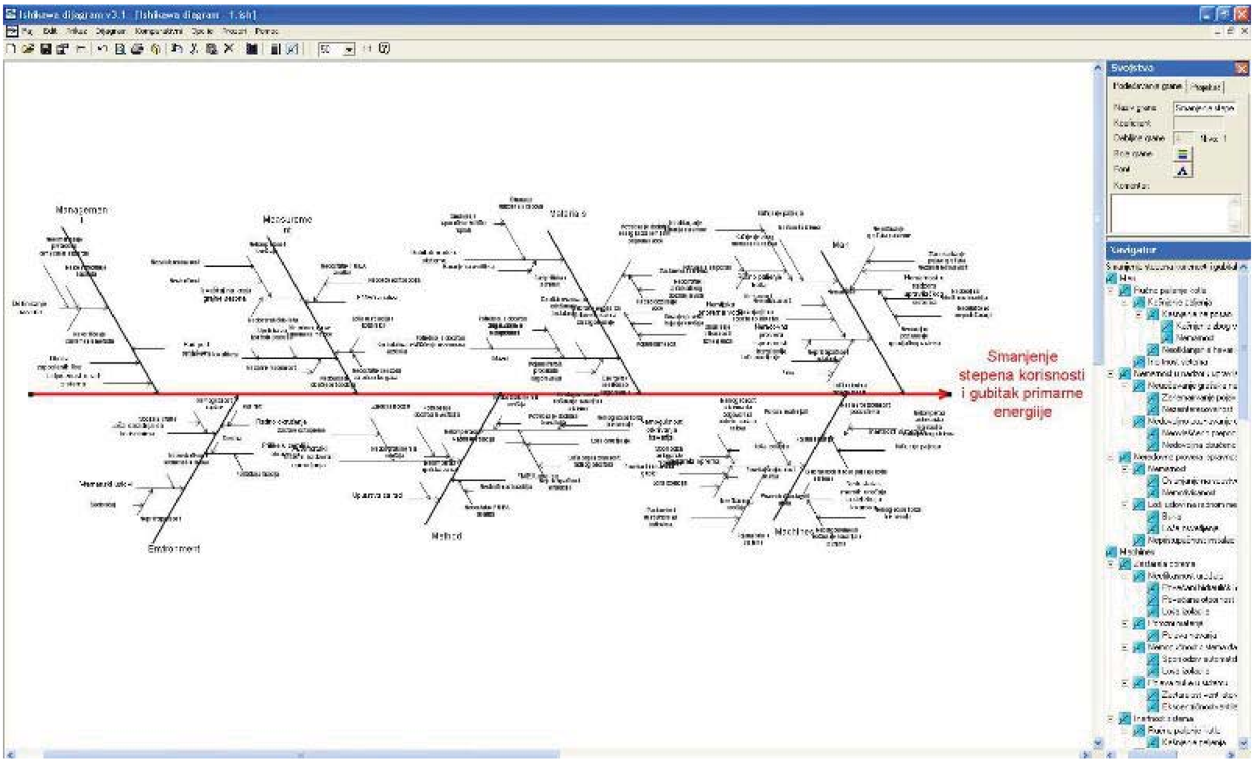


Figure 6 – Ishikawa diagram

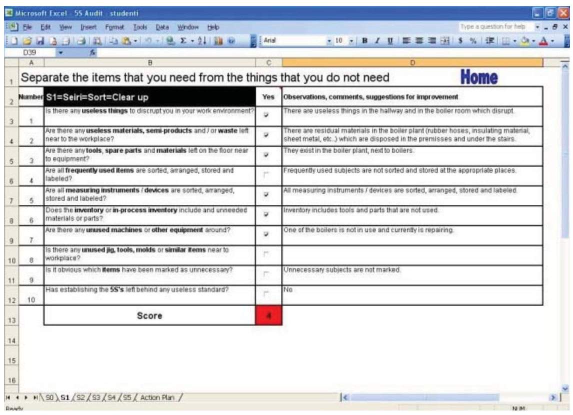
5. 6S METHOD

6S is modeled after the 5S model of organization and visual control of the workplace, and it is basically the 5S model with one added phase, **Safety/Security** [6].

5S audit is implemented to obtain a true picture of the current situation. One of the major problems that appears is poor hygiene at the boiler plant and a large amount of material, equipment and machines that are not in use and that only take up space. It is necessary to clean up the boiler plant, to remove old stuff, machines, tools and equipment that are no longer used, to regulate ventilation and lighting in all rooms. The sixth pillar of the 6S method is based on creating a safe workplace and eliminating hazards. Another problem that arises are various bumps or irregularities in the floor, and the steps that lead to boilers are small and unstable, so it is also necessary to regulate that in order to eliminate possible hazards and injuries. Beside this, it is necessary that everyone who works next to a machine wears protective gear to avoid possible injury.

After completion and implementation of 5S audit, based on the results, the action plan is developed which gives a description of the problem, root cause and proposed corrective measures to eliminate this problem. The result is the realization of an action plan for a clean and safe workplace, where each next occurrence of a malfunction, hazard or anomaly can be easily identified and eliminated.

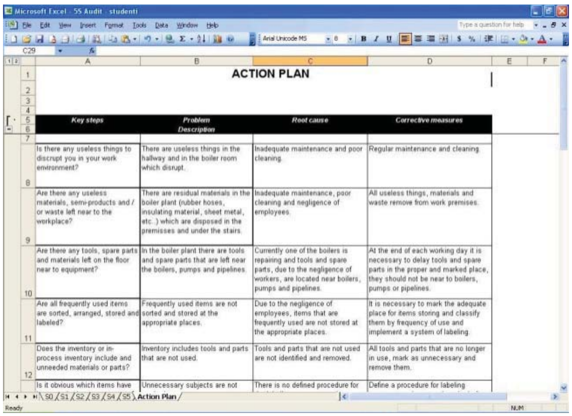
Below, Figure 7 shows the first phase of 5S audit - Sort, while Figure 8 shows a part of the action plan. Software Systems2win was used for creating the 5S audit and action plan.



Separate the items that you need from the things that you do not need — Home

Number	S1=Seiri=Sort=Clear up	Yes	Observations, comments, suggestions for improvement
1	Is there any **useless things** to discrupt you in your work environment?	✓	There are useless things in the hallway and in the boiler room which disrupt.
2	Are there any **useless materials, semi-products** and / or **waste** left near to the workplace?	✓	There are residual materials in the boiler plant (rubber hoses, insulating material, sheet metal, etc..) which are disposed in the premisses and under the stairs.
3	Are there any **tools**, **spare parts** and **materials** left on the floor near to equipment?	✓	They exist in the boiler plant, next to boilers.
4	Are all **frequently used items** are sorted, arranged, stored and labeled?		Frequently used subjects are not sorted and stored at the appropriate places.
5	Are all **measuring instruments / devices** are sorted, arranged, stored and labeled?	✓	All measuring instruments / devices are sorted, arranged, stored and labeled.
6	Does the **inventory** or **in-process inventory** include and unneeded materials or parts?	✓	Inventory includes tools and parts that are not used.
7	Are there any **unused machines** or **other equipment** around?	✓	One of the boilers is not in use and currently is repairing.
8	Is there any **unused jig, tools, molds** or **similar items** near to workplace?		
9	Is it obvious which **items** have been marked as unnecessary?		Unnecessary subjects are not marked.
10	Has establishing the **5S's** left behind any useless standard?		No
	Score	4	

Figure 7 – The Audit for the first phase – Sort



ACTION PLAN

Key steps	Problem Description	Root cause	Corrective measures
Is there any useless things to discrupt you in your work environment?	There are useless things in the hallway and in the boiler room which disrupt.	Inadequate maintenance and poor cleaning.	Regular maintenance and cleaning.
Are there any useless materials, semi-products and / or waste left near to the workplace?	There are residual materials in the boiler plant (rubber hoses, insulating material, sheet metal, etc..) which are disposed in the premisses and under the stairs.	Inadequate maintenance, poor cleaning and negligence of employees.	All useless things, materials and waste remove from work premises.
Are there any tools, spare parts and materials left on the floor near to equipment?	In the boiler plant there are tools and spare parts that are left near the boilers, pumps and pipelines.	Currently one of the boilers is repairing and tools and spare parts, due to the negligence of workers, are located near boilers, pumps and pipelines.	At the end of each working day it is necessary to delay tools and spare parts in the proper and marked place, they should not be near to boilers, pumps or pipelines.
Are all frequently used items are sorted, arranged, stored and labeled?	Frequently used items are not sorted and stored at the appropriate places.	Due to the negligence of employees, items that are frequently used are not stored at the appropriate places.	It is necessary to mark the adequate place for items storing and classify them by frequency of use and implement a system of labeling.
Does the inventory or in-process inventory include and unneeded materials or parts?	Inventory includes tools and parts that are not used.	Tools and parts that are not used are not identified and removed.	All tools and parts that are no longer in use, mark as unnecessary and remove them.
Is it obvious which items have	Unnecessary subjects are not	There is no defined procedure for	Define a procedure for labeling

Figure 8 – Part of the Action plan

6. IMPROVEMENTS

Based on the analysis of the Ishikawa diagram and 5S audit it is possible to suggest the following improvements in order to increase energy efficiency of the heating plant:

- Installation of economizer – temperature of the output gases would be utilized. The output gas temperature without the economizer is 150-200 ºC, and an installed economizer would reduce the temperature to 80-90 ºC. Therefore, there would be constant saving in preheating of combustion air.
- Reconstruction of the heat pipelines route to the Faculty of Electronic Engineering (including the Student Dormitory and canteen “Index”) and to the technical secondary schools, where the old steel pipes DN200 would be replaced with new preinsulated pipes. This would reduce the thermal losses to consumers, making the monitoring of the appearance of leakage or damage simpler.
- Automatic regulation of all substations - regulation of the secondary circuit. Constant monitoring and defining of all necessary parameters will prevent overheating, which would result in savings of delivered energy of up to 15-20%. Automatic regulation provides a fast response and correction of the given parameters, in order to guarantee the necessary amount of heat. Regulation is achieved through the regulating valve and enables the connection to the central SCADA computer in the heating plant. Thereby, the operators in the heating plant can monitor almost all of the parameters necessary for the efficient functioning of all substations at any time.
- Automatic regulation of the sixth floor of the Faculty of Mechanical Engineering. A few years ago there was an expansion in the capacity of the Faculty of Mechanical Engineering and the sixth floor was upgraded, where the heat is now regulated with fan convectors. This separate thermal pipeline of the Faculty of Mechanical Engineering does not have the automatic regulation and appropriate connection with the SCADA.
- Automatic regulation itself provides monitoring and control of parameters that have an influence on the process, and the operators of the heating plant can also affect the pump operation at each substation. What is missing in this system is the supervision and management of additional sensors and alarms to detect failures from the heating plant to the consumers, as well as the supervision at the substation itself. This way it will be possible to respond on time and prevent any possible damage and water loss in the system.
- Water losses that occur in the system due to overheating or possible leakage of water through the plant are compensated by chemical treatment of water which consists of a water softener, the salt container and the distribution pipe with appropriate fittings. Prepared water goes into the tank and from there into to system by feeding pumps. Existing installations for the chemical water treatment are started manually, so that automatic dosing should be enabled when it comes to losses in the system. This way would ensure that the system is always full of water and a quicker response in the damaged conditions.
- Installation of sensors to detect the gas presence in the boiler room. This helps to ensure a safe and secure handling of the boiler plant in the sense of detecting the possible occurrence of hazards on time.
- The heating plant “Technical faculties” has a tendency to expand its supplier network. This way it would be able to have a full heat capacity even in the transient terms. Potential customers are: “Nišauto Gemos” Ltd. - showroom, the building of the University of Niš and the complex “Technology Park” whose construction is planned. The showroom “Nišauto Gemos” Ltd. currently uses processed oil as fuel in the heating process, while the building of the University of Niš uses coal. The inclusion of these consumers in the district system would reduce the large losses in their previous heating and also reduce emissions and ensure the reduction of energy consumption.

The initiative of the City Public Utility of District Heating of Niš is to begin with the “payment based on calorimeter” next year, which means that any installed heating unit in the district system should have a sensor element. In this way consumers can at any time control their heat consumption, and affect the amount of heat energy according to their requirements by adjusting a thermostat. With the current system of heating payment, which has thus far been calculated per m^2, all existing heat losses that occur during the production and during the transport of heat would have further influence on the energy efficiency of the heating plant. With the application of this, all mentioned improvements would provide that these losses remain minimal.

7. CONCLUSION

Improving the energy efficiency and the development of district heating systems represent significant topics for Serbia. Since our country does not possess a large energy potential per citizen, particular attention must be paid to the development of centralized energy systems for heating, as well as the preparation of consumable water and technological processes [7], [8]. The energy supply of consumers and its rational use represent a complex problem considering our reserves of conventional fuels and increasingly stringent environmental requirements in the cities. The heating plant “Technical faculties”, as a very important part of the heating system, represents a system on which one should focus in order to increase the quantity of delivered heat energy.

Based on the suggested improvements, it can be noted that the investment in the modernization of automatic process regulation of the boiler plant is necessary and that it would directly impact the improvement of the efficiency and safety in the distribution of heat energy. The modernization of the existing system will create the opportunity for further expansion of capacity and increase the number of users of district heating. The reconstruction of the system will yield a completely new modern system that will be able to provide quality heating for all users and meet the needs of energy, economic and environmental standards.

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AN EFFICIENT HEUTISTICAPPROACH FOR SOLVING THE MAX-MIN DIVERSITY PROBLEM

Nina Radojičić[1], Miroslav Marić[1], Zorica Stanimirović[1], Srđan Božović[2]
[1]Faculty of Mathematics, University of Belgrade, Serbia
[2]MFC Mikrokomerc, Belgrade, Serbia

Abstract – *This paper describes an efficient metaheuristic methodfor solving a discrete facility location problem, namedthe Max-Min Problem Diversity Problem (MMDP). Taking in consideration numerous solution methods proposed in the literature up to now for solving the MMDP instances of larger dimensions, the use of probabilistic algorithm gives a significant contribution to a real application. We design and implement a variant of Variable Neighborhood Search method for solving the MMDP and benchmark it on appropriate MMDP instances. The obtained experimental results of the proposed method are compared with the results obtained by using the IBM ILOG CPLEX software package for smaller problem dimensions. For larger and large-scale MMDP instance that were out of reach for CPLEX, the proposed heuristic method produced solutions in short CPU times. Regarding its efficiency and robustness, the implemented heuristic method can be applied to similar discrete location problems with appropriate modifications of the algorithm.*

Key Words *– Discrete optimization, NP-hard problems, Variable Neighborhood Search, Metaheuristic, Location theory.*

1. INTRODUCTION

Optimizing algorithms minimize or maximize the value of an objective function subject to a number of constraints that impose limits on the choice of solution. Optimization algorithms may be divided in two basic classes: deterministic and probabilistic algorithms. A rough taxonomy of global optimization methods is given in [16] and it is presented in Figure 1.

Deterministic algorithms are often used when there exists a clear relation between the characteristics of the possible solutions and their utility for a given problem. In this case, the search space can be explored in efficient manner. On the other hand, if the relation between a solution candidate and its "fitness" is not so obvious or too complicated, or the dimension of the search space is large, it is much harder to solve a problem deterministically. Trying to solve these problems in a deterministic way, we would most likely obtain an exhaustive enumeration approach of the search space, which is extremely time-consuming, even for problems of relatively small dimension.

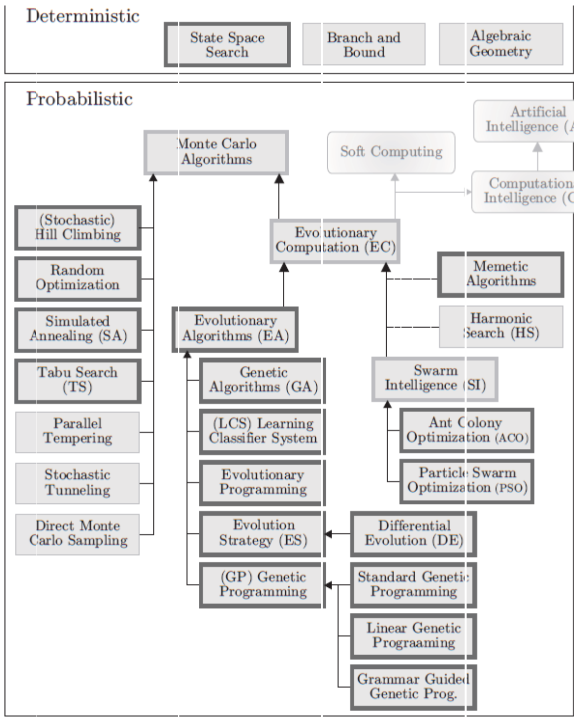

Figure 1.The taxonomy of global optimization algorithms[16]

For these reasons, probabilistic algorithms have gained an important role when solving optimization problems, especially the problems of real-life dimensions. Although they have a lack of guaranteed optimality of the solution, their huge advantage is a relatively short execution time. As it was mentioned in[16], this does not mean that the results obtained using them are incorrect – they may just not be the global optima. On the other hand, a solution a little bit inferior to the best possible one is better than one which needs hundreds of years to be found.

Popularity of location problems was due to their numerous applications in different areas. During the last two decades there has been a major effort to develop location models capturing more features of real problems.Traditionally, the most of literature in location theory has concentrated on the median and center measures (and their variations), but issue of equity in location problems on networks is motivated by several potential applications (see [1]). In the paper[11], authors consider single facility location problems with equity measures, defined on networks.

In selecting sites for facilities, the issue of equity has recently become very important. Several equity criteria have already been applied in different areas. In this paper, an equity measure, the maximum of minimum diversity, is analyzed.

2.THE MAX-MIN DIVERSITY PROBLEM

The problem is NP-hard and can be formulated as an integer linear program [14]. Since the 1980s, several methods for solving this problem have been developed and applied in various fields.

In the paper [14], empirical results indicate that the proposed hybrid implementations compare favorably to metaheuristics previously proposed in the literatures, such as tabu-search and simulated annealing.

2.1 PROBLEM FORMULATION

The goal of the *Max-Min Diversity Problem* (MMDP)is to choose a subset *M*of *m*elements (|*M*| = *m*) from a set *N*of *n*elements in such a way that the minimum distance between the chosen elements is maximized.

Let Nbe a finite collection of points (elements), and let $N(m) = \{X \subset N : |X| = m\}$, the set of all m element subsets of$M$, where $2 \leq m \leq n-1$. Real number$d_{ij}$is associated with each pair of points$i, j \in M,\ i \neq j$and called a *distance*between i and*j*. In many formulations (see [10]), distanced_{ij}does not necessarily satisfy the properties of a customary distance metric (for example triangle inequality) and may even be negative.

The classical Maximum Diversity Problem (MDP) deals with selecting asubset $M \in N(m)$, which maximizes the sum of the distances d_{ij}over all pairs$i, j \in M, i \neq j$. There are many research papers in the literature that consider the MDP, see [9], [2], [3], [15].As it was observedin [9], the maximum diversity problem has numerous applications in plant breeding, socialproblems, ecological preservation, pollution control, product design, capital investment,workforce management, curriculum design and genetic engineering.

The MMDP is a variant of the classical MDP, which involves the objective that showed to be more suitable for some applications in practice. Instead of the sum of distances between the points$i, j \in M$, $i \neq j$we try to maximizes the minimum distance between distinct points from the chosen subset *M*.

As mentioned in [9] and [3], the MMDP has important applications in plant breeding, social problems and ecological preservation. In most of these applications, it is assumed that each elementcan be represented by a set of attributes.Let s_{ik} be the state or value of the k-th attribute ofelement i, where $k = 1, \dots, K$. The definition of distance between elements is customized to each specific application. For example, the distance between elements i and $j$can be defined as:

$$d_{ij} = \sqrt{\sum_{k=1}^{K} \left(s_{ik} - s_{jk}\right)^2}.$$

I

n this case, d_{ij} is one of the most popular metrics, i.e. the Euclidean distance between $i$and j.

In this paper, we use one of the integer formulations presented in [14]. The considered MMDP formulation has a quadratic binary nature and uses the distance values mentioned before. Binary variable x_i, $i = 1, \dots, n$takes the value of 1 if element $i$is selected and 0 otherwise. By using this notation, the MMDP can be formulated as:

$$(MMDP) \max z_{MM}(x) = \min_{i<j} d_{ij} x_i x_j$$

$$\sum_{i=1}^{n} x_i = m$$

$$x_i = \{0, 1\}, \ \ i = 1, \dots, n.$$

The MMDP is NP-hard, which was proven byErkut in [4] and Ghosh in [2] independently. As it was mentioned in [14],one should not expect that a method developed for the MDP will perform well for the MMDP. In [14], the authorsgive an exhaustive literature review on the MMDP and propose several solution methods for this problem, based on hybridization of the GRASP, path relinking and evolutionary path relinking methodologies.The authors in [9] state that the MMDP is harder to solve than the MDP for both exact and heuristic methods.

In paper [10],another heuristic approach for the MMDP is discussed. The proposed approach relies on the equivalence between this problem and the classical max-clique. It solves different decision problems about the existence of cliques with a given size.

3.VARIABLE NEIGHBORHOOD SEARCH

Variable neighborhood search (VNS) is a metaheuristicmethod designed for solving combinatorial and global optimization problems. The basic idea of the VNS is systematic change of neighborhood within a local search. The basic VNS is a descent, first improvement method, based on local search principles(see [12], [13], [5], [6], [7], [8]).

Let us denote a finite set of pre-selected neighborhood structures with$N_k (k = 1, \ldots, k_{max})$. Let$N_k(x)$be the set of solutions in the k-th neighborhood of a solution$x$.The definition of a neighborhood structure is very important for a successful VNS implementation. Note that local search heuristics usually use one neighborhood structure, i.e.$k_{max} = 1$.

In our VNS implementation, a solution of the MMDP problem is represented as a permutation $(i_1, \ldots, i_n)$ of integers from the set$\{1, 2, .., n\}$, where $n = |M|$. The first $m$integers in the permutation are taken as chosen points.

Generally, neighborhoods of a given solution $x$are defined by taking into account the properties of the considered problem and chosen solution encoding. In the proposed VNS concept, if we randomly replace a selected point from the code of the solution $x$by randomly chosen non-selected point (swap those two points), we obtain a new solution x' that belongs to $N_1(x)$. If we randomly exchange two selected points with two non-selected ones, we will obtain a new solution from $N_2(x)$, etc.

After the initial solution x and stopping criteria are chosen, the basic VNS runs through a series of iterations a stopping criterion is satisfied. Each iteration of the basic VNS involves the following steps:

1. Set $k = 1$ to explore $N_1(x)$ and repeat the following steps until $k = k_{max}$ is reached;
2. When the VNS achieves a local optimum, we randomly move to a solution x'in the current neighborhood $N_k(x)$, no matter if this solution is better or not (*Shaking*);
3. Starting from this new solution x' and applying local search, we try to find a new local extremumx''(*Local Search*);
4. If the change didn't lead to a better local extremumx'', we stay in the neighborhood of the current solution $x$and increase k in order to get another $N_k(x)$. Otherwise, we continue search in the first neighborhood of $x''(k = 1)$.

The Reduced Variable Neighborhood Search (RVNS) is a variant of the basic VNS method, which results from removing the local search step from the VNS cycle (step 3.). The RVNS method showed to be more efficient than the basic VNS for solving problems of larger dimensions, since we avoid costly local-search procedure, see [6].

In our implementation, we combine the RVNS and basic VNS method in order to solve the MMDP efficiently. We first apply the RVNS method, which quickly produces a solution of theproblem. An initial solution for the RVNS is chosen randomly and RVNS runs through limited number of iterations. An Improvement Procedure (based on multiple local search applications) has been applied on the best solution obtained by the RVNS. This improved solution is further used as the initial solution of the VNS method.The VNS cycle is repeated until we reach the maximal number of iterations (stopping criterion).

4.EXPERIMENTAL RESULTS

The VNS and RVNS methods described in previous section have been coded in C# and run on an IntelCore i7-860 2.8 GHz with 8GB RAM memory under Windows 7 Professional operating system. To evaluate the computational effectiveness of the proposed approach, a comprehensive computational has been performed. Optimization package CPLEX 12.1has been used to solve considered instances to optimality (if possible) and it was run on the same platform.

A comprehensive set of benchmark instances of the MMDP that were previously used for computational tests have been collected in [14] and named the MMDPLIB. In our computational experiments, we have used one of the sets from this library, named "Glover" instances.

The "Glover" data set was developed and presented by Glover in [3]. It contains 75 matrices for which the values were calculated as the Euclidean distances from randomly generated points with coordinates in the 0–100 range. The number of coordinates for each point is also randomly generated between 2 and 21. The problem generatordescribed in details in[3], was usedto construct MMDP instances with n=10, 15, and 30. The value of m ranges from $0.2n$ to $0.8n$.

The results of conducted computational experiments showed that the proposed combination of the VNS and RVNS quickly reaches all optimal solutions on "Glover" instances with up to 30 nodes. Instances from this data set were previously solved to optimality by CPLEX 12.1 solver. From the comparison presented in Figure 2, it can be seen that for all three groups of instances ($N = 10$, $N = 15$, $N = 30$), the proposed method was faster than CPLEX 12.1.

Detailed presentation of the obtained results is out of this paper's scope. The detailed results can be found at http:/www.matf.bg.ac.rs/~nina/Glover.pdf.

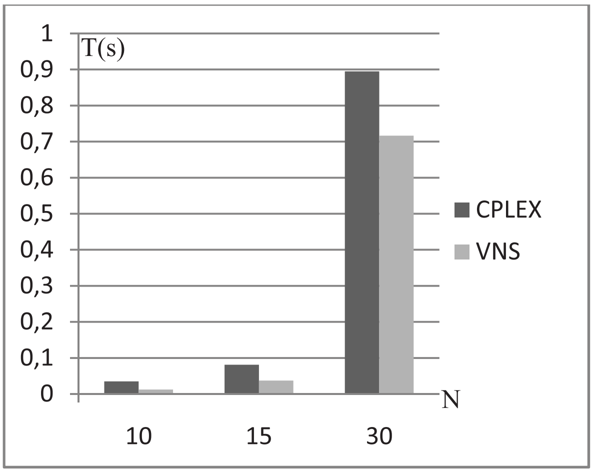

Figure 2. Comparison

5. CONCLUSION

In this paper, we have considered the max-min diversity problem and proposed an efficient VNS based metaheuristic for solving it. Computational experiments on a benchmark data set from the literature showed that the described metaheuristic quickly reaches all optimal solutions previously obtained by CPLEX 12.1 solver. Short CPU times and high-quality solutions clearly indicate that the proposed method is suitable for solving the MMDP, as well as other similar equity optimization problems.

There are several directions for the future work. We will test this approach on some challenging real-life data set of the MMDP. We will also make some modification of the proposed method in order to solve similar large-scale equity location problems. Furthermore, we will try to hybridize it with some other heuristic methods in order improve its robustness and efficiency.

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OUTPUT QUALITY INDICATORS IN THE VOCATIONAL EDUCATION - FORMER STUDENTS PERSPECTIVE

M. Gerasimovic[1], U. Bugaric[2], M. Bozic[3]
[1]Institute for Improvement of Education, Belgrade, Serbia, Fabrisova 10, 11000 Belgrade, milica.gerasimovic@zuov.gov.rs
[2]University of Belgrade - Faculty of Mechanical Engineering, Serbia, Kraljice Marije 16, 11120 Belgrade, ubugaric@mas.bg.ac.rs
[3]Autonomous University of Barcelona, Barcelona, Spain – Interuniversity Doctoral Programe in Environmental Education, marija.bozic@e-campus.uab.cat

Abstract *Vocational Education provides the acquisition of knowledge, skills and competencies for further education as well as for the possible entry into the labor market. Vocational education quality assurance involves specifying the criteria and standards that are subject to periodic review and assessment. The objective of this research was to determine the reached levels of output indicators by examining the perception of students in regard to the pilot curricula they completed in the seven educational profiles in the field of food processing. The output indicators of the educational process that were evaluated in this study were: the number of students who have completed the educational process, the number of students who upon completion started to work or continued their studies, students' perspective of their vocational competence at work and their competence to continue education.*
Keywords*: vocational education, quality assurance, labor market, vertical mobility*

1. INTRODUCTION

Vocational education provides the students with the opportunity for personal choice of education, employment and further continuous professional development. It provides the knowledge, skills and competencies for further education and the possibility of entering the labor market.

Quality assurance in education involves specifying the criteria and standards that are subject to periodic review and assessment which refer to all forms of vocational education. The effects of vocational education are evaluated using, among other, the relevant statistical data aimed at monitoring progress and maintaining the set standards, i.e., "The evaluation provides the basis for plan corrections, new activities and further cycle repetition" [1].

Periodic evaluation of the quality of education relates to the determination of:

- Input indicators of quality for every level of education;
- Process quality indicators for each level of education;
- Output quality indicators for every level of education;
- Feedback information for educational process improvement;
- The successfulness of the adjustment to labor market needs.

The establishment of a system for monitoring and evaluating the quality of education would provide valid and relevant information about the effectiveness and impact of education, quality of educational activities and their outcomes and the quality of conditions in which the educational process takes place. Stakeholders that are beneficiaries of such information include teachers, pupils and parents, schools and local communities [2]. The results obtained by periodic measurement of education indicators are necessary in the context of economic development planning and the definition of mobility by levels of education. Evaluation and development of output education indicators is needed by the economy and the labor market as an important basis for creating their own policies, because the evaluation contributes to decision-making and leads to action, i.e. to changing practices [3]. The requirements of these stakeholders are not only quantitative (graduates' capacity), but also qualitative and relate to the usability of the acquired professional competencies in the work environment [4]. Vocational education provides access to other forms of education at all levels, including access to institutions of higher education. Periodic evaluation of the output indicators of vocational education defines the quality at the input of the process of studying including programs in an integrated system of education quality assurance [5].

Modernization of Vocational Education in the Republic of Serbia started with the introduction of the Pilot curricula in the 2002/03 academic year in the field of food processing. Pilot curriculum improves the quality of education and teaching and introduces new organizational aspects. The curriculum is organized modularly. Modules represent specific learning segments, and they lead to the achievement of clearly defined learning outcomes regarding professional competencies, i.e., to knowledge, skills and attitudes acquisition. Pilot program also includes establishing a system of education quality assurance at the national and school level.

2. METHODOLOGY

The objective of this research was to determine the reached levels of output indicators by examining the perception of students in regard to the pilot curricula they completed in the seven educational profiles in the field of food processing. The study involved the three-year (*agricultural machine mechanic (AMM), baker, butcher and milk processor (MP))* and the four-year education profiles (*veterinary technician (VT), food processing technician (FPT), agricultural technician (AT))*. Specific objectives that were selected for this study were to: determine the reasons for unemployment, determine professional qualification, and determine qualifications to continue education.

Instruments designed for this study were a questionnaire and telephone interviews. The questionnaire was designed in accordance with the relevant literature and reflecting the model of the questionnaire used in the study of monitoring students of the business administrator education profile, conducted by GTZ project and the Institute for Improvement of Education.

The survey included three generations of students of the three-year educational profiles, and two generations of the four-year educational profiles. Total number of students in all the generations was 1881, out of which 538 participated in the research (28.6%).

The survey was conducted from March to June of 2008. Statistical analysis included basic descriptive statistical measures.

3.RESULTS

Based on the sample of 538 students it has been found that approximately equal number of respondents belonged to each of the three categories: 187 unemployed (34.7%), 177 employed (32.9%) and 174 students who continued their education (32.3%).

Students that completed three-year educational profiles are dominant among unemployed respondents. The greatest number of the unemployed respondents is milk processors (19.8%) and the lowest number veterinary technicians (4.3%). According to the respondents the main reasons for the unemployment are the lack of vacancies in their local communities and lack of financing for continuing further education.

In the category of employed respondents the respondents who completed a three-year educational profile are dominant (73.45%).

Most frequently employed in their profession are butchers (34.78%) and bakers (22.83%) and least numerous are food processing technicians (3.26%). Veterinary technicians stand out by the number of those who continued their education in the professional field (27.88%).

Among respondents who continued their education the most numerous were food processing technicians (31.03%).

The most important positive effects expected of the pilot curriculum are rapid adaptation of students to work conditions in practice, the application of the acquired functional knowledge and skills and a willingness for further continued training at the workplace by life-long learning. The fulfillment of these results was determined by measuring the application of expert knowledge in the workplace, the need for additional training after starting to perform at the workplace as well as willingness of respondents for advanced training. On a four level scale (1-not at all, 2-a bit, 3- mostly and 4-fully) respondents estimated the level of application of expert knowledge at work place and these results are shown in Table 1 as values of arithmetic means. Most successful application of acquired expert knowledge has educational profile Butcher ($M = 3.50$).

Table1 – Application of expert knowledge at the workplace and willingness for further continued training

<table>
<tr><th colspan="2"></th><th>N</th><th>M</th><th>SD</th><th>Statistically significant difference</th></tr>
<tr><td rowspan="2">Application of expert knowledge at the workplace (numerical assesment scale from 1 to 4)</td><td>Four-year education profile</td><td>18</td><td>3,00</td><td>0,907</td><td rowspan="2">No statistically significant difference p<0,05</td></tr>
<tr><td>Three-year education profile</td><td>74</td><td>3,34</td><td>0,727</td></tr>
<tr><td rowspan="2">Willingness for further continued training at the workplace (scale from 1 to 5)</td><td>Four-year education profile</td><td>18</td><td>3,94</td><td>0,725</td><td rowspan="2">No statistically significant difference p<0,05</td></tr>
<tr><td>Three-year education profile</td><td>74</td><td>3,96</td><td>0,824</td></tr>
</table>

N=number of respondents, M=arithmetic means, SD=standard deviation

Willingness for professional development in parallel with work was expressed by respondents on the scale of values from 1 to 5, with 1 being the lowest and 5 highest. In most educational profiles great willingness to develop professionally was expressed. For reliable statistical conclusions educational profiles were grouped according to the length of school education. Differences of means, as an indicator of applying knowledge acquired at school in the workplace as well as readiness for training at work, were analyzed by t-test (Table 1).

For more than three-quarters of the employees (77.2%) no additional training was needed, so respondents were involved in the work immediately upon hiring. Additional training for other respondents (22.8%) depended on the type of job and company organization. In a small number of companies there is an organized training for all new employees, while in other companies the introduction to the new job is done with the help of the instructor, or more experienced workers.

The pilot curriculum is designed so that, in addition to introducing students to the labor world, it provides the possibility for continuing further education. Out of 174 respondents who continued their education 104 (59.77%) continued the education in their professional field (Table 2). Respondents who completed a three-year education profile mostly opted to continue their education at higher vocational schools and less to acquire additional training. Respondents who have completed four-year education largely continue to study at colleges and less at higher vocational schools.

Most respondents who completed the four-year educational profile stated that the knowledge acquired in vocational school was useful to them *much* and *very much* in their further studies.

Educational profiles were grouped according to the length of schooling (Table 2).

With regard to the application of vocational school knowledge in further education it was found that there are no statistically significant differences at $p < 0.05$ (t-test) between these groups.

Table 2 – Application of vocational education knowledge in further education by levels of education

<table>
<tr><th rowspan="2">Education profile</th><th rowspan="2">Schooling duration (years)</th><th colspan="4">%</th><th rowspan="2">N</th><th rowspan="2">M</th><th rowspan="2">SD</th><th rowspan="2">Statistically significant difference</th></tr>
<tr><th>Not at all (1)</th><th>A little (2)</th><th>Much (3)</th><th>Very much (4)</th></tr>
<tr><td>VT</td><td rowspan="3">4</td><td>0</td><td>31,00</td><td>37,90</td><td>27,60</td><td rowspan="3">79</td><td rowspan="3">2,94</td><td rowspan="3">0,817</td><td rowspan="7">No statistically significant difference p<0,05</td></tr>
<tr><td>FPT</td><td>8,30</td><td>33,30</td><td>45,80</td><td>12,50</td></tr>
<tr><td>AT</td><td>3,80</td><td>11,50</td><td>50,00</td><td>34,60</td></tr>
<tr><td>AMM</td><td rowspan="4">3</td><td>0</td><td>25,00</td><td>75,00</td><td>0</td><td rowspan="4">25</td><td rowspan="4">2,64</td><td rowspan="4">0,743</td></tr>
<tr><td>Baker</td><td>0</td><td>60,00</td><td>20,00</td><td>20,00</td></tr>
<tr><td>MP</td><td>14,30</td><td>42,90</td><td>28,60</td><td>14,30</td></tr>
<tr><td>Butcher</td><td>0</td><td>44,40</td><td>33,30</td><td>22,20</td></tr>
</table>

N=number of respondents, M=arithmetic means, SD=standard deviation

4. CONCLUSION

Although there is no integrated vertical system of quality of education, it can be concluded that students who have completed the education profile in this sector are largely able to continue their education and that they highly appreciate the application of vocational school knowledge. Those who are employed in their professional field believe that they are well trained to perform the job due to the fact that they did not need additional professional training and that they apply professional knowledge at the workplace to a large extent. They are also willing to pursue continuous professional development.

When it comes to professional competencies it can be stated that the projected outcomes have been reached: students quickly adapt to working conditions, they apply functional knowledge and skills in the workplace and they are willing to pursue continued professional training. The overall conclusion of the professional competencies of employees, however, can be performed taking into account also the opinion of employers.

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M2M PRODUCTION IN CLOUD

Vojislav Bobor[1], Ljiljana D. Ristic[2], Ivan Barac[3]
[1]JP ETV, Jovana Ristića 1, Belgrade, Serbia
[2]Faculty of Mechanical Engineering, Kraljice Marije 16, Belgrade, Serbia
[3]IB, Ratka Mitrovica 7, Belgrade, Serbia

Abstract - *Communication between machines in the production and monitoring of production processes in the cloud environment give us a new challenge in industrial production. The development of wireless networks and cloud environments today has led us to the emergence of M2M (Machine to machine) technology and software. M2M provides communication and monitoring of machines in the production process from different locations. This technology uses network sensors and controllers with which to obtain information on production processes (state machines, and its temperature, the number of processed items, start the machine, etc). Cloud development environment and software as well as new ways of networking machines offer new possibilities in industrial production monitoring from any location, but also a new challenge in the field of security of communication between them.*
Keywords - Cloud computing, M2M technology, cloud security.

1. INTRODUCTION

The changed conditions in business today placed in the foreground communication in order to achieve interaction and connection of all elements of the environment [1]. A new challenge today is connecting machines and devices in a single network and overseeing their work with other geographic locations. The advantages of these technologies are improved safety, reduction of energy consumption, better quality and lower product prices, as well as improving the overall production process. Application development, network infrastructure, software platforms slowly leads us to the machine interaction in the production processes. Software processes information and gives a better picture and insight into the production process and the solution to increase productivity.
M2M technology has the potential to increase revenue, reduce costs and improve services to clients of an organization [2]. Connectivity M2M technology and cloud technologies and the collection of information is more new business opportunities in the form of improving product quality and customer service

2. M2M TECHNOLOGY

Expansion and development of wireless networks has led to the emergence of M2M (Machine to Machine) technology and software. M2M provides communication and monitoring of machines in production at large distances from the more different locations using cloud technology. This technology uses network sensors and controllers with which to obtain information on production processes (state machines, and its temperature, the number of processed pieces, start the machine, etc.). Through sensors, the information is sent to server systems located in remote cloud sites.
In this way, at any time you can monitor the production process (start the machine, the number of units processed on the machine, increasing the temperature of the machine, the end of the process on machine, etc.).
For many organizations and companies, unlimited capacity, accessibility and flexibility, as well as the potential savings are huge benefits and savings by using Cloud computing, offer to renting infrastructure, complete platforms or specific applications.
This method of monitoring and information processing, improving its efficiency, its progress is monitored and controlled portions of production in which the notice is less productive.

3. PRODUCTION OF DISTANCE AND ITS SAFETY

The development of cloud technology (Figure 1) and software, gives us new possibilities for monitoring of production in industry.
Cloud brings new services and new types of vulnerabilities that brings virtual environment client and server sides.
Cloud security system is a critical factor, and requires the application of all known security

services, as well as specific solutions to cover new types of vulnerabilities.

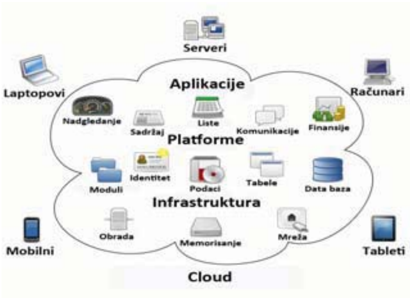

Figure. 1. cloud environment

From any location, easy access to the server and logging software application, you can follow the work of employees (time of arrival and departure from work, absence from work, etc.) Monitors and supervises the production process (phase of the production process, consumption of electricity and heat , the state machine (machine failure, or following the last overhaul, the temperature of the machine, installing new software, etc..) or final product quality and quantity of units produced.
Cloud allows multiple users to simultaneously access and process data. Combining machine and cloud technology is important for business success, because it allows monitoring of a large number of machines in real time from different locations.
Besides all the advantages of this new virtualized multi-user environment poses some new security issues, as some traditional security measures are not applicable here.
By accepting the cloud environment, a large part of the network, computer systems, applications and data coming under the control of third party service provider that offers the Cloud.
This concept includes the development and use of IT and computer-based Internet, where users abstracting the details and do not need to know or control the technology infrastructure in the cloud, which supports them by providing services over the Internet: a dynamic, scalable and virtualized resources (hardware, software, platforms, storage, etc.) [3].

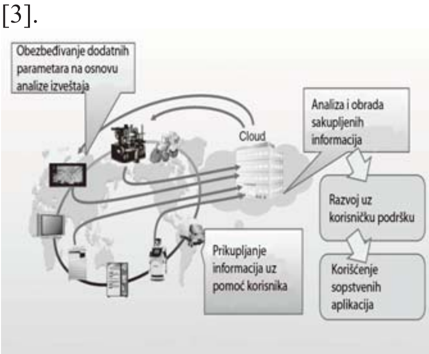

Figure. 2. M2M and cloud technology [3]

4. M2M TECHNLOGY TODAY

Today, in his first days we can see an example parking payment service via mobile phone services, payments through POS terminals, ATMs or use Busplus introducing the system of payment in public transport vehicles in Belgrade.
In the next few years we will be witnessing the development of M2M technology in the household and automotive industries. The software will monitor printer status, cars or machinery. The microcontroller in the printer, a car or machine will send information to the server in the cloud need to order toner or need regular maintenance, replacement of printers, automobiles or machines that had the problem.
The vehicle will wirelessly send information to a server that is in service of a complete diagnosis of the car, engine condition, worn-out brakes, coolant level and oil in the machine and the like. (Figure 3).
Server will process the information and notify the owner of the vehicle on the required replacement or repair. Manufacturers will thus be able to follow the product life, and maintain and extend its life cycle.
This concept requires a fast, stable and secure internet connection. Also need a stable platform, and software that is properly designed computer network.

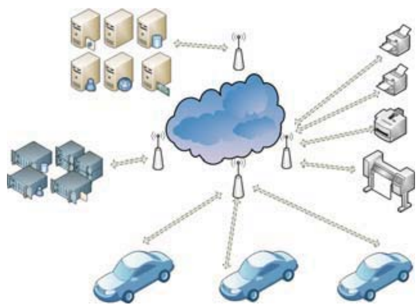

Figure. 3. Monitring cars and printers via cloud

Programming platform in the cloud enabling the development of user applications and storage in the environment and existing infrastructure replaces the actual user physical infrastructure (servers, disks, databases, devices to ensure safety).
The right cloud environment provides the following capabilities:
1. Unlimited scalability (capacity if needed services are dynamically scaled)
2. Payment to use (paid only what is used and how much is used).
3. No charge to establish services (current, free establishment of service, only the operating costs),
The user does not have to maintain the system (maintenance comes down to user administration and monitoring of Service) [4].

4.1. Practical use and security threats

The development of applications, platforms and network infrastructure will lead to the very machine

interaction in the production processes. Just as a printer or a car to be sent information about their operation (the number of printed pages or kilometers), so the machine itself in the process of sending it wirelessly to cloud the information on the number of units produced on it, increasing the consumption of electricity or heat in the process production, the necessary repairs or the number of hours the machine.
Your information will be processed by the software and give a better picture and insight into the production process and the solution to increase productivity and improve. Along with the interaction of machines in production, manufacturing process and will incorporate the human factor that is employed.
The system will have information when employees come to work, which had the effect of the work day (the effect for the entire month or year), the effective working time is spent on the machine, whether it is someone who has changed and in another production process, whether it should be rewarded and the like. And all in the cloud! Start using cloud technology is a complex decision for any organization, which must first weigh the advantages and disadvantages that it brings her. Cloud is not necessarily more or less safe than the usual way of storing data on a server and other user systems. As with any other new technology, and this solution opens up new risks and new opportunities [5].
Application of these technologies that will take over the sale and servicing of the device enables more productive and efficient operations and better service to customers.

4.2 *M2M areas*

Some of the areas that are currently available M2M telemetry, data acquisition, remote control, robotics, remote surveillance and monitoring, road transport, diagnostics and maintenance, security systems, logistics services and telemedicine [6].

5. THE CHALLENGES OF INDUSTRIAL PRODUCTION AND CLOUD COMPUTING

The last 20 years have passed in the development of technologies of communication between people (mobile phones, PCs, laptops, tablet PCs, PDAs, etc.). What comes as a new challenge is to connect the machines and equipment (cameras, printers, electric household appliances, medical equipment, construction machinery, industrial machinery manufacturing, automobile, etc.) in the unique network monitoring and control of their work with other geographic locations.
It is estimated that by 2015. The number of devices that will use M2M technology will grow to 25 billion units. M2M will become a huge market that will develop a large number of platforms and software.
Past development of the network was focused on improving quality of communication between people and the exploitation of network capabilities for transferring image and sound.
Time to come will require a change in approach to the use of network capacity, the introduction of new communication protocols, complete geographical coverage, far larger and more stable flows of communication, new systems of protection devices and connection security.
The auto industry is sure to record the largest developing of M2M technology. Modern cars now have over 70 microcontrollers that control vehicle functions on the level of oil in the car and lock the GPS vehicle navigation. Internal network in the car has more than 6 km of cables and allows for better and safer driving and also provides information on required maintenance repairers of vehicles.
Application of these technologies in industrial production in the distance will be more represented a cloud environment will significantly contribute to a better and cheaper product. (Figure4).

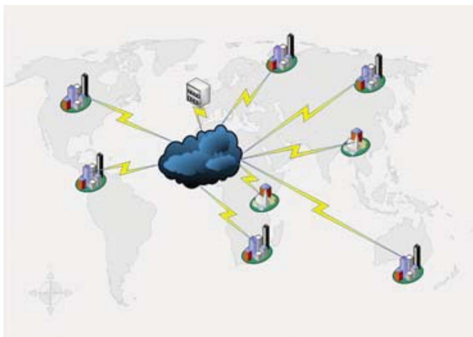

Figure4. Monitoring of industrial production

5.1 *M2M expertise*

What course follows the development of applications, platforms and network infrastructure and expertise that the company will need to have industrial plants to switch to new M2M technology and in what form they divert the cloud.
CSA (Cloud Security Alliance) has developed a guide for users "Security Guidance for Critical Areas in Cloud Computing." This guide has quickly become the industry guide for the safety of this technology. Various organizations around the world use this guide in order to manage their cloud environments and resources [7].
Companies will have to meet the standards within their production processes in the cloud. (stable and secure Internet connections, software licenses, the latest upgrade and patch using the SOFTWARE, filled with firewall and security standards, trained and certified engineers, brandname hardware, etc..).

6. CLOUD PRODUCTION PERSPECTIVE

Cloud is still not represented in the market to the extent that it could be, so that the experts have to continue working on its development and creation of new innovation, customization of existing solutions while ensuring that the safety of the whole system remains good enough.

Cloud will reach its full growth potential only after the removal of current problems, especially the problem of security.

Cloud has a bright future because it weighs increasing capacity and new capabilities without investing in new infrastructure, training new staff or buying new licensed programs. These are all great advantages compared to current methods of data storage that help organizations make large financial savings and provide them with the possibility of faster and greater development, investment in new research and new projects, including the further development of the IT sector.

Today there are many companies that deal with architecture and network connectivity devices and machines in manufacturing plants.

They deal with:

• monitoring and control of vehicles in the company
• management of alarm systems
• management of resources in production
• logging and control over mobile devices (PDA, mobile phones, tablet, etc.).
• the supervision and control of machines
• Industrial control and monitoring, etc..

Its use are in:

• reading of electricity consumption remotely
• Control of transport vehicles and trailers
• monitoring alarms on cars
• control and monitoring of street lighting in cities
• counting the number of visitors in large shopping centers
• control and monitoring of water pumps
• control and monitoring of heating systems in cottages
• monitoring and control of cooling systems and refrigerators in large shopping centers
• monitoring of water flow in plumbing systems

6.1 Next step

M2M is still mainly focused on smartphone devices, POS terminals, ATMs, remote monitoring and access control systems, SCADA systems and the like.

In the future we can expect large investments in telecommunications and software companies in the development nanonetworks, M2M applications and platforms as well as the increasing speed wireless Internet and cloud environments.

M2M will be focused on application development and user interface that will adapt to the human factor to control household devices, surveillance systems, medical devices, control of vehicles, machinery manufacturing and the like.

7. CONCLUSION

M2M technologies have emerged from the framework of communication between mobile phones, computers and people. Interaction and exchange of information between major communication systems in industrial manufacturing environments within the cloud is the next step of progress and development of production processes. These networks and technologies offer new opportunities of development and require further development of wireless networks, software, hardware and training people.

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INFORMATIONAL SYSTEMS DESIGNING AND IMPLEMENTATION

M. Radic [a,*], N. Radelja[b] , D. Begonja[c]
[a] PNF, Ludvetov breg 18, 51000 Rijeka, Croatia, *miodrag.radic1@ri.htnet.hr
[b]Shipyard "3 maj" Rijeka, Croatia
[c]Shipyard "3 maj" Rijeka, Croatia

Abstract. Purpose: *Problems which are likely to manifest themselves in the course of implementation cannot be envisaged at the design stage of an informational system without employing the approach presented in this paper.*
Methodology: *All the procedures as well as all the processes need to be located through application of both analysis and synthesis; a through dismembering to the most plain constituent element to be made followed by reintegration of the same into a whole of mutually connected elements. The quest of a method providing for optimum results is solved theoretically as well as practically, given that any problem which may appear in the course of implementation of the system had been resolved through analytic approach at the very start of the design stage. Such approach provides for the only viable manner for an applied informational system to be optimally utilized at minimum costs.*
Findings: *This has been reconfirmed and proven by research monitoring and analysis of a number of informational systems applied in various organizations, from shipyards, oil/petrochemical plants, steel mills etc., and way further to nonindustrial organizations, such as hospitals.*
Research limitations: *Analytical/synthetical approach led to a conclusion that all stages of design and development of an informational system are of equal importance, so each and everyone of them must be given equally careful consideration.*
Practical implications: *By employment of data flow model all complex processes have been solved, all basic elements having been featured on the model with the logically required mutual connections. Linkage and basic elements flow sequence represents the basis for successful problems resolve in any informational system.*
Originality: *This scientific, engineering approach to problems solving in the system operational use provides for applicability in most various cases, such as where design, development, implementation of an informational system represents the very basis for a sound and profitable business operation in an organization. Besides; the approach provides for high flexibility over a wide range of problems, whereby the same can be predicted, located and interconnected.*

Keywords: *engineering approach, process modelling, data flow model, data modelling, entity relationship model*

1. INTRODUCTION

The paper presents an approach for developing an information system based on relations software. The thesis is divided in two parts: indispensability for an engineering approach in developing informational systems; designing and implementation using data flow model.

In the first part, engineering approaching in informational systems development have been dealt with. Advantages of such an approach as well as application fields have been presented.

The second part engages in the very system designing process presentation and description of the system introduction through an illustrative employment of the data flow model. The data flow model has been utilized for subdividing the development process into 21 subprocesses. Explained has been the introduction of an informational system composed of 6 basic processes and 21 subprocesses. If of importance/necessity for the development process, ulterior subdivision to yet greater number of subprocesses could have been possible. Emphasized have been the advantages of such an approach in the designing process as well as crucial spots in evolving the design process at which the data flow model proved as optimally illustrative tool. It ought to be indicated, however, that the subject data flow model cannot be expected to provide resolve for all problems on the way and therefore recurring to other proven methods for informational systems designing has been made.

2. INDISPENSABILITY OF AN ENGINEERING APPROACH

Notwithstanding the explicitly future oriented character of the informatics science and its exploitation of the most modern scientific achievements, as far as engineering approaches are concerned, it is still lagging behind in respect of many other sciences. In particular has such in equivalence been noticeable in the informational systems development field. Such approaches in the informatics science, or actually already developed methods, have within the most recent years, however, lived radical improvement, particular progress having been achieved in automatization of the same, implying the so called Computer Aided System Engineering (CASE) tools [1]. Application of the subject methods has been mainly covering [2]:

• strategic planning
• process modelling
• data modelling
• structural designing

Engineering approach [3] to design of an informational system, or application alike, is as indispensable as it has been in developing a design of an architectural object, a ship, an aircraft, a bridge, or whichever else complex technological product.

An IBM made study [4] of errors corrections attributable to costs amount at different informational system design process levels and introduction process levels clearly proves that engineering approach is a must in both designing and implementation of informational systems (Figure 1).

A common mistake made by many (due to lack of knowledge) in both design developing and/or implementation of informational systems is skipping over the STRATEGIC PLANNING, LOGICAL and PHYSICAL DESIGN DEVELOPMENT, and immediate jumping into (physical) implementation (application and test performance) [5-6]. In the related Figure, together with the particular processes names, given are the appropriate methods to be applied as standard for achieving the processes realization, i. e.:

• for strategic planning level: BUSINESS SYSTEM PLANNING (BSP) developed by IBM.
• for process model forming: STRUCTURAL SYSTEM ANALYSIS (SSA), BASED ON DATA FLOW MODEL (DFM).
• for data model forming: OBJECTS-CONNECTIONS DIAGRAM (OCD), respect. ENTITY RELATIONSHIP MODEL (ER) [7].
• for programme design: STRUCTURAL DESIGNING

Since at present time prevailingly in use are the relational data bases as most advanced data bases management tool [8], and software support systems have been widely developed for the same, herein presented is exactly the process of design and implementation suited to the relational data base model or (colloquially) the relational software [9]. The advantages the engineering approach has been proving to provide are the following:

• simple method for project task defining.

Information system design development and instruction:

1. EXISTING STATUS DESCRIPTION
1.1. Models elaboration of existing status processes
1.2. Models elaboration of existing status data
1.3. Existing resources models elaboration
1.4. Existing status analysis elaboration

2. FUTURE STATUS DESCRIPTION
2.1. Future status model elaboration
2.2. Future status data model elaboration
2.3. Analysis and project realization variant selection
2.4. Adjusment of logical models
2.5. Necessary resources model elaboration
2.6. Corrections and solutions adoption

3. RESOURCES REALIZATION
3.1. Neccessary resources realization plan elaboration
3.2. Neccessary resources realization

4. PHYSICAL DESIGN DEVELOPMENT AND DATA BASE SET UP
4.1. Adapted data model to concrete system
4.2. Translation of objects-connections model into relational model
4.3. Data base physical realization

5. PHYSICAL DESIGN DEVELOPMENT AND PROGRAMME REALIZATION
5.1. Processes logical description elaboration
5.2. Programme code writing

6. IMPLEMENTATION AND TESTING
6.1. Instructions for use elaboration
6.2. Aplication testing and correction
6.3. Delivery effecting
6.4. Project realization report elaboration

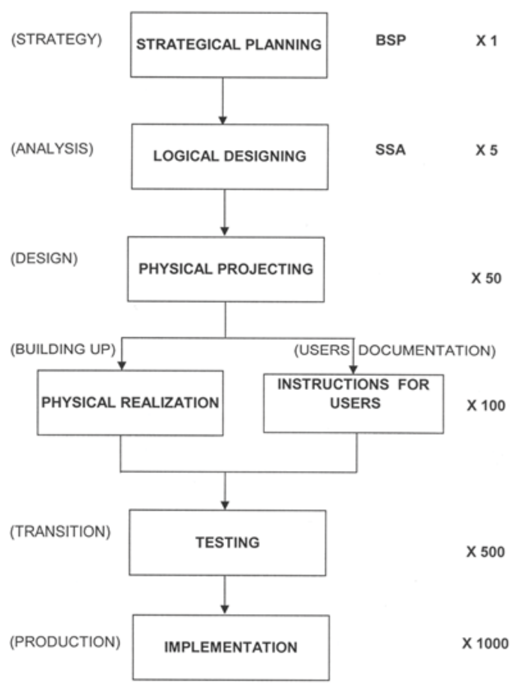

Fig. 1. Errors correction costs

• presentation of objects/relations within the project task frame (by utilization of ER model).

Processes for project tasks defining:
1. Problem identification
2. Making the description of existing conditions
3. The evalution of aptness of the existing condition
4. Aims defining
5. The defining of possible variants of future condition
6. Defining of the resources which are at disposal
7. Evalution criteria defining
8. The evalution and choice of acceptable variants

9. Defining of resources for project task management
10. The description of project for realization
11. Making of project task proposal
12. The correction and accepting of project tasks
• efficient project task defining (Figure 2).

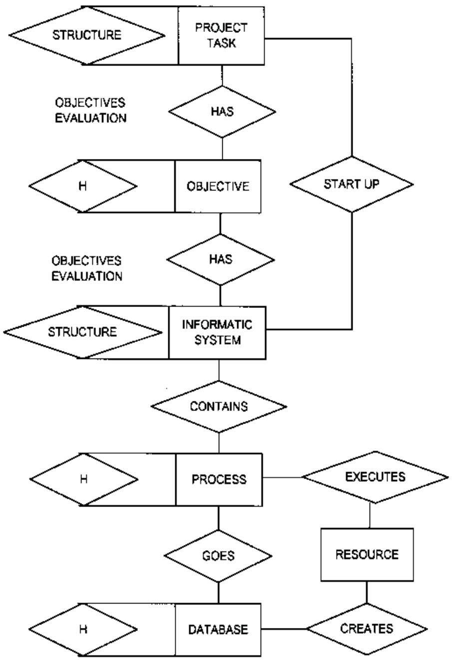

Fig. 2. Project task

• informational systems development planning (from strategical level up to finalization).
• implementation / introduction of integrated informational systems (introduction per subsystems integrating into composited system).
• optimized utilization of all available resources, (data normalization) [10].
• cost efficiency policy.
• enhancing software productivity, together with an easier software maintaining.
• graduality, systemity and comprehensiveness in taking down the real system.
• a more complete analysis of users' requirements.
• efficient communication with users and proper adapting to users' needs.
• higher quality software products, plus complete documenting.
• logical models made in complete independence from either software or hardware, i.e. universally applicable logical models [11].
• regularity in setting the limits for both manual and automatic process performance.
• proper defining and real system reorganizing for the purpose of adapting to automated informational system.
• individuating errors at early stages of design process, thus minimizing possibility for errors.
• possibility for informational systems development automation as a result of formalization and standardization (CASE tools).
• introduction of standards into informational system development process [12].
Substantial cost savings/cost reduction in both system introduction and maintenance.

3. PROCESS MODEL

As already set forth in the introductory passage, in this second part of the work given is a presentation of informational systems design process and implementation process that is, how to design and how to implement what has been designed.

At the first level of break-down (or a division into subprocesses), the subject process contains six (6) BASIC SUBPROCESSES, and at the next level, following a further subdivision, twenty one (21) BASIC SUBPROCESSES result to be contained within the process.

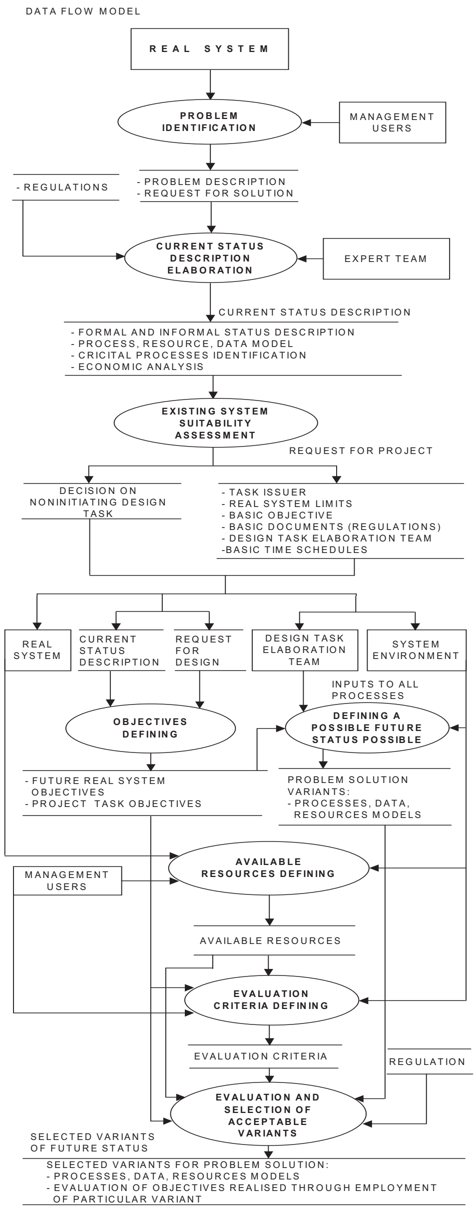

Fig. 3. Project task defining

Project task defining (Figure 3) is shown as data flow model:
- real system defining
- problem identification
- current status description
- existing system suitability
- objectives defining
- future status defining
- available resources defining
- evaluation criteria defining
- future status variants selecting

Data flow model is shown on Figure 4 (Informational systems designing and implementation):
- superior system description
- design task
- vocabulary defining
- existing status description
- existing status description
- users defining
- future status description
- logical model defining
- resources realization
- data base structuring
- programmes defining
- implementation and testing.

A future status description data flow model is given in the Figure 5:
- existing status data model defining
- existing processes status model defining
- superior system description
- existing status analysis
- model variants organizing
- users defining
- future status data model defining
- future condition process analysis
- future condition data analysis
- selection realization
- logical model adopting
- model realization
- solutions adopting

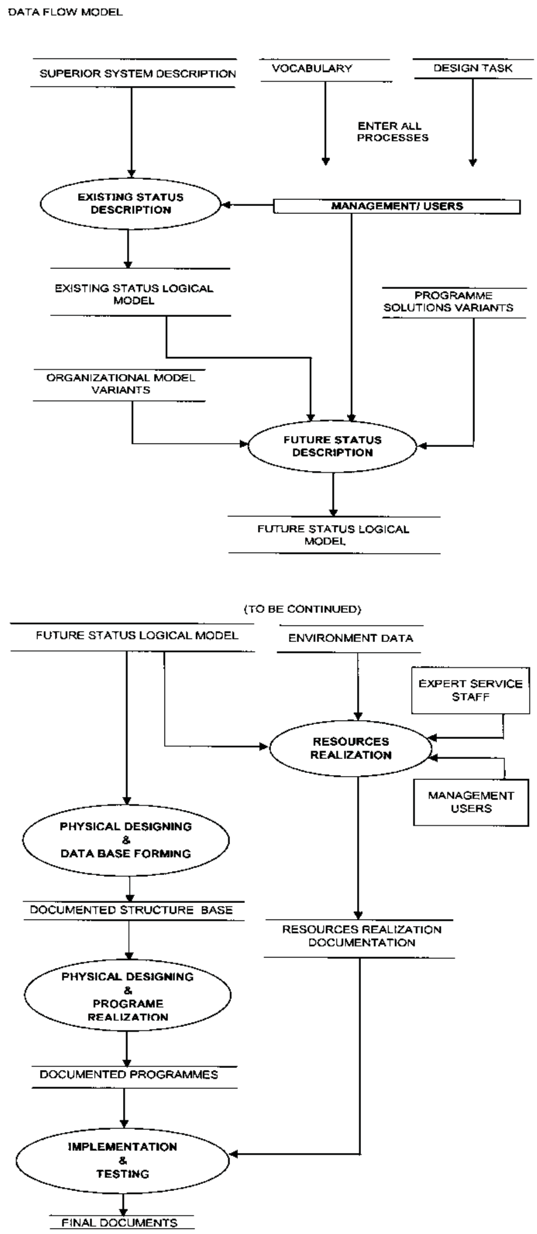

Fig. 4. Informational systems designing and implementation

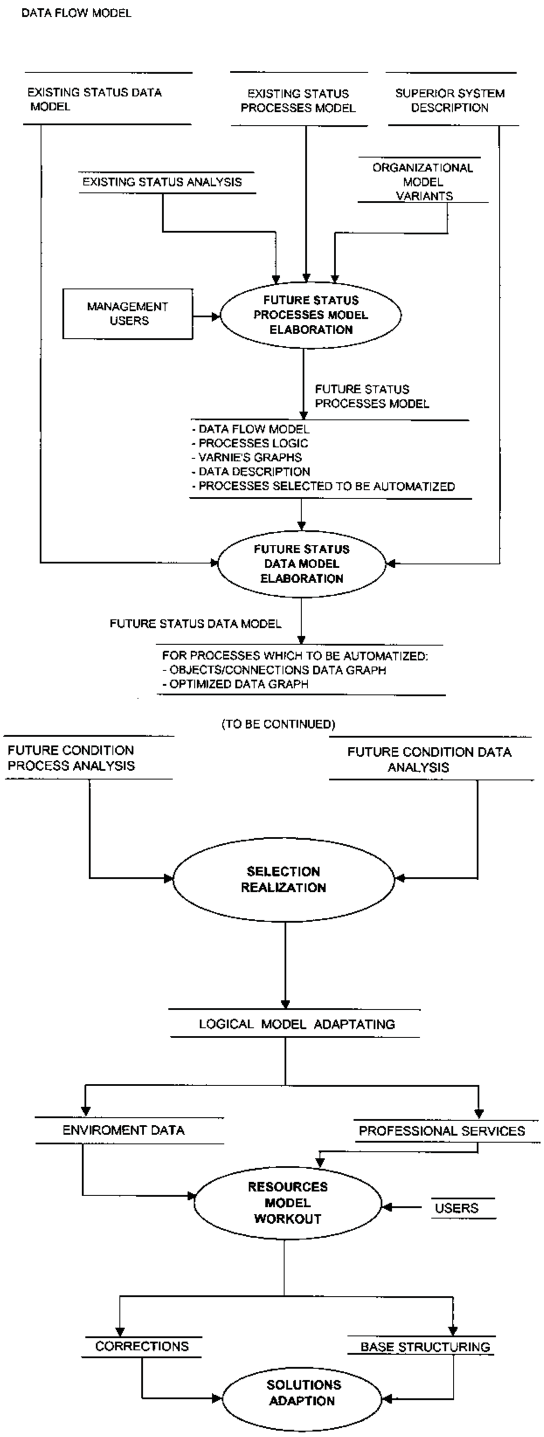

Fig. 5. Future status description

Figure 6 data flow model for resources realization:

- model defining
- solution selection
- environment data
- resources plan
- real system reorganizing
- resources procurement planning
- operative staff defining
- realization report

Figure 7 shows data flow model for physical designing description and data base realization:

- process status model defining
- data status model defining
- resources documentation realization
- resources model realization
- data model adjusting
- translating
- data realization model
- data base realization
- structure defining

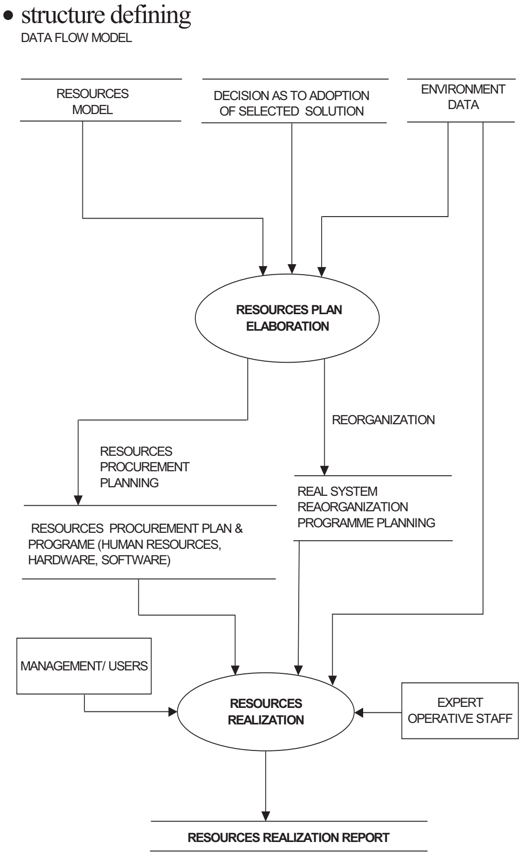

Fig. 6. Resources realization

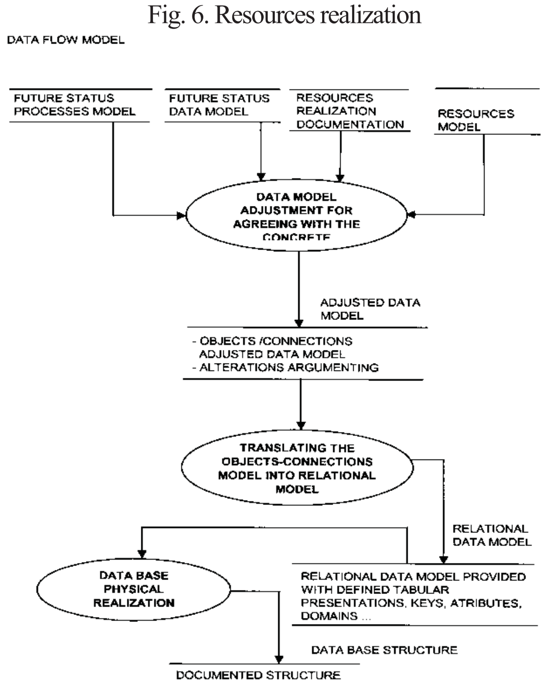

Fig. 7. Physical designing and data base realization

A physical designing and programme realization description data flow model is given in the Figure 8:
- processes future status defining
- resources documentation realization
- data base structure defining
- programme logic describing
- programme logic defining
- programme code writing
- programme code explaining

A implementation and testing description data flow model is given in the Figure 9:
- data base structure defining
- documentation realization
- programme code documenting
- programme describing
- future status data model defining
- instructions for users
- application
- testing
- correcting
- users defining
- project task controlling
- documents correcting
- delivering
- project realization
- delivery decision
- project realization report.

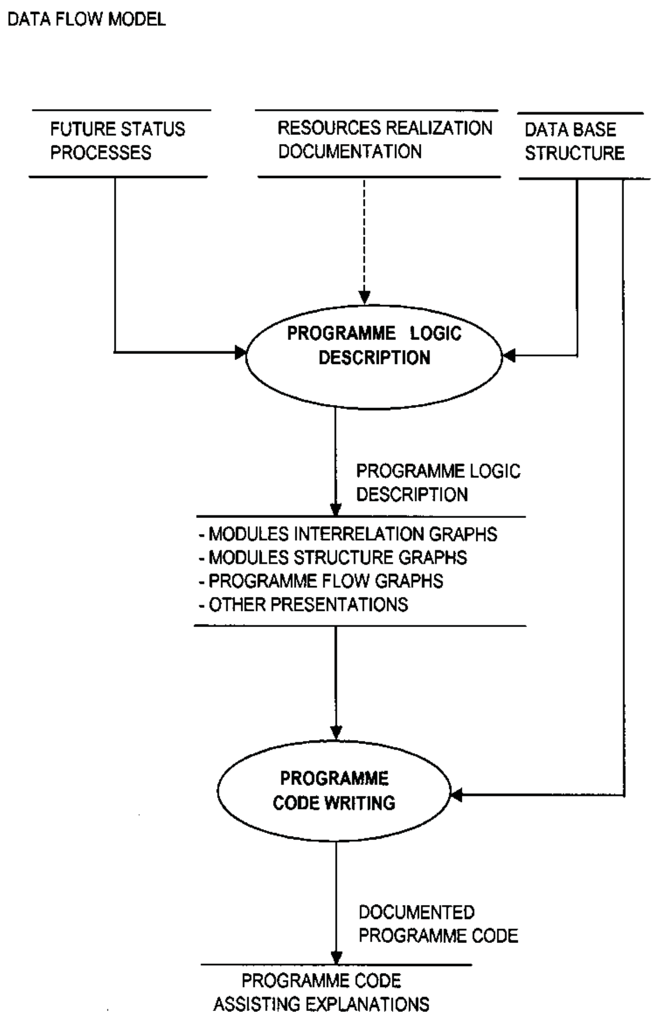

Fig. 8. Physical designing and programme realization

DATA FLOW MODEL

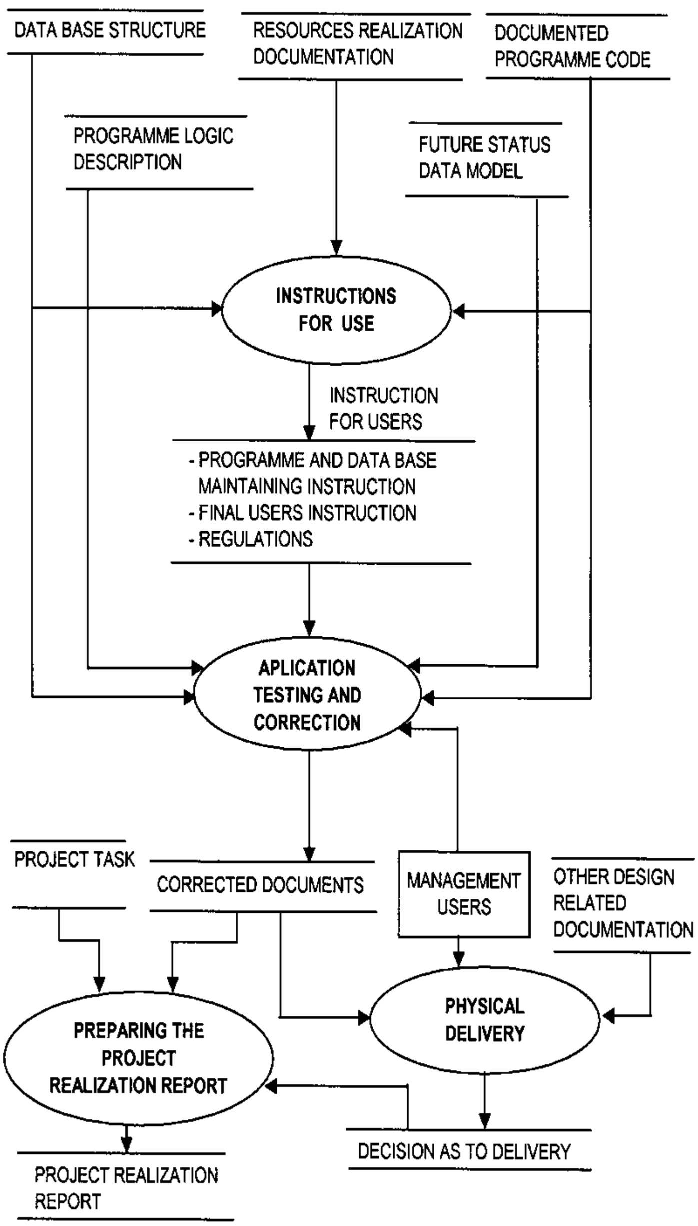

Fig. 9. Implementation and testing

Those data banks, denomination/code of which has been situated outside the graphical presentation, appear for the first time, while those with denomination/code inside the graphical presentation, had been appearing already earlier. The same applies to interfaces (sources and abysses). Possible to be applied (carried out) is, of course, an even more elaborated (detailed) break-down into greater number of subprocesses. Any particular, concretized informational system ought to be introduced on the basis of and in conformance with a previously carefully defined strategic plan [13]. It should be assumed that a strategic plan defined through use of the BSP method is invariably to preceded the design workout.

The data flow model shown provides for obtainment of causal-consequential relation between subprocesses (subprocess interrelations) [14], as well as all input-output data flow, which enables for a set of crucial moments to be spotted, such as:

- when to select process which to undergo automatization [15].
- when, and on the basis of which input data, should a choice of resources be made for an eventual informational system.
- when users and the management are to be involved.
- have the feed-backs, i.e. loops, within which optimum solutions are being sought, been established, and how well so.
- when organizational changes expected to be brought by the new system reveal themselves (and/or whether they do actually appear).

• what, if any, appears to be the impact of a ready made software [16] on the given informational system design process and when such an impact shall emerge (manifest itself).

The herein shown data flow model reflects the processes of informational systems designing and implementation in broad general lines, aimed at satisfying, to the best possible measure, any of the currently existent applicational solutions (selection of suitable ready made software, own designed software, and so on), thus where a particular case can make no use of certain subprocesses, these, of course can be dropped out. For a more complete description of the process it would have been enriching to employ some additional presentations for a better illustration of the resources, such as Gant graph (in view of times analysis), etc.

4. CONCLUSION

Informational system which in its constructional solutions employs the relational software makes impossible for errors to appear in any segment of testing or application and does so in the simplest and most inexpensive of ways. Error which would have likely be appearing through use of conventional way(s), namely by skipping over any of the design or implementation phases become eliminated through relational software solutions.

When an informational system does not function in the way as presented, that is by way of data flow model, errors that will generate will be demonstrating themselves primarily as inadequate design stage solutions and thereafter throughout the system implementation as well as in the testing stage, when designed values are to be verified and compared to realizations obtained. Usual errors appearing within informational system(s) should be resolved by using the processes as presented in this paper that is from strategic planning all the way and conclusively up to everyday working practice. Such an approach eliminates possibilities for errors, which otherwise if let to slip through and become identified only at the concrete everyday level usage can no longer be eliminated without introduction of new software and very likely also new hardware units, meaning, of course, new investments.

Either new procurements, or eventually improvement attempts, call for adjustments/appropriations of either the hardware equipment or software creation, which is pouring new investments into an already introduced informational system which had hardly been allowed the time to prove its efficiency.

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INFORMATIONAL SYSTEMS DESIGNING AND IMPLEMENTATION USING NETWORK TECHNIQUES

M. Radić [a,*], B. Smoljan [b], S. Naglić [c]
[a]PNF, Ludvetov breg 18, 51000 Rijeka, Croatia
[b] University of Rijeka, Faculty of Engineering, Croatia
[c] Shipyard "3 Maj" Rijeka, Croatia
Corresponding author: E-mail address:miodrag.radic1@ri.htnet.hr

Abstract. Purpose: *Time needed for design elaboration and implementation of the system, together with the related costs, must be defined concurrently, so as to obtain these two crucial indications in anticipation. As demonstrated in this work this is possible to be done by use of network graph and a computer simulation programme.*

Methodology: *Using the activity flow graph, and description of activities involved and their interconnection, by employment of the network techniques obtained are probability, amount of time, and the realization cost. For different realizations all parameters can be obtained through analysis and use of a simulation programme.*

Findings: *Through use of the described methodology, design and implementation of informational systems can be solved to optimum suitability for various organizations from shipyards, oil/petrochemical plants, steel mills etc., and way further to nonindustrial organizations, such as hospitals.*

Research limitations: *For each activity diagram, activities description and related network diagram it is necessary to define the time parameters (4 distributions: constant, normal, β-distribution, as that in the PERT, and the logarithmic-normal) as well as to define cost related to each of the activity. Where collected and analysed data on probability, amount of time and realization cost are not available, and/or have not been defined to suit the requirements of a simulation programme, this may represent a problem. As will be evident further in this work, stochastic processes accounting for real environment (in this context the activities) are pretty hard to define deterministically.*

Practical implications: *Informational system of an adequacy and efficiency is of essence for business running of any organization. In light of this fact, the following quests require very serious consideration:*

- *what level of probability may be assumed for a designed informational system optimum exploitation?*
- *what amount of time is to be supposed for a complete introduction of a system, counting from the start of designing, through test run, implemention and up to smooth every day practice/use?*
- *what minimum price/cost/investment would design and implementation of a system call for, under consideration that it be maximally exploited at lowest possible running cost?*

The above issues would better to be absolved during first stage of design process using computer simulation programme. Simulation application provides optimum of needed data inasmuch as it includes organizing, management, planning, quality control/quality management and prognostication.

Originality: *Rather than the so far utilized network techniques (PERT, GERT), the network technique involving a simulation programme provides for least time consuming and easy to obtain solutions of any given problem. Besides, on the basis of planned and analysed realization it serves a display of the following important indicators:*

- *realization probability*
- *realization time*
- *realization cost*

On request of the user, the Programme can provide required solutions and computer record/listing for any combination of analysed activities, thus substantially assisting the decision making.

Keywords: *network technique, activities, events, network diagram, flow diagram, simulation program*

1. INTRODUCTION

This work has been divided into three parts.

The first part explains the basic particulars of the network diagram, solving methods, defines activities with their sequence, presents the activities interconnections, and relates as the repeating activities and those to be abandoned.

The second part deals with analysis of the activity flow diagram and detailed description of all considered activities. Defined are all events, activities, ingoing and outgoing paths, probability parameters, distributions related to times assessment, and realization costs. Presented is a corresponding network diagram, as well as a few ones relating to other possible realizations.

In the third part, worked out has been the probability data, as well as those on realization time and realization cost, obtained through use of a simulation programme within which errors are identified and remedied using loops.

2. NETWORK TECHNIQUE CHARACTERISTICS

In order to reach optimum indicators on time, cost and probability of a realization for an informational system design and introduction it is best to use the network technique in as much as it easily organizes [1] , plans [2], controls quality [3], and enables prognostication [4] of all events and activities throughout all stages of design and implementation of a system. Using the network graph technique [5] enables for activities and their interconnections to be defined concurrently with designing and introduction process. All activities are to be listed and arranged within the activities flow diagram, so as to define the activities sequence. Without activities flow diagram it is impossible to draw up the network diagram. Activities flow diagram, whereby activities interconnections and sequence are demonstrated in a bee- line, defines parallel activities, activities to be repeated (showing position of a loop or more of them which stand for repeating of certain activities), as well as those which remain unrealized (e. g. discarded as an impossible solution).

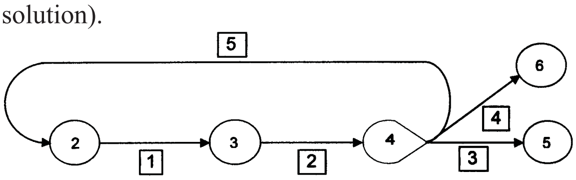


Fig. 1. Presentation of deterministic nodes and a stochastic one

Characteristics of the network diagram can be shown in the simplest of way by employing the deterministic and stochastic nodes as follows (Figure 1.).

By realization of activities 1 and 2 (deterministic nodes) and through activity verification 3 within the stochastic node 4 obtained are three (3) realization possibilities, each with its probability, duration and realization cost. A loop used for denoting repetition; activity 5; is employed in order that activities 1 and 2, the results of which do not satisfy the required quality, may be repeated. Within any stage of design process and/or implementation of a system, repeating of any number of activities calls for realization time and cost increase, with realization probability declining. Besides the loops, the diagram also treats activities, such as 4 above, which are to be discarded (“data not processed”).

3. DEFINING THE CHARACTERISTICS OF THE ACTIVITIES FLOW DIAGRAM AND NETWORK DIAGRAM

Most important characteristic of the activities flow diagram is lining up the activities along the basic line. Adding parallel activities, non-realizable (refuted) activities and repetition loops completes a defined activities sequence valid up to final realization (Figure 2. Activities flow diagram for design and implementation of informational systems), and provides all necessary data for activities defining (Table 1. Activities Description).

Introducing a stochastic [6] approach into the network diagram ensures for the activity time to be defined by employment of four types of distribution (constant, normal, β as in PERT, logarithmic-normal). Indicating cost of each activity provides for exact transposition of reality into the diagram, and by application of a computer simulation programme, realization can be worked out in accordance with the plan and specific need of a professional branch (Figure 3. Network diagram for design and implementation of informational system).

It is logical to start analysis and planning of an informational system by creating of an adequate system model in an organization. STRATEGIC PLANNING [7] represents the first stage of the system planning and introduction, providing logical linkage [8] of future project models in an organization [9]. Further herein presented is a designing methodology and implementation model for informational system elaborated by a designer [10] for optimum results in every day practice. In the second stage, named LOGICAL DESIGNING [11], approached are informational system characteristics defining. Processes contained in the system are being defined employing structural analyses. Upon completing the processes defining (structural elements), follows the PHYSICAL PLANNING [12], which accounts for solution of the programme logic by way of a structural designing method and represents the third stage. The forth stage “PHYSICAL REALIZATION” [13] defines type anal characteristics of computer device, with the users programme which explains how the devices should be used. Fifth stage comprises”TESTING” [14], and the sixth “IMPLEMENTATION” [15] is the delivery stage with supply of instructions for use. The design, planned as above set forth, has been presented in the form of an activities flow diagram. Activities described in the network represent complex work processes for which required parameters have been assessed by the designer, and critical

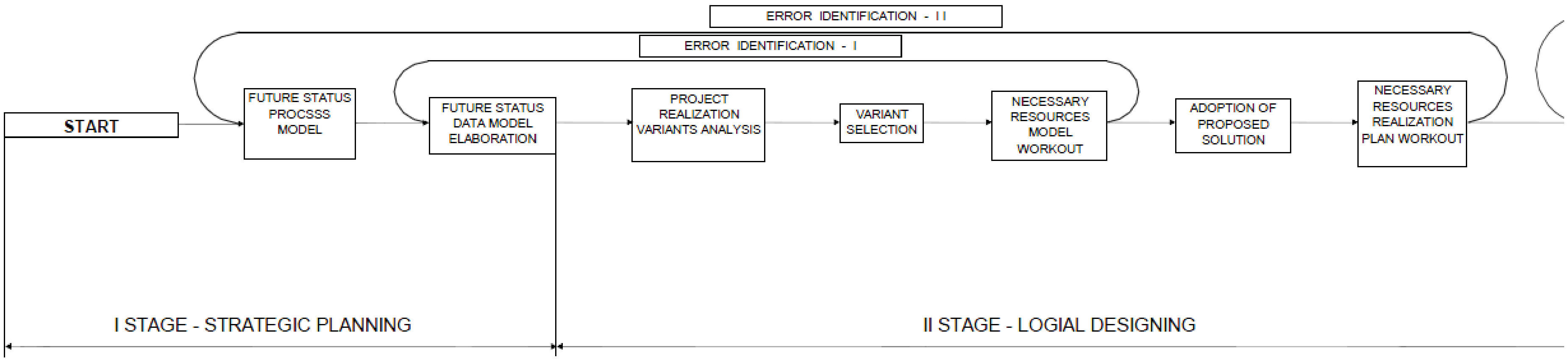
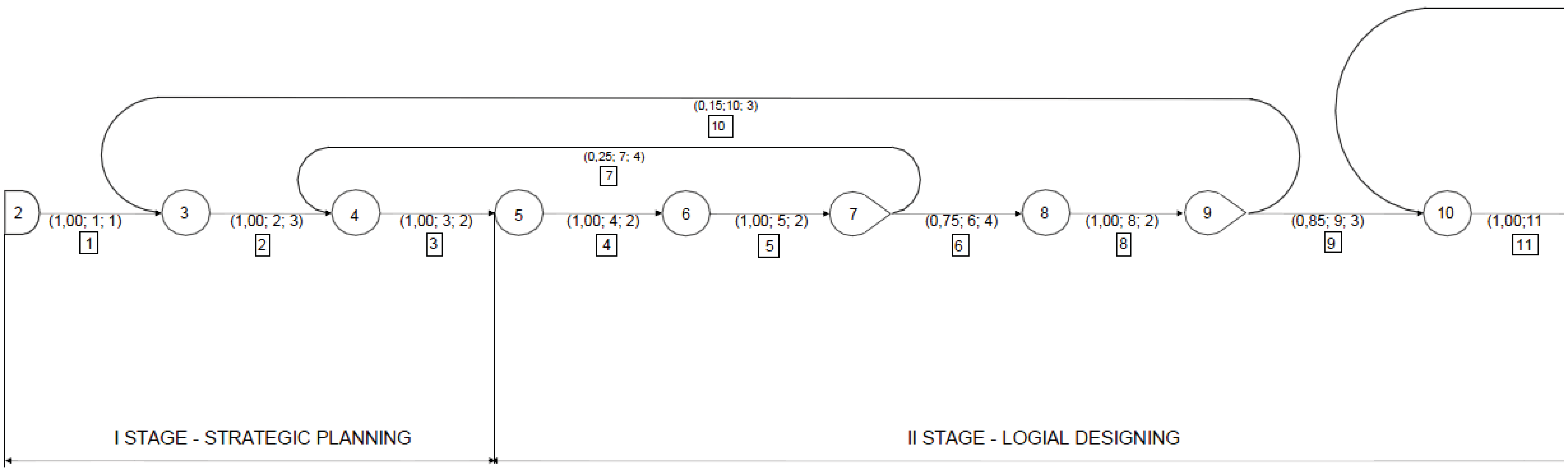


FIGURE 2. ACTIVITIES FLOW DIAGRAM FOR DESIGN AND IMPLEMENTATION OF INFORMATIONAL SYSTEM



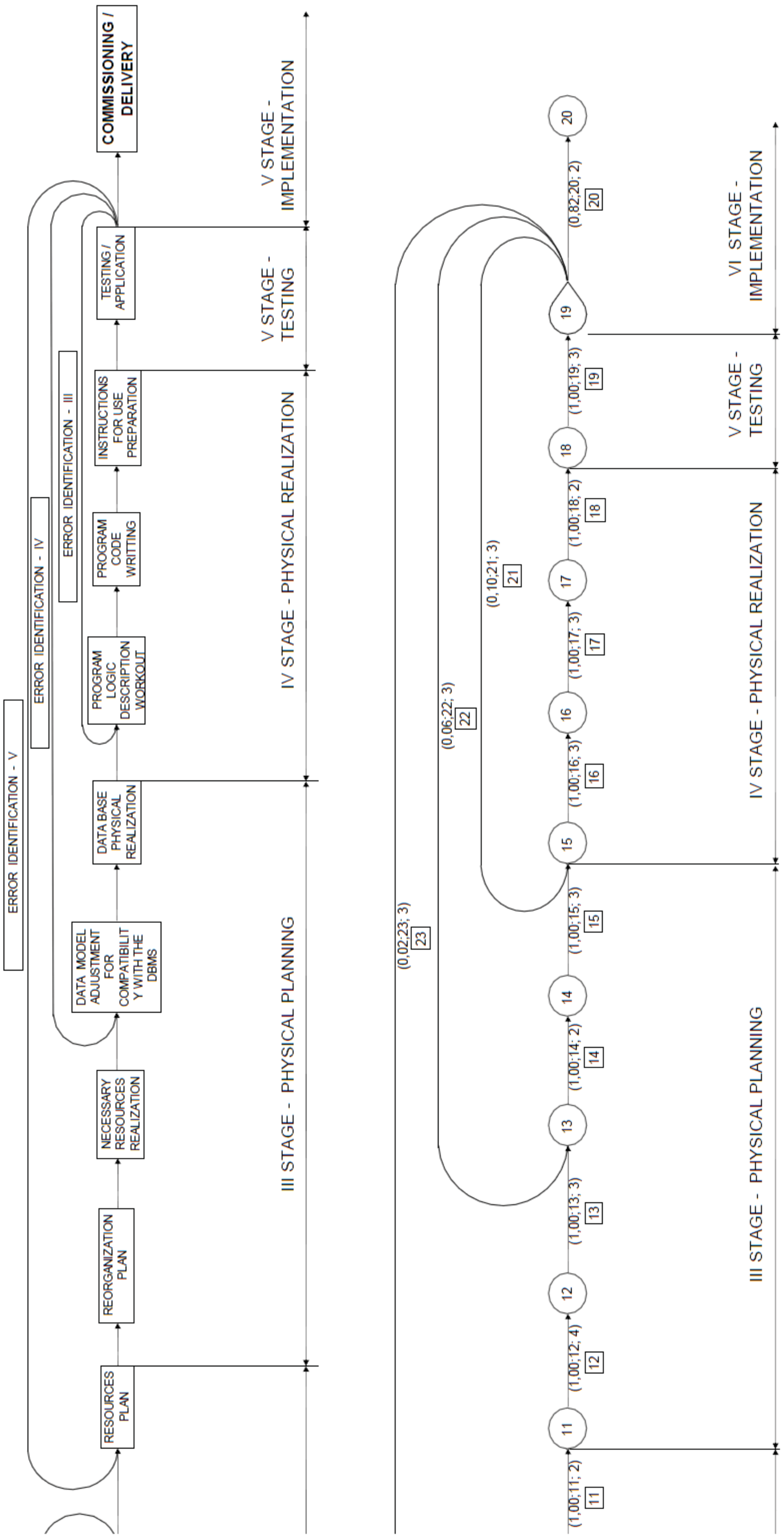

ERROR IDENTIFICATION - V
ERROR IDENTIFICATION - IV
ERROR IDENTIFICATION - III
RESOURCES PLAN
REORGANIZATION PLAN
NECESSARY RESOURCES REALIZATION
DATA MODEL ADJUSTMENT FOR COMPATIBILITY WITH THE DBMS
DATA BASE PHYSICAL REALIZATION
PROGRAM LOGIC DESCRIPTION WORKOUT
PROGRAM CODE WRITTING
INSTRUCTIONS FOR USE PREPARATION
TESTING / APPLICATION
COMMISSIONING / DELIVERY
III STAGE - PHYSICAL PLANNING
IV STAGE - PHYSICAL REALIZATION
V STAGE - TESTING
V STAGE - IMPLEMENTATION
(1,00;11; 2)
11
(1,00;12; 4)
12
(1,00;13; 3)
13
(1,00;14; 2)
14
(1,00;15; 3)
15
(1,00;16; 3)
16
(1,00;17; 3)
17
(1,00;18; 2)
18
(1,00;19; 3)
19
(0,82;20; 2)
20
(0,02;23; 3)
23
(0,06;22; 3)
22
(0,10;21; 3)
21
III STAGE - PHYSICAL PLANNING
IV STAGE - PHYSICAL REALIZATION
V STAGE - TESTING
VI STAGE - IMPLEMENTATION

Fig 3.

analyses of the same having been mad by the author of this work.

Table 1, and pertaining network diagram (Figure 3), features all parameters through which the activities have been defined.

Activity [1] "START" (in the network diagram [1]) is a fictional activity, defined by three (3) parameters (1,00; 1; 1).

The first figur 1,00 representing activity realization probability while the second figure 1 stands for reference number under which realized time and cost parameters can be read off in the Table 1. The third figure 1 denotes the distribution selected. Numeral codes for distributions are: CONSTANT-1, NORMAL-2, β (as in PERT)-3, LOGARITHMIC NORMAL-4.

Activity [2] "FUTURE STATUS PROCESS MODEL" represents a description of concrete requirements for data processing, describing the contents and structure of input data, contents and structure of flows and data bases, processes logic developmente.

Activity [3] "FUTURE STATUS DATA MODEL ELABORATION" represents, through a cluster of data and their interconnections, a status of the system in a particular moment of time. Such model contains data as well as interpretation thereof, representing a structured quantity of information on past, present and future of the system.

Activity [4] "PROJECT REALIZATION VARIANTS ANALYSIS" has been defined for several possible variants to be analyzed on the basis of process model and data model.

Activity [5] "VARIANT SELECTION" has been defined by description of selected variant including reasons leading to its selection as well as organizational requirements resulting from the selected variant.

Activity [6] "NECESSARY RESOURCES MODEL WORKOUT" is defined by encompassing and describing the needed resources (operators, computers, program tools) for obtaining automation of the process.

Activity [7] "ERROR IDENTIFICATION-I" featured by an activities repeating loop, repeat of activities from [3] up to and inclusive [5] (to be repeated in 25% cases). Data model has not been satisfactorily solved, therefore a better solution is to be sought.

Activity [8] "ADOPTION OF PROPOSED SOLUTION", on the basis of data and processes model, as well as on the resources model, one of possible solutions results as accepted.

Activity [9] "NECESSARY RESOURCES REALIZATION PLAN WORKOUT", with the plan basis being defined by herebelow listed resources which result in consequence of the realized activities [2] to [8].

Activity [10] "ERROR IDENTIFICATION-II" is featured by a loop. Due to process model solving method (future process model transposed into reality), data model (inconvenient for future adjustments) and necessary resources model (illdefined resources), there appears an error to be remedied through repeating of the activities [2], [3], [4], [5], [6] and [8] (in 15% of cases).

Activity [11] "RESOURCES PROCUREMENT PLAN" A mode of resources realization defined in activity [9] to be planned. In respect of the personnel, the following problems/quests to be resolved/determined: adequate skilled personnel, personnel qualification structure, available personnel profiles.

Activity [12] "REORGANIZATION PLAN" Planned is a real system reorganization on the basis of future status process model and the available resources in order to defining the utilization technology of such systems.

Activity [13] " NECESSARY RESOURCES REALIZATION"

For realization of the same, funding to be foreseen to be applied for procurement of computer hardware and software, new working spaces, and new skilled personnel.

Activity [14] "DATA MODEL ADJUSTMENT FOR COMPABILITY WITH THE ACTUAL DBMS" Data base models (relational, netting and hierarchical models) represent the basic tool for an informational system realization, in particular when decision on DBMS is to be made.

Activity [15] "DATA BASE PHYSICAL REALIZATION" Defining a data quantum and data processing dynamism constitutes the actual physical organization of data.

Activity [16] "PROGRAM LOGIC DESCRIPTION WORKOUT" Through defining of algorithm for programs operated by one of the program logic, the program is being described in order to be used in a concrete automatic processing.

Activity [17] "PROGRAM CODE WRITING" Program logic is translated by means of coding, into any of the computer program language (COBOL, FORTRAN, etc.) used in a given informational system.

Activity [18] "INSTRUCTIONS FOR USE WORKOUT", usually prepared by specialized organization/companies. These instructions contain applications utilization procedures to be assisting the users (users' books).

Activity [19] "TESTING/APPLICATION", which concurrently functions as a controlling/monitoring activity in respect of how successful has the introduction of the system resulted to be. If all activities (from [2] to [18]) have been logically connected and adequately solved, application testing stands for final result of informational system design and implementation. In cases when applications fail to yield desired results, particular activities are done a new as presented in the network diagram. Application testing means verification of functional operation of the whole system, as well as verification of the application on the envisaged subsystem. Assessment has been made on the basis of the application testing results obtained in a CAD/CAM centre. Following the testing of all the applications the results obtained proved unsatisfactory, and therefore it was necessary to locate at which point the error has occurred. Errors are to be identified and remedied; thorough check up to be applied throughout. Through realization of activity [21] "ERROR IDENTIFICATION-III", activity [22] "ERROR IDENTIFICATION-IV" and activity [23] "ERROR

IDENTIFICATION-IV", obtained is the activities repeated realization. On the basis of comprehensive experience, and findings obtained during monitoring of certain system segments introduction, it has been concluded that activities 16, 17 and 18 need to be repeated in 10% of cases; activity 21. Likewise, activity 22, activities 14, 15, 16, 17 and 18 to be repeated in 6% of cases; activity 23, activities 11, 12, 13, 14, 15, 16, 17 and 18 to be repeated in 2% of cases.

Activity 20 "COMMISSIONING/DELIVERY " Delivery and acceptance of system constitutes acceptance of the system by the users as the same has resulted on the basis of the designed parameters.

4. REACHING NETWORK DIAGRAM REALIZATION THROUGH AID OF A COMPUTER SIMULATION PROGRAM

Total value, time and cost for given network diagram realization are obtained by employment of simulation programme [16].

1st REALIZATION Calculated have been probability, time, and cost in relation to design and implementation of an informational system for the case in which not one activity needs to be repeated.

- realization probability: p1=52.27%
- realization time:t1=376.6 days
- realization cost:C_1=113,010.00 EUR

Also calculated have been probability, time and cost in relation to design and implementation of an informational system for the case in which:

2nd REALIZATION - activity 7 realizes.

- realization probability: p2=18.75%
- realization time:t2=398.10 days
- realization cost:C_2=119,430.00 EUR

3rd REALIZATION - activity 10 realizes.

- realization probability: p3=12.75%
- realization time:t3=442.50 days
- realization cost:C_3=132,750.00 EUR

4th REALIZATION - activity 21 realizes.

- realization probability: p4=1.23%
- realization time:t4=485.00 days
- realization cost:C_4=145,710.00 EUR

5th REALIZATION - activity 22 realizes.

- realization probability: p5=0.74%
- realization time:t5=476.70 days
- realization cost:C_5=143,010.00 EUR

6th REALIZATION - activity 23 realizes.

- realization probability: p6=0.25%
- realization time:t6=514.20 days
- realization cost:C_6=154,260.00 EUR

As set forth herein under 2nd to 6th REALIZATION employing combinations other than these treated herein would have been possible, e. g. repeated are activities 7 and 10, or activities 7 and 21, or activities 7 and 22, etc.

4. CONCLUSION

On the basis of activities flow diagram and activities description it becomes possible for a network diagram to be defined, with all the characteristic of both the input and output deterministic, as well as stochastic, nodes and introducing of corresponding loops.

For design and implementation of an informational system using the network diagram technique aided by a simulation program, calculated and presented are the following values relating to the design stage:

- realization probability
- realization time
- realization cost

Presented herein has been only a part of possible realizations solved by means of this simulation program.

In presented network diagram technique, aided by application of a simulation, provides for a business company or other organization management a position/possibility to already within the design stage learn on necessary time for project realization , investment amount for hardware and software acquisition as well as realization probability levels.

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DEVELOPMENT OF DECISION MAKING CRITERIA SYSTEM FOR PRODUCTION PROGRAM IN INDUSTRIAL COMPANIES

Jasmina Vesić Vasović, Miroslav Radojičić, Zoran Nešić
University of Kragujevac, Tehnical Faculty Čačak, Serbia

Abstract*: In this paper is created a system of criteria for multi-criteria decision making for a program relevant to the production of industrial companies. The development a system of relevant criteria, included development aspect, technical and technological aspect, economic aspect, competitive aspect and humanity aspect with a set of relevant criteria indicators of quantitative and qualitative nature. The establishment of relevant criteria for evaluation of alternative solutions enables the expression of multiple layers of problems and creates a basis for comparing different products in terms of assessment of contributions in achieving the overall utility and the desired objective of a company. This approach enables the detection and study of products which are essential for enterprise development on long term basis.*

Key words: *production programme, multi-criteria decision making, product management*

1. INTRODUCTION

irecting the program orientation of a company is of crucial importance for the survival and development of a company. By defining their own development, in accordance with market needs, a company strengthening the competitiveness and perform its mission in an area which presents its business. Growth and development of companies has the most effective realization by approach of appropriate optimization of the production program. On the basis of the production program is performing a choice of technology and capacity, estimates incomes and costs, efficiency, effectiveness and performance of the investment at all.

Each enterprise works out in an appropriate way the basic concept of its production programme, by developing it in compliance with strategic approach to make the product sale as much stable as possible, safe and efficient on a long-term basis.

Studying of the enterprise production programme for the purpose of its optimization, is a field of interest of a number of authors in various areas, which results in diversified approaches to the examination of the enterprise production programme, and/or implementation of various methods with the aim to optimise the production programme. In that sense this paper presents an analysis of relevant approaches to the programme orientation with a focus on products, systemized by the capture range.

Decisions on the production programme, from the long-term aspect, imply among others the analysis of expenses and profit relating to the product. Many papers consider possibilities of applying different methods in the decision making process of the selection of the production programme [3], [4]. Some authors combine the model of linear programming with certain decision making methods, e.g. methods of whole-number programming [7], non-linear programming, fuzzy mathematical programming. One of the most applied single-criterion model for solving the issue of optimization of the production programme is a model of linear programming.

Dynamic changes of products regarding market demand impose a need for adjustments with production capacities of the enterprise to produce products of appropriate quality, appropriate price and in appropriate time. The paper [9] presents a holistic framework of Key characteristics (KCs) methodologies and practices from the perspective of enterprise integration and product lifecycle management (PLM).

Fuzzy hierarchical model of decision making on the production programme based on the theory of fuzzy sets and AHP method for multi-criteria decision making is considered in the reference [1]. In paper [2] considers product mix problems including randomness of future returns, ambiguity of coefficients and flexibility of upper value with respect to each constraint such as budget, human resources, time and several costs. Portfolio approach has a great application in planning and managing diversified industrial enterprises [5].

The analysis of relevant approaches indicates that they are only a partial frame for the product analysis and decision making, whereby there are dominant approaches in which decision on the production

programme, and/or selection of products are based on financial ratios. Relative isolation, as well as partial one-sidedness of the analyzed approaches does not offer sufficient possibilities for reviewing interactions among products through various stages in the lifecycle, as well as among the product and environment; it does not provide an overall picture about complexity and multi-level feature of the problem of programme orientation optimization. Apart from the insufficient scope of approaches so far, we may say that they present a solid base for further research.
In that sense this paper points out some methodological aspects of decision making on the production programme in an industrial enterprise and some options for the decision maker to control the process of multi-criteria decision making and participate in the selection of the final solution.

2. DYNAMIC ASPECTS OF CHANGES IN PRODUCTION PROGRAMME

For an enterprise, the identification of a production programme is one of the most important decisions relating to production planning. Such decisions imply using limited resources in order to maximize pure values of production outputs. Products within a production programme differ in the level of compliance of production and work technology with the structure and size of production capacities. For all such reasons it is necessary to analyze each product from the production programme, understand advantages and weaknesses of the wide and narrow production programme, and select an optimal solution for relevant conditions and possibilities available.
The production programme is not a static category, with permanently defined product quantities and structure, it should rather be treated as a dynamic category, which constantly changes over time. Quantitative changes of the production programme are made every year (in each new production cycle) and imply minor changes within the same production programme. Qualitative changes in production programme relate to long-term establishing of the production programme and they include significant changes in the structure of the production programme. Through flexible reaction in accordance with requirements and acquired experience, it is possible to do the following: introduce a totally new solution – new product, modify the product for the purpose of its improvement, substitute, replace the product, eliminate the product from the production programme.
Since the changes differ very much in their frequency and intensity, we cannot apply the same procedure of decision making for all changes, from the smallest ones to the decision of the production of a totally new product (figure 1). The performance of the range of a totally new product is connected with high costs and investments, as well as with the risk of return of invested resources.

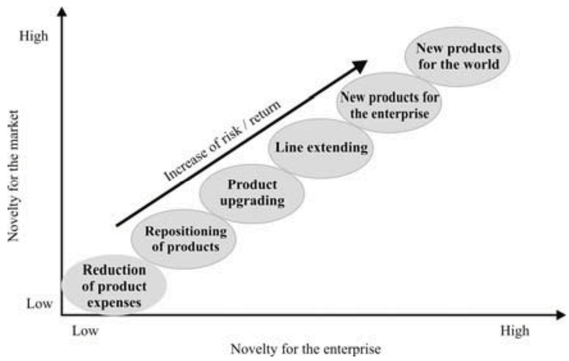

Figure 1 – Qualitative changes in the production programme

The enterprise has to conduct changes in the production programme according to a plan, on the basis of adjusting buyers' needs, market requirements and internal capacities of the enterprise, in order to avoid a highly specialized or a much diversified production programme which does not suit its production abilities and its market position.

3. DESIGN OF A CRITERIA SYSTEM

The analysis of relevant approaches of decision making regarding the production programme imply dependence on a large number of factors with complex nature. The impact of these factors is complex and it constantly changes its direction and intensity depending on the overall conditions at which they manifest. The dynamic feature of these factors over time, as well as mutual dependence present, result in an extremely complex decision making process regarding the production programme of the enterprise.
Complexity of interactions between determinants is subject to multi-criteria approach which implies the need to formulate criteria-based indicators of quantitative and qualitative nature in the context of multi-criteria optimization of the programme orientation.
Using a unique complex criterion, that includes a number of different aspects of the development process, is possible to achieve by establishing a numerical value (of weight factor) for each individual magnitude achieved only under certain conditions. Frequent changes in conditions impose the need of correcting such established numerical values, taking along a number of interrelated activities, so it is almost impossible to apply the a/m procedure consistently when optimising programme orientation.
Possibility of strategic selection of products in the process of optimization of the enterprise programme orientation must be carefully reviewed through a number of assessing criteria in order to make rational decisions. In such context it is necessary to

identify relevant criteria indicators that in appropriate manner represent a complex nature of the optimization process of the programme orientation, providing thereby to take into account external and internal impacts on each product from the production programme.

For the purpose of deciding on production program of companies, based on previous studies, it is designed a system of criteria for optimization a program orientation of companies (Table 1). It should be pointed that the theoretical number of criteria is not restricted, and that are separated those relevant to conditions of discontinued manufacturing production, with all specific factors of the production.

Table 1 – The projected criteria system

Development aspect
➢ A phase in the life cycle
➢ Investing in development
➢ Needs for highly qualified staff
Technical and technological aspect
➢ The level of product complexity
➢ Level of applied technology
➢ Production volume
➢ Degree of capacity utilization
➢ Needs for material
➢ Needs for production workers
Economical aspect
➢ Cost price per unit
➢ Sales price per unit
➢ Profit per unit
➢ Average working assets
➢ Invested funds rate of return
➢ Rate of profit
➢ Total cost
➢ Total revenue
Competitiveness aspect
➢ Market share
➢ Product quality
➢ Delivery period
Humanity aspect
➢ Ecological eligibility
➢ Ergonomic adjustments
➢ Handling safety

The projected criteria system includes a development aspect, a technical and technological aspect, an economical aspect, a competitiveness aspect and a humanity aspect with a set of relevant criteria indicators of quantitative and qualitative nature. In this way the complexity of the product selection is expressed, both in the current production programme and in the newly projected one. The remainder of this paper reviews some specifics of the proposed system of criteria.

Developmental aspect - Effective management of developmental processes, of new and improved existing products, is one of the prerequisites for a successful development of companies. At the same time, development requires the involvement of highly qualified personnel and appropriate investment of certain funds. Depending on the phase, in which a product is located, will differ scope and activities that should be implemented.

Technical and technological aspects includes criteria which constitute the basis for decisions about the program orientation of enterprise, from the point of production possibilities of the company. In accordance with that, each product will be evaluated based on degree of complexity, level of applied technology, materials required for production and invested work. A higher level of applied technology mean a higher proportion of amortized cost at their prime cost of products, but enables achievement of higher level of product quality. Intensive use of production capacity reduces the amount of value transferred from the machine to the product. This allows a lower cost price, consequently better alignment of production flow, deadlines for procurement, delivery.

A set of criterion indicators, specified within the **economic aspect**, enables evaluation of products, based on appropriate economic effects of certain products in the product range, as well as effects which every product achieves, in relation to business results which company achieves as a whole. It is important to take into account the differences between products based on cost price, selling price and the realized profit, per product unit and the total production volume. In addition to these indicators, every product from the production program will be evaluated on the basis of certain relative indicators, profit rates and rates of return on assets.

Aspect of competitiveness - Good competitive position is reflected in a rapid adaptation to market demands, the use of technological changes, rationality and modern approach to the organization of labor and business. Competitiveness is achieved through the products that meet customer expectations in terms of price, quality, time of delivery. Modern market demands high level of quality products, affordable, low prices, with shorten delivery times. The intention of manufacturers is reducing the time of the production life cycle, for more efficient deadline of delivery of the finished product.

The aspect of humanity shows the importance of taking into account human dimension of the product application, which represents a very important determination in present conditions. In addition to basic functional requirements of products and product quality, for successful implementation is necessary to take into account human relationship between people and products. This aspect includes the ecological suitability of products, adaptability with ergonomic standpoint and safety, or the safety of users while using products. Taking into account specificities of each product, in terms of these criteria, as well as the nature of criteria for every product, should be done appropriate assessments.

It is possible to adjust the initial system of criteria to specific features of products and specific conditions of its application, which we showed in the example of evaluation and ranking complex programmes, performed in the paper [8] and example of multi-criteria ranking of development programs for specific conditions in the production of cutting tools, in the paper [6].

Prerequisites for multi-criteria ranking and selection of priority products are created by defining an appropriate system of criteria and alternatives, which will enter into the base for multi-criteria decision making, defining the structure of preferences of the decision maker, determining the relative importance of criteria and selection of appropriate preferential functions and necessary parameters.

4. CONCLUSION

The proposed system of criteria for evaluation of alternative solutions of programs allows to be expressed all the complexity and multiple layers of problems. This creates the conditions for application of a multi-criteria method. By preferences of a decision-maker will perform mutual comparison and establishment of ranking list of priority of certain programs over others. In this way is created a basis for comparing different products in terms of assessment of contributions in achieving the overall utility.

By comparative analysis of products from the production programme in the system of different and various criteria of quantitative and qualitative nature, it is possible to determine contribution of each product, as well as its importance for the success and further development of the enterprise as a whole. This ensures the base for timely decision making regarding amendments in the production programme, in compliance with the set up targets of the enterprise.

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THE ROLE OF HUMAN RESOURCES MANAGEMENT IN BUSINESS PROCESS REENGINEERING

Prof.Dr. Ahmed El Kashlan[1], Dr.Motaz –Elfeki[2]
[1]Productivity and Quality Institute, Academy for Science and Technology, P.O. Box 1029, Alexandria, Egypt. e-mail:kashlan@aast.edu (#Corresponding Author).
[2]Productivity and Quality Institute ,661 Al horrya Avenue. Ganaklis , Alexandria, Academy for Science and Technology . e-mail: motazelfeky@yahoo.com

Abstract *: The present paper explores how human resources management practices integrates with the concept of business process reengineering and how to be the corporate strategy for an organization to achieve success in the business process reengineering in the long run. Business process reengineering encompasses technical and human activities. Yet human resources and change management-related issues areas that need to be addressed and considered as requirements for organizational capability. The most effective interaction among the organization is that between human resources management department and the reengineering project. Such positive interaction and coordination is necessary and sufficient for success. Business process reengineering and human resources management takes into account four components that affect the business processes. These are jobs and structures, values and beliefs, management systems and information systems. Human resources management identifies employee's knowledge and competencies that fits the business process reengineering projects. Using innovative information technology to satisfy and generate increasing values for customers and stakeholders.*
Keywords*: Business process reengineering (BPR), Human resources management (HRM), Change management, Business processes, Resistance to change models.*

INTRODUCTION

Although Human resources management (HRM) and Business process reengineering (BPR) have evolved independently from one another, recently both are considered as complementary resources that require senior leadership commitment towards gaining competitive advantage. There are various definitions for BPR since the celebrated work of Hammer and Champy, the founders of BPR [1], stated as "*fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporarymeasures of performance such as cost, quality, service, and speed*". BPR as a discipline received extensive research and numerous methodologies are presented, it focuses on business processes and the organization will be as effective as its business processes [2]. Much of HRM difficulty in understanding BPR centers around the vagueness in defining the constituents of "business processes" whether it is core, support, management, or business network processes as it is intangible and there is no agreed and clear straightforward definition for the term, some are as follows

(i) A set of activities that taken together, produce a result of value to a customer [1].
(ii) A set of logically related tasks performed to achieve defined business outcomes [3].
(iii) An ordering of work activities with a beginning, end, and clearly identified inputs and outputs [4].
(iv) Any sequence of pre-defined activities executed ro achieves a pre-specified type or range of outcomes [5].

Business processes are invisible because people think about departments more often than the processes with which all of them are involved. A business process is a collection of activities performed sequentially in some order that has goal, uses specific input(s) to produce one or more specific output via the available resources. Business processes may affect more than one organization unit. BPR is a business and/or management change process and has significant impacts across organizational boundaries and generally has impacts on external suppliers and customers as well as organizational structure. Employees support change rather than resist change imposed by others. HRM appears to get employees actively participate in the design of work, increase their commitment to the new approach and reduce resistance to change. Moreover, BPR involves changes in people (behavior and culture), processes and technology. As a result, there are many factors that prevent the effective implementation of BPR, and hence resist innovation and continuous improvement unless effective HRM are aware. A common feature of a reengineered organization is that many formerly parallel jobs or tasks are integrated and compressed into one, non-value added activities are often eliminated to speed up response and development times, thus downsizing employees in certain areas, and structures are changed. Also instead of embedding outdated processes, one should obliterate them and start over using the power of modern information technology to radically redesign business processes. Employees in the reengineered organizations are usually empowered to have the authority to make decisions and assume more responsibility for controlling their processes; this is in line with HRM tasks.

BPR AND HRM COMPATIBILITY AND COORDINATION

Human resources management are the key in business process reengineering as it supports for group formation, team building, evaluate performance, participate rather than command and control. Moreover the department plays a key role in building an organization's BPR culture.BPR involves an intensive focus on customers. BPR main objective is to rethink the business processes in an organization to find a better design, and hence multiple methodologies can be found. Hammer and Champy [1] claim there are no rules for this, common stages organizations should take into account include

- Top management commitment.
- Creating a team, its members have to be trained in the philosophy of BPR.
- Evaluating the environment.
- Assessing the organization.
- Defining the changes needed.
- Determining the technical and human resources which are needed.
- Testing when appropriate.
- Implementation.
- Evaluating the results.

There is no standard methodology that fits all reengineering applications. Each organization reengineers their processes in a different way. Implementing BPR is different for every organization; it is even different for each business process that is reengineered. However, there are some similarities in the pattern and common characteristics that can be found in most BPR projects. For reviewing various methodologies of BPR and some reasons for its failure efforts [6].

Although BPR is fundamentally designed and controlled from the top of the organization,BPR principles must be communicated organization-wide, training and education programs implemented to coach employees their tasks in the new process design, and to be multi-skilled [7]. Focusing on harnessing more of the potential of employees, and applying it to activities that deliver value to customer, and introduce short feedback loops into business processes.

Well selected motivated skilled reengineering team, good interpersonal relationships, training and education, successful communication, performance management, performance appraisal, job design, staffing, and motivation are some matters of HRM in the organization and need to be aligned around core business processes.

CHANGE HRM TO FIT BPR PRINCIPLES

BPR in its basis is about making change in management and business processes that starts by planning through the following questions and their answers

Q1: What goes on in the activity? Answer: Flow chare.

Q2: What is the big problem? Answer: Pareto diagram.

Q3:What are the causes of the big problem? Answer: Fish bone diagram.

Q4: What does a review of the past data show? Answer: Histogram.

Q5: What is the cause/effect relationship? Answer: Fish bone diagram.

Q6: What does current data show about the activity? Answer: Control charts.

Resistance to change is normal and not a freak accident, but a normal behavior. Management's responsibility is to detect opposing trends so as to be able to identify changes whether due to internal or external factors, and identify resisting forces.Resistance can be dissolved by effective leadership and commitment from top management. It is important to estimate what impact a change will likely have on employee's behavior and social dimensions of the changes– a factor that was missed in Hammer's presentation-, workprocesses, and motivation. Several change models and procedures are available in the literature to help organizations manage change [8]. Models of change management are useful in that they describe and simplify processes, to understand what is going on. Two popular change management approaches are briefly described. To achieve successful change in the organization, Levitte [9] presented a framework known as the diamond model and proposed that change may focus on the following items:

Structure: the work itself, and how the organization is structured to do it.
People: job profile, clear rules, responsibilities, values, attitudes.
Task: the controls and mechanisms that influence performance.
Technology: the tool that enables the work to be done.
By inspection it is clear that most of the above items are HRM oriented, thus HRM plays an important role in achieving management change. BPR demands that old assumptions, values and rules that do not add values are obliterated. Instead of striving to make incremental improvements to existing processes, BPR urges the radical reexamination of current practices in order to determine processes that add values and search for new ways to achieve results and outcomes. A three-stage change process in organization known as Lewin's model [10] and implemented through; *"unfreezing* " the status quo to become motivated to change, reinforce new behavior, be open to feedback, and determine what needs to change, then *"movement"* to a new state to provide employees with new information, new behavioral model, describe benefits, empower employee, and a way of looking at things. Finally *"freezing"* the new change to make it permanent, establish feedback system, develop ways to sustain the change, and this is the stability and productive state where everyone is informed and supported.

INFORMATION TECHNOLOGY AND PROCESS THINKING IS AT THE HEART OF BPR

Davenport [4] one of the founders of BPR in his review of methodologies, techniques and tools used for BPR implementation considered innovative information technology to be an enabler and natural partner to analyze existing processes and design new ones. He defined this relationship as a recursive pattern. Such recursive relationship implies that organizations should align the design of information system with the design of corresponding new business processes to achieve maximum benefits from their synergy. A variety of software exists to assist BPR professionals in the application of their methodologies aimed at building strong organizational capabilities for improved performance and competitive advantage. Information systems techniques ant tools like expert systems (ES) enables limited capabilities employees perform the role of trained experts, communication networks enables and combines decentralized and centralized performance, decision support systems (DSS) enables empowering, wireless communication enables remote geographically separated departments to share information, interactive videos. Needless to mention that these skills needs condensed specialized training courses HRM must arrange for. Perhaps the most effective application that suits BPR is the enterprise resource planning (ERP) system as it integrates all departments and functions across the whole organization onto a single computer by a single information system for the organization's internal processes that can serve all the different department's needs and requirements [11] towards serving customers in a better way.ERP systems integrate the key business processes into a single software system that enables information to flow seamlessly throughout the organization. Moreover ERP systems allowed organizations to replace older software applications with new applications.

CONCLUSION

The direct effect and influence of HRM roles in BPR efficiency is investigated. Top management must be aware, create awareness and ready to face employees resistance to change. They must consider BPR as a tool for managing the change. Two famous change models are mentioned for HRM to fit BPR. Strong support from upper management and facing resistance to change is necessary and sufficient for BPR success. Intensive use of information technology enables redesigns business processes. HRM has to provide support and training for the reengineering team, focuses on team building and team skills, because teams are more powerful than individuals, keep everyone informed, create a reward system and develop ways to sustain change.
Organization must be patient in its efforts to empower employees, and HRM department be prepared to increase commitment to training to increase employees satisfaction and complacency. By recognizing and ensuring these issues, organizations can plan to implement the BPR project. Information technology constituents (expert systems, data base, decision support systems, electronic data interchange,…) plays a vital role in BPR implementation. Information technology enables employees at all levels to think strategically, communicate with other organizations that have related technology. For HRM to fit BPR principles it is suggested to reengineer HRMactivities to develop contingency plans against risk in order to pursue the following reengineering projects.

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THE SOCIALLY RESPONSIBLE BUSINESS ORGANIZATIONS IN THE PHARMACEUTICAL INDUSTRY: THE CASE OF PFIZER

Sorin-George Toma, Paul Marinescu
Faculty of Administration and Business, University of Bucharest, Romania

Abstract: *Social responsibility of business organizations has increasingly become a major subject both in theory and in practice. The aims of our paper are to present in brief the corporate social responsibility concept, and to analyze the case of Pfizer, the world's largest pharmaceutical corporation.*
Key Words: *corporate social responsibility, business organizations, pharmaceutical industry, Pfizer*

1. INTRODUCTION

While corporate social responsibility (CSR) has become a concept debated by numerous researchers from different fields of study such as sociology, marketing, philosophy, management, law or theology in the last century, the relationship between business and society was evident at least as early as the nineteenth century. In the late eighteenth century and the beginning of the nineteenth century, the starting and expansion of the First Industrial Revolution brought not only economic development, but also social malaise. However, a so-called "corporate paternalism" emerged both in Britain and the United States of America (USA), promoting the idea that business has societal obligations. Visionary British and American businessmen (e.g., G. Cadbury, W. Lever, G. Pullman) built factory towns in order to provide workers and their families with housing and other facilities in the second half of the nineteenth century.

The appearance of the big business organizations in the beginning of the twentieth century, especially in the American economy, led many people to blame them for being too powerful. As the number of corporations increased, so did their economic and financial power. In the early 1930s two famous American economists warned that "the economic power in the hands of the few persons who control a giant corporation is a tremendous force which can harm or benefit a multitude of individuals, affect whole districts, shift the currents of trade, bring ruin to one community and prosperity to another" (Berle and Means, 1932, p. 46).

The social responsibility of business organizations has increasingly become a major subject in the business literature since the end of the 1950s. A relatively long period of heightened interest in CSR has begun with an effervescence of ideas regarding the field of social responsibility. On the other hand, the CSR movement was guided especially by big corporations as they had become the representative institutions of the capitalist society after the Second World War. Also, in the late 1960s and the early 1970s, several organizations such as the Conference Board in the USA and the Confederation of British Industry issued calls for businesses to give greater attention to social responsibility. In the twenty-first century these calls are more specific and urgent (N. Craig Smith, 2003), and are coming both from many business associations (e.g., World Business Council for Sustainable Development- WBCSD, Business for a Better World- BSR, International Business Leaders Forum- IBLF, Foundation for Corporate Social Responsibility- FCSR, Global Reporting Initiative- GRI) and governmental organizations (e.g., United Kingdom's Department of Trade and Industry). In the last years, governments around the world have begun to see CSR as "a subject with relevance for public policy, due to its ability to enhance sustainable and inclusive development, increase national competitiveness and foster foreign investment" (United Nations Global Compact and Bertelsmann Stiftung, 2010, p. 8).

One of the main reasons is the fact that several corporate scandals in the USA and Europe have shaken once again public confidence in businesses since the late 1990s. In this respect, the cases of Enron, Lehman Brothers, Parmalat or Ahold were associated with a corporate culture of greed and a climate of mistrust. That is why D. Cameron, the British prime minister, criticized the turbo-capitalism of recent past decades and called for a socially responsible and genuinely popular capitalism in January 2012 (Watt, 2012).

Today's business organizations understand that their performance is strongly tied to the environment and communities within they function. As a result, more and more business organizations establish social responsibility objectives to address the specific demands of their various stakeholders (Toma, et al., 2011).

The aims of our paper are to present in brief the social responsibility of business organizations concept, and to analyse the case of Pfizer, the largest pharmaceutical corporation in the world. The methodological approach was based on the literature review.

The paper is structured as follows. The second section outlines in short the theoretical framework related to the concept of social responsibility within the business organizations, emphasizing some of the main contributions derived from the literature. The third section of the paper displays a study case regarding social responsibility in the pharmaceutical industry. The paper ends with conclusions.

2. THEORETICAL FRAMEWORK

While the importance of this concept is fully recognized, there are as many definitions of CSR as are corporations. During the time, CSR has been described through multi-faceted approaches and points of view. The intensive debate among academics, researchers, consultants, and businessmen led to hundreds of definitions referring to "a more humane, more ethical, more transparent way of doing business" (Marrewijk, 2003, p. 95). In this respect, CSR was defined as:

- "a concept whereby companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis" (Commission of the European Communities, 2006, p. 1);
- "a commitment to improve community well-being through discretionary business practices and contributions of corporate resources" (Kotler and Lee, 2005, p. 3);
- "the continuing commitment by business to contribute to economic development while improving the quality of life of the workforce and their families as well as of the community and society at large" (WBCSD, 1998, p. 3).

Based on the above mentioned definitions, the CSR concept points out that a socially responsible business organization has social and environmental obligations in addition to its economic purposes. After the analysis of 37 different definitions, Dahlsrud (2006) states that the definitions of CSR reveal five main dimensions of the concept (Fig. 1).

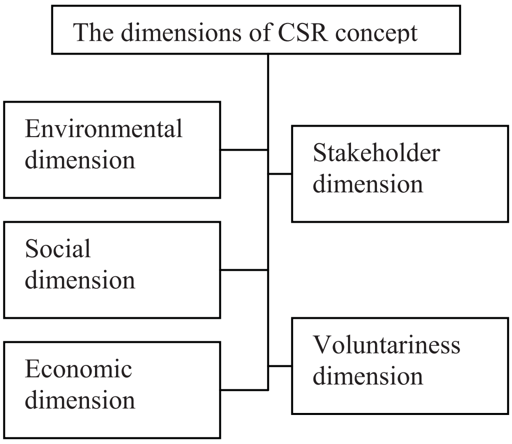

Figure 1. The main dimensions of CSR concept

These dimensions are related to the pyramid of CSR, promoted by A. B. Carroll (1991). In his view, a company has economic responsibilities ("be profitable"), legal responsibilities ("obey the law"), ethical responsibilities ("do what is right and fair and avoid harm"), and philanthropic responsibilities ("be a good corporate citizen"). On their turn, these responsibilities are derived from the seven principles that serve as the foundation of social responsibility (Fig. 2). According to ISO 26000-2010, business organizations should apply these principles of socially responsible behavior in good faith.

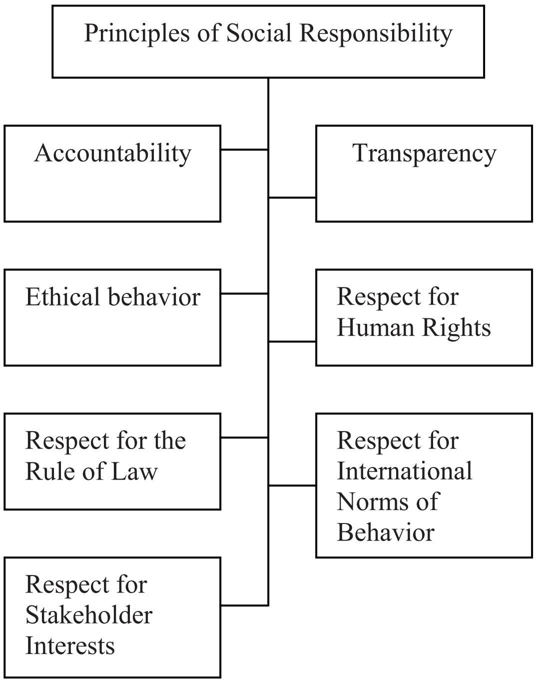

Figure 2. The seven principles of social responsibility from ISO 26000-2010

A socially responsible behavior brings multiple benefits both to business organizations (e.g., good organizational reputation, better relationships with stakeholders) and society (e.g., more cohesive society). That is why, "by addressing their social responsibility enterprises can build long-term employee, consumer and citizens trust as a basis for sustainable business models" and help "to mitigate the social effects of the current economic crises, including job losses" (European Commission, 2011, p. 3). The mutual dependence of business organizations and society implies that "both business decisions and social policies must follow the principle of shared value" (Porter and Kramer, 2006, p. 10). As a result, the past decades have seen a greater attention paid by the business organizations to CSR. In this respect, Pfizer constitutes a valuable example.

3. SOCIAL RESPONSIBILITY IN THE PHARMACEUTICAL INDUSTRY: THE CASE OF PFIZER

Highly diversified, knowledge intensive and globalized, the pharmaceutical industry represents one of the most profitable and competitive sectors in the world economy. Some of its main characteristics are the following:

- significantly contributes to the world GDP;
- achieves a high economic productivity;
- employs an important number of high skilled workers;
- allocates huge amount of financial resources to the research and development investments;
- launches yearly many new products;
- owes a robust intellectual property system that rewards innovation;
- possesses one the world's largest scientific research base;
- has established strong connections with the academic environment, etc.

The world's largest pharmaceutical companies are multinational and transnational, being historically located in the USA and Western Europe (Table 1).

Table 1. World's largest pharmaceutical companies

No.	Company	Sales ($ bil.)
1.	Pfizer (USA)	67.4
2.	Novartis (Switzerland)	58.6
3.	Merck & Co. (USA)	48
4.	Roche Holding (Switzerland)	45.3
5.	Sanofi (France)	43.2

Source: Forbes, 2012

Located in the USA, Pfizer is the largest research-based biopharmaceutical company in the world. According to Forbes Global 2000 Leading Companies, Pfizer is ranked no. 34 in the world, respectively no. 103 in sales, no. 39 in profit, no. 135 in assets, and no. 23 in market value (Forbes, 2012).

However, the American colossus is not only a very profitable corporation, but also a socially responsible one. In this respect, "The Blue Book" of Pfizer summarizes its policies on business conduct and emphasizes the following (Pfizer, 2012):

- Pfizer competes lawfully and ethically in the marketplace.
- Patient safety is no. 1 priority.
- Pfizer prohibits all types of bribery and corruption.
- Pfizer pursues sound growth and earnings goals while maintaining integrity in all that it does. Pfizer operates in the best interests of the company and its shareholders.
- Employees are encouraged to be active and interested in the communities in which they live and work.
- Pfizer is committed to treating its colleagues and job applicants with fairness and respect. Pfizer provides equal employment opportunities for anyone.
- Pfizer values a work environment that is free of verbal or physical harassment.
- Pfizer delivers accurate and reliable information to the media, investors and other members of the public.
- Pfizer is committed to participating actively in and improving the communities in which it does business.
- Pfizer strives to develop and implement sustainable programs. Pfizer strives to protect the environment and the health and the safety of its colleagues and communities in which it operates.

All of these demonstrate that Pfizer is a socially responsible business organization. This statement is supported by several key elements. Firstly, Pfizer has always considered that CSR plays a key role in achieving its mission: "Working together for a healthier world". Secondly, social responsibility at Pfizer is strongly connected with its values (e.g., integrity, community, customer focus, respect for people, quality). Thirdly, there is a mutual dependence of CSR and Pfizer's imperatives for building value. Fourthly, Pfizer has recognized in its CSR reports that a responsible and accountable (socially, ethically and environmentally) company is a trusted company (Pfizer, 2009 and 2007). Fifthly, Pfizer has striven to develop and implement several CSR programs such as Mobilize Against Malaria- 2007, Global Health Partnership- 2007, Connect HIV- 2007, Global Health Fellow- 2003.

In sum, Pfizer has expressed clearly its commitment to social responsibility during its long history.

CONCLUSIONS

Our paper has shown that the social responsibility of business organizations constitutes an important issue both in theory and in practice. Companies gain sustainable benefits through satisfying the needs of their various stakeholders (e.g., employees, shareholders, society). In essence, CSR refers to a voluntary commitment taken by companies towards managing their businesses in a responsible manner.

By assuming an active role in the development of the community, the economy, and the environment, a socially responsible enterprise ensures the long-term viability of its businesses. That is why business organizations should fully integrate CSR into all their activities and processes.

ACKNOWLEDGEMENTS

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UNTAPPED POTENTIAL OF ENTREPRENEURSHIP–YOUNG AS ENTREPRENEURS

Srđan Bogetić[1], Dejan Đorđević[2], Dragan Ćoćkalo[3]
[1]PhD, Professor, Belgrade Business School, 11000 Belgrade, Kraljice Marije 73, Republic of Serbia
[2]Ph.D, Professor, University of Novi Sad, Technical faculty "Mihajlo Pupin" in Zrenjanin, 23000 Zrenjanin, Djure Djakovica bb, Republic of Serbia
[3]Ph.D, Assistant Professor, University of Novi Sad, Technical faculty "Mihajlo Pupin" in Zrenjanin, 23000 Zrenjanin, Djure Djakovica bb, Republic of Serbia

Abstract: *Stimulating enterprising behaviour of the young is especially important in transitional countries faced with recession. The ambience where young people can be stimulated to start their own business is not developed enough in Serbia. Possible solutions can be education and encouragement of the young to start and perform their own business. The authors of this paper are analysing the necessity of implementing a modern enterprise concept on the territory of the Republic of Serbia with a special attention to the role of young people and the opportunities of their involvement in enterprise activities. In this paper are compared and presented the results of three consecutive researches carried out among Serbian students.*

Key words: *entrepreneurship, knowledge, SMEs, young entrepreneurs.*

1. INTRODUCTION

Global economic crisis has caused a lot of economic problems identical for most counties in the world. As a result national economies started transformation of their economic policies and they began the process of creation of new economic policy able to cope with the changes on the market. One of the greatest world economic problems is unemployment which is rising and, therefore, its reduction by opening new possibilities for employment and encouragement of business start-ups represent the most challenging economic task in the future.

Encouraging opening of small and mid-size enterprises (SMEs) whose aim is reducing unemployment represents a new economic recepe. In other words, the experiences of developed countries such as Italy, Germany, South Korea, USA and the others, have confirmed that it is a good direction which should be followed during recovery of national economies. The examples of Italy and Germany have become demonstrative – they show how to start economic development in damaged economies. However, the crucial fact in these countries was the existence of appropriate ambience which made possible promotion of effective entrepreneurship through:

- State support through institutions;
- Creation of efficient legislation for the work of SMEs;
- The existence of institutions which are closely specialized for help and support to SME sector;
- The existence of a bank which directs its financial means to quality programs of the present and new SMEs;
- Cooperation with Universities and other institution;
- Encouraging the making of clusters and competitiveness;
- Encouraging establisment of incubators as crucial institutions for young entrpreneurs;
- Cooperation of SME sector and big companies through cooperative relations;
- Encouraging entrepreneurship of the young through programs of support.

As we can see, the creation of entrepreneurial ambience requires the engagement of all participants on the marke, especially the state. Namely, the state should found the system in which all elements will have the common aim related to entrepreneurial encouragement.

2. NEW ENCOURAGEMENT PROGRAMS FOR THE YOUNG RELATED TO ENTREPRENEURSHIP IN EU

European Union have understood that the results of global crisis negatively influence the economy of its members and the Union as well. As a solution for economic problems European Commission has created a strategy „Europe 2020“ wishing that EU economy becomes: intelligent, sustainable and comprehensive. The aim of these three segments is to provide EU and the member countries with high degree of unployment, productivity and social cohesion.

The program „Europe 2020“is consisted of 7 holders and they are [1, p. 4]: digital agenda;young on the move; union of innovations; new industrial policy;new skills and new business; platform against poverty and resources efficiency.

The initiative “Young on the move” has the following aim – reducing the rate of unemployment of the young so it started cooperation with numerous institution in EU and created European network for employment of the young. This network has several pillars and they are [1, p. 14]: help in getting the first job and starting the career; support to the young in risky situations; providing an appropriate network of social security for young people;support to young entrepreneurs and self-employment.

According to the information of Eurostat for 2012, it can be concluded that the percentage of unemployment in EU is in permanent rise during the period from 2010 to 2012. Namely, the unemployment rate in EU 27, in February 2012 was 10.2% which represents a small increase comparing to the previous two years - 9.8% (2011)and i 9.6% (2010).The unemployment rate for the Eurozone countries in February 2012 was 10.8%, which is for 0.5% more comparing to November 2011,or 0.8%comparing to November 2010 [2]. In the Tables 1.and 2. We can see Table review of three countries with the lowest and highest rate of unemployment in EU.

Table 1.Highest rate of unemployment

Country	Percentage (February 2012)
Spain	23,6
Greece	21
Lithuania	15

Source: Eurostat

Table 2.Lowest rate of unemployment

Country	Percenage (February 2012)
Austria	4,2
Holand	4,9
Luxemburg	5,2

Source:Eurostat

The unemployment rate in the group of young people in EU is in permanent rise which indicates a systemic problem that European Commission is trying to solve. The data show that in 2012 the unemployment rate of the young in EU is 22.4%, which is a small rise comparing to the previous two years: 2011. (2.3%) and 2010 (21%). The same situation is in Eurozone where we can notice a rising unemployment rate considering young people, in February 2012 it was 21.6 %,and in the previous two years 21.7% (2011)and 20% (2010).

The Tables 3 and 4 we can see the list of countries with the highest and lowest unemployment rates considering young people. According to them Spain and Greece have the highest unemployment rate. In comparison to the last two years this trend is constantly increasing. In 2010 this rate in Spain was 43%,and in Greece 36.3%, but in 2011 this relation in percentage has come closer, so in Spain it was 49.6%, and in Greece 46.6%.

Table 3.Highest unemployment rate of the young

Country	Percentage (February 2012)
Spain	50,5
Greece	50,4
Portugal	35,4

Source: Eurostat

Table 4.Lowest unemployment rate of the young

Country	Percentage (February 2012)
Holand	9,4
Austria	8,3
Germany	8,2

Source: Eurostat

What is new comparing to the previous two years is that Portugal appears as a country with high percentage of unemployment concening the young. In the last two years the third country according to high unemployment rate was Slovakia which has managed to reduce the unemployment rate in 2012.

Table 4 shows the countries with the lowest unemployment rate. It is interesting that Holand, Austria and Germany have had the lowest unemployment rate in EU in the last three years. However, inspite of the fact that these three countries have the lowest unemployment rate concerning the young in EU, this rate is constantly changing. In 2010 Germany had 9.1% which is for 1% more than Austria and 0.7% more than Holand. However, in the following year this relation was changed so in Germany the unemployment rate of the young was 8.1%, which is 0.2% less than in Austria and 0.5%less than in Holand.

In 2011 European Commission created an aid program to future and the present SMEs owners and big companies’ owners in order to improve the state of EU economy. The program „The program for competitiveness of companies and SME“ has been focused on the following groups [3, p. 1]: entrepreneurs, especially SME which will benefit from easier access to financial means for financing their own business; citizens who want to start their own business and who face with difficulties during

this process; authorities of member countres which will create and apply effective ploicy of reforms with great efforts.
The budget of this program is 2.5 billion EUR and its main aims are [3, p. 1]: improvement of the access to financies for SME in the form of capital and loans ; improvement of the access to the market within EU and global market as well; promotion of entrepreneurship: the activities will include development of entrepreneurial skills and attitudes especially among new entrepreneurs, young people and women.

3. THE RESEARCH OF ATTITUDES OF THE YOUNG TOWARDS ENTREPRENEURSHIP IN REPUBLIC OF SERBIA

In November and December 2011 a research was carried on the territory of 16 towns and municipalities in Serbia under the name „The analysis of attitudes and opinions of the young in relation to business start up and implementation of socially responsible busines". Within this research 654 students from 19 to 27 years of age who were surveyed expressed their attitudes about own business start up, socially responsible business and competitiveness of domestic economy. In the last three years (2008, 2009 and 2010) similar researches were carried out which can serve as comparison and help in. creating the picture of the relations of young people towards their own business start up.
According to research results from 2011, the majority of students, 76.88% of them, wanted to start their own business. These data are similar to the previous two researches (2008, 2009.and 2010) which showed high preference of the young to start their own business. The results from 2011 showed that private business represents: risk and uncertainty (23.53%), challange (21,93%), pleasure and self-confirmation (14.90%).
The interviewed students mainly agree (44.90%) with the statement that private business is more successful than the one in other forms of ownership and that the people here still do not know real business possibilities of private companies (32.92%). The interviewed students, 49.77% of them, agree with this statement which points at the need for promotion of successful entrepreneurs in Serbia in order to change certain sterotypes related to entrepreneurship and managing private companies.
The interviewed students are in most cases turned to their own financial means for business start up (60.38%). The reason for such attitude is a consequence of their insufficient trust in banks and other institutions which offer financial means for business start ups. As a support to this goes the attitude of the interviewed students (5.74%) that start up loans of commercial banks are not favourable. Namely, they think that start up loans of commercial banks are overloaded with high interest rates (80.38%) and a long process for getting the means (14.42%). The data from 2008 research showed that the students (54.03%) were not satisfied with conditions of start up loans and among other reasons they emphasized high interest rates (33.79%) [5, p. 473]. The researches from 2010 and 2011 had similar indicators as previous two, 68.57%, and 70.17% of the interviewed students would finance their own business from their own finances. Young people think that start up loans are not favourable 54.17% (2010) and 60.46% (2011), and that the main problem represented high interest rates 48.07% (2010) and 4.,38% (2011),
One of the reasons against business start up the interviewed students found in the lack of ideas - (78.42) of them said this**,** which means that it is necessary to insist on development of entrepreneurial skills at faculties and high schools within promotion of entrepreneurial concept [6, p.71].The researches carried out in 2010 and 2011 showed that the reasons agaist business start up according to the interviewed students were: insufficient financial means (29.43%) and (26.77%) insecure political and economic situation (20.38%) and (23.99%). From these data can be concluded that the young still do not have enough self-confidence for starting their own business.There are several reasons for insufficient self-confidence of the young and one of them is education from the field of entrepreneurship which is still insufficient and inappropriate. There is a need for finding new ways of education and promotion of entrepreneurial concept. Young people in Serbia are still not enabled enough for development of entrepreneurial initiative and business start up. Another reason for lack of self-confidence of the young is inappropriate ambience for encouraging entrepreneurship of the young.
The research results from 2011. point at the fact that 55.95% of the interviewed students are not informed about the existence of stimulating funds for business start up.
The research results from 2011 show that the majority of students (89.30%) think that in Republic of Serbia does not exist an appropriate ambience that stimulates the young for business start up. The main reasons for this, according to students, are: lack of financial means (31.59%), unstable political and economic situation (28.91%) and too high taxes (23.77%). In the research from 2008 the students expressed dissatisfaction (78.70%) with the ambience for encouraging young people for business start up. The most important factors which represent barriers related to business start up are the same as in the research from 2009. The only thing which is different is the sequence of reasons:unstable political and economic situation (36.54%), long and complicated procedure of registration (13.75%), as well as too high taxes (1.02%) [6, p.72].These indicators point at the inappropriate state's policy

towards the young as potential entrepreneurs, but towards a private entrepreneurship itself. Unstable political and economic situation, long procedure for getting registration and too high taxes have been repeated for two years in the similar research which points at the lack of appropriate ambience for business start up. When we add the lack of specialized institutions that would support the young to start their business then we come to the reasons for dissatisfaction with the ambience for encouraging the young to start business. Without appropriate ambience which will encourage the young for business start up it is not possible to encourage them seriously to behave entrepreneurially.

The majority of the interviewed persons in all researches from 2008 to 2011 considered that the state should have a key role in stimulating the young to start their business. The last research (2011) showed that 91.44% of the interviewed thought that the state should have a key role in stimulating the young to start their business. The interviewed extinguished the following supporting ways as the key ones: favourable loans, education and laws/regulations related to the young as entrepreneurs. Such an attitude was supported by 90.33%, 88.08%, and 90.78%of the interviewed students in the research carried out in 2010, 2009 and 2008. The ways of support is the same, only their sequence is different.

4. CONCLUSION

Young entrepreneurs represent unused resource for development of national economies which is especially significant in the period of global economic crisis. Namely, according to statistic data in EU unemployment is in constant rise and unemployment of the young as well. Business start up represents one of the ways for reducing unemployment and revival of national economies. Europen Union has understood in time the importance of encouraging the young to start their own business because it has begun developing differnt programs for stimulating the young to go in entrepreneurship since 2000. However, as the situation on the market has changed the ways and initiatives of support have changed too.

Unfortunately, the young in Republic of Serbia are still not in the position to believe that their own business start up will be the best solution. The main reason is: the lack of appropriate ambience on domestic market which will stimulate entrepreneurship. The problems like lack of financial means, too high taxes and unstable political and economic situation are making difficultes to the present entrepreneurs and discouraging the future ones.

Possible solution can be in creating the ambience for stimulating entrepreneurship with a special accent on the young. Creating the ambience is not only a task for the state but it should be the common task of the state and: Serbian Chamber of Commerce, Union od employers, universities, NGO, National Bank of Serbia and other interest bodies which understand that the young represent unused potential and resource for developing entrepreneurship and national economy as well.

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INNOVATION AND ENTREPRENEURSHIP IN GLOBAL ECONOMIC CRISIS

Prof. Slobodan Pokrajac[1], PhD, Prof. Nikola Dondur[1], PhD, Djordje Mitrovic[2], PhD, Sonja Josipovic[1], PhD student, Marko Savanovic[1], PhD student
[1]Faculty of Mechanical Engineering, University of Belgrade
[2]Faculty of Economics, University of Belgrade,

Abstract. *The paper investigates the process of reactualization of the role of entrepreneurship in modern economy in time of actual global economic crisis. Under the influence of global economy changes, the meanings of the innovation and entrepreneurship have been drastically altered. Having understood the importance of innovation and entrepreneurship for the economic growth, many countries have recognized these processes as vital factors of their development. Innovation requires constant iteration between Technology, Market and Implementation.*
In short, entrepreneurship and firm creation have long been recognized as a vital force driving innovation. In our opinion innovation and entrepreneurship are the only weapon that would enable a company and national economy to survive a crisis. Also, we deeply believe that economic crises are historically times of industrial renewal and creative destruction.
Key words: *entrepreneurship, innovation, economic crisis, economic growth, entrepreneurial economy, innovative entrepreneurship.*

1. INTRODUCTION

The key fundamental drivers of sustainable prosperity are innovation and productivity growth**,** and their interaction over time. Although an innovation is successful only with a good idea and efforts to convert the idea into a tangible product or service, innovations are usually investigated in three distinct research agendas: *new product development*, *process innovations* and *management innovations.* Innovations of products and processes are of particular interest to manufacturing and service applications. Many authors describe innovation as a virtuous circle of research, development and application, all of which must be pursued together in other to maintain a competitive edge. In fact, innovation is the process of putting ideas into useful form and bringing them to market. We are using "innovation" to mean the process of moving new and valuable i,deas into the marketplace, where benefits accrue to the users and where return is extracted for investment in the process. Therefore, we also think that innovations are the best - and maybe the only - way the countries like Serbia can get out of its economic problems.

Indeed, innovation is one of the essential factors of enterprise performance as well as national economic growth. Either on the micro or the macro economic level, the relationships between innovation and performance have been (and are still being) studied in several important works (Schumpeterian and neo-Schumpeterian analyses, endogenous growth theories, etc.). Although Schumpeter emphasized a multiplicity of innovation forms, the accent in most of these analyses is essentially upon technological innovation (based on Research and Development). Schumpeter explains the nature of entrepreneurship by the recognition and assertion of opportunities through innovation, which includes "the introduction of new commodities" as well as "technological change in the production of commodities already in use, the opening up new markets or new sources of supply".

The study of innovation is of interest to engineering, business, social and behavioral sciences, and spans sociology, history, philosophy, economics, psychology, and political science. Innovations transform economies into the knowledge-based economy and alter global relations and produce new structures of social control. Innovations change day-to-day lives of individuals. Also, innovations in any

domain can be enhanced by principles and insights from other disciplines. However, the process of identifying the linkages between different domains and the need for innovation science is apparent.
Successful innovation requires contributions from managers, salespeople and customers just as much, if not more than, researchers and scientists. Therefore, without *entrepreneurial people* there can be no future, yet without people able to work in an efficient, consistent manner there can be no present. In short, the promise of an innovative, entrepreneurial and competitive economy is being held out as the so-called panacea for economic ills. Innovation has become an increasingly complex process with an increasing number of interacting actors involved.

The so-called ''new growth theory'' has exploited this old Schumpeterian idea to formalize the link between innovation and long run growth. According this theory (Romer 1990) differences in economic development across countries should be understood as the outcome of differences in endogenous knowledge accumulation within (largely national) borders.

Romer established the connection between knowledge, human capital, and economic growth through his *endogenous growth model*, arguing that investments in human capital generate spillovers and increasing returns. Endogenous growth models emphasize the importance of knowledge, knowledge spillovers and technological substitution in the process of economic growth, conceptually parallel to Schumpeter's early growth theory. Lastly, we also can say that innovation is a necessary condition of entrepreneurship, just like the existence of entrepreneurial opportunities and heterogeneous risk taking individuals that organize the exploitation of these opportunities.

2. ECONOMIC CRISIS IS THE RIGHT TIME FOR INNOVATION AND ENTREPRENEURSHIP

The current economic and financial crisis is the first of this severity to hit developed countries since they have shifted to knowledge-based service economies. We think that the problem of the current economic crisis is not, inherently and mainly, a problem of supply, but a problem of active demand for goods and services. The current economic crisis, however, is not the result of the emergence of a superior innovation that has rendered some existing industries obsolete. Instead, today's economic crisis is the result of a sharp change in demand conditions which resulted from a severe financial crisis leading to a major credit squeeze. Although the global, hypercompetitive nature of the current business environment makes any competitive advantage short-lived, it would be a mistake to view these turbulent times as anything other than an unparalleled era of opportunity. Therefore, we accept opinion of many authors that current economic crisis can provide a perfect backdrop for disruptive or radical innovation. Moreover, we believe that economic crises are also historically times of industrial renewal and creative destruction. In a few words, the current financial and economic crisis is providing the impetus for new entrepreneurs to take the step into self-determination and to build the employment base for the future.

Furthermore, we think there is nothing like a economic crisis to fuel the growth of new innovative energetic businesses. It has long been recognized that innovation is a major driving force in economic growth and social development. According to the growth theory, governments can promote economic development through a variety of means including supporting education and training to develop a more educated work force, stimulating capital investment, stimulating a reallocation of resources from low productivity to higher productivity industries and promoting technological progress and innovation. Using Schumpeter's term of *creative destruction*, some authors suggest that transformative innovation (which leads to creative destruction) is how entrepreneurs sustain the capitalist system. Also, we believe that in a current economic crisis an entrepreneurial culture will be a new "modus operandi" that will drive individuals, organizations, and societies towards an expanding set of new possibilities, ensuring not only business survival, but also self-renewal and the long-term health and well-being of the economy and society. In this way, and by using new applications of technology, because this is the essential point, the company's (and to a macroeconomic extent, the country's and in turn the global economy's) production possibility frontier will shift, without necessarily the company (or the country or the global economy) having access to new sources of funds. Besides, through this process, more favourable costing of raw materials will be made possible, since a production process with reduced costs will be applied. The results of this procedure will have an impact on the demand side. Lower costing will result in lower pricing, which translates to lower prices for consumers.

3. INCREASING ROLE OF ENTREPRENEURSHIP AND ENTREPRENEURS IN GLOBAL ECONOMY

The role and functions of entrepreneurship in new global economy have taken on added significance and face compounded challenges. In recent years, also there has been increasing interest in comparing entrepreneurs from different cultures. Entrepreneurship according to different contexts is defined differently by authors. The most of authors have defined entrepreneurship as forming and growing something valuable from virtually nothing; process starts from creating or grasping an opportunity, and then pursuing it. As we mentioned above, entrepreneurship is a very important dynamic process involving opportunities, individuals, organizational contexts, risks, innovation and resources. In this context corporate entrepreneurship is especially important.

Corporate entrepreneurship is often defined as a process that goes on inside an existing firm and that may lead to new business ventures, the development of new products, services or processes and the renewal of strategies and competitive postures. Corporate entrepreneurial advantages (ventures, innovation and renewal) can be created relying on tangible (e.g. physical, financial and labour resources) and intangible resources (e.g. human, social and intellectual capital).

Considering the role of entrepreneurship in the crisis, we can see that due to its ability of innovation and growth of investment, entrepreneurship is able to play a vital role in the current financial scenario by creating job opportunities and economic growth. Although these difficult times are seen negatively because of their socio-economic effects (loss of purchasing power, unemployment, social tension, etc.), they reveal certain dysfunctions and insufficiencies within these organizations, which stay latent in normal times.

The key agents of entrepreneurship are entrepreneurs (from the French *entrepreneurs,* literally: between takers). An entrepreneur is a person who undertakes the creation of an enterprise or business that has the chance of success. In fact, entrepreneur, as a term, applies to someone who establishes a new entity to offer a new or existing product or service into a new or existing market. Entrepreneurs are vitally important to any economy. Also, entrepreneurs are defining the new rules of activity on the economic landscape as they come to grips with contemporary challenges and new opportunities. In fact, the word "entrepreneurship" refers to the economic undertaking of entrepreneurs. In this new environment, entrepreneurs need to articulate a pragmatic vision, exercise effective leadership and develop a competent business strategy. They should create the synergies that will allow them to integrate the interactive ingredients of the new economy in order to enhance their competitive advantage. Their business strategy should embrace flexibility, a quick response time and a proactive approach to economic opportunities. Entrepreneurs distinguish themselves through their ability to accumulate and manage knowledge, as well as their ability to mobilize resources to achieve a specified business or social goal.

Typically, entrepreneurs create a novel response to an opportunity by recombining people, concepts, and technologies into an original solution. An opportunity evaluation is perhaps the most critical phase of the entrepreneurial process, as it allows the entrepreneur to assess whether the specific product or service has the needed returns. Entrepreneurs are perceptive and goal-oriented. The ability to spot business ideas, to launch new products, or open new markets is triggered by the accumulation of confirming or disconfirming evidence as perceived by the entrepreneur. Entrepreneurs' ideas and intentions form the initial strategic template of new ventures, products, and processes. Entrepreneurs must have great inspiration, sustained attention, and intention which are needed for ideas and innovations to become realities. Also, entrepreneurs have a need for achievement or a strong ego-drive and strive to make a difference in their own lives.

Entrepreneurship can consist of innovation or the introduction of creative change and change is generally considered as part of the entrepreneurial expectation. In that sense, the entrepreneur is a *change agent.* Therefore, more innovators need to be entrepreneurial, and more entrepreneurs need to be innovative.

As we mentioned above, innovator, entrepreneur and strategist are different people so they need to be separated. Also, a new socio-economic model that prepares conditions for innovators, entrepreneurs, and investors need to be set that lets them discuss and work with each other. With a precise definition of everybody's role; innovators can be free from taking the risks of being entrepreneurs, while entrepreneurs, by relying to research and strategy specialists' knowledge, can be bolder on their journey.

4. FOSTERING ENTREPRENEURSHIP IN CRISIS AND CREATING A CULTURE OF INNOVATIVE ENTREPRENEURSHIP

Fostering entrepreneurship means channeling entrepreneurial drive into a dynamic process that takes advantage of all the opportunities the economy can provide. To flourish, entrepreneurship requires efficient financial markets, a flexible labor market, a simpler and more transparent corporate taxation system, and business rules better adapted to the realities of the business world.

Enterprises large and small have a great trouble sustaining long-term superior performance. Even with large R&D budgets, success at innovation is not automatic. To sustain superior performance, the business enterprise must do a lot more than simply allocate large expenditures to R&D. The innovation process requires active orchestration of both intangible and tangible assets by entrepreneurs and

managers. This is true whether the context is the small or the large enterprise (Teece, 2007). Moreover, we have remembered that the high-growth companies have been built by entrepreneurs with: 1) an innovative idea, 2) great ambitions and 3) significant market and business related skills. In short, entrepreneurship is a great magnet to deliver new ideas, unique approaches and innovative technologies. When conducted in a proper way, turning people into entrepreneurs improve a country's economic performance and aid economic and global progress. However, transition to become an entrepreneur is not that aspiring to all.
The empiric data shows that teaching of entrepreneurial skills at all education levels has a significant impact on levels of entrepreneurship throughout the world. Much is made within these days of which countries produce the highest numbers of scientist and engineers.

Due to, fostering entrepreneurship is commonly viewed in the light of economic growth, competitiveness and job creation. But this perception falls short on the social relevance entrepreneurship has for society. In fact, any faster structural and competitive economic changes are leading to significant changes in society. This affects the individual life plans of particularly the youth and requires an increasing degree of self-reliance. In this context, fostering entrepreneurship and self-employment also provides the population with a career option parts of society might be better suited with to meet the changing demands of modern economies. In this respect fostering entrepreneurship is not only an economic but a socio-economic challenge for most economies. Their economic, social and cultural differences however require a tailor-made approach that responds to the socio-economic realities within the single countries. As we mentioned, entrepreneurship has more to it than just self-employment, learn and hard work; to start its full potential one needs to put emphasis on the generation and development of ideas. Entrepreneurial initiative covers the concepts of creation, risk-taking, renewal or innovation inside or outside an existing organization. Promoting innovative entrepreneurship is therefore a central concern for government, economy and all social segments. It is obvious that innovative entrepreneurship is becoming the cornerstone of economic growth in the developed world. Entrepreneurship education and research are seen as important means to foster entrepreneurial culture. Lastly, innovative entrepreneurship needs not to rely on inspiration or luck, but can be systematic fostered.

Except these, innovative entrepreneurs create ideas and have the ambition to build them into high-growth enterprises. Fostering innovative entrepreneurship is critical to our future competitiveness. It is these innovative entrepreneurs who are more likely to seek growth, create the majority of jobs and wealth, and therefore contribute to growth of productivity. Improvements in productivity are crucial to raising long-term economic performance and increasing living standards and quality of life.

Regardless of its traditional antipathy to innovators, every corporation must search for, recognize, communicate with, support, reward, publicly thank and emulate the actions of its quiet "positive deviants." Working with, instead of against, the corporation's silent innovators will require a significant shift in corporate ideas regarding risk. Firms must be intentional in creating an environment where appropriate risk is welcomed and corporate incentives must likewise be designed to reduce risk-averse behavior.

In other words, we can develop a tentative and working definition of the innovative entrepreneur as follows: a person who identifies an opportunity from an innovation, whether social or commercial, evaluates its market potential based on their own knowledge networks and social, financial or educational capital, and establishes an organizational structure, either within an existing entity or by creating a new one, that allows that innovation to be developed. Any survey and any measurement need to be able to capture both of these types of change as well as the interaction if it is to be capable of understanding the impact that the innovative entrepreneurs have on wider society.

Of course, it is important to distinguish between the "innovative entrepreneur" and the "innovation process". Overall, the innovation process is the interaction between individuals within an organization or business once the innovative entrepreneur has identified, articulated and devised a strategy to implement a commercial opportunity from an innovation. The process can take place in existing enterprises or in new entities and is measurable through input and output proxies such as amount spent on R&D or percentage of turnover accounted for by "innovations".

However, the "innovative entrepreneur" is an individual and the interest of any further work should be on identifying their attributes, the sources of their ideas, their finance, their social capital networks, their knowledge capital and, of course, the challenges and barriers that they face. In Schumpeterian light ''innovative entrepreneur'' **is the hero of the business drama.** First of all, he must be able to identify opportunities to define a new winning business models which come in variety forms in turbulent environment.

Becoming a successful entrepreneur does not require a lot of money but require innovative ideas and a strong urge to do something extraordinary and prove oneself. It is amazing that there is no need of huge investment to become an entrepreneur. Because, if this would be the major requirement then none of the following would have existed who have created history of economic and business successes.

5. CONCLUSION

Entrepreneurship and innovation provide a way for many people and professionals to overcome the global challenges of today, building sustainable development, creating jobs, generating renewed economic growth and advancing human welfare.

In sum, creativity, innovation and entrepreneurship are essential elements for economic progress as it manifests its fundamental importance in different ways:

1) by identifying, assessing and exploiting business opportunities;

2) by creating new firms and/or renewing existing ones by making them more dynamic;

3) by driving the economy forward – through innovation, competence, job creation and by generally improving the wellbeing of the society.

Entrepreneurialism does more than rise to this challenge. In modern times, it also spreads beyond the economy - into arts and culture, sport, professions, even pure science, which must fight harder for public interest when the public purse is otherwise engaged.

Therefore, individual initiative must not be devalued by arguing that businesses do well (or badly) because of background factors: strong science research, a supportive legal framework, efficacy government, or just an *"*entrepreneurial culture*"* that makes businesses easy to form and transform.

Innovation can also contribute to resolving environmental challenges, such as climate change. Last but not least, a catalyst for globalization and innovation, new technology (notably, the Internet) have become a fundamental component of the global economic infrastructure. (OECD, 2007; p. 29)

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SOME PROBLEMS OF IMPLEMENTATION OF STANDARDS IN THE FIELD OF HUMAN - COMPUTER INTERACTION

Aleksandar Zunjic
Faculty of Mechanical Engineering, Kraljice Marije 16, Belgrade, Serbia, azunjic@mas.bg.ac.rs

Abstract. *The main purpose of publishing of standards relating to the system human - computer consists in the fact that their application provides ergonomic design of individual system components, but their application also may have to provide safe, efficient and comfortable user experience. Although international standards, such as for example ISO 9241, by their nature and content permit their worldwide application, they are usually implemented in practice and applied within a limited number of countries. This paper discusses some problems related to designing and adoption of standards in the field of human - computer interaction, as well as the difficulties associated with the practical application of these standards.*

ABOUT THE EMERGENCE OF STANDARDS IN THE FIELD OF HUMAN - COMPUTER INTERACTION

The main purpose of publishing of standards relating to the system human - computer consists in the fact that their application provides ergonomic design of individual system components, but their application also may have to provide safe, efficient and comfortable user experience. The application of some of the standards in this area facilitates the choice between different existing variants and solutions, related to the observed component or phenomenon in a system human - computer.

International standards in the field of human - computer interaction are mostly developed under the auspices of the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC), (Serco usability services). From the name of the standards can be concluded which of these organizations has participated in its designing. Design of standards represents a complex and time-consuming process, mainly due to achieving the consensus among groups of people involved in their design, as well as the need to achieve stability in relation to appearance and use of the new technology (Travis). Certainly, the structure of the content and scope of standards largely determine the time dimension which is related to their creation and beginning of application in the practice.

In the formation of ergonomic standards under the auspices of the International Organization for Standardization, national bodies for standardization of member states of the ISO group participate. The work of the ISO organization is performing within the technical committees and subcommittees that have a meeting as needed each year, and whose members are delegates from member states of this international organization. In practice, technical jobs perform so-called Working groups of experts, who are assumed to act independently of external influences. Adoption of standards represents a process that often takes several years, until a consensus is reached (usually within the Working groups of experts). When a standard enters the further procedure, a formal voting (usually within the parent sub-committee) is performed. Thus, when the proposed standard passes all the planned stages of development, its ultimate status gets a name the international standard.

In the following chapter will be discussed about the standard that is most frequently used and cited in the field of human - computer interaction, which was developed by the ISO. This standard has the ISO 9241 label, and its initial name is "Ergonomic requirements for office work with visual display terminals".

ISO 9241 STANDARD

In late seventies of the last century, in the public grew concern about ergonomic aspects of work on video display terminals. At that time, the main concern was related to whether the prolonged use of video display terminals may cause a worsening of vision of users. This research subject matter, as well as some others that have emerged in the meantime, have led that the existing Committee for Information Technology made the decision which related to the statement that the mentioned area is suitable topics for consideration within the established special committee ISO/TC 159. Working material was submitted to the ISO/TC159/SC4 subcommittee. Inaugural meeting was then held in Manchester in 1983. This meeting was very well attended by delegates from many countries, whereby several important decisions were made. At that time, in practice, the office work got a strong momentum, so it was decided that the standard should be focused on VDT work in offices. It was also decided that the standard should be conceptualized from several parts, which would cover a wide field of ergonomic requirements related to VDT work. Six initial working groups was formed (Stewart).

So, the basic idea was to make the standard that should consist of several parts, which could be partly related to hardware and partly to software. Accordingly, the first six parts of the standard refer to the hardware, while the parts of 10 to 17 relate to the software. In addition, the parts of the standard related to the hardware were added, such as reflection (7), color screens (8) and devices for data input that are different from a keyboard (9), (Stewart). In this way, the structure of the standard in essence reflects the history of its formation, which lasted slightly more than 17 years (Stewart).

ISO 9241 is intended for the general population of users, from engineers, professionals in the field of usability, designers of software tools, end users, as well as companies that produce hardware and software. Some parts of the standard require certain technical and ergonomic knowledge, while other parts of the standard are understandable for every user of the computer technology. Many countries have adapted this ISO standard and they apply it as a national standard (Travis). In Table 1 are listed ISO/TC 159/SC4 members.

As noted above, ISO 9241 standard consists of 17 parts. The names of the parts of this standard are:

ISO 9241-1: General Introduction
ISO 9241-2: Guidance on task requirements
ISO 9241-3: Visual display requirements
ISO 9241-4: Keyboard requirements
ISO 9241-5: Workstation layout and postural requirements
ISO 9241-6: Environmental requirements
ISO 9241-7: Display requirements with reflections
ISO 9241-8: Requirements for displayed colours
ISO 9241-9: Requirements for non-keyboard input devices
ISO 9241:10: Dialogue principles
ISO 9241-11: Guidance on usability
ISO 9241-12: Presentation of information
ISO 9241-13: User guidance
ISO 9241-14: Menu dialogues
ISO 9241-15: Command language dialogues
ISO 9241-16: Direct manipulation dialogues
ISO 9241-17: Form-filling dialogues.

From 2006, the standard changed its name to the "Ergonomics of Human System Interaction". As part of this change, ISO has renumbered some parts of the standard, so now the new ergonomic standard covers somewhat more topics (for example, example tactile and haptic interaction). The new standard is structured according to the series, as follows:

100 series: Software ergonomics
200 series: Human system interaction processes
300 series: Displays and display related hardware
400 series: Physical input devices - ergonomics principles
500 series: Workplace ergonomics
600 series: Environment ergonomics
700 series: Application domains - Control rooms
900 series: Tactile and haptic interactions.

OTHER STANDARDS IN THE FIELD OF HUMAN - COMPUTER INTERACTION THAT HAVE AN INTERNATIONAL CHARACTER

In practice, it is very difficult to achieve a uniform standard that would be universally accepted. It is common that for one area, there are a number of standards. Another reason behind this phenomenon (especially when it comes to the interface design) represents the fact that computer technology constitutes the basis for a greater number of industries, so that the standards have profound influence on a market success (Stewart).

However, to the duplication of standards comes not only at the international plane, but a similar phenomenon can be noticed at the national level. Thus in the UK, the Committee for SC4 BSI (British Standards Institution) has published an initial version of the first six parts of ISO 9241 standards, as British Standard BS 7179: 1990 (Stewart). The main reason for this is contained in the provision of recommendations for the workers at video display terminals, in order help them to choose the equipment that would suit their needs.

Country			
Austria	Tanzania	Hungary	Czech Republic
China	Belgium	Canada	France
Germany	Danmark	Finland	Japan
Korea	Ireland	Italy	Poland
Slovakia	Netherlands	Norway	Thailand
United Kingdom	Spain	Sweden	Romania
Australia	United States	Mexico	

Table 1. Member states ISO/TC159/SC4.

A similar phenomenon was noticed in the United States. HFES (Human Factors and Ergonomics Society) has initially brought HFES 100 standard, which refers to the ergonomics related to the use of video display terminals. Later, the same institution by developing HFES 100 has brought a new national standard HFES 200. This standard contains most of the ISO 9241 standards that are related to the software (Stewart).

In the following part of the text will be listed names of international standards in the field of human - computer interaction (according to Serco usability services), which can be applied in practice in addition to the standard ISO 9241:

ISO/IEC 11581: Information technology — User system interfaces and symbols — Icon symbols and functions
ISO/IEC 10741-1: Cursor control for text editing
ISO 14915: Software ergonomics for multimedia user interfaces
ISO 13406: Ergonomic requirements for work with visual displays based on flat panels
ISO/IEC 14754: Pen-based interfaces — common gestures for text editing with pen-based systems
ISO/IEC 15910: Software user documentation process
ISO 13407: Human-centred design processes for interactive systems.

Besides the mentioned standards, it should be noted that there are other standards that could be applicable for VDT workplaces. One of the such standards is, for example, BIFMA G1. Business and Institutional Furniture Manufacturer's Association (BIFMA) released this standard.

DIFFICULTIES IN THE APPLICATION OF STANDARDS IN THE FIELD OF HUMAN - COMPUTER INTERACTION

In practice, it is often the case that the ergonomic standards in the field of human - computer do not apply to the extent necessary, or they do not apply at all. Many people believe that these standards are difficult for understanding and usage (Stewart). Schaffer and Sorflaten state the reasons why standards do not function in practice:

- too many standards to be remembered
- ambiguity: recommendations versus standards
- they create the biases
- too general for certain specific tasks
- problems with versions
- there is no creativity
- demanding for the application
- tedious to track of amendments
- the application is expensive
- too specific to certain platforms.

Analyzing the causes for which the standards in the field of human - computer interaction are not widely used, Travis emphasizes the following reasons:

- Standards are expensive.
- The use of the name "office jobs" in the name of the ISO 9241 suggests that the standard is intended for work in offices. However, the standard can be applied to other business conditions and to different tasks.
- Standards are big and often too large.

CONCLUSION

Successful implementation of standards means that designers working in the field of human - computer interaction and other people who want to use ergonomic standards in practice understand first of all the aim and benefits from the implementation of any recommendation from the standards. Also, it is necessary that they are familiar with the conditions under which certain recommendations should be implemented, with the essence of the proposed solutions and procedures that should be implemented to ensure the application of certain recommendation from the standard.

If the application of standards is not legally required, there is no obligation for their usage in practice. This is one of the reasons (besides the already mentioned) due to which standards in the field of human - computer interaction are not applied sufficiently. It is usually the case that the application of certain standards is dictated by the market, especially when it comes to computer technology manufacturers. In order to achieve a certain quality of products from the assortment, producers are forced to apply, to some extent, ergonomic standards, when designing and implementing the manufacturing program. The application of ergonomics standards in the manufacture of computer technology also has a strong marketing effect, because then, as one of the reasons for buying products on the market emphasizes that the product meets the ergonomic criteria and standards.

Passing legislation by which a standard from the ergonomics domain would be applied in practice may also be justified, especially if the application of this standard ensures that it will preserve the health of VDT operators, and the work makes more efficient. In this way can be avoided litigations that became a phenomenon in some developed countries, initiated as a result of adverse effects associated with the use of non ergonomically designed software or hardware. By application of ergonomic design of the interface in the system human - computer can be achieved significant reduction of the absence from work due to health problems, arising as a result of performing of working tasks at a workplace with the video display terminal, which is not designed according to the ergonomic principles. Applying the standards in this area mentioned problems can be substantially eliminated.

Although international standards (such as for example ISO 9241) by their nature and content permit their worldwide application, they are usually implemented in practice and applied within a limited number of countries. By comparing IEA member countries (International Ergonomics Association) and member states that participated in the creation of ergonomic standards ISO 9241 (given in Table 1), it is evident that 26 IEA members have not taken a part in the design of this standard. Among them are some of the world's most populous countries like India and Russia. Serbia also has not been participating in the writing of aforementioned standard, as well as other ergonomic standards in this field, although it is the IEA member. This may represent one of the reasons why the ISO 9241 standard in our country does not have significant practical application.

When exist, the national standards in the field of human - computer interaction are usually in agreement with some of the international standards in this field. The reason for this is that the world is increasingly seen as the global market. A man is in this sense treated as a whole that has universal characteristics, taking into account national and regional specificities of each country. However, Serbia does not have a national standard in the field of human - computer interaction. The adoption of such a standard in addition to gathering experts in the mentioned areas requires a comprehensive action, which refers to spreading of consciousness about the necessity of applying the standard, introducing with the benefits related to the practical application of standards, and increasing the level of general knowledge in the ergonomics among the general population of users of computer technology.

Ergonomics standards in the field of human - computer interaction were created based on the results from numerous studies in this field. However, certain standard in this field should not be treated as unchanging category, or a category that will automatically provide the most optimal working conditions. The standards provide elevating of conditions of using the computer technology to a higher level, which in the given period of time can be treated as conditionally optimal. The standards should also include new researches and knowledge relating to the ergonomic use and design of working places with video display terminals, and to comply with the advancement of computer technology and with the emergence of new products based on the application of ergonomic knowledge. Such an approach can contribute to continuous improvement of conditions and results of the work of users and operators in workplaces with a video display terminal.

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STRUCTURAL ANALYSIS OF INFORMATION PROCESSING MODELS ACCORDING TO BOWER AND MAZUR

Aleksandar Zunjic
Faculty of Mechanical Engineering, Kraljice Marije 16, Belgrade, Serbia
azunjic@mas.bg.ac.rs

Abstract. *Information processing models of Bower and Mazur are models that are used in some textbooks for explanation of human information processing. Human information processing approach is of great importance for controlling and managing of the man - machine system. The aim of this research is to give a new consideration about adequacy of the models of Bower and Mazur for explanation of the human information processes, by means of structural and functional analysis of the models. It is pointed out to some shortcomings of the models and to a conditional limitation of the models for explanation of the human information processing.*

Keywords: *human information processing, information processing models.*

INTRODUCTION

The basic purpose of different information processing models is to provide the insight about the ways of processing of different information by human beings, by using the symbolic (schematic) presentation. Although these models are generally formed to explain some specific phenomena about processing of information, some researchers often try to explain almost all occurrences concerning information processing by using one complex model. However, it is not a rare case that some weaknesses of models become apparent by application of a detailed structural and functional analysis (see for example Zunjic and Milanovic, Zunjic 2007, Zunjic 2009).

THE AIM OF RESEARCH

Models of information processing that are created by Bower and Mazur are the models that are used in some textbooks for explanation of ways of information processing. The aim of this research is to give a new insight about adequacy of the models of Bower and Mazur for explanation of the human information processes, by means of structural and functional analysis of the models.

ANALYSIS AND DISCUSION OF BOWER'S MODEL

Bower's model of Information processing is shown in figure 1. This model of information processing is an example of a cumbersome model, whose complicated structure leads to the situation where loses to a great extent the use-value of the model, because the function of explanation of information processing in such a way becomes virtually impossible (Velickovskij). Such a cumbersome structure is the result of the aspirations of the author to integrate in a single model as many different phenomena related to information processing, in order to get the universal character of the model. A feature that distinguishes this model from other models is the differentiation on short-term and working memory. The basic functions of long-term, short-term and working memory are shown in the figure.

Although the complexity characterizes this model (perhaps excessive), however, by careful observation, can be noticed the basic structural components that also contain other models.

Thus, we can notice the central processing segment whose function is almost identical to the function of the block that relates to the control processes, in the model of Atkinson and Shiffrin. However, Bower's central processing unit does not have a decision-making function, like it, for example, has the central mechanism for decision-making in the Luczak's model. The function of decision-making is taken over by the short-term memory in the Bower's model, based on the information that is processed in the working memory. It can also be noted that auditory, visual and tactile buffer act as sensory registry, in the previously mentioned models of information processing. Generator of responses in the Bower's model also exists under the similar name in the most models of information processing (such as, for example, the block of organization of responses, in Schneider's and Shiffrin's model).

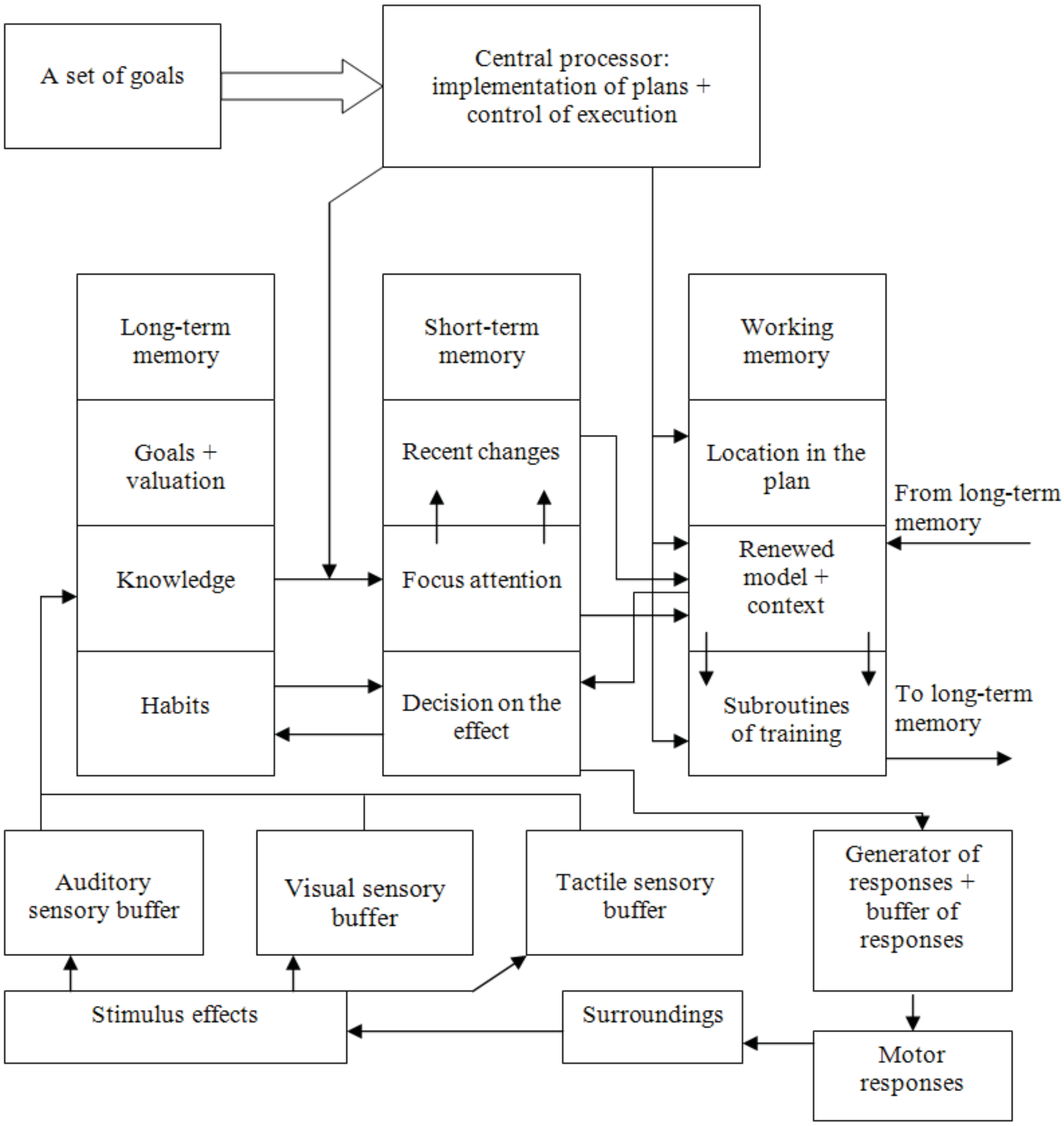

Figure 1. Model of information processing according to Bower (Velickovskij).

Despite the complexity that it possesses, Bower's model is not without shortcomings. From Figure 1, we notice that the information from the sensory register goes first to the long term, and only later to the short-term memory. This concept is in contrast in relation to most models of information processing, which explicitly show the memory components (as it is the case with the models of Atkinson and Shiffrin, Wickens, Haber and Hershenson). In addition, it is well known that upon the receipt of the stimulus an information retains only a few seconds. If the long-term memory is responsible for this process, then its name certainly should be changed. From Figure 1 also can be noted that there is no flow of information from any memory (or other components within the model) to the central processor, so it is not clear how an information is processed in that block, when it previously not arrived for processing.

Bearing in mind that the response generator receives information only from short-term memory, where, moreover, creates a decision, Bower's model can be classified as a single-channel model of information processing.

ANALYSIS AND DISCUSION OF MAZUR'S MODEL

Mazur's model of Information processing is shown in figure 2. After registering, the information is sent from the receptor to the correlator, which has multiple purposes. Generally speaking, in this block, with already memorized information incoming information compares, whereby after the registration and processing of such information, it incorporates in the memory fond, for a longer or shorter time. Homeostat is a block whose function consists in determining the usefulness of received information, for the person who participates in the process of information exchange with environment.

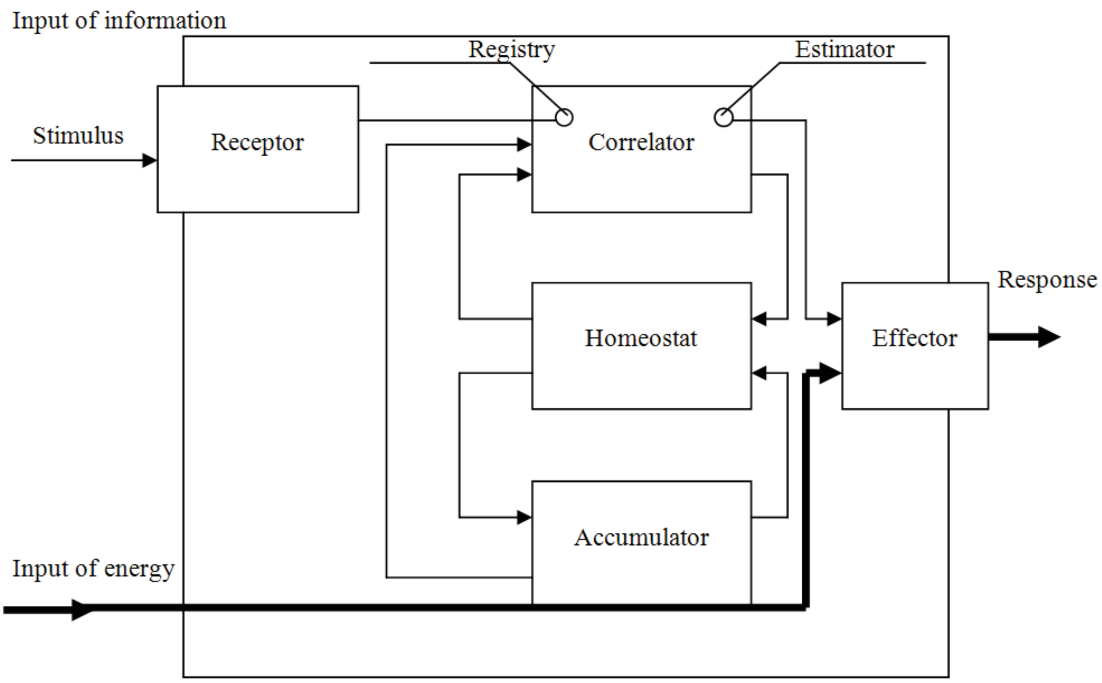

Figure 2. Model of information processing according to Mazur (Filipkowski).

On the basis of the memory, homeostat determines whether the information is interesting to the recipient. If the information is less important, the potential of the correlator decreases rapidly, so that from this segment, information will not be sent further for the effector. So, the response will be absent, because the potential in the correlator is not enhanced by additional impulses, whereby the information remains unmemorised. In the case of incidence of strong and short-time stimulus, the fast reactions arise, because the impulse itself has the sufficient potential to lead to the response. Similarly, if the homeostat evaluate the information as important, additional impulses will enable that in the correlator reaches the threshold necessary for decision making, so immediately after that it will occur the execution of responses. Performing of all of these processes require a certain power consumption. Accumulator has the task to provide the additional energy necessary to achieve the potential of correlation, i.e. potential that can lead to the reaction (Filipkowski).

Mazur's model in terms of structure is quite different from all other models of information processing. We note three completely new structural segments (correlator, homeostat and accumulator), whose functions also appear at the first time in any of information-processing models. One of the novelties of this model is also presented through the function of estimation in the correlator, where the decision-making process performs, depending on the achieved energy value of the impulse in the relation to the decision making threshold. In this model, also for the first time we meet with the notion of the importance of information, for whose assessment the homeostat is responsible. The function of accumulator in terms of obtaining of energy for the execution of mental processes is a novelty compared to previous models. All in all, Mazur's approach with regard to the presentation of the structure and flow of information processing is different from approaches that are represented in the models of other researchers.

As a possible drawback to this model can be pointed out that is to a single structural segment (correlator) attributed almost the entire function of information processing. What the correlator symbolizes in Mazur's model, in other models of information processing is separated through functions of a greater number of structural segments, which essentially constitute the very core of these models. Thus, for example, Mazur's model does not provide the insight into the information flow between different memory segments, and also is omitted the block that relates to organization of responses.

Since the effectors receive information only from the correlator that in the model of Mazur represents the "bottleneck", this model of information processing can be classified as a single- channel.

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POSSIBILITIES AND CONSTRAINTS OF APPLICATION OF THE WERA METHOD FOR RISK ASSESSMENT ASSOCIATED WITH VDT WORK

Aleksandar Zunjic[1], Nikolina Orlovic[2]
[1]Faculty of Mechanical Engineering, Kraljice Marije 16, Belgrade, Serbia, azunjic@mas.bg.ac.rs
[2]Sequester employment, Palmoticeva 22, Belgrade, Serbia

Abstract. *The WERA is a relatively new method, which has been used for assessment of risk factors, associated with work-related musculoskeletal disorders. The method was tested previously at the plasterer workplace by the authors of this method. Since there are no published data about the application of the WERA method on tasks where is dominant the static work, the authors of this paper consider that is of importance to examine the sensitivity of this method in occupations where is prevalent the static working activity, such as it is in the case of VDT work. VDT work is one of the activities that is performed in sitting position, which does not require special tools, and for which is characteristic certain static stress of large musculo - skeletal regions. Possibilities and constraints of the WERA method are examined in this preliminary study, which was performed on a relatively small group of VDT users.*

INTRODUCTION

The Workplace Ergonomic Risk Assessment (WERA) represents an observational tool, which has developed to provide a method for controlling of the working tasks, in relation to the exposure to the physical risk factors, associated with Work-related Musculoskeletal Disorders (WMSD).

The WERA tool covers six physical risk factors, including posture, repetition, forceful, vibration, contact stress and task duration, and it involves the five main body regions for the assessment (shoulder, wrist, back, neck and leg). It has a scoring system and action levels, which provide a guide to the assessment of levels of risk and indicating the character of action that should be undertaken. This tool has been tested in terms of reliability, validity and usability during the development process. Because the WERA tool is a "pen and paper" technique that can be used without any special equipment, it also can be performed for any workplace without disruption of workers' activity (Rani et al, Rahman et al).

PROBLEM

As already mentioned, WERA method is intended to assess the risk of musculo - skeletal disorders in different workplaces. The authors of this method, Rahman et al, did not specify any restrictions regarding the application of this method in terms of types of work activities to which this method can be applied. By the authors themselves, this method was tested at the plasterer workplace. Work activity in this area is characterized by the continuous dynamic work. According to the above-mentioned authors, WERA method proved to be sufficiently sensitive instrument for risk assessment of the analyzed workplace.

ANALYSIS AND DISCUSION OF THE MODEL

Since the WERA method is not tested on tasks where is dominant the static work, the authors of this paper consider that is of importance to examine the sensitivity of this method in occupations where is prevalent the static working activity. VDT work is one of the activities that is performed in sitting position, which does not require special tools, and for which is characteristic certain static stress of large musculo - skeletal regions. Bearing in mind that the work on VDT workplaces over a longer period of time is associated with the emergence of numerous musculo - skeletal disorders (Malinska and Bugajska, Wilkens), this workplace was chosen to test the sensitivity of the method WERA. The main hypothesis that is necessary to check consists in assumption that the WERA method is sensitive enough, in terms of risk assessment at VDT workplaces.

METHOD

The procedure for using the WERA method can be described in short through five steps (Rani et al), as follows:

Observe the job/task

Observe the job/task in order to formulate a general ergonomic workplace assessment, including the impact of work layout and environment, use of equipment, and behaviour of the worker with respect to risk taking. If it is possible, record the data by making of photos or by using of a video camera.

Select the job/task for assessment

Decide which job/task to analyze from the observation that was described in the first step. For this purpose, the following criteria can be used:

- the most frequent activity of the job/task
- extreme positions of body parts, unstable or awkward postures
- the job/ task that is known to cause discomfort
- requires the greatest forces, involves a contact stress or use of a vibration tool.

Rate the job/task

Using the WERA tool, calculate the score for each item (risk factor) including parts A and B. The part A consists of five main body areas, including the shoulder, wrists, back, neck and legs. This part covers two risk factors for each body part, including posture and repetition. The part B consists of four risk factors, including forceful, vibration, contact stress and task duration.

Calculate the score relating the exposure

Calculate the score relating to each item (parts A and B) and the final score. Register the numbers at the crossing point (of chosen columns and rows). For example, in the part A, for items 1-5, pairs for posture and repetition should be chosen. In the part B, for items 6-8, the calculations should be performed, taking into account determined postures (from the part A). After calculating the score for each item of the risk factor (items 1-9), calculate the total score.

Consider the action level

Based on the value of final score, assess the risk and choose the action level, according to the next classification:

- the task is acceptable (the final score of 18-27, low risk level)
- task requires the change, and further examination is needed (the final score of 28-44, medium risk level)
- the task is not acceptable, and requires the change immediately (the final score of 45-54, high risk level).

As the comparative methods, the method of interviewing of VDT users was used, method of observation (independent of the WERA method), as well as the method of indirect observation, based on recording of activities at workplaces by using a camera. The main purpose of the interviewing method consisted in collecting information related to basic difficulties and obstacles in the work of VDT users. The method of observation was conducted in order to analyze work activities to the observed workplaces. Recording using a camera (making of digital photographic record) was used in order to implement the subsequent visual analysis and for identification of risk elements in the work process.
The risk was estimated at five VDT workplaces. Work activity was primarily focused on data input and editing. The average age of users was 30.8 years. The average time of use of computers amounted to 6.58 years.

RESULTS

Results obtained by the WERA method are shown in the concise form in table 1. This table contains the results in terms of scores for all nine items that are involved in the risk assessment using the WERA method, to all workplaces that are included on the assessment.

WP	Score for the WERA assessment									Final score	Action level
	SH	WR	BC	NC	LG	FC	VB	CS	TD		
1	2	6	3	4	4	3	3	3	4	32	Medium
2	3	5	2	4	4	2	3	3	4	30	Medium
3	3	5	2	4	4	2	3	3	4	30	Medium
4	2	5	2	4	4	2	3	3	4	29	Medium
5	2	5	2	4	4	2	3	3	4	29	Medium
Mean	2.4	5.2	2.2	4	4	2.2	3	3	4	30	Medium

Table 1. Scores obtained by the WERA method, per items and total, for all workplaces that are included in the risk assessment.

Abbrevation used in table 1: SH - shoulder, WR - wrist, BC - beck, NC - neck, LG - leg, FC - forceful, VB - vibration, CS - contact stress, TD - task duration, WP - workplace.

Figure 1. Typical working postures of the back and neck, for the VDT user who was positioned in the workplace number 1.

The table also shows the total scores for individual workplaces, and the average score for all five workplaces. Figure 1 shows one of the VDT workplaces within the scope of risk assessment. From the figure can be seen characteristic body angles, during the execution of usual working operation.

ANALYSIS AND DISCUSSION OF RESULTS

When observing shoulder, the highest score is achieved at workplaces number 2 and 3. Among VDT users at these workplaces, the shoulder is moderately bent, with the movements that are performed with several breaks. When considering the wrists, the highest score is noticed at the workplace number 1. Among VDT users on this workplace, the wrists are extremely bent with twisting, due to an intensive entering of texts from the paper. In relation to the back, the highest score was also recorded in the workplace number 1. For this user, the back is moderately bent forward, with repetitions of movements from 0 to 3 times per minute. Scores for the neck are the same in all subjects. It was noted a moderate bending of the neck forward, with the execution of movements with more breaks. The highest overall score of 32 has workplace number 1, indicating a medium level of risk. Other workplaces showed lower scores, but they are also located in the zone of medium level of risk.

CONCLUSION

The highest average value of the scores that was obtained using the WERA method is noticed for the wrist, and amounts to 5.2. This value indicates that the wrist was most burdened part of the body for observed VDT workplaces. Given this data, for remedying this problem, it is necessary to undertake measures in the medium-term period, with the aim of avoiding of appearance of the carpal tunnel syndrome among users over time. The overall mean value of the score for all five workplaces equals 30. The obtained value indicates a medium level of risk at the observed VDT workplaces. This means that the task can be accepted, with some improvements needed in the workplace, in terms of application of advanced design solutions and adjustments of the workplace to the user. These findings are largely congruent with the findings obtained using the comparative methods in this research.

However, WERA method has been shown some weaknesses in this preliminary study. Although from the theoretical aspect, the environment is mentioned as an option within this method, it is clear from the procedure of application of this method that only the influence of vibration is included. Other environmental factors that may have a negative impact on the human body are not covered by the WERA method. The reason is probably because in this method the primary focus is placed on effects on the muscular - skeletal system. However, it is known that VDT work is characterized by the existence of visual fatigue, which is partly caused by the movement of the eye muscles. This effect is not treated by the WERA method. This can also be considered as a conditional deficiency, in the case of risk assessment at VDT workplaces.

Generally speaking, WERA method can be characterized as a useful tool for risk assessment in the workplaces, in conditions where the intensive dynamic activity is not performed, and when the work is not characterized by significant use of muscle forces. This method has shown a considerable sensitivity level in relation to risk assessment at VDT workplaces that were studied. In this regard, workplaces that have tested were appropriately classified according to the existing level of risk. However, it should be noted that this preliminary analysis was conducted on a relatively small sample of workplaces, which does not exclude the possibility of subsequent identification of weaknesses, which can be attributed to this method.

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THE OPTIMAL LIFE CYCLE OF PASSENGER CAR

Radomir Mijailović
Faculty of Transport and Traffic Engineering, University of Belgrade, Vojvode Stepe 305, Serbia

bstract: *The timely passenger cars replacement plays an essential role in the decrease of the world's* CO_2 *emission. This paper is about the problem of optimization of life cycle of passenger car. The life cycle of passenger car has modeled using eight main life cycle sequences. The total* CO_2 *emission has been selected as the objective function. Comparison of the obtained numerical results was performed on examples for the data of new passenger car fleet from the EU14 countries.*
Keywords: *life cycle, passenger car, optimization.*

1. INTRODUCTION

The problem of optimization of life cycle of passenger car, using different models, objective and constraint functions, was studied by several authors.

Van Wee et al. [4] have opinion that by reducing the age of the current car fleet may result in an increase of life-cycle CO_2 emissions. The authors have modeled vehicle cycle by the following sequences: production, materials, uses and scrapping of cars (including recycling). The authors also analyzed differences in performance and sequence "use" between old and new cars.

Zamel and Li [5] have modeled vehicle cycle by the following sequences: material production, assembly, distribution, maintenance and disposal.

Kim et al. [2] determined optimal lifetimes using life cycle assessment, a comprehensive environmental measurement tool, dynamic programming and engineering optimization tool. The model inputs consist of a collection of life cycle inventories describing materials production, manufacturing, use, maintenance, and end-of-life environmental burdens as functions of product model years and ages.

Leduc et al. [3] solved the problem of the environmental impacts of new average cars from a life cycle perspective using complex process flow diagram of cars. In this paper, five main life cycle sequences were identified: production phase, spare parts production, fuel transformation process upstream to fuel consumption, fuel consumption for car driving and car disposal and waste treatment.

The paper's objective is to suggest model for determining optimal life cycle of passenger car. Model includes eight main sequences of life cycle of passenger car. Combining the mathematical interpretations of the itch life cycle sequence, an optimization model is developed. The CO_2 emission has been selected as the objective function. The model should facilitate to us to obtain optimal life cycle of passenger car.

2. THE MODEL OF PASSENGER CAR LIFE CYCLE

The life cycle of passenger car includes all the main sequences required to make up the life cycle of that system.

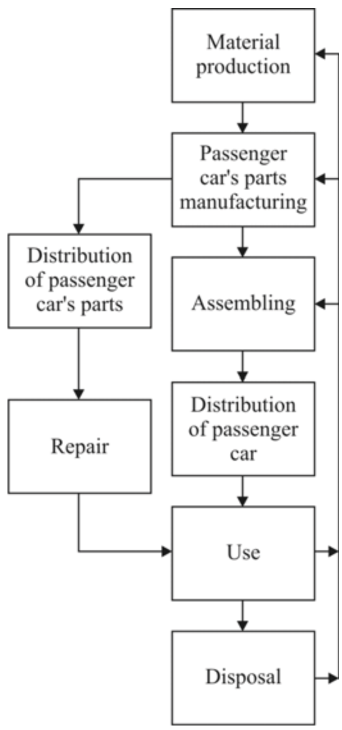

Figure 1. The passenger car life cycle diagram

The life cycle of passenger car (Figure 1) follows the sequences below:

- material production (E_1),
- passenger car's parts manufacturing (E_2),
- assembling (E_3),
- distribution of passenger car (E_4),
- use (E_5),
- repair (E_6),
- distribution of passenger car's parts (E_7),
- disposal (E_8).

The total CO_2 emission during life cycle of passenger car is determined by the following expression:

$$E = \sum_{i=1}^{8} E_i \text{, } kgCO_2 \text{ .} \quad (1)$$

The CO_2 emission during material production sequence depends on the CO_2 emission during production of all materials used to produce passenger car:

$$E_1 = \frac{44}{12} M\{\sum_{i=1}^{nm} qm_i [ec_i^{v.m.}(1 - reuse_i - recov_i - recym_i) + + ec_i^{r.m.} \cdot recym_i] \cdot \sum_{j=1}^{ne} ef_j \cdot pmp_{j,i}\}, \quad (2)$$

where

- ef_j – emission factor for type of energy ″*j*″,
- *ne* – number of different types of energy used to produce of material ″*i*″,
- $pmp_{j,i}$ – participation of type of energy ″*j*″ in the production of material ″*i*″,
- $ec_i^{v.m.}$ – energy consumption per kilogram during material ″*i*″ production breakdown for 100% virgin material,
- $ec_i^{r.m.}$ – energy consumption per kilogram during material ″*i*″ production breakdown for 100% recycled material,
- $reuse_i$ – reuse rate during production of material ″*i*″,
- $recov_i$ – recovery rate during production of material ″*i*″,
- $recym_i$ – recycling rate during production of material ″*i*″,
- *M* – passenger car weight,
- qm_i – participation of material ″*i*″ in the passenger car weight,
- *nm* – number of different materials used in production of passenger car.

The CO_2 emission during passenger car's parts manufacturing can be defined as the sum of emissions that depend and emissions that do not depend on weight of materials:

$$E_2 = M \cdot (\sum_{i=1}^{nm} qm_i \cdot \sum_{h=1}^{ntp} ptp_{i,h} \cdot em_{i,h}) + 889 \text{ ,} \quad (3)$$

where

- *ntp* – number of different transformation processes used to passenger car's parts manufacturing,
- $em_{i,h}$ – the CO_2 emission during the manufacturing of material ″*i*″ by type of transformation process ″*h*″,
- $ptp_{i,h}$ – participation of type of transformation process ″*h*″ in the manufacturing of material ″*i*″.

The CO_2 emission during passenger car's assembling is modeled as a linear function from the passenger car weight:

$$E_3 = \frac{44}{12} M \cdot ec_{as} \cdot \sum_{j=1}^{n_e} ef_j \cdot pas_j \text{ ,} \quad (4)$$

where

- pas_j – participation of type of energy ″*j*″ in passenger car's assembling,
- ec_{as} –the energy consumption per kilogram during passenger car's assembling.

The sequence ″distribution of passenger car″ includes distribution of passenger car from the assembly line to the dealer. The CO_2 emission during distribution of passenger car also depends on the passenger car weight:

$$E_4 = S_{dis} \cdot e_{dis} \cdot M \text{ ,} \quad (5)$$

where S_{dis} denotes the average transportation distance and e_{dis} denotes the specific CO_2 emission during distribution of passenger car.

The sequence ″use″ is a function of fuel type, engine displacement, car's age and kilometers driven:

$$E_5 = \sum_{i=T_N}^{T_E} S_i \cdot q_{T_N,k}^{new} \cdot [1 + u_k \cdot (T_i - T_N)^{v_k}] \text{ ,} \quad (6)$$

where

- T_i – year,
- T_N – passenger car model year, i.e. first year of life cycle of passenger car (we presume that the year of passenger car production is equal to first year of life cycle of passenger car),
- *k* – passenger car type (it is function of engine type and engine displacement – Table 1),
- u_k, v_k – coefficients (they depend upon engine type and engine displacement – Table 1),
- $q_{T_N,k}^{new}$ – the specific CO_2 emission of model year T_N and type *k* for new passenger car (the CO_2 emission for new passenger car can be found in the passenger car catalogue).
- S_i – passenger car's kilometers driven for T_i year,
- T_E – the last year of life cycle of passenger car.

The CO_2 emission during sequence ″repair″ depends upon weight of component parts, their repair frequency and CO_2 emission during following sequences: material production, passenger car's parts manufacturing and assembling:

$$E_6 = S \cdot rep \cdot (E_1 + E_2 + E_3) \text{ ,} \quad (7)$$

where *rep* denotes the coefficient of repair and *S* denotes the passenger car's kilometer driven for whole life cycle of passenger car.

engine type	*engine displacement, cm^3*	*k*	u_k	v_k
petrol	< 1400	1	0.0215	1
petrol	1400 ... 2000	2	0.02562	1
petrol	> 2000	3	0.00096	2
diesel	< 2000	4	0.00027	3
diesel	≥ 2000	5	0.00029	3

Table 1. The passenger car type (*k*) and coefficients (u_k, v_k) [1]

The CO_2 emission during distribution of passenger car's parts depends on the CO_2 emission during distribution of passenger car, weight of component parts and their repair frequency:

$$E_7 = S \cdot rep \cdot E_4 . \quad (8)$$

Disposal is the sequence that appears at the end of the life cycle of passenger car. The CO_2 emission during the sequence ″disposal″ is defined as the sum of the CO_2 emissions during its transportation from the dismantler to a shredder and the shredding CO_2 emission:

$$E_8 = \frac{44}{12} \cdot M \cdot ec_{di} \cdot \sum_{j=1}^{n_e} ef_j \cdot pdi_j , \quad (9)$$

where

- ec_{di} – the energy consumption per kilogram during the sequence ″disposal″,
- pdi_j – the participation of type of energy ″*j*″ in the sequence ″disposal″.

The ratio between specific CO_2 emission of model T_N year and type *k* for new passenger car and passenger car weight was approximated based on EU14 data (data taken from [6]) by regression analysis:

$$\frac{q_{T_N,k}^{new}}{M} = a \cdot (T_N - 1994)^b \quad (10)$$

where *a, b* have writen in Table 2.

k	*engine type*	*a*	*b*	*c*
1, 2, 3	petrol	0.194	-0.12	0.0236
4, 5	diesel	0.157	-0.153	0.0492

Table 2. Coefficients *a*, *b* and *c*

The specific CO_2 emission of model T_N year and type *k* for new passenger car using the equation (10) can be rewritten as follows:

$$q_{T_N,k}^{new} = M \cdot a \cdot (T_N - 1994)^b . \quad (11)$$

The average passenger car weight was approximated base on EU14 data. We have included assumption that every passenger car has the same function shape. Hence, the passenger car weight can be written in the form:

$$M = m \cdot (T_N - 1994)^c , \quad (12)$$

where *m* denotes the passenger car weight for 1995 year.

The difference between T_E and T_N can be defined as optimal life cycle of passenger car:

$$t = T_i - T_N . \quad (13)$$

3. OBJECTIVE AND CONSTRAINT FUNCTIONS

The total CO_2 emission during life cycle of passenger car (1) is a function of the passenger car model year (T_N) and the last year of passenger car life cycle (T_E). Let's consider that car's replacement series are composed of ″*nps*″ passenger cars. The model describes single replacement/retirement scenarios in which one passenger car is replaced by another passenger car that have the same passenger car type. The passenger car ″1″ is replaced with passenger car ″2″; the passenger car ″2″ is replaced with passenger car ″3″... Finally, the passenger car ″*nps*–1″ is replaced with passenger car ″*nps*″. We have denoted passenger car model year (T_N) for passenger car ″1″ by T_1 and for passenger car ″2″ by T_2. Finally, the passenger car model year for passenger car ″*nps*″ is denoted by T_{nps}. We have also denoted the last year car's cycle (T_E) for passenger car ″1″ by T_2 and for passenger car ″2″ by T_3. Finally, the last year car's cycle for passenger car ″*nps*″ is denoted by ″*nps*+1″. Hence, for example, the CO_2 emission during life cycle of passenger car ″2″ calculated during period of time between T_2 and T_3 year.

The total CO_2 emission during life cycles of passenger car's series that compose ″*nps*″ passenger cars has been selected as the objective function:

$$Etotal = \sum_{b=1}^{nps} E(T_b, T_{b+1}) , \quad (14)$$

where $E(T_b, T_{b+1})$ denotes the total CO_2 emission during life cycle of passenger car ″*b*″.

Let's consider the case when the passenger car ″*b*″ is replaced with following passenger car ″*b*+1″. The passenger car ″*b*″ is used during period of time between T_b and T_{b+1} year. The following passenger car ″*b*+1″ is used during period of time between T_{b+1} and T_{b+2} year. The difference between the sum of emissions E_5, E_6, E_7 and E_8 of car ″*b*″ and sum of emissions E_5, E_6 and E_7 of car ″*b*+1″ during period of time between T_{b+1} and T_{b+2} year must be higher than sum of emissions E_1, E_2, E_3 and E_4 of car ″*b*+1″. Therefore, constraint function for the case when the passenger car ″*b*″ is replaced with following passenger car ″*b*+1″ can be written in the following form:

$$\sum_{i=5}^{8} E_i^{(b)} \geq \sum_{i=1}^{7} E_i^{(b+1)}, \ \ for \ T_{b+1} \leq T \leq T_{b+2} . \quad (15)$$

The determination of optimum parameters (T_1, T_2 ... T_{nps}) was performed by the minimization of the objective function (14) with satisfy the constraint functions (15).

4. NUMERICAL EXAMPLE

The implementation of the model was performed on following examples, where has been included assumption: the passenger car's kilometers driven (S_i) are equal for all passenger car types and all years. We have analyzed case when *nps*=4; T_1=1996. In the Table 3 are shown the optimal life cycle of passenger cars (t_i) only for S_i=20000 km (because the number of pages of paper is limited).

m, kg	*k*	t_1	t_2	t_3	t_4
		year			
1000	1	7	10	12	13
	2	6	10	11	12
	3	8	11	12	12
	4	7	8	8	9
	5	7	8	8	9
1500	1	7	10	12	12
	2	6	10	11	11
	3	7	11	12	12
	4	7	8	8	9
	5	6	8	8	8
2000	1	7	10	12	12
	2	7	9	11	11
	3	7	11	12	12
	4	7	8	8	9
	5	6	8	8	8

Table 3. The optimal life cycle of passenger cars (t_i)

After analysis of results (for several values of passenger car weight and passenger car kilometers driven) we have concluded:

– the passenger car weight (*m*) has a minor impact on the optimal life cycle of passenger car for the same passenger car type (*k*) and passenger car kilometers driven (S_i),
– the optimal life cycles for petrol cars are higher than optimal life cycles for diesel cars,
– the total CO_2 emissions during life cycle of passenger cars increase with ″*b*″,
– the sequence ″use″ has the greatest influence on the total CO_2 emission – between 47 and 75%,
– emissions during sequences distribution of passenger car, distribution of passenger car's parts and disposal may be neglected.

5. CONCLUSION

In this paper is suggested model for determination of optimal life cycle of passenger cars. The analysis was carried out based on CO_2 emission. The optimal life cycle of passenger car was also determined as a function of fuel type, engine displacement, passenger car's age and kilometers driven.

Acknowledgement. The research presented in this paper has been realized in the framework of the technological project named ″Development of the model for managing the vehicle technical condition in order to increase its energy efficiency and reduce exhaust emissions″ financed by the Ministry of Science and Technological Development of the Republic of Serbia (Grant No. 36010).

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THE CO_2 MANAGEMENT – A PASSENGER CAR CASE

Radomir Mijailović
Faculty of Transport and Traffic Engineering, University of Belgrade, Vojvode Stepe 305, Serbia

Abstract: *What is repair interval for timely repair case? Tolerance of the CO_2 emission does not exist in practice. In attempt to archive that aim tolerance of the CO_2 emission is analyzed in this paper. The paper's goal is to connect tolerance of the specific CO_2 emission, repair intervals and reduction of the CO_2 emission. According to the paper's results the environmental burden decreasing of the CO_2 emission might attain up to 10%.*
Keywords: *maintenance, CO_2, tolerance, passenger car.*

1. INTRODUCTION

The problem of minimization of CO_2 emission of passenger cars using different models was studied by several authors. Nederveen et al. [5] have opinion that good maintenance of the engines of old vehicles might have an equal or even bigger positive impact on emission reductions. Kim et al. [3] added maintenance stage into model for determination optimal vehicle lifetimes. Bin [1] analyzed relationship between carbon monoxide and hydrocarbon emission and vehicle characteristics. The results indicate that probability of emission test failure is higher as vehicle becomes older, more driven and smaller engine size. Kaplanovic and Mijailovic [2] have defined approximation functions of the average CO_2 emissions on the vehicle age. As vehicle age (i.e. kilometers driven) increase emission of CO_2 increases too. Authors have defined different approximation functions for different engine displacements and fuel types. We have opinion that timely maintenance (i.e. timely repair) plays an essential role in the decreasing of CO_2 emission that emits passenger cars. Tolerance of the CO_2 emission does not exist in practice. Thus, it is of exceptional importance to determine it. Therefore, possible range of the tolerance of specific CO_2 emission is calculated in this paper. We have also connected tolerance of the specific CO_2 emission, repair intervals and reduction of the CO_2 emission.

2. METHODOLOGY

The CO_2 emission increases with vehicle age. Pollution control must be realized in practice. We suggest introduction of tolerance of CO_2 emission. Passenger cars must go to inspection centers at least once a year. Inspection centers can measure the CO_2 emission on passenger cars. We suggest introduction of new assignment that inspection centers must apply. They must compare real CO_2 emission with the emission limit. If the real CO_2 emission is higher than CO_2 emission limit, inspection center will send passenger car to maintenance centre. It is one of the possibilities for timely repair implementation.

Tolerance of CO_2 emission does not exist in practice. Thus, it is of exceptional importance to determine it.

The approximation function of the specific CO_2 emission without repair on the passenger car age for any passenger car can be written in the form [2]:

$$q_k^*(t) = q_k^{new} \cdot (1 + u_k \cdot t^{v_k}),\ g\,CO_2 / km, \quad (1)$$

where

- q_k^{new}, $g\,CO_2/km$ – the specific CO_2 emission for new passenger car (the specific CO_2 emission for new passenger car can be found in the passenger car catalogue),
- t, year – passenger car age,
- k – passenger car type (Table 1),
- u_k, v_k – coefficients [2].

We will take a look of the specific CO_2 emission ($q_{T_N,k}$) of model year T_N and k type passenger car. Over a period of time ($\Delta t_{T_N,k}$) this passenger car has timely repair. The period of time ($\Delta t_{T_N,k}$) will be defined as repair interval. Now, we will introduce an assumption: passenger car emission after repair is equal to emission that this passenger car had when it was new. That means that specific CO_2 emission increase but not unlimited. The specific CO_2 emission limit value is higher than the emission for new passenger car by the tolerance of the specific

CO_2 emission ($TOL_{T_N,k}$) (Figure 1). Therefore, the CO_2 emission of model year T_N and k type passenger car during T years can be written in the form:

$$q_{T_N,k}(T) = q_{T_N,k}^{new}\{1 + u_k[T - (T_N + j_{T_N,k} \cdot \Delta t_{T_N,k})]^{v_k}\}$$
$$for$$
$$T_N + j_{T_N,k} \cdot \Delta t_{T_N,k} \le T < T_N + (j_{T_N,k} + 1) \cdot \Delta t_{T_N,k},$$
$$j_{T_N,k} = 1,\ldots,n_{T_N,k}, \quad (2)$$

where

- T – year,
- T_N – passenger car model year,
- $q_{T_N,k}^{new}$, g/km – the specific CO_2 emission of model year T_N and k type new passenger car,
- $j_{T_N,k}$ – the repair ordinal number of model year T_N and k type passenger car,
- $n_{T_N,k}$ – number of repair that model year T_N and k type passenger car had during his lifetime.

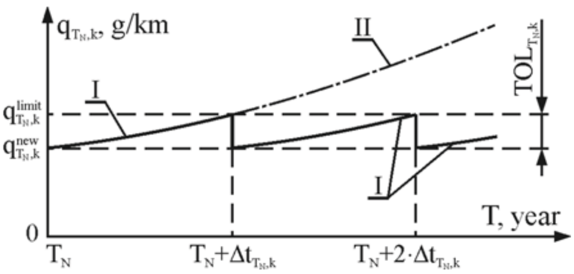

Figure 1. Dependence specific CO_2 emission ($q_{T_N,k}$) of model year T_N and k type passenger car upon year (T) (I – with repair, II – without repair)

By analyzing Figure 1 the specific CO_2 emission limit may be observed:

$$q_{T_N,k}^{limit} = q_{T_N,k}^{new} + TOL_{T_N,k}. \quad (3)$$

The specific CO_2 emission limit must be greater or equal to the real specific CO_2 emission:

$$q_{T_N,k}^{limit} \ge q_{T_N,k}(T). \quad (4)$$

By using (2), (3) and (4) the repair interval (period of time after that passenger car must repaired) can be written in the form:

$$\Delta t_{T_N,k} \le \left(\frac{1}{u_k} \cdot \frac{TOL_{T_N,k}}{q_{T_N,k}^{new}}\right)^{\frac{1}{v_k}}. \quad (5)$$

The world target is to decrease environmental burden of the CO_2 emission. The possible solution is development of more energy-efficient and cleaner passenger cars. Analyzing passenger car fleet it can be noticed that previous solution is automotive industry trend. The number of used passenger cars (passenger car age higher than zero) is several times higher than number of new passenger cars. We have opinion that better solution for decrease of CO_2 emission is to calculate specific CO_2 emissions from whole passenger car fleet instead only for new passenger cars.

The size of model year T_N passenger car fleet during T year is given by expression:

$$m_{T_N}(T) = \sum_{k=1}^{5} m_{T_N,k}(T), \quad (6)$$

where $m_{T_N,k}(T)$ denotes the number of model year T_N and k type passenger cars during T year,
The average specific CO_2 emission of model year T_N passenger car fleet during T year can be obtained by the following expression:

$$\bar{q}_{T_N}(T) = \frac{\sum_{k=1}^{5} q_{T_N,k}(T) \cdot m_{T_N,k}(T)}{m_{T_N}(T)}. \quad (7)$$

By using equation (7) the average specific CO_2 emission of model year T_N new passenger car fleet ($T=T_N$) can be written in the form:

$$\bar{q}_{T_N}(T_N) = \frac{\sum_{k=1}^{5} q_{T_N,k}(T_N) \cdot m_{T_N,k}(T_N)}{m_{T_N}(T_N)}. \quad (8)$$

Finally, the CO_2 emission of model year T_N passenger car fleet between T_N and T_N+t years is given by expression:

$$Q_{T_N}(t) = \sum_{T=T_N}^{T_N+t} \sum_{k=1}^{5} q_{T_N,k}(T) \cdot m_{T_N,k}(T) \cdot S_{T_N,k}(T), \quad (9)$$

where t is passenger car age.

3. RESULTS

This paper in its analysis uses data of new passenger car fleet from the EU14 countries [7]. The results were calculated for nine model years passenger car fleets (1995 – 2003). The results are presented assuming the average lifetime of the present car fleet to be 12 year [6]. Distribution of average kilometers driven by passenger car age was taken from [4]. Analyzing results (Table 1) it may be concluded that passenger car type (k) has significant impact on the tolerance of CO_2 emission ($TOL_{T_N,k}$). The repair intervals for petrol passenger cars types 1 and 2 are smaller than repair intervals for petrol passenger cars types 3. The repair intervals for diesel passenger cars are approximately equal. That means that passenger cars types 3, 4 and 5 require repair after longer period of time then other passenger cars types. Therefore, owners of passenger cars types 3, 4 and 5 have smaller costs than owners of other passenger cars. Previous conclusions are valid for the same ranges of CO_2 emissions.

Petrol passenger cars												
$q^{new}_{T_N,k}$, g/km	$TOL_{T_N,k}$, g/km											
	5			10			30			50		
	k			k			k			k		
	1	2	3	1	2	3	1	2	3	1	2	3
<140	2.8	2.5		4.6	4.0		11.7	10.0		18.9	16.0	
140...150	2.6	2.3		4.2	3.7		10.6	9.1		17.0	14.5	
150...160	2.5	2.3		4.0	3.5		10.0	8.6		16.0	13.6	
160...170	2.4	2.2		3.8	3.4		9.5	8.1		15.1	12.8	
170...180	2.3	2.1	6.5	3.7	3.2	8.7	9.0	7.7	14.4	14.3	12.2	18.3
180...190	2.3	2.1	6.3	3.5	3.1	8.5	8.5	7.3	14.0	13.6	11.5	17.8
190...200	2.2	2.0	6.2	3.4	3.0	8.3	8.2	7.0	13.7	12.9	11.0	17.3
200...210		2.0	6.0		2.9	8.1		6.7	13.3		10.5	16.9
210...220		1.9	5.9		2.8	8.0		6.4	13.1		10.1	16.6
220...250		1.8	5.7		2.7	7.7		6.0	12.5		9.3	15.9
>250		1.6	5.0		2.2	6.7		4.6	10.9		7.1	13.7

Diesel passenger cars								
$q^{new}_{T_N,k}$, g/km	$TOL_{T_N,k}$, g/km							
	5		10		30		50	
	k		k		k		k	
	4	5	4	5	4	5	4	5
<130	6.4		7.7		10.7		12.5	
130...140	6.2		7.5		10.4		12.1	
140...150	6.0		7.3		10.2		11.8	
150...160	5.9		7.2		9.9		11.6	
160...170	5.8	5.7	7.1	6.9	9.8	9.6	11.4	11.1
170...180	5.7	5.6	7.0	6.8	9.6	9.4	11.2	11.0
180...190	5.6	5.5	6.8	6.7	9.4	9.2	11.0	10.8
190...200	5.6	5.5	6.7	6.6	9.3	9.1	10.8	10.6
200...220	5.5	5.3	6.6	6.5	9.1	8.9	10.6	10.4
220...250	5.3	5.2	6.4	6.3	8.8	8.6	10.2	10.0
>250		5.0		6.1		8.3		9.6

Table 1. The repair intervals (year)

For example, look at passenger cars whose CO_2 emissions are from range 170 – 180 g/km in case where tolerance of CO_2 emission is 10 g/km. The repair intervals for petrol passenger cars type 2 are the smallest – 3.2 year. The petrol passenger cars type 1 has bigger value – 3.7 year. The biggest value has the petrol passenger cars type 3 – 8.7 year. The repair intervals for diesel passenger cars types 4 and 5 are smaller than last value – 7 and 6.8 year, respectively. We have calculated CO_2 emission of model year T_N passenger car fleets (9) using presumes that tolerance of CO_2 emission is equal for all values of passenger car types (k). Upon Figure 2 analyses it can be concluded that tolerance of CO_2 emission must be less than 50 g/km. The CO_2 emission of model year T_N passenger car fleets are approximately equal for the $TOL_{T_N,k}$ >50 g/km.

Upon graph analyses it can be concluded that CO_2 emission of passenger car fleet does not always decrease by model year passenger car fleets. The CO_2 emission of model from 1995 passenger car fleet is less than CO_2 emission of model from 1999 passenger car fleet, but bigger than CO_2 emission of model year 2003 passenger car fleet. These conclusions can be explained by analyzing passenger car fleets. The size of model year 1995 passenger car fleet is less than size of models from 1999 (20%) and 2003 passenger car fleets (14%). The number of petrol passenger cars type 3 for model year 1995 is less than number of petrol passenger cars type 3 for model year 1999 (1%). Percentage of diesel passenger cars increases with increasing model year. Upon data analysis we also concluded that CO_2 emissions of diesel passenger car fleets are higher than CO_2 emissions of petrol passenger car fleets.

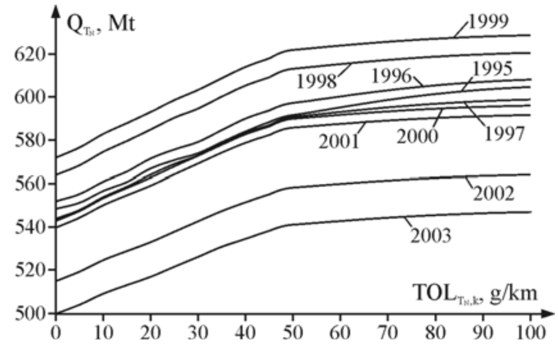

Figure 2. Dependence CO_2 emission of model year T_N passenger car fleet upon tolerance of CO_2 emission for t=12 year

model year (T_N)	$TOL_{T_N,k}$, g/km			
	5	10	30	50
1995	9.7	8.7	5.4	2.2
1996	9.6	8.4	5.0	1.8
1997	9.3	8.2	4.5	1.4
1998	9.2	8.0	4.4	1.2
1999	9.1	7.9	4.2	1.1
2000	8.9	7.8	4.1	1.1
2001	8.7	7.6	4.0	1.0
2002	8.6	7.5	4.0	1.1
2003	8.6	7.5	4.0	1.1

Table 2. Dependence reduction of the CO_2 emission (%) upon tolerance of CO_2 emissions and model year passenger car fleets

On the basis of analysis of dependence reduction of the CO_2 emission upon tolerance of CO_2 emissions and model year passenger car fleets (Table 2) it can be concluded that using timely maintenance we may achieve environmental burden decreasing of the CO_2 emission in interval from 1 to 9.7 %.

4. CONCLUSIONS

In this paper is analyzed relationship between tolerance of CO_2 emission, repair intervals and reduction of the CO_2 emission. The analysis was carried out based on approximation functions of the CO_2 emissions without repair on the passenger car age. We have opinion that better solution for decrease of CO_2 emission is to calculate its value for whole passenger car fleet instead only for new passenger cars. The paper's results are especially important for countries with old passenger car fleet as Serbia.

Acknowledgement. The research presented in this paper has been realized in the framework of the technological project named ″Development of the model for managing the vehicle technical condition in order to increase its energy efficiency and reduce exhaust emissions″ financed by the Ministry of Science and Technological Development of the Republic of Serbia (Grant No. 36010).

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ANALYSIS OF APPLYING PAYBACK PERIOD METHOD IN ENGINEERING ECONOMY

Dragan Lj. Milanovic, Zivko Ralic, Dragan D. Milanovic, Mirjana Misita
Industrial Engineering Department, University of Belgrade, Belgrade, Serbia

Abstract. *The paper deals with the analysis and promotion of the payback period method. The disadvantage of the method (herein referred to as the payback period method) is disregard of the time value of money concept, i.e., it cannot identify the distinction between present and future value of money. To eliminate this drawback, the paper proposes the application of a modified payback period method or a method involving the time factor, i.e., the time value of money. Comparative analysis of the two concepts was carried out using one project and results indicated the differences in obtaining the number of years needed for the return on investment outlays. Therefore, the proposal is to abandon a classical method and apply a modified payback period method in practice.*

Key words: *payback period, time value of money, discount factor*

1. INTRODUCTION

A number of methods are used to estimate engineering investment projects. However, all methods are mutually compatible and must give the same final result. It means that if some project is acceptable, each of the applied methods will confirm it. What distinguishes them is the way of expressing the result. Thus, for example, the method of net present value expresses the result as the present value of money, i.e., how much money the estimated project will bring in. The internal rate of return method indicates the percentage of income that the project makes, while the method of benefit-cost analysis, relating all costs and benefits of the project, expresses the result as a dimensionless number (the number should be > 1 if the project is acceptable). Finally, the result of the payback period method possesses time dimension, because it indicates how long it takes (number of years) to payback the investment outlays.

All above mentioned methods have advantages and disadvantages. The method of net present value requires determination of a discount rate to reduce all values to the initial (zero) year, which is not always easy to do. This method, on the other hand, indicates clearly how much money the project considered will earn. In the benefit-cost analysis method all benefits and costs of the project have to be identified and quantified, which is also not always easy to do. All other methods have their advantages and disadvantages too.

This paper analyzes the payback period method. Effort is made to overcome the weaknesses observed by a proposed modification of the above method. Comparative analysis was carried out, conditionally speaking, of the classical method and modified payback period method using a concrete project and results are presented.

2. CLASSICAL METHOD OF PAYBACK PERIOD

The method of payback period was commonly used in investment decision-making by the late 1950s. This method indicates how long it takes for the investment outlays to return.

The time period (number of years) needed to return the investment outlays on some project is referred to as the payback period (time period of return). If decision is made on the grounds of payback period, then only projects of payback period shorter than maximum acceptable payback period are considered. The choice of the time period is determined by management policy; for example, hi-tech firms, such as computer manufacturers, determine a shorter time period for each new investment, because their products become obsolete very quickly. The payback period method has the advantage of simplicity. The testing of engineering investment projects focuses on the time period of which the initial investment outlays are expected to return.

This method is also suitable for comparing a few alternatives, where the project that returns the investment outlays in a shorter period of time is more favorable.

The two major disadvantages of the payback period method are:

1.Impossibility to measure the project's profitability. Simplicity of obtaining the time period of return on initial investment outlays contributes very little to estimating cash inflow of the realized project.

2.The analysis of payback period does not respect the time value of money concept, i.e., it cannot identify the distinction between present and future value of money.

The number of years required for the project investment outlays to return is calculated using the formula $\sum_{i=1}^{t}(R_i - C_i) = I$ in non-uniform net cash inflows and $t \cdot (R - C) = I \Rightarrow t = \frac{I}{R - C}$ in uniform net cash inflows, respectively, where

R – total income per annum

C – total expenditure per annum

I – total investment project outlays

T – number of years required for the investment outlays to return

3. PAYBACK PERIOD METHOD WITH THE TIME FACTOR

There is always a time period between the moment of investing in an engineering investment project and the moment of achieving the effect, i.e., making profit. In this sense, it is logical that the value of money is higher at the moment of capital budgeting than at the moment of receiving a payback (the time value of money concept).

To reduce future effects to the present value, a discount rate is employed. It is the way to include the time value of money phenomenon in calculating the project profitability.

This is the reason why this paper proposes the application of a modified payback period method that would involve the time factor. This way, the basic drawback of the payback period method, disregard of the time value of money concept, is successfully eliminated. Applying the payback period method with the time factor included, the number of years required for the return on investment outlays is obtained by cumulative calculations of net present value of money per year of project duration (from zero year and onwards), i.e., the number of years it takes for the return on investment outlays is obtained by summing up all years with a negative present value. The year of a present value transition from a negative into a positive value is the year of investment outlays payback.

$$NPV_t(\mathrm{k}) = \text{-I} + (\mathrm{R}_1 - C_1) \cdot (f_{SB})_k^1 + (\mathrm{R}_2 - C_2) \cdot (f_{SB})_k^2 + ...$$
$$.. + (\mathrm{R}_t - C_t) \cdot (f_{SB})_k^t \geq 0$$

$(f_{SB})_k^t$ – present value factor for the year t.

4. COMPARATIVE ANALYSIS USING ONE PROJECT AS AN EXAMPLE

Using a concrete example, we will try to find out if there are essential differences between obtaining the number of years required for payback on the investment outlays by classical payback period method and by payback period method with the time factor included. The project considers cost-effectiveness of investment in energy efficiency of residential buildings. The analysis comprised 10 buildings and 5 alternatives were compared, involving the corresponding technical readjustment for energy rehabilitation to increase energy efficiency of buildings. The alternatives considered and estimated were as follows:

- alternative A_1: non-insulated building, windows of quality 1, insulation strips are used to reduce ventilation losses,
- alternative A_2: non-insulated building, windows of quality 2,
- alternative A_3: building insulated with a 5cm insulation layer, windows of quality 1,
- alternative A_4: building insulated with a 10 cm insulation layer, windows of quality 2,
- alternative A_5: building insulated with a 20 cm insulation layer, windows of quality 3, walls between heated and non-heated rooms are insulated with a 5 cm insulation layer,

where the classification of quality implies:

- quality 1 – timber framed double-pane window, U = 2.3 W/(m2.K)
- quality 2 – PVC framed double-pane window, U = 1.5 W/(m2.K)
- quality 3 – PVC framed window with low-emission glass, U = 1.1 W/(m2.K).

For the needs of this paper and to obtain a net cash flow, required by comparative analysis, the following cash flow elements of the project are taken into account:

1. Energy rehabilitation of residential building.
2. Savings equal outlays required for building's central heating equipment, achieved by energy rehabilitation measures, reduce costs of connection to the central heating system.
3. Difference between Alternative A1 and Alternative A5.
4. Increase of building's energy efficiency achieved by energy rehabilitation measures, reduces monthly bills for central heating.

Elements 1-3 are present at the beginning of the engineering investment project life. Element 4 is present in the project's life all the time.

To the investor, a discount rate means opportunity costs of resource mobilization. In this paper, we used a discount rate of 12%. Exploitation lifetime of the project is 20 years.

Figure 1 gives graphic representation of cash flow in the observed period.

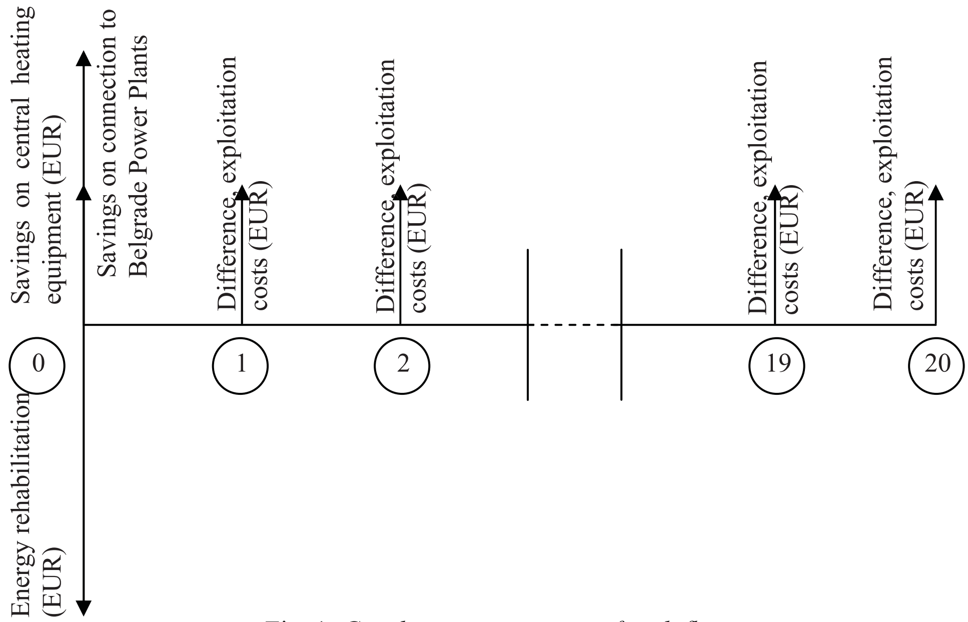

Fig. 1. *Graphic representation of cash flow*

Comparative analysis of classical and modified payback period methods applied to 10 residential buildings gave the results as follows:

1. Table 1 presents the results of calculations involving the time factor (modified method) per building:

Tab. 1 Results of calculations for payback period with the time factor per building

Building	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
CF elements	€	€	€	€	€	€	€	€	€	€
Energy rehab..	-108.080	-66.396	-35.573	-84.253	-70.796	-49.325	-49.936	-95.918	-34.103	-91.821
Inv. equipment	19.041	8.795	5.704	11.185	10.922	8.777	7.740	13.014	4.727	12.416
Connection costs	41.329	18.656	11.113	24.430	22.801	18.422	15.002	30.459	10.238	25.231
Σ	-47.709	-38.945	-18.756	-48.638	-37.073	-22.126	-27.193	-52.444	-19.138	-54.173
Exploitation costs.	13.772	7.360	5.135	8.305	8.002	7.497	6.302	13.207	5.026	8.885
Year	**Net present value, NPV (12%)**									
0	-47.709	-38.945	-18.756	-48.638	-37.073	-22.126	-27.193	-52.444	-19.138	-54.173
1	-35.412	-32.373	-14.171	-41.222	-29.929	-15.432	-21.566	-40.652	-14.650	-46.240
2	-24.433	-26.505	-10.077	-34.601	-23.550	-9.455	-16.542	-30.123	-10.644	-39.157
3	-14.630	-21.266	-6.422	-28.689	-17.854	-4.119	-12.057	-20.723	-7.067	-32.833
4	-5.878	-16.588	-3.158	-23.411	-12.769	645	-8.052	-12.330	-3.873	-27.187
5	1.936	-12.412	-244	-18.699	-8.229		-4.476	-4.836	-1.021	-22.146
6		-8.683	2.357	-14.491	-4.176		-1.284	1.854	1.525	-17.645
7		-5.354		-10.735	-556		1.566			-13.626
8		-2.381		-7.380	2.675					-10.038
9		273		-4.386						-6.834
10				-1.711						-3.973
11				676						-1.419
12										862

Results of calculations indicate the specificity of each building. Payback period ranges from 4 to 12 years. Yet, payback period for the majority of buildings is 6 years. The least favorable case is building 10, because its payback period is 12 years. It is even in this case that the payback period is shorter than project's life (20 years).

2. Table 2 shows the results of calculations for payback period without involving the time factor per building (classical method).

Tab. 2 Results of calculations for payback period without the time factor per building

Year. \ Buil.	1	2	3	4	5	6	7	8	9	10
0	-47.709	-38.945	-18.756	-48.638	-37.073	-22.126	-27.193	-52.444	-19.138	-54.173
1	-33.937	-31.585	-13.621	-40.333	-29.071	-14.629	-20.891	-39.237	-14.112	-45.288
2	-20.165	-24.225	-8.486	-32.028	-21.069	-7.132	-14.589	-26.030	-9.086	-36.403
3	-6.393	-16.865	-3.351	-23.723	-13.067	365	-8.287	-12.823	-4.060	-27.518
4	7.379	-9.505	1.784	-15.418	-5.065		-1.985	384	966	-18.633
5		5.215		-7.113	2.937		4.317			-9.748
6				-1.192						-863
7										8.022

The differences between investment payback periods for all alternatives, when applying classical and modified methods, are evident. In the classical method the payback period ranges from 3 to 7 years.

5. CONCLUSION

Considering the fact that the time value of money exists and that it is unidentifiable by the classical payback period method an error is made in estimating the number of years required for payback of investment outlays, i.e., a false report on the payback period is provided. The extension of error, occurring due to neglecting the time value of money, depends primarily on the value of discount rate and difference between the cash invested and profit made by the project during its exploitation life, as demonstrated by the example of the project analyzed. It is proposed on the grounds of these results to fully replace the classical method by a modified method with the time factor.

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ANALYSIS AND MONITORING THE PERFORMANCE OF EFFICIENCY IN PRODUCTION COMPANY

Nebojša Lapčević[1], Mirjana Misita[2], Dragan Lj. Milanović[2]
[1]Production Manager, Metalika-Volf,Vojka
[2]Faculty Mechanical Engineering, University of Belgrade

***Abstract**: Productivity is a complex concept of governance. Different aspects of observations, and give different results. Here is an example of company from Serbia, which produces graphite brushes and brush holders, which is a method of monitoring the implementation of productivity achieved high efficiency and effectiveness.*
***Keywords**: productivity, efficiency*

1. INTRODUCTION

In its simplest form, labor productivity could be defined as the hours of work divided by the units of work accomplished. However, in reality, labor productivity is a much more complex phenomenon which largely depends on quite diverse factors such as site conditions, workers' competence, materials availability, weather, motivation, supervision, to name just a few. Management also affects labor productivity. For example, reported that incompetent management of is a prime cause of low productivity [1]. Often, labor productivity is a key factor contributing to the inability of many contracting organisations to achieve their project goals, which include, most importantly, the profit margin. Therefore, it is paramount to understand the main determinants of labor productivity, and to keep and compare accurate records of productivity levels across projects.

Globalization is a phenomenon, which has changed many concepts of competitiveness. With the expansion of businesses and the vastness of the global economy, geographical boundaries are no more a limit. The complete world has become a common market, anyone from anywhere, can potentially enter the field of competition. With this changing scenario, methodologies used for measuring productivity, and even defining productivity, need more thorough research and study [2].

2. SUBJECT OF METHODS USED FOR MEASURING AND MONITORING WORKING EFFICIENCY

The expansion of world trade, the globalization of economies, and the emergence of new markets has made productivity a critical success factor for any country in the world. Anticipating these developments, most countries have formulated strategies and policies to ensure that their local businesses have the capability to compete in the global market. Problems faced in developing countries are not only the results of underdevelopment but rather of mis-management .

Numerous studies have been conducted to find out the relationship of job behaviours of employees with employee commitment, turnover, absenteeism, productivity and occupational stress [2]. Productivity has been identified as the most serious challenge confronting management.

With the changing situation, methodologies used for measuring productivity and even defining productivity needs more thorough research and study. In the past few decades many research studies have been carried out on productivity all over the world. The word "productivity" most probably was used first by Quesnay in 1766, i.e. about 200 years ago [2].

Since then, different definitions of the term have been suggested. Productivity and production are terminologies, which have been misused and misunderstood by many people for long. Differentiated between these terminologies and explained that production is concerne with the activity of producing goods and/or services, were as, productivity is concerned with efficient utilization of resources (inputs) in producing goods and/or services (output). Authors have further distinguished between concepts such as partial productivity, total-factor productivity (TFP), total productivity and total productivity model (TPM). Despite clear theoretical demarcation, practical implementation of these terminologies in industrial applications remains a grey area.

Productivity and performance are terms often confused and incorrectly used interchangeably along with the terms of efficiency, effectiveness and profitability. Many researchers believed that by referring to productivity, people actually are working on performance improvement[2]. A similar myth prevailed regarding productivity and profitability that they go hand in hand, so most organizations concentrated on profitability and performance in financial terms rather than concentrating on productivity enhancement techniques. Many researchers ([4],[5]) indicated this myth and elaborated that these three terms must not be taken as similar. Tangen in 2005 developed a triple - P model explaining the differences of productivity, profitability and performance as being physical phenomenon, monetary relationship and an umbrella term, for both the first two, with an aim of easy understanding, more accurate measurement and enhancement support. After this demarcation, a much research has been carried out across the globe to develop improvement methodologies specifically for productivity enhancement [2].

3. RESEARCH REVIEW

The research has been done here is treated in a company which manufactures electro-graphite brushes and brush holders. The present company was formed on the basis of blacksmith and locksmith-workshop back in 1870th year. In 1976 was started production of flexible copper connections and electrical contact, then in 1988 the first series took off carbon brushes. From then until now traversed a long path of development, and products are now represented in almost all industrial plants Serbia and throughout former Yugoslavia. From the year 2000 the company became the leader in manufacturing carbon brushes, blades, bearings, different types of power trolley, brush holders.

The largest consumers of our products are: Companies within the Electric Power Industry of Serbia, JP Serbian Railways and other railway administrations in the region, GSP Beograd, mines, cement plants, sugar mills and workover companies.

To make products is used the best materials known manufacturers: Carbone Lorraine, PanTrac, Morgan, Schunk, Leoni.

In Serbia, the company is currently considered the largest and most productive company in this field. The company has ISO9001 and ISO14000 standards and system developed by ourselves, which are best result showed in management and improving productivity.

The company currently employs 35 workers, of which the production department of electrical carbon brushes employs 15 production workers, with an average age 42nd. The research that was done was done on a random sample of 01-31.06.2010. During this period, recorded in 1596 operations were realized by 142 work orders, 55 different types of brushes.

4. RESULT OF RESEARCH

The figure1 shows the average productivity by days 01.-30.06.2010.

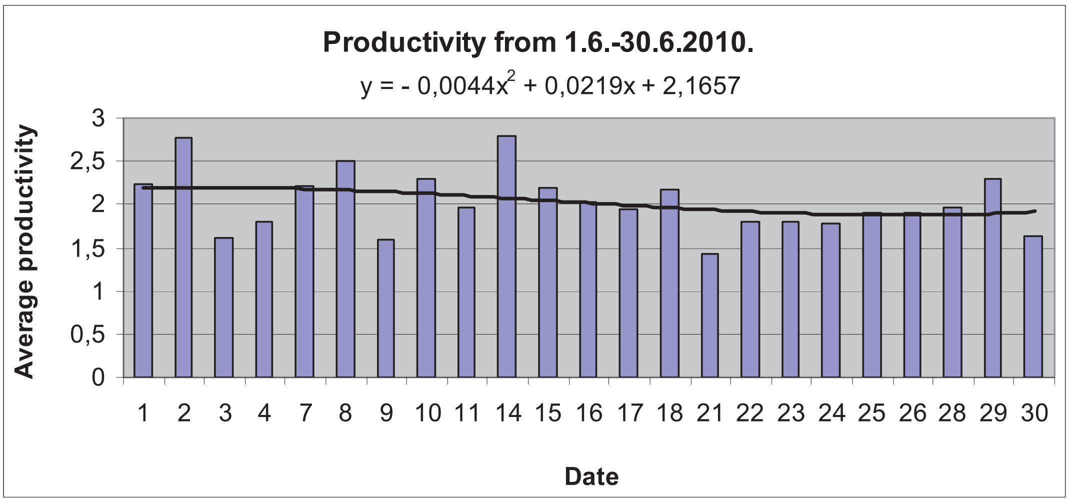

Figure1. The average productivity by days for period 01.-30.06.2010

The average productivity per day is calculated as follows: each operation has a standardized time (norm), the worker records the time that has spent to do that operation on the amount that worked on and by what work order, time and quantity are entered into the system and then calculates its productivity so that time spent divided by the norm and the amount which the employee has done for this operation (efficiency). The average productivity of the working day is the sum of average mean productivity of operations for the working day.

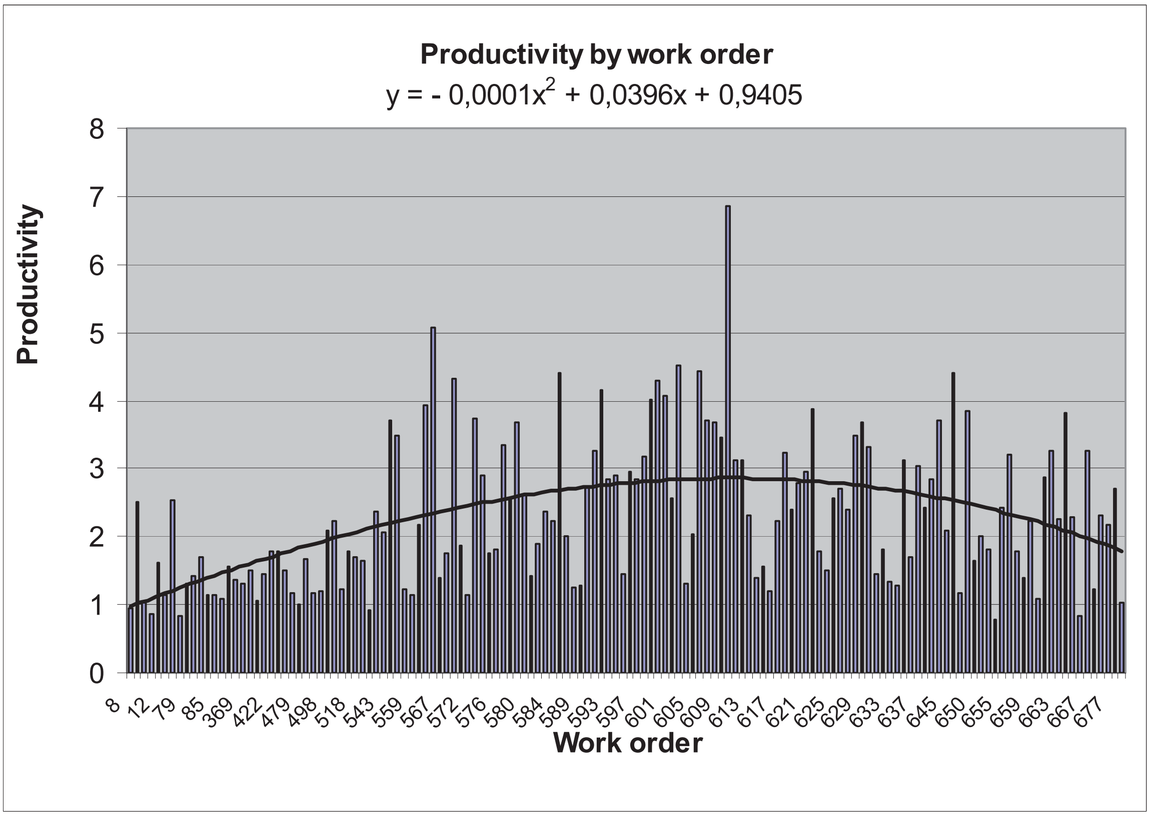

Figure 2. Productivity per work order for period 01-30.06.2010

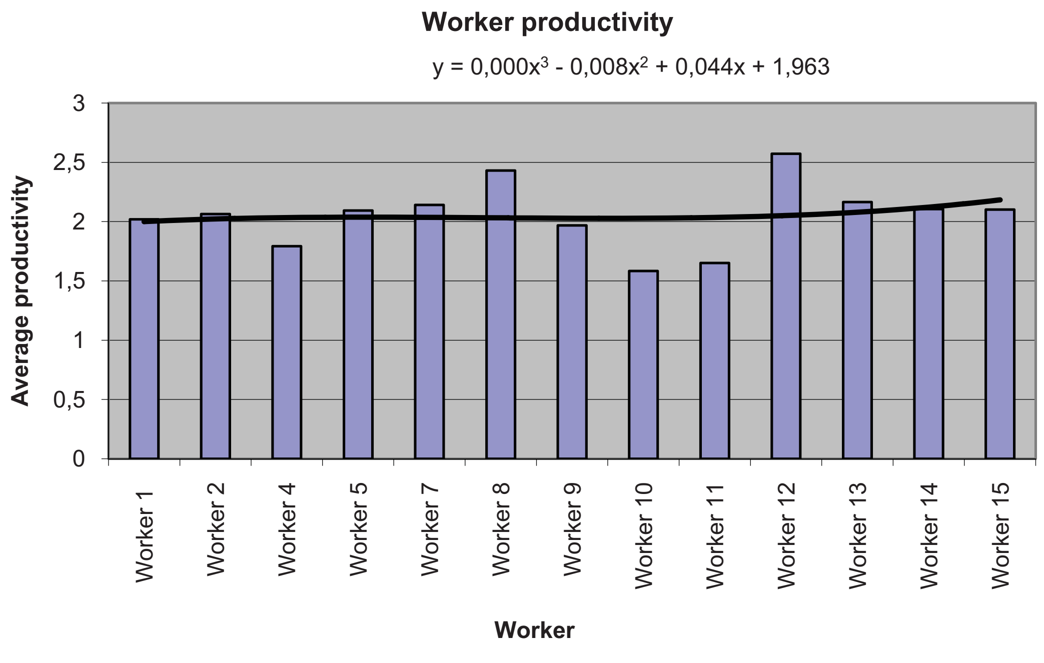

Figure 3. Productivity per worker for period 01-30.06.2010

Productivity per work order is determined as follows: each operation has a standardized (norm) time, the worker records the time that has already been used for the amount spent and on what the work order, time and quantity are entered into the system and then calculates its productivity so that time spent divided by the norm and the amount which the employee has done for this operation (efficiency). The average productivity of the workorder is the sum of the average mean productivity of operations for a particular work order.

Productivity per worker is defined as follows: each operation has a standardized time (norm), the worker records the time that has already been prepared for the amount spent and on what the work order, time and quantity are entered into the system and then calculates its productivity so as to divide the time spent with a standardized amount of time and the employee has done for this operation (efficiency). The average productivity per worker for a given period is the sum of mean productivity of operations for certain workers.

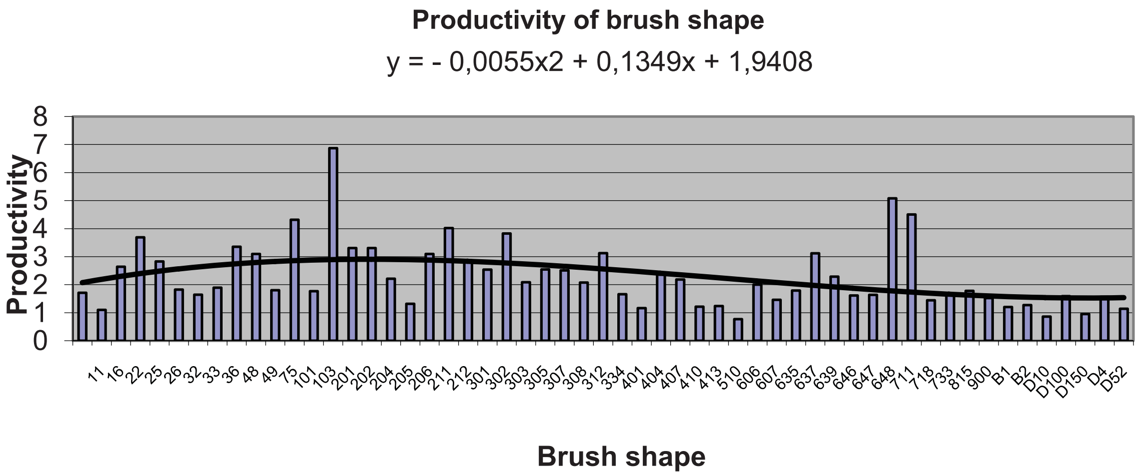

Figure 4. Productivity by the shape of the brush 01.-30.06.2010

The productivity of the brush shape is determined as follows: each operation has a standardized time (norm), the worker records the time that has already been prepared for the amount spent and on what the work order, time and quantity are entered into the system and then calculates its productivity so that time spent divided by the normalized time and the amount which the employee has done for this operation (efficiency). The average productivity of the brush shape for a given period is the sum of mean productivity operations necessary to produce a given form of brushes.

5. CONCLUSION

The paper presents a study of monitoring and analysis of productivity in the observed company.

The analysis and monitoring of productivity per work order, the worker and the shape of the brush. For each analysis was performed according to the equations of observed variables on the basis of which we can determine the size of the observed trend, and on that basis draw conclusions necessary for forecasting and planning of production continues.

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RISK ASSESSMENT INTEGRATION INTO THE TECHNICAL PRODUCT DEVELOPMENT

dr Mirko Djapic, dr Predrag Popovic, dr Vladimir Zeljkovic
University of Kragujevac, Faculty of Mechanical Engine. Kraljevo, mdjapic@yahoo.com
University of Belgrade, Institute, Vinca, Belgrade, biro@vinca.rs
LOLA Institute, Belgrade, vladazz@yahoo.com

Abstract: *European Union has accomplished, through introducing New Approach to technical harmonization and standardization, a breakthrough in the field of technical products safety and in assessing their conformity, in such a manner that it integrated products safety requirements into the process of products development. This is achieved by quantifying risk levels with the aim of determining the scope of the required safety measures and systems. Follow that in the paper are presented concept of the international standardization in the risk management field and integrating risk assessment in the New Approach Directives (NAD) into the technical product development.*
Key words: *Risk, New Approach Directive, Standardization*

INTRODUCTION

European Union through introducing the New Approach to technical harmonization and standardization achieve a breakthrough in the product safety by integrating its safety requirements into the product development process [1]. In the directives for technical products, essential health and safety requirements have been set, which each technical product has to satisfy prior to place in the market. These requirements are defined in general form and the way of their implementation is given in the harmonized standards. In this way, designers and suppliers of technical products have got clear instructions regarding the way to accomplish conformity of these products to the directives' requirements and the way of integrating safety requirements into the phase of developing these products. In this way, fundamental change has been achieved in preventing possible occurrence of accidents. The decision regarding level of safety measures is based on previously conducted risk assessment.

Risk assessment is the methodology through which risk levels are quantified with the objective of determining the scope of required safety measures [2].

The main objective of this paper is to preset way of risk assessment integration required in the EU New Approach Directives (NAD) into the technical product development process. In order to fulfill this objective, the text to follow first presents the concept of international standardization in the risk management field and on the end the model of risk assessment integration into the technical product development process.

RISK MANAGEMENT STANDARDIZATION

All organizations, regardless of their field of activity and size, are faced, in realizing their objectives, with some form of risk. The objectives may vary and may be related to a strategic initiative, operative realization of a project, product, service and similar. The importance of individual risks for an organization is determined by numerous factors, both internal ones depending on the organization itself and by external factors set forth by the environment in which the organization operates.

Experience in the business practice in the last fifteen years has shown that the risk management concept has been in the phase of significant changes. This is substantiated by the fact that business associations, international, regional and national standardization body have created several models, standards and operation frameworks.

International standardization in the risk management field

Presenting the standards, i.e. frameworks presented in the world today surpasses the objectives of this paper. Therefore, we are going to focus further only on standardization in the field of risk conducted by the International Organization for Standardization and some of the most significant national standardization bodies (Table 1).

Table 1. The most influential international and national risk management standards

Publisher	Standards	Publisher	Standards
ISO	**ISO 31000:2009,** *Risk management -- Principles and guidelines*	CSA (Canada)	**CSA Q 850: 1997**, *Risk Management Guidelines for Decision Makers*
ISO/IEC	**ISO/IEC 73:2009**, *Risk management -- Vocabulary*	JSA (Japan) (withdraw)	**JIS Q 2001:2001**, *Guidelines for development and implementation of risk management system*
	ISO/IEC 51:1999, *Safety aspects -- Guidelines for their inclusion in standards*	AS/NZS (Australia / New Zealand)	**AS/NZS 4360:2004**, *Risk Management*
	ISO/IEC 31010:2009, *Risk management -- Risk assessment techniques*	BSI (Great Britain)	**BS 25999-2:2007**, *Business continuity management. Specification*
ISO	**ISO 14121-1:2007**, *Safety of machinery — Risk assessment — Part 1:Principles*		**BS 31100:2011**, *Risk management. Code of practice and guidance for the implementation of BS ISO 31000*
	ISO/TR 14121-2:2007, *Safety of machinery -- Risk assessment -- Part 2: Practical guidance and examples of methods*		**BS 6079-3:2000**, *Project management. Guide to the management of business related project risk*
	ISO 14971:2007, *Medical devices -- Application of risk management to medical devices*	ON (Austria)	**ONR 49000:2010**, *Risk Management for Organizations and Systems - Terms and basics - Implementation of ISO 31000*
ISO/IEC	**ISO/IEC 27005:2011**, *Information technology -- Security techniques -- Information security risk management*		**ONR 49001:2010**, *Risk Management for Organizations and Systems - Risk Management - Implementation of ISO 31000*
ISO	**ISO 14798:2009**, *Lifts (elevators), escalators and moving walks -- Risk assessment and reduction methodology*		**ONR 49002-1:2010**, *Risk Management for Organizations and Systems - Part 1: Guidelines for embedding the risk management in the management system - Implementation of ISO 31000*
	ISO 17776:2000, *Petroleum and natural gas industries -- Offshore production installations -- Guidelines on tools and techniques for hazard identification and risk assessment*		**ONR 49002-2:2010**, *Risk Management for Organizations and Systems - Part 2: Guideline for methodologies in risk assessment - Implementation of ISO 31000*
EN	**EN 1127-1:2011,** *Explosive atmospheres. Explosion prevention and protection. Basic concepts and methodology*		**ONR 49002-3:2010**, *Risk Management for Organizations and Systems - Part 3: Guidelines for emergency, crisis and business continuity management - Implementation of ISO 31000*
	EN 13463-1:2009, *Non-electrical equipment for use in potentially explosive atmospheres. Basic method and requirements*		**ONR 49003:2010**, *Risk Management for Organizations and Systems - Requirements for the qualification of the Risk Manager - Implementation of ISO 31000*

The concept of standardization in the field of risk, implemented by the International Organization for Standardization ISO and European standards bodies (CEN and CENELEC) has got the hierarchical structure of standards, as depicted in Figure 1. The concept starts from the fact that successful implementation of risk management in any organization requires a standards structure which sets up from general standards and through the standards defining terminology to standards in which risk analysis and assessment requirements are set for individual business processes and/or functions, and further on to standards in which there are guidelines directing about how to execute these analyses and assessments, and finally, there are structures defining the tools to be used in the risk analyses and assessments. Figure 1 depicts complete hierarchy structure of international and regional standards in the field of risk management, which are of importance for implementing the NAD directives.

At the highest generic level, there is the standard ISO 31000:2009 which provides for general instructions and principles for developing and implementing risk management in any organization. In the following level, there are the standards and guidelines incorporating the vocabularies of terms. These are ISO/IEC Guide 73:2009 and ISO/IEC Guide 51:1999 standards.

This group of standards defining the terms might also be extended by standard ISO 12100-1:2010, expressing the basic overall methodology to be followed when designing machinery and when producing safety standards for machinery, together with the basic terminology related to the philosophy underlying this work. The requirements for technical products safety are given in the New Approach directives. They are defined in general form so that they cannot not become obsolete so quickly. From the risk point of view, the requirements defined in such a manner represent the risk management objectives in the process of product development related to safety of the products.

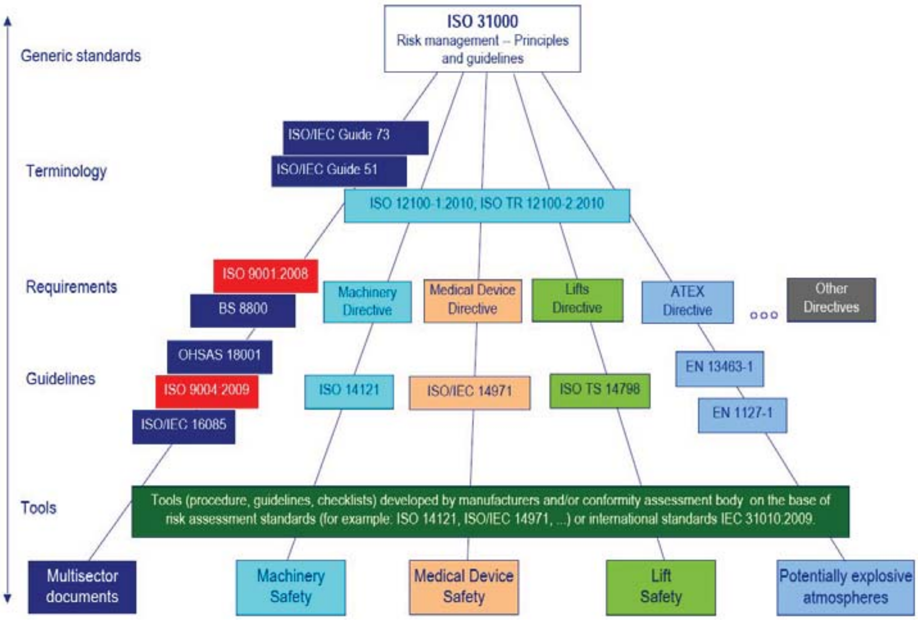

Figure 1. Hierarchy structure of standards in the risk management field, of importance in implementing the EU technical legislation (Adjusted on the basis of [3])

In the course of product development, designers has a dilemma of how to determine if a product is safe or not, i.e. how to execute the risk analysis and assessment and how to improve the design solution on the basis of this. It is difficult to determine in practice the safety of a non-standardized product if there is no adequate reference with respect to which it can be done.

In response to this problem, the European Commission has initiated with CEN the development of generic harmonized standards enabling the systematic approach and providing the guidelines for: (1) identification of hazards; (2) risk assessment due to these dangers, and (3) assessment of acceptability of the selected safety measures.

Thus, a set of generic standards ensued for assessing risks in the NAD, such as: ISO 14121-1:2007 for machines products, EN ISO 14971: 2002 for medical products, ISO TR 14798:2006 for lifts, etc.

From the standpoint of product safety, these standards serve as guidelines on how to conduct the risk analysis and assessment. Thus, as it is depicted in Figure 2 and 3, they have got a dual role. On the one hand, they serve as the tool (guidelines) used by designers and engineers in analyzing and assessing the level of safety of design solution in the course of product development process, while on the other hand they are also the tool for the organization's staff and/or conformity assessment body in assessment whether a product satisfies the requirements of directives and/or harmonized standards, i.e. whether they possess satisfactory levels of safety.

At the lowest level of the standards structure hierarchy, there are the tools developed as independent standards, such as, for example, ISO/IEC 31010:2009 which provides large number of techniques that can be applied in risk assessment. In addition to the standards serving as tools, organizations very often also develop specific tools in which the risk assessment methodology given in some of the standards, such as for instance ISO 14121:2007, is adjusted to products and business practice present in that particular organization. These tools are presented in the form of various procedures, instructions or, most often, in the form of checklists (Figure 3).

RISK ASSESSMENT INTEGRATION INTO THE PRODUCT DEVELOPMENT PROCESS

All designers and employees who take decisions in product development process have to be familiar with the general and/or specific processes for risks assessment which is required by NAD (Figure 2).

Risk assessment in that process is the constituent part of the phase in which the designer adjusting its design to the requirements (create design solution) and on the other hand the constituent part of final product conformity assessment (final control and inspection) (Figure 3) conducted by the organization itself and/or the body for conformity assessment.

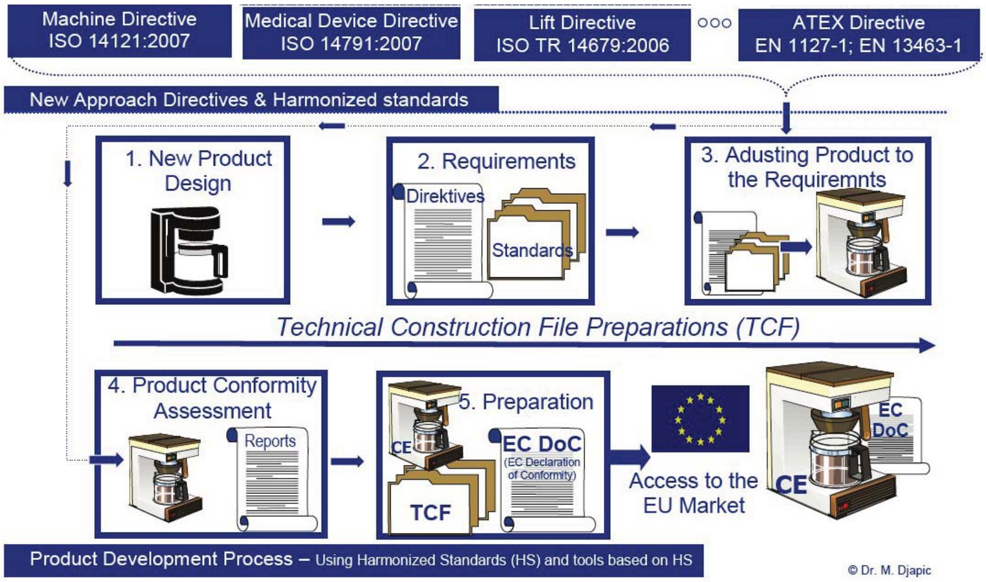

Figure 2. Integrating risk assessment in NAD into the technical product development

Subclause	Safety requirements and/or measures	Visual inspection (see note 1)	Performance check/test (see note 2)	Measurement (see note 3)	Drowings/ Calculations (see note 4)
5.3.14	Two-hand control devices	x	x	x	x
5.3.15	Safty distance	x	x	x	x
5.3.16	Motor and clutch interlocking	x	x		x
5.3.17	Singl stroke device	x	x		x
5.8	**PROTECTION AGAINNST OTHER HAZARDS**				
5.8.1	ELECTRICAL HAZARDS	x		x	x
5.8.2	THERMAL HAZARDS	x		x	x
5.8.3	HIGH PRESSURE FLUID EJECTION HAZARDS	x	x		
5.8.4	HAZARDS GENERATED BY NOISE			x	
5.8.5	HAZARDS GENERATED BY VIBRATION	x	x	x	
5.8.7	HAZARDS GENERATED BY NEGLECTING ERGONOMIC PRINCIPLES	x	x	x	x

Safety measures verification

Figure 3. Verification of safety measures – mechanical press ARP 160

To illustrate product conformity assessment on the Figures 3 is display some of the results and verifications performed on the mechanical presses ARP 160 [4].

CONCLUSION

European Union has accomplished, through introducing New Approach to technical harmonization and standardization, a breakthrough in the field of technical products safety and in assessing their conformity, in such a manner that it integrated products safety requirements into the process of products design and development. This is achieved by quantifying risk levels, in the course of the designing process, with the aim of determining the scope of the required safety systems, where the safety requirements are preventively considered during the designing process. In that respect, the European Commission has given a task to CEN to develop generic standards to serve as guidelines and to alleviate technical products' risk assessment in the phase of assessing their conformity.

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DEVELOPMENT OF COMPETENCES OF NATIONAL REFERENCE LABORATORY FOR MASS MEASUREMENT

Dr.sc. Samir Lemeš[a], Dr.sc. Nermina Zaimović-Uzunović[a], M.sc. Šejla Ališić[b], M.sc. Haris Memić[b]
[a] University of Zenica, Mechanical Engineering Faculty, Zenica, Bosnia and Herzegovina
[b] Institute for Metrology of Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina

Abstract: The national reference laboratory for mass in Bosnia and Herzegovina uses non-automatic weighing scales as a national reference standard. This research was performed in order to prove competences of this laboratory through accreditation in accordance with international standard EN ISO/IEC 17025. The analysis of measurement results obtained by calibration of weighing instruments described in this paper, describes the effects of individual contributions to the combined measurement uncertainty.
Key words: Mass measurement, Calibration, Measurement uncertainty, Interlaboratory comparison

INTRODUCTION

Metrology Institute of Bosnia and Herzegovina (IMBIH) contains the National laboratory for mass. Laboratory intercomparisons are one of the basic requirements to prove laboratory competence. National Mass Laboratory uses standards (weights) in the range from 1 mg to 50 kg, traceable towards international standards. The traceability is realized through a calibration set of national weights (E1 accuracy class from 1 mg to 5 kg), while dissemination of mass is realized by transfer of mass unit from national sets to weights with lower accuracy class, which have applications in various fields of industry and commerce.
Calibration of these weights is performed on the comparators and balances with different accuracy classes, while the calibration of comparators and scales is performed using a calibrated scale weights (mutual dependence).
A large number of laboratories in Bosnia and Herzegovina is designated by the Institute of Metrology of Bosnia and Herzegovina to enable them to perform verification in the field of mass. In order to ensure the performance of these laboratories, the Institute of Metrology aims to provide them with the same laboratory calibration services of their working standards and provide calibration of their scales which are used for the verification of working weights for third parties, who used to perform calibration out of the borders of Bosnia and Herzegovina, requiring signifficant expenses and time of transport.
National Laboratory for the mass is currently in the process of proving its competence through Regional Metrology Organization (RMO) EURAMET.
Laboratories can demonstrate their competence in two ways, namely through accreditation in accordance with EN ISO/IEC 17025, or via RMO (technical Committee for a particular field of metrology and technical committees for quality), but in this case it is valid only for national metrology institutes and laboratories which are holders of national standards. As no inter-calibration of scales exists at the RMO level, this leads to aggravation of proving competence in the field of calibration of non-automatic weighing scales, MIBH decided to demonstrate its competence through accreditation in accordance with standard EN ISO/IEC 17025.

CALIBRATION OF NON-AUTOMATIC SCALE XS 205

The scale being calibrated (Fig. 1) is manufactured by Mettler Toledo. Maximum load is 220 grams. The smallest unit in the first measurement range (up to 81 g) is d_1 = 0,00001 g. The smallest unit in the second measurement range (maximum load 220 g) is d_2 = 0,0001 g.
The environmental conditions were as follows:
- Air pressure: 964 mBar
- Humidity: 61,00 %
- Temperature: 19,65 °C
- Temperature of weighs: 18,70 °C
- Acclimatization time: 24 h

Fig. 1. Non-automatic scale XS 205

The ratio of the maximum scale capacity (220 g) and test division (0.001 g) gives total number of divisions of 220000, which indicates that the scale has class I accuracy.
The greatest contribution of measurement uncertainty when small masses are used comes due to repeatability and contributions from the working standards (weights). In the range near the maximum of scale capacity, the largest total contribution comes due to the eccentricity. In the range near the minimum of scale capacity the major contribution is due to applied working standards (weights).

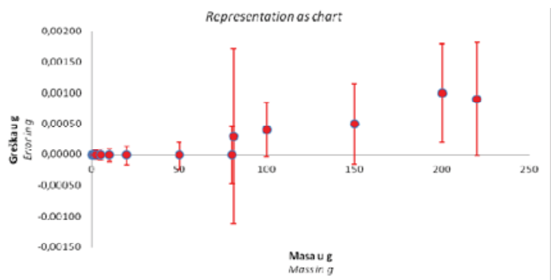

Fig. 2. Calibration results for XS 205

CALIBRATION OF NON-AUTOMATIC SCALE CENT 6000 HR-CM
The scale being calibrated (Fig. 3) is manufactured by Gibertini. Maximum load is 6200 grams. The smallest unit d = 0,01 g.
The environmental conditions were as follows:
- Air pressure: 964,7 mBar
- Humidity: 54,70 %
- Temperature: 21,40 °C
- Temperature of weighs: 20,80 °C
- Acclimatization time: 24 h

Fig. 3. Non-automatic scale CENT 6000 HR-CM

The ratio of the maximum scale capacity (6200 g) and test division (0.01 g) gives total number of divisions of 62000, which indicates that the scale has class II accuracy. The greatest measurement uncertainty occurs near the maximum of the scale range. The greatest contribution to measurement uncertainty is due to repeatability. In the range near the maximum of scale capacity, the largest total contribution comes due to the eccentricity and contributions from the working standards (weights).

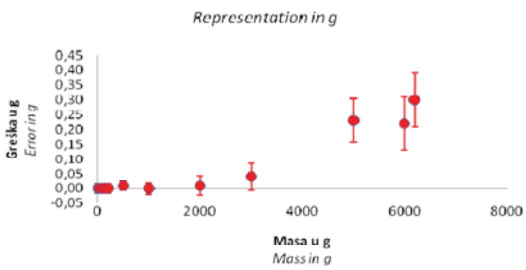

Fig. 4. Calibration results for CENT 6000 HR-CM

CALIBRATION OF COMPARATOR CCE60K2
The comparator is manufactured by Sartorius (Fig. 5). Maximum load is 64000 grams. The smallest unit d = 0,01 g.
The environmental conditions were as follows:
- Air pressure: 964,6 mBar
- Humidity: 34,05 %
- Temperature: 21,74 °C
- Temperature of weighs: 20,35 °C
- Acclimatization time: 24 h

As the total number of divisions of this comparator is larger than 10^6, we can observe it as an analytical scale. When calibration was performed with small weights, the measurement uncertainty was 3,6%, and in other cases (larger weights) the measurement uncertainty was between 0,072% for 50 g weights and 0,0009% for 64 kg weights.
The major contribution comes from eccentricity.

Fig. 5. Comparator CCE60K2

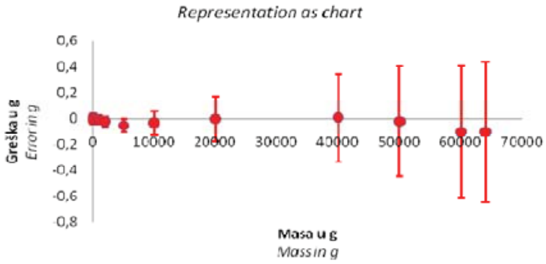

Fig. 6. Calibration results for CCE60K2

CALIBRATION OF 1 kg MASS STANDARD

The calibration procedure requires verification of weights magnetism. Magnetic fields inside and outside the scales may increase systematic error of weighing, if the weighed subject has strong magnetic susceptibility. The maximum measured polarity is 8,0 µT, and this weight, with E_2 accuracy class had polarity of 0,03 µT.The maximum allowed magnetic susceptibility is 0,07, and the measured susceptibility is 0,00345.

Fig. 7. Comparator Sartorius CCE1000 S-L and susceptometer

Measurement uncertainty analysis

Standard uncertainty of weighing process is calculated from standard deviation:

$u_A = 0{,}002069$ mg

Type B uncertainty of calibration reference is:

$u(m_{cR}) = 0{,}075$ mg

Measurement uncertainty due to drift of the reference since last calibration:

$u(m_d) = 0{,}00866$ mg

Measurement uncertainty of air density, derived from the CIPM formula is:

$u(\rho_a) = 0{,}00065$ kg/m^3

Variance of measurement uncertainty due to the effect of buoyancy:

$u_{cb}^2(\Delta m_w) = 0{,}003840$ mg^2

Measurement uncertainty of the comparator resolution:

$u_d = 0{,}00048248$ mg

Measurement uncertainty due to the eccentricity of the comparator:

$u_E = -0{,}000052$ mg

Measurement uncertainty due to the sensitivity of the comparator:

$u_S = 2{,}71288 \cdot 10^{-8}$ mg

The standard uncertainty of type B evaluation is:

$u_B(m_{cT}) = 0{,}097677$ mg

Extended standard measurement uncertainty (with coverage factor k=2):

$U(m_{cT}) = 0{,}20$ mg

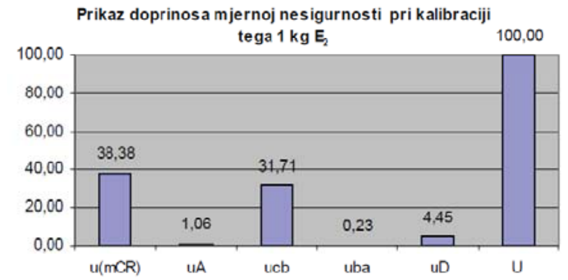

Fig. 8. Contributions to measurement uncertainty of reference mass standard of 1 kg

The analysis of contributions to measurement uncertainty presented in Fig. 8, leads to conclusion that the dominant contribution to measurement uncertainty of the standard and its share in the expanded measurement uncertainty is 38,8%.

The following contribution with significant impact is the standard uncertainty due to buoyancy, because the measurements were performed in air and density of standards and test loading weights are different, and next to the measurement uncertainty the mass correction due to differences in the density of the two loading weight is done.

The measurement uncertainty due to drift of standards, which represents the internal stability of the standard uncertainty, reflects the full impact of standards on this calibration and the precise calibration of standards that prove lower levels cannot be ignored.

Measurement uncertainty of type A, which comes from the reproducibility of the measurement and the contribution of measurement uncertainty of the comparator (including eccentricity, sensitivity and resolution effects) represent the influence of the instrument which is measured, and in this case it has no significant share in the expanded measurement uncertainty, because it is a precise high-performance instrument.

If one observes contribution to the uncertainty of comparator/scale, it is noticeable that the largest share of uncertainty comes due to the scale resolution, which is also called the measurement uncertainty of indication.

Table 1. Measurement uncertainty of standard mass of 1 kg (E_2 accuracy class) using substitution method with 6 ABBA cycles, automatic measurements

Case	Comparator used	division d (mg)	Expanded measurement uncertainty
1	CCE1000 S-L	0,001	0,195399
2	CCE1000 S-L	0,001	0,279226
3	C 1000S	0,002	0,240776
4	C 10000 U-L	0,01	0,237594

Measured standard uncertainties are the same as the 1 kg standards (accuracy class E_1) were used which are calibrated with U = 0,15 mg, and this is the limit for this measurement uncertainty and this weight class accuracy.
The standard uncertainty of the drift depends on the history of a weight standards, and it is more precise when weight has documented history, while the location in the case 2 is estimated.
The appearance of buoyancy of the air is a significant source of uncertainty.
Standard uncertainty of type A assessment, which includes the statistical analysis of series of observations, is smaller than the standard measurement uncertainty obtained from type B assessment, which is based on scientific judgment and use of available data. Type A uncertainties largely depend on the devices and methods of measurement. If all measurement on all instruments are automatic (or more accurately semi-automatic because the operator only sets the weights to the recepient of weight) and the actual impact of the operator during the measurement is off. In fact, prior to measurements the comparators are centered by repeatedly raising and lowering them.
The largest contribution to measurement uncertainty of the comparator is at a device with worst resolution and the weakest repeatability. The same is concluded with a standard uncertainty of type A, where the worst case is case 4.

CONCLUSION

The subject elaborated in this paper includes calibration of mass with high accuracy and analysis of sources of measurement uncertainty and assessment of their contribution to the uncertainty budget. The research involves determination of sources of measurement uncertainty, measuring process model equation specific for determination of conventional mass, approach for assessment of the contribution of measurement uncertainty that are based on statistical calculations and scientific assessments. Assessment of measurement uncertainty of measurement is based on the GUM, Guide for the estimation of measurement uncertainty, which provides a framework for assessment of the dispersion of measurement results. The results of calibration and analysis of compared measurements showed that the Reference laboratory for mass at the National Metrology Institute of Bosnia and Herzegovina confirmed the competences and the reliability of measurements. It is important to present a reliable measurement uncertainty which is part of the complete results of the mass calibration, and which allows the comparability of measurements, and proper dissemination of measurement unit.
The future researches should include intercomparisons, at least with other reference laboratories in the region.

Fig. 9. National laboratory for mass in Bosnia and Herzegovina Institute for Metrology

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A COMBINING GENETIC LEARNING ALGORITHM AND RISK MATRIX MODEL USING IN OPTIMAL PRODUCTION PROGRAM

Galal Senussi[a], Mirjana Misita[b], Marija Milanovic[c]

[a] Industrial Engineering Department, Omar El-Mohktar University, El-Baitha,Libya;[b,c]Industrial Engineering Department, Faculty of Mechanical Engineering, University of Belgrade, Belgrade, Serbia.

Abstruct-*One of the important issues for any enterprises is the compromise optimal solution between inverse of multi objective functions. The prediction of the production cost and/or profit per unit of a product and deal with two obverse functions at same time can be extremely difficult, especially if there is a lot of conflict information about production parameters.*

But the most important is how much risk of this compromise solution. For this reason, the research intrduce and developed a strong and cabable model of genatic algorithim combinding with risk mamagement mtrix to increase the quality of decisions as it is based on quantitive indicators, not on qualititive evaluation.

Research results show that integration of genetic algorithim and risk mamagement matrix model has strong significant in the decision making where it power and time to make the right decesion and improve the quality of the decision making as well.

Key woeds: *Multi-objective function, Genetic Algorithim, Risk Mamagement, Optimum Production Program.*

INTRODUCTION

The analysis of the production program of enterprises is an important and complex segment of managing the enterprise, considering the fact that it influences all elements or resources, such as planning of the material, human resources, machinery resources, research and development, marketing etc. All of these resources influence in multi-criteria optimization of production program. To reduce and improve the decesion making quality, it is important and necessary to evaluate them to minimize the risk of operating losses.

In investigations carried out to date the production program optimization was based on multi-criteria approach using linear functions [**1, 2**]. Using nonlinear functions in multi-objective optimization enables the application of genetic algorithms and is a step forward in

the analysis of the product optimal quantities to maximize production resources utilization [**3, 4, 5**]. On the other hand, economic calculation of the product cost price is a complex procedure, so that the analysis of optimal production program most commonly employed direct costs to determine the cost price and to define the cost function. However, cost functions based only on product variable costs cannot provide real optimal product quantities but are more suitable for ranking products that should be given priority in manufacturing. Introducing overhead costs in the function of cost price is a complex calculation procedure most often difficult to understand by the user in a concrete enterprise, considering that it is not easy to classify individual expenses. It is thought that in metalworking companies, roughly assessing, direct costs account for about 60% of total unit costs, while the share of overhead costs is 40% [**6**].

In business of enterprises, there are several categories of risk: risk of equipment failure (estimated in relation to human safety, to evironment, to business losses, ect.), risk management as a security measure, finacial risk assessment in cases of loan approval, quality management risk, ect.

Generally, Enterprise Risk Management is relatively new concept, Fraser and Simskins [**7**] distinguish following risk categories: Shareholder value risk, Financial reporting risk, Governance risk, Customer and market risk, Operations risk, Innovation risk, Brand risk, Partnering risk, Communications risk.

Risk management consisit of strategic risk, operational risk, financial risk and risk acceptance. Strategic risk deal with competition, market position and economic conditions. Operational risk Concerned with the daily operations, precisely, to the consequences of daily decisions made in the company. The financial risks are related to relations with banks and stockholders, etc.

The types of risk and process steps itroduced by Risk Management Committee 2003 [**8**].

ERM Framework				
	Types of Risk			
Process Steps	Hazard	Financial	Operational	Strategic
Establish Context				
Identify Risks				
Analyze/Quantify Risks				
Integrate Risks				
Assess/Prioritize Risks				
Treat/Exploit Risks				
Monitor & Review				

Table 1. Enterprise Risk Management [8]

The risk is defined as product of probability and consequence of certain events, which can be expressed in formula:

$R = P.\,Q$

P - Probability a particular event.

Q – Consequences of particular event.

For any enterprises, there are external and internal of n-sources of risk. The total risk will represented by high-risk, medium-risk and low-risk sources of operating losses.

$$R_i = \{R_{high}, R_{medium}, R_{low}\} \quad i = 1,2,\ldots n.$$

The based approach of applying risk are risk identification - what can affect the implementation of production program, risk analysis - defining the probability of occurrence of that, and risk assessment - determining the consequences, expressed in the form of operating losses.

The most low-risk sources of operating losses refer to good quality decision. Figure 2 shows the map for identifying Business risks.

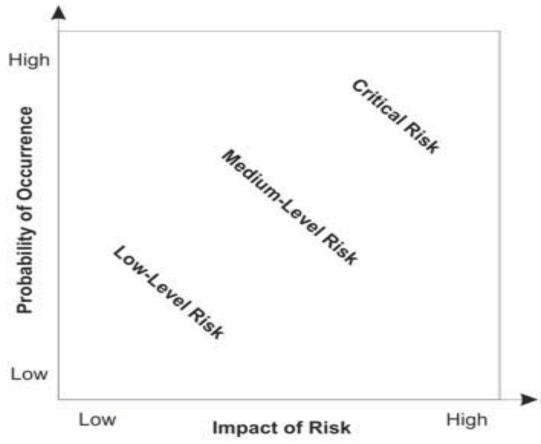

Figure 2. Risk Impact/Probability Chart

Glover at all [**9**] states that the most real life optimization and scheduling problems are too complex to be solved completely and that the complexity of real life problems often exceeds the ability of classic methods. Miettinen [**10**] considered that a key challenge in the real-life design is to simultaneously optimize different objectives through taking into account different criteria low cost, manufacturability, long life and good performance, which cannot be satisfied at the same time.

Profit maximization is the main objective of business enterprises and as such the subject of numerous investigations. Profit is defined as the difference between the total revenue generated by selling products on the market and the overall costs, i.e.:

P = TR – TC

Where

P – Total profit

TR – Total revenue

TC – Total cost

When analyzing the possibilities of profit maximization, it is important to consider the fluctuation of the TR and the TC. The TR depends on supply and market demands for particular types of goods, while the TC depends on different constraints faced by the company, such as the mechanical facilities, number and structure of employees, possibility of providing necessary specific materials for the manufacturing process implementation, delivery etc. For the company, to be competitive on the market means to produce a product at an appropriate price and quantity with the use of capital and labor in the appropriate volume and costs. Therefore, profit maximization refers to the optimization of variable parameters in the observed model, with given production constraints.

Max P $= \sum_{i=1}^{n} Q(W_{pi} - W_{vi}) - T_c$

Where

P – Profit
Q – Quantity of product
W_{pi} – Selling price of the i^{th} product
W_{vi} – Variable cost of the i^{th} product
T_c – Constant cost

In real life, the functions of dependence of production quantity and the TR and the TC are nonlinear. The maximum profit is the maximum difference between the total profit curve and the total cost curve, as represented in the figure3.

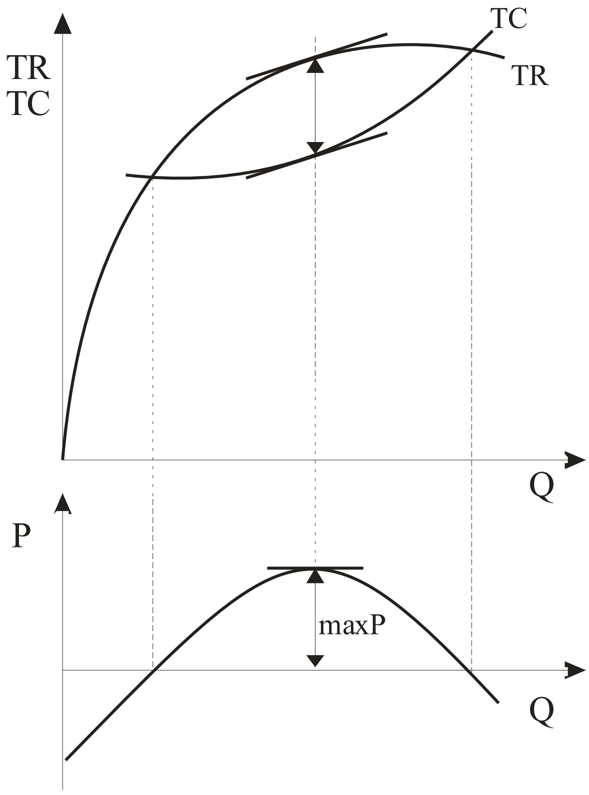

Figure 3. Graphic representation of profit maximization

In real enterprise's operating conditions the functions of the TR and the TC are nonlinear and to determine them two different approaches must be applied.
The TR function consists of the sum of variable and fixed costs, therefore, the sum of linear mathematical form by applying the Lagrange interpolation polynomial based on the values of variable costs from the previous period.
It is possible to determine the nonlinear function of fixed costs in a Lagrange interpolation polynomial is, in our case, a function of production quantity P (Q) with ≤(n-1) level if we have n data points on the value
of costs from the previous period.

$$P(Q) = \sum_{j=1}^{n} P_j(Q)$$

Where:

$$P_j(Q) = y_j \prod_{\substack{k=1 \\ k \neq j}}^{n} \frac{Q - Q_k}{Q_j - Q_k}$$

METHODOLOGY

Methodological steps in developing model for risk management integration methodology and GA is shown on figure 4.

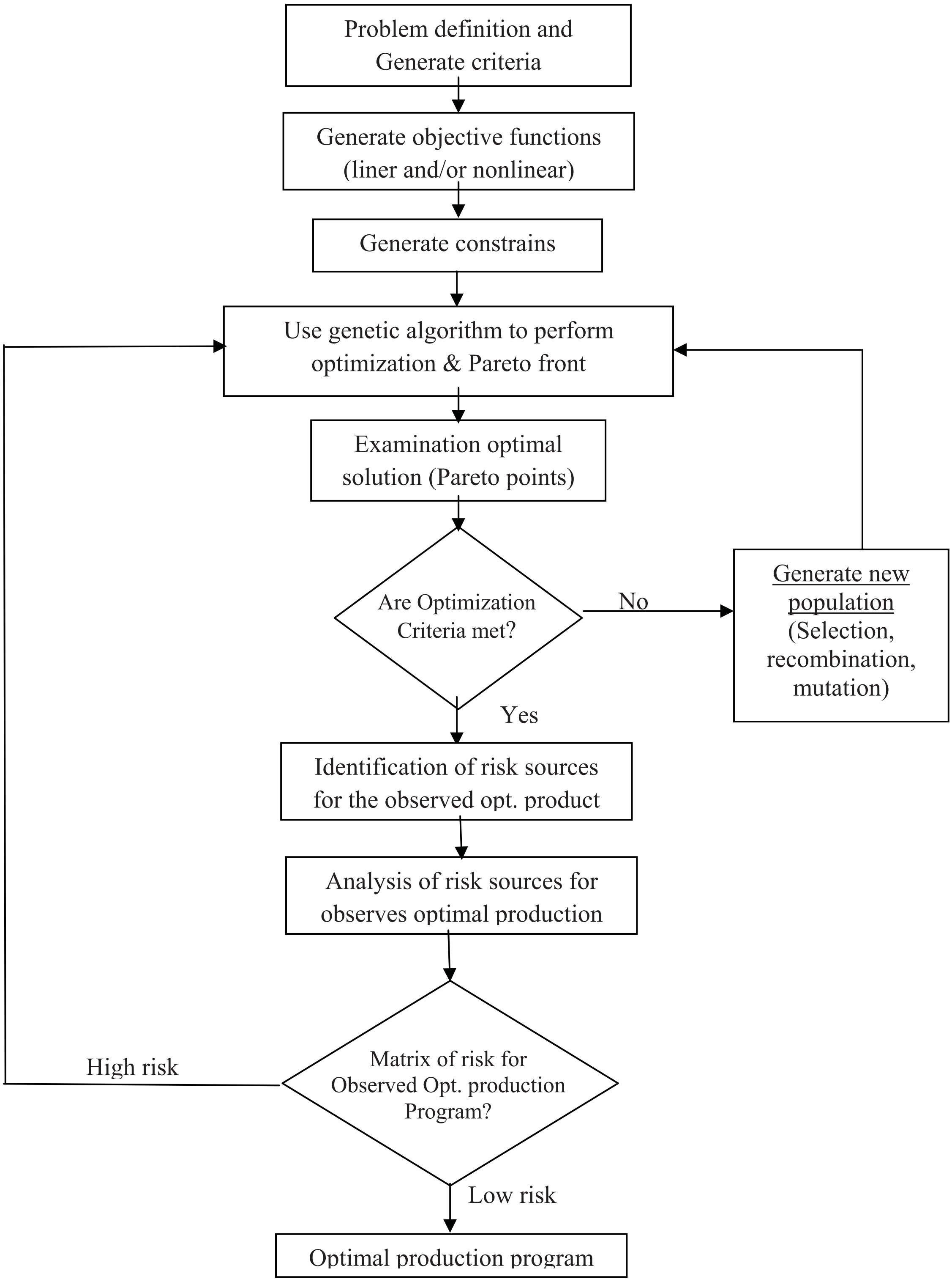

Figure 4. Steps in developing model for risk management integration methodology and GA

CASE STUDY

In the company engaged in manufacturing precision measuring instruments, we have analyzed the available data and formed nonlinear functions of the TR and the TC for the three products:

a) Clocks

Revenue function

$$f(x)_{11} = TR(Q) = -0.04Q^2 + 686Q - 1375.3$$

Cost function

$$f(x)_{21} = TC(Q) = -0.024Q^2 + 410.Q - 4342$$

b) Water meter

Revenue function

$$f(x)_{12} = TR(Q) = -0.18Q^2 + 4298Q - 343884$$

Cost function

$$f(x)_{22} = TC(Q) = -0.49Q^2 + 3382.4Q - 463764$$

c) Gas meter

Revenue function

$$f(x)_{13} = TR(Q) = -0.87Q^2 + 5984.5Q - 5715.1$$

Cost function

$$f(x)_{23} = TC(Q) = -0.58Q^2 + 3818.2Q - 3643.6$$

The functions of criteria for profit maximization will have the form:

$$max\, f(x) = \sum_{i=1}^{3} f_{1i} = f(x)_{11} + f(x)_{12} + f(x)_{13}$$

$$min\, f(x) = \sum_{i=1}^{3} f_{2i} = f(x)_{21} + f(x)_{22} + f(x)_{23}$$

Respectively:

f(1)= -0.04*x(1)^2 + 686*x(1) - 0.18*x(2)^2 + 4298*x(2) - 0.87*x(3)^2 + 5984.5*x(3) - 350975.4;

f(2)= -0.024*x(1)^2 +410*x(1) - 0.49*x(2)^2 + 3382.4*x(2) -0.58*x(3)^2 + 3818.2*x(3) - 463066;

Constraints:

If we consider the production capacity as a key constraint in the production quantity of some products, temporarily ignoring the structure of demand for mentioned products on the market, the restrictions are:

$0 \le x1 \le 4400$

$0 \le x2 \le 2444$

$0 \le x3 \le 1100$

***Employees and raw material in the observed company are not of limiting character.

The Pareto front and values of the functions f1 and f2 are shown in Fig. 5.

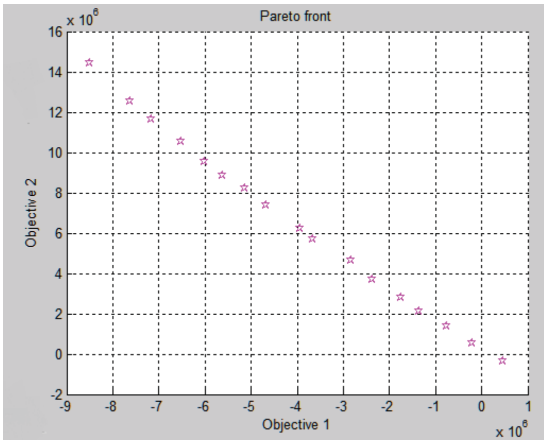

Figure5. The Pareto front of optimum solution

From the Pareto front diagram, it is evident that optimum solution for production quantity and profit maximization under given constraints is a set [2312; 219; 944], where the maximum profit is 5,950,340 RSD calculated as max (f1-f2).

After getting the optimum solution, the second step is Identify and analysis of risk sources for the observed optimum product program. In our case, we have focused on the internal resources only. Identification, evaluations, and determination of trend are shown in the table below:

Risk Source	Risk rating 1st Q. 2010	Risk 2nd Q. 2010	Risk rating 3rd Q. 2010
Operation cost.	Low	Medium	Medium
Labor cost	Low	Medium	Medium
Lubricant cost	Low	Low	Low
Raw martial cost	Medium	High	High
Fixed cost	Medium	Medium	Medium
capital availability	Medium	Medium	Medium
business operations – supply chain management	Medium	Medium	Medium
information technology	Medium	High	High
planning	Medium	Medium	High
reporting	Low	Medium	Medium

Table 5. Evaluation of risk sources and determination of trend

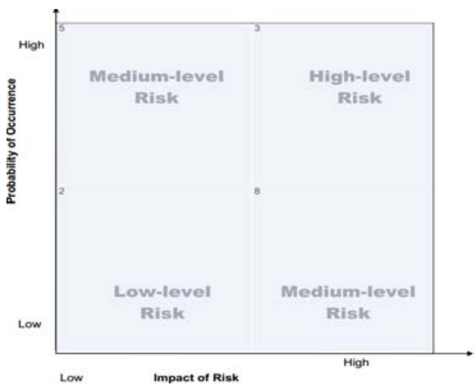

Figure 6.A Two-Dimensional Risk Map

This figure 6 shows a two-dimension risk map. The vertical axis represents loss likelihood and the horizontal axis represents loss impact. The four quarter panels stand for different combinations of likelihood and impact.

Risk matrix indicates a small number of high-risky, a small number of low-risk risk sources, but the largest number risk sources with medium probability and consequences for business losses, namely:

$$R_i = \{R_{high}, R_{medium,} R_{low}\} = \{2,15,3\}$$

Over all research results indicate that at these restrict conditions of production, there is comparatively high risk of production losses. Therefore, it is necessary to resolve our problem to find another optimal solution and repeat analysis until achieved an optimal production program.

CONCULSION

A strong and cabable model of genatic algorithm combinding with risk mamagement mtrix is intrduced and developed to get optimal production program and increase the quality of decisions.

Applying genatic algorithm as a technique deals with huge conflect constrains to create one or altrenative optimal solusions. On ther hand, applying risk mamagement mtrix for choice of optimal production program reduces the risk of operating losses and affects the efficiency of management. Furthermore, qualitative aspects that are defined trough risk sources and by its identification and evaluation, more realistic production program evaluation can be taking into account. Integrated both of them, genetic algorithim and risk mamagement mtrix guide to optimal production program.

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FIBRILLAR MATERIAL AS A COBINDER IN COATING COLORS FORMULATIONS

Dimic-Misic Katarina[1], Paltakari Jouni[1]
[1]Aalto University, Helsinki, e-mail:katarina.dimic.misic@aalto.fi

Abstract. *The micro-fibrillated cellulose (MFC) is a potential material which will at least partly substitute the synthetic co- binders, such as carboxymethyl cellulose (CMC), in paper coating color formulations. Co-binders play an important role in controlling both the flow properties and the dewatering rate of coating colors during the application process as well as during the subsequent film immobilization/1-10/.*

In this study, MFC fibers are used to substitute standard, synthetic co-binder material, CMC, affecting both dewatering and rheological properties of coating colors. This study was partly attempting to establish standard measurement procedures that can give overall picture of complex rheological behavior of MFC coating colors. Elastic effects of coating color in low shear rate influence both the flow and blade load. By influencing leveling, elasticity, substitution of CMC with MFC influences coating color application and immobilization process, as well as the uniformity and optical properties of the coating film /11,12/. It has been demonstrated that coating colors which contained MFC fibers as a co-binder had pronounced shear-thinning characteristics which is a desirable property for paper coatings. However, a complete substitution of CMC with MFC fibers in paper coatings induced low retention properties, longer shear-recovery time and fast immobilization of coating colors, which can have a negative influence on leveling and final coating layer uniformity.

BACKGROUND OF THE STUDY

This work focuses on determining general rheological and dewatering behavior of coating colors that contain MFC fibers used as co-binders. A thickener is added to prevent an excessive loss of water from coating color into the base paper and to adjust the rheological properties of the color, a thickener is usually added /13, 14/. The physical and chemical properties of the thickeners differ, and they can be roughly divided into synthetic and natural polymers/16/. Water retention and immobilization are the key properties for successful paper coating formulations.

The main task of research is to evaluate how the replacement of CMC co-binder with MFC material influences the viscoelastic and dewatering properties of the coating color. It was expected that the introduction of the MFC material into the coating formulation affects the coating color rheology since the MFC fibers are highly flocculated and have reactive groups on their surface.

Micro-fibrillated cellulose material (MFC), can be produced through several pre-treatment and refining routes, each giving products with very different morphological and chemical properties. Correlation of the data matrix obtained from dewatering, low-shear viscoelastic and immobilization time measurements will show if a pattern providing general understanding of the MFC fiber performance in coating suspensions exists. It is important to understand what the typical behavioral pattern of all MFC coatings would be once they are in the coating process.

A key characteristic of the response of a viscoelastic material, as are coating colors, to deformation is its ability to recover after cessation of the force which causes deformation /40/. More elastic structures of clay coatings yield larger elastic moduli than the carbonate coatings /22, 40/.

EXPERIMENTAL PART

Reference coating colors were examined in respect to different solid content (50,55 and 60%) and pigment types (kaolin, carbonate, blend of 50%kaolin and 50 % carbonate). The second set of experiments was done with MFCfibers as co-binders, i.e. MFC fibers are partially replacing CMC in the coating recipe. A set of eight different coating colors, with different MFC fibers, obtained from side stream cellulose with different chemicals used in pretreatment and refined with consistency of micro-fibrillated material, in different refining stages, were used for standard dewatering-rheological measurements. Solid content of MFC coatings was adjusted, so that their Brookfiled100 viscosity stays within coating color viscosity window, recommended for good processability. Different pretreatment and refining routes gave the fibers with very different finesses and reactivity towards pigments and other polymers in coating formulation, Table 1.

		Reference Coating Color								MFC Coating Colors							
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]									[illegible]								
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tf	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tc	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tfs	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cme	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]
Te	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]
Mf	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]
Cmd	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]
Td		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1

Table 1 Coating colors recipes/Reference and MFC coatings

Testing of the coating colors was first done according to quick test procedure, dry solid content oven drying, Brookfield viscosity 50 and 100 RPM and ÅA-GWR, ÅboAkademi Gravimetric Water Retention Device. Additional dynamical low-shear measurements were performed on a MCR 300 PaarPhysicaRheometer. The immobilization cell IMC enables the recording of the time to immobilization, i.e. the time for complete build-up of filter cake .The immobilization cell enables monitoring of the dewatering process at thin applied layers and at controlled shear forces /17/.

RESULTS

As can be seen from Figure4, the dewatering of coating colors increases in the order: kaolin<$CaCO_3$, and decreases with increase in solid content, Figure 1.This is due to the shape of carbonate and kaolin pigments, as water passes easily through carbonate pigments but platy kaolin pigments make this more difficult/2,3,4/.

It is obvious that kaolin pigment coating color has a more pronounced shear thinning behavior as kaolin with CMC forms three dimensional structure in a coating dispersion ("house of cards" structure) which brakes when shear is applied, only to be again reconstructed after shear ceases /22 /.Decrease in apparent viscosity measured with increase in spindle rotation rate, from 50 to 100 RPM is shown in Figure 2.

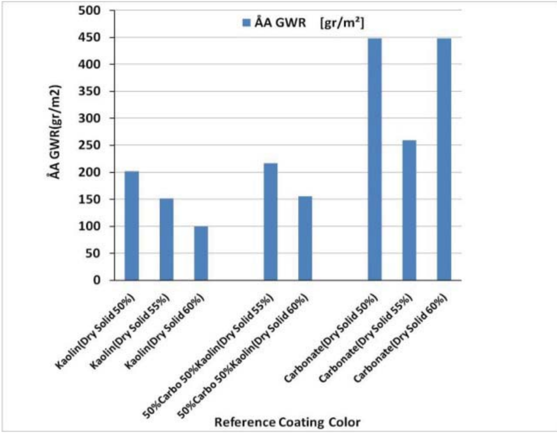

Figure 1 Gravimetric dewatering results for reference colors

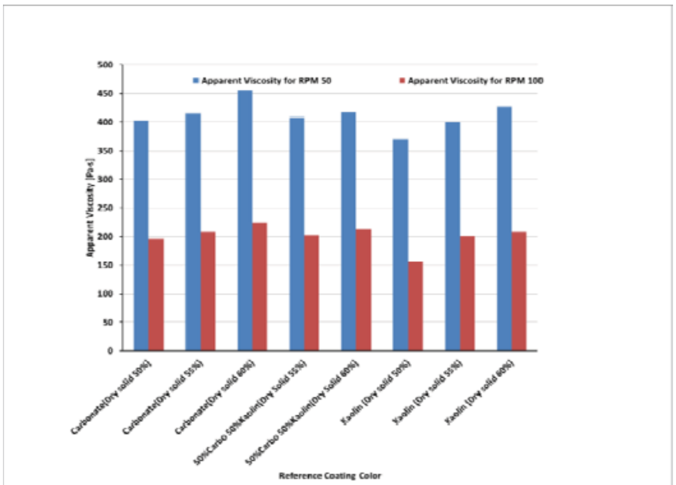

Figure 2 Brookfield viscosity for the reference coating colors.

Within the frequency sweep test within the linear viscoelastic region, elastic modulus of clays is higher than that for carbonate coatings. Particle flocks induced by hydrodynamic and surface interactions group together into a macro scale three-dimensional network which comprises the elastic structure of the coating dispersions.

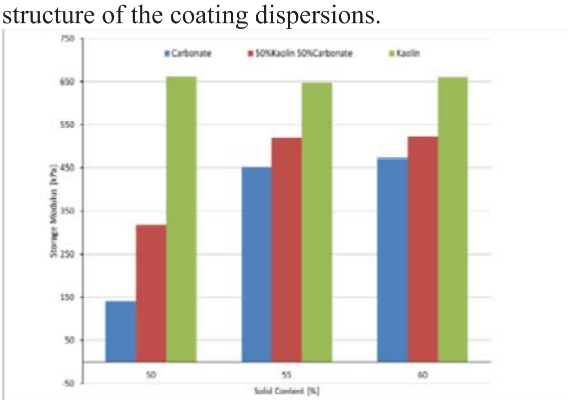

Figure 3 Storage moduli G` at frequency 100 s^{-1}(reference coatings)

It is obvious from this figures that elasticity prevails rather in kaolin based than carbonate-based coatings, as the frequency sweep shows a more elastic structure for kaolin than carbonate-CMC,Figure 3, /25,40/.

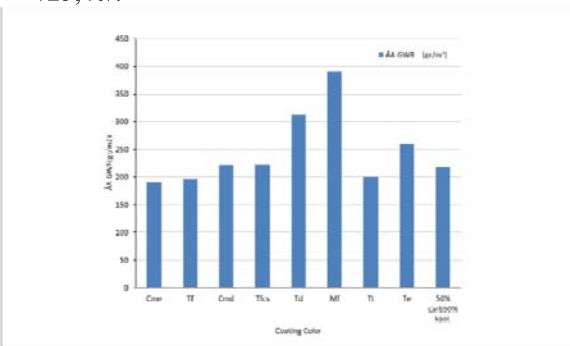

Figure 4 ÅA-GWR Water retention values for MFC coating colors

For some MFC coatings (Tf, Tt, Cme) both apparent and complex viscosity is much higher than for reference coating, while for others (Mf, Td, Tfcs viscosity is lower, Figure 5. It is important that the coating color immobilizes quickly after metering, and therefore too long immobilization times are not desirable /14 /. High solid content normally means a faster immobilization of the coating layer, which reduces the structural changes of the paper matrix under the coating layer, but in the case of MFC faster immobilization is achieved with lower solids than in conventional coatings

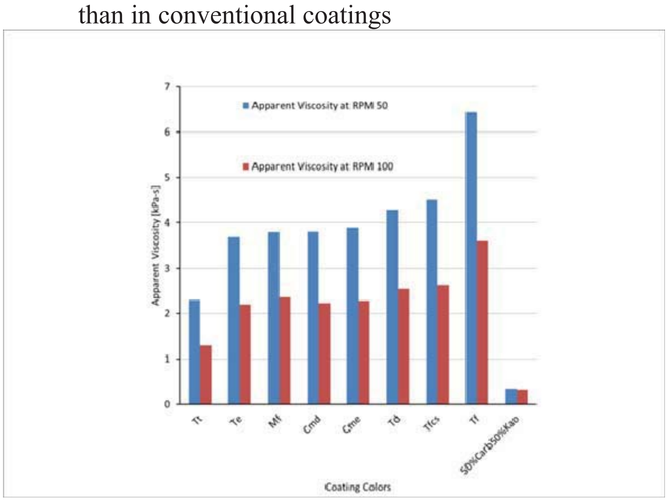

Figure 5 Brookfield viscosities for MFC coating colors.

It is evident from Figure 6 that for some types of MFC fibers, like for those carboxymethylated prior to refining (Cmd, Cme), both immobilization time and storage modulus of immobilized layer cake are in better range, more similar to those of reference coating colors.

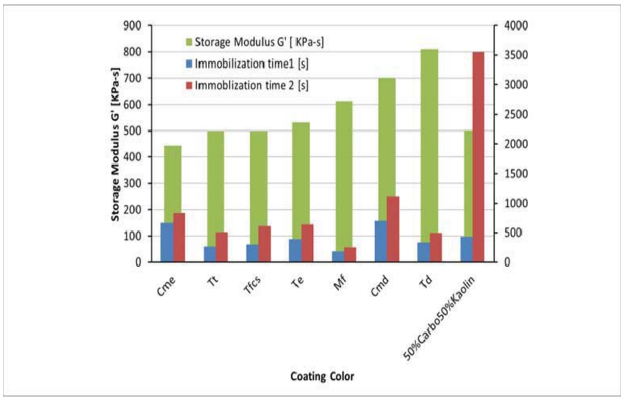

Figure 6 First and Second Immobilization time vs. final Storage modulus; MFC coatings

CONCLUSION

At low frequencies, elasticity of carbonate coatings increases with replacement of CMC with MFC fibers, while shear thinning is higher for MFC coatings which have kaolin inside. Low-shear frequency sweep oscillation measurements showed that MFC coating colors have astronger " memory effect" after shear. Results show that fiber finesse, hence pre-treatment and refining route of MFC fibers determines consolidation, low shear rheology and immobilization time of coating color, as well as there is different reactivity of fibers in respect to pigment types. MFC samples had different amount of fibrous material depending on the type of pretreatments, with less fibrous material indicating a better refining result, higher shear thinning effect, better dewatering /higher immobilization time with lower filter cake elasticity. Generally all MFC coatings had lower water retention and much faster immobilization, than reference CMC coating colors.

Acknowledgement

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PLANNING OF EMISSION CONTROL SYSTEMS FOR STORAGE AND DISTRIBUTION OF LIQUID FUEL

Ivan Rakonjac[1], Ljubomir Lukić[2], Milorad Rakonjac[3]
[1]Project Management College, Belgrade, Serbia
[2]Faculty of Mechanical Engineering Kraljevo, University of Kragujevac, Serbia
[3]Republican Directorate of Commodity Reserves of Republic of Serbia, Serbia

Abstract: *Distribution and storage of liquid fuels causes massive emission of volatile organic compounds to atmosphere. In most cases these evaporations represent environmental hazard and economic loss. In order to prevent this phenomenon, emission control should be applied. Emission control can be achieved by storage tanks' design optimization and/or installation of vapour recovery units. This paper will give the reader a better understanding of the proven uses of storage tank designs as well as an insight in some commercially available vapor recovery solutions.*
Key words: *Liquid fuel, vapour recovery, storage, distribution, emission control*

1. INTRODUCTION

Fuels, such as gasoline and naphtha are consisted of Volatile Organic Compounds (VOC). VOC are large family of hydrocarbons with high volatility, which are produced in many industrial processes. In a wide range of industrial applications, especially petrochemical industry the use of VOC leads to substantial emissions mainly caused by evaporation, displacement and purge procedures.

The use, storage and distribution of solvents and petroleum products have been identified as the most significant sources for VOC emissions. Displacement and evaporation processes affect the release of organic vapours, which are in most cases mixed with air or other permanent gas.

These emissions can cause significant health and environmental risks, due to their toxic and carcinogenic properties. In order to protect environment and public health, certain measures must be taken in order to minimise the resultant emissions. Furthermore, capturing of vapour could generate some serious fuel savings, thus economical benefits.

2. FUEL STORAGE AND DISTRIBUTION

The main opportunities of vapour lost are during fuel distributions (Fig. 1): at loading terminals during loading and discharging tankers, at retail stations during discharging tankers into underground tanks and during vehicle fuelling at retail station.

Bhatia and Dinwoodie (2004) induce that vapour losses will vary with the true vapour pressure of loaded fuel, its average molecular weight and vapour growth factor and inversely with the average vapour temperature. However, API (1992) states that typical discharge losses explaining 80–90% of total crude oil losses are 0.03% of volume for fully loaded tanker crude oil and 0.05% for lightered or short loaded tankers, varying with vapour pressure prior to discharge. Based on shipboard measurements (Uhlin, 1985) evaporative loss from a 250,000 tonne on a voyage from Persian Gulf to Northern Europe of 0.13% of cargo volume includes loading (0.033%), loaded voyage (0.015%) and discharging (0.079%). According As reported by Adamson (2005) fuel losses during tanker loading at terminal could reach 0.15%, discharging at retail station 0.15% and vehicle filling even 0.20%.

According to Bhatia and Dinwoodie (2004) losses in storage depend on terminal design, which includes shore tank design incorporating access, shape, size and type of roof and tank calibration .

As stated by Ramachandran (2000), there are six basic tank designs used for organic liquid storage vessels:

- Fixed roof (vertical and horizontal)
- External floating roof
- Domed external floating roof
- Internal floating roof
- Variable vapour space, and
- Pressure (low and high).

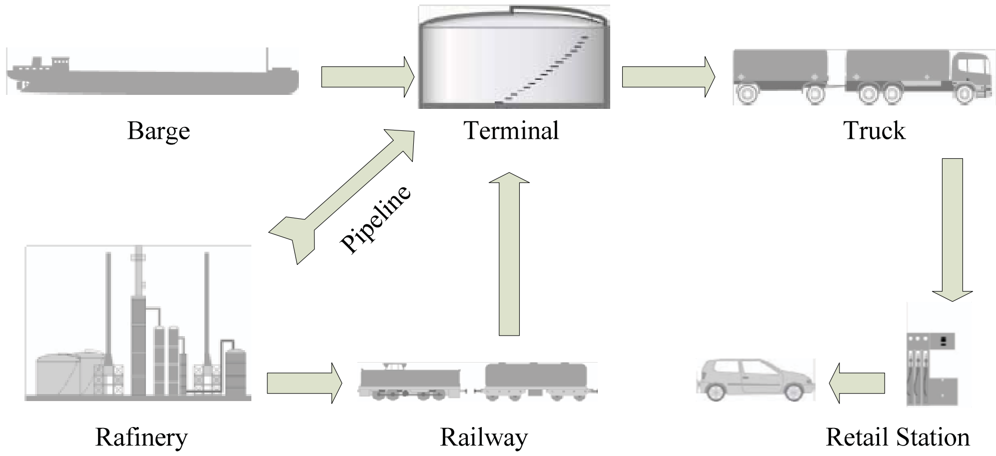

Figure 1. Fuel distribution

According to the same author the fixed roof design is the least expensive to construct, same time - least acceptable for storing liquid fuel. Savings of other design types compared to fixed roof vary from 76% for external floating roof to over 99% for domed external floating roof, while costs are 30% more for external floating roof up to 60% for domed external floating roof compared to fixed roof design (Ramachandran, 2000).

3. EMISSION CONTROL

Vapour emission control can be carried out by venting, flaring or recovering vapour using vapour recovery units (VRU). Venting represents direct waste, flaring reduces environmental and health hazards, but still is a loss of product.

Emission control represents control of vapour losses. In different storage tank types, several different types of vapour loses can be identified. For fixed roof tanks Ramachandran (2000) defines storage loss as a results of changes in temperature and barometric pressure which can be controlled by using a pressure-vacuum relief valve and working loss as the combined loss from filling and discharging fuel. In the floating roof tanks withdrawal losses occur as the liquid level, and thus the floating roof, is lowered. According to same author this loss cannot be controlled. Furthermore, he states that standing storage loss at floating roof tanks are composed of rim seal losses and deck fitting losses. Rim seal losses at external roof tanks are wind induced and this phenomenon must be taken in consideration during designing as well as proper seal selection. Deck fitting loss occurs during openings in the deck, so vents design should be adapted to reduce these loses.

Installing an internal floating roof in at fixed roof tanks and selection of proper seals can minimize evaporation of the stored fuel. Another means of emission control is vapour recovery.

Vapour recovering is the process where the vapour mixture is taken to vapour recovery unit where VOCs are separated from the air and the fuel is recycled back to the tank. VRUs are relatively simple systems that can capture about 95% of the fuel vapours (EPA, 2006). This percentage varies on type of fuel stored and VRU type applied.

Separation process defines basic differences between the various VRUs. Today, many different VRU types are available on the market, and beside separation technology applied, they differ in investment and running costs, maintenance, environmental friendliness and some other aspects.

As an example, Table 1. presents comparison of some types of vapour recovery unit in commercial use today.

Efficient planning of emission control can be achieved both by estimating vapour loss from storage tanks and techno-economic analysis of VRUs.

The storage tanks evaporation loss calculation takes into account following parameters (Ramachandran, 2000):

- Type of tank, overall dimensions and present condition,
- Physical and chemical properties of product stored,
- Seasonal and daily variations in temperature and pressure,
- Wind velocities at tank location,
- Various deck fittings and relief valves,
- Type of rim seals used,
- Tank utilization (turnovers),
- Shell and roof paint colour and condition.

EPA (2006) defines economic assessment of VRU installation trough five step decision processes:

- Identification of possible locations for VRU installation,
- Quantification of the volume of vapor emissions,

- Determination of the value of the recovered emissions,
- Determination the cost of a VRU project,
- Evaluation of VRU project economics.

When estimating overall costs it is important to consider investment costs both for VRU and peripheral equipment. Also, operational cost must be taken into account. Maintenance, energy consumption and waste disposal cost as well as flexibility to other components like additives and to future changing product specifications may determine VRU selection rather than investment itself. Also in consideration should be taken lifetime and reliability of the VRU.

Table 1. VRU comparison

VRU Process	Opportunities	Threats
Active Carbon technology	• Easy handling of peaks • Moderate investment costs • Efficient on low concentration	• Cannot handle various products • Problems with additives like MTBE or ethanol • Safety concerns according to the Institute of Petroleum London (IP, 2000) (exothermic reaction in explosive atmospheres) • Emission false due to regeneration with fresh air • High Power consumption for low emission limits according to VDI 2440 • Hidden power consumption due to regeneration requirements • Difficult and expensive waste disposal of activated carbon
Cryogenic technology	• Easy process from the equipment point of view • Low investment costs • Flexible to handle various products	• Low availability due to freezing of moisture • Need to double equipments • High Power consumption even in standby mode • High maintenance requirements • Does not reach low emission limits
Membrane technology	• Flexible to handle various components including chemicals • Very attractive maintenance costs • Easy process • High availability at nominal capacity (no regeneration requirement) • Safe process due t he membrane properties (no reaction at all)	• Need to increase equipment size to handle peaks • Can be heavy investment
Lean oil absorption	• Efficient at high humidity streams • Wide range of vapor flow rates and VOC concentrations	• Dependability on absorbent • Liquid absorbent may be transferred to the exit gas • Frequency and severity of regeneration must be properly chosen

4. CONCLUSION

This paper provides general insight in planning of emission control system rather than exact solution. Solution choice will depend on investment economy, legislative regulations and existing storage installation.

Upgrading and optimizing tank storages would drastically reduce vapour loss, provide environmental benefits and in most cases an economic revenue.

Vapor recovery can provide significant returns due to the relatively low cost of the technology (EPA, 2006). For example, gasoline single stage VRUs can achieve an average efficiency of 99% (EC, 2006). Therefore VRUs should be installed wherever and whenever it is possible, taking into account all of the benefits environmental and economic.

5. ACKNOWLEDGMENTS

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THERMOGRAPHIC INVESTIGATIONS OF POWER PLANT ELEMENTS

Mr Božo Ilić[1], PhD Živoslav Adamović[2], PhD Ljiljana Radovanovic[3], PhD Branko Savić[3], Mr Nenad Stanković[3]
[1]Technical School Centre Zvornik, Republika Srpska
[2]University of Novi Sad, Technical faculty Mihajlo Pupin, Zrenjanin
[3]Higher Education Technical School of Professional Studies in Novi Sad

Abstract. *During the work of power plants there can occur malfunctions whic, if not recognized and repaired timely, can lead to some more significant failures and accidents, therefore even to unplanned interruptions in supplying of consumers with electric current. Due to that fact, within the programme of preventive maintenance we perform regular thermographic investigations of power plant elements. In this paper we presented a new approach to establishing the place of malfunctioning by thermographic method based on determination of the way, mechanism and direction of heat spreading, as well as the analysis of temperature profile which indicates that the place of overheating does not always neccessarily represent also the place of malfunctioning. The results obtained by this approach showed very high correlation with the results obtained by electric U-I method of measurement of connecting terminals..*

Key words: *thermographic investigations, power plant elements, the assessment of thermal condition, heat spreading, the places of overheating.*

1 INTRODUCTION

The basic task of power plants is to provide a continual supply of consumers with electric current. In order to achieve this task, it is necessary to provide a reliable functioning of power plant elements which is also achieved by regular (systematic) thermographic investigations. Thermographic investigations can be applied in all the cases when the malfunctions are manifested by deviation of the temperature of the observed object from normal working temperature. In that way the conditions for the repair of malfunctioning in the most favorable moment are created, which prevents the occurrence of more significant failures and accidents, as well as unplanned interruptions in supplying of consumers with electric current [1-4].

In this paper we presented the results of a new approach to establishing the place of malfunctioning of power plant elements by thermographic method based on the determination of the way, mechanism and direction of heat spreading, as well as analysis of temperature profile. Among other things, the results indicated that the places of overheating do not always necessarily represent also the places of malfunctioning, on which occasion we investigated connecting terminals of conductive insulators and current measuring transformers in a power plant 35/10 [kV].

2. CRITERIA FOR THE ASSESSMENT OF THERMAL CONDITIONS OF POWER PLANT ELEMENTS

Since there are no international standards according to which on the basis of the degree of overheating it can be assessed thermal condition of power plant elements, in these investigations we applied criteria established on the experience of “Infrared Training Centre”, the greatest world company for training in the field of thermography. According to these criteria on the basis of the degree of overheating, it should be determined the class of thermal condition of elements (“A”, “B” or “C”), and then diagnostic recommendations on maintenance activities which are to be undertaken should be adopted, as presented in Table 1 [1-4].

Table 1

The degree of overheating ΔT [°C]	The class of thermal condition of elements	Diagnostic recommendations on maintenance activities that should be undertaken
$\Delta T > 30$ [$°C$] ili $T > 80$ [$°C$]	A	Urgent intervention is necessary
5 [$°C$] $\leq \Delta T <$ 30 [°C]	B	Intervention during the first power plant switch-off is necessary
0 [$°C$] $\leq \Delta T <$ 5 [$°C$]	C	It is necessary to follow up the condition and plan the intervention

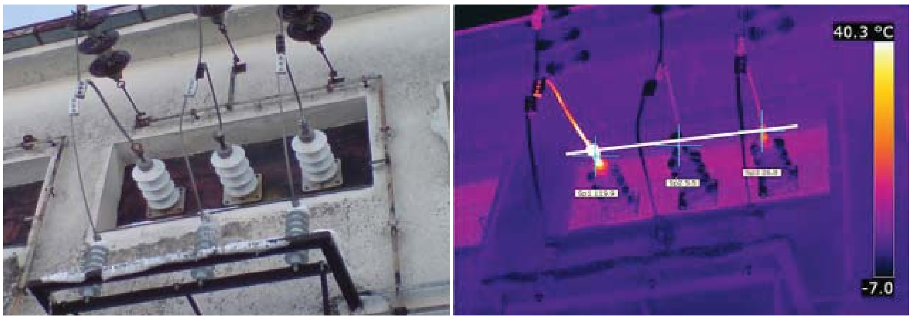
The mentioned criteria refer to nominal load current of elements. However, if the current load at the moment of thermographic imaging is less than nominal, then the measured degrees of overheating are also lower than those that could be present in nominal current load [5]. Due to that fact, in cases like those it is necessary to calculate the overheating that the elements could have in nominal current load, and then establish the class of thermal condition of that element, which is performed according to the relation [1]:

$$\Delta T_n = \Delta T_m \left(\frac{I_n}{I_m} \right)^2 \quad [°C] \qquad (1)$$

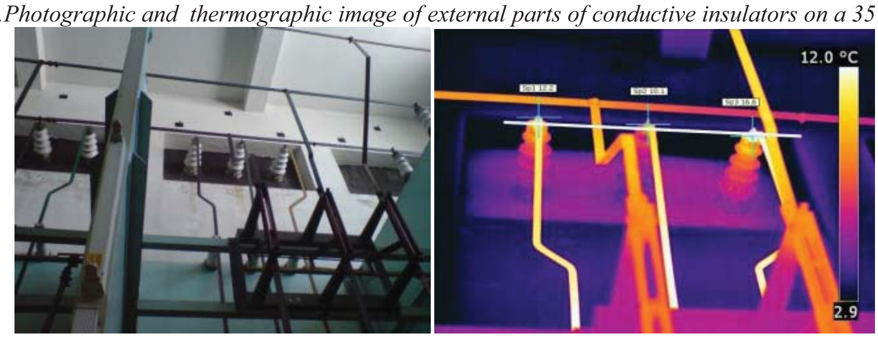
where:
I_n [A] – nominal current of elements
I_m [A] – current through element at the moment of thermographic imaging
ΔT_n [$°C$]– the degree of overheating which the observed element could have in nominal current load
ΔT_m [$°C$]- the degree of overheating of the observed element in current load that was present at the moment of thermographic imaging.

3. THE RESULTS OF THE INVESTIGATIONS

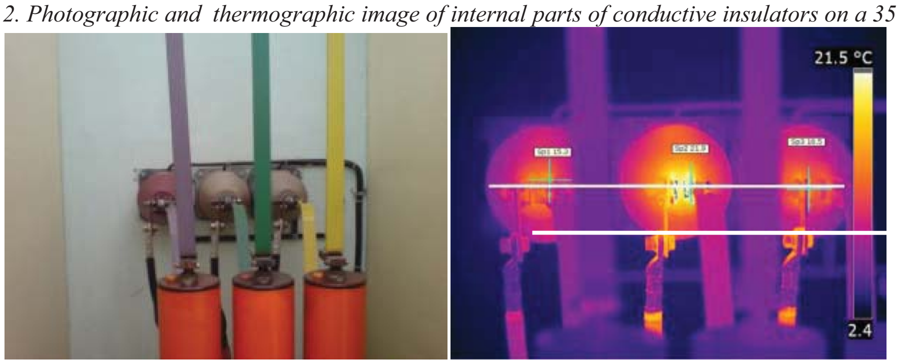
In this paper we presented the results of thermographic investigations of external and internal parts of conductive insulators on a 35 [kV] side of energy transformers, as well as current measuring transformer on 10 [kV] side.
As a result of thermographic imaging, we obtained photographic and thermographic images of external and internal parts of conductive insulators on a 35 [kV] side of energy transformers, as well as current measuring transformer on 10 [kV] side, which we presented in Pictures 1, 2 and 3, respectively.



Picture 1.Photographic and thermographic image of external parts of conductive insulators on a 35 [kV] side



Picture 2. Photographic and thermographic image of internal parts of conductive insulators on a 35 [kV] side



Picture 3. Photographic and thermographic image of external parts of current measuring transformer on a 10 [kV] side

In Table 2 we presented the values of nominal I_n and measured I_m currents through individual elements, then the values of absolute temperatures of individual elements T_i, temperatures of referential elements T_{ref} and the degree of overheating $\Delta T_m = T_i - T_{ref}$ which those elements had during load at the moment of thermographic imaging, as well as the degree of overheating which those elements could have in nominal current load ΔT_m calculated according to the relation (1) and Table 1, and the classes of thermal element conditions determined separately for each phase.

From Table 2 we can see that the values of the measured currents in all the three phases are approximately the same, i.e that the load is approximately symmetrical, therefore the same elements in all the phases should have approximately the same temperatures. However, in the thermographic image presented in Picture 1, it can be noted that connecting terminal of external parts of conductive insulators on 35 [kV] side in some phases have different temperatures. Connecting terminal in phase L_2 has the lowest temperature, therefore it is considered to be the right one and adopted as a referential one; its temperature is compared to the temperatures of the very same connecting terminal in the remaining phases. Connecting terminals in phases L_1 and L_3 have higher temperatures than referential connecting terminal in phase L_2 for ΔT_m = 114.4 [°C] and ΔT_m = 21.3 [°C], respectively. The given differences in temperatures (the degrees of overheating) refer to current load which was I_m = 201 [A]. From Table 2 we can see that in nominal load of I_n = 230 [A] the values of these overheating could be even higher; for connecting terminal in phase L_1 the overheating would be ΔT_n = 149.7 [°C], and for connecting terminal in phase L_3 it would be ΔT_n = 27.8 [°C].

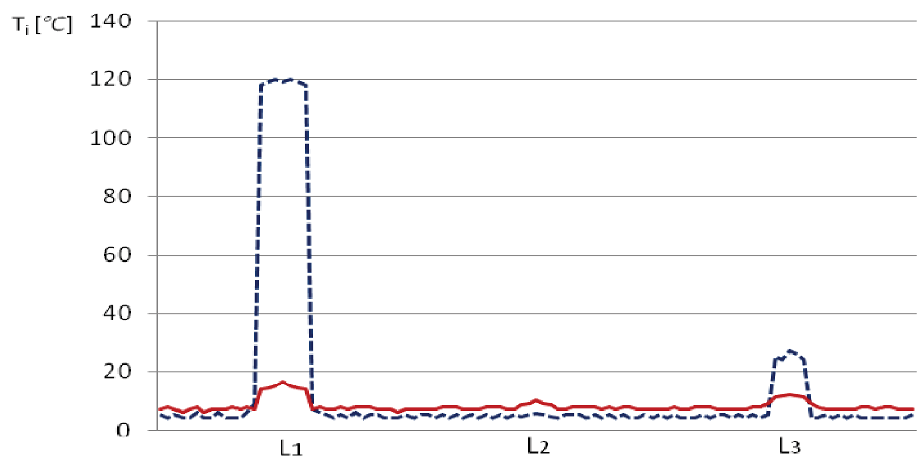
According to the criteria given in Table 1, on the basis of the degree of overheating of connecting terminal in phase L_1 of ΔT_n = 149.7 [°C], it could be concluded that its thermal state is of "A"class, which means that it is necessary to perform an urgent repair of malfunctioning. Also, according to the same criteria on the basis of the degree of overheating of connecting terminal in phase L_3 of ΔT_n = 27.8 [°C] it is estimated that its thermal state is of "B"class, which means that there is a need for an intervention on the first power plant switch-off. However, since it is necessary to perform power plant switch-off in order to perform an urgent repair of connecting terminal in phase L_1, it is suggested that at the same time the repair of connecting terminal in phase L_3 is also performed.

Table 2.

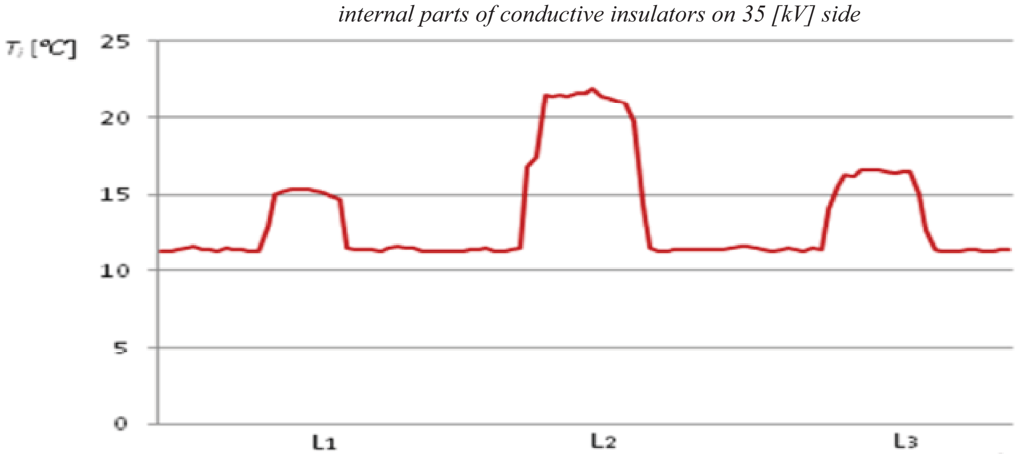
Investigated element	Phase	I_n [A]	I_m [A]	T_i [°C]	T_{ref} [°C]	ΔT_m [°C]	ΔT_n [°C]	Class of the thermal state of the element
Connecting terminal of external parts of conductive insulators on 35 [kV] side	L_1	230	201	119,9	5,5	114,4	149,7	A
	L_2	230	202	5,5	5,5	-	-	ref. el.
	L_3	230	201	26,8	5,5	21,3	27,8	B
Connecting terminal of internal parts of conductive insulators on 35 [kV] side	L_1	230	202	16,6	10,1	6,5	8,4	B
	L_2	230	201	10,1	10,1	-	-	ref. el.
	L_3	230	201	12,2	10,1	2,1	2,7	C
Connecting terminal of current measuring transformer on 10 [kV] side	L_1	800	781	15,3	15,3	-	-	ref. el.
	L_2	800	782	21,9	15,3	6,6	6,9	B
	L_3	800	781	16,6	15,3	1,3	1,3	C

Analogous to previous analysis, on the basis of Picture 2 and Tables 1 and 2, it is possible to establish that thermal condition of connecting terminals of internal parts of conductive insulators on 35 [kV] side is such that connecting terminal in phase L_2 is correct, for which reason it was chosen to be the referential one; the connecting terminal in phase L_1 is of "B" class technical condition, which means that there is a need for an intervention during the first switch-off of power plant, and the connecting terminal in phase L_3 is of "C" class technical condition, which means that there is a need for a follow up of its condition and planning of an intervention. However, when we carefully analyze thermographic image, actually determine the way, mechanism and direction of heat spreading, we can conclude that connecting terminal overheating in phase L_1 of ΔT_m = 6.5 [^{0} C] is not the consequence of a bad condition of the connection point, but the consequence of a heat conduction by conduction to that terminal from the connection point of the external connecting terminal in the same phase, due to its excessive overheating of ΔT_m = 114.4 [^{0} C]. This can be also noted if in Picture 4 we compare temperature profiles along lines drawn in thermographic image through connecting terminals on external and internal parts of conductive insulators on 35 [k*V*] side; broken blue line refers to thermographic image 1 b), and full red line refers to thermographic image 2 b). It can be seen that the external connecting terminal in phase L_1 has significantly higher temperature than the the internal one. There is no need for an intervention on the internal terminal, but it would be a good thing to do due to the fact there there will follow power plant switch-off aiming at repairing of the malfunctioning on external connecting terminal in phase L_1 because overheating could have led to its damaging.

Also, analogous to previous analyses, on the basis of Picture 3 and Tables 1 and 2, it is possible to establish that thermal condition of connecting terminals of internal parts of conducting insulators on 35 [k*V*] side is such that the terminal in phase L_1 is correct for which reason it was chosen to be the referential one; the terminal in phase L_2 is of "B" class of thermal condition which means that there is a need for an intervention during the first power plant switch-off, and the terminal in phase L_3 is of "C" class of thermal condition which means that there is a need for a follow up of its condition and planning of an intervention. However, when we carefully analyze thermographic image, actually determine the way, mechanism and direction of heat spreading, we can conclude that connecting terminal overheating in phase L_2 of ΔT_m = 6.6 [^{0} C] is not the consequence of a bad connection point condition, but the consequence of a heat conduction by conduction, convection and radiation to the very terminal from close distance of busbar connection point, primary of current measuring transformer and current bridge for overriding the transforming ratio, for which reason it is necessary to check up the quality of that connection point during the intervention. This can also be noted if in Picture 5 we observe temperature profile along the line drawn in thermographic image through connecting terminals of current measuring transformer on 10 [k*V*] side; actually, it can be seen that the temperature of busbar connection point, primary of current measuring transformer and current bridge for overriding the transforming ratio (the point with the highest temperature in the diagram) is higher than the temperature of connecting terminal of current measuring transformer in phase L_2, which indicates that there occurred the transmission of heat from that connection point to the connecting terminal.



Picture 4. Temperature profile along lines drawn in thermographic image through connecting terminal on external and internal parts of conductive insulators on 35 [kV] side



Picture 5. Temperature profile along lines drawn in thermographic image through connecting terminal on of current measuring transformer on 10 [kV] side

It is known that due to bad connection points their contact resistance is increased which leads to the occurrence of Joule heat losses ($Q = RI2t$ [J]), as well as their overheating. Therefore, by measuring of contact resistances of connection points we can determine the quality of the very connection points and the cause of their possible overheating [1]. Because of that, aiming at checking up of the results of thermographic investigations, we performed measurements of contact resistance of connection points of connecting terminals by the application of electric $U – I$ method; we applied connection point with current and voltage terminals suitable for measurements of low resistances.

After reading measured values of voltage U and current I, we calculated the values of contact resistances of connection points according to the relation $R = U/I$ ($m\Omega$). The results of the calculated values are presented in Table 3.

Table 3.

Investigated element	**Phase**	**Calculated values of contact resistances of connection points [*mΩ*]**
Connecting terminal of external parts of conductive insulators on 35 [k*V*] side	L_1	5,883
	L_2	1,665
	L_3	3,698
Connecting terminal of internal parts of conductive insulators on 35 [k*V*] side	L_1	1,663
	L_2	1,675
	L_3	1,66 2
Connecting terminal of current measuring transformer on 10 [k*V*] side	L_1	1,347
	L_2	1,345
	L_3	1,358

Analyzing the obtained results in Table 3, it can be concluded that increased contact resistances in relation to referential terminals are present only in connecting terminals of external parts of conductive insulators on 35 [k*V*] side in phases L_1 and L_3 for more than 4, actually 2 (mΩ), for which on the basis of thermographic investigations it was also established to have bad connection points. For connecting terminal of external parts of conductive insulators on 35 [k*V*] side in phase L_1 and connecting terminal of current measuring transformers on 10 [k*V*] side in phase L_2 we measured no increased contact resistances in relation to referential terminals, which means that their connection points are good, confirming the accuracy of the results of thermographic investigations which showed that the overheating of these terminals were the consequence of heat transmission onto them from other terminals. The other terminals were overheated due to bad connection points. In this way we showed a very good correlation of the results of power plant elements investigation with the results obtained by *U-I* method of measuring contact resistance of connection points of connecting terminals.

4. CONCLUSION

The results of the conducted thermographic elements investigations of power plant 35/10 [k*V*] showed that there existed certain malfunctions of some of the elements. Since some of the malfunctions required an urgent repair, we performed power plant switch-off at the most favourable moment for the purpose of repairing the malfunctioning, which was also used for the of repairing malfunctions which were not that urgent. On the occasion of repairing of the noted malfunctions by the application of electric *U-I* method, we performed the measuring of contact electric resistance of connection points of connecting terminals and established that only connection points of connecting terminals which proved to be malfunctioning (i.e bad) had increased contact resistances in relation to referential (functional) connection points of connecting terminals. In that way, we confirmed the accuracy of the new approach in establishing the place of malfunctioning based on determination of the way, mechanism and direction of heat spreading, as well as analysis of temperature profile which proved that places of overheating do not always represent also the places of malfunctioning.

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THE APPLICABILITY OF RISK-BASED MAINTENANCE AND INSPECTION TO A PENSTOCK

Tamara Sedmak[1], Stojan Sedmak[2], Aleksandar Stamenkovic[1]
[1]University of Belgrade, Faculty of Mechanical Engineering
[2]University of Belgrade, Faculty of Technology & Metallurgy

Abstract. *Current practice in maintenance of technical systems is mostly focused on risk based approaches. Anyhow, it is very difficult to establish one unique standard for risk based maintenance and inspection, even in one industry. Only existing standards are American Petroleum Industry standard (API 581), as well as European workbooks derived from RIMAP project. In this paper guidelines for risk based maintenance for penstock of hydro-electrical power plant (HEPP) are given, since accidents caused by failure of penstock are known to happen. Hydro-electrical power plant (HEPP) systems might require large amount of water in the surge tank and high fluid flow rate for the operation. For such a system the consequences of unexpected failure can be catastrophic, producing a great risk in service.*

Key Words: *risk based approaches, penstock, welded joints, maintenance, consequences, risk matrix*

1.INTRODUCTION

Penstock failures in HEPP

Hydro-electrical power plant systems might require large amount of water in the storage lake (surge tank) and high fluid flow rate for the operation. For such a system the consequences of unexpected failure can be catastrophic, producing a great risk in service. One of very important component in HEPP is a penstock, which can be exposed to high stresses, and because of that it is susceptible to failure. To reduce the risk, operational safety of individual components in HEPP, including penstocks, must be at very high level.

Mechanical damages observed before and during service, fatigue, corrosion defects, welding imperfections and environment effect are referred to as most important causes of failures of penstocks.

Typical example of brittle fracture is catastrophic failure of penstock (length 2640 m, hydrostatic pressure 864 m), occurred in 1973 in hydro-electrical power plant „Santa Isabel" in Bolivia. Water jet passed through the hole 1 m long and 0.7 m wide, and destroyed tropical vegetation along 130 m., 10 m in width. About 6000 m^3 of water leaked for one four, before the closing the valve in surge tank. Metallographic examination revealed that failure cause is brittle fracture, initiated in the heat-affected-zone (HAZ) of longitudinal welded joint.

The next example, cracking in welded joints of penstock in „Peručica" hydro power plant, also showed the significance of quality assurance in welding. Neither brittle fracture nor leakage occurred, but the occurrence of cracks in welded joints required measures for preventing of the break of power plant operation, [1].

These two cases are taken as typical for significance of maintenance system and possible risk in service of a penstock.

About risk based inspection and maintenance

Maintenance of technical systems has been developed and changed ever since it was introduced. Corrective maintenance, which implies to repair something when it is broken, is first generation of maintenance strategies, and as such, is very simple and overcome nowadays. Second generation of maintenance was scheduled maintenance, which considered higher plant availability, longer equipment life and lower costs. Last thirty years many complex strategies have been developed as third and fourth generation. Those include TPM (total productive maintenance), LCC (life-cycle costing), RCM (reliability centered maintenance), RBI (risk based inspection), RBM (risk based maintenance), etc, [2].

Nowadays most researches are focused on the risk based maintenance and inspection. Risk can be defined, in simplest form, as the product of probability of an event and its consequences.

Current considerations are that maintenance based on risk analysis gives best results in multiple ways. Risk analysis can provide information for different type of consequences that can arrive from failures of equipment, like environmental, health, safety and business consequences. This is very important for large and complex industries such as oil refineries, chemical and petrochemical plants, steel production and power plants.

In contrast with these findings current practice of inspection and maintenance planning in power plants is still mostly time oriented and based on prescriptive rules and experience rather than being an optimized process where risk measures for safety and economy are integrated [3].

This is probably because there is still no unique standard which provides conceptual guidelines and rules for RBM.

Making decisions concerning a selection of a maintenance strategy using a risk-based approach is essential to develop cost effective maintenance polices for mechanized and automated systems because in this approach the technical features (such as reliability and maintainability characteristics) are analyzed considering economic and safety consequences, [4].

Furthermore, according to [3] the use of risk-based methods in inspection and maintenance of piping systems in power plants gives transparency to the decision making process and gives an optimized maintenance policy based on current state of the components.

Lack of unique standard for risk based maintenance results in various methods and techniques for analyzing risk and making inspection decisions based on those analysis. Accordingly [5] showed that there is no unique way to perform risk analysis and risk-based maintenance, and [4] emphasized that there are different risk-based approaches reported in the literature and they range from the purely qualitative to the highly quantitative.

Only applicable and available risk standard is API 581, Risk-Based Inspection Base Resource Document [6]. However this is standard for American industry and applicable only for process plants. In 2001 the large European project RIMAP, [7], was launched, with purpose to develop unified approach for making risk based decisions within inspection and maintenance. Project was finished in 2004, and it has produced four industry specific workbooks for the petrochemical, chemical, steel and power generation industries. The purpose of these workbooks is to provide more specific guidance on how to apply the RIMAP approach within these industrial sectors.

Lately, papers are most about suggestions for RBM optimization of specific problems, like water seepage in highway tunnel operation, bridge structures, aging highway bridge decks, etc.

Taking into account aforementioned, in this paper the proposal for the risk based maintenance optimization of penstock will be given, in order to improve safety and reliability on one hand, and to reduce maintenance cost on the other. So, in this case, not the whole hydro power plant, but rather one of its most critical components, the penstock, will be analyzed, in the way similar to the case of critical equipment in a factory. The proposal will be given in a form of recommendations and directives which can be further elaborated in more detailed estimation and application of RBI (RBM).

2.APPLICATION OF RBM TO A PENSTOCK

General

According to API, as well as according to RIMAP, risk analysis can be performed on three different levels, depending on detail of analysis, namely qualitative, semi-quantitative and quantitative analysis, known also as screening, intermediate and detailed analysis. In any case the first step consists of risk analysis using risk matrix approach [8], [9].

A qualitative risk assessment ranks system and components relative to each other. When you perform a qualitative risk assessment, you assign relative failure probabilities and consequence severities in broad groups, such as ‘high’, ‘medium’ and ‘low’. Although you can use any number of groups, you will probably not be able to assign, with sufficient confidence, more than five failure probability and consequence severity groups. Qualitative analysis uses words to describe the magnitude of potential consequences and the likelihood that those consequences will occur. These scales can be adapted or adjusted to suit the circumstances, and different descriptions may be used for different risks [8].

Quantitative analysis comprise detailed collecting and processing of large amount of data, regarding failure modes, effects and history of equipment being analyzed. Probability and consequences need to be quantified, afterwards risk value is obtained by multiplying them.

Qualitative

Dominant failures of pressure equipment are fast fracture, leakage and corrosion. Fast fracture could be brittle fracture under plane strain condition or ductile fracture due to overloading. Leakage is a consequence of through wall crack, achieved as time dependent stable crack growth. Corrosion can be developed in specific environment condition, and stress corrosion is supported by applied stress. Common feature of these three failure modes is the existence of crack in structure. Penstocks can be very long, in order to deliver water to hydraulic turbines. Hence, they have to be constructed of several welded rings.

Welded joints are prone to cracking, and they are most critical regions of welded structure in this regard (as in two cases presented earlier).
It is not very likely that the inspection of any part of penstock would be possible in periods less than 10 years because of the need to empty it. This process is too complicated and expensive, because power production has to be stopped. Finally, even when it is done, the inspection would be too expensive if performed on all welded joints. For that, from risk point of view it is necessary to assess the risk level for all welded joints before inspection, and perform the inspection only joints of high risk.

Therefore, the proposal presented here, includes risk quantitative estimation of all welded joint, as the basis for their inspection.
In literature there are numerous different scales for consequences and likelihood, and corresponding risk matrix. Furthermore, scales and matrix can be define in respect to specific problem which is analyzed, so there is no strict rule which to choose. For qualitative analysis of penstock suitable scales and risk matrix can be taken from RIMAP qualitative approach, [10] as shown in figure 1.

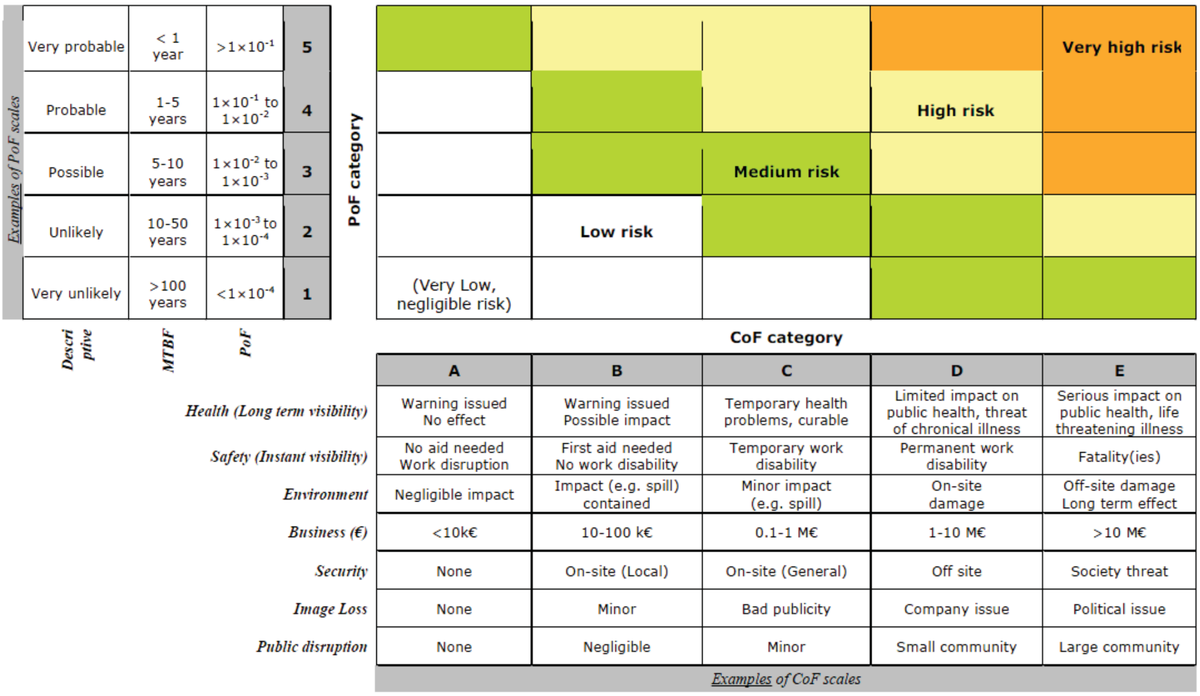

Figure 1. Risk matrix with scales for probability and consequences

In the case of penstock welded joints, consequence of eventual failure, namely water leakage, is the same for all its parts. Therefore, the same category of consequence is chosen for penstock welded joints. As already mentioned and shown in Fig. 1, consequences can be different: business, health, environmental, etc. In order to define it, all penstock failures happened so far, should be analyzed. Data is needed about number of fatalities, environmental effects (e.g. as for the Santa Islabel penstock, destroyed tropical vegetation along 130 m and 10 m in width), as well as about costs caused by a failure.

Likelihood category for each welded joint should be based on data of "generic" or "average" failure frequency, on failure data of particular penstock if they exist, and data regarding construction of penstock. Typically, where the water pressure is the highest, there is the highest probability of failure. Therefore, while estimating penstock welded joint risk, one should focus on those under the highest pressure and categorized them accordingly. Having this in mind, it is clear that failure probability might change from joint to joint. Even if one takes into account that larger thicknesses and higher strength steels are used for penstock sections under higher pressure, such welded joints are still the most critical because they are far the most sensitive to cracking.
Once this process is finished, the likelihood and consequences categories should be defined, by means of qualitative assessment. The consequence and the likelihood are then combined to give a risk value for each welded joint, according to risk matrix (figure 1).
As result of first part of analysis, e.g. qualitative analysis, welded joints are ranked by risk. Then according to those results decision can be made about which joint will undergo more detailed analysis. Once inspection is conducted (every 10 years), that joint will be inspected in much more detailed manner, with purpose to find all potential cracks and analyze their effects on structural integrity of a penstock.

Quantitative

The suggestion for the second step in the scope of RMBA application to a penstock would be, once all cracks has been recorded, to use qualitative analysis to estimate risk level for each crack and then make a decision which cracks should be removed and which to be inspected again.

Structural integrity depends of crack behavior. For the control of a crack two aspects are important. It is necessary first to detect crack and to identify its location and size by different non-destructive testing (NDT). Then crack significance has to be assessed applying convenient parameter and method based on fracture mechanics.

3.CONCLUSION

Based on the aforementioned discussion, one may conclude that eventual failure of the large majority of welded joint would have high consequences, but low probability, positioning them as of low or medium risk. At least one welded joint would be of the higher risk, the one under the highest water pressure, typically at the turbine inlet. Therefore, at least one welded joint should be tested during the first regular inspection, as detailed as possible, so that all eventual findings, especially cracks, would be later on treated individually, including quantitative risk assessment. Based on this assessment, inspection plan should be made for each crack and for the eventual repairs. This is just a framework idea which can be further developed with the ultimate goal to standardize RBI maintenance of penstocks and hydro power plants in general.

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A NEW FUZZY MODEL FOR SITUATION AWARENESS ASSESSMENT RELATED TO RESILIENCE: CASE STUDY OF SMALL AND MEDIUM ENTERPRIZES IN SERBIA

Aleksandar Aleksić[1], Danijela Tadić[1], Miladin Stefanović[1]
[1]Faculty of Engineering, University of Kragujevac, Serbia

Abstract. *High level of situation awareness represents one of organization target values during the normal period operating. The considered problem has a critical effect on the competitive advantage of small and medium manufacturing enterprises of developing countries which exists in the periods of crisis. The relative importance of business processes and indicators of situation awareness, as well as values indicators on the process level of every tested enterprise are given by fuzzy rating of management team. In order to rank business processes of considered enterprises group, a new fuzzy model is proposed and applied.*

Key words: *Organizational resilience, situation awareness, Fuzzy sets, degree of belief*

1. INTRODUCTION

Business conditions that have changed recently and put in the first plan global economic crisis induced presence of organizations that can manage its own vulnerabilities and even strive in the moments after disturbances emphasizing the process approach. Situation awareness represents a part of resilience, and it is area of science interest that is most studied in the organizational management. Indicators that are used as the assessment tool of situation awareness were first given by McManus (2007). The need for indicators update has emerged with the standard ASIS SPC.1-2009. In this paper, the indicators of situation awareness are related to the presented demands of ASIS SPC.1-2009 standard which sets the requirements which are needed in order to enable adequate resilience of organization. In order to find the way for the situation awareness assessment, organization must be approximated to some level and presented as a certain model. In this paper, we made a decision to choose an enterprise as a type of organization and treat it as a system. Model of enterprise system can be gained through the different reference models - PERA (Purdue Enterprize Reference Model), GRAI / GIM (Group de Recherche en Automatisation Integree / Integrated Methodology), etc. can be used to represent the organization as well as reference standard – ISO 14258 - Concepts and Rules for Enterprize). In this paper, the organization is represented by its processes. In general, the importance of each business process depends on multiple factors, such as the type of economic activity, firm size, and others. It can be assumed that the relative importance of business processes at the enterprise level have different relative importance. Weight value of business processes are almost unchanged during a predefined period of time and involve a high degree of subjective assessment of the management team. In this paper, the weight of business processes and the weight of situation awareness indicators are given by a matrix pairs of comparison the relative importance of business processes and indicators, respectively.

In this paper, the values of situation awareness indicators are described by fuzzy rating of management team. Their judgments are expressed by predefined linguistic expressions. Also, in this paper, uncertainty in relative importance of business processes, the relative importance of indicators and parameters values are modelled by fuzzy sets (Zimmermann 2001). Fuzzy set theory resembles human reasoning in its use of approximate information and uncertainty to generate decisions (Kaur and Chakrabortyb 2007).

The main contribution of this paper can be presented as introduction of structured model for assessment of situation awareness in organization. The paper is structured as follows: In Section 2, modeling of all uncertainties is presented by applying theory of fuzzy sets, in Section 3 the fuzzy Algorithm is proposed, in Section 3 the proposed fuzzy model is illustrated by example with real-life data and the Section 5 sets conclusions.

2. MODELLING OF UNCERTAINTIES

It is closer to human reasoning if decision makers express their opinions and evaluations by using linguistic expressions rather than numeric values. The number and type of linguistic expressions representing relative importance of business processes and indicators of situation awareness as well as indicator are determined by the management team. It can be assumed that decision makers of management team can be made decisions by consensus in the small and medium enterprises.

2.1 The relative importance of business processes and situation awareness indicators

The importance of business process p compared to the business process $p', p, p' = 1,..,P$, and the importance of indicator i compared to the indicator i' in every enterprise f, f=1,.., F is described by one of five predefined linguistic expressions which are modelled by fuzzy triangular numbers $\tilde{w}^f_{pp'}$, and $\tilde{w}^f_{ii'}$, $i, i' = 1,...,I$, respectively. These fuzzy numbers are defined in interval [1,5], where 1 denote as the lowest relative importance and 5 denotes the highest relative importance:

- *Very low importance* - $\tilde{R}_1 = (x;1,1,2)$
- *Low importance* - $\tilde{R}_2 = (x;1,2,3)$
- *Medium importance* - $\tilde{R}_3 = (x;2,3,4)$
- *High importance* - $\tilde{R}_4 = (x;3,4,5)$
- *Very high importance*- $\tilde{R}_5 = (x;4,5,5)$

The highest and the lowest limit of these fuzzy numbers is highlighted as $l^f_{pp'}, u^f_{pp'}$, and $l^f_{ii'}, u^f_{ii'}$ and modal value is $m^f_{pp'}$ and $m^f_{ii'}$ respectively.

If the importance of process p' compared to the process p, and the importance of indicator i' compared to the indicator i in the enterprise f, is significantly greater, respectively, then the value of element in the pairs matrix of process comparison must be presented by fuzzy triangular number: $\tilde{w}^f_{pp'} = \left(\frac{1}{u^f_{pp'}}, \frac{1}{m^f_{pp'}}, \frac{1}{l^f_{pp'}}\right)$, and,

$\tilde{w}^f_{ii'} = \left(\frac{1}{u^f_{ii'}}, \frac{1}{m^f_{ii'}}, \frac{1}{l^f_{ii'}}\right)$ respectively.

If the importance of the matrix elements described above are equal, it can be represented by a single point whose value is 1 and which is represented by triangular fuzzy number (1,1,1).

2.2 Fuzzy rating of indicator values

In this paper, fuzzy rating of management team is expressed by predefined linguistic expressions, which are modelled by triangular fuzzy numbers, $\tilde{v}^{pf}_{ij}$, $i = 1,..,I; j = 1,2,3; p = 1,.....P_f; f = 1,..,F$.

The lowest and the highest limit of this modal value of triangular fuzzy number $\tilde{v}^{pf}_{ij}$ are set as L^{pf}_{ij}, U^{pf}_{ij}, M^{pf}_{ij}, respectively. The values in the fuzzy triangular domain, $\tilde{v}^{pf}_{ij}$ belongs to the interval [1-9] and they have the same meaning and values as a standard scale which is defined by AHP (Saaty, 1990). In this paper, we use five linguistic expressions for describing the fuzzy rating of indicators value, which are defined by triangular fuzzy numbers in the following way:

- *very low value* - $(y;1,1,2.5)$
- *low value* - $(y;1,3,5)$
- *medium value* - $(y;2.5,5,7.5)$
- *large value* - $(y;5,7,9)$
- *very large value* - $(y;7.5,9,9)$.

3. THE PROPOSED FUZZY ALGORITHM

The proposed fuzzy model is realized in the following steps:

Step 1. The matrix pair of comparing the relative process importance in each enterprise needs to be set. The process p weight ($p = 1,.., P_f$) is calculated:

$$\tilde{w}_p = \frac{1}{P_f} \cdot \sum_{1}^{P_f} \tilde{w}^f_{pp'} .$$

Step 2. The matrix pair of comparing indicators importance in each enterprise needs to be set. The weight of indicators i , i=1,..,I is calculated as:

$$\tilde{w}^f_i = \frac{1}{I} \cdot \sum_{1}^{I} \tilde{w}^f_{ii'}$$

Step 3. The weight of indicator i, i=1,..,I on the level of process p, in enterprise f , $\tilde{w}^f_{ip}$, is calculated:

$$\tilde{w}^f_{ip} = \cup(\tilde{w}^f_p, \tilde{w}^f_i) = \left(x; \mu_{\tilde{w}^f_{ip}} \right)$$

Step 4. The scalar value of fuzzy number $\tilde{w}^f_{ip}$, w^f_{ip} by applying moment method must be determined (Zimmermann, 1996).

Step 5. The value of every parameter can be described through the fuzzy number $\tilde{v}^{pf}_i$ by management team. Applying the normalization process, domain of the triangular fuzzy numbers, $\tilde{v}^{pf}_i$ is mapped into a set of real numbers on the interval [0-1] and in that way they are becoming comparable. Normalized values of triangular fuzzy numbers are triangular fuzzy numbers and they are presented as $\tilde{r}^{pf}_i$. In this paper, a linear normalization procedure is applied (Shih, et al, 2007).

Step 6. Weighted value of indicator i, on level of each process p of enterprise p need to be calculated,

$$\tilde{d}^{pf}_i = w^f_{ip} \cdot \tilde{r}^{pf}_i \quad , i=1,..,I;\ p = 1,.., P_f ; f = 1,.., F$$

Step 7. The value of situation awareness of process p in the enterprise f of the SMEs analysed group must be calculated:

$$\tilde{SO}^f_p = \frac{1}{I} \cdot \sum_{i=1}^{I} \tilde{d}^f_{ip} \ , \ \tilde{SO}_p = \frac{1}{F} \cdot \sum_{i=1}^{I} \tilde{SO}^f_p$$

Step 8. The processes on the level of enterprise f, f=1,..,F and on the level of SMEs should be ranked by using method in (Dubos, Prade, 1979).

Step 9. The measure of belief should be calculated in order to check if process ranked on the second place, p' is in the worse condition than the first ranked process, p^*, $p, p' = 1,..., P_f ; p \neq p'$ in the enterprise f, f=1,..,F and in the treated SMEs.

Step 10. By applying statistical tests for parameter hypothesis, it can be calculated if processes that are not ranked on the first place can be bad as the first ranked processes.

4. CASE STUDY

According to the demands of ASIS SPC.1-2009, some indicators are updated, so the assessment model is consisted from: (1) Roles and responsibilities, (2) Understanding and Analysis of Hazards and Consequences, (3) Recovery priorities, (4) Internal and External Situation Monitoring and Reporting, (5) Monitoring, measurement and analysis of process performance.

In this paper, the enterprise is presented by its processes. Small and medium enterprises of production sector can be interpreted through the six business processes: Management (p=1), Marketing and sale (p=2), Design and development (p=3), Purchasing (p=4), Production (p=5) and Support processes (p=6).

Developed fuzzy model and are tested on the real data which are gained from SME of Central Serbia production sector. The relevance of this type of enterprise can be illustrated through the data from EU which claims that 80 million workers are employees of SME which gives approximately 60% of total GBP of EU (Lukacs E., 2005). Based on the input data, by applying proposed fuzzy Algorithm (from Step 1 to Step 9) the next results are gained: The worst ranked process on the treated SMEs level is Marketing and sale process (p=2) which is the first ranked process in the 32% of SMEs. The best ranked process on the level of treated enterprises is the process of Management (p=1). Expected results are related to the best ranked process (Management) because enterprise managers should dispose with the most of relevant business information. The result that show bad economic situation in treated organizations is related to the ranking of Marketing and sale process which indicates the lowest level of situation awareness in business. This must be treated in order of strategic improvement since a lot of production and development input information are acquired through this process.

The values of situation awareness on process level on the treated group of SME are:

$\tilde{SO}_1 = (1.0837,\ 1.3422,\ 1.6158)$,

$\tilde{SO}_2 = (0.4625,\ 0.5697,\ 0.6958)$,

$\tilde{SO}_3 = (0.343,\ 0.4841,\ 0.6092)$,

$\tilde{SO}_4 = (0.176,\ 0.5458,\ 0.7318)$,

$\tilde{SO}_5 = (0.6468,\ 0.9013,\ 1.145)$,

$\tilde{SO}_6 = (0.2939,\ 0.481,\ 0.6906)$

The rank of enterprises and the measure of belief that the process p is in the worse condition than process p^* which is ranked on the first place is presented in the Table 1.

Table 1 – Rank of business processes in SMEs with respects to Situation awareness

Business processes	Rank	The degree of belief that processes can be at the first place
p=1	**6**	0
p=2	**2**	0.92
p=3	**4**	0
p=4	**1**	1
p=5	**5**	0
p=6	**3**	0

Based on the acquired results, it is easy to see that process of Purchasing (p=4) has the lowest performances in the treated group of SMEs. Process which has the best performances is Management (p=1). Second ranked process is the process of Marketing and sale (p=2). The degree of belief that process p=2 je is in the worse condition than process p=4 is 0.92. Management team needs to realize statistical analysis which should confirm that processes p=4 and p=2 are in the equally bad condition in treated SMEs. Applying the test about arithmetical mean of two populations with the risk rate of 5% it can be concluded that these two processes has equally bad business performances. This indicates that management team should take corrective actions in order to improve these processes condition. Applying technique of variance analysis, with the risk rate of 5%, it can be concluded that process p=4 is in the worse condition than process p=2. This result indicates that process of purchasing needs to be treated first.

5. CONCLUSION

The industrial management practice shows that in almost every enterprise, decreased situation awareness can be categorised as the most relevant cause of the decline of organizational business performance. In this paper, a new fuzzy model for evaluation and ranking of situation awareness on the process level and on the enterprise level is proposed. The proposed fuzzy model was tested on a selected group of SMEs of production sector in Central Serbia. The following conclusion is made: It is possible to describe the considered problem by formal language that enables to look for the solution by exact method; the uncertainties which exist in the model can be described by fuzzy sets.

The further research will cover the scope of process improvement measures as well as improving overall organizational resilience.

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INDUSTRIAL SAFETY – COORDINATION OF EUROPEAN RESEARCH

Snežana Kirin[1], Aleksandar Sedmak[2], Radivoje Mitrovic[2], Predrag Djordjevic[3]
[1] Innovation center of the Faculty of Mechanical Engineering, Belgrade, Serbia
[2] University of Belgrade, Faculty of Mechanical Engineering
[3] JP EPS, Serbia

Abstract. *Industrial safety has been analysed in the scope of ETPIS (European Technological Platform on Industrial Safety) and EU project SAFERA with an aim to achieve (by 2020) a new safety paradigm for European industry. Safety is treated as a key factor for successful business and an inherent element of business performance. Industrial safety performance should be progressively and measurably improved in terms of reduction of reportable accidents at work, occupational diseases, environmental incidents and accident-related production losses.*
"Incident elimination" and "learning from failures" cultures should be embedded in design, maintenance, operation at all levels in enterprises. Structured self-regulated safety programs should be applied in all major industry sectors in all European countries. Measurable performance targets for accident elimination and accident free mind set workplaces as the norm in Europe.

Key Words: *SAFERA, ETPIS, risk based safety approaches,*

1.INTRODUCTION

One of the key-factors and prerequisites for long-lasting competitiveness of European industry is safety: it is an important and contributing part of a successful and well managed business. In order to allow uninterrupted production of goods and thus profitable industrial production processes, the goal of a business-oriented approach should be to guarantee that the industrial production process is safe. Unsafe operations can influence business profitability through direct costs due to industrial accidents and disruption, but also due to a loss of credibility and reputation of individual businesses even of entire industrial sectors or branches. The commonly used phrase "*If you think safety is expensive, try an accident*" has become a reality in many industrial sectors.

Industrial safety is typically problem in process industry, chemical industry as well as the production of oil and oil products, and their transport and distribution, electricity generation, transmission and distribution, and transportation systems related to industrial activities. The reputation of the oil production sector has recently been tarnished by the major industrial disaster in the form of Gulf of Mexico oil spill which poured crude oil into the ocean for three months in spring 2010. It was the largest accidental marine oil spill in the history of the petroleum industry. It occurred after an explosion on the Deepwater Horizon drilling rig which killed instantly 11 platform workers and injured 17 others. The spill has been a terrible environmental disaster as well as damaging the Gulf's fishing and tourism industries. According to BP, the total charge for the incident is estimated to be $40 billion. The disaster has been predicted to have far reaching consequences sufficient to impact on global economies, marketplaces and policies, including structural shifts to energy policy.

The largest accident in the chemical industry to date is the Bhopal Disaster which occurred in India in December 1984. In the disaster at Union Carbide plant a faulty tank containing poisonous methyl isocyanate leaked, causing the immediate death of several thousands of people. Hundreds of thousands have suffered physical injuries; this disaster has caused major health problems to the region's human and animal populations. After the Bhopal Disaster, concern about chemical accidents led to the passage of the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA) in the United States. In the EU, the Council Directive 82/501/EEC on the major-accident hazards of certain industrial activities was issued already in 1982, and was amended after the Bhopal Disaster. The Directive, which was aimed at improving the safety of sites containing large quantities of hazardous materials, is also known as the Seveso Directive, after the Seveso disaster in

July 1976. The Council Directive 96/82/EC on the control of major-accident hazards - the so-called Seveso II Directive - was adopted in 1996 and has replaced its predecessor. The Seveso II Directive was extended to cover risks arising from storage and processing activities in mining, from pyrotechnic and explosive substances and from the storage of ammonium nitrate and ammonium nitrate based fertilizers. The industrial accidents that provoked to this development included an explosion at a fertilizer factory in Toulouse in 2001. It killed 29 people, and also caused extensive structural damage to buildings in the vicinity. A review of the Seveso II Directive is currently ongoing and implementation of the upcoming Seveso III Directive will create new research needs, requiring coordination of current national research programmes within EU if there is to be significant change in finding ways to resolve these traditional but still current problems such as the recurrent pollution from mining industries e.g. the Baia Mare cyanide spill in Romania in 2000 and Hungary's red sludge spill in October 2010.

2. SAF€RA – COORDINATION OF EUROPEAN RESEARCH TOWARD INDUSTRIAL SAFETY [1]

Prevention of major industrial accidents with off-site consequences to the environment, society and people is a challenge that has to be tackled through research which will subsequently lead to innovations to promote safe processes and products. Research on safety and dissemination of results are essential for European industries. It enables the use of new technologies and innovations. Therefore, the prerequisite for improving the use of new technologies is open communication about the risks based on joint research activities on industrial safety, and this will demand improved coordination and collaboration between national or regional research programmes.

Safety science is not, however, a single scientific discipline. It requires the co-operation of researchers from different backgrounds: engineering in order to analyze risks and to devise barriers, sociology to understand risk aversion to be sure that barriers are in accordance with stakeholders perceptions and expectations. Today, research activities cannot be handled by individual disciplines; instead one builds a research community bringing several disciplines to handle safety issues. Moreover, risk management approaches are strongly dependent on national cultures and regulations. Thus, national research programmes address safety from their own specific viewpoints. Therefore, transnational joint research represents an opportunity to understand how the most culturally diverse region in the world can share common European safety culture attributes.

Safety has traditionally been connected with regulations and norms aimed at the elimination or reduction of hazards and risks. However, the operational environment for safety research and safety regulation is changing because of globalization, complexity, changes in consumers' values and increase of juridical and legal liabilities. There is an ongoing development leading to an increased value being placed on safety. Investments in safety are related not only to the reduction of financial losses caused by industrial accidents but it is also seen as an opportunity for sustainable business and competitiveness leading to industrial growth. Research-proven safety can provide a continuously increasing added value in several industrial sectors. Therefore, one important goal of safety research is to identify, assess and evaluate the impacts on all parts of the value chain to be impacted on by the increased safety and thus to help improve business profitability and development of new safety innovations.

There are many different aspects to industrial safety, as shortly illustrated above. In many European countries, research programmes are targeted to topics aimed at the improvement of safety related to industrial activities, including fixed installations in production systems, transportation systems, as well as safety and security of critical infrastructures. Defragmentation is essential in the area of safety research, and the SAF€RA project will aim at overcoming the fragmented R&D landscape in these fields and will stress the importance of tackling urgent common subjects that would not otherwise be conducted unless in partnership. The subjects have to be relevant to support European global competitiveness as described in the EU2020 Strategy and to contribute to creating the European Research Area. It is within the scope of the SAF€RA to address the issue of finding the optimal balance between investment in safety and the growth and competitiveness of industry, which will potentially help to improve long-term performance and to generate markets for safety solutions. One important extension of the cost-benefit analysis is to develop common good practices and basic principles for legislation and standards. Cooperation and exchange of expertise will be sought with other ERA-NETs and Technology Platforms in the area of industrial safety and security of critical infrastructure to synergize strategies and to avoid duplication of efforts. A pictorial representation of the SAF€RA concept is provided in Figure 1.

SAF€RA will focus on improving the level of safety in the European industry through coordinated research to achieve sustainable growth and enhanced competitiveness. The scope of SAF€RA will include coordination of research on the prevention of major accidents and in particular the economical benefits of industrial safety solutions, safe innovative processes, preparedness and response as well as protection of the environment, new methods to enhance the creation of a safety culture and prudent attitudes, reference technologies for life extension of aged and repaired structures, as well as products and systems required to increase industrial safety.

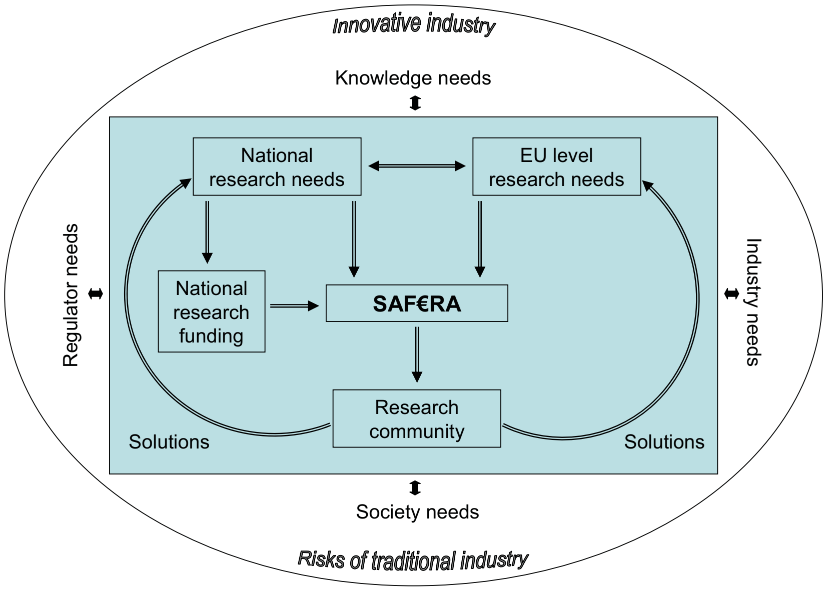

Figure 1. SAFERA concept

This scope is complementary to the NEW OSH ERA project which focused in coordinating and cooperating on research on new and emerging risks at work, the task which is continued by PEROSH, the Partnership for European Research in Occupational Safety and Health. In the collaborative research promoted by the NEW OSH ERA project the personal health and safety was in the focus whereas the SAF€RA coordinates research related to the major industrial hazards which have the potential to cause major accidents with off-site consequences and risks to the environment and society.

The SAF€RA project aims at improving industrial competitiveness by reducing the occurrence and the consequences of incidents resulting in extensive damage to populations, the environment and property due to major accidents or un-managed unpredicted risks creating critical situations in a number of commercial enterprises. The aim is to demonstrate that the prevention of major accidents leads to better competitiveness of EU industry by reducing direct and indirect costs due to accidents influencing business profitability. The SAF€RA project will be divided into two overall parts. The first part is concerned with how the SAF€RA partners will work together by exchanging information on programme management and preparing arrangements and agreements to cover a wide range of joint activities. The second part is focused on creating complementary, synergistic and coordinated research activities in the field of industrial safety, based on a common vision and joint strategies in particular towards harmonisation of safety methods and practices.

Future Initiative by ETPIS and through these activities, SAF€RA will support the implementation of the EU's 2020 Strategy and address the EU's Grand Societal Challenges.

The aims of SAF€RA are in line with the long term-vision of ETPIS according to which a new safety paradigm will have been widely adopted by European industry by 2020. At the time safety is seen as a key factor for all successful businesses in fact it is an inherent element of business performance. As a result, industrial safety performance will have progressively and measurably improved in terms of a reduction in the numbers of reportable accidents at work, occupational diseases, environmental incidents and accident-related production losses. It is expected that an "incident elimination" and "learning from failures" cultures will develop where safety is embedded into design, maintenance, operation at all levels of the enterprises. In addition, there will be structured self-regulated safety programmes in all major industry sectors in the EU, which will have firm, measurable performance targets for accident elimination and accident-free mindset workplaces will become the norm in Europe. These will contribute in a major way to sustainable growth for all industrial sectors throughout Europe leading to an improvement in social welfare.

As the competitiveness of EU industry is continually challenged by cheap labour countries, it can also be seen that the higher safety awareness and research-proven, assured safety of EU products and services could become a competitive edge combating against cheap imports or improper production values. Making the value of safety transparent provides added value, and this is a result of safe operation of systems. The added value is generated through reduced costs of accidents and incidents, the better operational efficiency, and companies acting this manner become desirable business partners and service providers.

For the safety authorities in the EU and its Member States, this kind of coherent and focused safety research will unquestionably help to improve their safety surveillance and regulatory work as well as the development of internationally harmonised standards, e.g. based on the adaptation of ISO 31000 to major accident prevention or the revision of the OECD report on Guiding Principles for Prevention, Preparedness and Response. In its Action Plan for European standardization the European Commission states that European harmonized standards are considered as state of the art solutions meeting the essential safety requirements in the most economic way. Standards are understood as enablers for SME in particular to interact with each other on an agreed technical basis. Increased co-operation between Member States safety operatives and common theme research projects will provide the basis for more harmonized safety regulation. Co-operation between research bodies, authorities and industry will also improve the future development of cost-effective safety regulations. The concept of safety as a market value will alleviate the work of the authorities, provide competitive new business potential and improve the overall industry safety culture in EU in order to meet the challenges of the future.

3. SERBIAN CONTRIBUTION TO SAF€RA

Serbian contribution to SAF€RA project will be focused on:

- Dissemination of the project results at national level to the policy makers, representatives of the scientific community, potential future partners as well other stakeholders.
- Analysis of management approaches of the national research programmes and exchange of information on implementation and administrative procedures and on evaluation practices.
- Providing a review on the state of the art of the regional, national and bi-national research programmes on industrial safety.
- Making the overview of complementarities and gaps in national research on industrial safety and risks to be tackled in future approaches.
- Making conclusions for the future joint strategy on industrial safety.
- Discussing the possible approaches for funding of (Post)Doctoral Grants, partners pool funds in order to finance projects (real common pot), partners participate in collaborative research projects (institutional funding) or a mixed virtual pot model.
- Identifying research needs as well knowledge needs related to e.g. standardization, pointed out by the stakeholders.
- Launching a programme of transnational research activities, materializing in joint calls for proposals.

4. CONCLUSIONS

SAF€RA will bring dynamism to safety research in Europe by promoting collaboration in research programmes and by fostering lateral thinking as well as promoting innovations. SAF€RA will contribute to the objectives of the FP7-ERANET-2011-RTD in the following ways:

- Building up sustainable channels for communication and effective instruments for collaboration between national programme owners and/or managers and promoting the creation of collective, strategic coalitions at a European level
- Increasing awareness about the importance of research in the field of industrial safety as a major contributor to a dynamic knowledge-based economy as well as working to strengthen the impact of this research at the EU, national and international levels.
- Exploiting synergies and avoiding duplications of research and development among the partners of the Consortium and reducing fragmentation of the European Research Area by increased coordination.
- Establishing joint programmes of transnational research projects between the involved Member States, materializing in a pilot programme collaborating research projects between the SAF€RA partners and serving as a test bed for the future joint programming.
- Developing and implementing common, joint, strategic activities to establish a durable European network for cooperation between key actors in the field of industrial safety.

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