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FACULTY OF ENGINEERING - HUNEDOARA

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Aims & Scope

General Aims:

ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING is an international and interdisciplinary journal which reports on scientific and technical contributions.

ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING publishes invited review papers covering the full spectrum of engineering. The reviews, both experimental and theoretical, provide general background information as well as a critical assessment on topics in a state of flux. We are primarily interested in those contributions which bring new insights, and papers will be selected on the basis of the importance of the new knowledge they provide.

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- *surveys of work accomplished to date*
- *current trends in research and applications*
- *future prospects.*

As an open-access journal ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering will serve the whole engineering research community, offering a stimulating combination of the following:

- *Research Papers - concise, high impact original research articles,*
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ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING encourages the submission of comments on papers published particularly in our journal. The journal publishes articles focused on topics of current interest within the scope of the journal and coordinated by invited guest editors. Interested authors are invited to contact one of the Editors for further details.

Every year, in three issues, ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING publishes a series of reviews covering the most exciting and developing areas of engineering. Each issue contains papers reviewed by international researchers who are experts in their fields. The result is a journal that gives the scientists and engineers the opportunity to keep informed of all the current developments in their own, and related, areas of research, ensuring the new ideas across an increasingly the interdisciplinary field.

ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING exchange similar publications with similar institutions of our country and from abroad.

Audience:

Scientists and engineers with an interest in the respective interfaces of engineering fields, technology and materials, information processes, research in various industrial applications. It publishes articles of interest to researchers and engineers and to other scientists involved with materials phenomena and computational modeling.

About us:

ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering is an international and interdisciplinary journal which reports on scientific and technical contributions and publishes invited review papers covering the full spectrum of engineering.

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ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering has been published since 2008, as an online supplement of the ANNALS OF FACULTY ENGINEERING HUNEDOARA – INTERNATIONAL JOURNAL OF ENGINEERING.

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The journal's coverage will reflect the increasingly interdisciplinary nature of engineering, recognizing wide-ranging contributions to the development of methods, tools and evaluation strategies relevant to the field. Numerical modeling or simulation, as well as theoretical and experimental approaches to engineering will form the core of ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering's content, however approaches from a range of environmental science and economics are strongly encouraged.

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ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering publishes invited review papers covering the full spectrum of engineering. The reviews, both experimental and theoretical, provide general background information as well as a critical assessment on topics in a state of flux. We are primarily interested in those contributions which bring new insights, and papers will be selected on the basis of the importance of the new knowledge they provide.

The editorial policy of ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering is to serve its readership in two ways. Firstly, it provides a critical overview of the current issues in a well-defined area of immediate interest to materials scientists. Secondly, each review contains an extensive list of references thus providing an invaluable pointer to the primary research literature available on the topic. This policy is implemented by the Editorial Board which consists of outstanding scientists in their respective disciplines. The Board identifies the topics of interest and subsequently invites qualified authors. In order to ensure speedy publication, each material will be report to authors, separately, thought Report of the Scientific Committee. For an overview of recent dispatched issues, see the ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering issues.

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The members of the Editorial Board may serve as reviewers. The reports of the referees and the Decision of the Editors regarding the publication will be sent to the corresponding authors.

The evaluated paper may be recommended for:

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The manuscript accepted for publication will be published in the next issue of ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering after the acceptance date.

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We are very pleased to inform that our journal ACTA TECHNICA CORVINIENSIS – BULLETIN of ENGINEERING is going to complete its four years of publication successfully. In a very short period it has acquired global presence and scholars from all over the world have taken it with great enthusiasm. We are extremely grateful and heartily acknowledge the kind of support and encouragement from you.
ACTA TECHNICA CORVINIENSIS – BULLETIN of ENGINEERING is seeking qualified researchers as members of the editorial team. Like our other journals, ACTA TECHNICA CORVINIENSIS – BULLETIN of ENGINEERING will serve as a great resource for researchers and students across the globe. We ask you to support this initiative by joining our editorial team. If you are interested in serving as a member of the editorial team, kindly send us your resume to redactie@fih.upt.ro.

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Content of FASCICULE 1 [JANUARY–MARCH]

ABSTRACT: *TQM is the approach for improvement of competitiveness, efficiency and flexibility of the entire company. It is the necessary mode of planning, organizing and understanding of each activity, depending upon each individual at each level in the company. The paper presents experience in implementation of Standard series ISO 9000ff, 14000ff and 17000ff to TQM in the automobile service center. The research was conducted in the company that possesses ISO certificates. Presented was the possibility of TQM implementation in the company. TQM in service centers can be observed as an opportunity for fundamental improvement of business functions and processes within the service, with the purpose of providing services and improving business results.*

ABSTRACT: *The global increase of manufacturing activities and the need for sustainability calls for manufacturing strategies and technologies with reduced environmental impact. On the basis of industrial experiences and academic reviews, this paper presents an elaborated framework presenting drivers for life cycle considerations in product realization within the manufacturing engineering industry. The framework considers the total life cycle of the product and production system with the phases of material processing, production, usage and afterlife. For each phase the drivers for an increased life cycle perspective is reviewed by the categories of cost reduction, value increase and regulatory initiatives.*

ABSTRACT: *This paper deals with process management in the diagnostic science with usage of the Decision Support System (DSS). Unlike the other common processes, diagnostic processes have some specifics. The outputs of diagnostic process can be used again as inputs. These outputs are measured data as well as gained knowledge and experience. Hence we are focused on increase of efficiency of data evaluation, optimizing of diagnostic processes and acceleration of development of new materials. Decision Support Systems are defined as "interactive computer-based systems, which help decision makers utilize data and models to solve unstructured problems". Therefore DSSs can be advisable solution for diagnostic processes, which are primarily unstructured. Unstructured problems can be partially supported by standard computerized quantitative methods, but it is necessary to develop customized solutions. This solution may require certain expertise that can be provided by intelligent system. Intuition and judgment may play a large role in this type of decisions. In the scope of development and diagnostic of new materials, DSSs can be used for optimizing of diagnostic processes and reduction of development time following the anterior data, knowledge and experience. DSSs provide new possibilities in discovery of materials and combination of materials with exactly defined properties. In addition, they can reduce related costs.*

ABSTRACT: *Controlling visible ozone injury on conifer species were in locality Kopaonik – Serbia. The trials were set in accordance with methods PP 1/152 (2) (EPPO, 1997), the treatment plan was made according to a fully randomized block design. Phytotoxicity was estimated according to instructions of PP methods (1/135 (2). Intensity of injury was performed using standard statistical methods Towsend- Heuberger, the efficiency according to Abbott, analysis of variance to Duncan test and methods PP/181 (2). The differences of the disease intensity were evaluated by the analysis of variance and LSD-test. In locality Kopaonik ozone forecasts are made daily during the ozone forecast season.*

ABSTRACT: *In the paper optical measurements of geometrical features on crankshafts were presented. The requirements of contemporary customer are getting higher and higher. It is particularly visible in aviation and automotive industry. For truck manufacturers it means efficient work with no repairs for hundreds thousand kilometers. It means also more measurements in every batch and on each workpiece. In this project we investigated possibility of use optics for fast inspection of diameters, lengths and form deviations. It was necessary to prepare a measurement strategy and elaborate uncertainty evaluation.*

ABSTRACT: *Injection moulding is one of the most important processes of cyclic polymer and other materials processing. It enables the production of very complex parts, in one cycle. For successful injection moulding, injection moulding system is necessary. It consists of main elements: the mould, injection moulding machine and device for mould temperature regulation (tempering), and additional elements: dryers, robots etc. All of the mentioned elements consume significant amounts of energy. The paper presents the analysis of the possibilities of energy savings in injection moulding process, starting with moulded part geometry, in order to obtain more energy efficient process.*

ABSTRACT: *Robust product environmental evaluation has to consider the whole lifecycle, called "cradle to grave" analysis. This activity gives wide benefits if carried out in the early design phases. CAD-SLCA integrated systems are innovative eco-design tools usable during product design feature definition in order to support SLCA (Simplified Life Cycle Assessment) method application. The present work describes how the CAD-SLCA approach can be put in practice by considering the assessment of the complete product lifecycle and by using a new software tool which integrates data from different design supporting systems. Particular focus has been placed on the use phase and end of life treatment. An example shows the approach results.*

ABSTRACT: *A combined cutting and joining process of technical textiles should help to reduce the number of production steps. Additionally, resources needed and waste should be minimized by a combined process. Process development is supported by Finite Element (FE)-simulations keep the number of experiments as low as possible. ANSYS software has been chosen for process simulation and examples of polypropylene fibers cutting are presented. Depending on process characteristics one or two laser sources will be used for experiments. First experiments have been performed on polyamide, polyester and polypropylene woven and knitted fabrics. It is intended that energy consumption as well as resource-efficiency of the combined laser cutting and joining process will be optimized and compared to conventional processes. Increased efficiency simplified and reduced requirements on storage and logistics could be beneficial especially for small- and medium-sized enterprises (SME's) in Europe.*

ABSTRACT: *In order to assure that the software service levels required by the service consumer are met by the service provider, constant monitoring and verification of the software is required. We propose a new XML schema for defining service level parameters. In documents based on this schema we define parts of application to be monitored, which metric is going to be used and what are expected values. We present the DProf tool for constant monitoring of software performance. The system is implemented in Java, but, with minor modifications, it can be used for .NET applications.*

ABSTRACT: *The wider objective of student's internship is the achievement of better interaction between universities and enterprises for timely preparation of the university graduates for labour market. Within the frame of the Automotive Engineering course at Politecnico di Torino, the internship is considered to be an instrument to reduce the distance between the theoretical and methodological knowledge acquired during the academic carrier, and the applicative integrated and systematic knowledge which characterizes the industry. Internship represents an opportunity for the students of their temporary introduction into the industrial community, with the purpose of establishing a first contact with companies, and at the same time, carrying out a training period without the setting of a subordinate work. This paper is presenting the general information about the internship program at the Politecnico di Torino, its understanding, types, philosophy and objectives, benefits and correlation with academic credits, complete organizational structure and collaboration with industrial partner institutions. The applying procedure and activation of an internship, rights and obligations of the parties, and necessary documents relevant to student practice, are also described. Finally, a brief review of internship reports with final evaluation criteria of performed work, and internship evaluation questionnaire is given.*

ABSTRACT: *In today's process manufacturing environment, innovation is viewed as critical to sustainable growth and business profitability. While open innovation is regarded as the answer, the companies can effectively measure the return on R&D investment, have acceptable product success rates, achieve acceptable promotional effectiveness, or have visibility into their compliance risks or operational readiness for new product launches. While open innovation is an actual topic, capitalizing on the opportunity requires holistic strategy, not just increased collaboration. Companies must have repeatable, compliant and responsive business processes, global information infrastructure that provides a single source of the truth, alignment across departments and solutions that evolve without coding. With holistic strategy and supporting infrastructure, companies can consistently minimize the time to scale, improve product success rates and promotional effectiveness, and enjoy sustainable and profitable growth. With open innovation providing unlimited opportunities, the company should start to identify the best open innovation opportunity and deliver top and bottom line of the company's benefits. The companies must first focus on the needs of their customer, continually minimize time to scale, eliminate waste, drive out costs and improve. These are core concepts of a Lean strategy. This paper will describe how Lean concept with PLM business strategy can leverage Lean with integrated compliance, continual improvement and other PLM best practices to increase the return on R&D investments and provide sustainable and profitable growth for business processes mainly manufacturing processes. The purpose of this paper is to review PLM approach linked to Lean concepts in order to achieve sustainable and innovative business processes with sustainable and profitable growth.*

ABSTRACT: *The business is experiencing intense development of standardization in the first decade of the 21st century. So far developed dozens of standards / models and recommendations for management systems, which are now applied separately or integrated with one or more standardized management system. The basis for the development of standardization of business was a series of ISO 9000, which has now reached that stage IV of development. The basis for their development from the year 2000 are principal quality management, their eighth We can also say that they are - the principles of quality management have always been the basis for the development of other models and standardized management system, which in this work and investigated. Namely, to determine what is the relationship between them and the practice of IMS applications in the Serbian economy, which in this paper and in detail and illustrated.*

ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering, Fascicule 1 [January-March] is a volume dedicated to THE 3rd INTERNATIONAL SCIENTIFIC CONFERENCE – MANAGEMENT OF TECHNOLOGY – STEP TO SUSTAINABLE PRODUCTION – MOTSP 2011, organized in Bol, Island Brac, CROATIA (8–10 June 2011). In this sense, ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering, Fascicule 1 [January-March] includes nine scientific papers which was presented in the Conference's sections. The new current identification numbers of papers are #11 – 19, in the content list.
Also, ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering, Fascicule 1 [January-March] includes three scientific papers presented in the sections of Conference on INDUSTRIAL SYSTEMS 2011 – IS '11, organized in Novi Sad, SERBIA (14 – 16 September 2011). The current identification numbers of papers are #20 – 22, in the content list.
ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering, Fascicule 1 [January-March] includes, also, original papers submitted to the Editorial Board, directly by authors or by the regional collaborators of the Journal [papers #1-10, and 23-25].

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SURFACE FINISH ANALYSIS OF WEAR ON TRIBOLOGICAL FACILITY

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ABSTRACT: *Laws of the cutting process create the required shape and size components constitute the essence of the machining process. Removing material in the form of chips by cutting affects the accuracy of dimensions, geometric shapes and surface quality. Surface quality is a complex concept characterized the surface integrity. Surface integrity is a summary statement of the conditions of production of functional areas, technologies used and their effect on the properties of machined surface. Efforts to complete concept of quality of surface layer (surface integrity) is starting to take only in recent decades. It is based on the technological processes and their effect on the depth and distortion of the surface layer. The parameters value of surface quality of machine parts is to be found in the production technology itself, particularly in machining. The geometry of machined parts is different from the ideal geometry entered drawings. On the machined surface generated micro roughness. The force effects of cutting tool during operation, then the thin layer of the machined surface deforms. As a result of deformation and heating of the surface layer heat (heat- that is always accompanied by a machining process) are formed in this layer of tension and change and its physical and mechanical properties. The task of examining the surface integrity is to create new theories in light of current trends in technological practice, thus improving the functionality of the qualitative component surfaces.*

KEYWORDS: *Hard turning technology, grinding, surface integrity, surface functionality, tribological characteristics, radial wear, friction coefficient, friction force*

INTRODUCTION

It is necessary to know the wear mechanisms that occur during the machining of metallic materials, in our case the machining of hardened steel. These wear mechanisms allows us to examine the tribological analysis. This concept was introduced in 1966 by Mr. Jost [5]. Tribology is therefore the notion that science and technology, independently of one another have begun exploring the friction surface to each other and develop their corresponding technological processes. Tribology therefore contains branch of friction, wear and lubrication. The structure of a tribological system consists of four basic elements: the base body, acting against the body, surrounding medium and the surrounding environment.

For these elements operates stressed summary consisting of the normal force "F_n", cutting speed "v_c", time and temperature stresses. If we transpose these conditions the machining process, then the resulting system "tool basic element" - along with the outgoing chips - acting against the body. It called "substance" may affect the type of friction against the base body and the body, further cooling substances such as particles with a chemical reaction between the various system elements. Surrounding medium is generally air, being right on the tip of the cutting knife can be expected vacuum. Different is defined as usual "open" and "closed" tribo-system. We can talk about an open system, when the basic body is permanently in contact with the new material acting against the body. Thus, they look almost all machining processes. In contrast, the principle of closed tribological system can be defined when the body repeatedly against the same-material comes into contact with the main body. Tribological interaction parameters resulting physical and chemical processes, which are reflected in four main mechanisms: adhesion, abrasion, surface quality and tribo-chemical responses [5]. The authors [1] carried out research on the tribological characteristics of thermally processed steels. In this paper, the research by the authors [4] deals about the field of heat-treated steels turned hard with cutting ceramics CC6050 dry cooling, as well as authors like to compare the measured and calculated values of hard turned and sanded samples.

MEASUREMENT OF FUNCTIONAL SURFACES OF COMPLEX VARIABLES STUDIED STEELS

Tribological test device used to measure the adhesive wear of machined surfaces of cylindrical test samples, test samples were therefore designed to specific dimensions because of wear measurements.

The main part of the friction knot, which consists of two elements operating thrust perpendicular to the rotating sample from both sides. These elements are the friction generated by the touch screen just under the surface of the specimen, i.e. grinding disc-shaped samples of cast iron casing and lapping using diamond paste. Pinch elements are hardened steel, tungsten carbide HW-K10. Each element applied to the specimen contact force, which can be set in the range of F_N = 0 to 650 N. The force is exerted by the pressure springs. Union member, in which the pinch elements, provides the same thrust of both elements.

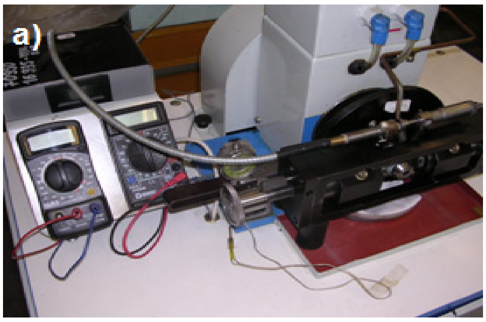

Fig.1a: Apparatus for determining the operation [authors]

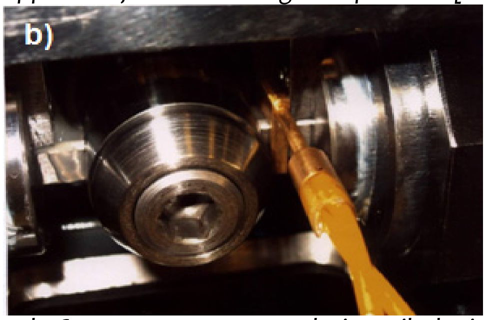

Fig.1b: Course measurements during tribological characteristics [authors]

Test sample was deployed to the shaft and the screw facing upline cut forehead and then centered. Shaft speed of the test sample provides us the electric power P = 0.25 kW. Belt drive allows you to change speed in 3 stages. Lubrication and cooling of the friction node provides a cooling system with pump and tank with a trickle of equipment, so I can vary the intensity of lubrication (cooling). How a coolant I used emulsion DASCOL 2500 (ARAL) - E5%.

The test facility allows you to monitor and evaluate the wear test specimen diameter, frictional force (F_t), coefficient of friction (μ) and temperature in the friction node (°C) continuously in arbitrarily long time (up to 300 min = 5 hrs).

Wear surface of the samples was measured by inductive proximity sensor associated with the friction elements. Value is measured by inductive transducer converted into an electrical signal fed to a digital meter. It shows the measured value on display.

Temperature measurement was carried out using a thermoelectric temperature sensor and the value (height) is shown on the display of the other device.

Measurement of frictional forces (F_t) and the reaction force (F_r) is secured by means of resistance strain gauges placed on the arm firmly connected with the drag plate and at the same time was also controlled by a graduated U-dynamometer sentinel watches that measure the movement of the dynamometer arm.

Measurement of tribological characteristics of samples from heat-treated steel construction turned dry, turned with coolant and round grinding was carried out in conditions on tribological devices designed for the Department of machining and assembly in Trencin. The duration of each test was set at 300 min. Test equipment continuously evaluates reaction force and temperature in friction knot. For the calculation of the coefficient of friction and drag force are based on the structural design of friction tribological test device node. [4]

To calculate the friction coefficient the equation:

$$\mu = \frac{F_R . l}{F_N . D} \qquad (1)$$

where: F_R - drag force [N]; l - distance sensor drag force from the axis of the sample (l = 0,147 m);
D - outer diameter of the sample [mm]

During the different tests at the selected contact force F_N and the sliding speed I recorded the value of drag force F_R [N] and the friction temperature T [°C] and the final radial wear D_d [mm]. From the measured drag force we find F_R F_T frictional force by the relation:

$$F_T = \mu . F_N \qquad (2)$$

where: F_T - friction force [N]; F_N - contact force [N]

RESULTS OF TRIBOLOGICAL TESTS

The charts shown in the following pages are documented measured and calculated values tribological samples from cultivated material 102Cr6 hard but also conventional turning (for comparison, since the authors [2, 3] studied only uncooked, steel) and round grinding. Each measured and calculated value but is in fact the arithmetic mean of 3 values.

Table 1: steel 102Cr6 dry hard turned, F_N = 500N

t [min]	ΔD [μm]	T [°C]	F_T [N]	μ[-]
0	0	20	81,75	0,1638
1	2	25	77,28	0,1546
2	4	35	77,28	0,1546
3	8	45	76,13	0,1523
4	11	52	73,71	0,1474
5	20	56	72,56	0,1451
7	25	55	72,56	0,1451
12	34	53	72,56	0,1451
15	39	58	72,56	0,1451
20	47	55	71,35	0,1427
25	55	54	70,77	0,1415
30	60	58	70,14	0,1403
45	71	58	68,3	0,1366
60	77	57	67,78	0,1356
90	82	55	64,21	0,1284
120	85	53	63,42	0,1268
180	86	56	63	0,126
240	84	60	61,85	0,1237
300	83	57	59,43	0,1189

Table 2: steel 102Cr6 hard turned with coolant, F_N = 500N

t [min]	ΔD [μm]	T [°C]	F_T [N]	μ[-]
0	0	27	83,67	0,1678
1	3	38	79,69	0,1594
2	6	52	78,49	0,1569
3	10	54	78,49	0,1569
4	12	56	78,49	0,1569
5	24	53	78,49	0,1569
7	29	54	78,49	0,1569
12	36	55	78,49	0,1569
15	51	54	78,49	0,1569
20	57	53	77,91	0,1558
25	65	58	77,3	0,1546
30	71	58	77,3	0,1546
45	75	57	78,4	0,1565
60	79	57	79,69	0,1594
90	83	59	78,51	0,158
120	81	62	78,51	0,158
180	82	59	76,13	0,1523
240	82	55	76,13	0,1523
300	80	52	74,92	0,1498

Table 3: steel 102Cr6 round grinded, F_N = 500N

t [min]	ΔD [μm]	T [°C]	F_T [N]	μ[-]
0	0	36	86,12	0,1729
1	4	55	83,27	0,1665
2	10	65	80,85	0,1617
3	12	68	80,85	0,1617
4	15	68	80,85	0,1617
5	30	69	80,85	0,1617
7	32	68	80,85	0,1617
12	40	68	80,85	0,1617
15	54	67	80,85	0,1617
20	60	68	80,85	0,1617
25	67	68	80,85	0,1617
30	74	67	80,85	0,1617
45	82	66	83,42	0,1668
60	90	64	82,06	0,1641
90	92	65	81,74	0,1635
120	94	66	80,85	0,1617
180	95	63	79,69	0,1594
240	93	60	78,49	0,1569
300	94	58	76,13	0,1523

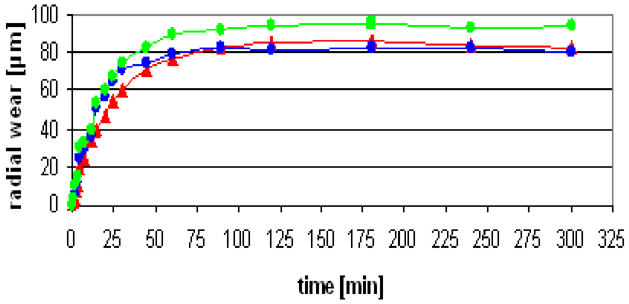

Figure 2a. Complex tribological characteristics of samples of material 102Cr6. The radial wear vs. time

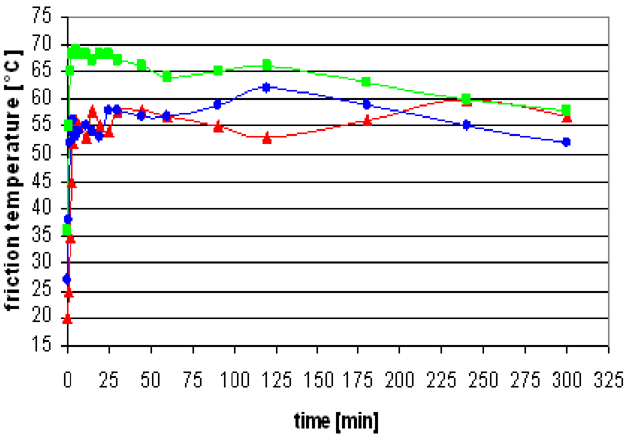

Figure 2b. Complex tribological characteristics of samples of material 102Cr6. The friction temperature vs. time

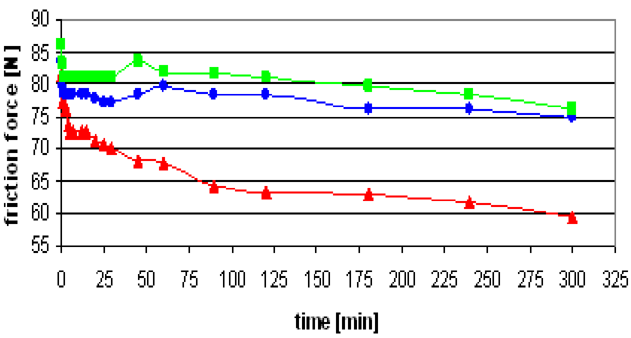

Figure 2c. Complex tribological characteristics of samples of material 102Cr6. The friction force vs. time

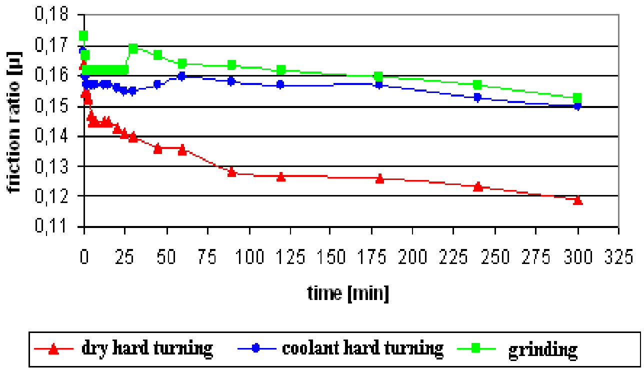

Figure 2d. Complex tribological characteristics of samples of material 102Cr6. The friction ratio vs. time

CONCLUSIONS

Tribological tests were performed on tribological equipment with cooling (see Fig.1, b). Performed experiments confirmed the fact about machined parts surface hardness, then is more slowly wear out. The tribological characteristics of the individual measurements of hardened steel and a comparison chart of the tribological characteristics based on the following findings:

- *ΔD radial wear of samples measured is always the largest recess after grinding, which may explain the slightly greater roughness of the sanded surfaces and thermal affection where there is a tempered martensite structure, unlike the hard turned surfaces.*
- *turning on hard surfaces is not a significant difference in ΔD between samples turned dry or turned with coolant application.*
- *at the grinded surfaces is the largest and the friction force and coefficient of friction.*

The experimental measurements for selected hardened steel shows that in terms of technological progeny of wear surfaces in tribosystems (adhesive wear) is particularly effective in supporting and microgeometry share when worn as well as influencing surface after machining (hardening, respectively. slack for turning small and large tempered layer after grinding recess), i.e. hardness of the coating.

While the literature sources are not present data and examples of the functionality of the machined surfaces of hardened steel. Our accomplishments, although do not give complete information, but watching the other shows the direction in machining the same material, such as turning a polycrystalline cubic boron nitride and compared with the longitudinal grinding precise definition of cutting conditions. Previously documented changes of microgeometry, microhardness and structure indicate a possible change in performance of surfaces, which was confirmed by tribological tests on all kinds of materials selected.

Acknowledgment

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ADVANCED TREATMENT OF PHARMACEUTICAL WASTEWATER BY NANOFILTRATION AND OZONATION

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ABSTRACT: *In this research, we aimed at treating the pharmaceutical wastewater, applying two systems that combined: ozonation- nanofiltration. We investigated the effect of ozonation before the nanofiltration. Pharmaceutical wastewater were treated with ozone, and the effects of the ozonation time and the flow rate on the flux, the membrane fouling and the COD retention were measured. The fouling of the NF DL membrane was studied. We compared the observed permeate flux during filtration with conventional nanofiltration (no preozonation), and with hybrid ozonation–nanofiltration process. In the filtration tests with ozonation, the permeate fluxes and the removal of the organic compounds was higher than that seen without ozone pretreatment. These results demonstrate the effectiveness of the hybrid system compared to the conventional polishing configuration.*
KEYWORDS: *Pharmaceutical wastewater, nanofiltration, ozonation*

INTRODUCTION

Wastewater of pharmaceutical industry is characterized by high organic matter contents, toxicity, deep color, and high salt contents. The removal of these contents from the pharmaceutical wastewater has been a big task of the most industrial park wastewater treatment plants in Hungary. The treatment of pharmaceutical wastewater requires some complementary techniques that could efficiently remove pollutants and enable the wastewater to be discharged into receiving water or be reused for industrial purposes (Xinyu et al., 2010). Membrane processes such as nanofiltration (NF) with high efficiencies in removing organic and inorganic pollutants can overcome the shortcomings of the traditional methods. The membrane separation processes offer various advantages, e.g. a compact system, easy control of operation and maintenance, and low needs for chemicals. The main limitation of the membrane processes is the flux decline caused by membrane fouling, which may result from plugging of organic and inorganic materials in the membrane pores (thermal water). Membrane fouling is a main obstacle to the application of membrane techniques in pharmaceutical wastewater treatment (Byung et al., 2007). Ozonation is considered to be one of the most promising processes with which to control the levels of organic pollutants in wastewater. Several studies have also been published on ozone pretreatment prior to membrane filtration. These studies have shown a decrease in membrane fouling when the filtered effluent was first degraded by ozone. (Mika et al., 2008 and László et al., 2009). Ozone has been reported to improve filtration efficiency. This effect has been called, among other things, microflocculation or ozone microflocculation (Langlais et al., 1991). By combining the oxidation characteristics of ozone and membrane technology, a better quality of water is expected to be produced more easily and at lower cost (Norman et al., 2008).

Ozone is a very powerful oxidant for water and wastewater treatments, and once dissolved in the water, reacts with a high number of organic compounds in two different ways: by direct oxidation, as molecular ozone, or by indirect reaction, through the formation of secondary oxidants such as free radicals, especially hydroxyl radicals (Byung et al., 2007). By means of ozonation, it is expected to achieve great color and COD eliminations and an increase of the biodegradable organic carbon for later physical or biological stages (Benítez et al., 2008).

In this work, experimental study on NF for advanced treatment of a real complex pharmaceutical wastewater was carried out. The primary aim of this research was to assess the potential use of an integrated ozone and NF process for improving the NF performance in a preozone-NF hybrid scheme. The role of ozonation was specifically examined, focusing on the followings: (1) the reduction of fouling due to the integration of ozonation prior to the NF membrane process and (2) the oxidation efficiency both before and after the NF process.

MATERIALS AND METHODS

The wastewater was collected from a pharmaceutical processing plant in Hungary whose is characterized by high organic matter contents, toxicity, deep color, and high salt contents (Table 1.).

We evaluated the feed water quality and monitored the process quality. The plant discharge the treated waste water to a dead channel, the limit for COD of treated water is 150 mg/L.

Table 1. Characteristics of the raw water

	Conductivity (µS)	COD (mg/l)	Turbidity (NTU)
Raw water	2250	1387	23

First time we used ozone pre-treatment prior to membrane filtration. The ozone gas was generated from oxygen (Linde, 3.0) by the Ozomatic Modular 4 ozone generator (Wedeco Ltd., Germany). The actual generated ozone-gas output was controlled by the inlet air flow rate as regulated by a rotameter to within 1-3 $dm^3\ min^{-1}$. The ozone-containing gas was bubbled continuously through a 6.0 dm^3 batch reactor during the treatment. The treatment time was 10, 20 min. The ozone concentration of the bubbling gas was determined with a UV spectrophotometer (WPA Lightwave S2000) directly at 254 nm, before and after the passage through the reactor (Table 2.).

Table 2. The absorbed ozone concentration

Time / Flow rate	10 min	20 min
1 $dm^3\ min^{-1}$	16.58 mg	23.45 mg
3 $dm^3\ min^{-1}$	4.86 mg	6.17 mg

After the ozonation the solution was supplied to the membrane system. A laboratory-scale apparatus was applied in the experiments. A tubular membrane with a filtering surface area of 0,024 m^2 was placed in the NF module. Polyamide film membrane with 75% $CaCl_2$ retention, were used for nanofiltration. All measurement was carried out at 8 l/min cross-flow velocity, 30 bar transmembrane pressure and 25°C temperatures.

Table 3. Characteristics of the membrane

Membrane	Material	Max. pH
AFC30	Polyamid film	1.5-9.5
Max. pressure	Max. temperature	Retention
60	60	75% $CaCl_2$

As the filtration process continues, fouling will eventually occur. This causes the permeate flux to decay with time. The decaying permeates flux is described by the power law:

$$J = J_0 t^{-k} \quad (1)$$

where t is time, J_0 is the initial flux and k is the fouling rate constant. Both J_0 and k can be calculated from the measured data by using the curve-fitting technique (Kertész et al., 2008).

Determination of the COD was based on the standard method involving potassium-dichromate oxidation; for the analysis, standard test tubes (Lovibond) were used. The digestions were carried out in a COD digester (Lovibond, ET 108); the COD values were measured with a COD photometer (Lovibond PC-CheckIt). The absorbance of solutions at 255 nm relating to the presence of humic substances was measured with a UV spectrophotometer (WPA Lightwave S2000).

RESULTS

We investigated the effect of ozone pretreatments before the NF. The flux is shown in the function of the time of the NF in Figure 1. It was found, that the ozone pretreatments were effective, the ozone treatment improved the flux values. The ozone dose at the applied ozone concentration range had not affected significantly on the flux. The results show that, the lower absorbed ozone amount caused higher improving in the flux. The highest flux values obtained with the 4.85 mg/l absorbed ozone dose.

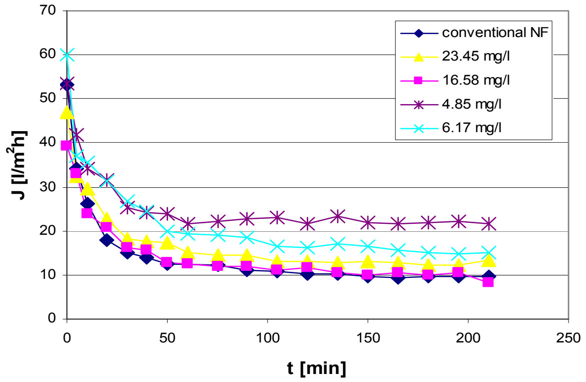

Figure 1. Effect of ozone dosage on permeate flux

The average permeate fluxes (J) shows the filterability of the solution. (Figure 2) These results are in accordance with the fouling index (k) results: ozone treatment results increased permeate flux and decreased fouling index. The k can be calculated from the measured flux data by using a curve-fitting technique. It was found, that (in accordance with the permeate fluxes) ozone treatment decrease the fouling index. The ozone dose has no significant effect on the k, but the lower ozone doses results no significant decreasing in fouling of membranes. These results confirm the suppose that the ozone treatment have microflocculation effect on the particles of the waste water, the larger flocculated particles can not move into the membrane pores, resulting decreased fouling index. It may be remarkable result for the practice of the membrane techniques, because the decreased fouling of membrane pores may results increased membrane life-time.

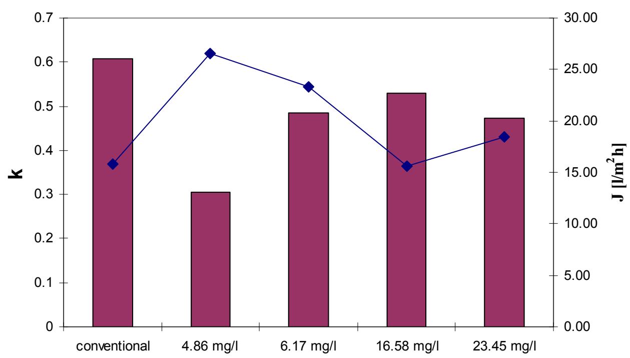

Figure 2. Effect of ozone dosage on the membrane fouling

The hybrid technology decreased the COD of the solution from 1300 mg/l below 50 mg/l in each sample. It was found, that the efficiency of COD removal improves with the ozonation. The higher ozone flow rate caused higher COD decrease, even if the ozone dosage was smaller. The higher COD retention at higher flow rate may be explained by microflocculation effect of ozone treatment. The ozone treatment cause the microflocculation of the particles, the greater particles can be filtered from waste water with better efficiency. The higher ozone concentration does not cause significantly smaller COD removal.

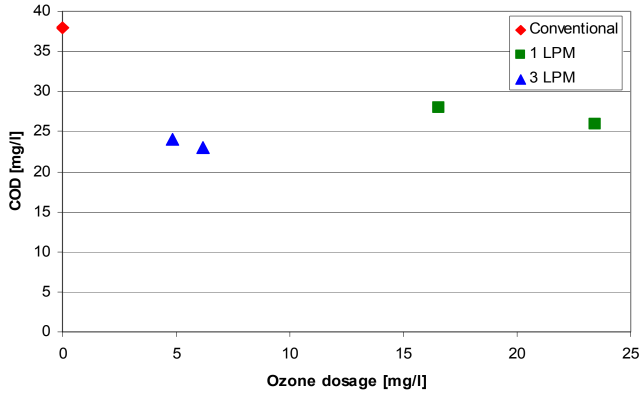

Figure 3. Effect of ozone dosage and flow rate on the COD in the permeate

Finally, it is also interesting to establish the partial contribution of the two stages individually considered to the global effectiveness of the combined process. These contributions are represented in Figure 4. Thus, the NF membrane process stage provided a major contribution in the three pollutant parameters, while the ozonation stage contributed in a less extent in the three remaining indices. The removal of COD during the ozonation stage provided higher contribution.

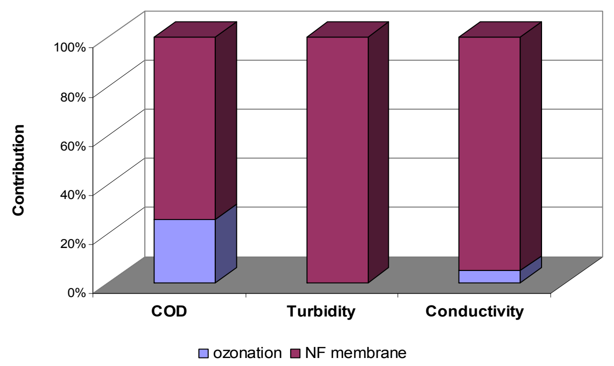

Figure 4. Contributions of the global removal int he ozonation and NF membrane combined process

SUMMARY / CONCLUSIONS

The effectiveness of a combination of the membrane separation technique and ozone treatment was investigated for the removal of COD from pharmaceutical waste water. The results obtained by examining the effect of ozone treatment on filterability of the waste water show that the ozone pretreatment enhanced the flux and decreased the fouling during membrane filtration. This phenomenon can be explained by microflocculation effect of ozone treatment. This means also that the decreased fouling of membrane pores may enhance the life-time of the membrane.

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ON THE INTEPRETATION OF SHEAR WAVE VELOCITY FROM BENDER ELEMENT TESTS

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ABSTRACT: *Shear wave velocity measurement using bender elements has become more widely adopted in determining the small strain shear modulus (G_o) of soil specimens in recent years. Apart from being a non-destructive and hence easily repeatable test on the same specimen, the adaptability of the bender element transducers for installation in existing test apparatus has also helped popularize the method. With a pair of bender elements, i.e. a transmitter and a receiver, and the assumption of a homogeneous and elastic medium, the shear waves' transmitter-to-receiver travel time is measured, hence giving the shear wave velocity (velocity = transmitter-receiver distance / travel time). Taken in the plane wave propagation context, G_o is conveniently computed as a multiplication of the specimen's bulk density and square of the velocity. Unfortunately simplicity of the test procedure does not extend to the actual characteristics of shear wave propagation through the specimen, which inadvertently affect the received signal for reliable arrival time interpretation. Various factors contribute to distort the received signals and mask the accurate identification of arrival time. These factors were individually examined in this study with unconfined specimens, which were prepared from cement-stabilized artificial kaolin clay. A pair of 80 mm high cylindrical specimens, with 76 mm and 100 mm diameter respectively, was subjected to the shear wave velocity measurements using bender elements. It was found that these influencing factors can be categorized under those of the input frequency, specimen geometry, near-field effects and attenuation of the sent waves. Discussions based on the signals analyzed are presented under each of these categories, and the effects on the shear wave arrival time were assessed. While no best method for identifying the arrival time could be ascertained, a conclusion not dissimilar with reports by other researchers in similar endeavors over the years, these insights can be useful and instructive to minimize uncertainties when using this convenient measuring tool.*
KEYWORDS: *bender elements, shear wave, velocity, stabilized soil*

INTRODUCTION

A bender element test essentially involves sending elastic waves through a specimen to cause transient perturbation to the particles, of which the resistance encountered by the induced vibration is translated as stiffness of the material.

The elastic waves can be compression waves (also known as P-waves), or shear waves (other names include S-waves and transverse waves). The temporary disturbance is observed as being parallel to the direction of the wave movement if a compression wave is transmitted, and perpendicular if it is a shear wave. Logically, a stiffer material would accelerate the wave propagation through the medium. Putting these wave motions in the assumed and simplified context of plane waves passing through a homogeneous, elastic and isotropic medium, the module of stiffness at such small strains can be derived as bulk modulus, $K = \rho v_p^2$, and shear modulus, $G_o = \rho v_s^2$, respectively (ρ = bulk density, v_p = compression wave velocity, v_s = shear wave velocity).

Setup for a bender element test mainly consists of a pair of bender element probes (i.e. a transmitter and a receiver), with the transmitter connected to a function generator, the receiver plugged into an amplifier, and both transducers linked to an oscilloscope, as shown in Fig. 1. Similar setups were used by Leong et al. [1], Hird and Chan [2], Yang et al. [3], Lee and Huang [4], Clayton et al. [5].

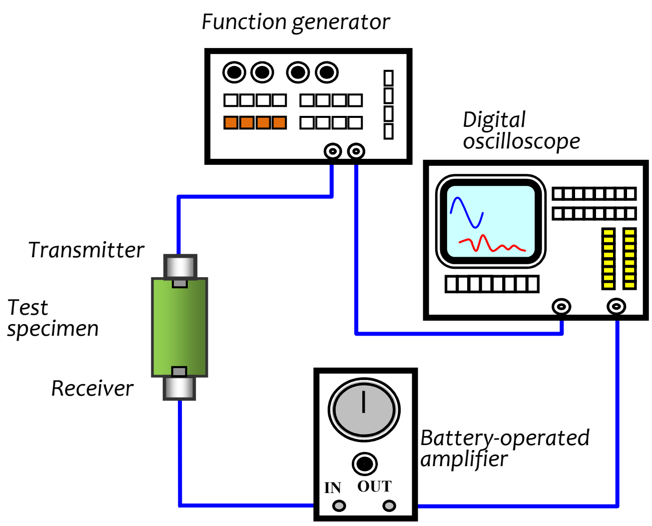

Figure 1. The bender element test setup

Later improvements which replaced the external controllers with specific computer programs and data acquisition cards were demonstrated by researchers like Chan et al. [6] and Boonyatee et al. [7]. Nevertheless the basic principles of shear wave velocity measurement remain the same: the transmitter is powered up by a function generator to vibrate, while the receiver picks up the vibration across the medium on the opposite end and begins to vibrate itself. Bender elements, coming from the family of piezoelectric ceramics, are capable of generating an electrical output when subjected to a mechanical deformation (hence the receiver) and vice *versa (the transmitter). The amplifier used in the original setup mentioned earlier was meant to amplify the received signals as representing the receiver's vibration is significantly smaller compared to the transmitted signal.*

The shear wave arrival time is next determined from both signals captured on a timescale plot, either by direct identification, as with the time domain methods, or with further manipulation in the frequency domain. In recent years, there have been a number of attempts to accurately define the shear wave arrival time in bender element test. For instance, Leong et al. [1], Hird and Chan [2] as well as Lee and Huang [4] have explored shear wave arrival time definitions in the time domain, while Boonyatee et al. [7] and Arroyo et al. [8, 9] experimented in the frequency domain. Some of the work described in the literature also revealed efforts in establishing the configuration effects of bender elements in the resulting signal interpretations. In addition, most of the bender element measurements were incorporated in conventional or specially built test cells and apparatus, as an additional monitoring tool during the primary tests.

This paper discusses the main factors affecting the interpretation of shear wave velocity using bender elements in unconfined specimens, specifically. As bender element test has been widely acclaimed as a quick and simple test to conduct for measure the small strain shear stiffness of a soil material, the use of the transducers without incorporation in an existing apparatus remains relevant. This is particularly so in the quality control of stabilized soils, where bender element tests can be conveniently carried out on unconfined specimens prior to routine compression tests, e.g. Mokhtar and Chan [10], Chan [11] and Mattsson et al. [12].

EXPERIMENTAL WORK

Test Specimens

The test specimens were a pair each of cement-stabilised kaolin cylinders, 76 mm in height, 38 mm (i.e. specimen S1 and S2) and 114 mm (i.e. specimens L1 and L2) in diameter respectively. Pre-mixed in dry forms of kaolin powder and ordinary Portland cement (3 % based on weight of kaolin powder), 50 % of water (also based on weight of kaolin powder) was then added to produce a uniform mix in a food mixer. The mixture paste was next transferred to split mould, compacted using miniature hand tools with combined kneading effect in 3 layers. When extruded from the mould and with the ends trimmed off, the specimens were wrapped in cling film and cured in a moist chamber for the same period of time before tests. A slot 12 mm long x 3 mm wide x 7 mm deep was formed by inserting a Perspex block at each end of the specimen. The slots were later used for insertion of the bender elements, with plasticine used as the coupling agent. This was necessary as curing significantly stiffened the specimen and made it impossible to insert the bender elements without damaging the transducers or the specimen.

Shear Wave Velocity Measurements

The transmitting bender element or transmitter was excited with ±10 V single cycle sine pulses of frequencies ranging between 1-20 kHz using the Thandor TG503 function generator, which was triggered by a separate function generator, Continental Specialities Corporation Type 4001. The received signal, as detected by the receiving bender element or receiver, was amplified through a battery-powered amplifier. This inadvertently reversed the polarization of the signal but was conveniently rectified with the oscilloscope. The transmitted and received signals were both captured on the Tektronix TDS3012B digital phosphor oscilloscope (100 MHz, 1.25 GS/s) and the digitized data were processed in spreadsheets for further analysis described later. The penetration dimensions of the bender element transducers on both ends of the specimen were 12 mm wide and 7 mm long. Two cables were connected to the transducers, a coaxial cable for the electrical connectivity, and an additional cable for earthing purposes. Shielding and earthing were crucial to avoid electromechanical interference, which can distort the received signals and complicate determination of the actual shear wave arrival time [1].

FACTORS AFFECTING INTEPRETATION OF SHEAR WAVE VELOCITY

Input Frequency

The input frequency (f_{in}) was used to compute the wavelength, $\lambda = v_s/f_{in}$, where v_s is the shear wave velocity determined using the visually picked arrival time. The wavelength (λ) is therefore dependent on the frequency with which the transmitting bender element was excited with during the test, assuming that it was also the dominant frequency in the received signal. Note that this is not always the case. Yamashita et al. [13] compiled results from international parallel bender element tests and concluded that the change in input frequency does not result in corresponding or proportional change in the frequency of the received signal. Therefore the assumption is unlikely to hold true, implying the inherent errors of some shear wave arrival time determination methods (e.g. cross-correlation) which involve matching up the transmitted and received signals.

Lutsch (1959) and Thill and Peng (1969), as reviewed by Leong et al. [14], highlighted the obscuring of the first major deflection in the received signal if the wavelength is equal to the average grain size, taken as

D_{50} (grain diameter with 50 % material passing on the particle size distribution curve). Also, the ratio of λ/D_{50} is recommended to be more than 3 to avoid dispersion in ASTM Standard 2845-95 [15]. The wavelengths in the present tests ranged between 13 - 300 mm for S1 and S2, 14 - 100 mm for L1 and L2 (Table 1).

Table 1. Influence of input frequency on dispersion and attenuation

Specimen S1							
fin kHz	to ms	vo ms-1	λ m	L/λ L = 61 mm	L/D	D/λ	Go MPa
1	0.260	235	0.235	0.260		0.162	94
3	0.250	244	0.081	0.750		0.467	102
5	0.240	254	0.051	1.200		0.748	110
7	0.240	254	0.036	1.680	1.605	1.047	110
9	0.240	254	0.028	2.160		1.346	110
12	0.230	265	0.022	2.760		1.719	120
15	0.230	265	0.018	3.450		2.149	120
20	0.230	265	0.013	4.600		2.866	120

Specimen S2							
fin kHz	to ms	vo ms-1	λ m	L/λ L = 61 mm	L/D	D/λ	Go MPa
1	0.200	305	0.305	0.200		0.125	160
3	0.220	277	0.092	0.660		0.411	132
5	0.225	271	0.054	1.125		0.701	126
7	0.225	271	0.039	1.575	1.605	0.981	126
9	0.230	265	0.029	2.070		1.290	121
12	0.230	265	0.022	2.760		1.719	121
15	0.220	277	0.018	3.300		2.056	132
20	0.240	254	0.013	4.800		2.990	111

Specimen L1						
to ms	vo ms-1	λ m	L/λ L = 63 mm	L/D	D/λ	Go MPa
-	-	-	-		-	-
0.200	315	0.105	0.600		1.086	166
0.230	274	0.055	1.150		2.081	125
0.230	274	0.039	1.610		2.913	125
0.220	286	0.032	1.980	0.553	3.583	137
0.230	274	0.023	2.760		4.994	125
0.230	274	0.018	3.450		6.243	125
0.230	274	0.014	4.600		8.324	125

Specimen L2						
to kHz	vo ms	λ ms-1	L/λ L = 63 mm	L/D	D/λ	Go MPa
-	-	-	-		-	-
0.215	288	0.096	0.645		1.186	139
0.220	282	0.056	1.100		2.023	132
0.220	282	0.040	1.540		2.832	132
0.220	282	0.031	1.980	0.544	3.641	132
0.210	295	0.025	2.520		4.634	145
0.200	310	0.021	3.000		5.516	160
0.200	310	0.016	4.000		7.355	160

f_{in}=input frequency (kHz)
t_o=shear wave arrival time (visually picked) (ms)
v_o=shear wave velocity (based on visually picked arrival time) (ms^{-1}); λ=wavelength (m); L=shear wave travel distance (tip-to-tip of bender elements) (m)
D=diameter of specimen (m)

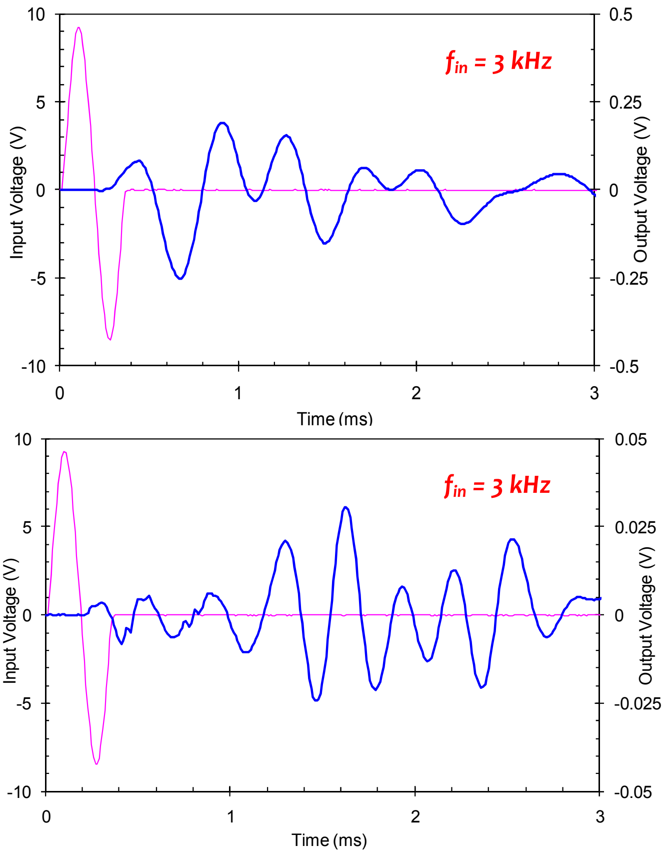

Figure 2a. Transmitted and received shear waves for specimens S1 (up) and L1 (down)

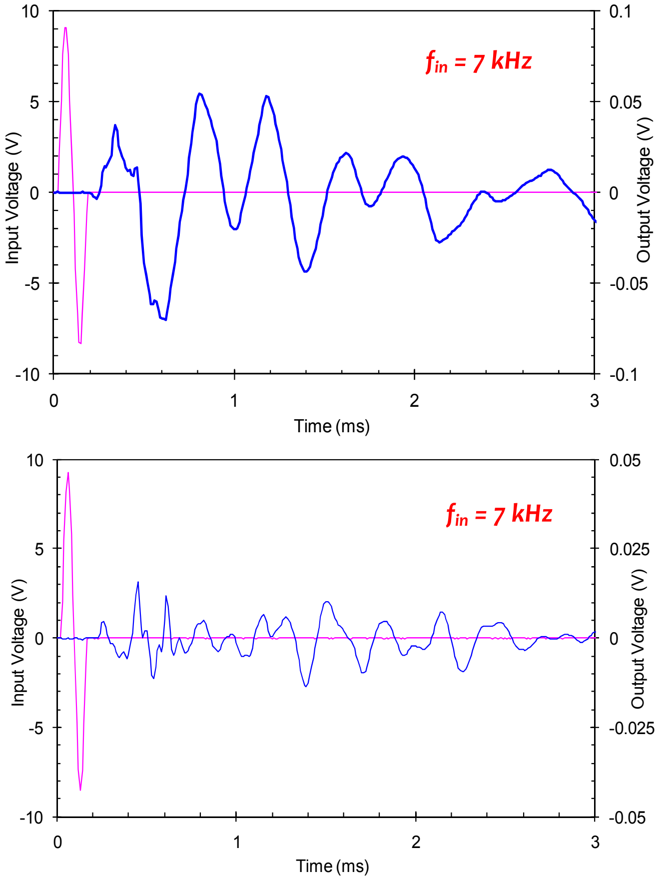

Figure 2b. Transmitted and received shear waves for specimens S1 (up) and L1 (down)

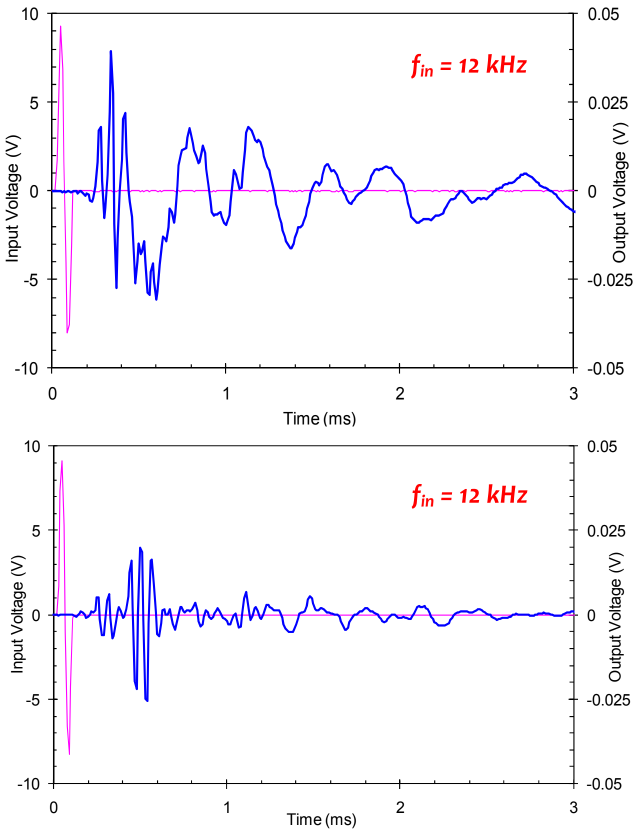

Figure 2c. Transmitted and received shear waves for specimens S1 (up) and L1 (down)

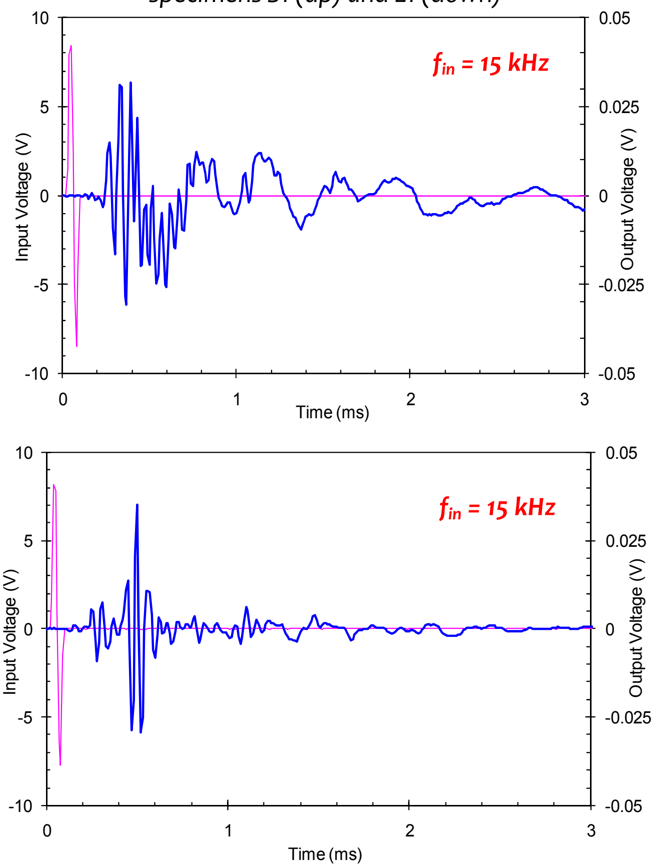

Figure 2b. Transmitted and received shear waves for specimens S1 (up) and L1 (down)

Considering that the specimens were essentially composed of clay particles with small quantities of cement, D_{50} could be assumed to be sufficiently low, satisfying the criteria recommended in both sets of test specimens. This contributes to the clearly discernible shear wave arrival time on the received traces for both pairs of the specimens, Figure 2.

It is also apparent from Figure 2 that higher input frequencies (f_{in}) tend to introduce interference to the received signal prior to the first positive major deflection. In some cases, a minor negative deflection can be observed to precede the positive departure (e.g. specimen S1, f_{in} = 7 kHz). Strength of the received signals also diminished with increased f_{in}. These behaviors are further discussed and explained in the following sections.

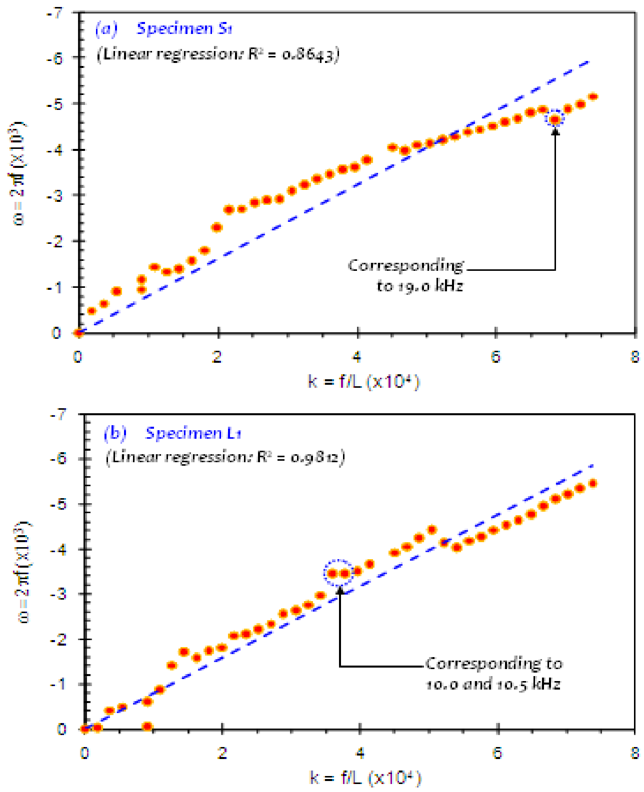

Figure 3. Dispersion plots for specimens (a) S1 and (b) L1; f_{in} = 7 kHz

Specimen Geometry

As soil is an attenuating medium, an excessive travel distance for a low energy shear wave would significantly reduce its amplitude and mask the time of arrival at the receiver. Therefore attenuation ultimately limits the length or height of test specimens. However, the length of the specimens in the p resent test series was fixed at 76 mm, hence leaving the diameter, D, as the variable in terms of specimen geometry. The shear wave travel distance, L, was taken from tip to tip of the bender elements, as proposed by pioneers like Dyvik and Madshus [16] and Viggiani and Atkinson [17].

The ASTM Standard 2845-95 (2000) recommends the minimum specimen length or height to be at least 10 times D_{50} to accurately define the average propagation velocity. Referring to the discussions in the previous section, it can be seen that this criterion was readily satisfied in the present work.

Distortion of a signal (dispersion) can occur due to interference of reflected waves from the medium boundaries, resulting in a composite wave with various frequency components. Such an occurrence could easily obscure the arrival of the transmitted shear wave. According to Wasley [18], and as mentioned in the ASTM Standard 2845-95 [15], the lateral dimension, i.e. D, should exceed the wavelength, λ, by at least 5 times (D/λ ≥ 5) in order to avoid such dispersion.

From Table 1, it is shown that S1 and S2 barely meet the requirements even with high frequencies, whereas L1 and L2 do, but only at frequencies higher than 12 kHz. In the corresponding dispersion plots, Fig. 3, the linearity of the plots improves at higher frequencies, indicating a reduction of dispersion effects. However, with closer inspection, it can be seen that Fig. 3(a) depicts a non-linear trend, indicating varying group and phase velocities with frequency, while Fig. 3(b) shows better linearity and hence less dispersion.

Based on the analysis and discussion above, it is clear that lateral boundaries have a significant effect on how well the received signal represents the transmitted signal, in terms of frequency content. When the diameter of a cylindrical specimen is restricting the free propagation of waves through the specimen, a phenomenon that is comparable to 'waveguide effect' is observed. The further the distance of the boundaries is in the direction of polarization (perpendicular to the direction of propagation) of the shear wave, the less prominent is the effect of lateral rebounds and distortion of the propagating wave. That explains why dispersion plots from the larger specimens display better linearity than those from the smaller specimens.

On the other hand, Chan et al. [6] experimented with isotropically consolidated Kasaoka clay specimens of different diameters (i.e. 33, 40 and 50mm) but with a constant height/diameter ratio of 2, and found that there was no difference in the shear wave velocity measured in all the specimens (f_{in} = 5 kHz, L/λ > 2). Lateral rebound and waveguide effects were apparently absent in their studies, though the diameter difference was arguably much smaller compared to those of the present study. This could be a factor of the negligible differences reported.

Near-field Effects

Most of the traces showed the presence of near-field effects in varying degrees, where the first deflection of the received signal is reversed, Fig. 2. This is primarily attributed to a shear wave component traveling at the velocity of compression wave, with an early arrival prior to the actual shear wave. Sánchez-Salinero et al. [19] suggested keeping the ratio of L/λ between 2 and 4, where the lower limit was meant to avoid near-field effects, and the upper limit was to cater for attenuation via damping (discussed in later section). More recently Leong et al. [1] recommended an increase of the lower limit to 3.33.

The L/λ values for both sets of specimens only fall within between 2 and 4 when frequencies are higher than 9 kHz (Table 1), with corresponding diminished the near-field effects. To meet the criteria of Leong et al. [1], however, f_{in} must be higher than 15 kHz (Table 1). Jovičić et al. [20] recommended mechanical remediation which involved manipulating the shape and frequency of the input shear wave. However it was thought that such manipulations could not only be inconveniently time-consuming, but could also adversely increase the subjectivity of the interpretation method.

Looking at the discussions so far, since D/λ ≥ 5 is necessary to avoid lateral rebound and waveguide effects, and L/λ > 2 is satisfied to keep off near-field effect, then logic follows that the lower limit for λ ought to be ≥ 5D. Most test specimens have aspect ratios (height to diameter) of at least 2, but these may not be wide enough to avoid lateral interference. Combining both criteria results in D/L ≥ 2.5, a ratio which is perhaps more readily met by, for instance, oedometer or Rowe cell specimens.

Attenuation

Although higher frequencies are sometimes preferred to avoid near-field effects, the guideline recommended by Sánchez-Salinero et al. [19], as discussed in the previous section, ought to be used with caution. At higher frequencies the energy-absorbing nature of soil makes it ineffective in sustaining prolonged and effective dynamic interaction between the bender element and the soil, hence resulting in attenuation. Leong et al. [1] also cautioned against high frequency input waves as the damping properties and soil-bender element interaction can cause lower frequencies in the received signals.

According to Brignoli et al. [21], input waves with f_{in} ≥ 5 kHz tend to generate received signals of considerably lower frequencies than the sent ones. This was however not observed in the present work. Frequency decomposition of both the input and output signals (via Fast Fourier transform, FFT) showed that the dominant frequency component in the output signal strongly represented that of the input signal. Cho and Finno [22] used 2-10 kHz shear waves in glacial clay specimens and reported no discordance between f_{in} and f_{out} too. Nevertheless in the present study, the amplitude of the output signal was observed to reduce with increased input frequency, which obviously indicated the effect of attenuation.

CONCLUSIONS

Various factors were found to affect the measurement of shear wave velocity, with the main ones being input frequency, specimen geometry, near-field effects and attenuation. The quality of the received signals was found to be satisfactory when the input frequency was kept high enough to achieve $\lambda/D_{50} > 3$. In terms of the specimen geometry, less dispersion was found when fulfilling the criterion $D/\lambda \geq 5$. Also, keeping the specimen height at least 10 times D_{50} helps ensures accurate definition of the average shear wave velocity propagating through the soil specimens. Near-field effects and attenuation were found to be reduced when the ratio L/λ was kept between 2 and 4. High frequency input waves, while giving the necessary wavelength for avoiding near-field effects and attenuation, should be used with caution against damping and frequency-incompatibility of the received waves.

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LEACHING OF STIBNITE BY MIXED Na_2S AND NaOH SOLUTIONS

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ABSTRACT: Kinetics of the reaction between particulate stibnite and mixed Na_2S + NaOH solutions were studied. The effects of concentrations of Na_2S and NaOH, temperature, particle size and liquid-to-solid ratio were investigated. It was observed that the rate of leaching of stibnite: a) increased with an increase in both Na_2S and NaOH concentration (from 0.5 wt. % to 2.0 wt. %), and temperature (from 292 K to 327 K); b) reached its maximum at Na_2S:NaOH molar ratio equal to 1:2; c) decreased with an increase in particle size (from 0.04 mm to 0.5 mm) and L/S ratio (from 10 to 100). The results are presented in terms of the shrinking-particle model. Calculated values of the kinetic parameters indicate that the leaching process is controlled by the chemical reaction between Sb_2S_3 and Na_2S at the liquid/solid interface. Apparent activation energy is approximately 44 kJ mol^{-1} and the apparent reaction order for Na_2S varies from 1.4 to 1.7.
KEYWORDS: stibnite, alkaline leaching, kinetics, apparent activation energy, apparent order of reaction

INTRODUCTION

From the thermodynamic point of view dissolution of antimony compounds (oxides, sulphides) can take place both in acidic and alkaline solutions, which stems from the amphoteric properties of antimony [1]. In industrial applications Sb_2S_3 dissolves in mixed leaching solutions of Na_2S + NaOH [2-10]. Alkaline Na_2S solution acts as an universal solvent for the majority of antimony compounds. On the other hand, most other metals exhibit low solubility in this solution. Exceptions to this rule would include arsenic, tin and mercury [11, 12]. Leaching of Sb_2S_3 in Na_2S solution can be described by the following chemical reaction:

$$Sb_2S_{3(s)} + 3Na_2S_{(aq)} = 2Na_3SbS_{3(aq)}$$
$$\Delta G^0_{298} = -71.41 kJ \quad (1)$$

Negative value of the standard Gibbs energy suggests that reaction (1) is feasible and spontaneous. In case that mixed leaching solution (Na_2S + NaOH) is used, sodium hydroxide reacts with Sb_2S_3 according to the reaction:

$$Sb_2S_3 + 6NaOH = Na_3SbS_3 + Na_3SbO_3 + 3H_2O \quad (2)$$

Reactions (1) and (2) describe the process of Sb_2S_3 leaching in alkaline solutions [13]. The resulting leaching solution is a complex system containing various species (Sb, S, Na), which upon reaction with water create a series of complex ions. These ions can be identified using the equilibrium pH – potential diagrams of the Sb-S-H_2O and Sb-S-Na-H_2O systems at 298 K as presented in [14]. At pH<13.6 antimony passes into solution as a complex trivalent anion SbS_3^{3-}

For non-porous stibnite particles, the dissolution of antimony during the initial stage of the process may be controlled by the surface chemical reactions (1) and/or (2), or by external mass transfer [15]. When the surface chemical reaction is a rate-determining step, high values of apparent activation energy (from 40 kJ mol^{-1} to 300 kJ mol^{-1}) are observed [16]. The non-porous shrinking-particle model in the form [17]

$$1-(1-\alpha)^{1/3} = k' t \quad (3)$$

was used to analyze the leaching process. α is the fraction of antimony dissolved, t is the reaction time and k´ is the rate parameter.

This article presents the results of the experimental determination of the effect of temperature, composition of the leaching solution, speed of agitation, liquid/solid ratio and particle size on the leaching rate of stibnite in Na_2S + NaOH solutions.

EXPERIMENTAL - MATERIALS

Natural stibnite from Pezinok (Slovak Republic) was used in the present study. Table 1 summarizes the chemical composition of the sample (in wt.%). Minor elements present in the sample (wt.%) were: 0.65% Al, 0.63% Pb, 0.37% Mg and traces of Ti, Mn, As, Sn, Bi, Hg and Ag.

Table 1. Chemical composition of the stibnite sample

Element	Sb	S	Si	Zn	Ca	Fe
Weight%	49.3	19.15	10.4	5.43	1.81	0.84

Size fractions were obtained by crushing, dry-grinding and dry-screening. The contents of antimony, silicon, iron and zinc (in wt.%) in different size fractions are shown in table 2.

Table 2. Chemical composition (in wt.%) of individual size fractions

Particle size (mm)	0.5-0.25	0.25-0.18	0.09-0.071	0.071-0.04
Sb	34.76	29.70	47.00	54.75
Si	15.46	20.62	12.66	6.14
Fe	1.12	1.01	1.01	0.90
Zn	1.03	0.86	0.73	0.52

Stibnite (Sb_2S_3) and quartz (SiO_2) were found to be the predominant mineral phases according to the results of the X–ray diffraction analysis. Accompanying minerals were identified as pyrite (FeS_2) and wurtzite (ZnS). Other mineral phases were not identified [10].

Analytical reagent grade chemicals and distilled water were used in all experiments. In each of the experiments at least three runs were made for a given set of reaction conditions.

EXPERIMENTAL PROCEDURE & EVALUATION OF KINETIC DATA

Leaching of the samples of stibnite was carried out in a 0.2 L mixed glass batch reactor at constant temperature. Constant agitation rate (equal to 10 s^{-1}) was used in all experiments. The temperature was maintained to within 1 K by a heating glass coil connected to a thermostat.

When the Na_2S + NaOH solution in the reactor had reached the required temperature, 0.4 g of stibnite sample was added. Samples (about 2 mL) of the reaction mixture were withdrawn from the reactor at appropriate time intervals, filtered and the filtrates were analyzed using AAS method.

The experiments were carried out under reaction conditions as follows: temperature from 291 K to 333 K, concentrations of Na_2S and NaOH from 0.5 wt. % to 2 wt. %, Na_2S : NaOH molar ratio equal to 1:2.

In each case of testing a fresh Na_2S+NaOH leaching solution was prepared in order to avoid its possible coagulation. In one case, however, the coagulation process appeared and was noticed visually after twelve hours in the solution containing 2 wt.% Na_2S+2 wt.% NaOH.

RESULTS AND DISCUSSION - EFFECT OF TEMPERATURE

The temperature dependence of the leaching rate was determined for size fractions 0.18–0.25 mm and 0.25–0.5 mm, at solution temperatures in the range 291 K to 327 K. A typical situation is shown in Fig. 1. It can be seen that the rate of stibnite dissolution is very sensitive to the temperature.

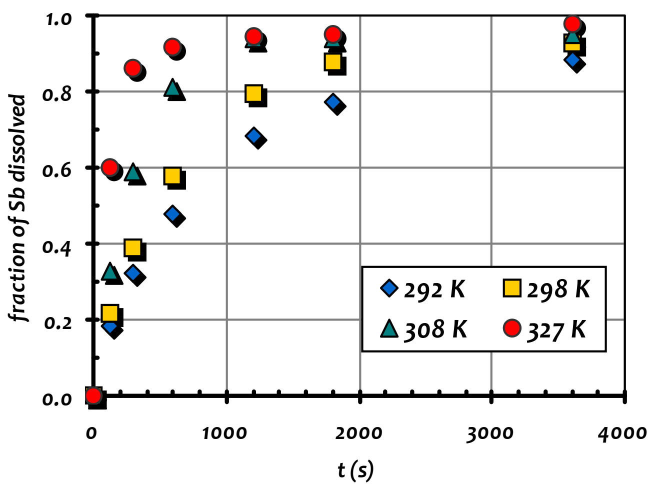

Figure 1. Effect of leaching temperature on fraction of antimony dissolved (reaction conditions: 1wt.% Na_2S + 1wt.% NaOH; particle size 0.18–0.25 mm; agitation rate 10 s^{-1}).

EFFECT OF Na_2S AND NaOH CONCENTRATIONS

The effect of Na_2S and NaOH concentrations was studied in a series of tests performed at 292 K. The experiments showed that the rate of stibnite dissolution is significantly affected by concentrations of Na_2S and NaOH. An example is shown in Fig. 2.

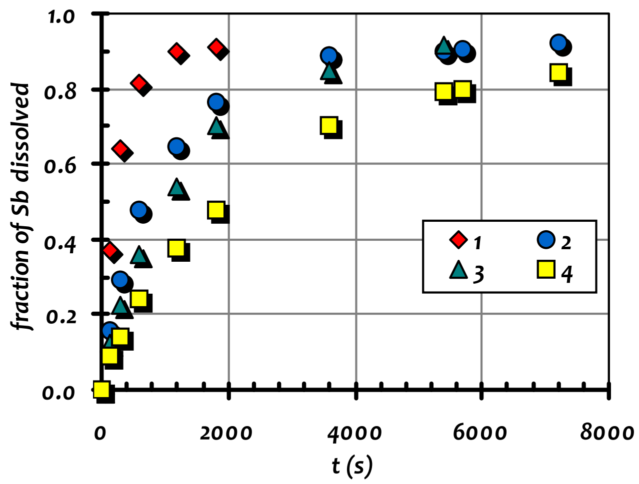

Figure 2. Effect of chemical composition of the leaching solution on fraction of antimony dissolved: 1 – (2wt.% Na_2S + 2wt.% NaOH); 2 – (1wt.% Na_2S + 1wt.% NaOH); 3 – (0.75wt.% Na_2S + 0.75wt.% NaOH); 4 – (0.5wt.% Na_2S + 0.5wt.% NaOH); (reaction conditions: T = 292 K; particle size 0.18–0.25 mm; agitation rate 10 s^{-1}).

EFFECT OF PARTICLE SIZE

The effect of particle size on the leaching behavior of stibnite at 292 K is shown in Fig. 3. It is evident that the rate of chemical dissolution of the antimony increases as the particle size decreases.

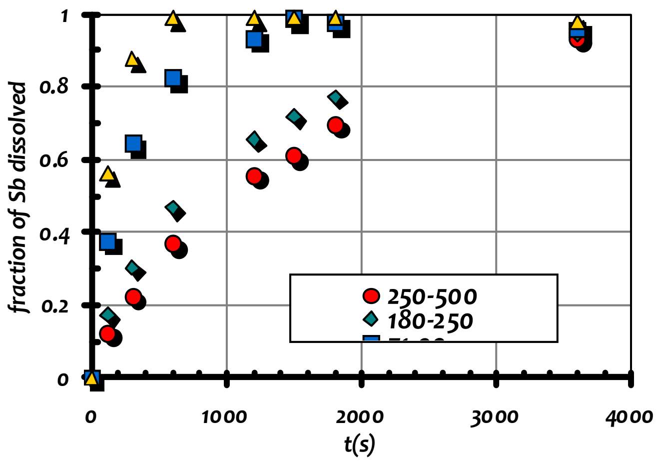

Figure 3. Effect of particle size on fraction of antimony dissolved (particle diameter in micrometers / μm) (reaction conditions: 1wt.% Na_2S + 1wt.% NaOH; T=292 K; agitation rate 10 s^{-1}).

DISCUSSION - EXPERIMENTAL METHOD

The kinetic experiments were carried out under reaction conditions characterized by a relatively high excess of Na_2S (and NaOH) in the solution, in order to eliminate possible effects of the changes in lixiviant composition during individual runs on the rate of leaching.

In this study, Na_2S : Sb_2S_3 molar ratio ≥ 18.6 was used, and the concentration of Na_2S (and NaOH) in the bulk aqueous phase was maintained constant within >85 % rel. during each run.

Some preliminary experiments were carried out with the objective to find the optimum reaction conditions for the actual kinetic measurements. The effects of the rate of agitation, liquid-to-solid ratio and the Na_2S:NaOH molar ratio were investigated; the results are shown in Figs. 4, 5 and 6, respectively. No noticeably significant effect of the first two process parameters on the rate of leaching of the original sample of stibnite (crushed and dry-milled) has been observed for the rate of agitation ≥ 8 s^{-1} (Fig. 4) and L:S ratio ≥ 50 (Fig. 5).

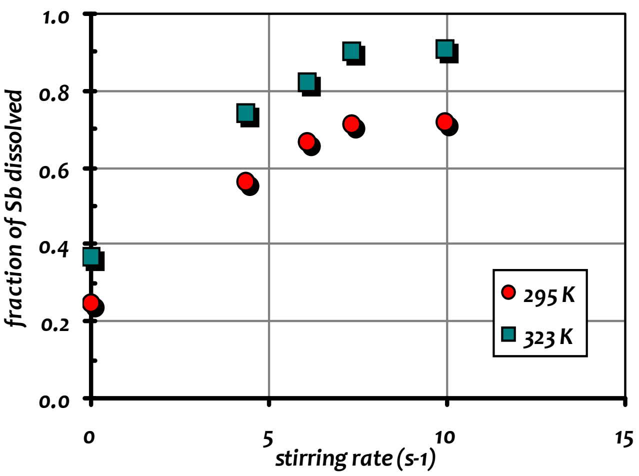

Figure 4. Effect of stirring rate on fraction of antimony dissolved (reaction conditions:1wt.% Na_2S + 1wt.% NaOH; leaching time 5 min; temperatures 295 K and 323 K).

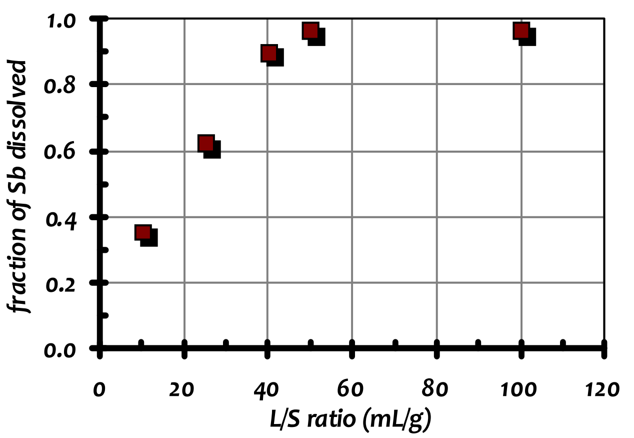

Figure 5. Effect liquid to solid ratio on fraction of antimony dissolved (reaction conditions: T=297 K; agitation rate 10 s^{-1}; particle size 40–180 μm; 1wt.% Na_2S + 1wt.% NaOH; leaching time 30 minutes).

The experiments also showed that the rate is significantly affected by the Na_2S : NaOH molar ratio and reaches its maximum at Na_2S:NaOH ≈½; the situation is represented in Fig. 6. The kinetic experiments were therefore carried out under the reaction conditions which were as follows: agitation rate = 10 s^{-1}, L:S weight ratio =50, Na_2S:NaOH molar ratio 1:2.

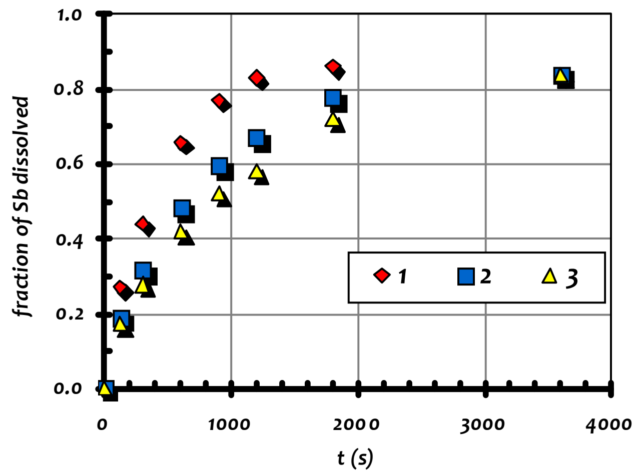

Figure 6. Effect of Na_2S to NaOH molar ratio on fraction of antimony dissolved: 1 – (2wt.% Na_2S + 2wt.% NaOH); 2 – (2wt.% Na_2S + 0.5% NaOH); 3 – (0.5wt.% Na_2S + 2wt.% NaOH); (reaction conditions: T=292 K; agitation rate 10 s^{-1}; particle size 250–500 μm).

MECHANISM OF LEACHING

The applicability of the non-porous shrinking particle model (NSPM) was evaluated by graphical analysis. The NSPM model (3) in the form

$$\alpha = 1 - (1 - 0.2063\, t/t_{0.5})^3 \quad (4)$$

was used to analyse the leaching process. The reaction half-time $t_{0.5}$ represents a period of time, which is necessary under certain reaction conditions to dissolve one half of the amount of Sb_2S_3 initially present in the sample of stibnite. The values of $t_{0.5}$ for individual experiments are summarized in Table 3.

Table 3. Half-times of stibnite leaching in Na_2S+NaOH solutions

Experiment	wt. % Na_2S	wt. % NaOH	Particle size (μm)	T(K)	$t_{0.5}$(s)
1	0.5	0.5	180–250	292	1860
2	0.75	0.75	180–250	292	1050
3	1	1	180–250	292	660
4	2	2	180–250	292	180
5	1	1	180–250	298	420
6	1	1	180–250	308	210
7	1	1	180–250	327	90
8	0.75	0.75	250–500	292	1320
9	1	1	250–500	292	1050
10	1.25	1.25	250–500	292	810
11	2	2	250–500	292	360
12	1	1	250–500	291	1260
13	1	1	250–500	297	840
14	1	1	250–500	301.5	630
15	1	1	250–500	307	450
16	1	1	250–500	317	240
17	1	1	250–500	327	150
18	1	1	71–90	292	210
19	1	1	40–71	292	90
20	2	0.5	250–500	292	630
21	0.5	2	250–500	292	840

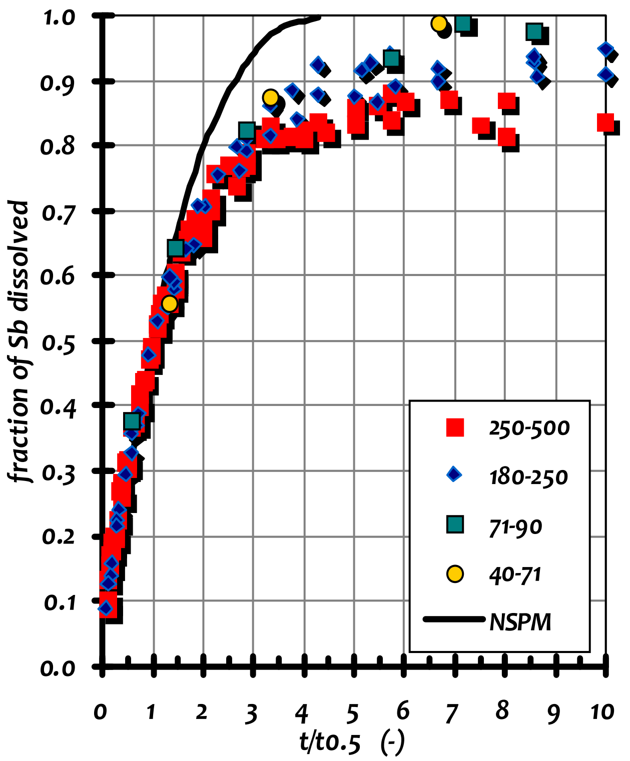

Figure 7. Conversion vs. reduced time relationship for dissolution of stibnite: points – measured data, full line – Eq. (4) (reaction conditions: Na_2S to NaOH molar ratio = 1/2; agitation rate 10 s^{-1}).

The diagram depicting the results of experiments as scattered points shown in Fig. 7 reveals that there is a very good correlation between model and experiments for a portion of antimony dissolved in the solution up to 0.8. Therefore only α–t kinetic data characterized by $\alpha < 0.8$ were used to calculate the values of model parameters.

Eliminated effect of agitation rate on the overall rate of the leaching process indicates that the surface chemical reaction (1) and/or (2) might be the rate-determining step. The difference between the last two values of $t_{0.5}$ in Table 3 indicates that the reaction (1) is much faster under the conditions considered in the present work. When the rate r of the surface reaction is expressed as a power-law function of the concentration of Na_2S at the particle surface, $c_{Na2S,w}$, the result is

$$r = k\ c^{n}_{Na2S\ w}\ . \qquad (5)$$

The coefficient k is the apparent reaction-rate constant and n is the apparent order of the overall surface chemical reaction. Temperature dependence of k can be expressed using the Arrhenius expression

$$k = k_o \exp(\ \ E/(RT)), \qquad (6)$$

where k_0 is the frequency factor; E the apparent activation energy; R the gas constant. Both the apparent activation energy E and the apparent reaction order for Na_2S n were obtained by multiple linear regression using the expression

$$\ln t_{0.5} = const + (E/R)T^{1} - n \ln c_{Na2S} \qquad (7)$$

and are summarized in Table 4.

Table 4. Apparent activation energy E and apparent order of reaction n fitted by experiments

Size fraction (μm)	E (kJ mol^{-1})	Apparent reaction order n	r_c^2
250–500	44.1±2.2	1.42±0.14	0.985
180–250	44.4±2.1	1.70±0.09	0.996

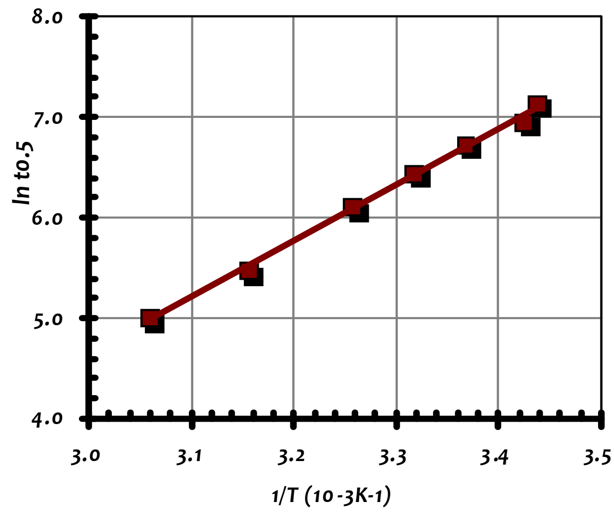

Figure 8. An example of Arrhenius plot (reaction conditions: particle size 250–500 μm; 1wt.% Na_2S + 1wt.% NaOH; agitation rate 10 s^{-1}).

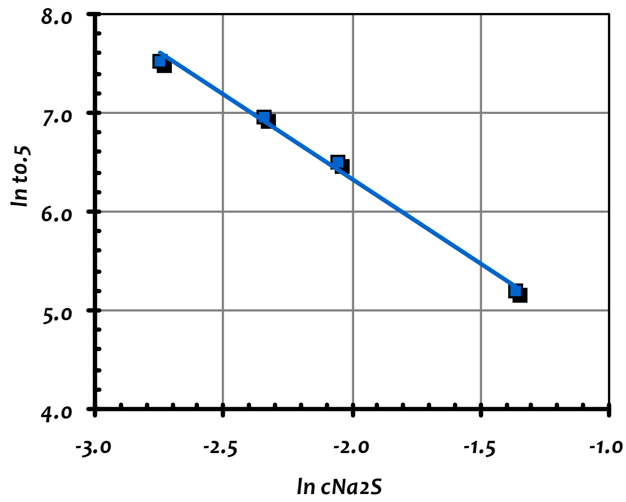

Figure 9. An example of logarithmic ln $t_{0.5}$ vs. ln c_{Na2S} (reaction conditions:particle size 180–250 μm; T=292 K; agitation rate 10 s^{-1}).

Typical examples of Arrhenius plot and ln $t_{0.5}$ vs. ln c_{Na2S} plot are shown for illustration in Figs. 8 and 9, respectively. Fractional order of reaction with regard to Na_2S and relatively high activation energy are indicative of a process controlled by the surface reaction.

CONCLUSIONS

This paper brings the measured kinetic data on stibnite alkaline leaching. Kinetics of the dissolution of natural stibnite in mixed Na_2S + NaOH solutions were investigated.

Several facts indicate that the dissolution is controlled by the surface chemical reaction of Sb_2S_3 with Na_2S + NaOH solution at the liquid-solid interface:

a) The effect of agitation speed on the rate of leaching was eliminated using high agitation rates.

b) The value of apparent activation energy is relatively high, ≈ 44 kJ mol^{-1}.

It was concluded that the reaction between Sb_2S_3 and Na_2S (Eq. (1)) is much faster than that between Sb_2S_3 and NaOH (Eq. (2)) under the conditions considered in the present work and fractional order of reaction with regard to Na_2S (from 1.4 to 1.7) was obtained.

ACKNOWLEDGEMENT

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NOTATION

c_{Na2S} bulk concentration of Na_2S in the leaching solution, mol L^{-1}

$c_{Na2S\ w}$ concentration of Na_2S at the particle surface, mol L^{-1}

E apparent activation energy, J mol^{-1}

k apparent reaction-rate constant, mol m^{-2} s^{-1}

k_o frequency factor, mol m^{-2} s^{-1}

n apparent reaction order for Na_2S; -

r dissolution rate of Sb_2S_3, mol m^{-2} s^{-1}

r_c coefficient of correlation, -

R gas constant (8.314), J mol^{-1} K^{-1}

t time of leaching, s

$t_{0.5}$ half- time of reaction for Sb_2S_3, s

T temperature, K

α fraction of antimony dissolved, -

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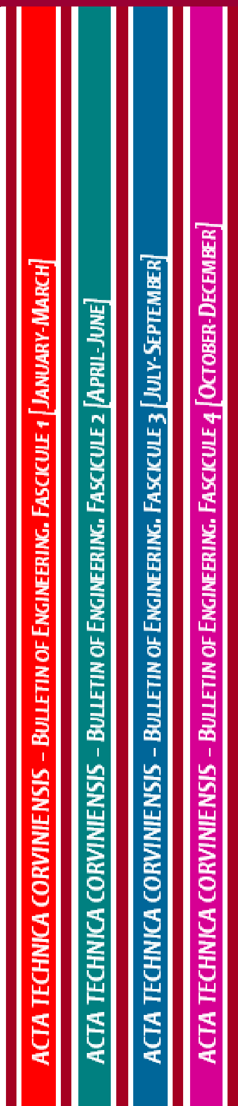

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OPTIMIZATION OF INTERNATIONAL ROAD TRANSPORT ACTIVITY

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ABSTRACT: Enterprise Requirement Planning (ERP) softwares have many advantageous and disadvantageous properties. Most important advantage is that the software includes much information relating to the activity of the company. But disadvantage is that not easy to fit the standardized nonflexible software to the individual requirements and processes of the users and some special evaluations can not be prepared automatically. The paper introduces the conception of software to be developed for a company in frame of a research project. This software has two modules, the first is an evaluation module, and the second is a planning module. The planning module support the organization and optimization of transport loops which can result higher profit and lower operation costs for the company, lower specific transport cost for the customers and lower air pollution.
KEYWORDS: Enterprise Requirement Planning (ERP) softwares, planning & optimisation of transport

INTRODUCTION

Enterprise Requirement Planning (ERP) softwares have many advantageous and disadvantageous properties. Most important advantage is that the software includes much information relating to the activity of the company. But disadvantage is that not easy to fit the standardized nonflexible software to the individual requirements and processes of the users and some special evaluations can not be prepared automatically.

The aim of our research-development project is to develop a software module to provide and evaluate logistics indicators relating to the transport activity automatically and develop a transport planning software. Indicators can be useful for both of general management and route planners, the planning software results organization of cost effective transport loops.

At first we defined the structure of logistics indicators which can be provided based on available historical database and after it we make suggestions for improvement of actual database which required to the planning and optimisation of transport paths (Figure 1).

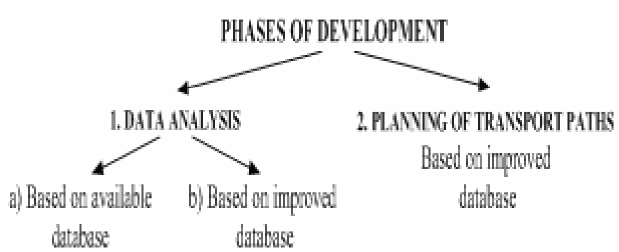

Figure 1. Phases of development

STRUCTURE OF INTERNATIONAL TRANSPORT LOOPS

The aim of transport loop planning are a more efficient transport activity, reduction of total amount of emission and the realization of higher profit, which require the integration of more transport tasks into one transport loop as it can be seen in figure 2.

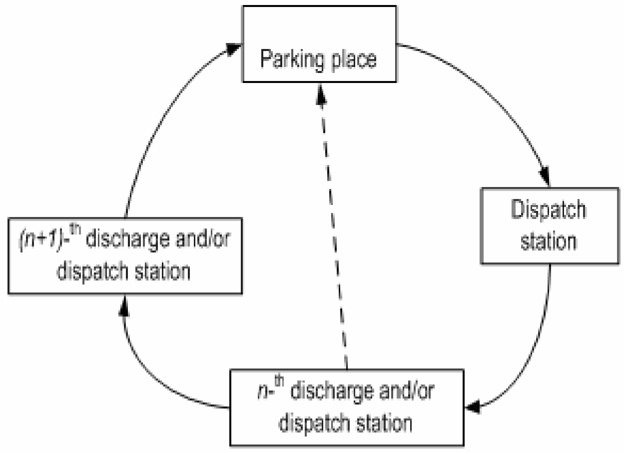

Figure 2. Structure of transport loops

It means that the vehicle starts from the parking place of the company to the first dispatch station where the products to be transported are loading in. After it the vehicle goes to the first discharge station where the products to be transported are loading out and goes to the next dispatch station. The number of dispatch and discharge stations can be n and a discharge station can be a dispatch station simultaneously. After the last discharge station the vehicle goes back to the parking place of the company. It is possible that only a part of the total transported load of a vehicle is loading in or loading out at some stations.

EFFECT OF ROAD TRANSPORT ACTIVITY ON ENVIRONMENT

International research report of DHL showed that the 30% of camions after the last discharge station on the back way are going without useful load (empty vehicles). It results approximately 33,5 milliard euro additional fuel cost and 20-30 tons of CO_2 emission per year.

Logistics has a significant role in environmental protection. Because of the transport cost represents the 30 % of the total supply chain cost, all of forwarding companies attempt to optimize their transport activities. Optimization means increase of utilization of transport loops, reduction of amount of burnt fuel and reduction of vehicles emission.

Possibilities of reduction of emission of international road transport activities are the followings:

- *modernization of vehicle fleet, usage of low emission engines or hybrid powered vehicles,*
- *training of drivers which can improve driving techniques,*
- *application of multimodal transport mode which is the combination of road-, rail-, water- and air transportation,*
- *optimization of transport tasks:*
  - *integration of more transport tasks into one transport loop,*
  - *elimination of transport ways without useful load (empty vehicles),*
  - *maximization of vehicle capacity during the transport way (the adequate vehicle size is used),*
  - *selection of the optimal transport route (taking into consideration the topography (across flatland, downy or mountain)).*

TOTAL PRIME COST OF A TRANSPORT LOOP

At first we have to define the total prime cost of a transport loop to find the possibilities of cost reduction. It is suggested to define the sections of the total loop. A section is a way between a dispatch station and a discharge station. The cost components of the sections are different due to the different volume of transported goods, fuel consumption depending on topography, etc.

Total prime cost of the α^{th} transport loop $(K_{T\alpha})$ can be calculated:

$$K_{T\alpha} = K_{L\alpha} + K_{UL\alpha} + K_{W\alpha} + K_{A\alpha} + K_{D\alpha} + K_{M\alpha} \quad (1)$$

where:

$K_{L\alpha}$ *- cost of transport way with useful load (loaded);*

$K_{UL\alpha}$ *- cost of transport way without useful load (unloaded);*

$K_{W\alpha}$ *- cost of waiting time;*

$K_{A\alpha}$ *- total additional costs (fee of motorway usage, parking fee, ...);*

$K_{D\alpha}$ *- wage cost of drivers;*

$K_{M\alpha}$ *- maintenance cost of own vehicles;*

α *- identifier of the loop.*

Cost of transport way with useful load

The cost of transport sections with useful load can be calculated:

$$K_{L\alpha} = k_{L\alpha} \cdot L_{L\alpha} \text{ [euro]} \quad (2)$$

where:

$k_{L\alpha}$: *specific cost of way with useful load in case of α^{th} transport loop $\left[\frac{euro}{km}\right]$,*

$L_{L\alpha}$: *length of way with useful load in case of α^{th} transport loop [km].*

$$k_{L\alpha} = \varepsilon_{L1}^{\alpha} \cdot \varepsilon_{L2}^{\alpha} \cdot \varepsilon_{L3}^{\alpha} \cdot k_{L0}^{\alpha} \left[\frac{euro}{km}\right] \quad (3)$$

where:

k_{L0}^{α}: *specific cost of vehicle of α^{th} transport loop (in case of an empty vehicle)*

$$k_{L0}^{\alpha} = \frac{f_R}{100} k_{fR} \quad \left[\frac{euro}{km}\right] \quad (4)$$

where:

f_R: *specific fuel consumption $\left[\frac{litre}{km}\right]$*

k_{fR}: *cost of fuel $\left[\frac{euro}{litre}\right]$*

$\varepsilon_{L1}^{\alpha}$: *correction factor for fuel consumption depending on features of the ground*

$\varepsilon_{L2}^{\alpha}$: *correction factor for different fuel price of different countries*

$\varepsilon_{L3}^{\alpha}$: *correction factor for different loading condition (weight of useful load)*

Cost of transport way without useful load

The cost of transport sections without useful load can be calculated:

$$K_{UL\alpha} = k_{UL\alpha} \cdot L_{UL\alpha} \text{ [euro]} \quad (5)$$

where:

$L_{UL\alpha}$: *length of way without useful load in case of α^{th} transport loop [km].*

$k_{UL\alpha}$: *specific cost of way without useful load $\left[\frac{euro}{km}\right]$,*

$$k_{UL\alpha} = \varepsilon_{UL1}^{\alpha} \cdot \varepsilon_{UL2}^{\alpha} \cdot k_{UL0}^{\alpha} \left[\frac{euro}{km}\right] \quad (6)$$

where:

k_{UL0}^{α}: *specific cost of vehicle of α^{th} transport loop (in case of an empty vehicle)*

$$k_{UL0}^{\alpha} = \frac{f_{Ü}}{100} k_{fÜ} \quad (7)$$

$f_{ü}$: *specific fuel consumption $\left[\frac{litre}{km}\right]$*

$k_{fü}$: *cost of fuel $\left[\frac{euro}{litre}\right]$*

$\varepsilon_{UL1}^{\alpha}$: *correction factor for fuel consumption depending on features of the ground*

e.g. 1 - normal (flatland),

1,3 - hard (mountain),

$\varepsilon_{UL2}^{\alpha}$: correction factor for different fuel prices of different countries

Cost of waiting time

The cost of waiting time during the transport way can be calculated as the sum of the following components:

$$K_{W\alpha} = (T_{RA\alpha} + T_{WA\alpha} + T_{HA\alpha} + T_{PA\alpha} + T_{SA\alpha}) \cdot k_{W\alpha} \text{ [euro]} \quad (8)$$

where:

$T_{RA\alpha}$: time consumption of loading in and loading out, $[hour]$

$T_{WA\alpha}$: waiting for loading in and loading out activity, $[hour]$,

$T_{HA\alpha}$: waiting time at the frontier station, $[hour]$,

$T_{PA\alpha}$: waiting time due to required resting, $[hour]$,

$T_{SA\alpha}$: waiting time due to camion stop, $[hour]$

$k_{W\alpha}$: specific cost of waiting, $\left[\frac{euro}{hour}\right]$.

Additional costs

Total additional cost is the sum of the motorway fee ($K_{AM\alpha}$) and parking fee ($K_{AP\alpha}$):

$$K_{A\alpha} = K_{AM\alpha} + K_{AP\alpha} \text{ [euro]} \quad (9)$$

- motorway fee: fee of motorway sections used by vehicles

$$K_{AM\alpha} = k_{AM}^{\alpha} \cdot m^{\alpha} \cdot \varepsilon_{AM}^{\alpha} \text{ [euro]} \quad (10)$$

where:

k_{AM}^{α} average fee of a motorway section $\left[\frac{euro}{section}\right]$

m^{α} number of sections of the loops

$\varepsilon_{AM}^{\alpha}$ correction factor relating to different cost of different countries

- parking fee: fee of parking times in the loops

$$K_{AP\alpha} = t_{P}^{\alpha} \cdot k_{P}^{\alpha} \cdot \varepsilon_{Pt}^{\alpha} \cdot \varepsilon_{Pd}^{\alpha} \cdot \varepsilon_{T}^{\alpha} \text{ [euro]} \quad (11)$$

where:

t_{P}^{α} average parking time of a loop $[hour]$

k_{P}^{α} average parking fee of a loop $\left[\frac{euro}{hour}\right]$

$\varepsilon_{Pt}^{\alpha}$ correction factor for the average parking time

$\varepsilon_{Pd}^{\alpha}$ correction factor for the average parking cost

ε_{T}^{α} correction factor depends on the category of vehicles (light track, camion, etc.)

Average wage cost of drivers

Average wage cost of drivers can be calculated with:

$$K_{D\alpha} = T_{\alpha} \cdot b_{\alpha} \cdot \varepsilon_{D}^{\alpha} \text{ [euro]} \quad (12)$$

where:

T_{α} is the time consumption of a transport loop [hour],

b_{α} is the average wage cost of a driver $\left[\frac{euro}{hour}\right]$,

ε_{D}^{α} is a correction factor for the average wage cost of a driver.

Maintenance cost of the vehicles

Maintenance cost of own vehicles include the costs which are independent on usage of vehicles, it means that these costs are realized when the vehicles are not on way (e.g.: leasing, maintenance, assurance ...).

Maintenance cost of a transport loop:

$$K_{M\alpha} = T_{\alpha} \cdot k_{M\alpha} \cdot \varepsilon_{M}^{\alpha} \text{ [euro]} \quad (13)$$

where:

T_{α} is the time consumption of achievement of a loop $[day]$,

$k_{M\alpha}$ is the specific maintenance cost of vehicles (leasing, maintenance, assurance, ...) $\left[\frac{euro}{day}\right]$,

ε_{M}^{α} is a correction factor for maintenance cost of different vehicles.

During the route planning optimization the total prime cost should be minimized.

The main aim of our software to be developed is the optimization of transport tasks.

Well organized transport loops result higher profit and lower operation costs for the company, lower specific transport cost for the customers and lower air pollution.

ROUTE PLANNING METHOD

Actually at the forwarding company the route planning is completed by planners without any optimisation. There is a demand for application of an efficient optimisation algorithm during the planning process.

The software module to be developed will be used during the long and short term route planning and generation of master- and fine scheduling.

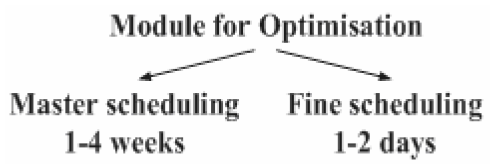

Figure 3. Time horizons of scheduling

Aims of master- and fine scheduling are the scheduling of forwarding activity and allocation of vehicles to destinations and tasks. Time interval of master scheduling is 1-4 weeks, 1-2 days in case of fine scheduling.

This software module can support the activity and decision making of general management and planners.

Figure 4 shows the generation algorithm of transport plans.

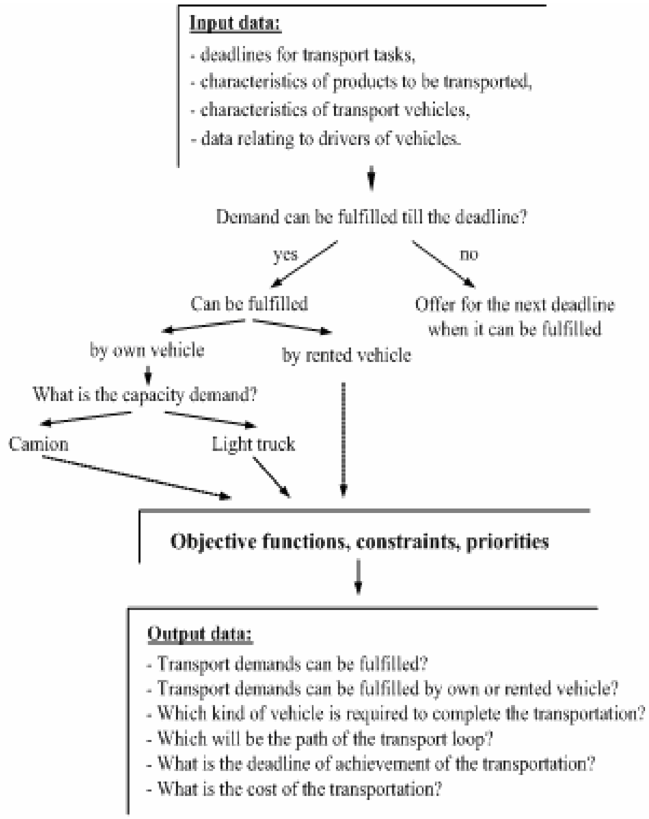

Figure 4. Process of generation of transport plans

Steps of master scheduling are the followings:

a. Input data are the followings:
- *deadline for transport tasks,*
- *characteristics of products to be transported,*
  - *volume,*
  - *special requirements,*
- *characteristics of transport vehicles,*
  - *available the required vehicle or not,*
  - *capacity demand,*
  - *fuel consumption,*
- *data relating to drivers of vehicles.*

b. Demand can be fulfilled till the deadline? If can not be fulfilled the next deadline should be defined till the transport task can be completed.

c. Task can be fulfilled by own vehicle or by rented vehicle. If the task can not be fulfilled by own vehicle or by rented vehicle offer for the next deadline when it can be fulfilled.

d. What is the capacity demand? Camion or light truck is required?

e. Objective functions, constraints, priorities are applied for the optimisation.

Possible objective functions of a multi-objective optimisation:
- *total prime cost of transportation should be minimal,*
- *lead times should be minimal (time consumption of transport activity, loading in and out, waiting time, ….).*

Constraints:
- *Utilization of resources should be maximised:*
  - *vehicles,*
  - *human resources.*
- *Customer demand satisfaction should be maximised.*
- *Constraints for vehicles:*
  - *Loading capacity (camion or light track).*
- *Constraints for products.*

Priorities:
- *for vehicles:*
  - *own or rented,*
  - *preferred one of own vehicles.*
- *for customers:*
  - *regular customers,*
  - *new customers.*
- *for transport loops:*
  - *task arrived earlier has priority.*
- *for products.*

f. Output data are the followings:
- *Transport demand can be fulfilled?*
- *Transport demand can be fulfilled by own or rented vehicle?*
- *Which kind of vehicle is suggested to complete the transportation?*
- *Which transport tasks can be integrated together to maximize utilization?*
- *Which will be the path of the transport loop?*
- *What is the deadline for achievement of the transportation?*
- *What is the cost of the transport task?*

ADVANTAGES PROVIDED BY THE APPLICATION OF SOFTWARE MODULES

Evaluation of logistics indicators relating to transport activity can provide useful information because the analysis of historic data provides a real view of the company activity. This information can be useful for decision making of the general management, and during the daily routine (planning on short and long time interval) on operative level.

Transport loop planning based on optimisation provides automatic / semi-automatic plans for short and long time intervals and optimal utilization of resources (human and vehicle). Application of this software module results planning of low cost transport loops so a higher profit can be realized at the company. The lower transport cost provides lower price for the customer, which results higher satisfaction of customers.

The amount of used fuel is globally can be decreased, which results lower air pollution.

The R+D project is under elaboration, after the finalization of optimization algorithm software modules will be developed.

SUMMARY / CONCLUSIONS

The paper introduces the conception of software to be developed for a company in frame of a research project.

This software has two modules, the first is an evaluation module, and the second is a planning module.

The planning module support the organization and optimization of transport loops which can result higher profit and lower operation costs for the company, lower specific transport cost for the customers and lower air pollution.

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SOLVING THE DECISION-MAKING PROCESS IN ROUTE PLANNING RELATED WITH REPAIR OF ELECTRICAL BREAKDOWNS

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ABSTRACT: *The Vehicle Routing Problem (VRP) has been widely study by different authors, often specialist from Operation Research and Logistic fields. However, in the real context of decision making, new variants of VRP are found. These variants also show peculiar conditions which require a new approach for the existing methods. According to literature there are two types of optimization methods for solving VRP, exact and approximate methods. Sometimes, decision makers are subject of uncertainty about which method (exact or approximate) should be used according with the problem dimension, and also their characteristics. For these reasons, this paper proposes Discriminant Analysis for solving uncertainly about which optimization methods can be used with high quality results, due to the results of Discriminant Analysis we introduce a modified Ant Algorithm for route planning in the repair of electrical breakdowns. The meta-heuristic performance has been compared with a Branch and Bound strategic. Computational results confirm the effectiveness of the algorithm proposed.*
KEYWORDS: *discriminant analysis; uncertainty*

INTRODUCTION

In the industry and services sector, transport costs represent a significant portion of the goods or services provided. Proper distribution planning can mean considerable savings. These potential savings largely support the use of Operation Research techniques as planning supporting, since it is estimated that transport costs represent between 10% and 20% of the final cost of goods. In that sense, several variants of Vehicle Routing Problems have received a lot attention in the recent years, such as, theoretical and practical groups (e.g. [4]). This kind of problem is a well-known NP-Hard combinatorial optimization problem which is encountered frequently in decision making process, beside in logistics system. Exact methods have been used with feasible results [2] for solving different variants of VRP, although the Traveling Salesman Problem (TSP) has received a great deal of attention. However, most of these approaches have been developed for small to medium problems with at most a few customers to be performed by a small fleet of trucks. In the last decade, approximate methods have made significant progress in the optimization of VRP families, specifically meta-heuristics [3]; [1]. Many real world problems have been solved by feasible use of approximate methods, often problem with obvious big dimension. For these problems, most exact methods proposed in the literature are unfeasible due to computational time and available time for decision making in the operative context. Nevertheless, uncertainty behavior appears when the decision makers have to desire which kind of methods should be used in those problems with none palpable dimension. For that reason this paper proposes a multivariate analysis in order to decrease the uncertainty about using exact or approximate methods in VRP, with an emphasis on route planning related with repair of electrical breakdowns. Moreover, due to the results of multivariate analysis and other peculiar conditions a hybrid algorithm of Sweep Heuristic (SH) and Ant Colony System (ACS) is presented. The paper is structured as follows: In Section 2 is formulated the real problem mentioned, Discriminant Analysis for uncertainty in decision making is showed at Section 3. Hybrid algorithm of SH-ACS is defined at Section 4. Computational results and the algorithm performance can be found in Section 5. Conclusions and future researches are outlined in Section 6.

PROBLEM DEFINITION

The route planning for repair of electrical breakdowns is in principle a variant of m-TSP, but with dynamic approach. The problem consists in a tour planning from dispatch (D) multiple vehicles, with homogeneous characteristics, for repairing different types of breakdowns. The breakdowns have different priorities: first priority in electrical networks between 220 and 33 KV; second priority for those of 4 KV; and the third in electrical networks under 4 KV (the most frequent). The problem also present dynamic approach, when the tours for repairing are already planning, new breakdowns occur. The problem complexity increase when new breakdowns have to be inserted according to their priorities, but this approach will be considered in feature research. Different types of integer programming formulations are proposed for the m-TSP. We use one of them considering the priorities for breakdowns. The decision variable can be defined as follows:

$$X_{ij} = \begin{cases} 1 & \text{if arc}(i,j)\text{ is used on the tour} \\ 0 & \text{otherwise} \end{cases}$$

The objective function "(1)" and the constraints can be given as follows:

$$\text{minimize} \sum_{i=D}^{n}\sum_{j=D}^{n} C_{ij} \quad X_{ij} \qquad (1)$$

s.t.

$$\sum_{j=1}^{n} X_{Dj} = m \qquad (2)$$

$$\sum_{i=1}^{n} X_{iD} = m \qquad (3)$$

$$\sum_{i=D}^{n} X_{ij} = 1, \quad j = 1,\ldots,n \qquad (4)$$

$$\sum_{j=D}^{n} X_{ij} = 1, \quad i = 1,\ldots,n \qquad (5)$$

$$\sum_{i\in S}\sum_{j\in S} X_{ij} = |S| \quad 1, \ \forall S \subseteq V \setminus \{1\}, S \neq \varphi \qquad (6)$$

$$X_{Dj} = 1, \ \forall j : (\text{first}) \text{ and } (\text{second}) \text{ priority} \qquad (7)$$

Where "(2)" and "(3)" ensure that exactly "m" vehicles depart from and return back to node D (the Dispatch). The constraints "(4)" and "(5)" allow to the vehicles visit once different breakdowns. Expression "(6)" is for the classical sub-tour elimination and "(7)" is a hard constraint which ensure that fleet of vehicles should to visit breakdowns with first and second priority starting from dispatch.

DISCRIMINANT ANALYSIS FOR UNCERTAINTY IN DECISION-MAKING

From scientific literature is well-know the classical group of methods (exact or approximate) for solving any variant of VRP. Sometimes the decision making for solving VRP is carried out under uncertainty. For small and medium VRP exact methods have shown good performance according to solution quality and computational time. Similarly, approximate methods can to solve VRP with big dimensions and also medium dimension with hard constraints due to the real context of decision making in VRP. Therefore, there is uncertainty to establish relevant optimization methods regarding dimension boundaries. This paper proposes Discriminant Analysis in order to know which group of methods will be relevant considering the problem dimension with multivariate approach. In the Table 1, dependent and independent are shown. These variables were extracted of literature, specifically of [5].

Knowledge base was created regarding these variables, 122 cases from literature about best practices in VRP solution, using both optimization methods. In the knowledge base, 28 belong to exact category and 93 to approximate. Considering the customer demand, 99 are classified as deterministic and 22 stochastic, based on time constraints, there were 69 with time windows and 52 otherwise. In 76 cases was considered one-objective and homogeneous fleet.

Table 1. Classification variables

Variables	Type	Instances
Relevant method	Dependent	▪ Exact ▪ Approximate
Number of nodes	Independent	▪ Discrete number
Fleet size	Independent	▪ Discrete number
Fleet type	Independent	▪ Homogeneous ▪ Heterogeneous
Number of objective	Independent	▪ One-objective ▪ Multi-objective
Time constraints	Independent	▪ With time windows ▪ Without time windows
Customer demand	Independent	▪ Deterministic ▪ Stochastic

The Discriminant Analysis is given by "(8)"; beside independent variables appear in the same order that Table 1.

$$D = b_1 \cdot X_1 + b_2 \cdot X_2 + b_3 \cdot X_3 + b_4 \cdot X_4 + b_5 \cdot X_5 + b_6 \cdot X_6 \qquad (8)$$

Base on the proposal for decrease uncertainty in decision making, we introduced the problem of route planning for repair of electrical breakdowns in knowledge base and thus Discriminant Analysis for classification process. The Table 2 figures main characteristics of the problem regarding defined variables. We use as statistical package the SPSS, obtaining results in Figure 1. Statistical test indicates that approximate methods are relevant for solving the problem defined in Section 2.

Table 2. Variables of defined problem

Route planning for repair electrical breakdowns
Number of nodes: 56 (breakdowns) Time constraints: Without time windows Fleet size: 3 vehicles Fleet type: Homogeneous Number of objectives: One-objective Time for repair: Stochastic

Casewise Statistics

Case Number	Actual Group	Highest Group: Predicted Group	Highest Group: p	Highest Group: df	Highest Group: P(G=g | D=d)	Highest Group: Squared Mahalanobis Distance to Centroid	Second Highest Group: Group	Second Highest Group: P(G=g | D=d)	Second Highest Group: Squared Mahalanobis Distance to Centroid	Discriminant Scores: Function 1
112	1	1	.421	1	750	.647	2	.250	2.844	1.009
113	1	1	.815	1	545	.055	2	.455	.419	-.030
114	2	1(**)	.187	1	825	1.741	2	.175	4.844	1.523
115	1	2(**)	.785	1	.652	.074	1	.348	1.332	-.950
116	2	2	.473	1	.735	.514	1	.265	2.555	-1.395
117	2	2	.483	1	.733	.493	1	.267	2.507	-1.379
118	2	2	.458	1	.739	.551	1	.261	2.636	-1.420
119	1	1	.420	1	.750	.652	2	.250	2.852	1.011
120	1	1	.420	1	.750	.652	2	.250	2.852	1.011
121	1	1	.420	1	.750	.652	2	.250	2.852	1.011
122	ungrouped	2	.513	1	.724	.428	1	.276	2.359	-1.332

** Misclassified case

Figure 1. Discriminant Analysis results using SPSS

HYBRIC ALGORITHM OF SH-ACS

This paper proposes a feasible strategy according with the results of application of Discriminant Analysis in Section 3. The strategy consists of make breakdown clusters, with Sweep Heuristic, considering geographic position of each breakdown, also a feasible and consistent distribution of vehicle available time. Finally, for each cluster of breakdowns Ant Colony System is proposed.

The group of breakdowns formed in each cluster is given by Algorithm 1, which considers segmentation according to the fleet size allocating each vehicle for each cluster built. Also the allocation of available time is considered.

Algorithm 1: Sweep Heuristic
Step 1: Initiation -Order increasingly breakdowns according to an angle "ϑ" according with [6] -If two breakdowns have the same "ϑ", decide regarding polar coordinate "ρ" Step 2: Selection -If all nodes (breakdowns) belong to the same cluster C_k execute Step 3, else: If each breakdown "A_i" satisfies the available time: $C_k := C_k \bigcup \{A_k\}$; else: Do k:= k + 1 and create a new cluster with $C_k := \{A_k\}$ Step 3: Optimization -For each C_k solve TSPAnhörenUmschrift

Algorithm 2: General procedure for Ant colony System

1. Initiation phase
Initialize parameter for Ant Colony System: (q_o); (α); (β); (ρ)
Get the initial solution (ψ^{nn}) based on nearest neighbor heuristic
$\psi^{gb} \leftarrow \psi^{nn}$: where ψ^{gb} is the best global solution
$L_{gb} \leftarrow L_{nn}$: Total length of the best route
Initialize initial pheromone (τ_0)
$\forall(i,j) \rightarrow \tau_{(i,j)} = \tau_0$: where $\tau_0 = (n \cdot L_{nn})^{-1}$
2. Cycle executed by each ant "k"
Do until Termination criterion = True
For each Ant "k"
Route construction (ψ^k) using (**new ant algorithm**)
If $L_k \le L_{gb}$ **Then**
$L_{gb} = L_k$: $\psi^{gb} = \psi^k$
End If
End For
Loop
3. Updating global pheromone
$\tau_{(i,j)}(\text{current}) = (1-\alpha)\cdot\tau_{(i,j)}(\text{previous}) + \frac{\alpha}{L_{gb}} \quad \forall(i,j) \in \psi^{gb}$

q_o: Relative importance (Intensify vs. Diversify) mechanisms α : Global pheromone evaporation β : Relative importance Pheromone vs. Heuristic ρ : Local pheromone evaporation

The Ant Colony System is bio-inspired in the real ant behavior (Dorigo & Stützle, 2004). The real ants always find the shortest between their nest and food sources, due to indirect exchange of information through pheromone trail. While shorter is the path, greater number of ants passes through it, and therefore, greater amount of pheromone is deposited. This pheromone trail influences when ants deciding which path should be taken. In the Algorithm 2 is presented a general procedure followed for achieve high quality solution in route planning.

The probabilistic construction followed for each artificial ant is formulated in Algorithm 3, also a new heuristic (η_{ij}) is proposed as desirability for adding a node (breakdown) to a tour. Beside, a priority index (P_j) is fixed depending of the breakdown type: (0.6) when "j" is a first priority breakdown; (0.3) when "j" is a second priority breakdown; and (0.1) for the third priority. For route construction two stochastic mechanisms are defined in the "(9)" and "(10)".

$$\text{Intensify}(i,j) = \begin{cases} \arg\max\{\tau(i,j)\cdot[\eta(i,j)]^{\beta}\} & \text{if} \quad \text{Rnd} \le q_o \\ \text{Diversify}(i,j) & \text{otherwise} \end{cases} \tag{9}$$

$$\text{Diversify}(i,j) = \begin{cases} \dfrac{[\tau(i,j)]\cdot[\eta(i,j)]^{\beta}}{\sum_{j \in J_k(i)}[\tau(i,j)]\cdot[\eta(i,j)]} & \text{if} \quad \text{Diversify} \in J_k(i) \\ 0 & \text{otherwise} \end{cases} \tag{10}$$

Algorithm 3: New Ant
1. Initiation **Locate** the ant "k" ant node dispatch (D) **Initialize** Current $\text{Time}_k \leftarrow 0$ **2. Cycle for doing a tour by each ant "k"** **For** ant (k) located at node (i) (start at Dispatch), it determines the set of nodes (N_i^k). If node (i) is not the Dispatch, include it in the set **For each** $i \notin N_i^k$ $\text{Dist}_{ij} = \text{Max}(1, \text{Travel}_{ij})$ $\eta_{ij} = \frac{1}{\text{Dist}_{ij}} \cdot \frac{RT_j}{AT} \cdot P_j$ $RT_j = \begin{cases} U(45,60) & \text{if} \quad \langle j \rangle \text{is first priority breakdown} \\ U(25,35) & \text{if} \quad \langle j \rangle \text{is second priority breakdown} \\ U(10,20) & \text{if} \quad \langle j \rangle \text{is third priority breakdown} \end{cases}$ Stochastic selection for next node (i) using η_{ij} **Update** the route: $\psi^k \leftarrow \psi^k + (j)$ **Update** the total length: $L_k \leftarrow L_k + \text{Travel}_{ij}$ **Update** local pheromone: $\tau_{(i,j)}(\text{current}) = (1-\rho)\cdot\tau_{(i,j)}(\text{previous}) + \rho\cdot\tau_0$ **End For**

COMPUTATIONAL RESULTS

In this section some computational results are presented in order to evaluate the performance of the algorithm described in Section 4. Algorithm runs have been carried out on a personal computer equipped with an Intel Pentium dual-core processor 1.6 GHz and 1 GB of ram memory. The SH-ACS was coded Java 1.5.0. The configuration of the SH-ACS has been defined as follows: 10 artificial ants were used, 50 iterations were executed for each run, the parameters q_o, β , α , ρ were 0.75, 1, 0.1, 0.3 respectively. The algorithm is tested into 10 different runs. In Table 3, the best found solutions are reported for two strategies: SH-ACS and exact method called Branch and Bound.

Starting from figures of Table 3 we obtained non significant differences between these algorithms, due to results of Wilconxon coefficient as statistic test. The Branch and Bound strategic computed the runs about 25 minutes as average, existing significant differences compared to a few seconds of SH-ACS. For these reason results of multivariate analysis described in Section 3 are validated, approximate methods, such as SH-ACS is relevant solution for the real problem formulated in Section 2.

Table 3. Numerical results for SH-ACS compared to branch and bound

Algorithm runs	SH-ACS	Branch and Bound
1	154	149
2	175	149
3	171	149
4	171	149
5	154	149
6	175	149
7	154	149
8	186	149
9	171	149
10	186	149
Average	169.7	149

CONCLUSIONS

In this paper, Discriminant Analysis is presented for assisting decision making for decreasing uncertainty before optimization process in VRP; also a hybrid algorithm SH-ACS is formulated. Moreover, the performance of SH-ACS in the real problem defined outcomes relevant. According with numerical and statistic test, we can conclude that SH-ACS can solve the real problem defined more effectively than Branch and Bound strategic.

FUTURE RESEARCH

Future researches would focus to modify SH-ACS considering unexpected breakdown, also define an Ant Algorithm to obtain integrated solution, vehicles allocation and route planning at the same time. Beside we have to consider sensitivity analysis of the fixed parameters in the algorithm.

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MATLAB POSSIBILITIES FOR REAL TIME ETL METHOD

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ABSTRACT: *This article describes how to implement improved ETL process in Matlab environment. New architecture real time ETL process stills automated without human – database administrator interference, in cost of reduced accuracy rendered by level of trust. This method is constructed in Matlab environment, due to simple transformation and convert routines and functions. First we described ETL as a part of KDD, what is Real time ETL and problem how to achieve real – time in real world. In next part we present our improved near real time ETL model with new architecture containing equation for calculation the level of trust. And finally we shows how to use Matlab routines and toolkit for achieve simplicity in ETL phases.*
KEYWORDS: *Matlab; Extraction Transformation Loading; real time; data warehouse*

INTRODUCTION

Our research is about finding new methods and tools using in different stages of Knowledge Discovery in Databases. In the early stages of the KDD it is necessary to collect and preprocess data [5]. Especially, we improved the Near Real Time ETL phase (Extraction Transformation Loading), using the new architecture. Several approaches can be used, as described in [6]. Main rule is application of structures and processes in environment, which supports simple code and transformation to tasks performed in real time.

ETL PROCESS

The usual process of ETL-ing the data during the night in order to have updated reports in the morning is getting more complicated if we consider that an organization's branches may be spread in places with totally different time-zones. Based on such facts, data warehouses are evolving to "active" or "live" data producers for their users, as they are starting to resemble, operate, and react as independent operational systems. In this setting, different and advanced functionality that was previously unavailable (for example, on-demand requests for information) can be accessible to the end users. For now on, the freshness is determined on a scale of minutes of delay and not of hours or a whole day. As a result, the traditional ETL processes are changing and the notion of "real-time" or "near real-time" is getting into the game. Less data are moving from the source towards the data warehouse, more frequently, and at a faster rate. [1]

The ETL market has already made efforts to react to new requirements. The major ETL vendors have already shipped "real time" ETL solutions with their traditional platforms. In practice, such solutions involve software packages that allow the application of light-weight transformations on-the-fly in order to minimize the time needed for the creation of specific reports. Frequently, the delay between the moment a transaction occurs at the operational site and the time the change is propagated to the target site is a few minutes, usually, five to fifteen. Such a response should be characterized more as "near real time" reaction, rather than "real time", despite how appealing and promising can the latter be in business terms. Traditionally, ETL processes have been responsible for populating the data warehouse both for the bulk load at the initiation of the warehouse and incrementally, throughout the operation of the warehouse in an off-line mode. Still, it appears that data warehouses have fallen victims of their success: users are no more satisfied with data that are one day old and press for fresh data – if possible, with instant reporting. This kind of request is technically challenging for various reasons. First, the source systems cannot be overloaded with the extra task of propagating data towards the warehouse. Second, it is not obvious how the active propagation of data can be implemented, especially in the presence of legacy production systems. The problem becomes worse since it is rather improbable that the software configuration of the source systems can be significantly modified to cope with the new task, due to (a) the down-time for deployment and testing, and, (b) the cost to administrate, maintain, and monitor the execution of the new environment.

A more pragmatic approach involves a semi-automated environment, where user requests for freshness and completeness are balanced against the workload of all the involved sub-systems of the warehouse (sources, data staging area, warehouse, data marts) and a tunable, regulated flow of data is enabled to meet resource and workload thresholds set by the administrators of the involved systems [1].

The general ETL architecture of a near real time data warehouse consists of database sources of different types [7] including extraction tool, which pushes extracted data into temporary store.

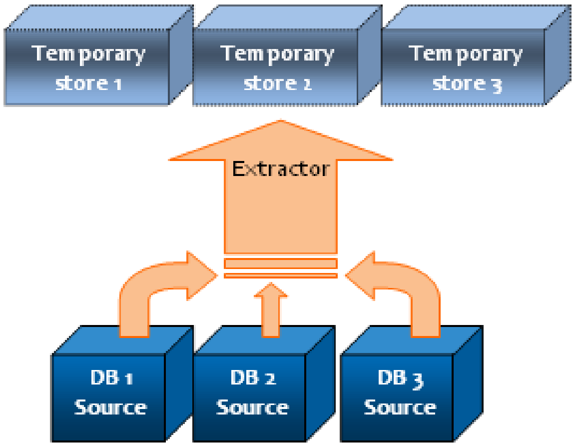

Figure 1. Extraction – part of an ETL process

Then it prepares data for transformation process into transformation function – ready data format. Transformation runs in DPA (Data processing area) where data are transformed and cleaned and after then are data exported by transformation function. Our research is focused on Near real time ETL improvement, using new compensation parts constructed in Matlab environment, showed on Figure 2. The difficulty of such a simple Transform function is to keep it simple. As though they can exert a vacuum of complexity, simple Transform functions attract additional functions and complexity to them. Resist this temptation at all costs. A simple Transform function is another beautiful and elegant design, and should be allowed to remain that way.[2]

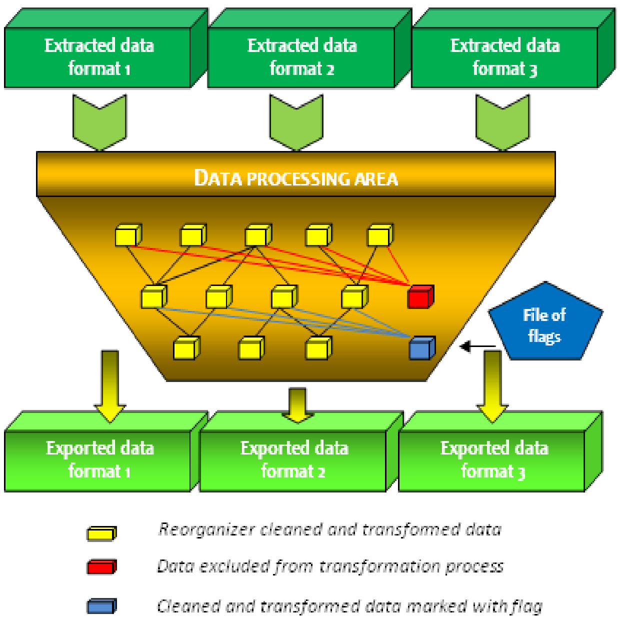

Figure 3. Transformation – part of an ETL process

Whole process in DPA runs automatically even there is no reason for excluding the data, like reference error or the system is overloaded due to high refreshment rate or high number of users. Each situation should be tested first. [4]

Loader then loads data into data warehouse fact and dimension tables. Whole process shows Figure 3.

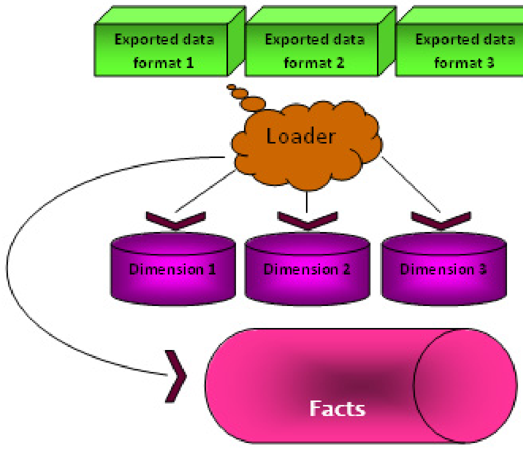

Figure 3. Loading – part of an ETL process

On this architecture is based traditional ETL. In case of near real time ETL there are built in compensation structures, which alleviates impact of high frequently refreshment. In a real world this cannot be performed, due to many possible reasons like high number of users, high rate refreshment or too expansive software and hardware parts, and this situation is solved by several technical and structural accessories. Practically it leads to compensated schema which contains complementary parts.

There is situated also a file of flags, containing file of conditions edited by administrator, that are used for additional inspection. Excluded and marked data are evaluated as well as reorganized, cleaned and transformed data. After then is calculated level of trust all outgoing data, which describes on how much valid the data are. It is showed on Equation (1).

Of course, for each data row is also available the pertinent time, so level of trust should be calculated for a certain time interval.

$$[\%]=100-\frac{\left(\text{Data excluded from transformation process}+\text{Cleaned and transformed data marked with flag}\right)\cdot 100}{\text{Reorganized cleaned and transformed data}} \qquad (1)$$

This model of improved near real time ETL should be applied on the either ETL approach, and also should be applied on sequential, pipelining and partitioning execution of ETL process too described in [1].

Transformation process is reorganizing data according to DWH needs, transforming measuring units, performing reference assignment, modifying key values, sorting products in sections and so on. File of flags contains exceptions for transformation process, like certain company (customer) assignment, some product exceptions, which are stored in "Exported data format for errors" (eDFE). Loading process then pushes exported data into DWH as well as exported *"error" data, which are marked with flag in the fact table (Profit).*

If any data are needed for analyzing, level of trust is calculated for specified data selection.

This way we can determine the level of trust for analyzing data, while the (near) real time ETL process is maintained.

ETL PROCESS IN MATLAB ENVIRONMENT

Whole DPA process runs via routines constructed in Matlab environment, which the transformation makes more transparent and simple. Matlab contains many functions, which can be used to convert data into specified format. Example of the transformation process is showed below.

```
% Data Sources Extraction
% Reading arguments and storeing to temporary store
AA = xlsread('*.xls', 'field margins eg. A2:A1194);
BB = xlsread('*.xls', 'field margins eg.C2:C1194);
CC = xlsread('*.xls', 'field margins eg.A2:A203);
DD= xlsread('*.xls', 'field margins eg.E2:E203);
EE = xlsread('*.xls', 'field margins eg.C2:C988);
FF = xlsread('*.xls', 'field margins eg. B2:B988);
%Cleaning data and calculating field sizes
cycle1 = size(EE);
cycle1(1);
%Transformation process area
%Assignment data and searching for foreign key values
for i=1:cycle1(1)
  j=1;
  while EE(i)  ~= AA(j) & j<cycle2(1)
    j=j+1;
  end;
  O(i,1)=BB(j);
  j=1;
  while FF(i)  ~= CC(j) & j<cycle3(1)
    j=j+1;
  end;
  P(i,1)=DD(j);
end;
%Storeing foreign key values to Exported data format
xlswrite(*.xls', 'field margins eg. O, BB, P);
%Loading  process
% Reading arguments for loading process
%Assignment dimensions to facts
Field1 =    xlsread('*.xls', 'field margins eg. A2:A1681');
Field2 =    xlsread('*.xls', 'field margins eg. G2:G1681');
%Calculating field sizes
cycle1 = size(Field1);
%Storeing to data warehouse
xlswrite('*.xls', Field2,'sheet name','begnning of the field storeig eg. G2');
```

CONCLUSIONS

Managing ETL process during different phases must be clear and explicit. Although data from data sources can be in different formats and quality conditions, ETL must significantly assign each input to any output data.

Improved ETL process together with appropriate development environment and toolkit helps manage extraction, transformation and finally delivering data to data warehouse.

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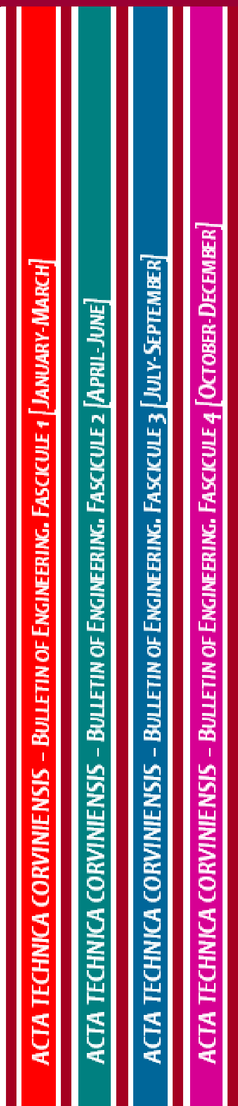

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INCREASING THE ELASTICITY OF MULTITASKING MACHINING USING TOOLING FOR TOOLS AND WORKPIECE CLAMPING IN A CNC MACHINE TOO

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ABSTRACT: *The article presents rules for designing a device for fastening tools and machined parts to a CNC machine tool. Suggested tooling was used on machine tools already working in machining industry. Those machine tools can be elements of Flexible Production Systems. Presented solutions facilitate the application of CNC machine tools in low-volume and piece production.*
KEYWORDS: *workpiece, tool, fastening, CNC machine tool setting*

INTRODUCTION

Flexible production systems (FPS) are integrated, computer-controlled machines and appliances of numerically controlled, technological measuring, transporting and machining systems, designed to manufacture products of desired class in a specific order, the appliance of which is limited by the number and diversity of the product.

In mass or, more visibly, in low-volume production, a considerable part of manufacturing cycle time is not occupied by the machine time but such processes as: total tools re-setting time, the time of FPS subsystem restoration after failure as a result of functional or parametric failures, awaiting semi-finished products and their transport. This is a typical drawback of FPS.

That is why, basing on the classification of CNC machine tools efficiency and reliability improving methods, the article will discuss constructional solutions for setting and fixing the workpiece and the tool.

THE CLASSIFICATION OF CNC MACHINE TOOLS EFFICIENCY AND RELIABILITY IMPROVING METHODS

The classification of CNC machine tools efficiency and reliability improving methods includes following types of operations:

- *internal – conducted only after stopping machine,*
- *external – conducted while machine is working.*

The most important part of machine re-setting is to [3, 5, 6]: separate internal and external operations (transport and switching tools and instruments), substituting internal operations with external operations (preparing the machine tool in advance, standardization of tools and devices assembly, reducing the application of mediating devices) as well as optimization of preparatory operations:

- *optimization of external operations, i.e. storing and transport of exactly specified quantity of tools, devices and materials prepared for consecutive operations,*
- *optimization of internal operations, i.e. using fast mounting devices, elimination of manual adjustment, mechanization of some preparatory operations, carrying out preparatory operations simultaneously by two people.*

Preparatory operations time is yet another element that will have a significant effect on the improvement of the FPS. The aforementioned preparatory operations include:

- *setting, placing and adjusting tools,*
- *setting, placing and adjusting machining devices.*

TECHNOLOGICAL METHODS CONCERN CONDUCTING PREPARATORY OPERATIONS IN A PRODUCTION PROCESS

Setting a CNC machine tool with a programme placing the device-retaining element

In this method of machine tool setting [1, 4, 7], the placing of the device retaining element, which determines the last cell of the appropriate device measurement chain, takes place directly on the CNC machine tool following a special program, within the operating technological process setting outline. The method relies on the possibility of compensation for the device measurement mistakes chain by means of arranging the element directly retaining the workpiece with a special program. It is therefore unnecessary to take measurements of the actual location of retaining elements (clots, tiles). There is, moreover, no need to adjust the steering program, basing on the measurements. In addition, application of this method simplifies the construction of the body of the device (bases, stab) as a result of the elimination of retaining elements placing holes.

Setting a CNC machine tool relatively to the measuring base changing its location in the system of coordinates of the machine tool

The suggested method enables setting the machining tool relative to every measuring base changing its location in the system of coordinates of the machine tool. Additionally, it prevents from machining parts of surfaces that are not to be machined. In addition, this method expands technological possibilities of a multitask CNC machine tool by reducing the number of parts settings while changing the setting base. It also lets the CNC machine perform operations that, in the past, were carried out, following the test passages method, on universal machine tools.

This method does not require any devices to regulate external tools, since it is possible to programme them from the level of the machine, without applying additional position sensors.

Setting a CNC machine tool in relation to a moving base

This method is designed for automatic adjustment of multitask CNC machine tools, both single axis, as well as multi axis ones, working autonomously as well as in flexible production systems on universal machines. This method aims at increasing the placing accuracy and placing processing parts by eliminating the mistake of placing the retaining element.

STRUCTURAL METHODS

These methods are connected with the construction of the machine tool, machining tools and mounting parts and consist in substituting internal operations with external ones – preparing the machine tool in advance.

Setting the workpiece relatively to a bottom surface of a T slot locating face

The device is designed to set the workpiece in a multitask CNC machine tool working in FPS and to reduce the re-setting time for machinning a workpiece of another kind. [3, 5]

Setting a workpiece relatively to the top surface of a T slot locating face

The tool may be used as an universal device for setting parts in multitask CNC mechine tools, working individually or as a part of FPS. The aim of its workings is to improve precision of setting parts and to lower labour intensity. In the suggested method, in comparison to the one presented in [2, 5], the action of the ring on the bottom of a T slot during the movment of the retaining element is abandoned. This results in improved precision of fixing and shortened re-setting time. Additionally, owing to broadened tolerance range, the preparation of slots is facilitated.

The device consists of a locating face, 1, with T slots, 2, (Figure 1.) and retaining elements, 3, fixed in the slots. The locating face has an initial position, 4, and the base surface, 5. Each retaining element, 3, consists of a ring, 6, with a disk, 7, and a thrust element, 8, so a nut located in the thread of a ring, 6, and freely set on the spring collet, 9, with a chamfer Z, the thrust ring, 10, and a set of disk springs, 11.

Between the disk, 7, of the ring, 6, and the bottom G of a T slot there will be a space S, and the thrust ring, 10, interacts with surface I of a T slot, 2, opposite the bottom, G, of the slot.

Retaining elements,3, in slots, 2, are moved by the socket, 12, supplied with thrust splines, 13, and a fixing axle, 14, with a lead-in chamfer M. There is a T slot, 15, in the fastening position, the vertically extended part of which is bigger than the height of the vertically extended T slots, 2, of the grid. The locating face, 16, is placed on the base surface 5.

The re-setting procedure takes place as follows:

The coordinates of the machine tool need to include the coordinates of part 17 (Figure 1). Therefore, it is necessary to set the retaining elements, 3, in proper operative positions of the slots, 2. The operative readiness of retaining elements is achieved by correcting consecutive errors by the means of nuts, 8 (Figure 1 and 2):

$$(K+D)<(H+B),$$

$$(B>D),\text{while}\quad(B\quad D)<e\quad n,$$

where: K – the height of an unpressed set of disk springs and a thrust ring; T – the distance in the fastening position, from the base surface to the thrust ring; H – height of an extended part of a T slot, 2; B – the size from the base surface to the extended part of a T slot, 2; e – maximum permissible pressing of a disk ring; n – the number of disk rings in a set.

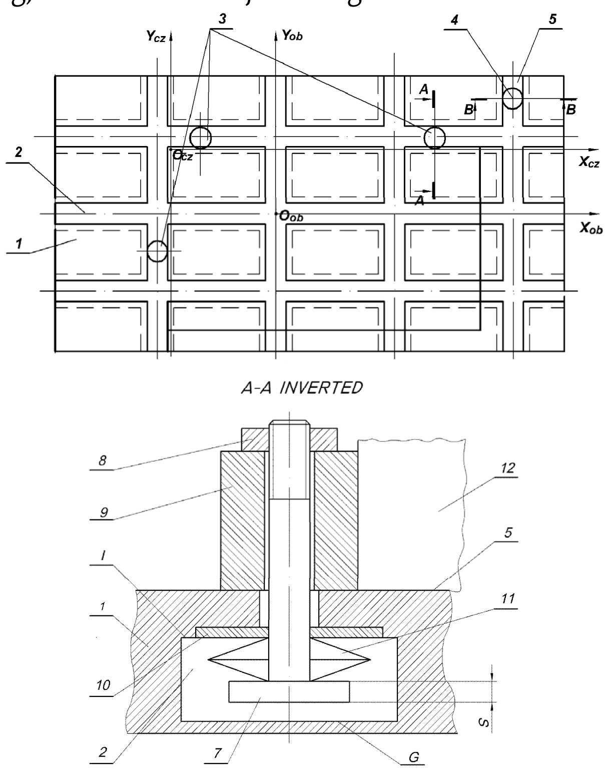

Figure 1. A retaining element

The prepared retaining element moves into fastening position at the same time, the chamfer of the base socket, 9, is set in a locating face, 16, what ensures required corner location of chamfer B (Figure 1 and Figure 3). The set of disk springs, 11, is unpressed, so $H_1 > H$. Consequently, according to the programmed instructions, a spindle, let it be with socket 12, approaches the fastening position 4.

The spindle axis with the socket are compatible with the retaining element axis, 3, at the same time oil supplied into the hydraulic cylinder of the socket exerts such a pressure that moves the axle 14 to the right (Figure 3). The spindle with the socket lowers, the retaining element, 3, enters the thrust axle inlet, 14 (Figure 4). The thrust splines, 13, pressing the thrust ring, 10, press the set of disk springs 11 (Figure 2 and Figure 3). Next, clamping the retaining elements in socket 12, results in dropping the oil pressure in the socket cylinder and the wedging axle 14, pressed by disk springs, moves to the left, wedging the collet 9 (Figure 3).

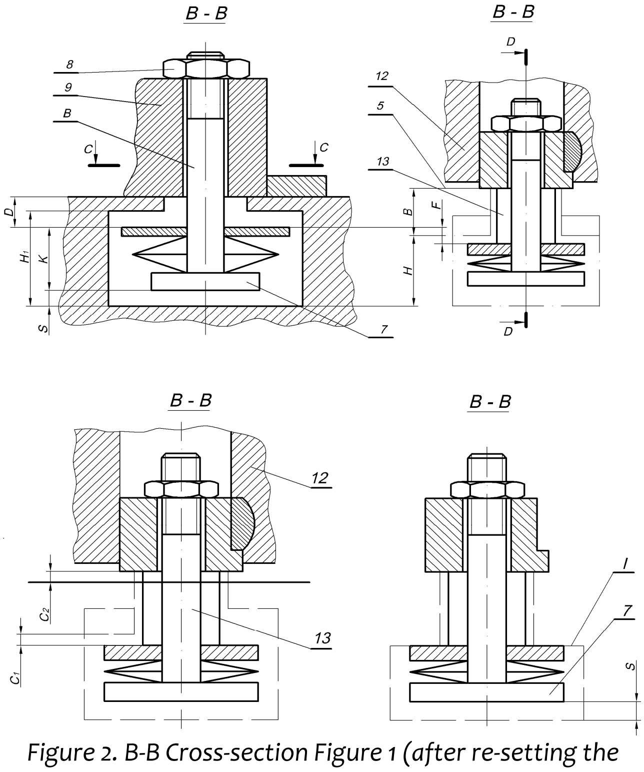

Figure 2. B-B Cross-section Figure 1 (after re-setting the retaining elements)

The spindle with the retaining element clamped in socket, 12, moves up along the axis in order to keep the spaces between the bottom face surface of the base socket 9, and the the base surface 5, of the clamping face 1, as well as between the T slot locating face 2, and the thrust ring 10 (Figure 2). In such a position the spindle with the retaining element moves along the T slot 2, according to the coordinates of the machine tool (Figure 2) into the required position, setting the system of coordinates (Figure 1). In this position, the oil is supplied into the socket, 12, cylinder releasing the base collet.

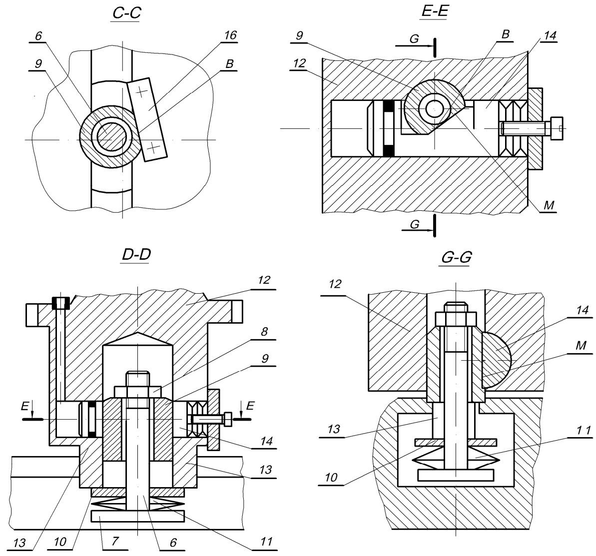

Figure 3. C–C and D–D cross-sections in the Figure 2., E–E and G–G cross-sections

Device for clamping rotational tools and retaining elements relative to processing part moving base

This device may be applied to multitask CNC machine tools with a view to automated clamping of the tools with an automated tuning of the tool outlet relative to a moving base, as well as for an automated clamping the retaining elements in a socket (Figure 4.). The device consists of the casing, 1, the shank of which is clamped in the machine tool spindle. There are two longitudinal unthrough holes in the casing, 2 and 3, and two transverse ones, 4 and 5, intersecting the longitudinal. The casing, 1, holds also inlet channels 6, 7, and 8, providing hydraulic pressure in the outlets at the ends of holes 3 and 4, where the rams, 9 and 10, are fixed. At the one end of the rams 9 and 10, there are seals 11 and 12, and on the other end disk springs 13 and 14, washers 15 and 16, as well as screws 17 and 18 adjusting the pressure of the disk springs. Seal 11 prevents oil leaks after casing-spindle joint. Longitudinal, 2, and transverse, 5, holes hold springs, 20, designed to interact with face surfaces of tools 21 and 22, or with retaining elements, the chamfers of which, 23, interact with the ones on the rams, 24.

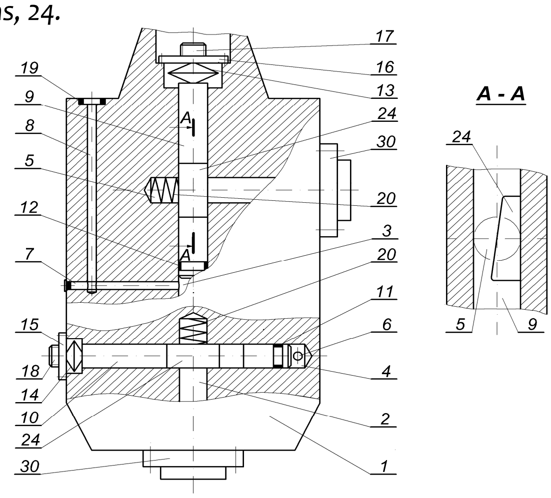

Figure 4. The device and its cross-section on an A-A surface

Figure 5 presents a retaining element and its longitudinal section. The retaining element has a shank, 25, identical to the shank of the tool. The shank of the retaining element holds also a washer, 26, and a ring 27, with disk rings, 29, fixed between them with a screw. The casing holds thrust sockets, 30, fixed coaxially to the holes 2 and 5.

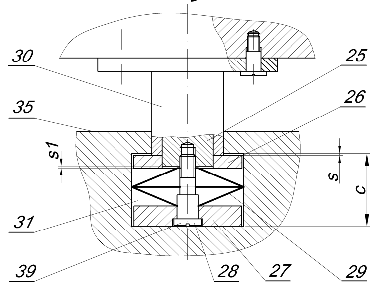

Figure 5. Retaining element and its longitudinal section

As the movement of the spindle along the retaining element axis continues, thrust socket 30 presses thrust ring 26, pressing at the same time the set of disk springs, 29, with a value Z. As soon as there is an adequate space between ring 26 and T slot locating face 31, shank 25 is clamped in hole 5. The pressure in hydraulic system drops and, as a result of the pressure from disk springs 13, ram 9 moves towards hole 3 fixing the retaining element in the device.

Figure 6 shows the device with an end mill fixed - a), the device with a bar holder fixed - b);

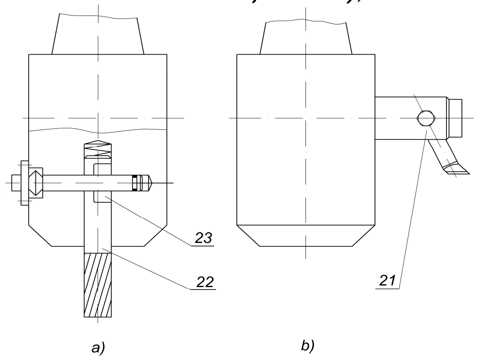

Figure 6. The device with an end mill fixed -a; the device with a bar holder fixed -b);

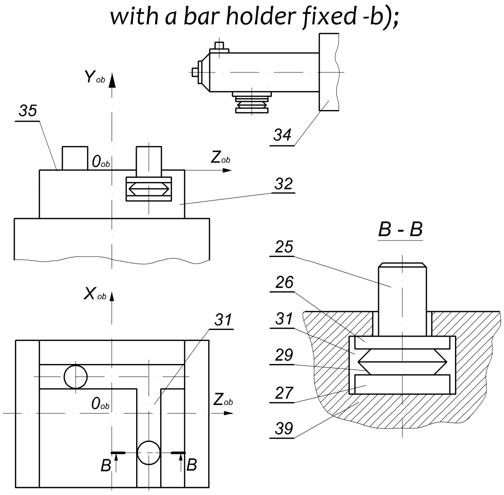

Figure 7. The diagram of setting retaining elements in a locating face or a pallet. The base locating surface, parallel to the spindle axis – a), retaining element clamped in a T slot of the tool or the pallet - b);

Figure 7 shows the diagram of setting retaining elements in a locating face or a pallet. The base locating surface, parallel to the spindle axis – a), retaining element clamped in a T slot of the tool or the pallet - b);

The firmness of the clamp is provided by chamfer 24 and an appropriate truncation, 23, on the retaining element.

According to the programme, the spindle moves the retaining element along T slot 31 and further, into the desired position set by the machine tool system of coordinates X_{ob} O_{ob} Z_{ob}.

Once again, the oil is supplied into the hydraulic system of the device, ram 9 moves away from the shank of the retaining element and, released from the pressure from the set of 29 disk springs, is fixed into the T slot of the pallet or of the device (Figure 5, Figure 7)

Figure 8 shows the diagram of setting retaining elements on a V-block device, the base surface of which is perpendicular to the spindle axis -a), schematic machining of a workpiece -b);

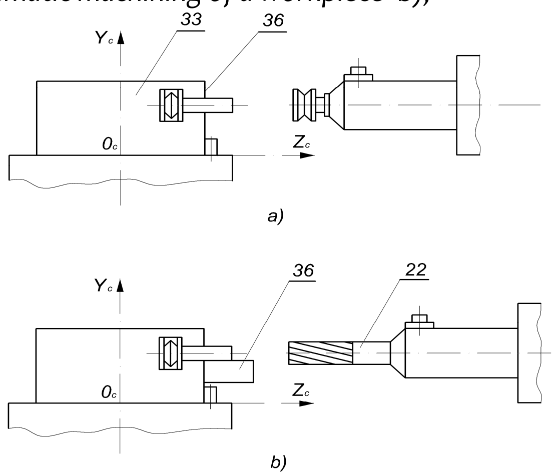

Figure 8. The diagram of setting retaining elements on a V-block device, the base surface of which is perpendicular to the spindle axis-a), schematic machining of a workpiece-b)

Figure 9 shows: The diagram of mutual initial positions of the device and retaining element -a), retaining element in the device -b), retaining element movement diagram -c);

Then, following the programmed sequence, the spindle with the device moves perpendicularly to the locating surface 35, away from the retaining element. The following conditions need to be met (Figure l3):

$$H_z = (A_{z0} - A_{z1}),\ B = A_{z1},$$

where A_{z0} – the distance between the spindle axis and the bottom surface, 37, of a T slot 31, and the initial position. A_{z1} is the length of a programmed movement of the spindle with the device with disk springs of the retaining element pressed to value Z; W – is the distance between ring 27 of the retaining element and the bottom of a T slot while relieving the spindle with a fixed retaining element into the initial position.

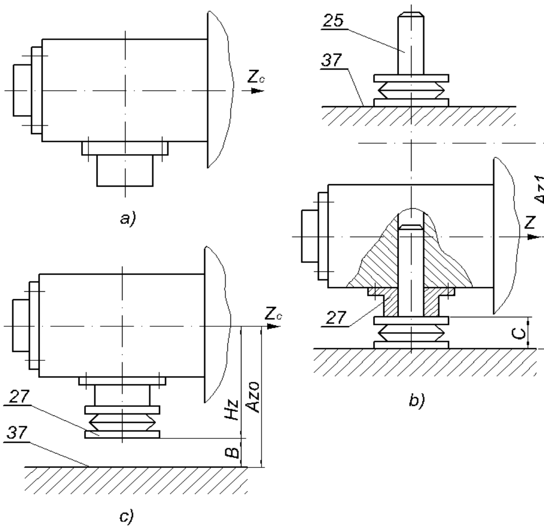

Figure 9. The diagram of mutual initial positions of the device and retaining element -a), retaining element in the device -b), retaining element movement diagram -c)

Having set the retaining elements in the machine tool set of coordinates $Y_{ob}O_{ob}Z_{ob}$, $X_{ob}O_{ob}Z_{ob}$ (Figure 1), their clamping elements in T slots set and fix workpiece 38 or 39, which is then machined according to the programme (Figure 6, Figure 8).

Other retaining elements are set accordingly (Figure 7, Figure 8). While fixing retaining elements the axis of which is parallel to the spindle axis (Figure 8a), another pair of mutually perpendicular holes, 2 and 4, of the casing is used (Figure 4). In such a case, the workpiece (38) is set in a base clamping surface, 36, perpendicular to the spindle axis.

Thrust sockets after re-setting the device, may, if required, be removed from the casing, 1. The device may be then used for automatic fixing and removing the cutting tool, 22, e.g. a shank cutter from socket 21, (Figure 6). Fixing the cutting tool is the same as in case of fixing the retaining tool.

Figure 10 shows a model machining of a workpiece 39 – milling with a cutter 22, and boring with a boring cutter 21.

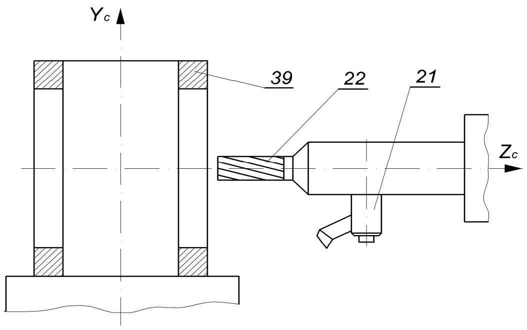

Figure 10. Machining scheme

Device for automated fastening shank tools

The device is designed to use with the CNC machine tools, improves and expands technological possibilities during setting the shank outlet relative to every processing part moving base or the device itself.

Figure 11 introduces the device set relative to the tool outlet and clamped in spindle's socket.

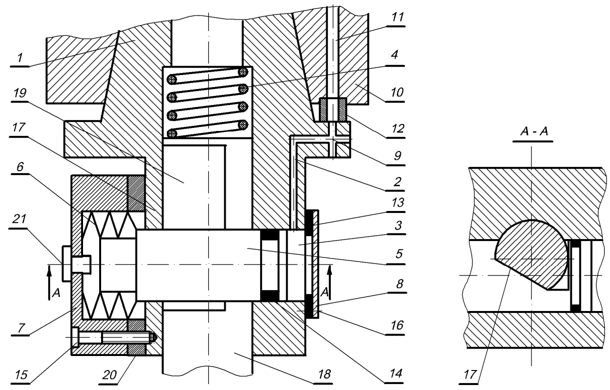

Figure 11. Socket regulating Az a tool outlet

The device is composed of (Figure 11): a tool socket, 1, with channels, 2, supplying oil to the space, 3, of the spring, 4, closing axle, 5, disk springs, 6, a shell-case 7, the cover 8, a return valve 9.

The device is set in the spindle's cone, 10, with an oil-supplying channel, 11. Gaskets 12 – 14 prevent any oil leaks. The shell-case and the cover are secured with screws 15 and 16. The closing axle, 5, has a chamfer 17, adjusting the tool, 18, with a proper cutting, 19, on its end. The required tool clamping power is achieved by the right ring thickness, 20. A thrust screw, 21, limits the jump of a closing axle, 5, therefore prevents the machining tool jumping off into a not clamped state.

During setting, machining tool outlet runs into the moving base, 22, of the workpiece (or of the device) 23, placed on the CNC machine table 24 (Figure 12).

Figure 12. shows setting the machining tool outlet pattern, where: z_o - the distance of the spindle front surface from the table surface in the initial position ("0" for the machine tool in relation to Z axis); A_z - the measurement along the spindle axis, set from moving base, 22, to the spindle front surface (tool outlet); z_a - value of movement of the spindle with tool after setting the tool outlet; K – the spring, 4, pressing value assuring the guaranteed contact of the machining tool outlet with the measurement moving base; z'_a - the distance between the fastened machining blade and the moving base with a spindle in the initial position ("0" for the machine tool), while $z_a = z'_a$.

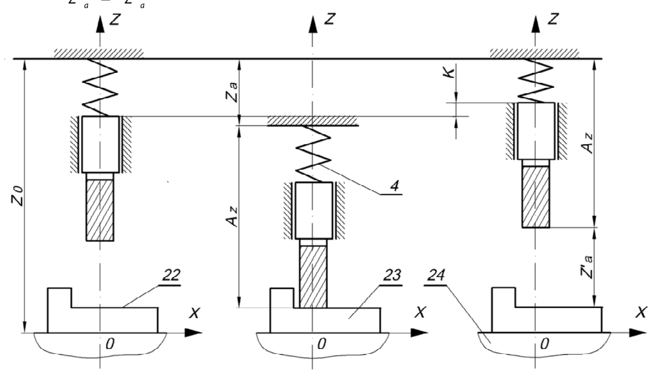

Figure 12. Setting the machining tool outlet according to A_z outlet

The device operates in the following way.

Before machining and after the tool change, the spindle is in the initial position. The pressure in the hydraulic system, moves the closing axle 5 (Figure 11) to the left, towards the thrust screw, 21, pressing the disk spring, 6, at the same time, the machining tool, 18, remains unclamped. Next, following the steering programme, the spindle, 10, with the tool mounted, moves towards the moving base, 22, of the part (or of the device, 23), pressing the spring, 4, to value K so as to guarantee the contact of the machining tool with the part (or the device) moving base. Then, in rFPSonse to a steering signal, the tool is clamped, and the pressure in the hydraulic system drops as a result of valve 9 action. Under the pressure from the disk spring 6, axle 5 moves to the right, mounting the machining tool (Figure 11).

This is the location in which an automatic setting of the tool towards the moving base takes place. Finally, the spindle, following the steering programme, moves either to the initial location ("0") or to the part-processing zone.

The possibility of automatic setting of the tool outlet to the moving base improves and expands the technological possibilities of the CNC machine tool. It reduces the number of necessary operations (e.g. parts setting, which is essential for moving the base) and enables to conduct a series of operations, that were previously carried out on conventional machines using the test passages method, on CNC machines.

A multitask CNC machine tool with an automatic tools fastening device

In the suggested solution, tool fastening does not involve mechanisms for setting the spindle and sockets. Unlike in previous solutions, there is a simplified control block placed in each tool magazine socket. Those blocks, then, have two functions: setting the tool holder in the tool magazine socket and clamping the tool holder with the spindle's parallel keys. Previous solutions lacked the possibility of controlling the presence of the socket in the spindle. The tool change, there, takes place in certain spindle and socket positions, set with orientation mechanisms. At the same time, the tool holder should be in the spindle for the tool-changing device to operate. Setting the first device manually lowers the level of a CNC machine automation. The presented device both changing tools and setting the magazine may be fully automated, for the tool sockets may be located in the tool magazine.

CONCLUSIONS

The cost and effect analysis, carried out after applying certain CNC machine re-setting time shortening methods, draws the attention to resolving the question of improving their reliability and efficiency by appropriate structural solutions for devices used in machining.

The analysis of prepared classification of methods for increasing the productivity and elasticity of CNC multi-roles machine tools as well as the analysis of dependence between this elasticity and the level of the retooling automation confirms, that technological methods, constructional particularly, are the optimum solution for increasing the productivity and the reliability of these machine tools.

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SIMULATING QUEUING SYSTEMS: A TEST OF PARAMETER CHANGE

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ABSTRACT: *This paper examines queuing models, in particular the single-server queuing system. Queuing models assist firms achieve this objective. Queuing models may help firms reduce queues by helping determine what type of system best suits the business. The paper is theory based and uses steady-state equations and simulation to model queuing systems. In particular, the paper examines whether the robustness of steady-state equations and the change of parameters will have a significant effect on queuing models. The paper finds that system complexity does have an impact on the accuracy of the steady-state method results. It is also found that the use of this method is subject to use requirements.*
KEYWORDS: *queuing models, steady-state equations, simulation, queuing systems*

INTRODUCTION

Queuing models can be in the form of both physical and non-physical queues. For example, a queue at a bank is physical, whereas a telephone call to a service centre may be held on a non-physical queue. As firms recognise that customers dislike queuing [1, 2], the desire to maintain relationship with its customers means that firms seek to "manage the trade-off between longer queues, improved service quality and increased costs" [3]. Queuing models assist firms achieve this objective. Queuing models may help firms reduce queues by helping determine what type of system best suits the business.

Queuing models however have their limitations. For example, the classes of algorithms that they handle may be limited in scope and complexity [4]. Queuing models also require independent assumptions to be made which may not be very accurate. For example, the speed the server on average can serve, may differ depending on the day or the customer requirements, yet a decision must be made on how to best describe this distribution overall. As a result, queuing models are often an approximation of a real system. To obtain more accurate characteristics of a real life system, simulation is often recommended [5]. Simulation involves programming specific software to model the queuing system. Even though this is more accurate it can take a long time to implement due to the computer programming that is required because of the detail of information that is required.

Based on this, the objective of this study is to examine a number of existing analytical single-server models and to determine their limitations using simulation software. The single-server models discussed will be tested using a set of theoretical distributions, for both the steady-state equation method and the simulation method, as the simulation method is more accurate; this will be used as a benchmark to show how robust the queuing model is.

QUEUING MODELS AND THEIR ASSUMPTIONS

One of the simplest queuing systems is the standard M/M/1 model which is a single channel model with Poisson arrivals and exponential service times [6]. Poisson probability distribution best describes the distribution pattern and the service time is assumed to follow an exponential distribution.

Assumptions formulas may be developed and used to discover certain aspects of the queue. For these the mean number of arrivals within the time period must be known which is notated by λ and the mean number of services conducted within the period must be known notated by μ. Anderson et al [3], suggest that;

Probability that no units are in the system:

$$P_o = 1 \quad \frac{\lambda}{\mu} \qquad (1)$$

The average number of units in the queue:

$$L_q = \frac{\lambda^2}{\mu(\mu \quad \lambda)} \qquad (2)$$

The average number of units in the system:

$$L = L_q + \frac{\lambda}{\mu} \qquad (3)$$

The average time a unit spends in the queue:

$$W_q = \frac{L_q}{\lambda} \qquad (4)$$

The average time a unit spends in the system:

$$W = W_q + \frac{1}{\mu} \qquad (5)$$

The probability that an arriving unit has to wait for service:

$$P_w = \frac{\lambda}{\mu} \qquad (6)$$

The probability of n units in the system:

$$p_n = \quad \frac{\lambda}{\mu} \quad ^{n} P_o \qquad (7)$$

For these to achieve steady-state there must be the constraint that the mean service rate μ is greater than the mean arrival rate λ otherwise the system will grow without a "limit because the service facility does not have sufficient capacity to handle the arriving units" [3] and the steady-state can never be achieved.

THE STUDY

The experiment uses two quantitative methods to model queues. These methods are the steady-state equation method which is conducted on Microsoft Excel and the simulation method which is preformed using a software package called Simul8.

Simul8 allows randomly generated trials to be performed based on the numbers imputed into the model. It also enables users alter the service and arrival probability functions, change the queue discipline and set a capacity on the queue, which is required to produce results that represent each independent queue model. To test the parameters of each queuing model, a set of scenarios will be conducted for each queuing model. The steady-state equations require the service and arrival rate over a certain time period which is one hour for this experiment, whereas the Simul8 software requires the time between arrivals and the time it takes to serve one unit. For example, if μ=25 and λ= 20 for the steady-state method, then the numbers required for a compatible simulation would be μ=2.4 and λ= 3 which is 60 divide the steady-state equations inputs. We note that as long the numbers imputed represent the same distribution for each method then the comparison is valid. The input numbers will be consistent, so that comparison can occur between the simulation and steady-state approach for each queuing system.

Using the Simul8 package, a model of the single-server queue was made; which has a work entry point, a storage bin representing the queue, a work centre followed by exit point, all connected by routing arrows. Once the basic model was formed and the correct probabilities and numbers imputed, the duration time was set. Although Simul8 is automatically set to the working week, this experiment required a non-terminating model to be simulated (to be comparable to the steady-state method). For this reason, the duration was set to 480 minutes which is one continual working day. Simul8 also incorporates the transient period with in its results, which must be excluded. To allow for valid comparison, the warm-up period was set. To determine the warm-up period, the results were plotted against time. To overcome the problem of auto-correlation, multiple runs were performed, thus ensuring that the random numbers generated for each run do not correlate and are independent of each other. This is because if autocorrelation occurs, it will impact on the reliability of the method. Another reason why multiple runs are required is to give an appropriate average for the model, so that extreme results don't affect the overall average. The number of trials performed was determined by the confidence level set, which for this experiment was 95%. Simul8 can automatically run the correct number of trials to achieve this confidence level, therefore ensuring the reliability of the results. The confidence level of 95% was based on 4 different results; average queue size, average use, average time in system and average queuing time.

To analyze the results and to justify the aim of the experiment, which is based on the comparison of two quantitative methods to model queues (using Microsoft Excel and Simul8), a direct comparison was performed using the simulation results as a benchmark. This indicated how the results varied. The difference between the average results for each method was taken and averaged. t-tests were also conducted using Microsoft Excel on the two different methods results, to show whether their difference was significant. The t-test was be "two-tailed" with a null hypothesis that 'both methods are equal in predicting queue characteristics' and the alternative hypothesis 'that the steady-state method is inaccurate and differs.'

RESULTS AND ANALYSIS

The M/M/1 SIRO model was not tested because it can't be easily modelled via Simul8. As it is not common to choose people randomly from a queue, this requirement was excluded from the experiment. Another model that has been discussed, but not experimented on is the G/M/1 model, this is because its formulas directly predict the aspects of the queue and not the average, and therefore comparison couldn't occur.

M/M/1 Model analysis

Examining the results from M/M/1 show that all 4 queue characteristic results differ between the simulation and steady-state method (shown in Figure 1). The t-tests designed to test the significance between the two methods results, examines whether the null hypothesis is still valid or if the alternative is now accepted, as stated in the methodology.

Table 1. M/M/1 t-test

	L_q	L	W	W_q
T-statistic	4.311968995	4.196175071	3.56127571	4.733482978
P-Value	0.001956039	0.002319796	0.006107069	0.00106866
Critical T-Value	2.262157158	2.262157158	2.262157158	2.262157158

From Table 1, it can be seen that the difference between the two methods is significant for all the characteristic results. The reason for this is because *the t-statistic for all 4 is significantly greater than the critical value and the p-value is lower than the significance level of 0.05. Examining the summarized t-test table the W_q results are seen to have the most significant difference because its p-value is the lowest at 0.001(3dp) and it has the greatest difference between the critical t value and the t-statistic of 2.47 (2dp).*

M/M/1 **Lq** **L**

λ	μ	Simulation	Steady-state method	Difference	Simulation	Steady-state method	Difference
20	25	[1.68,1.77,1.86]	3.2	1.43	[2.45,2.54,2.64]	4	1.46
20	30	[0.67,0.71,0.74]	1.333333333	0.62333333	[1.29,1.33,1.37]	2	0.67
20	35	[0.34,0.36,0.38]	0.761904762	0.40190476	[0.84,0.87,0.9]	1.333333333	0.4633333
15	20	[1.09,1.15,1.2]	2.25	1.1	[1.83,1.89,1.95]	3	1.11
15	25	[0.4,0.42,0.44]	0.9	0.48	[0.98,1.01,1.04]	1.5	0.49
15	30	[0.19,0.2,0.21]	0.5	0.3	[0.67,0.68,0.7]	1	0.32
10	15	[0.56,0.59,0.62]	1.333333333	0.74333333	[1.24,1.28,1.32]	2	0.72
10	20	[0.18,0.19,0.2]	0.5	0.31	[0.71,0.72,0.74]	1	0.28
10	25	[0.08,0.08,0.09]	0.266666667	0.18666667	[0.51,0.52,0.53]	0.666666667	0.1466667
10	30	[0.04,0.04,0.04]	0.166666667	0.12666667	[0.41,0.41,0.41]	0.5	0.09
			Average	0.57019048			0.575

W **Wq**

Simulation	Steady-state method	Difference	Simulation	Steady-state method	Difference
[8.21,8.47,8.73]	12	3.53	[5.29,5.54,5.8]	9.6	4.06
[4.77,4.89,5]	6	1.11	[2.24,2.34,2.44]	4	1.66
[3.45,3.51,3.57]	4	0.49	[1.21,1.26,1.31]	2.285714286	1.0257143
[8.03,8.27,8.5]	12	3.73	[4.51,4.73,4.95]	9	4.27
[4.66,4.76,4.85]	6	1.24	[1.72,1.8,1.88]	3.6	1.8
[3.41,3.46,3.51]	4	0.54	[0.87,0.91,0.95]	2	1.09
[7.79,7.99,8.18]	12	4.01	[3.32,3.49,3.66]	8	4.51
[4.6,4.68,4.75]	6	1.32	[1.09,1.14,1.2]	3	1.86
[3.4,3.44,3.47]	4	0.56	[0.48,0.5,0.53]	1.6	1.1
[2.78,2.8,2.83]	3	0.2	[0.26,0.27,0.28]	1	0.73
		1.673			2.2105714

Figure 1. M/M/1 Result

Examining the L_q and W_q results shows that changing the service rate by 5 can drastically change the results; take distribution λ=20 and μ=25 compared to λ=15 and μ=25. Between these two scenarios a decrease of over 60% has occurred, showing that the parameters have a significant effect on the model and its results. The simulation results for L_q also went from the average of 1.77 to 0.42 due to the change in the arrival rate between this periods.

M/M/1 Finite Model analysis

As with the standard M/M/1 model, all of the characteristics significantly differed, with the p-values being under the significance level of 0.05. However, with the M/M/1 Finite model (Figure 2), the difference was more significant as seen in the t-test which shows the highest p-value to be 0.0000134308 (Table 2).

The difference between its critical value and t-statistic is 6.25 (2dp) which is also greater than any other models. It contains the biggest difference between the t-statistic and the critical value of 14.32 (2dp) for L which is the most significant difference of the model with a p-value of 0.0000000471623. The steady-state method is severely flawed and inaccurate because on average it has overestimated the units in the queue by 2.71(2dp) and their wait by 5.83(2dp).

M/M/1 finite **Lq** **L**

λ	N	μ	Simulation	Steady-state method	Difference	Simulation	Steady-state method	Difference
20	6	25	[1.24,1.31,1.37]	3.752693966	2.442693966	[1.99,2.07,2.14]	4.751496648	2.681496648
20	6	30	[0.61,0.65,0.68]	3.503591954	2.853591954	[1.22,1.27,1.31]	4.502155172	3.232155172
15	6	20	[0.96,1.01,1.06]	3.669646658	2.659646658	[[1.7,1.75,1.81]	4.668369519	2.918369519
15	6	25	[0.39,0.41,0.43]	3.337590464	2.927590464	[0.97,1,1.03]	4.33599404	3.23599404
10	6	15	[0.56,0.59,0.62]	3.503591954	2.913591954	[1.25,1.28,1.32]	4.502155172	3.222155172
10	6	20	[0.18,0.19,0.2]	3.005747126	2.815747126	[0.71,0.72,0.74]	4.003831418	3.283831418
20	7	25	[1.35,1.42,1.5]	4.750510621	3.330510621	[2.1,2.18,2.27]	5.750283678	3.570283678
15	7	20	[1.01,1.06,1.12]	4.667231502	3.607231502	[1.75,1.8,1.87]	5.66698943	3.86698943
15	5	20	[0.9,0.95,1]	2.678021087	1.728021087	[1.63,1.69,1.75]	3.673154907	1.983154907
10	5	20	[0.18,0.19,0.2]	2.02189781	1.83189781	[0.71,0.72,0.74]	3.01459854	2.29459854
				Average	2.711052314			3.028902852

W **Wq**

Simulation	Steady-state method	Difference	Simulation	Steady-state method	Difference
[7.27,7.5,7.73]	11.41726205	3.91726205	[4.09,4.3,4.5]	9.017262047	4.717262
[4.87,4.98,5.09]	9.017266187	4.03726619	[2.09,2.19,2.28]	7.017266187	4.8272662
[7.88,8.11,8.34]	14.0230179	5.9130179	[4.09,4.29,4.5]	11.0230179	6.7330179
[4.89,4.99,5.08]	10.42302526	5.43302526	[1.7,1.78,1.86]	8.023025264	6.2430253
[8.09,8.29,8.5]	18.03453237	9.74453237	[3.33,3.51,3.68]	14.03453237	10.524532
[4.85,4.93,5]	12.03454894	7.10454894	[1.09,1.15,1.2]	9.034548944	7.8845489
[7.59,7.83,8.07]	13.8038135	5.9738135	[4.41,4.63,4.85]	11.4038135	6.7738135
[8.03,8.26,8.49]	17.00508475	8.74508475	[4.24,4.46,4.67]	14.00508475	9.5450847
[[7.66,7.88,8.1]	11.07334963	3.19334963	[3.86,4.06,4.26]	8.073349633	4.0133496
[4.84,4.92,5]	9.110294118	4.19029412	[1.08,1.14,1.19]	6.110294118	4.9702941
		5.82521947			6.6232195

Figure 2. M/M/1 Finite Result

Table 2. M/M/1 Finite t-test

	L_q	L	W	W_q
T-statistic	11.62901644	16.57898294	8.512696385	9.703550601
P-Value	1.00568E-06	4.71623E-08	1.34308E-05	4.59414E-06
Critical T-Value	2.262157158	2.262157158	2.262157158	2.262157158

On examining the parameters, it is observed that λ=15, μ=20 and the changing the N value to 5,6 and 7 a rounded increase of 1 between each change occurred using the steady-state method for the L and L_q characteristics, as shown in figure 4.4. It also resulted in a change of 0.06 between N=5 and N=6 and 0.05 between N=6 and N=7 using the simulation method. For W and W_q the same applies with a difference of 3 occurring with the steady-state method. Overall this model is shown to be the least robust concerning the steady-state method.

M/M/1 LIFO Model analysis

M/M/1 LIFO resulted in the same steady-state equation results as the standard M/M/1 model and the simulation results were very similar to the M/M/1 models. Similar t-test results were also observed. The average difference for $L_q$was show to be 0.58(2dp) units and the average difference for $W_q$was 2.3 minutes (see Table 3). The simulation results took into account slight changes, even if this was only 0.02 units, which is the difference between the two models $L_q$results where λ=20, μ=25.

Table 3. M/M/1 LIFO t-test

	L_q	L	W	W_q
T-statistic	4.252385054	4.153794538	3.527840075	4.623601975
P-Value	0.002134956	0.0024704	0.006435727	0.001247953
Critical T-Value	2.262157158	2.262157158	2.262157158	2.262157158

M/G/1 Model analysis

From these models results, it is observed that the average difference for the characteristic was slightly lower than that of the standard M/M/1 model. The average difference for the characteristic was also less significant. For example, for W, a p-value of 0.315(3dp) is observed (Table 4). This is above the 0.05 significance level. At the same time, the t- statistic value 1.065(3dp), is below the two tailed critical value. The most significant difference came from the average waiting time in the queue which had a t- statistic value of 0.725(3dp) which is greater than the critical value. The p-value of 0.015(3dp), even though being significant is small compared to the models previously discussed, thus showing M/G/1 to be a more robust model.

Table 4. M/G/1t-test

	L_q	L	W	W_q
T-statistic	2.959748927	2.437143552	1.065238156	2.987433563
P-Value	0.015966028	0.037540114	0.314510559	0.015264341
Critical T-Value	2.262157158	2.262157158	2.262157158	2.262157158

As with the other models, changing the parameters did impact the results. By changing the standard deviation, it is observed in Figure 3, that the average for all the characteristics decreased.

M/G/1

			Lq			L		
λ	μ	σ	Simulation	Steady-state method	Difference	Simulation	Steady-state method	Difference
20	25	0.025	[2.34,2.47,2.59]	2.225	0.245	[3.19,3.33,3.45]	3.025	0.305
20	30	0.025	[1.16,1.22,1.28]	1.041666667	0.17833333	[1.9,1.97,2.03]	1.708333333	0.26166667
15	20	0.025	[0.86,0.91,0.95]	1.40625	0.49625	[1.64,1.7,1.74]	2.15625	0.45625
15	25	0.025	[0.39,0.41,0.43]	0.62578125	0.21578125	[1.04,1.07,1.1]	1.22578125	0.15578125
10	15	0.025	[0.23,0.24,0.25]	0.760416667	0.52041667	[0.94,0.96,0.97]	1.427083333	0.46708333
10	20	0.025	[0.09,0.1,0.1]	0.3125	0.2125	[0.65,0.67,0.68]	0.8125	0.1425
15	20	0.03	[1.24,1.31,1.37]	1.53	0.22	[2.08,2.12,2.19]	2.28	0.16
15	20	0.02	[0.58,0.61,0.64]	1.305	0.695	[1.34,1.37,1.41]	2.055	0.685
15	20	0.015	[0.39,0.41,0.43]	1.22625	0.81625	[1.13,1.16,1.19]	1.97625	0.81625
15	20	0.01	[0.27,0.28,0.3]	1.17	0.89	[1.01,1.03,1.05]	1.92	0.89
				Average	0.44895313			0.43395313

W			Wq		
Simulation	Steady-state method	Difference	Simulation	Steady-state method	Difference
[10.66,11.02,11.38]	9.075	1.945	[7.29,7.64,7.99]	6.675	0.965
[6.8,6.98,7.16]	5.125	1.855	[3.72,3.9,4.07]	3.125	0.775
[7.55,7.73,7.91]	8.625	0.895	[3.63,3.8,3.98]	5.625	1.825
[5.14,5.23,5.33]	4.903125	0.326875	[1.74,1.82,1.89]	2.503125	0.683125
[6.23,6.32,6.4]	8.5625	2.2425	[1.38,1.45,1.52]	4.5625	3.1125
[4.52,4.56,4.6]	4.875	0.315	[0.59,0.62,0.65]	1.875	1.255
[9.14,9.4,9.66]	9.12	0.28	[5.13,5.38,5.63]	6.12	0.74
[6.37,6.49,6.61]	8.22	1.73	[2.53,2.65,2.76]	5.22	2.57
[5.55,5.64,5.72]	7.905	2.265	[1.76,1.84,1.92]	4.905	3.065
[5.06,5.12,5.18]	7.68	2.56	[1.28,1.34,1.39]	4.68	3.34
		1.4414375			1.8330625

Figure 3. M/G/1 Result

Within the results it can be seen that the steady-state method has underestimated some characteristics compared to the simulation approach. For W when λ=20, μ=25, σ=0.025 it is 1.945 lower than the simulation average which is a more accurate approach. This underestimation could result in the user underestimating the resources required for the task, resulting in negative side effects.

M/D/1 Model analysis

All of M/D/1 characteristic results differ significantly, as shown in the t-test highlights (Table 5), which have p-values under 0.05 and a t-statistic greater than the critical value.

Table 5, M/D/1 t-test

	L_q	L	W	W_q
T-statistic	4.0266627	3.475546778	3.090027026	4.486895995
P-Value	0.0029879	0.006987412	0.012928908	0.001517281
Critical T-Value	2.26215715	2.262157158	2.262157158	2.262157158

The largest significance was observed in W_q which had a t-statistic of 2.225 over the critical value and a p-value of 0.0015(4dp). This shows that there is a significant difference between the two methods and the steady-state method is not that robust at efficiently predicting the characteristics of the queue.

$M/E_k/1$ Model analysis

The results of the $M/E_k/1$ Model analysis (Figure 4) was similar to the previous models. The exception was however in the M/G/1. The results of the $M/E_k/1$ Model analysis shows that the average number of units in the system, L, was the most significant with a p-value of 0.00022(5dp) and a t- statistic 3.677(3dp) greater than the critical value.

M/Ek/1

			Lq			L		
λ	μ	k	Simulation	Steady-state method	Difference	Simulation	Steady-state method	Difference
20	25	3	[0.81,0.85,0.89]	1.610522505	0.7605225	[1.57,1.61,1.66]	2.666666667	1.05666667
20	30	3	[0.29,0.3,0.32]	0.670104881	0.3701049	[0.89,0.9,0.93]	1.333333333	0.43333333
15	20	3	[0.46,0.49,0.51]	1.134962424	0.6449624	[1.2,1.23,1.26]	2	0.77
15	25	3	[0.15,0.15,0.16]	0.452959454	0.3029595	[0.72,0.73,0.74]	1	0.27
10	15	3	[0.22,0.23,0.24]	0.675330423	0.4453304	[0.92,0.93,0.94]	1.333333333	0.40333333
10	20	3	[0.05,0.06,0.06]	0.252213872	0.1922139	[0.58,0.6,0.6]	0.666666667	0.06666667
15	20	5	[0.35,0.37,0.38]	1.178794828	0.8087948	[1.09,1.11,1.13]	1.8	0.69
15	20	4	[0.39,0.41,0.43]	1.153125	0.743125	[1.12,1.15,1.17]	1.875	0.725
15	20	2	[0.62,0.65,0.69]	1.12640625	0.4764063	[1.35,1.39,1.44]	2.25	0.86
15	20	1	[1.08,1.14,1.19]	1.125007031	0.014993	[1.81,1.88,1.93]	3	1.12
				Average	0.4759413			0.6395

W			Wq		
Simulation	Steady-state method	Difference	Simulation	Steady-state method	Difference
[5.63,5.75,5.87]	7.231567515	1.661567515	[2.69,2.81,2.93]	4.831567515	2.0215675
[3.62,3.66,3.71]	4.010314642	0.350314642	[1.07,1.12,1.16]	2.010314642	0.8903146
[5.58,5.68,5.78]	7.539849696	1.859849696	[2.02,2.13,2.22]	4.539849696	2.4098497
[3.67,3.71,3.75]	4.211837818	0.501837818	[0.73,0.76,0.79]	1.811837818	1.0518378
[5.86,5.94,6.01]	8.051982538	2.111982538	[1.32,1.38,1.44]	4.051982538	2.6719825
[3.91,3.94,3.97]	4.513283232	0.573283232	[0.36,0.38,0.39]	1.513283232	1.1332832
[5.14,5.21,5.29]	7.715179312	2.505179312	[1.59,1.66,1.73]	4.715179312	3.0551793
[5.29,5.37,5.46]	7.6125	2.2425	[1.75,1.83,1.9]	4.6125	2.7825
[6.2,6.33,6.46]	7.505625	1.175625	[2.66,2.78,2.9]	4.505625	1.725625
[7.99,8.22,8.45]	7.500028125	0.719971875	[4.47,4.68,4.9]	4.500028125	0.1799719
		1.370211163			1.7922112

Figure 4. $M/E_k/1$ Result

Table 6. M/E$_k$/1t-test

	L_q	L	W	W_q
T-statistic	5.54287921	5.939409466	3.763802306	5.416771379
P-Value	0.000359712	0.000218172	0.004458812	0.00042362
Critical T-Value	2.262157158	2.262157158	2.262157158	2.262157158

By changing the parameters it can be seen that via the simulation approach the more phases (higher k value), the less time or units are in the system or queue. Between scenarios μ=20, λ=15 and K=5 to μ=20, λ=15 and K=1, the average units in the queue has decreased by 0.77 units. These findings show that the steady-state method is insufficient in estimating the systems characteristic, especially as it doesn't reflect the fact the more phases the system has the lower the results.

ADD-ON TEST, RESULTS AND ANALYSIS

Simul8 was utilized to test a variety of probability functions which have not be previously used. The objective being to test the robustness of the original model in relation to changing the probability functions. A total of 20 different scenarios which had similar input values were considered.

An examination of the Add-on results showed that using simulation allowed the standard M/M/1 model to be very flexible due to the ease of its modification. However, using the binomial for the arrival rate and exponential for the service rate, resulted in significantly larger results compared to the other exponentially distributed service rate models which had an L_q average that varied between 0.05 and 2.98 (whereas for this scenario it was 15.4. The fact that this model's results differ significantly from the others shows that changing the probability distribution can have a serious impact on the results and therefore managers must ensure they choose the correct type of probability function to use when modeling a system.

When the service rate was changed, a similar result occurred with the combination of Poisson arrival rate and gamma service rate. The average delay in the system was 87.13 minutes, whereas the other Poisson arrival models varied from 0.84 minutes to 5.95, excluding the model with negative binomial which had an average of 23.55. The model with a negative binomial service rate also shows a significant difference, but this is small compared to the gamma service rate model. Both imply that the steady-state is not being me.

The M/M/1 model is shown to be very adaptable using simulation primarily because of its ease of use, especially when inserting new distributions into the standard model. This is contradictory to the steady-state equation method. Here, for every variation of the original model new formulas need to be determined.

CONCLUSIONS

The study shows that the steady-state equation is not robust as only the M/G/1 model contained an insignificant difference between the two methods. Even so, only one characteristic was insignificant out of the 4 different results that is average queue size, average use, average time in system and average queuing time. The experiment also showed that changing the parameters does have a significant impact on the results, especially if the probability distribution is changed, as seen in the Add-on experiment. Overall the experiment showed the steady-state equation method to be very limited, as even the standard M/M/1 model was inaccurate compared to the simulation method. Although this is the case, the use of the steady-state equation method can still be justified. This is because organizations will need to make a compromise on whether the increase cost and time that is associated with the use of simulation software is worth the improved accuracy of the data.

Overall the findings are consistent with the theory that the more complex the queuing model, the less accurate the results are, however, it was surprising to discover that even the standard M/M/1 model had a significant difference. It showed the two most complex models to be the least accurate and as previously stated has recommended the use of simulation instead of the steady-state equations.

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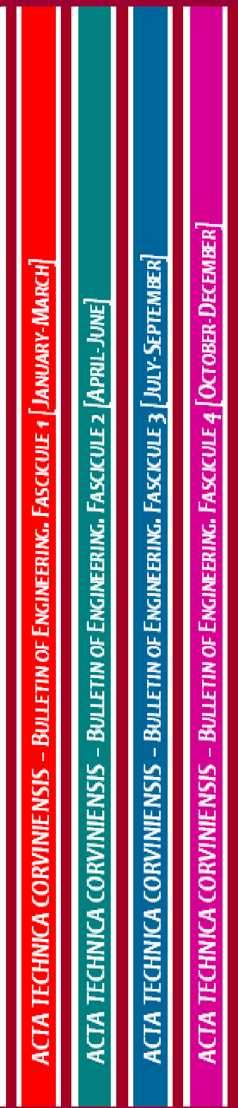

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RESEARCH ON PRECISION DIE FORGING USING SIMULATION

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ABSTRACT: *Precision die forging can be defined as a production of drop forgings whose shape is not very different from the shape of source part at the optimization of production costs and times. This paper deals with precision die forging of gear wheels in closed dies. The process has been realized on one forming operation in heat from ring billet. In comparison with open die forging, costs for forged material have been evaluated. Material flow in die cavity and effective plastic strain of the designed forging process has been realized with the help of computer simulation.*
KEYWORDS: *precision die forging, computer simulation, gear wheel, closed die, material flow*

INTRODUCTION

Manufacturing processes as well as products in the area of the production of drop forgings must be still analyzed and improved to meet all customers' requirements, environmental legislation and international competition. It's necessary to provide high precision of drop forgings and low usage of forming material at the lowest production times and production costs. Therefore, production of drop forgings by conventional die forging with open die in heat is not very proper. It is due to high costs of the forming material and lower available dimensional accuracy of drop forgings. With this, production of drop forgings by the precision die forging is the main area of research and development within the frame of advanced methods of the production of drop forgings.

EXPERIMENTAL PART

Research on the precision die forging in closed dies has been applied on spur gears with a hub. Shape of the spur gear is shown in Figure 1. Spur gears are enhanced especially in machine industry – for example as a part of machines and gear boxes.

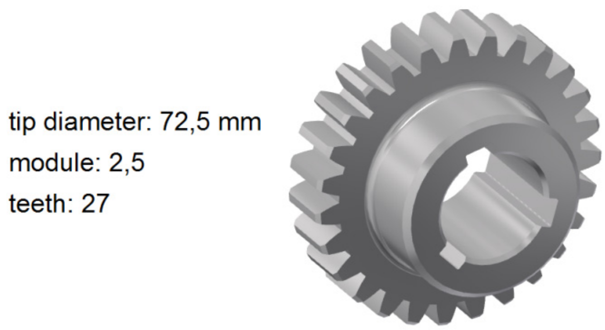

Figure 1. Spur gear with a hub

As a material for drop forging was chosen case hardening steel STN 41 4220 (16MnCr5). The best results within the frame of research on precision die forging of gear wheels in closed dies were achieved by using of this steel. Chemical composition of steel STN 41 4220 is shown in Table 1.

Table 1. Chemical composition of steel STN 41 4220

	Chemical composition [percent by weight]					
	C	Mn	Si	Cr	P	S
in	0,14	1,1	0,17	0,8		
max	0,19	1,4	0,37	1,1	0,035	0,035

PRESENT FORGING METHOD

At the present time gear wheels are manufactured by conventional die forging with flash in heat. Shape of this type of drop forging is illustrated in Figure 2. Manufacturing of given type of drop forging by forging in open dies usually consists of three forming operations: upsetting, rough forging and final forging. The result is increase of production times, tooling costs and machine costs. Low efficiency of charging semi-product is the next insufficiency of the conventional die forging. The result is the creation of flash and a web.

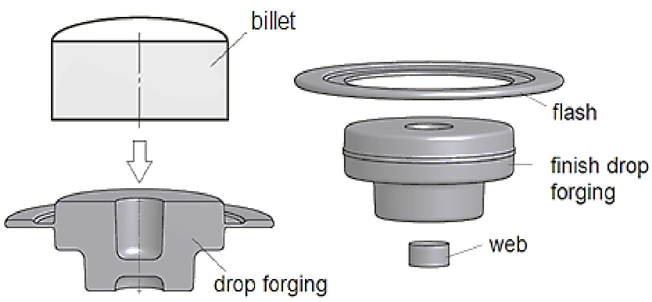

Figure 2. Drop forging with flash and a web

DESIGNED FORGING METHOD

The limitations of present die forging are eliminated by the use of precision die forging in closed dies. Manufacturing of drop forging of gear wheel will consist of one forming operation – precision die forging in closed die in heat from ring billet. Principle of forging tool design and final shape of drop forging is illustrated in Figure 3.

Drop forging of gear wheel will be provided by required minimal material allowance per flank and material allowance for machining of bore hole and *slots (shown in Figure 3). Face areas of toothed ring and outside cylindrical surface of a hub will be made net-shape. Cutting operations of the fillets from toothed ring into the hub is unnecessary, too.*

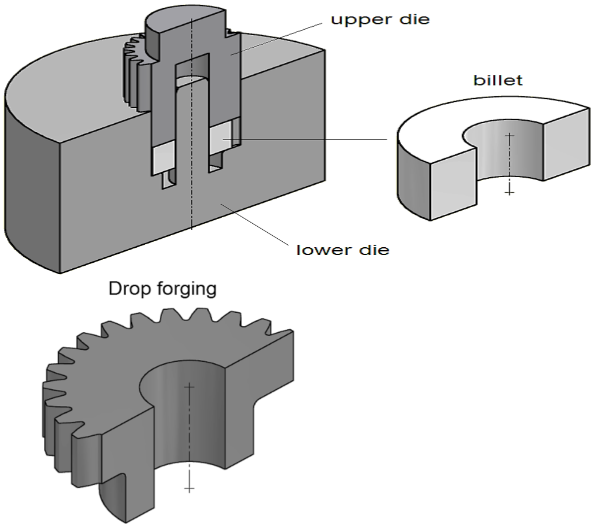

Figure 3. Tool design for precision die forging

COMPUTER SIMULATION

Computer simulation is useful solution for prediction of the course of process and material behavior in die cavity. In this way, it is possible to optimize the tool shape and design technological process and by that considerably reduce financial costs of preproduction stages and production itself. Utilization of computer simulation at the forging processes allows also increase in quality of drop forgings and tool life. Computer simulation was realized by Simufact.forming simulation program which uses final element method (FEM) and finite volume method (FVM).

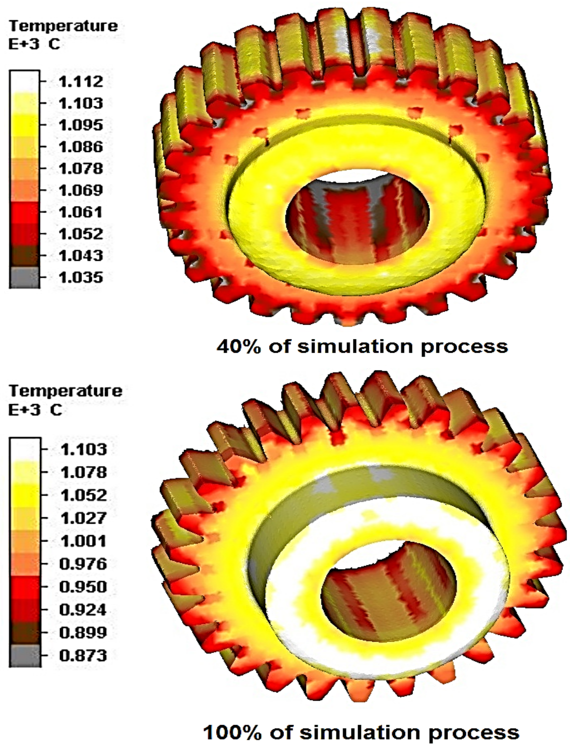

Figure 4a. Results of computer simulation at the various stages of simulation process

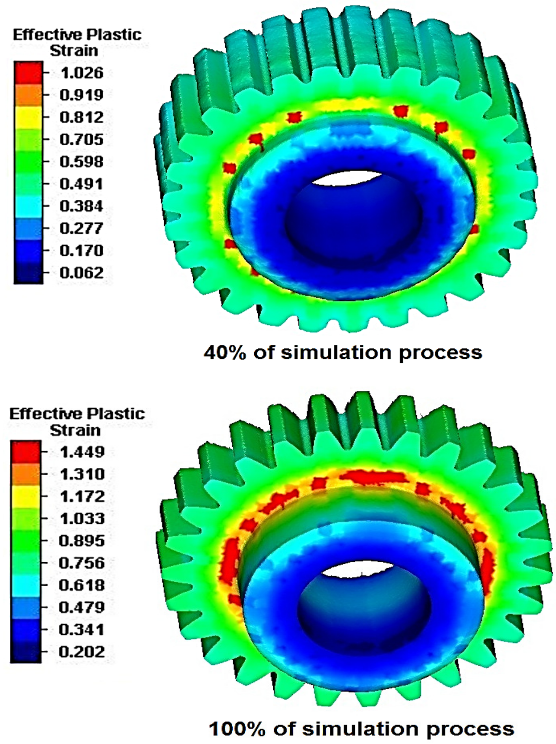

Figure 4b. Results of computer simulation at the various stages of simulation process

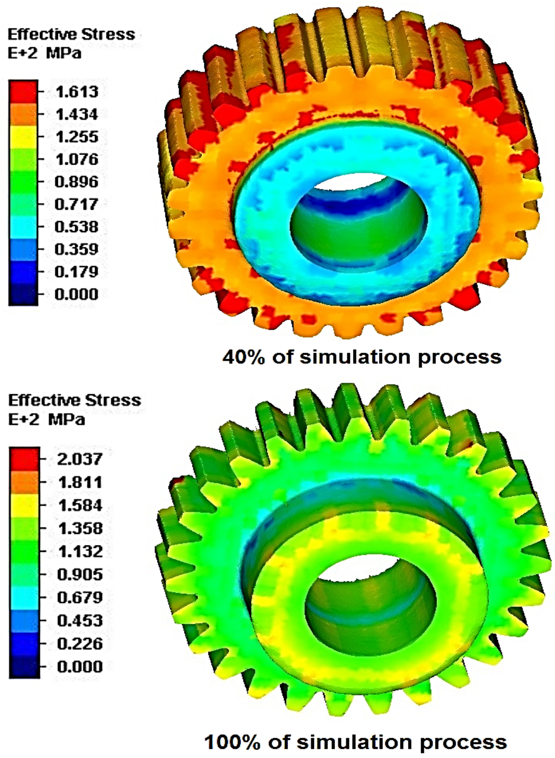

Figure 4c. Results of computer simulation at the various stages of simulation process

The program is suitable for simulation of bulk forming processes in heat, warm or cold. For starting the simulation it is necessary to properly define the input data. For starting a simulation of gear wheel these necessary input data were defined:

- *process - closed die forging in heat*
- *material of billet - DIN 17210 (1.7131)*
- *material of the tool - ASTM A 681 (H13)*
- *temperature of billet - 1100 °C*
- *temperature of the tool - 250 °C.*

Results of computer simulation at the various stages of simulation process are shown in the Figure 4.

EXPERIMENT EVALUATION

In comparison with present die forging, production of the given drop forging by precision die forging is more suitable, especially because of the highest material savings. Comparison of charging weight between present and designed forging method of drop forging of gear wheel is shown in Table 2.

Table 2. Comparison of charging weight m_C of drop forging

Method	m_F [kg]	m_C [kg]
Present die forging	0,89	**1,07**
Precision die forging	0,55	**0,57**

$$m_C = m_F + m_{FLASH} + m_{WEB} + m_S \quad [kg] \qquad (1)$$

where: m_F – weight of finish drop forging [kg],
m_{FLASH} – weight of flash [kg],
m_{WEB} – weight of web [kg],
m_S – weight of scale [kg]

Comparison of material costs for present and precision die forging of drop forging of gear wheel is illustrated in Figure 5.

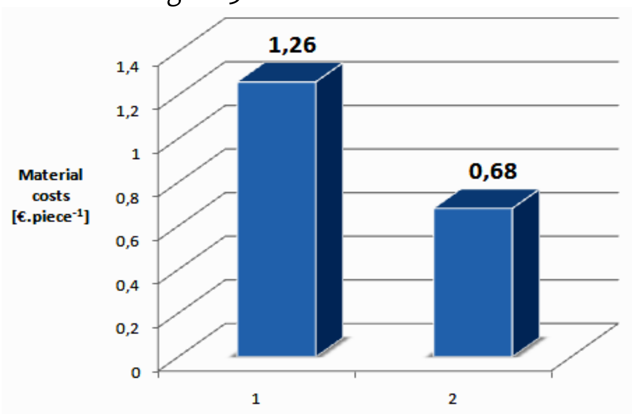

Figure 5. Comparison of material costs for drop forging
1 – present die forging; 2 – precision die forging

CONCLUSIONS

Precision die forging in closed dies represents lucrative method of drop forging production. In comparison with conventional die forging of gear wheels with flash in heat, by precision die forging in closed dies it is possible to reach savings of material costs more than 40 percent, reduction of cutting operations and reduction of production times more than 60 percent. The final filling in die cavity was ended when the fillets on the bottom of a hub were filled. Evaluation of the further results showed that the highest effective plastic strains were in the area of the fillets from toothed ring into the hub. The lowest effective plastic strain was in the area near the bore hole of the drop forging. Evaluation of the results of effective stress showed that the highest values were in the area of the tooting and in the lower part of a hub. To meet all requirements on drop forgings of international competition, producers should have utilized this forging method.

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SUSTAINABLE PRODUCTION: DESIGN BY COMPONENTS METHODOLOGY IN ORDER TO OBTAIN A TAILORED PRODUCT

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ABSTRACT: A sustainable production needs a change in the design methodology. By applying both the approach of Design by Components and Systems Design, the focus of the project becomes the human being and no more the final product. In order to design for a "human being" it is important not to project for a "user" but for a "subject", which has strong links with its territory and with its typical culture. The result of this methodology is a tailored product: different Countries and Cultures will define different needs and thus different products. The "customised product" will replace the standard one.
KEYWORDS: Sustainable design, components, tailored product, subject

INTRODUCTION

A sustainable production needs a change in the design methodology.

One of the biggest century challenges is the creation of "sustainable communities": social, cultural and physical environments where we are able to follow our needs, without a restriction on future generations.

A sustainable community is based on cooperation with the Nature and its principles.

The survival of the human being depends on our capacity to understand the rules of the ecology and consequently to live according to the Nature.

According to the theory of living systems, each organism – animal, vegetal, microorganism or human being- is seen an integrated whole, a living system. Throughout the living world, we find systems nesting within other systems. Systems theory entails a new way of seeing the world and a new way of thinking, known as systemic thinking. [1]

Through the Design by Component and Systems Design methodologies, the concept of "system" is also extended to the product and its production process. Therefore a product could be considered as a component of a big system, and each component is itself formed by several other sub-components. [2]

In a system each component is linked with the others through several flows of material, energy and social links. The study of relationships concerns not only the relationships among the system's components, but also those between the system as a whole and the surrounding larger systems. Those relationships between the system and its environment are what we call by "context", namely the "territory" (Figure 1).

In order to find a solution for human needs of all contexts in the world, designers should project tailored products for people, which live in different territories, located in several Countries.

The aim of this paper is to describe cultures and features' relevance of each different Country, in order to underline the necessity of a design of a customized product, namely "tailored product", and defined ad hoc for each territory.

In order to define a tailored product, it is necessary that the industrial companies change their production approach, that it means going from a "linear" system, where each actor of the process takes care only to its personal success, to an advanced type of interconnections, defined by cooperation and relationships between parts.

The Systems Design methodology applied to the industrial field moves the production towards the metabolism principles of Nature, where all the waste – namely output - are considered as resources for the same or other systems.

Applying the systemic thinking point of view the designer is able to consider not only the final product, but also the context: the final result is a more responsible product, deeply related with the local territory.

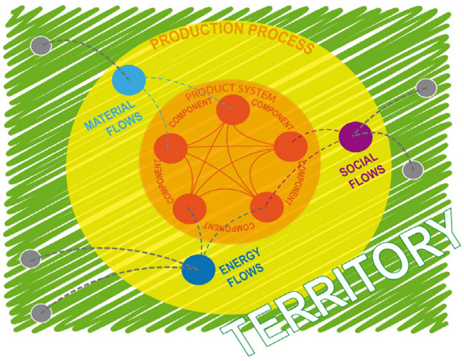

Figure 1 – Energy, material and social flows link together the product system, the production process and the territory

RESEARCH – DIFFERENCES BETWEEN "SUBJECT" AND "USER"

Until today the focus of the project was the "final product"; from now on the focus becomes instead the "human being" and its needs.

In order to design for a "human being" it is important to project not for a "user" but for a "subject", namely the "man". On the dictionary we can read:

- User[1]: a person or thing that uses something
- Subject[2]: the person, mind, ego, or agent of whatever sort that sustains or assumes the form of thought or consciousness.

Two different meanings take place.

The "user" is someone who uses something, the one who does something often driven by habits. He conforms his choices to those of the majority of people.

The "subject", on the contrary, is aware of his decisions. He consciously manifests the will to take action, he has the critical ability to define how and what to do. He is characterized also by a strong sense of belonging to territory.

Frequently advertising and marketing turn their attention to "users": persons that do actions, following their unconscious behaviours.

As pointed out by Professor Luigi Bistagnino (Design, Politecnico di Torino, Italy), "users" define the "target", described as a large group of people, characterized by a standardization of taste, needs and requirements.

Projecting for a "target" has simplified the design phase, but has also led increasingly to a product devoid of cultural specificity, identical all over the world. This kind of product is detached from its local context; it is possible to define it as a "standard product", sold in a global market, part of an international economy.

The "global economy" takes advantage of users' weakness and leads them to impulse buy of products in order to follow a suggested trend and life style. The vast majority of the people will choose a product not because of its intrinsic features but rather because of its market-based idea and personal belief that it will make them part of a group and elevate their social status.

The designer, basing the project on the mass culture, without links to the local context, cuts the cultural roots of individuals, creating a "globalized product" identical all over the world.

In order to reach a sustainable design, it is important to change the aim of the project: from a general product, to a customised one, founded on real human's needs and territory's resources.

The "subject", through conscious choices, will prefer local products instead of standard ones; so that he will move the market towards a holistic systemic approach, deeply related with the context and its characteristics.

[1] http://www.oxfordadvancedlearnersdictionary.com/dictionary/user
[2] http://www.merriam-webster.com/dictionary/

METHODOLOGY

The "old" design process, based on "users" as target and on standard products, might be replaced with a "new" approach, focused on the "subject" and its strong links with the local territory.

According to the Systems Design theory and to the Design by Components methodology, the man and its needs become the centre of the project: this focus point gives a specific identity to the product.

In order to reach this "design-changing", it becomes necessary to design according to people knowledge, respecting their culture, the characteristics of the territory and its resources.

The result of this approach is a new idea of product, which becomes a customised product, and a different concept of the consumer.

The expectation is that "users" will be inspired by this different design-way, becoming "active subjects" and creating positive relationships within their social context and their territory.

According to the systemic thinking, it is possible to say that the essential properties of a living system arise from the interactions and relationships among the parts. Systemic thinking is thinking in terms of relationships. The shift from the parts to the whole requires another shift of focus, from objects to relationships.

Designing for the "subject", with the Systems Design approach, brings to a new scenario, in which the person is autonomous but related with other individuals and with the environment. Systemic thinking is always contextual thinking. [1]

Relationships between elements are fundamental for the balance and the survival of the system: from these links take place reciprocal influences, which change the whole.

Therefore system components are strictly related to each other with bonds based on responsibility and awareness of each element and not on the exceeding of a subject to another. [3]

As pointed out by Fritjof Capra (Ph.D., physicist and systems theorist, http://www.fritjofcapra.net/): "life in the social realm can also be understood in terms of networks. Living networks in human society are networks of communications. Each communication creates thoughts and meaning, which give rise to further communications, and thus the entire network generates itself. As communications continue in a social network, they eventually produce a shared system of beliefs, explanations, and values – a common context of meaning, known as culture, which is continually sustained by further communications. Through this culture individuals acquire identities as members of the social network, and in this way the network generates its own boundaries.

The social network also produces a shared body of knowledge – including information, ideas, and skills – that shapes the culture's distinctive way of life in addition to its values and beliefs." [1]

Capra's theory is useful to understand the reason because of different territories and Countries – developed or not – are characterized by several different cultures, each defined by its values and meanings: the "man" creates networks of communication, which define specific cultures, depending on the context.

Each territory is also defined by its material resources: gradually the human being defines the ability - namely "know how" - to use this resources in order to solve its needs. Thanks to his "know how", the "man" develops a "material culture", formed by elements of the material realm, closely related to the territory.

These several cultural frameworks define the necessity of a new designing process, based on the project of customised products, which comes from different areas and cultures. This sort of product should be referred to specific resources of the territory, in order to enhance cultural and material peculiarities of any different geographical zone.

Following a customised project approach, designers should restrict their range of project action, in order to provide different solutions to several different subjects (Figure 2).

Figure 2 – Countries are characterized by several different cultures, each defined by its own resources, know-how, material and social culture

According to Design by Component approach, a product is like the union of several interrelated components that perform an action and that is connected with other elements to form a "macro-component". Each macro-component can be part of a more complex system. [2]

Applying this concept to product customization it is possible to imagine an object as the sum of several parts: the main part - the "heart" of the product - and the ancillary changeable ones - as cultural, social and environmental issues.

The "heart" of the product is responsible of the object's functioning; the ancillary components define the context characterization of the product (Figure 3).

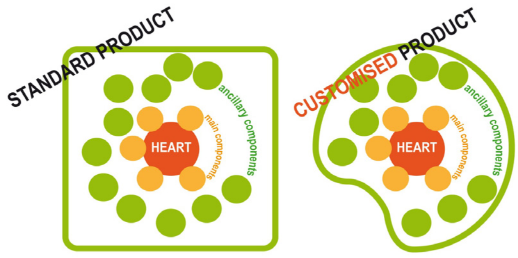

Figure 3 – Differences between standard and customized product. In a product, according to the Design by Components methodology, the shape follows the function.

The application of the Design by Components methodology to the product design generates a new holistic manufacturing model:

- *the main company will control the whole production systems thanks to its know how;*
- *the same company will produce the "heart" of the product;*
- *the "foreign" supplier will be turned in local producer, that means that they will produce the ancillary components, the accessories, or the out shell of the product, according the cultural background and technologies.*

This transformation should underline a flexible and adaptable object, obtained by a production structure model strictly linked to local features and resources. [4]

The Ikea Company applies a similar approach: this Swedish industry of furniture has 1220 suppliers located in 55 different Countries, but gives to its customers a "customized product" specific for each territory.

To give an example the Ikea's products follow Company's design rules, but they are produced in different part of the world (worldwide), in order to use local materials and human's characteristic. Thanks to this production approach, each product is made with local materials, which define a short logistic chain, according to the territory's resources. [5]

CASE STUDY: THE COOKING POINT

Applying the Design by Components methodology to a project of a cooking point, it will be necessary not to design a standard product, but to enhance the subject and its culture.

In order to obtain the necessary knowledge for a successful design, the first step is to know and analyze main dishes of the specific territory.

The analysis of the traditional dishes will bring out further information about local foods and their storage, and also about cooking steps and the necessary tools.

Thanks to these project details, designers understand which are the domestic zones involved during the food preparation, and what kind of relationships are established between different home areas and the subject movements.

Used tools, involved domestic environments and cooking methods of different dishes, will define the project of the cooking point.
The final product will be created according to the subject's needs and the available domestic spaces.
The observation of the local traditions and folklore – especially of the countryside – allows the designer to contextualize his product to the local culture. Traditions will suggest best materials, colours and patterns.
Through Design by Components and Systems Design methodologies, the designer is conscious and expert in a particular culture: the final product will answer to the needs of the subject and will respect the resources of the territory.
In order to better understand the concept of the tailored product, it is useful to analyze the differences between a cooking product developed for two different territories – for example the Arctic Zone and the Eastern Africa Area - defined by different cultures, traditions, climate and so on.
The first one, for the Arctic Zone - should be easy to move, resistant to the freezing temperatures, designed for small domestic spaces and useful for the ground cooking.
The second one – for the Eastern Africa Area – could be defined by bright colours, benches which allows the traditional "sitting cooking", a circular shape of the cooking furniture, in order to favour the sharing cooking moment through components of the family (Figure 4).

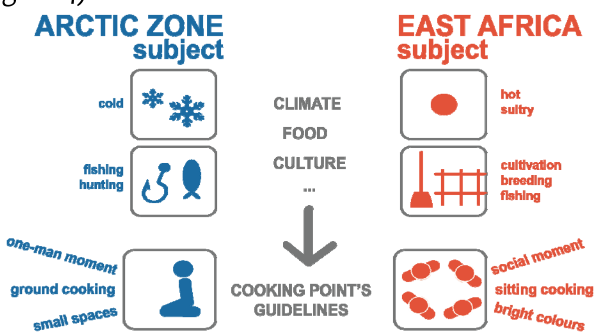

Figure 4 – Cooking point's guidelines for the Arctic Zone and the Eastern Africa Area

CONCLUSIONS

In conclusion, the methodology of Design by Components with a Systems Design approach, applied to a product, outlines:
- *the definition of a "customized product" for each different territory, instead of a "standard product";*
- *the creation of a "subject" - aware of its choices - opposed to a "user" - guided by unconscious behaviour;*
- *the maintenance of a local culture, which is not replaced by the global one;*
- *the origin of a "systemic production model", defined by a strong relationship between product and local resources (Figure 5).*

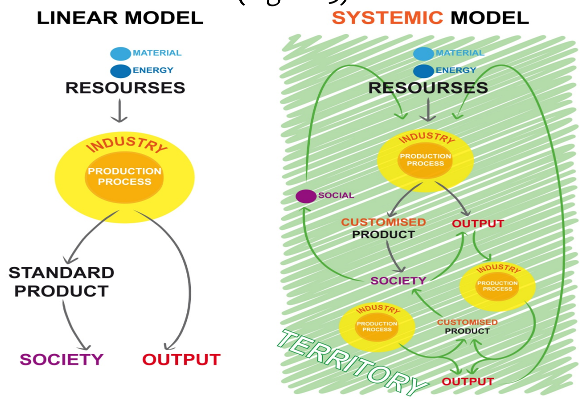

Figure 5 – Linear and systemic production models

This designing approach, based on the surrounding environment, leads to re-evaluate the near and local territory instead of the far and global one.
From this perspective, also the products flows undergo a radical change: the global logistic will be replaced with a limited range logistic. Products will be found locally at lower cost and superior quality.
This scenario reverses the economical globalization, in favour of a local development, which allows the preservation of local, social and material culture.
Strengthening of social bounds should lead to a shift into the industrial approach: from competition between parts – linear model – to cooperation between different stakeholders – systemic model.
It would be desirable a change on the production rules, in favour of systemic strategies deeply integrated with their own territorial, social and economical contexts.

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TQM IN THE MOTOR VEHICLE SERVICE

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ABSTRACT: *TQM is the approach for improvement of competitiveness, efficiency and flexibility of the entire company. It is the necessary mode of planning, organizing and understanding of each activity, depending upon each individual at each level in the company. The paper presents experience in implementation of Standard series ISO 9000ff, 14000ff and 17000ff to TQM in the automobile service center. The research was conducted in the company that possesses ISO certificates. Presented was the possibility of TQM implementation in the company. TQM in service centers can be observed as an opportunity for fundamental improvement of business functions and processes within the service, with the purpose of providing services and improving business results.*
KEYWORDS: *TQM, quality, ISO standards, business excellence, efficiency, flexibility, improvement*

INTRODUCTION

Since their development and acceptance, Standards series ISO 9000ff have found wide application worldwide, foremost in the automobile industry. This success of the Standards can be explained by the universality and applicability in almost all actions of human activity in automobile industry, with special emphasis in motor vehicle service. In order to satisfy customer demands in motor vehicle service, it is necessary to implement and maintain quality management system series ISO 9000ff, ISO 17000ff, ISO 14000ff, ISO 18000ff, as well as other standards in connection with automobile industry. Implementation of these standards creates the firm foundation for TQM. Permanent education and staff training in motor vehicle service, especially within the framework of integrated quality system implementation according to the standard requirements, are the most important attributes for the successful functioning of the company and protection of staff and environment [6].

QUALITY IN THE MOTOR VEHICLE SERVICE

Integrated quality management system series ISO 9000ff, ISO 14000ff and ISO 18000ff was introduced by a small number of organizations in Bosnia and Herzegovina, in relation to the number required for the EU (European Union) accession. Most companies in Bosnia and Herzegovina decide upon implementation of the quality management system ISO 9000ff. Thus far, about 1200 of these organizations have been certified. Organizations that have introduced quality management system most often opt for the recertification by the same standard, whereas 30% of organizations integrate their system with other standards. Organizations that implement integrated system follow the path to TQM. In the automobile industry, and therefore in motor vehicle services authorized by the parent organizations, this kind of approach is highly advisable. With authorized services the application of the basic common elements of the TQM model is evident, which demonstrates the ability to satisfy customer demands and desired work results.

With TQM the key common elements are the following: management determination, organization policy and strategy, staff engagement, resource allocation, process management, customer and user satisfaction, positive influence on the society and reached improvement level and business success.

Authorized motor vehicle services need to create their own quality philosophies, through the analysis of the development and creation of the superior characteristics for the successful service management. The basic notion of this philosophy is that the improvement of the motor vehicle service quality and customer satisfaction has to be the final objective of every manager's work. Especially interesting is the point of view of Tom Peters regarding the position and role of quality manager, particularly in regard to the future of the organization [3].

Through the implementation of integrated quality management system Twelve Golden Rules of Claus Moller should be implemented:

- set personal quality goals,
- establish your own personal quality account,
- check how satisfied other are with your efforts,
- regard the next link as a valued customer,
- avoid errors,
- perform task more effectively,
- utilize resources well,
- be committed,
- learn to finish what you started – strengthen your self-discipline,
- control your stress,
- be ethical – maintain you integrity, and
- demand quality.

According to Claus Moller, in order to increase the quality of any organization, including the automobile industry, it is necessary to identify seventeen basic quality hallmarks of the organization:

- *focus on quality development,*
- *management participation in the quality process,*
- *satisfied customers / users,*
- *committed employees,*
- *long-term quality development,*
- *clearly-defined quality goals,*
- *quality performance rewarded,*
- *quality control perceived positively,*
- *next person in work process is a valued customer,*
- *investments in personnel training and development,*
- *prevention and reduction of mistakes,*
- *appropriate decision level,*
- *direct route to end users,*
- *emphasis on both technical and human quality,*
- *company actions directed towards customers needs*
- *ongoing value analysis, and*
- *company recognition of its role in society.*

Through the seventeen quality hallmarks Moller has once again emphasized what his predecessors have already defined: either of the quality guru has missed the opportunity to offer one or two rule blocks that ensure successful quality system implementation. During the process, practically the same recommendations and, in fact the same quality philosophy, is interwoven always and at all points [3].

In order for service to be efficient each of its parts has to work together in a suitable manner. Each activity and each employee in the organization has an influence on it, as well as others. The procedure of the quality management system implementation is almost identical for all types and sizes of the motor vehicle service.

Evidently, there also exist significant differences in the technological solutions of certain quality system problems and TQM considerations that can be different from service to service. Unified systematic solutions are desirable, which, due to former experience, lead to shortening of the implementation deadlines.

In order for the organization to be managed efficiently, it is important to operate it in systematic and visible manner. Management guidelines are based on eight quality management principles whose acceptance facilitate quality objectives and lead the organization towards improving performances, always having in mind the needs of the interested parties. Principles of quality management are: customer orientation, leadership, involvement of people, process approach, system approach to management, continual improvement, factual approach decisions making, mutually beneficial supplier relationship [1,2].

REALIZATION OF MOTOR VEHICLE SERVICING – PLANNING OF MOTOR VEHICLE SERVICING REALIZATION

Heads of the main processes plan the realization of main processes with the purpose of satisfying customer demands, as well as environment and health protection, and employee safety, regarding:

- *programs and resources for planned business activities realization,*
- *performances, objectives and quality,*
- *acceptability criteria, and*
- *monitoring and measuring the achieved planned activities.*

During the planning of service realization, the following data and demands are taken into consideration:

- *defined annual quality objectives,*
- *internal demands for improvement process, and*
- *customer demands and expectations.*

In cases when customer demands are beyond our current possibilities/capabilities, needs and abilities of new process establishment are reviewed, i.e. engagement of other competent organizations. When part of business activities is assigned to other organization, our special control over these activities (processes) is planned, and it implies:

- *careful assessment and supplier selection,*
- *application of our specific documents (procedures instructions, plans of control/testing, etc.), as applied during the realization process,*
- *ensuring suitable proofs/records of compliance of realized business activities with our specifications.*

When the customer demands, or when we deem necessary, we create the control plan/quality plan.

PROCESSES IN RELATION TO CUSTOMER

Demands in relation to service are established through the process of market exploration, customer needs, and bidding and contracting process. Through the process activities, among other, established are:

- *customer needs and demands,*
- *demands of relevant regulations / provisions and other specific external documents in relation to service,*
- *demands that customer has not specified, but is necessary for complete specification of demand, that is customer needs.*

Responsibility for determining these demands lies on the manager and heads of the processes of the motor vehicle service, as required.

Prior to delivering customer offers, we implement review of the established specified demands for the service, and all other specific demands for service realization. Persons participating in the review are:

manager, heads of the processes, heads of the procurement process, and other employees, as required. The goal of this review is further analysis and validation:

- *that all relevant demands are fully determined and documented,*
- *that all relevant demands are fully understood,*
- *that all necessary pre-conditions for the realization of the service are secured.*

Demand review and our willingness to fulfill the demand is additionally conducted after receiving orders, that is, by determining contract proposal for verifying if there are possible differences in regard to offer, and if extra information for understanding and accepting the offer are clear and needed. This review is conducted in the same procedure as the bidding stage, and with the participation of all employees. Records of the review results are clearly kept and maintained.

When there is a need for change of the accepted order/contract, it is solved in the identical manner as their first version, with records of the accepted changes maintained, and (if needed) all employees are informed.

Adequate communication methods with customers and market are established and effectively applied, in terms of timely and complete understanding the customer demands, especially when considering feedback from customers, including the complaints and dissatisfaction on any basis. In that we use different shapes of communication, such as:

- *direct continual contacts (oral, phone, e-mail) during realization period of contracts/orders, i.e. solving*
- *any customer queries,*
- *flyers and other methods of presentation of organization possibilities,*
- *special meetings and deals with customers,*
- *participation in conferences and symposiums, etc.*

During the service realization for our customer, he always knows the person and the mean of communication in order to acquire all necessary information about the current state (phase) of the service realization.

PROCUREMENT

In order to achieve reliable and efficient realization of the commitments from our customers, special attention is given to process of material and spare parts procurement process, which are necessary for service realization. During the procurement process we always strive to operate (cooperate) with confirmed suppliers, based on principle of partnership and mutually beneficial long-term cooperation. Heads of the process are responsible for the clear and unequivocal specification of service, always having in mind the quality. Procurement process is implemented by the manager of the material-technical service, with prior ensured approval by the head manager or technical manager. He is responsible for the review of the adequacy and completeness of supply specification, before delivering it to the supplier.

Procurement process is effectively completed when the supplied materials, spare parts and supporting documentation are verified by the person responsible for qualitative and quantitative acceptance. Qualitative and quantitative acceptance is conducted by the process manager, or the person appointed by the manager, unless otherwise decided by the head manager. In case the delivery is different in any element from the procurement demand, an adequate claim record is established, which is further managed by the head of the material-technical service in the contact with the supplier.

REALIZATION OF MOTOR VEHICLE SERVICING

Realization of motor vehicles servicing is conducted in controlled conditions as planned and defined with corresponding documents, with established resources, responsibilities and deadlines. It is achieved through the established organizational structure, i.e. established regulated processes and sub-processes using:

- *corresponding technical-technological and operational documentation,*
- *established dynamic plans and corresponding responsibilities,*
- *quality system documents,*
- *adjustable service and other infrastructural capacities,*
- *manufacturing instructions for usage, machinery and materials,*
- *monitoring of the process, operational controls, measuring and testing,*
- *final control and verification of the provided services, with clear recognition of the people that verified the incorporated quality of individual phases, as well as complete process.*
- *continual cooperation and communication with customer representatives,*
- *quality plan, when implemented.*

Defined realization phases can start only when all necessary preparations have previously been conducted and with ensured controlled conditions, for which heads of the individual service realization processes are responsible. The stated realization phase cannot start prior to adequate verification of the previous phase.

Verification results are noted in the prescribed operational documents, which are maintained according to the defined record management *procedure. In case of any service inconsistencies, it should be noted and solved according to the procedure – control of inconsistent services.*

Permission for letting service in the next phase that is, giving the service to customer is given by the head of the realization process, or the person appointed by him. In case when customer appoints his representative for continual monitoring of the contracted work realization, a correct cooperation is established with the mutual benefit.

VALIDATION OF SERVICE REALIZATION PROCESS: *Motor vehicle servicing process, whose results cannot be verified with subsequent monitoring and measuring, where subsequent testing demand destruction or damage of the product or where negative quality testing results create significant subsequent costs of repair or rejection of larger amount of finished products, is subject to corresponding validation process according to the established engagements of the head of the process, that is, adequate technically competent staff. In most cases this implies:*

- *usage and continual maintenance of adequate technological equipment,*
- *usage and maintenance of adequate control-measuring and testing equipment,*
- *ensuring adequate competent operational staff,*
- *continual monitoring of the established working activities implementation.*

Adequate records are maintained about the implemented validation procedures.

IDENTIFICATION AND TRACEABILITY: *Generally, identification and traceability of services are ensured, regardless of the fact whether it is customer demand or not. Traceability is ensured with unique identification of all operational documents and records, which originate from realized contracted works.*

All mentioned documents have identification number of the contract/order, by which the services are realized. In this way relation of realized services with corresponding commercial & technical documentation is ensured. Simultaneously, ensured is also recognized service status during the period of storage, realization and transfer, as well as persons responsible for realization of individual phases and activities.

CUSTOMER PROPERTY: *In the case when customer is giving us his own property (motor vehicle, material, technical documentation, etc.) with the purpose of realizing contracted works, we treat it with the attention as if it is personal property. During the taking over of property required is implementation of quantitative and qualitative acceptance, followed by a corresponding written record. When it is established that delivered property does not correspond to planned purpose, the customer is informed, and the property is treated in accordance with the procedure – control of inconsistent product. Employees in the motor vehicle service consider trade secret all relevant data in relation to realization of the contract and/or obtained by the customer, and will not dispose them under any circumstances to third parties, except with the approval by the customer.*

STORAGE OF SPARE PARTS: *In order to preserve the product quality, raw materials or spare parts, we especially plan and undertake all necessary measures such as marking, packaging, transport and storage. Employees in the processes of storage, transport, realization and control, that is, quality testing, are responsible for the implementation of the established procedures for quality protection, as long as all products, raw materials or spare parts are under their supervision.*

MONITORING AND MEASURING TOOLS CONTROL

In order to ensure service realization in controlled conditions, we especially plan monitoring, measuring and testing activities. In this regard, we continually plan and ensure certain tools for these activities, in order to enable accurate, precise and reliable proofs of compliance of services with specified customer demands, i.e. our own criteria. When special demands are in question, special measuring/testing technology is stipulated, and special quality plans. According to outlined decisions, the procedure of storage, maintenance and treatment with monitoring and measuring tools is established, that implies:

- *unequivocal and clear identification of equipment and its current status,*
- *responsibility for planning and up-to-date calibration implementation,*
- *insurance/protection from physical damage, and negative influence of micro-climate conditions in which equipment is stored,*
- *application of occasional tool self-assessment methods, where applicable.*

Users of monitoring, measuring and testing tools cannot use the tools with expired calibration term, or if noticed any kind of irregularity/damage. In case of irregularities of the measuring tools after service delivery to the customer or letting service to the next realization stage, these kind of services are examined again and necessary action are taken. For monitoring and efficient application of described procedure, the head of the realization process if responsible, during which adequate equipment for monitoring and measurement is used [4].

CONCLUSIONS

TQM implementation creates a series of clear advantages: increases responsibility, particularly in public relations and public media, supports integrated demands of ISO standards, acquires significant advantages when reaching to new markets and *maintaining old customers, ensures easier implementation of risk management prevents the possibility of environment damages, reduces organization insurance rates in case of incident. According to all existing predictions the development of all world TQM models is directed to the kind of form that would enable achieving business excellence in automobile industry. Development of theory and practice of modern quality is practically impossible without clear insight into the historical and spatial development of basic TQM models [5].*

Excellence presents dynamic objective whose coordinates are identical to the coordinates of organizations' individual parameters that can be marked as the best world practice in class.

TQM uses the combination of two basic methods for excellence objectives determination and establishing continual improvement process and innovations to achieve these objectives:

- *benchmarking for determination of competition performances and best world practice in class, which can be defined as the organization's excellence objectives and comparison to it, as the best way for inciting and achieving own efforts and results,*
- *self-assessment for determination of activities and results in achieving excellence level which relate to selected model and areas in which improvements and innovations can be conducted, as well as planning of improvement and innovation measures whose progress is considered in long-term manner [7].*

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DRIVERS FOR LIFE CYCLE PERSPECTIVES IN PRODUCT REALIZATION

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ABSTRACT: *The global increase of manufacturing activities and the need for sustainability calls for manufacturing strategies and technologies with reduced environmental impact. On the basis of industrial experiences and academic reviews, this paper presents an elaborated framework presenting drivers for life cycle considerations in product realization within the manufacturing engineering industry. The framework considers the total life cycle of the product and production system with the phases of material processing, production, usage and afterlife. For each phase the drivers for an increased life cycle perspective is reviewed by the categories of cost reduction, value increase and regulatory initiatives.*
KEYWORDS: *sustainable manufacturing, life cycle, product realization, review*

INTRODUCTION

There is a long seen need for an environmental, economic and social sustainable society, meeting the needs of the present without compromising the ability of future generations to meet their own needs [1]. Focusing on environmental sustainability, it has lead to emerging legislation and industrially accepted emission targets. Meanwhile, a global wealth increase is evident. Through the means of globalisation, values are created worldwide with a worldwide 36 % increase of GDP in current prices over 1998-2008 [2]. By increased welfare the product demand increases, leading to increased manufacturing activity – we have seen a 42 % increase of manufacturing activities worldwide 1998-2008. In figure 1 the increase in economic activity in current prices within manufacturing over 1998-2008 is presented for the largest manufacturing countries. For instance China has seen an unprecedented manufacturing increase over the recent decade.

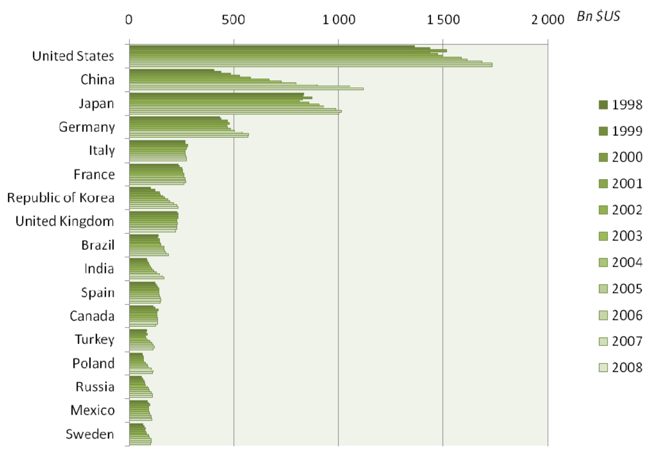

Figure 1. Manufacturing activities 1998 - 2008.
Data from UNSTAT [2].

These two trends, the need for sustainability and the globally increasing product demands and manufacturing activities drive the need for technology and strategies that globally will reduce environmental impact of manufacturing. There is a need of large improvements in terms of resource productivity - "doing more with less". The challenge is to reduce non-renewable material and energy usage by absolute numbers, in a fast increasing economic activity.

The resulting change in the manufacturing landscape requires companies to reconfigure both their business and manufacturing strategies in order to cope with the new pressures [3]. Production factors like energy and transportation are becoming more expensive and increasingly regulated. It may, for example, force companies to even more consider their manufacturing footprint as well as their supply system. A trend towards manufacturing close to market with more local sourcing may well be one consequence of the need for reducing transportation within the supply chain. Such examples of environmental considerations are of strategic nature, related also to the business model.

This paper reflects on technological possibilities to address this global challenge for sustainable manufacturing, based on industrial and research challenges. A framework is presented representing drivers for life cycle perspectives in product realization for the manufacturing engineering industry.

INTRODUCING A FRAMEWORK FOR LIFE CYCLE PERSPECTIVES IN PRODUCT REALIZATION

It is generally accepted that environmentally conscious actions need no longer be seen only as challenges and contrary to financial considerations. On the contrary, it can be the basis for competitive companies contributing to global environmental improvements. The environmental issues can be viewed as either constraints or opportunities for competition [4]. As Hart suggested; "the basis for gaining competitive advantage in the coming years will be rooted increasingly in a set of emerging capabilities such as waste minimisation, green product design, and technology cooperation in the developing world" [5]. As concluded in [6], sustainability can be classified as an order winning or an order qualifying objective depending on market, society and technology, using the terms coined in [7].

Competitiveness can be described as creating great value by low costs, under the values, costs and preconditions given by the market place. Improvements in competitiveness can thus be focused on three options; (1) improving the value function (as a function of the choices the decision maker can control), (2) decreasing the cost function (also a function of controllable variables), but also (3) influencing the feasible region for solutions, constraining all actors on the market place. By proactive actions on the constraints such as legislation, regulations or praxis, a new market landscape can be formed.

By using these three perspectives on competitiveness; value, cost and market place precondition, actions for leverage on environmental sustainability are described in Figure 2. The framework considers the total life cycle of the product and production system with the phases of material processing, production, usage and afterlife. For each phase the drivers for an increased life cycle perspective is reviewed by the categories of cost reduction, value increase and regulatory initiatives, as illustrated in Figure 2. This is an elaboration of framework and efforts for sustainability approaches presented earlier in [8], [9].

The purpose of the framework, and the paper, is to by a review present an overview and pinpoint specific drivers contributing to a more life cycle focused perspective in the product realization process.

MATERIAL PROCESSING PHASE

One of the major influences in the creation of modern products is the development of materials and materials processing techniques.

☐ Value increase

The underlying philosophy in this perspective is to increase customers' perception of value by an increased environmental focus in material selection and processing.

Figure 2. Illustrating the framework for life cycle approaches on product realization

From a value increasing perspective, the material properties are in focus. The development of new materials has accelerated so rapidly that most material available for today's product designers has been developed in the latest 100 years [10]. It concerns greater materials properties of engineered polymers, ceramics, metallurgical alloys and composite materials. The increased functionality at no increase in overall costs has been realized in magnetic thin film storage, high-strength automobile panel, miniaturization of silicon transistors etc. However, there is still large anticipated potential and industrial growth by advanced composites, advanced ceramics, novel polymers and alternative materials.

From a sustainability perspective input is needed in the product design phase. Specific techniques and guidelines on selection of material and production process, product life cycle management, ease of maintenance and remanufacturing with sustainability in focus are areas that need renewed attention from a research perspective.

☐ Processing cost decrease

The properties, durability and economy of traditional materials have improved dramatically over the past decades. This is a quiet revolution as the average customer does not perceive the change due to the continuous nature of the improvement [11].

The costs (in constant prices) of metals and minerals have fluctuated heavily over the latest decades. Initially the prices decreased by a factor two over thirty years, 1970-2000 (see figure 3). However, since 2000, the price of metals and minerals has increased drastically as illustrated in Figure 3. The World Bank reports that China has been a primary driver of metals prices in the 2000s and has become the world's largest consumer of metals as well as its largest steel producer [12]. Between 2000 and 2008, China's consumption of key metals such as aluminium, copper, lead, nickel, tin, and zinc grew on average by 16,1 percent a year. Outside China, metals demand rose by less than 1 percent a year.

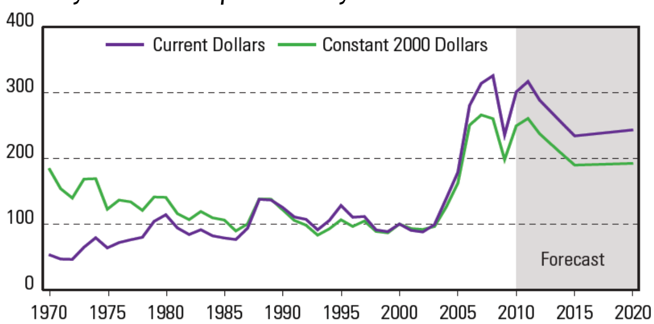

Figure 3. Metal and Mineral price indices (2000 = 100). Source World Bank [12]

In order to cope with this drastic increase in material costs in the latest decade, the yields within materials processing have increased dramatically. There have been large reductions in the processing costs of traditional materials. The needed steps towards a more sustainability focus in materials processing is to accelerate the reduction of the processing costs of the *renewable materials such as bioplastics, natural fibres and non-fossile based composites as well as techniques for replacing fossil based energy generation by CO_2 neutral generation such as solar, wind and water as well as energy storage techniques.*

- ***Regulatory initiatives***

Instead of regulating material content, most regulations focus on companies to be responsible for products at the end of their life cycle. This allows for creativity by companies and teams to not only go for renewable material but can drive the whole design process. The design process changes as the product will return to the manufacturer in a closed loop.

However, the often energy-consuming material processing activities are subject of legislations in terms of e.g. energy costs. The Kyoto Protocol contains legally binding commitments for the industrialized countries to reduce their emissions of greenhouse gases by a total of at least 5% [13]. In this total effort, the manufacturing industry has an important place. In Sweden, the industry contributes with 11% to the CO_2 emissions. In a recent governmental commission the target is set to reduce the industrial oil consumption by 25-40% [14]. The EU is committed to green growth through the Lisbon strategy from 2000, later materialized in the Göteborg strategy. The European Commission initiated a development and wider use of environmental technologies through implementing the Environmental Technologies Action Plan (ETAP), with 28 defined actions to be implemented at European, national, regional or local level. [15].

PRODUCTION PHASE

A competitive production system has in many cases been the basis for a successful industrial activity, with the industrial revolution and Toyota as merely two examples. Skinner emphasised the strategic importance of manufacturing, by stating "..what appears to be routine manufacturing decisions frequently come to limit the corporation's strategic options, binding it with facilities, equipment, personnel, basic controls and policies to a non-competitive posture, which may take years to turn around." [16].

- ***Value increase***

It is possible to create added value for the customer by sustainability actions within the manufacturing process. An illustrating example is organic agriculture products where the customer is willing to pay a price premium, due to the sustainability actions in the food production process. Within manufacturing this type of actions correspond to both added values for the customer, such as local manufacturing giving fast customer response and customisation, as well as fulfilling qualifying regulations and sustainability expectations from the customer on the supplier's manufacturing process.

Enabling features include developing manufacturing technologies for agile and sustainable manufacturing system as well as standard interfaces enabling rapid and customized manufacturing system setup. On a production system level, further development is needed within environmental impact assessment and certification tools as well as system modelling and solutions for local manufacturing providers.

- ***Cost decrease***

Cutting cost by efficient resource utilization is also in line with sustainability efforts. The most appropriate process is the most resource efficient. The key is however to make it appropriate over time. The concept of lean manufacturing deals with resource efficiency and waste elimination of all kinds, and can also have positive impact on sustainability, elaborated upon by e.g. the US Environmental protection agency [17].

On a manufacturing process level, the machining, assembly and logistic processes should be further developed towards zero-emission and high energy efficiency. Researchers and practitioners have advanced the knowledge within areas such as net shape manufacturing processes [18], dry or cryogenic machining [19], sustainable metal working fluids [20] as well as novel assembly processes and reverse logistic approaches. The specific focus for an increased sustainability perspective is processes for minimal energy and material usage.

Methodologies and decision support tools for process sustainability evaluation need further development, considering manufacturing footprint and supply chain aspects [21] as well process parameters and key performance indicators for sustainable manufacturing. One specific dimension is energy efficiency monitoring, where a number of indicators are presented in the literature e.g. energy efficiency in terms of energy per output (energy per tonne, etc), energy per $ of GDP (or profit, etc), or energy cost ($) per $ of GDP (or profit, etc) [22]. However, the evaluation of energy efficiency is ultimately a comparative exercise; to make meaningful decisions about energy efficiency the measured efficiency of a process must be compared to a benchmark [23]. An effort to estimate the linkage between energy efficiency and productivity is presented in [24].

Life cycle analysis on a system level during the product design phase is a strong area within research and practice [25]. Enabling features in need of development include next generation of integrated design processes for production and product considering life cycle aspects, modularity schemes and reusability aspects of material and components.

- **Regulatory initiatives**

Increased awareness, importance and understanding of environmental management systems (EMS) have demonstrated relationships with sustainability, competitiveness and institutional practice [26]. The EMS has become established as mainstream business practice for manufacturing companies. In support of EMS, a European Eco-Management and Auditing Scheme (EMAS) as well as the ISO 14001 has been developed on the roots in various European environmental auditing programs [27].

Within the ISO 14000 family a number of standards have been established, supporting the sustainability efforts. The performance measurement efforts earlier mentioned have strong links to environmental evaluation methods of manufacturing systems within ISO 14044: Environmental Management - Life Cycle Assessment – Requirements and Guidelines [28].

In addition to general environmental management systems and auditing schemes, specific regulations exists concerning material use, e.g. toxic substances, such as US Toxic Substances Control Act (TSCA) [29] concerning the reporting, record-keeping and testing requirements as well as restrictions relating to chemical substances and/or mixtures, addressing the production, importation, use, and disposal of specific chemicals. Also the transportation of hazardous materials is subject to strict regulations.

Companies can choose to adopt different positions ranging on a continuum from re-active environmental strategic positions following regulations, to pro-active positions where competitive advantages are sought for. Either way, the environmental concern requires manufacturing industries to develop strategies, technologies and practices that will reduce the environmental impact on both global and local scale.

USE PHASE

During the recent decades, the "greentech" (or "envirotech" or "cleantech") sector has emerged and grown with business based on products, services and technologies with a sustainability focus in their use phase.

- **Value increase**

A typical proactive sustainability action is to develop product and service solutions with neutral environmental impact while used. The actions are closely linked to material and technology development creating customer value. Examples are alternative fuel solutions for vehicles or energy saving technologies that implies a higher value for the customer. Actions focused on the product, specifically for industrial products, can also lead to fulfilling new future regulations and environmental expectations from the customer.

Enabling features include introducing products based on CO2-neutral materials, replacing fossil based materials, technology development for creating environmental and energy preserving offerings and business development including product service solutions for total life cycle sustainability.

- **Cost decrease**

The ideal situation is to develop and offer products and services lowering the cost for the customer in use phase as well as contributing to positive environmental effects. Products leading to higher energy efficiency and closed loops of material and energy will contribute to a more sustainable future.

Looking at areas in need of development, the product realization from design, throughout production, use and after life must be interlinked. Local manufacturing could be a bridge between the production and use phase of a product, creating a complete product service solution based on software services and feedback of information from use to improve product and production system development.

As new emerging renewable materials will be in use, processes enabling sustainable services must be explored for e.g. products based on light ultra high-strength steels and polymer composites, which today require a complete replacement when damaged.

- **Regulatory initiatives**

From regulative authorities a large number of initiatives are in place presenting incentives for the use of more environmental sustainable products. Guidelines, tax credits, legislations and regulation concerning energy consuming industrial and consumer products are presented on national and international level.

AFTER-LIFE PHASE

The life span of products is constantly decreasing as consumers' need for new products increases. A key aspect for increased sustainability is to create closed loops for product retake and reuse of material and components. The afterlife phase requires additional focus. The general definitions on activities in the after-use phase are illustrated in Figure 4.

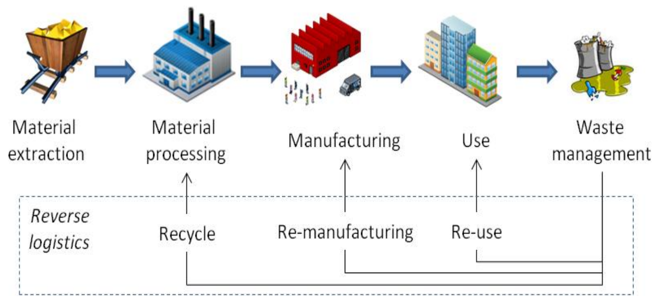

Figure 4. Terms here used for materials handling in after life phase

- **Value increase**

The possibility to retrofit and refurbish products could be increased and to a larger extend presented as value *increasing abilities in consumer and industrial products. Products need to be designed considering multiple life cycle use and retrofit potential. It is argued for a more proactive view on remanufacturing and identifies general environmental pros and cons with remanufacturing, such as the material resource perspective [30]. They further review literature concerning the environmental impacts of remanufacturing. Through product design based on component and material reuse, more drastic value increases can be gained.*

An even more comprehensive review of literature regarding green supply chain management is presented in e.g. [21, 32], including the aspect of green manufacturing, remanufacturing and reverse logistics.

- ***Cost decrease***

The concept of remanufacturing is often quantified in terms of cost advantages and referring to activities designed to reclaim value from a product at the end of its useful life. Industries that apply remanufacturing typically include automobiles, electronics and tyres. In a comparison between the remanufacturing of a traditionally-designed XEROX copy machine and a copy machine that was designed to facilitate remanufacture, the energy savings for the model which has been designed for remanufacturing equal a factor of 3.1 and materials/landfill savings equal a factor of 1.9 [31].

Enabling features include the design and industrialisation of products for multiple life cycles, as well as manufacturing processes for reuse/ remanufacture of material and components, especially fossil based material. The needs of improved technologies, increased automation as well as economic and technical viable systems and concept for pre- and post-fragmentation recycling processes are evident [32]. The information and logistic aspects are vital, supplying information required for reassembly etc as well as feedback from production and maintenance to product and production system redesign.

- ***Regulatory initiatives***

From governments and authorities, the industrial waste handling is highly regulated. The Resource Conservation and Recovery Act (RCRA) [33] in US controls hazardous waste from the "cradle-to-grave" including the generation, transportation, treatment, storage and disposal.

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) [34] provides a US federal "Superfund" to clean up uncontrolled or abandoned hazardous-waste sites as well as accidents, spills, and other emergency releases of pollutants and contaminants into the environment. Later the Superfund Amendments and Reauthorization Act (SARA) of 1986 reauthorized CERCLA to continue cleanup activities around US. Several site-specific amendments, definitions clarifications, and technical requirements were added to the legislation, including additional enforcement authorities. Also, Title III of SARA authorized the Emergency Planning and Community Right-to-Know Act (EPCRA).

The Waste Electrical and Electronic Equipment Directive (WEEE) [35] is the European Community directive on waste electrical and electronic equipment which, together with the RoHS Directive became European Law in February 2003, setting collection, recycling and recovery targets for all types of electrical goods. "Users of electrical and electronic equipment from private households should have the possibility of returning WEEE at least free of charge". Also, the companies are compelled to use the collected waste in an ecologically-friendly manner, either by ecological disposal or by reuse/refurbishment of the collected WEEE. In addition, the European Parliament decides in 2003 upon the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS) [35].

CONCLUSIONS

By describing a brief overview of approaches for an enhanced life cycle view on product realization, it is clear how the focus in product and process development to an increasing level must move towards the later phases of product realization. By to a larger extend considering the use and after life phases, a shift towards a sustainable future can be made. Based on industrial challenges and the proposed structure for environmental actions, more detailed research challenges can be identified for specific actors and sectors.

The need for environmental sustainability creates both restrictions and opportunities for the manufacturing industry. Products and transports/ logistics have been first in focus for environmental impact improvements. However, to reach a total effect, the manufacturing process also needs to be looked upon from an environmental perspective. The process industry can work as inspiration in some aspects with their long experience in energy efficiency efforts due to high energy consumption and potentially polluting processes.

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USAGE OF DECISION SUPPORT SYSTEMS FOR DIAGNOSTIC PROCESS MANAGEMENT

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ABSTRACT: *This paper deals with process management in the diagnostic science with usage of the Decision Support System (DSS). Unlike the other common processes, diagnostic processes have some specifics. The outputs of diagnostic process can be used again as inputs. These outputs are measured data as well as gained knowledge and experience. Hence we are focused on increase of efficiency of data evaluation, optimizing of diagnostic processes and acceleration of development of new materials. Decision Support Systems are defined as "interactive computer-based systems, which help decision makers utilize data and models to solve unstructured problems". Therefore DSSs can be advisable solution for diagnostic processes, which are primarily unstructured. Unstructured problems can be partially supported by standard computerized quantitative methods, but it is necessary to develop customized solutions. This solution may require certain expertise that can be provided by intelligent system. Intuition and judgment may play a large role in this type of decisions. In the scope of development and diagnostic of new materials, DSSs can be used for optimizing of diagnostic processes and reduction of development time following the anterior data, knowledge and experience. DSSs provide new possibilities in discovery of materials and combination of materials with exactly defined properties. In addition, they can reduce related costs.*
KEYWORDS: *diagnostic process, process management, decision support system*

INTRODUCTION

Application of process management in the field of diagnostics is the result of the search for new opportunities to diagnostics development. Process management involves continuous measurement and evaluation of processes as well as decision making about implementation of new, improvement of existing and termination of insufficient processes. Successful implementation of process management also requires the use of appropriate information systems and technologies (IS/IT).

Decision Support Systems are defined as "interactive computer-based systems, which help decision makers utilize data and models to solve unstructured problems". In fact, DSSs can be used to solve any type of problems. It means that they can be used to facilitate decision making in both cases, the diagnostic problem solving and diagnostic process management as well.

DIAGNOSTIC PROCESS MANAGEMENT

Diagnostics is a discipline that essentially deals with identifying the root causes of the problem and seeking solutions to the problem. Important attributes, with which the diagnostic processes work, are data, information and knowledge. Knowledge transforming data into information and information (diagnosis) is the output of a process, which should be called a diagnostic process (see Figure 1).

Diagnostic process is effectively planned sequence of activities, which enabling identify the structure or behavior of diagnosed object using information, knowledge, financial, material and human resources in accordance with customer requirements. Diagnostic object should be an element of the system, system or process. Customer is a person who required diagnostics.

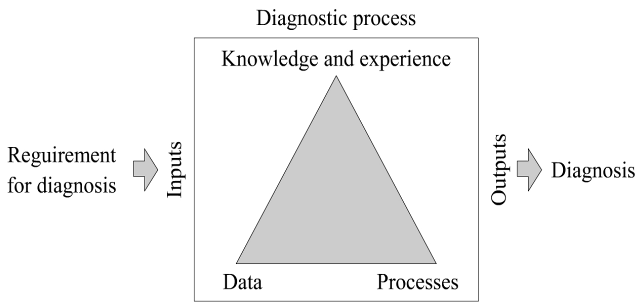

Figure 1 – Process view of diagnostics

Diagnostic process management is not clearly defined as a scientific discipline. Generally, diagnostic process management can be conceived as management of service providing. Nowadays, in terms of scientific focus, this issue can be defined as Service Sciences, Management and Engineering (SSME). It is a multidisciplinary field of research and academic initiative that integrates aspects of the areas of informatics, operational research, technical disciplines of engineering, management sciences, including strategic, social, cognitive and legal sciences. SSME is then defined as a management-engineering discipline focused on providing efficient services.

During implementation of diagnostic process management, following of particular stages of process management life cycle is highly recommended. These stages are:

1. *Determination of management strategy and process objectives defining*
2. *Analysis and processes mapping*
3. *Process modeling*

4. Process optimization
5. Creating of a system for measurement and evaluation of processes

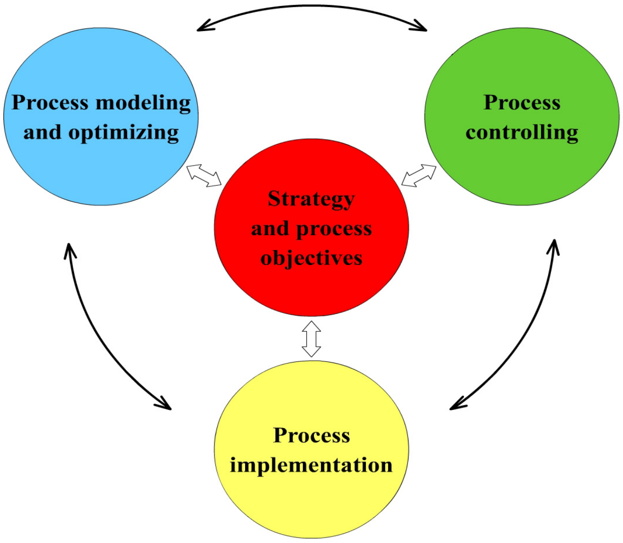

Figure 2 – Process management life cycle

These stages are complemented and extended with appropriate methods and techniques that are used in different areas separately. Then, the proposed methodology determines the order and concept of how to use these methods to create a coherent logical unit.

Usually, the diagnostic process should be easy described, surveyed, quantified by real metrics, and its added value can be evaluated easily. For these reasons, process controlling can be easy implemented and advantageously used in the field of diagnostics.

A prerequisite for the successful diagnostic process management is monitoring of real-time run of processes and recording of their attributes. These data could be stored in database or data warehouse and used by analytical tools, such as reporting tools, OLAP or other Business Intelligent (BI) tools. It provides continuous evaluating and measuring of the key attributes of diagnostic processes. It can leads to find process bottleneck and enables continuous optimizing of processes.

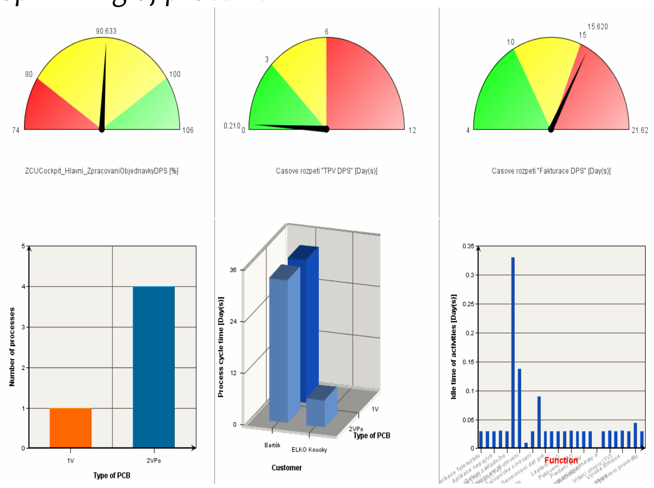

Figure 3 – Example of graphical outputs of queries in the analytical process controlling using ARIS PPM [5]

One of the promising tools which allow above mentioned functions is ARIS Process Performance Manager (PPM). It measures the real-time performance of process by calculation of selected key performance indicators, such as the duration of the process, the process rate, error rate, the process cost, a number of actors involved in the process, and other indicators as desired by the user.

DSSs SUITABLE FOR DIAGNOSTIC PURPOSES

As was already mentioned, DSS are interactive computer-based systems, which help decision makers utilize data and models to solve unstructured problems. DSS is an approach, a methodology for supporting decision making [2]. It uses specially developed interactive, flexible and adaptable computer-based information systems.

Generally, a common DSS application consists of four basic components: the data management subsystem, the model management subsystem, a knowledge-based management subsystem and the user interface subsystem.

The data management subsystem is basically a database. This database contains relevant data and is managed by database management system (DBMS). This subsystem is usually interconnected with data warehouse, a repository for relevant decision-making data.

The model management subsystem is a software package that includes quantitative models that provide the system's analytical capabilities, appropriate software management and modeling languages for building custom models.

The knowledge-based management subsystem is optional, but it provides many benefits by providing intelligence into the system. This component can supply the required expertise for solving some aspects of the problem and provide knowledge that can enhance operation of other DSS components [2].

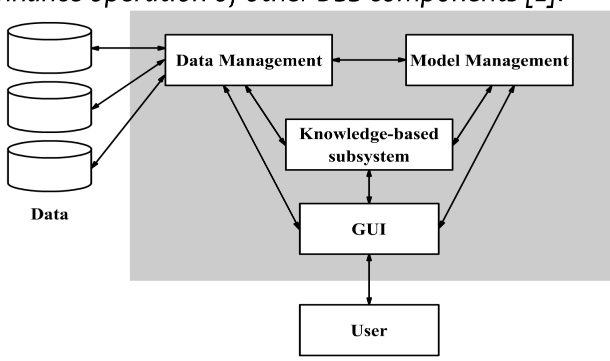

Figure 4 – A schematic view of Decision Support System

The user interface subsystem serves to facilitate user's communicating with and operating the DSS. Because the user is a fundamental part of the system, consistent, familiar and easy to use graphical user interface (GUI) application is highly recommended. GUI is advantageously provided by Web browser.

To help users to decide which type of DSS is the best solution for their specifications and requirements, several classifications of DSS applications had been create. Today most DSSs fit into the classification provided by the Association for Information Systems Special Interest Group on Decision Support Systems (AIS SIGDSS) [2]. This concise classification includes the following categories:

- *Data-Driven DSS*
- *Model-Driven DSS*
- *Knowledge-driven DSS, data mining and ES (Expert System) applications*
- *Document-Driven DSS*
- *Communications-Driven and group DSS*

To include the categorization in terms of functions and technology, Power extends these five major categories of DSSs by two more:

- *Spreadsheet-Based DSS*
- *Web-Based DSS*

Hybrid, or so called compound DSS, may also be creates as combination of two or more major categories.

In the field of diagnostics the DSS should be able to manage large amount of measured data as well as knowledge and experience gained in the past. To easy share the information and functions of such a system, using of network technologies is useful. To reach these characteristics, design of the Web-Based Data/ Knowledge-Driven compound DSS should be the best approach. Therefore we are closely focused on the three mentioned categories of DSSs.

WEB-BASED DSS

Web-Based DSS gives decision support information or decision support tools to users using a "thin-client" Web browser like Internet Explorer or Mozilla Firefox that is accessing the Internet or an intranet. The computer server that is hosting the DSS application is linked to the user's computer by a network with the TCP/IP protocol. Web technologies can be used to implement any of DSS main categories.

Web-Based means the whole application is implemented using Web technologies. In some cases key parts of application remain on a legacy system, but the application is accessed from a Web-based component and displayed in a browser. These types of applications are so called Web-Enabled.

DATA-DRIVEN DSS

A Data-Driven Decision Support System is an interactive computer-based system that helps decision-makers use a large amount of data. Users of the system can perform unplanned or ad hoc analyses and requests for data, process data to identify facts and to draw conclusions about data patterns and trends. Data-Driven DSS help users retrieve, display, and analyze historical data.

The elementary level of functionality is provided by simple file system accessed by query and retrieval tools. The additional functionality is represented by Data warehouse system. It allows the manipulation of data by computerized tools. The highest level of functionality and decision support is represented by Data-driven DSS with On-line Analytical Processing (OLAP).

This category of DSS is determined to help users "drill down" for more detailed information, "drill up" to see a broader, more summarized view, and "slice and dice" to change the dimensions they are viewing. The results of "drilling" and "slicing and dicing" are presented in tables and charts [3].

KNOWLEDGE-DRIVEN DSS

Knowledge-Driven Decision Support Systems store and apply knowledge for specific problems. They are computer programs that ask questions and reason with the stored knowledge about a narrow, specialized subject. This type of programs attempt to solve a problem or give advice.

In general, Knowledge-Driven DSS is a program with specialized problem-solving expertise. The "expertise" consists of three components: 1) knowledge of symptoms related to a particular domain, 2) understanding of the relations among symptoms, problems and solutions, and 3) "skill" or methods for solving some of the problems. It is knowledge-intensive program that captures the expertise of a human in a limited domain of knowledge and experience [3].

USAGE OF DECISION SUPPORT SYSTEMS FOR DIAGNOSTIC PROCESS MANAGEMENT

There are many different ways to use Decision Support Systems. It always depends on their purpose and user requirements. In the field of diagnostics we can profitably use the best practices from published case studies of implementation of maintenance and medical applications of DSS. The maintenance DSSs are generally more focused on the data which represents measured values of the key parameters of reference object. On the other side, medical DSSs are mostly designed to use and dissemination of knowledge.

In the field of general diagnostics we can find both of these mentioned approaches. In the next two subsections we will try to outline the possible application of both approaches on examples of diagnostic processes performed in our research team workplace. These diagnostic processes are diagnostics of solderability and diagnostics of organic polymers.

EXAMPLE 1 – PROCESS OF SOLDERABILITY DIAGNOSTICS

The aim of this diagnostic process is to evaluate solderability of electronic device leads or parts of printed circuit boards. Solderability consists of 3 *aspects – wettability, temperature requirement and resistance to soldering heat. Diagnosed object can be solder, flux, sample of one of the connected materials, or even the soldering process settings. For diagnostic itself, equipment for solderability testing using wetting balance test is used.*

Process of solderability testing strictly follows relevant standards. Therefore all evaluated parameters of soldering test are well known and defined. This knowledge, if necessary, can be with advantage used to build a knowledge-driven DSS based on well defined rules such as expert system (ES). For these purposes several free tools, so called expert system shells, are available. The most common ES shells include CLIPS, Jess, Jena and e2go.

However, the key role in this diagnostic process play obtained data and their evaluation. This is a typical example of the use of data-driven diagnostic decision support system. The obtained data should be shown as charts and graphs, with ability to be investigated from several angles of view, such as solder type, flux type, soldering process parameters etc. Whereas, the solderability testing does not produce a large amount of data so the suitable data-driven DSS could be built using common spreadsheet processors.

EXAMPLE 2 – PROCESS OF ORGANIC POLYMERS DIAGNOSTICS

The aim of this diagnostic process is the assessment of selected parameters of organic polymers that are used for the construction of sensors. Diagnosed object is composed of the substrate, the electrode system and a layer of organic polymer. For this sample changes in several electrical properties, such as complex impedance, permittivity, resistivity and loss angle, depending on changes in the environment, especially humidity, temperature, steam, are examined. For the deposition of organic polymer layer different technologies may be used, such as dip coating, spin coating, vapor plating, sputtering and electrochemical processes such as electric polymerization.

Besides the measured data, this diagnostic process produces a large amount of knowledge and experience. These knowledge contain information about the type of used material, used selected polymer coating technology, design layout of the measured samples, processes used for sample preparation, measurement conditions and used equipment, etc. Furthermore, the knowledge about influence of one process condition on another is also very important.

Characteristics of organic polymer diagnostics process show the key role of knowledge and experience. This is a typical example of the use of knowledge-driven diagnostic decision support system. Such a system could be built using intelligent techniques and tools like expert system technologies and data mining. Especially Artificial Neural Networks (ANN) are very promising technology for building knowledge-driven DSS. Neural networks attempt to learn patterns from the data directly by repeatedly examining the data to identify relationships and build a model [3]. They can be used to classify the data, to discover hidden knowledge, or to make predictions based on already learned knowledge. There are many free, mainly Java-based ANN tools that provide building, training and implementing of neural networks. The most popular are Joone, Encog and Neuroph.

WIDER USE OF DECISION SUPPORT SYSTEM

Apart from measured data and gained knowledge and experience, decision support system should be able to obtain, use and manage additional attributes of diagnostics processes. These attributes, such as duration of the process, utilization of key resources, costs, etc., are the key elements of diagnostic process management. Based on such attributes, the diagnostics processes could be controlled and optimized.

Usage of decision support systems for diagnostic process management provides significant advantages like sharing of information, knowledge and experiences, optimization of diagnostic processes in terms of time and costs, continuous improvement of diagnostics quality, coordination and planning of tests, risks elimination, etc.

SUMMARY / CONCLUSIONS

Process management is the set of activities for planning and monitoring the performance of a process. It includes the application of knowledge, skills, tools, techniques and systems to define, visualize, measure, control, report and improve processes. In the field of diagnostics, process management brings the possibility of optimization of diagnostic processes and therefore the acceleration of diagnostics, research and development of new materials, technologies and techniques. It eventually also leads to reduction of costs.

Usage of Decision Support Systems for the diagnostic process management seems to be a good opportunity for achieving the above mentioned goals. Especially the Data-Driven and Knowledge-Driven DSS, both developed as a Web-Based system, or their combinations, are suitable tools for diagnostic purposes.

This article deals with the process management in the field of technical diagnostics using Decision Support Systems. It brings the brief overview of diagnostic process management and the suitable types of DSS. The usage of Decision support systems for diagnostic process management is described and demonstrated on two process examples – Diagnostics of solderability and Diagnostics of organic polymers.

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LIFE CYCLE ASSESSMENT - OZONE INJURY IN FOREST ECOSYSTEMS

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ABSTRACT: Controlling visible ozone injury on conifer species were in locality Kopaonik – Serbia. The trials were set in accordance with methods PP 1/152 (2) (EPPO, 1997), the treatment plan was made according to a fully randomized block design. Phytotoxicity was estimated according to instructions of PP methods (1/135 (2). Intensity of injury was performed using standard statistical methods Towsend- Heuberger, the efficiency according to Abbott, analysis of variance to Duncan test and methods PP/181 (2). The differences of the disease intensity were evaluated by the analysis of variance and LSD-test. In locality Kopaonik ozone forecasts are made daily during the ozone forecast season.
KEYWORDS: LCA, forest, ozone, injury

INTRODUCTION

Vegetation is a major component of forest ecosystems. The composition, diversity, and structure of vegetation are important factors for assessing biological diversity of forest ecosystems. Vegetation is the source of primary production, plays a direct role in water and nutrient cycling, and interacts strongly with other biotic components (insects, game, etc.) being a determinant habitat for many species. Vegetation has also been identified as a specific target for the calculation of critical loads/levels.

The development of ozone-induced injury is inter- and intra-species specific, and depends apart from local ambient ozone concentrations on other environmental such as biotic and climatic factors. Due to the complex nature of the diagnosis and the given restrictions of the investment, results from the tree and vegetation assessment should be considered as semi quantitative. Ozone pollution leaves no elemental residue that can be detected by analytical techniques, as do fluorides [1] and sulfur dioxide [2]. Therefore, ozone-induced visible injury on needles and leaves is the only easily detectable evidence in the field as a result of oxidative stress, leading to a cascade of adverse physiological and morphological effects. These "ozone response variables," made at the needle, whorl, branch, tree, or stand level, and aggregated in analysis, can be an effective way to quantify ozone effects on pines [3]. Ozone response variables include microscopic and macroscopic injury to the foliage (primary effect), and injury to branches and roots (secondary effects) that can be quantified within defined levels of accuracy and precision. These "ozone response variables," made at the needle, whorl, branch, tree, or stand level, and aggregated in analysis, can be an effective way to quantify ozone effects on pines [3]. Ozone response variables include microscopic and macroscopic injury to the foliage (primary effect), and injury to branches and roots (secondary effects) that can be quantified within defined levels of accuracy and precision.

Until now, experiments have concentrated on explaining the mechanisms leading to injury observed in experimental studies, rather than to identify and characterize the symptoms observed in the field on a regional scale.

The evidence we have today strongly suggests that ozone occurs at concentrations - cumulative exposures greater than 60 ppb; [4] that cause visible foliar injury to a wide range of sensitive plants. Gaseous pollutants pass through the stomata of conifer foliage and cause direct damage to the photosynthetically active mesophyll cells, often producing a diagnostic visible injury pattern [5]. Next, degeneration of essential biological processes in the needles occur that may eventually lead to reduced crown vigor, increased susceptibility to other pathogens, and tree death [6].

Controlled exposures and field observations of ozone effects on western conifer species have confirmed that a distinct visible symptom known as chlorotic mottle typically occurs on needle surfaces [7,8]. Chlorotic mottle begins as the walls of mesophyll cells below the epidermis degrade, causing the loss of cellular contents and the subsequent degradation of chlorophyll within the cell [5,9,10]. Microscopically this condition appears as amorphous staining of cellular contents, plasmolysis of cell contents, and cell death. The degradation of chlorophyll beneath the epidermis appears on the needle surface as amorphous chlorotic blotches with diffuse borders that occur in irregular patterns, giving a yellow "mottled" appearance;

hence the terminology "chlorotic mottle". This foliar injury symptom is visibly distinct from foliar symptoms induced by other air pollutants.
Chlorotic mottle frequently appears in the one-third of the needle surface nearest the tip on 1-year-old or older needles, and progresses basipetally until the entire needle is affected [7,8].
This pattern is observed mainly in southern California. In the Sierra Nevada the mottle tends to occur randomly along the entire needle length [11,12]. The current–year's needles will show small amounts of chlorotic mottle only when summer ozone exposure levels are higher than usual and/or adequate soil moisture contributes to higher stomatal conductance and more ozone flux to needles, or both. This condition is usually the exception and not the rule for the response of current year needles to ozone exposures in the Sierra Nevada. Tip necrosis or necrotic bands can result from acute ozone exposures in fumigation experiments, but chronic field exposures typically induce only chlorotic mottling.
The assessment of ozone visible injury serves therefore as a means to estimate the potential risk for European ecosystems that are exposed to elevated ambient ozone concentrations and has to be considered in the context of ICP Forests aiming among others to document the presence of environmental drivers that may affect forest condition across Europe. Specific aims are set as follows: Quantification of ozone injury occurrence on a selected number of Level II plots in Serbia – Kopaonik. Conection between selected sample and real forest for future forest is 95% for 10 years.
Life cycle assessment (LCA) models the complex interaction between a product and the environment. The International Organisation for Standardisation (ISO), provides quidelines for conducting an LCA within the series ISO 14040 and 14044. Impact assessment the effects of the resource use and emissions generated are grouped and quantified into, a limited number of impact categories which may then be weighted for importance. Air pollution can have noteworthy cumulative impacts on forested ecosystems by affecting regeneration, productivity, and species composition. Ozone in the lower atmosphere is one of the pollutants of primary concern. Ozone injury to forest plants can be diagnosed by examination of plant leaves. Foliar injury is usually the first visible sign of injury to plants from ozone exposure and indicates impaired physiological processes in the leaves.
The paper presents a model Life Cycle Assessment in the complex interaction between ozone and the environment. The main objective of research of assessing ozone visible injury on a selected number of Level II plots is to assess the effect of tropospheric ozone at the sites where ozone monitoring is performed, and to contribute to an ozone risk assessment for European forest ecosystems.

MATERIALS AND METHODS

Symptoms of ozone injury was monitored on mature stands of red fir (Picetum excelsae oxalidetosum), with standard density (about 400 plants / m2). The site on which there is a measuring station for monitoring the health situation in the IPCC project is located at 74a department, G.J. „Samokovska reka" in national park „Kopaonik". The site is located directly below the road Kopaonik Brus, slightly above the Marino sources. Stands in which the research station is classified as irregular pure spruce stands. Circuit is thick (0.8 to 0.9). Spruce trees are right, little Mouse-tailed and developed crowns, which is logical given the height at which they are located. The average density is about 690 units / ha, the average volume of 460 m 3 / ha, the current increment is 8.30 m 3 / ha, mean stand diameter is 27 cm and mean stand height is 18.8 m.

- ***Materials:***
  - *a) Container: ice box cooler, boxes.*
  - *b) Magnifying lens.*
  - *c) Labels, pencil, scotch tape*

Tools: a sharpened punching tool (diameter 0.5-1cm), sharp scalpel, cardboard, tweezers, latex gloves, Kleenex.
Solutions: fixation medium (2.5% glutaraldehyde in Soerensen buffer at pH 7.0 distributed in 1.5 ml Eppendorf vials with screw caps).
Procedures: We were excised small samples (max. 0.5-1 cm in diameter for leaves, 3-4 mm for needles) from symptomatic as well as asymptomatic needles, in order to ease and thus speed up the penetration of fixative. We immediately had diped samples into Eppendorf vials with accurate labels (1 disc/needle segment per vial only) prior to storage in the cooler. Unless samples are collected to sort out stress symptoms by different stress factors, multisymptomatic samples should be avoided by close examination of needles prior to sampling. The hand lens should also be used to select asymptomatic samples from foliage close-by with similar light exposure. When we were backed to the lab, we renewed the fixative solution. We stored the samples at 4 °C until processing for microscopical analysis.

- ***Methods***

The trials were set in accordance with methods PP 1/152 (2) (EPPO, 1997) [13], and the treatment plan was made according to a fully randomized block design. The experiment was conducted in four repetitions on basic plots consisting of 8 trees (1 x 3 m apart), 25 m^2 in total.

The estimation of needles as follows: 3x5 well-developed shoots were selected from the outer zones of each tree. The scale of values which was used to record the results of each leaf is as follows: 0 = no injury, 1 = 1 – 5% of the needles per branch show ozone symptoms, 2 = 6 – 50% of the needles per branch show ozone symptoms, 3 = 51 – 100% of the needles per branch show ozone symptoms (Table 1).

The intensity of ozone injury assessed by the method of EPPO: and time of estimation was 11/07/2009. Phytotoxicity was estimated according to instructions of PP methods (1/135 (2) (OEPP, 1997) and time of estimation was 04/07/2010. [14].

Data processing was performed using standard statistical methods (intensity of injury according to Towsend- Heuberger [15], the efficiency according to Abbott [16], analysis of variance according to Duncan test [17] and methods PP/181 (2) (EPPO 1997) [18]. The differences of the disease intensity were evaluated by the analysis of variance and LSD-test.

Table 1 – Scoring and scoring definition for visible ozone injury as it is expressed on the respective needle years for the collected branches of conifer species

Score	Frequency class (%)	Definition
0	no injury	none of the needles are injured
1	1 – 5 %	1 – 5% of the needles per branch show ozone symptoms
2	6 – 50 %	6 – 50% of the needles per branch show ozone symptoms
3	51 – 100 %	51 – 100% of the needles per branch show ozone symptoms

RESULTS AND DISCUSSION

Estimates of ozone damage was done in the manner provided for the Manual on methods and criteria for harmonized sampling, assessment, monitoring and analysis of results of impact of air pollution on forests adopted by the International cooperative program for assessing and monitoring the impact of air pollution on forests [19].Visible damage to the assimilation organs of conifer expressed ozone in the upper parts of the crown, the top of the twigs and needles.

Minimum of 3 branches per tree and five trees per plot are assessed. The evaluation is very different for deciduous trees and coniferous trees and trees from which they reap the samples in Kopaonik are dominant spruce trees. The trees are on the ground marked the permanent markings on the bark, numbered 1-195, at 3 under plot. The numbers of trees to assess damage caused by ozone are 9, 20, 54, 76, 108.

Needles in the laboratory for evaluation prepared by placing the flasks with 2.5% solution of glutaraldehyde ON (SN2) 3SNO. Microscopic changes were found chlorotic-most common symptom induced by ozone damage.

The samples were assigned to these five trees with three branches - the three clusters (1-3, 3-5 ... 15) in the form LTF2004. The number of needles per sample is 30.

Other required parameters are listed in table-form LTF2004. (Type number, dates of sampling, analysis, method of detection and other observations). Needles are grouped by category (percentage share - a result with symptoms from each branch were taken to five trees on the experimental plot).

Table 2 – LTF2004- Determination of ozone injury on conifer

Point No	Tree No	Cod of species	Latin name	Material of claster
2	9	118	P.abies	1-3
2	20	118	P.abies	4-6
2	54	118	P.abies	7-9
2	76	118	P.abies	10-12
2	108	118P	P.abies	13-15
Point No	Date of taking samples	Date of analyses	Injury of conifer	Status of examples
2	131010	191110	0,0,1 a	NR
2	131010	191110	0,1,0 a	NR
2	131010	191110	1,0,0 a	NR
2	131010	191110	0,0,0 a	NR
2	131010	191110	1,0,0 a	NR

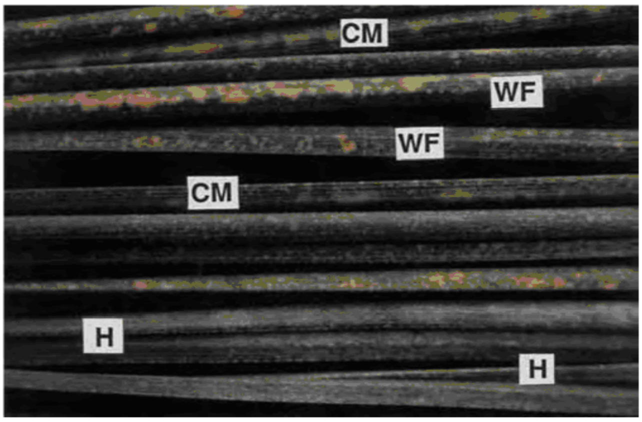

Figure 4. Three healthy (H) ponderosa pine needles (lower) are compared to those with a mixture of chlorotic mottle (CM) caused by ozone, best illustrated by the second needle from the top in which irregular chlorotic islands are visible. Weather fleck (WF) is displayed by the fourth and fifth needles from the top; note that weather fleck lesions are tan, not yellow, and borders are more irregular in shape. Weather fleck is found exclusively on the upper surfaces of needles (facing the sky). Chlorotic mottle can occur on all surfaces and is best evaluated on the lower surface where fleck is not present [22]. (Type of analyses on this figure are visible method).

Foliar injuries resulting from biotic agents may appear on needle surfaces, confounding diagnosis of ozone injury. Chlorotic and necrotic spots or blotches caused by sucking insects, such as aphids and pine needle scale, may sometimes closely resemble ozone chlorotic mottle. The most common confounding pests are fungi [20], and chewing (needle weevil) or sucking (scale or aphids) insects [6,11]. Chlorotic mottle can be differentiated from injuries brought about by these diseases and insects by in-hand observation of the color and pattern of the symptoms on the needles. Careful observation may reveal the presence of fungus fruiting bodies. Close inspection of chlorotic islands of tissue (aided by a hand lens) often reveals a distinct necrotic point at the center of the discolored area, where the insect penetrated the epidermis with its piercing mouth parts.

In many conifer species, foliage longevity can be measured by counting nodes on branches back from the branch tip to the oldest whorl, with each node separating a annual whorl of needles or needle fascicles corresponding to one year of growth. Reduction in needle longevity is recognized as an indicator of air pollution stress for these species when other factors leading to accelerated abscission of needles are taken into account. Foliage longevity is related to other factors, most particularly the elevation at which a tree grows [22], which is an indication of the length of the growing season at a particular site. Interpretation of data on foliage longevity must consider other confounding factors, for example, persistent infections of needle cast fungi can lead to tree crowns that are extensively defoliated. The bole and other crown variables that are associated with growth and overall tree vigor can respond to elevated ozone exposures. Branch mortality in the lowest portion of the crown has been observed in southern California [23], leading to a decrease in vertical crown length, as measured by percent live crown [24]. Before lower branch mortality occurs, a decline in vigor in the lower crown may be observed as a reduction in needle length [23], and the production of fewer numbers of needle fascicles [26,27]. A reduction in the vertical and radial growth of stems has been documented for ozone-stressed trees in southern California and southern Sierras [28,29,30], Cone and seed production can also be reduced by ozone stress in ponderosa pines [6]. Oleoresin exudation pressure, yield, and rate of flow were all substantially reduced in oxidant-injured ponderosa pines in southern California, while the crystallization rate was observed to increase [31]. The moisture content of phloem and sapwood were found to be reduced, as well as a reduction in phloem thickness. These phenomena have been associated with susceptibility to cambium damage from the heat of fire and successful attack by bark beetles [31, 32].

Monitoring of ozone injury to plants by our Institute has expanded over the last 1 year. Ozone damage to forest plants is classified using a subjective three-category biosite index based on expert opinion, but designed to be equivalent from site to site. Ranges of biosite values translate to no injury, low or moderate foliar injury (visible foliar injury to highly sensitive or moderately sensitive plants, respectively), and high or severe foliar injury, which would be expected to result in tree-level or ecosystem-level responses, respectively. Based on the tabular results of the Level II - Kopaonik can be monitored data of the ozone damage to forest in the next few years. Because that our research is only one year, monitoring of meteorological data will be an accurate forecasting model of possible ozone depletion over the next 10 years.

What are the sources of crop-damaging concentration of ozone? The first and the most important sources result from the activities of man. Other possible sources are the ozone-rich layers of the stratosphere, and thunderstorms.

United Nations Economic Commission for Europe, Convention on Long-range Transboundary Air Pollution, International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) prepared Manuel on methods and criteria for harmonized sampling, assessment, monitoring and analysis of the effects of air pollution on forests and in Part VII are Assessment of Ozone Injury [19], and their opinion is that based on methods we were used significant changes within 10 years are a 95% significance level for individual plots.

In NIVO II locality Kopaonik ozone forecasts are made daily during the ozone forecast season for each of several areas. Each forecast is a simple yes or no prediction for the question: Will ozone levels reach or exceed a target level for a particular area? Our meteorologists use a set of criteria from historic meteorological data, ozone measurements, and ozone prediction models to make these predictions.

CONCLUSIONS

- In Europe, ambient ozone levels are high enough to cause visible injury in native species. Assessment of visible injury is a feasible way to detect the impacts of this pollutant in forest plants and to identify potential risk areas. Ozone-induced visible injury has been incorporated in monitoring programmes, and it is surveyed at a pan-European scale under the protocols of ICP-Forests and FutMon (Life+) project.
- Conifers are presented on categories in percentage. Results with symptoms are showen from each branches from 5 trees from experimental plate. The peaces of conifers were estimated for 5 trees from 3 clasters (1-3, 3-5...15).
- Chlorotic mottle caused by ozone injury was on the toop of the tree, in first part of the conifer.
- Minimum 3 brances by tree and 5 trees by parceles are controled. Evaluation is different to leaves and conifers, and the experiment was made on red fir. In locality Kopaonik- Rtanj.

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FIDELITY OF OPTICAL TECHNIQUES FOR GEOMETRICAL INSPECTION OF CRANKSHAFTS

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ABSTRACT: *In the paper optical measurements of geometrical features on crankshafts were presented. The requirements of contemporary customer are getting higher and higher. It is particularly visible in aviation and automotive industry. For truck manufacturers it means efficient work with no repairs for hundreds thousand kilometers. It means also more measurements in every batch and on each workpiece. In this project we investigated possibility of use optics for fast inspection of diameters, lengths and form deviations. It was necessary to prepare a measurement strategy and elaborate uncertainty evaluation.*
KEYWORDS: *tactile measurement, optical measurement, CMM, measurement strategy, uncertainty*

INTRODUCTION

Present economical situation enforces manufacturers to ensure very high Quality of their products. It further implies cost reduction of the whole production process including following expenses connected with e.g. malfunctioning claims. These facts make it necessary to invest in machine tools that can produce fast, efficiently and precisely. Meanwhile, it is crucial to develop control and measurement systems and procedures to continuously monitor suppliers and own production. FOS POLMO Lodz, a co-author of this paper, is an example of a company that fulfils these requirements. History of the enterprise reaches year 1908, while present production portfolio comprises components for compressors and turbo compressors and assembly of the whole systems (fig. 1).

Figure 1 – Examples of elements manufactured in FOS POLMO SA

FOS POLMO Lodz SA is the biggest in Poland manufacturer of compressors for pneumatic braking systems used in trucks, buses and agricultural machines. These elements are designated for both: primary and secondary market, 80% of them goes abroad. High quality of products and trust of customers are confirmed by numerous awards that were granted to POLMO during last years. Continuous development of the company is possible also thanks to money from EU funds. Looking for new solutions and support from scientists POLMO together with Poznan University of Technology carried out a grant called: Introduction of new measurement technology regarding elements of compressors and turbo compressors. During this project a method for correction of grinding machine by means of a file generated by CMM measurement software was implemented. It was done by a Leitz PMM 12.10.6 [1]. At present another project goes on regarding implementation of contactless measurement methods regarding geometrical features in mass production of crankshafts. Some results of this project are presented in this paper.

THE USE OF TELECENTRIC MEASUREMENT SYSTEM

In contemporary length and angle measurements optical techniques play still more and more important role. Their basic merits are no contact between measuring element and workpiece as well as speed of measurement, what makes it possible to measure more parts and features during the same time. Thanks to this optical devices are getting common in industry. Among optical devices there are optical scanners [2] and traditional coordinate measuring machines equipped with cameras [3], and even surface roughness measuring instruments thought for the future [4], though here their practical application does not always look promising [5, 6]. Among optical measurement methods there are surface techniques (triangulation and space) and projection ones (laser, telecentric, central perspective and central projection) [7]. Telecentric system (used in our research) gives a possibility to identify workpiece geometry, determine lengths and diameters rotate at a given angle during measurement, measure threads and through bores. A measurement itself can be executed statically or dynamically. Workpiece is fastened in working space and measuring system moves along its axis. At one side of the workpiece there is a light source using semi conductive LED diodes and telecentric lenses that form light beam in a proper way. At the other side there is a CCD sensor that reads shape and dimensions on the border between light and dark area (fig. 2).

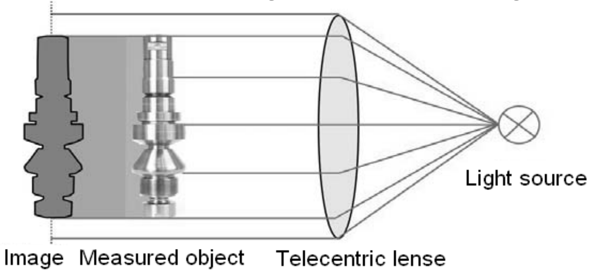

Figure 2 – Measurement principle of optical telecentric system

APPLICABILITY FOR MEASUREMENTS OF AXIS SYMMETRICAL WORKPIECES

FOS POLMO carries on mass production of different type of crankshafts for compressors used in pneumatic brake systems. Requirements put by customers are a challenge for both: production division and measurement laboratory. For some types of crankshafts cylindricity error should no exceed 0.005 mm, what determines choice of strategy and selection of measuring devices. For control a CMM Leitz PMM 12.10.6 is used working in a tactile routine, equipped with the most recent controller and a High Speed Scanning mode (HSS). The machine was shown on fig. 3. Because of great number of different measuring tasks performed on this machine and still growing production, it was necessary to implement a device that could ensure shorter measurement time maintaining accuracy of assessment. Solving the task it was necessary to develop an optical system, that could be able to execute a great number of measurements within a short time, with respective fidelity and independent on the operator. The system was based on Hommel Opticline, that is dedicated to do measurements of outer dimensions and form deviations for axis symmetrical parts, traditionally machined on turning or grinding machines for shafts. It is commonly used in car industry as well as aviation one, while its standard applications are valves, rotor shafts, gear shafts, injectors, turbine shafts, hydraulic pneumatic components, camshafts and crankshafts. It can measure elements with diameter up to 150 mm and 530 mm length, maintaining maximum error of ±(2+D/100) μm for diameters and ±(5+L/100) μm for lengths.

Figure 3 – Tactile coordinate measuring machine Leitz PMM 12.10.6

Opticline is equipped with setting discs and temperature sensors for compensation of thermal variations. Before every measurement the device balances a workpiece. During measurement a part is scanned optoelectronically and identified as a shape that stops light emitted by LED diode. During dynamic mode data regarding contour are collected when a workpiece rotates. Image is displayed on monitor and predefined features are assessed. The standard configuration - Opticline Contour 514 was presented on fig. 4. It is ready to work in workshop conditions, for 100% inspection.

Figure 4 – Optical coordinate measuring machine Hommel Opticline Contour 514

Maximum permissible error MPEE for Leitz CMM is ±(0.8+L/600) μm for the whole measuring space of 1200*1000*600 mm. For research a DEA Global Image Clima 7.7.5 CMM was used that is in Laboratory of

Division of Metrology and Measurement Systems at Poznan University of Technology. MPE_E for this machine is ±(1.5+L/333) µm. So considering all the described devices, CMM DEA is between Opticline and Leitz CMM. Comparison measurements were taken for various types of crankshafts. In all cases measurement times for both CMMs were similar, while measurement time for Opticline was significantly shorter (table 1).

Table 1 – Combination of measurement times regarding a single workpiece with different measuring devices

Measurement device	Leitz PMM 12.10.6	DEA Global Image 7.7.5	Hommel Opticline Contour 514
Measurement time of single workpiece	9 min 20 sec	10 min 25 sec	1 min 8 sec

In every case the same measurement features were considered. Optical devices can execute the same task about ten times faster. It is indeed a very important parameter from control possibilities as well as quality monitoring point of view.

Within a project it was necessary to define measurement uncertainty for optical device, to establish its application possibilities in every day use in the factory. When measuring features with very narrow tolerances, an influence form crankshaft geometry and weight was noticed (location of heavy parts regarding rotation axis - crankshaft may have one or two cranks). As a measurement is a dynamic one, vibrations of the shaft were observed and stick-slip phenomenon on center. To avoid this problem a new concept of center was constructed with two additional pins and fastening screw. This solution eliminated problems (fig. 5).

Figure 5 – Standard centre and new solution with fastening screw and setting pins

Another issue which is crucial at all the optical measurements with narrow field of tolerance is presence of all the kind of dust and liquids. They can significantly distort the result of measurement. Directly before mounting in a holder, a workpiece has to be thoroughly cleaned and dried. This is particularly important when measurement tasks are on the limit of accuracy for the measurement device and uncertainties are lower than maximum permissible errors defined by manufacturer.

MEASUREMENT UNCERTAINTY EVALUATION

Proper presentation of measurement result requires also uncertainty. Assessing uncertainty for coordinate measuring devices is a complex and time consuming process [8, 9]. Because of specific requirements it is necessary to evaluate each feature separately, as there are different ways to establish different features. Such a situation is for both: a CMM and optical system. Guide to the Uncertainty Evaluation (GUM) [10] introduced the term of combined standard uncertainty u_c, which is a parameter showing dispersion of the measurement results. Standard deviation of measurement results could simply be used as combined standard uncertainty. The border lines of this interval are determined by so-called expanded uncertainty U (formula 1). They comprise big, depending on level of confidence, part of distribution, that can be assigned to a measured value [11]:

$$U = k \quad u_c(x) \qquad (1)$$

where: U – expanded uncertainty,
$u_c(x)$ – combined standard uncertainty,
k – coefficient depending combined standard uncertainty on assumed level of confidence p. Practically, k is assumed to be equal to 2, what stands for level of confidence p = 95%.

Evaluating A type of uncertainty has experimental character and is based on a series of repetition of the inspected value. In this case, experimental standard deviation $s(\bar{x}_i)$ is considered as combined standard uncertainty u_c (formula 2).

$$u_c(x) = s(\bar{x}_i) \qquad s(\bar{x}_i) = \frac{s(x_i)}{\sqrt{n}} \qquad s(x_i) = \sqrt{\frac{\sum_1^n (\bar{x} \quad x_i)^2}{n \quad 1}} \qquad (2)$$

Experimental standard deviation of sample distribution based on measured values $s(\bar{x}_i)$ is an assessment of standard deviation of σ distribution. Mean value = $\bar{x} = \frac{1}{n} \sum_1^n x_i$ from certain number of results n where every result is x_i is an assessment of correct mean value µ of the distribution.

Table 2 – List of measurement features for which uncertainty was evaluated

1 – diameter of short pin 1; 2 – roundness of short pin 1;
3 – diameter of short pin 2; 4 – roundness of short pin 2;
5 – diameter of crank pin 1, 6 – roundness of crank pin 1,
7 – diameter of crank pin 2, 8 – roundness of crank pin 2,
9 – diameter of long pin 1, 10 – roundness of long pin 1,
11 – diameter of long pin 2, 12 – roundness of long pin 2,
13 – stroke

According to the above mentioned rules, assessment of measurement uncertainty by means of A method was performed for all three measuring devices. For this, each feature was measured 30 times. List of features is shown in table 2, while uncertainty values are presented on figure 6.

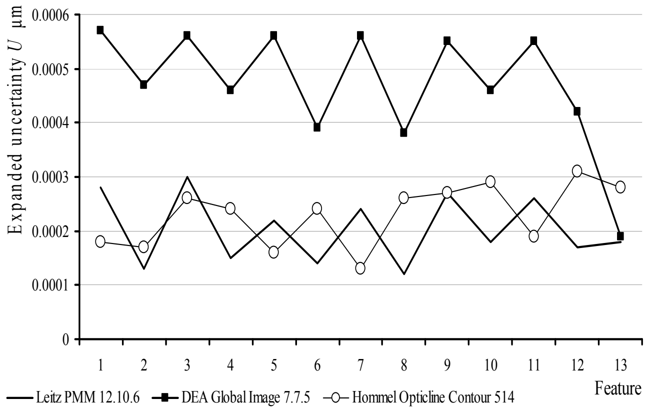

Figure 6 – Measurement uncertainty of particular features according to Table 2

As it was expected basing on maximum permissible error, uncertainty for CMM DEA is higher than for CMM Leitz. However, in both cases obtained values are smaller than MPE_E declared by manufacturers. Values obtained for Opticline are on the level of the respective ones for CMM Leitz. This fact was not expected, as comparing declared values of MPE_E the optical device has much worse parameters than both used CMMs. It means that right measurement strategy and proper use of the device with necessary modifications lead to obtaining much better uncertainty specs than showed in leaflets. It is also worth mentioning, that values for CMM Leitz and Opticline were obtained in production laboratory of FOS POLMO Lodz.

CONCLUSIONS

In the paper application of optical telecentric measurement system for inspection of geometrical features of crankshafts was presented. Some aspects connected with implementing it to control quality in production process were also shown. Basing on the obtained results it is clear, that the device is fully useful for the measuring tasks it should do, for accuracy and time of measurement. Duration of measurement process is about 10 times smaller with accuracy on the same level required to determine inspected features. Uncertainty for these features was also elaborated.

Some modifications regarding crankshaft holder was proposed. The overall project shows that specialized optical measuring device can be a good solution for quality control of crankshafts.

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ENERGY EFFICIENT INJECTION MOULDING OF POLYMERS

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ABSTRACT: *Injection moulding is one of the most important processes of cyclic polymer and other materials processing. It enables the production of very complex parts, in one cycle. For successful injection moulding, injection moulding system is necessary. It consists of main elements: the mould, injection moulding machine and device for mould temperature regulation (tempering), and additional elements: dryers, robots etc. All of the mentioned elements consume significant amounts of energy. The paper presents the analysis of the possibilities of energy savings in injection moulding process, starting with moulded part geometry, in order to obtain more energy efficient process.*
KEYWORDS: *injection moulding, energy efficiency*

INTRODUCTION

Injection moulding is the most important and the most widespread procedure of polymer processing. It enables production of very complicated product geometry in one cycle, possibilities of production of several identical or different products in the same cycle. Advanced injection moulding processes enable production of multicolour or multi-component products, production of hollow products, production of macro and micro products etc. For successful injection moulding process, basic equipment (system) is necessary. It consists of: mould, injection moulding machine and temperature regulation device. [1] Modern injection moulding process also relies on additional equipment which manly consists of dryers (for granulate drying), water cooling systems, robots and manipulators. Each of the mentioned elements consumes energy, directly or indirectly (Figure 1).

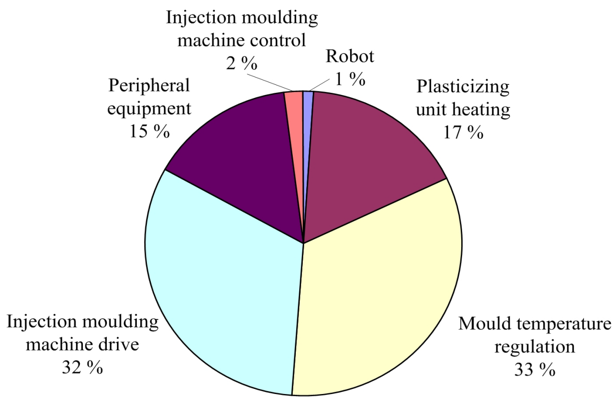


Figure 1 – The share of energy consumption in representative injection moulding system [2]

In recent years, decrease of the energy consumption in the field of equipment for injection moulding is general trend. Along with energy saving during injection moulding cycle (equipment), energy efficient injection moulding should be considered even in early phases of moulded part design, selection of moulded part material and mould design. Energy efficient injection moulding has not only economically positive impact, but environmentally as well. It is the fact that consumption of 1 kWh of electric energy presents approximately equivalent of 0.43 kg of CO_2 [2]. The paper covers the systematization of energy saving possibilities from polymer moulded parts development to their production by energy efficient injection moulding.

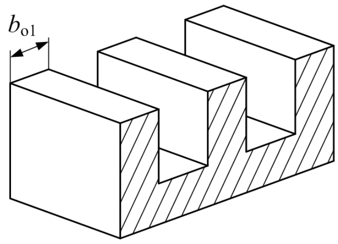
MOULDED PART DESIGN & MATERIAL SELECTION

The main activity of central moulded part development phase encompasses shaping, dimensioning and moulded part material selection where all activities are interconnected [3]. Based on set requirements on the product, it is possible to select adequate material (or more of them), and to perform a dimensioning of the moulded part. Even at the stage of moulded part development, it is possible to contribute to energy savings that will be realized later in the moulded part production. First of all, general guideline for polymer moulded parts development is achieving a uniform wall thickness while simultaneously conserving moulded part functionality.

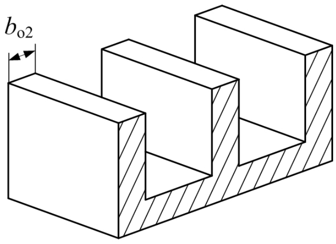
At the polymer materials market, recently it is possible to witness the trend of growth of number of new materials with properties tailored to the specific applications. Naturally, any advanced material property additionally raises its price. Material with better properties, e.g. reinforced with glass fibers, will allow production of molded parts with thinner walls (Figure 2) [4]. Although these materials are generally more expensive, they enable the production of molded parts with reduced weight. The result is lower consumption of materials per unit of product.

In adequate material selection process, the most common criterion is the cost of material, while processing costs are often out of consideration. In the case of injection molding, productivity of the system is mainly determined with molded part cooling time.

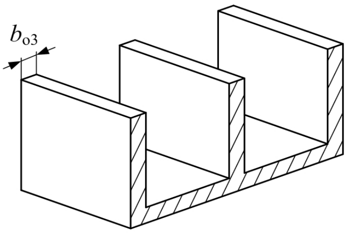
From general equation of molded part cooling time [1] it is clear that the molded part wall thickness is the most influential factor on the molded part cooling time.



polypropylene (PP)



polyamide (PA)



PA + 30 % GF (glass fibres)

Figure 2 - Comparison of product wall thickness with different materials [4]

$$t_h = \frac{b_o^2}{a_{ef} \cdot \pi \cdot K_O} \cdot ln\left[K_U \frac{T_T - T_K}{T_{PO} - T_K} \right] \quad (1)$$

where: t_h - moulded part cooling time (s), b_o - moulded part wall thickness (mm), a_{ef} - effective thermal diffusivity of polymer material (mm^2/s), K_O - coefficient of moulded part shape, K_U - coefficient of moulded part interior, T_T - polymer melt temperature (K), T_K - mould cavity wall thickness (K), T_{PO} - deflection temperature under load (K).

Therefore, when using materials that enable the production of molded parts with thinner walls, not only are possible savings in the amount of material, but still provide even larger opportunities for savings in the shortening the injection molding cycle. For example, if necessary wall thickness can be reduced from 2.0 mm to 1.5 mm, it is possible, under identical processing parameters, to shorten molded part cooling time for more than 40 %. If the average cycle time is e.g. 25 seconds, possible saving per cycle is 10 seconds. In the case of mass production, these 10 seconds can turn into months, which results in large energy savings.

MOULD FOR INJECTION MOULDING

Each mould for injection molding of polymers has to fulfill basic partial functions and possible special functions. One of the partial functions that have to be realized in every mould is mould cavity wall temperature regulation, respectively reaching and maintaining the requested temperature field. This means that the mould is a heat exchanger in which efficiency of heat exchange directly influences the moulded part cooling time. By means of the mould, moulded part cooling time can be influenced in two ways: by selection of appropriate material for elements of mould cavity and by appropriate cooling channels design. It should be aware that shortening of moulded part cooling time must be adjusted to the type of polymer material. For the majority of polymer materials there is prescribed maximum cooling rate, which results in satisfactory properties of the final product. This is particularly important in the processing of semi-crystalline thermoplastics.

INFLUENCE OF THE MOULD CAVITY ELEMENTS MATERIAL [1]

Influence of the mould cavity material on the molded part cooling time, and consequently injection molding cycle time is not simple. It depends on determined processing parameters such as mould cavity wall temperature (T_K), contact temperature (T_D), or coolant temperature (T_M) (Figure 3).

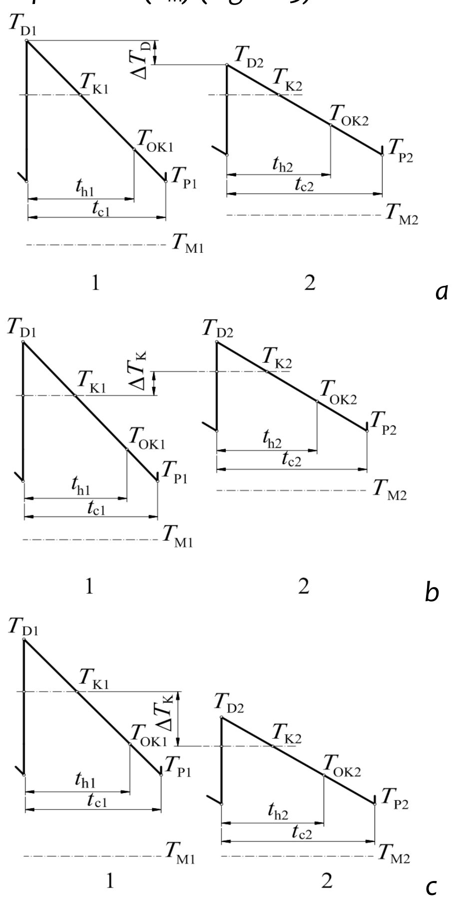
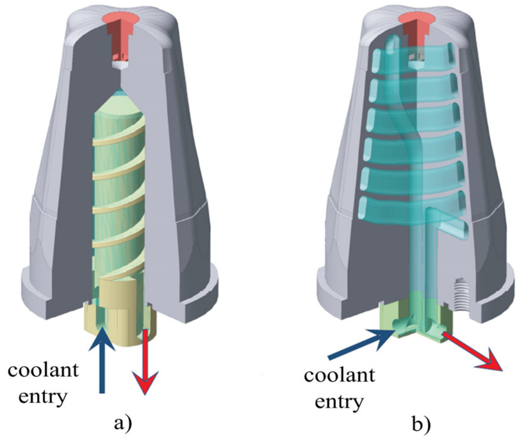


Figure 3 - Influence of mould material on moulded part cooling time: a) required cavity wall temperature, b) required contact temperature, c) required coolant temperature; 1 - material with lower thermal properties, 2 - material with higher thermal properties; T_D - contact temperature (K), T_{OK} - mould opening temperature (K), T_M - coolant temperature (K), T_P - start temperature (K), t_c - injection moulding cycle time (s) [1]

If the required mould cavity wall temperature is defined (Figure 3a) that has to be maintained during injection molding cycle (t_c), contrary to expectations, shorter cycle times can be achieved by application of materials with lower thermal conductivity. The reason lies in the fact that when using such materials the heat is accumulated under the surface of mould cavity. Therefore it is possible to achieve required cavity wall temperature with lower polymer melt temperature, which shortens the cycle time, and thus reduces the electrical energy consumption which is required for maintaining the necessary melt temperature in injection unit of injection molding machine. E.g., use of high alloyed steel can result in 10 % shortening of injection molding cycle, compared with the use of beryllium bronze. When the required coolant temperature is defined (Figure 3c), shorter cycles can be achieved with the use of materials with higher thermal properties.

INFLUENCE OF THE SYSTEM FOR MOULD TEMPERATURE REGULATION

Mould for injection molding is a heat exchanger in which heat exchange occurs between polymer melt, coolant that flows through the system for mould temperature regulation and environment. Many studies have shown that the use of innovative methods of mould temperature regulation can shorten the injection molding cycle times in range of 20 to 40 %, as thus save nearly the same amount of energy. One of the main advantages of applying modern additive manufacturing processes (AM) in the production of key mould elements is the possibility of design the cooling channels in these elements in such a way that they optimally follow the contour of mould cavity walls - so called conformal cooling (Figure 4) [5]. Classic mould manufacturing processes (milling, turning, electro-erosion etc.) do not allow this possibility. Application of conformal channels results with uniform mould cavity wall temperatures, shorter cycle times and higher molded part quality. [6,7]



Figures 4 - Example of mould insert cooling: a) classic, b) conformal [5]

Apart from their configuration, such cooling channels can additionally enhance intensity of heat exchange in the mould, and therefore additionally shorten of molded part cooling time by channel cross-section. If such a channel is produced in a six-pointed star shape of cross-section instead of a circle shape, cooling channel surface through which heat is exchanged in a mould, can be increased to 30 %. In that case two approaches are possible. First approach is based on maintaining the same cooling time, while thermal load of the system for temperature regulation is reduced, as well as the energy consumption. In the second approach, it is possible to shorten the cooling time. [6,7]

Some of the companies in the field of additive manufacturing of metal products develop different means of mould temperature regulation. Instead of single cooling channels, whole surface hollow structures are designed under the cavity wall surface.

The first structure is made of a number of consecutive nodes that are wriggling into a larger inlet and outlet holes. Consecutive nodes in this configuration ensure a large enough volume flow of coolant. Second structure does not consist of nodes, but of the net surface structure which is only 2 mm below the cavity wall, and ensures large coolant flow. Small net distance to the mould cavity wall enables very efficient temperature regulation, even in the case of using high alloyed steels for cavity elements. Net-like structure is combined with insulation layer which enables fast temperature changes in the phase of molded part cooling in the cavity (Figure 5). [8]

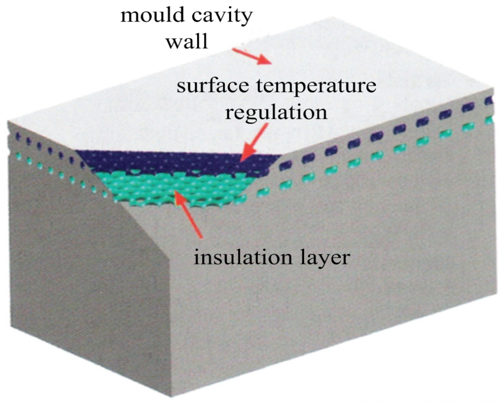


Figure 5 - Mould insert surface temperature control [8]

Another approach in optimization of injection molding process is application of so-called gradient materials. Approach is based upon the principle in which the outer layers of mould inserts are made of hard materials (for example high alloyed steels with high hardness), while the inner area of insert is made of materials with high thermal conductivity (for example copper alloys). The solution with copper core and classic, straight cooling channels can result in 15 to 25 % shortening of molded part cooling time. Combination of such approach with conformal channels results in the shorter cycle of approximately 30 %. [9]

So-called pulse approach to the mould temperature regulation is very interesting approach as well. Pulse temperature regulation enables that in the phase of polymer melt injection into the mould cavity, the flow of coolant is stopped. This directly increases the contact temperature of the mould cavity wall. After cooling the melt beyond the temperature of glass transition, system opens the valve, and intensive flow of the coolant through the mould is established. Pulse cooling senses the mould surface temperature and applies a pulse of coolant at maximum flow rate directly from the chiller or cooling tower during each molding cycle for maximum heat removal. Each cooling pulse equals the excess heat from each molding cycle and compensates for cycle time, melt and ambient temperature and coolant pressure changes (flow). The consequence is very fast mould cooling. Among many advantages of such principle of mould temperature regulation, it is also possible to recognize shortening of the molded part cooling time. [10]

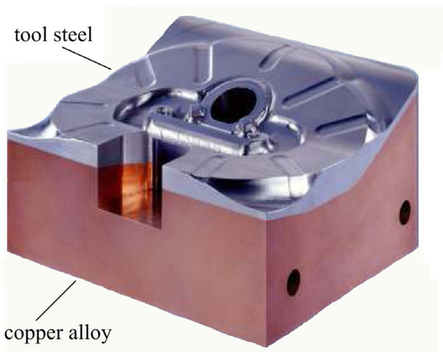


Figure 6 - Example of gradient mould insert [9]

INJECTION MOULDING MACHINES

In previous efforts to save energy during injection moulding, the maximum attention and research was focused on injection moulding machines. In order to be able to compare injection moulding machines, German federation of engineers VDMA developed a protocol EUROMAP 60 with the purpose of comparison of electrical energy consumption between injection moulding machines of the same size. The present state of the injection moulding machines market is characterized by the existence existing of three basic groups of injection moulding machines: hydraulic, hybrid (partly hydraulic and partly electric) and all-electric. [2]

Although all-electric injection moulding machines (Figure 7) are in average about 10 % more expensive than other two groups, higher initial investment can be returned very quickly because of the reduced energy consumption of all-electric machine and possibilities of faster operation, which indirectly shortens the injection moulding cycle. Basic advantage of all-electric injection moulding machines lies in the fact that during the phase of the moulded part cooling in the mould, apart from energy needed for polymer plasticizing in the unit for plasticization, there is no need for additional energy. [2,11]

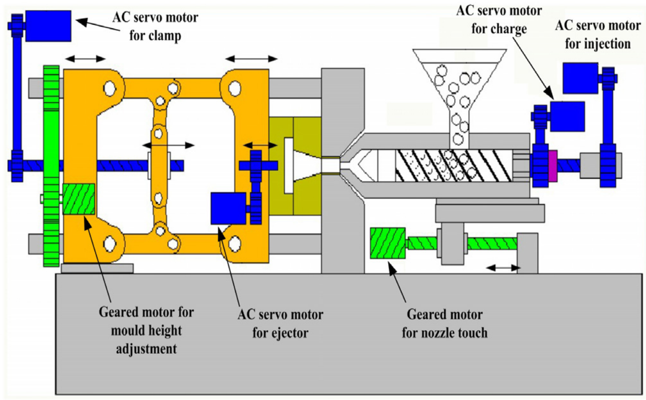


Figure 7 – All-electric injection moulding machine (cross section) [11]

Although in the domain of energy savings dominate all-electric injection moulding machines, injection moulding producers strive to achieve energy efficiency on all types of machines. First of all, energy saving can be achieved by means of servo-motors as drives for hydraulic pumps. Servo-motor has the capability of optimal adjustment of rotation according to real needs from the process (cycle) of injection moulding. Therefore in the phases in which there is no need for pump function, motor is in idle mode and saves the energy. Next are the machines with electric units for preparation and injection of polymer melt as well as electrical units for mould opening and closing, and moulded part demolding from the cavity.

In addition, the energy on the injection molding machines can be saved even with very common actions, such as additional insulation to the heaters of cylinder for polymer melting and proper selection of screw (enables processing of some polymer materials at lower temperatures than prescribed). [2]

PERIPHERAL EQUIPMENT - DRYER AND COOLING SYSTEMS

Although the peripheral equipment includes a large number of devices, according to energy consumption, there are two subsystems: systems for the drying of polymer materials and water cooling systems in large facilities for polymer processing.

Drying of polymer materials before processing is one of the most important preconditions for achieving high quality of finished moulded parts, efficient production and processing without problems and faults on moulded parts. Therefore, as additional equipment in the system for injection moulding of polymers, application of dryers is recommended. However, the dryers are one of the largest consumers of energy. Therefore, manufacturers of the drying equipment permanently improve drying to reduce energy consumption for drying polymers to the minimum level. In the drying of polymer materials, it is *possible to apply several approaches: drying in the oven, drying using hot air, drying using desiccants, drying using compressed air, low-pressure drying and infra-red drying.*

In the available literature, it is possible to find a large number of innovative systems and processes. The paper will shortly present only two systems based on drying using desiccants: X Dry process [12] and ETA process [13].

X Dry process of drying is based upon zeolitic technology that operates without compressed air or cooling water. The basic concept is the use of zeolites (volcanic mineral, inorganic polymer) as a filter, whereby the device does not consume power when it is not necessary, but use only the power required for the proper treatment of materials, all in accordance with the adjusted material flow. Variable air flow, uniform operation, a high dew point, the lack of use of cooling water and compressed air, finally result in very high energy savings of up to 72 % (Figure 8). [12]

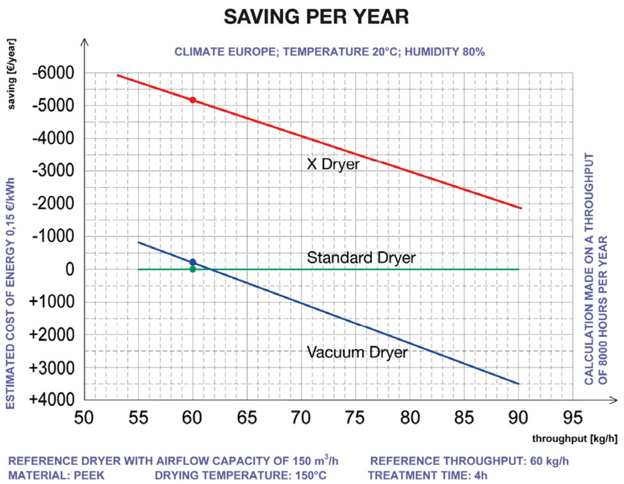


Figure 8 - X Dryer energy savings [12]

In the second case, the ETA drying process allows energy savings up to 40 %. Main characteristic of this process is the return of unused heat, i.e. hot air for material drying that is directly returned through heat exchanger system. Figure 9 shows the energy consumption for drying using the ETA process, depending on the type of dried polymer. [13]

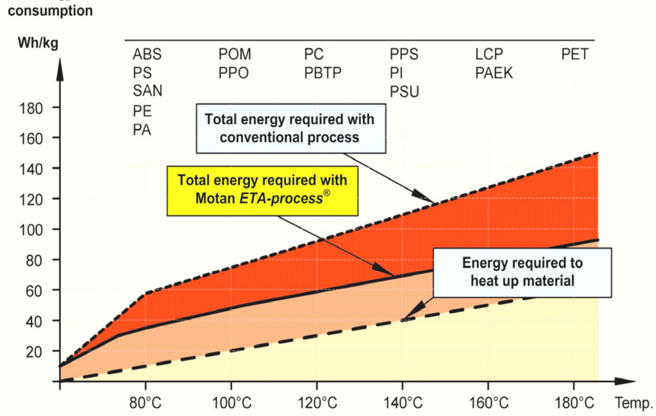


Figure 9 - ETA process energy consumption [13]

Suitable chilling equipment has a primary importance in all the plastic processing. In the past, regardless of the temperature level, the cooling of these processes has always been in charge of traditional water chillers. The continuous rise of the costs, the reduction of the margins due to the rising prices of the main materials and the growing number of competitors in the market, in the past years pushed all the polymer processing industries to improve and optimize the whole production process.

As far as concerns the cooling equipment, it is possible to improve the performances of the system by distinguishing the process temperature levels. It is possible to reach great energy savings by separation of the cooling of the low temperature utilities (0 to 20 °C), usually served by a traditional water chiller, from the high temperature utilities (25 to 40 °C) that can use the ambient temperature for the cooling of the process water. Using the ambient air for the cooling of all the high temperature utilities, enables obtaining relevant energy savings with a consequent short return to investment time (Figure 10). [2,14]

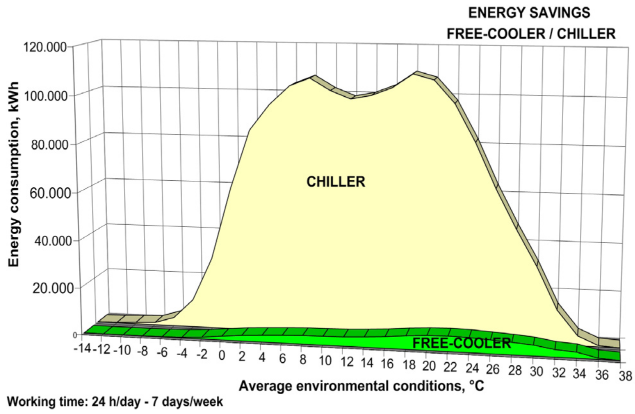


Figure 10 - Possible energy saving in application of Free Cooling (FC) system [14]

The Free Cooler permits the complete separation between the process water and the ambient. The heat exchange happens through one finned coil battery made of copper and aluminium, crossed by an adequate air flow. So the process water remains bounded into the circuit itself, with no contact with ambient. In this way it is possible to avoid all the faults due to this: high impurities content, high oxygenation of the water with consequent high formation of rust along the circuit, high proliferation of alga and bacteria, high evaporation or water loss with consequent increase of the hardness and necessity of continuous water refill, and so on. Moreover the running costs of this kind of unit are surely lower. The main disadvantages are: higher water temperature (related to the ambient dry bulb temperature), higher floor space needed and higher investment.

Free Cooler system (Figure 11) is able, at the same operating conditions, to produce water at 29 to 30 °C.

The main improvement that permits this result is a new high efficiency adiabatic spraying system (SSS). This system can, through one high pressure pump, increase consistently the quantity of water sprayed really adsorbed by the air: in this way it is possible to have the air around the Free Cooler in condition of saturation by water. Over the 80 % of the water sprayed is adsorbed by the air, against the 20 to 30 % of one traditional spraying system, avoiding puddles below the Free Cooler and waste of water.

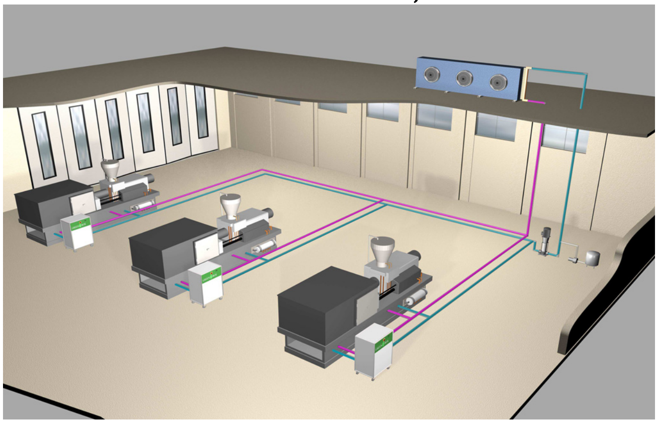


Figure 11 - Installation scheme of FC system in injection moulding facility [14]

Moreover this system is automatically switched on only when the Free Cooler is not able to maintain the set temperature. In the end, the particular disposition of the nozzles together with the polyurethane filters avoid any direct wet of the finned coil battery, wiping out the problem of scaling. Another improvement that gives high results in terms of energy saving is the continuous variation of the speed of the fans through an electronic control (EC fans). This system, compared to the traditional on/off adjusting system, permits a huge energy saving (around 80 to 90 %) and a higher accuracy of the process water temperature.

CONCLUSIONS

Continuous increase in costs, narrowing margins due to increasing prices of most of and a growing number of competitors in the market in recent years have encouraged all the polymer processing industries to improve and optimize the entire production process. By applying a systemic approach to reducing energy consumption on every place possible, from the geometry of the molded part, over the basic equipment for injection molding, to additional equipment, it is possible to achieve multiple energy savings. In each of these segments, partial energy savings of 10 do 80 % are possible. When these savings are summarized, total savings can exceed 200 % when compared with systems in which energy saving are not considered. If possible savings of modern systems for injection molding are compared to the systems from the year 1996, these values are additionally increased. For example, only the hydraulic and all-electric injection molding machines in the past 15 years have achieved reductions in energy consumption ranging between 75 and 80 %. Besides the positive economic impact, it should be noted no less important positive impact on the environment in the form of reduced production of greenhouse gases that are directly related to the energy consumption.

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ENVIRONMENTAL EVALUATION FROM CRADLE TO GRAVE WITH CAD-INTEGRATED LCA TOOLS

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ABSTRACT: Robust product environmental evaluation has to consider the whole lifecycle, called "cradle to grave" analysis. This activity gives wide benefits if carried out in the early design phases. CAD-SLCA integrated systems are innovative eco-design tools usable during product design feature definition in order to support SLCA (Simplified Life Cycle Assessment) method application. The present work describes how the CAD-SLCA approach can be put in practice by considering the assessment of the complete product lifecycle and by using a new software tool which integrates data from different design supporting systems. Particular focus has been placed on the use phase and end of life treatment. An example shows the approach results.
KEYWORDS: SLCA, Ecodesign, CAD, Environment

INTRODUCTION

Human sensibility and market strategies are promoting more and more the environmental aspect that explains why eco-design is becoming an important and useful topic in engineering design. Life Cycle Assessment (LCA) is an environmental accounting and management approach which considers all aspects of resource use and environmental releases associated with an industrial system "from cradle to grave". Specifically it is a method to assess the environmental impact of a product during its lifecycle, from the extraction of raw materials to the production and distribution of energy through the use, reuse, recycling and final disposal of a product. LCA as it is conceived, is a tool for relative comparison and not for absolute evaluation, thereby it can be used as decision makers to compare all major environmental impacts in the choice of alternative courses of action [1]. The core phase of an LCA analysis is the Life Cycle Inventory compilation that regards the identification of all input and output flows concurring in the product lifecycle. This phase is both time and resource consuming and for this reason complete LCA can be carried out mainly to assess the environmental impact of an existing product, where manufacturing, use and dismantling can be estimated with accuracy.

Simplified Life Cycle Assessment (SLCA) approaches were developed to improve LCA usability in the early design stages. They adopt dedicated tools to estimate the environmental impacts of product alternatives and to predict environmental costs or burdens for manufacturers [2]. A large number of simplified LCA methods has been developed to overcome this drawback and make it possible to perform and be used more easily. Many of these methods have been developed for a specific group of products and are not well documented. In the engineering design phase it is not easy to perform an environmental consideration for the complete life cycle when not all product data is available and fixed. Therefore, it is important to evaluate simplified methods and to study what type of information they require and what kind of results they can produce. New emerging Computer Aided Design (CAD) tools are trying to support the integration of SLCA methods within the traditional flow of product design activities. Their scope is to provide a concurrent analysis of product design solutions from a functional and environmental point of view. Such technologies can be called CAD-SLCA. Different solution are available in the market developed by the major CAD software house, however, even if the approach can be considered valid, it still requires wide improvements from a performance point of view.

In this work a method to conduct environmental analyses in the design phase, by CAD interface, is presented and discussed. The proposed approach has been developed looking at mechanical product design field. A simplified LCA not only has to be simple and easy to use but it also has to come up with reliable results. Through the analysis of priorities the best compromise between the CAD-based information and the LCA analysis accuracy has been evaluated. Thus it has been possible to define a CAD-SLCA tool able to propose meaningful results without weigh product design time. In order to demonstrate validity and advantages of this approach a significant case study has been analysed.

BACKGROUND

In this paper the attention is focused on the Life Cycle Assessment Simplification method (SLCA) and Computer-Aided LCA. Eco-design tools help the designer evaluate environmental aspects during the product design phase. A lot of research and tools *regarding the eco-design topics have been developed since environmental interest in the product engineering has become so widespread. The literature review of these approaches shows that many existing tools fail because they do not focus on design, but they aim at strategic management or retrospective analysis of existing products instead [3].*

The research developed in the eco-design context is based on different techniques and characterized by different levels of difficulty related to their implementation [4]. These approaches vary from simple checklists and guidelines as presented in Wimmer et al. and Stevels' works [5,6], to complex methodologies, which require the designer to have a high level of personal knowledge in order to apply them correctly.

Currently, many proposed approaches represent an "ecological" extension of traditional and well known design methods. This is the case of the different environmental versions of the Quality Function Deployment (QFD) [7], such as the quality function deployment for the environment proposed by Masui et al. [8] and the green QFD proposed by Zhang et al. [9]. An extension of the functional analysis method, which takes product life-cycle aspects during the design stages into consideration, was presented by Prudhomme et al. [10]. The use of these tools and methods unfortunately shows a lack of coordination in the design activities, as a consequence these obstacles putting the indications provided by eco-design tools into practice. An important crucial defect is that it is not often evident how to perform the comparative evaluation of the environmental impact of alternative eco-design solutions. CAD-integrated LCA tools can be useful and integrated within the day-by-day design activity, and they can help designers evaluate environmental impact of a product under investigation and compare the different solutions.

LCA methodology represents an assessment and comparison tool generally used for existing products. Many researchers have proposed to use and apply it as eco-design method [11]. In recent years, many efforts have focused on the development of SLCA methods. The main goal of SLCA is to reduce the complexity of several of the tasks involved, while maintaining the main features and soundness of a complete LCA. Such simplified methods can be employed in the early design stages of a product development, when the data available is incomplete and lacking in details. Perhaps it should be underlined that a complete LCA can only be correctly used for completely defined products and services. It means that products and services and their components, materials and processes are precisely defined before the assessment. Among all the different simplification methods proposed, most of them are related in some way to the reduction of the amount of data required to perform the analysis. This data reduction is usually achieved by excluding some life cycle stages in the assessment as reported by Hochschorner et al. and Hur et al [12, 13]. Despite the soundness of the their application in the design process as a tool of comparison for different design solutions is still a matter of debate.

A complementary approach, aimed to reduce the complexity and to automate the compilation of the life cycle inventory required to perform LCA, is represented by the integration of LCA tools with product life cycle management (PLM) systems [14-18]. A PLM system is an Information Technology (IT) platform, which aims to store and manage technical and administrative data related to the life cycle of the goods produced or services provided [19,20]. Technically, a PLM system is based on a central database, enabling integration of data produced by the different IT systems used by the different departments within the enterprise. Some examples of IT systems are: computer-aided design, manufacturing and engineering systems (CAD, CAM, CAE), material requirement planning, advanced production, manufacturing execution, enterprise resource planning systems (MRP, APS, MES, ERP), supply chain management and customer relationship management systems (SCM, CRM). In the market some CAD-LCA integrated approaches are already available. They makes it possible to evaluate the product being designed from an environmental impact point of view. Therefore it is possible to compare different design solutions concerning the material and the transformation process selection. This integrated approach seems to be functional but inaccurate and incomplete in some aspects. The main above mentioned tools have been developed by the major CAD software house like SolidWorks with the "Sustainability" module or Autodesk with the "Eco Materials Adviser" tool. In our previous work [21] a comparative analysis and critical evaluation of SolidWorks Sustainability tool has been done, this research shows the validity of the method but highlight the lack in results accuracy due to the simplifications of the method employed. The Autodesk Ecodesign tool is intended to give designers an immediate analysis of the ecological impact of a product, key eco indicators allow the designer to explore the impact of changes in material choice or design of the product. This tool offers a really advanced and complete approach for the material selection and evaluation, but it does not consider the manufacturing process and the product use phase. This is a simplification, in fact much of the environmental impact is attributed to the manufacturing and use phases.

PROPOSED APPROACH

The proposed approach aims to develop a SLCA tool which can be used in the product design stage, in particular the approach is focused on the industrial mechanical products. The main goals of this approach are: the acceptable accuracy of LCA indicator values, the user friendliness and, finally, the rapid visualization of LCA results at early design stages.

SYSTEM ARCHITECTURE

Figure 1 shows the system framework of the proposed CAD-SLCA integrated tool. The arrows connecting the different modules represent the flow data exchange which can be managed and modified by a dedicated user interface which allows interaction with CAD and LCA systems. Product geometrical and non-geometrical data can be retrieved from the CAD structure and the connected PLM database.

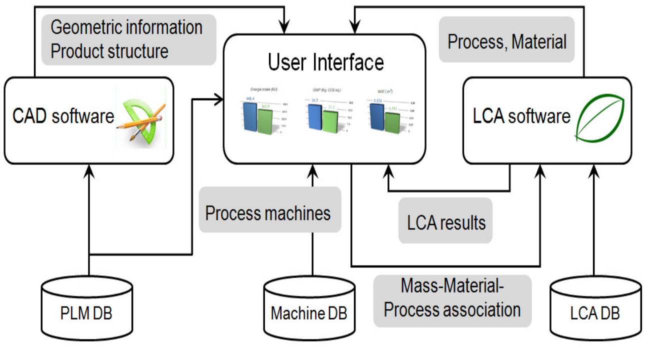

Figure 1. Proposed CAD-SLCA integration approach framework

The geometrical CAD model implicitly contains different data about the component, referred to its shape and dimensions. These values are useful to determine the production process characteristics. The data can be extracted from the CAD software by analysing the model data structure by the use of a specific tool based on the Application Protocol Interface of CAD system. In this case the application has been developed in Microsoft .NET. The user has to select the manufacturing processes, component materials, other processes involved in the use phase and, finally, the end of life treatment for the component. All information can be chosen from the LCA database, where processes are divided into sub-categories according to the different product life cycle phases (raw material extraction, manufacturing process, utilization, end of life).

The user interface allows the connection with the machine database. It contains all data (energy consumption, utilization range, manufacturing process type, etc) of the different machines available in the company. According to the selected manufacturing process, a list of machines is shown and the system proposes the most suitable by using decisional rules related to the specific geometrical product data. An important feature of the proposed approach is the possibility to modify the manufacturing processes selected from LCA database with the selected machine information (e.g. energy consumption). Therefore real process data can be computed. All the information from CAD and LCA software can be merged by the user and a "mass-material-process" link is created and sent back to LCA software to calculate the environmental impact of the product. For each component, designers can select more than one process for each phase in order to recreate the complete life cycle. The Results are automatically presented in the user interface as data and graphs, allowing a rapid comparison between different solutions to be made.

APPROACH IMPLEMENTATION

The proposed approach covers the whole product life cycle from the raw material extraction to the end of life treatment, through the manufacturing and use phase. In the following parts, the approach divided in its principal life cycle phases is explained, divided by the principal life cycle phases: Manufacturing, Transport, Use and End of life (EOL).

Manufacturing Phase

The manufacturing phase includes the material selection and the production processes used to transform the starting stock material in the finished product. A research for this topic has been carried out in [21], where the commercial available CAD-SLCA integrated tools have been evaluated. The considerations arisen from this comparison led to propose a better approach for the environmental analysis of the manufacturing phase. The manufacturing process distinguishes different types of mechanical components according to the manufacturing processes which they undergo. The main product components used in mechanics can be classified in three families, according to the manufacturing process: moulded components; machined components, and sheet metal components. These types of families and the related manufacturing parameters have been analyzed in order to reach the right compromise between LCA result accuracy and easy as well as rapid product data retrieval. Through the analysis of different manufacturing process characteristics, a list of parameters has been determined for each family. The main parameters related to the moulded family part are: material type, amount of scrap, percentage of recyclable scrap and the type of machine used. In the case of machined family part the parameters to be considered are: material type, starting stock material, the main machining processes, amount of scrap and the type of machines used. Finally, the parameters for sheet metal family part are: type of material, the starting *dimension of sheet metal, amount of scrap, the type of machines used and the quantity of scrap which can be recycled. The proposed approach for the manufacturing phase allows the entire production cycle to be considered, by taking into account all the processes employed and the real machine data used for the specific case, selected by the user from the machine database. This database contains all the data for the input and output flow of the machines available in the considered enterprise.*

Transport Phase

The product is generally featured by different components, each of them can be manufactured in the same factory where the product is assembled or can be made outside by a different company. Whilst in the first case there are no transportation for the components, in the case that they are manufactured by another company, each component can have one or more transport types with a specific distance. The proposed approach takes into account the transport phase and it gives the possibility to select and assign one or more transport type for each component by the Transport tab in the Component form.

Use Phase

In the LCA analysis the use phase represents an important aspect and sometimes it is the most relevant contribution to the environmental impact of a product. This phase includes both the use of the finished product and the use of each single component. The quantities and the processes included in this phase regard all that can be attributed to the use of the product. The proposed approach for the use phase is based on the selection of different usage processes for the product and of its single component. It is possible to select from the LCA software database and assign all the processes concerning the use phase to the product or to each component. Another important and relevant aspect of the Use phase is the degradation of the components and their subsequent substitution or maintenance. It is essential that this issue is considered in the LCA analysis because the component replacement and repair have a relevant contribution to the environmental impact, in fact a component replacement corresponds to the consideration and computation of two or more of them. Thanks to this tool are possible to analyze the complete product lifecycle, Manufacturing, Use and End of Life phases can be evaluated. The user can select and assign a usage process for the product. This selection can be multiple, so different processes for the Use phase can be selected, for example electrical power consumption, other consumption material like lubrification oil, water, compressed air and others. Usage processes can also be assigned to component level, each component can have multiple and different processes. The choices for the components are shown in a summary table, and the user can also modify these selections. The last table shows the life time period for each component of the product (LfpC), and automatically calculate the number of component (NC) used during the product life time period (LfpP).

Depending on the life time period of product and components, different number of units for each part are computed in the environmental analysis, this allows the maintenance and replacement phases to be considered. Currently present commercial CAD-LCA integrated tools available in the market just allow the power consumption to be considered. By the use of these tools, the environmental impact for the Use phase is extremely simplified and it does not represent the real product scenario, therefore the evaluation error can be significant.

End of life Phase

Product End of life (EOL) phase refers to the end of the function period of the product, when its use is no more useful or possible and its functions are no longer carried out. Depending on the EOL treatment, not only changes the environmental impact of EOL phase changes, but also the impact attributed to the others lifecycle component phases. In Gehin et al. work [22] the EOL reflection to the lifecycle environmental impact is studied and calculated. For example, if the component i is recycled in a closed-loop system (it is assumed that the recycled material is used to manufacture the same type of components) or remanufactured, or reused, then for each usage cycle between 2 and the number of usage cycle (ui) and for the percentage of recovered product, the material stage impact is set to zero. If the component i is remanufactured, or reused, then for each usage cycle between 2 and ui and for the percentage of recovered product, the manufacturing impact is set to zero. The environmental impact attributed to each lifecycle phase can be calculated depending on the EOL choices, in the mentioned research paper [22] the complete treatment is described and explained.

The proposed approach provides to select the EOL treatment for each component (Figure 2), the user can choose it and input the relative information to be computed in the LCA analysis. Different scenarios can be considered in the EOL phase: Reuse, Recycling, Remanufacturing, Other treatment (Disposal, Incineration, Landfill, etc...). In the Reuse case, the reuse times can be specified for the calculation of the environmental impact, a component can be reused more times during the product lifetime period, after that the component cannot be used anymore and recycle, remanufacturing or other treatment can be selected. For the Recycle case, the user can select "Closed loop" or "Generic recycle" as recycle types, in the first case the material is reused for the same component production, in the other case the material is used for other applications. The Remanufacturing treatment can be selected and considered in the analysis specifying the environmental impact of the remanufacturing phase, expressed in percentage of the manufacturing impact. A component can be remanufactured for specified times, the main reason is the material degradation, after that it can be recycled to produce new material or may undergo other treatments such as Incineration, Landfill and others. The last choice which can be selected is "Other treatment", in the following tab an EOL process can be selected from the LCA database. Some processes which can be found in this option are Incineration, Landfill, Municipal waste, etc..., despite the user interface these processes can be selected and removed by specific buttons.

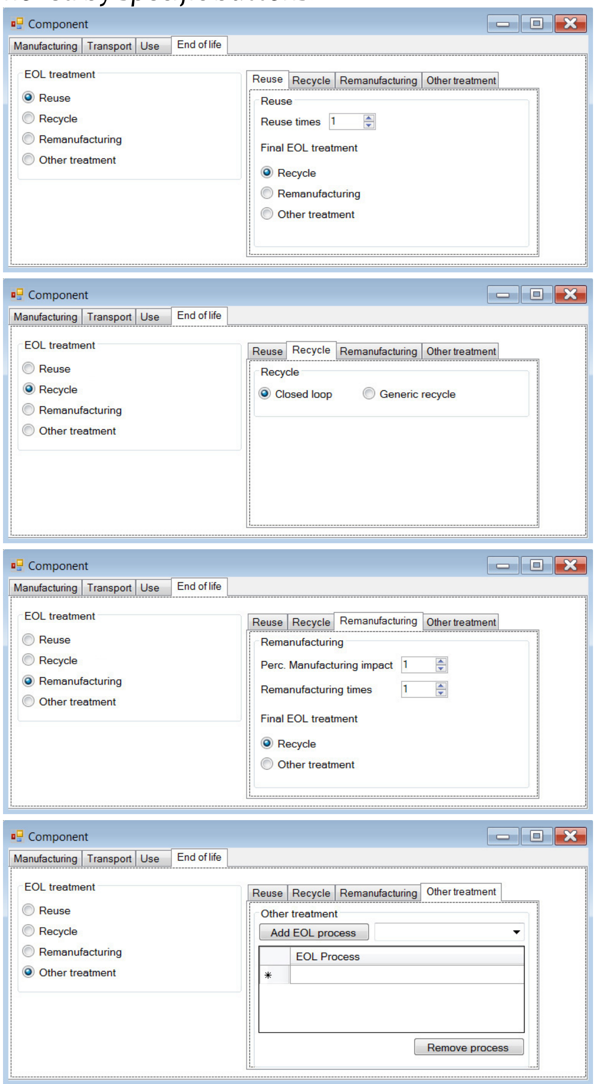

Figure 2 – Screenshot for the Component End of life phase

An EOL treatment can also be assigned to the product, in this case the same treatment is automatically computed in the analysis for all the components which characterizes it. Alternatively it is possible to specify the EOL treatment for the components which have a different EOL process compared to the product. In the next paragraph both the Use and EOL phase are illustrated and explained through a significant test case.

APPROACH VALIDATION AND DISCUSSION

The proposed approach has been validated and discussed through a case study. In this paragraph the LCA analysis is described and the choices made are illustrated and motivated. A simple comparison of different EOL treatments has been evaluated to demonstrate the opportunities offered by this approach.

EXPERIMENTAL CASE STUDY

The test case is a washing machine, analyzed from an environmental point of view. The LCA analysis has been conducted for the complete lifecycle, but only the Use and End of Life phase are examined and explained.

The overall LCA results have been obtained by analyzing the product lifecycle phases: manufacturing, use and End of life. The work focuses on the product Use phase and End of Life strategies.

Use phase

The lifetime period considered for a washing machine is 6 years; the data considered in the analysis are: energy, water and detergent consumption and component maintenance. In the Use phase not only have to be considered the consumptions, but also the product maintenance has to be evaluated. During the product lifetime, as for other products, it may happen that some of its components must be replaced as a result of their failure or breakage. In this case in the LCA analysis, the replaced components have to be computed. In the proposed approach it is possible to specify the lifetime of each component and through the product lifetime, the number of replaced components is automatically calculated. The processes selected for the product use phase are: Water (103.500 lt), Electricity (1866 kW), Washing detergent (186 kg), this data has been taken from a washing machine technical report (Use phase data of a washing machine, ENEA). The components which have to be replaced considering both their lifetime and the product lifetime are: hydraulic pump, electrical resistance, door seal, elastic belt, pressure valve, drain pipe group.

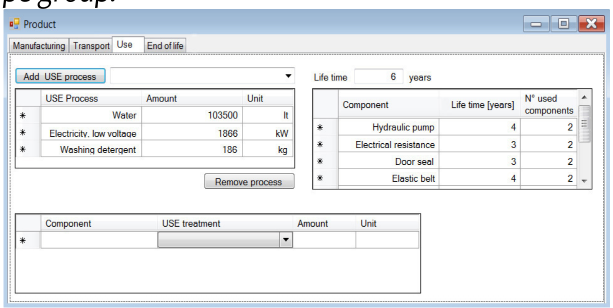

Figure 3 – Screenshot for the Product Use phase End of life phase

For the End of life phase the EOL treatment for each component has been considered. According to the proposed method, the EOL tab included in the component form (Figure 2) has been compiled with the corresponding data. In this paragraph the EOL treatments for each component are not shown. In Table 1 a summary overview of the EOL treatment for the components is shown.

Table 1 – Summary EOL treatment overview

Components	EOL	Components	EOL
Aluminum	Recycled	Steel and	Recycled
Plastics	Recycled	Electronic	Disposal
Rubber	Recycled	Concrete	Disposal

From the table it is possible to see that most of the components of the washing machine are recycled at the end of life, only some of them are disposed due to their impossibility to be recycled. A component has been taken as example to show the choices concerning the EOL treatment, the selected part is the command dashboard. The manufacturing material of this component is Polypropylene (PP), at the end of the washing machine lifetime this part is still functional but it cannot be reused because a new model will be produced. As a consequence this consideration the material can be recycled to produce other components from the same company (closed loop) or may be sold by those who recycle the material for the production of other goods. In this case the material is recycled not in a closed loop, but generic recycle has been selected.

RESULTS DISCUSSION

The LCA analysis for a complex product, like the washing machine, provides to assign for each component all the information about its lifecycle. As discussed above, this information is: the manufacturing material and process cycle, the eventual transportation from the manufacturing site to the assembly site, the specification about the use phase and the EOL treatment. After this data selection, the LCA analysis results can be visualized by the user through the "LCA results" tab (Figure 4). In the result tab each single lifecycle phase can be selected and the corresponding LCA results can be shown in form of tables and graphs. In the figure below the total LCA results are shown. Manufacturing, use and end of life contributions can be visualized.

PRELIMINARY EVALUATION OF FEM-LCA INTERACTION

The proposed approach covers the complete product lifecycle, allowing selecting the starting stock material, the manufacturing process, the use phase specification and the end of life treatment. Through this approach is possible to evaluate the environmental impact of the product and compare different design solution obtained with material and manufacturing process change. It is evident that a material change can influence both the manufacturing process and the component geometry according to the new material's mechanical properties. At this aim a FEM analysis can be performed to evaluate and optimize the component shape according with the loads defined in the design specifications. FEM analysis can be adopted as shape optimization tool, indeed some dedicated FEM software provide specific module for this scope. In this work shape optimization test has been conducted for a specific washing machine component. The analysed component is the transmission pulley attached to the steel drum. A material change from aluminium alloy to a special recyclable plastic reinforced with glass long glass fibres involves a change in the geometry of the component according with the different mechanical resistance properties. This optimization has been conducted using the specific shape optimization tool included in a ANSYS. The result of this optimization is a geometric change and mass reduction among the initial design solution, in fact using the special reinforced plastic, with the same applied loads is possible to reduce the section due to the higher mechanical resistance of the plastic material. The aluminium alloy pulley has a weight of approximately 1,2 kg, whereas the plastic solution has a weight around 0,45 kg. This different material and the consequently shape modification causes an environmental impact change, in particular using the special recyclable and fibreglass reinforced plastic the LCA impact results decrease compared to the Aluminium alloy solution (Figure 5).

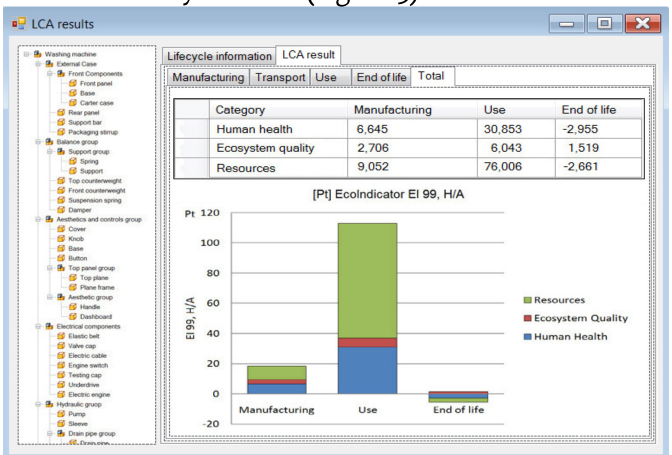

Figure 4 – Screenshot for the Product Total LCA results

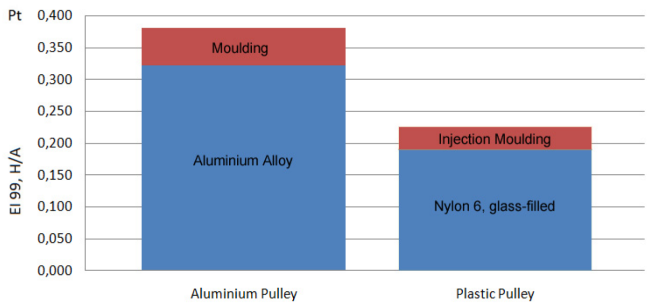

Figure 5 – LCA results comparison between different material solutions

This approach has been performed as a test case in this work, to show the potential and powerful application of FEM analysis in conjunction with LCA and integrated with CAD systems in design process. This test highlights the possibility to deep specify this method to the proposed approach in future.

CONCLUSIONS

The present work describes a new approach and the related preliminary software system useful to support the simplified LCA analysis during the early design phases. The approach is based on data extraction from the traditional design systems databases (ERP, PLM, CAD data structure). Data is properly elaborated and a rapid environmental estimation impact is provided by the user.

This approach seems quite robust in terms of accuracy but it needs several human interventions in order to choose parameters (i.e. the manufacturing processes and related parameters). This represents still a limitation due to the designer effort in terms of time. Furthermore the Uses and EOL phase contribution to the impact should be validated through a wider number of case studies by using different classes of products. On the other hand, the system usability is highly appreciated by the designers due to the integration with tools they generally use.

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SCWTEX – SIMULTANEOUS CUTTING AND WELDING OF TEXTILES

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ABSTRACT: *A combined cutting and joining process of technical textiles should help to reduce the number of production steps. Additionally, resources needed and waste should be minimized by a combined process. Process development is supported by Finite Element (FE)-simulations keep the number of experiments as low as possible. Ansys software has been chosen for process simulation and examples of polypropylene fibres cutting are presented. Depending on process characteristics one or two laser sources will be used for experiments. First experiments have been performed on polyamide, polyester and polypropylene woven and knitted fabrics. It is intended that energy consumption as well as resource-efficiency of the combined laser cutting and joining process will be optimized and compared to conventional processes. Increased efficiency simplified and reduced requirements on storage and logistics could be beneficial especially for small- and medium-sized enterprises (SME's) in Europe.*
KEYWORDS: *laser, textile, cutting, simulation*

INTRODUCTION

The main goal is the development of a process which combines cutting and welding of technical textiles by means of high power lasers. Although laser cutting is well established in cutting of technical textiles, laser welding of textiles is still in development. Nevertheless, welding of technical textiles allows the production of water-tight seams, which is important for functional clothing. Due to process characteristics, laser welding of textiles could be advantageous since no special tools are required. A combination of laser cutting and welding could be beneficial to reduce energy consumption as well as requirements on storage, logistics and waste management in the textile industry. In principle, one or two laser beams could be used for simultaneous laser cutting and welding. With a single laser beam the intensity at the centre of beam is chosen in such a way that the material is vaporized and the surrounding material is molten due to the reduced intensity of the beam and heat conduction. Unfortunately, due to the low heat conduction coefficient of synthetic materials heat flow is very limited which causes a steep thermal gradient within the textile and narrows the seam width.

With two independent laser sources, one beam could be used for cutting and the second beam could be used for welding. As an advantage, intensity, position and beam profile of two beams could be chosen independently. On the other hand complexity of the overall set-up, beam handling and shaping is increased.

MATERIALS

A careful selection of materials is of crucial importance for project progress. Main criteria were the suitability of materials for welding, as well as a certain use in the textile industry and ecological aspects. Since laser welding is a thermal process, thermoplastic behaviour is a basic requirement for weldability. As a consequence only thermoplastic synthetic fibres, fibres from the group of thermoplastic elastomers or fibres blended with such fibres as main components are considered. Process stability is facilitated by wide temperature interval between melting and vaporisation temperature of the chosen material.

Additives have also to be taken into consideration, since they can influence the behaviour of the material considerably. To reduce possible influences on results, sample materials with no, or at least as few as possible additives and finish have been chosen. Additionally, materials have been evaluated by means of their expected environmental impact during their whole live cycle. It is evident that the largest contribution to possible environmental hazards is related to pyrolysis of the particular polymer. In most cases, shielding gases can be used to decrease possible pyrolysis residues. With respect to an industrial application of the process, emissions caused by laser processing of materials have to be examined thoroughly. Additionally, possible contaminations of the laser treated textiles with toxic residues have to be judged in material selection. The following section gives a short overview about the selected materials:

***Polyester (PES)** - For first experiments, polyester has been chosens due to its vast number of applications in the textile industry. Besides its use in the clothing industry, polyester is used for agricultural-, medical or functional textiles. Thermo-physical properties of polyester are promising for the intended experiments: a deflection temperature of about 70°C, a melting temperature about 240°C and a vaporisation temperature higher than 300 °C (2).*

***Hazardous substances** - Most dangerous emissions during pyrolysis are p-creosols and benzenes (3).*

Polyamide (PA) *- Polyamides are characterised by high strength, good abrasion- and bending strength. During production, mechanical properties can be adjusted to a wide extent (4). Similar to PES, applications are wide spread, ranging from clothing to technical uses.*

Hazardous substances *- The major parts of emissions which appear during cutting with CO_2 Lasers are aerosols. They are mainly carbonyl compounds like formaldehyde and acetaldehyde (3). Formation of substances is caused by a radical oxidation of molecular oxygen, what indicates that these emissions can be decreased with an appropriate use of shielding gas.*

Polypropylene (PP) *- Industrial use of PP fibres is very versatile. Besides classic applications, PP fibres are used in medical, technical and agricultural applications.*

Hazardous substances *- The emissions which appear during pyrolysis of polypropylene can be explained by stochastic breaking of bonds between molecules, which results in the emission of n-Alkane, al-Olefins and al,om-diOlefins (3).*

EXPERIMENTAL SETUP

First orientating experiments have been performed with a single CO_2 laser beam and no additional measures to increase contact pressure. It is well known that the penetration depth of CO_2 laser radiation into synthetic materials is very limited (7). It was estimated that due to the finite thickness of the textiles used for experiments, a stable process can be achieved. Radiation in the wavelength range of Nd:YAG lasers shows almost no absorption without any additional measures. Evaluation of first results lead to the development of two-beam setup, see figure 1.

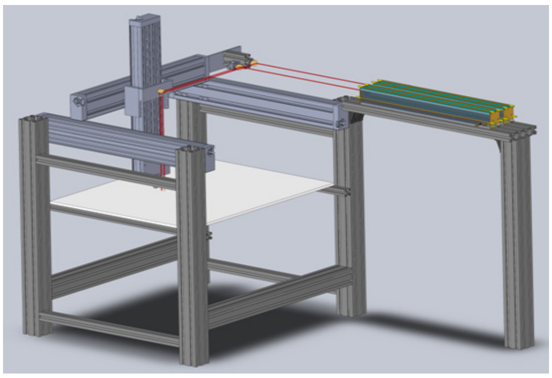

Figure 1 - Schematic view of a two beam experimental setup

Laser sources

First experiments have been done with two different CO_2 laser sources. Table 1 gives an overview of beam parameters.

Table 1 - Beam parameter EMCO LS140, Synrad L48-2.

	P max [W]	λ[µm]	d[mm]	Φ [mrad]
EMCO LS140	160	10,6	12	2
Synrad L48-2	25	10,6	3,5	4

P_{max} is the maximum optical Power, λ is the wave-length of the emitted radiation, d is the diameter of the raw beam, and Φ the full angle divergence of the beam.

Drawing device and sample support

To ensure a reliable thermal contact between textiles layers, a clamping device is required which is realized by means of a drawing roll, see figure 2. To influence the amount of heat flow into the drawing roll, a material with a low thermal conductivity e.g. ceramic and a second one with a higher thermal conductivity (steel) have been designed. Additionally, for well defined and constant dimensions of the welding zones such drawing rolls offer the possibility to influence the seam geometry. To ensure a constant contact pressure a compression spring with different spring pre-loads has been used. Preliminary experiments verified the assumption that heat flow into the support cannot be neglected. As a consequence, sample support has been changed accordingly.

Figure 2 - Different drawing rolls to ensure a well defined thermal contact between textiles. Steel (upper drawing) roll and ceramic roll

As already mentioned, shielding gas is needed to ensure a high quality of the produced seams. It inhibits or at least decreases the oxidation of the cutting edge, which decreases carbonation and emissions of hazardous substances. First experiments have shown that nitrogen inhibits at least carbonation significantly. But the use of shielding gas can also have a certain negative impact: Due to the gas flow a convective heat transfer occurs, which has a negative influence on the width of the weld seam. As a consequence, a careful control of gas flow is required.

Following first experiments, a two-laser setup has been designed and realised, where one laser beam is used for cutting and the second beam welding, see figure 3 and figure 4.

The lens can be tilted (0°-10°) around the axis in welding direction, which allow to chose a well defined distance between cutting and welding beam.

Table 2 - Parameter of the focusing element

Shape	Material	Diameter [mm]	Focal length [“]
Plan – convex	ZnSe	15	1.5

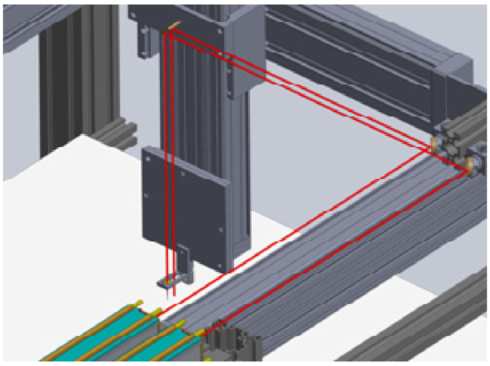

Figure 3 - optical path (schematically)

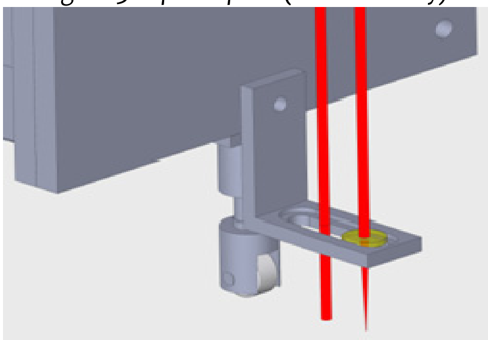

Figure 4 - detailed view of figure 3

EXPERIMENTAL RESULTS

First results indicate that with carefully chosen laser parameters cutting with almost no influence on the remaining material is possible with a simultaneous welding process. With a single laser beam used for first experiments it is clear that the interdependence of cutting and welding parameters restricts variations of parameters significantly, see figure 5 and figure 6.

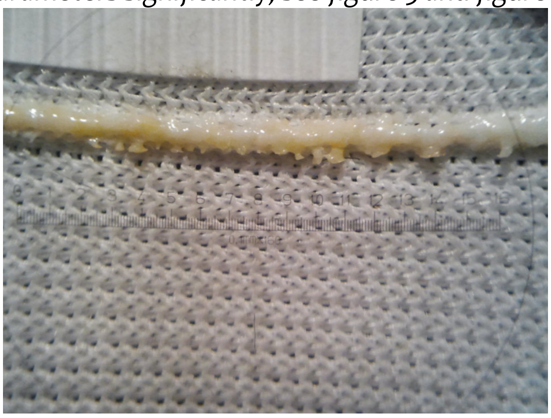

Figure 5 - Laser welded sample, line energy 4.8 kJ/m

Figure 6 - back side of a laser welded fabric, line energy 4.8 kJ/m

As can be seen from figure 7 and figure 8, textile laser welding process is very sensitive against carbonation. During first experiments cutting respectively welding speed has been varied between 7 and 40 mm/sec, optical power between 10 and 50 Watt and spot size between 3 and 3.5 mm, specifications of textiles are shown in table 3.

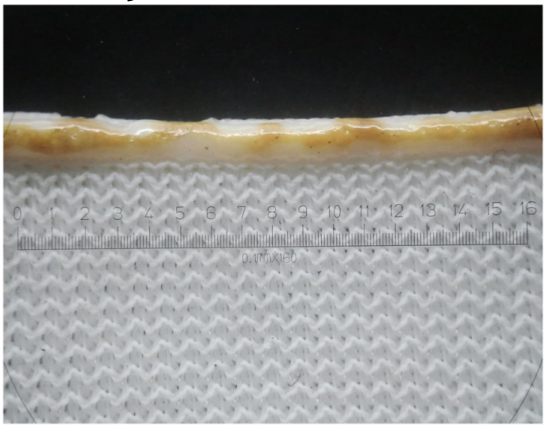

Figure 7 - Laser welded sample with carbonation of edges, line energy 4.1 kJ/m

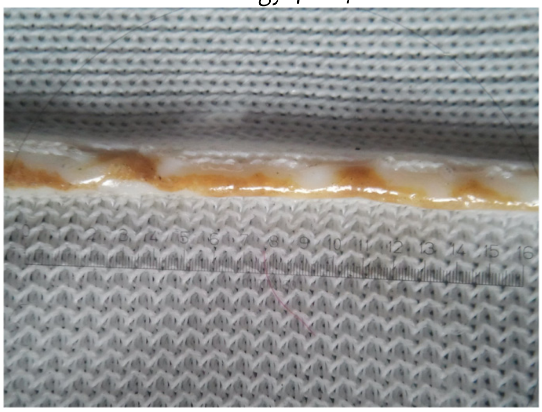

Figure 8 - Laser welded sample with carbonation weld seam, line energy 4.1 kJ/m

Table 3 - specifications of textiles used for experiments and knitting machine

Textile parameters	
Course/cm	21.5
Wale/cm	14.4
Yarn count	50dtex f40
Machine type	HKS 3-E28
Machine stitch fineness	28 needles / inch

Due to the limited possibilities of the single beam option, additional experiments will be performed only with the two-beam setup. First results of the two-beam setup show a good reproducibility with results achieved so far. Nevertheless, efforts will be focused on beam homogenisation to achieve more precise control on weld behaviour.

FE-simulation

As already mentioned, the experimental part has been accompanied by FE-simulations to obtain a better understanding of the process as well as to reduce the number of experiments. A critical point in simulation of laser material processing is the implementation of a well defined heat source.

The mathematical apparatus is based on the solution of the Fourier-Kirchhoff's differential equation of heat conduction (Eq. 1) using the finite element (FE) method. Fourier-Kirchhoff's equation is shown below:

$$\rho . c(x,y,z,T)\frac{\partial T}{\partial t}=\frac{\partial}{\partial x}\left(\lambda_x(T)\frac{\partial T}{\partial x}\right)+\frac{\partial}{\partial y}\left(\lambda_y(T)\frac{\partial T}{\partial y}\right)+\frac{\partial}{\partial z}\left(\lambda_z(T)\frac{\partial T}{\partial z}\right)+\dot{q}_v(x,y,z,t) \quad (1)$$

where: ρ - density [kg m^{-3}], c - specific heat [J kg^{-1} K^{-1}] T - temperature [K], t - time [s], λ - thermal conductivity [W m^{-1} K^{-1}], q_v - heat source [W m^{-3}]

It is well known that a precise heat input description is of crucial importance, especially including the laser beam cross-sectional energy density.

Following the literature, several heat source models can be applied. Within the model presented here, an approach as described by von Allmen (8) has been chosen. The laser beam used for simulation can be described by a by Gaussian distribution (Eq. 2):

$$q(x,y)=\frac{2(1-R)I}{\pi r^2}\cdot e^{\left(\frac{-2(x^2+y^2)}{r^2}\right)}$$

where q is the energy density that reaches the substrate interface, I is the peak intensity of the incident laser light, R is the reflectance, and r is the radius of the beam spot. The incident beam irradiates the target surface at z = 0.

Von Allmen's model has been chosen since a user defined local coordinate system allows an easy re-calculation of the amount of heat input directly to the each irradiated element separately, regarding its x and y coordinate in the local coordinate system. The centre of this coordinate system is adjusted to the centre of the laser beam.

Moving of the local coordinate system as well as the irradiated elements selection and appropriate heat input, based on the distance from the beam centre was ensured by a user defined macro in the APDL (Ansys parametric design language) scripting language.

As mentioned earlier, the energy absorbed by elements significantly depends on the element surface position according the incoming laser beam center. Higher amount of energy near the laser beam center causes a more prominent rise of the element temperature and analogically a lower energy near the outer beam radius causes a lower element temperature. A certain amount of heat is conducted to neighboring elements. Since material properties are temperature dependent, material properties have to be adjusted accordingly. Additionally, phase transformation and thus specific heat of phase transformation have to be considered.

The elements temperatures have to be evaluated at the end of each solution substep. If the element temperature exceeds the defined ablation temperature, element becomes fully transparent for the incoming laser beam and its material properties are changed to the surrounding "air". The partial results showed, that no simplifications such as a 2D model or 3D model with axial symmetry are allowed, because a complex and spatially complicated problem has to be simulated. The scheme of the proposed solution is shown in figure 9.

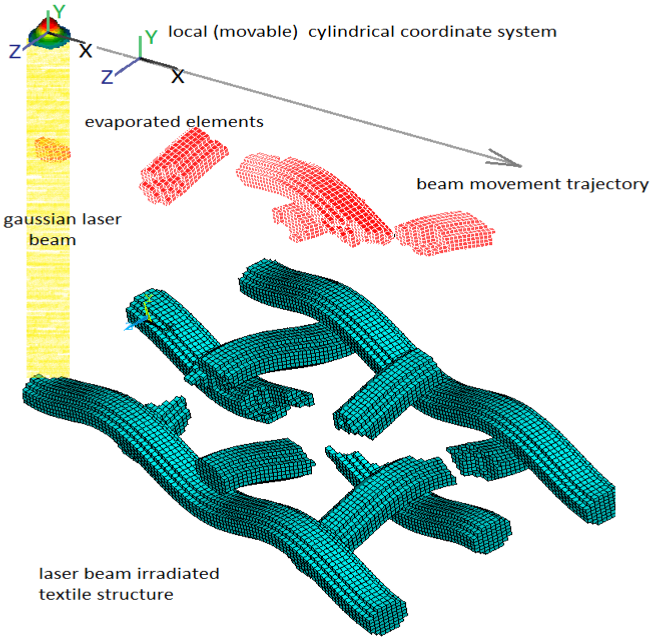

Figure 9 - Schematical view of model geometry used for FE-simulations.

Process parameters used for simulations are as follows: laser power = 50 W, beam radius 0.2 mm, polypropylene fibre radius 0.7 mm, velocity 1 m/s, absorption 95%, distance between the fibres 6 x fibre radius, evaporation limit 480 °C.

SIMULATION RESULTS

The proposed 3D model shows a promising way to predict the material removal by laser beams. The model provides full information about the cutting shape, the width of the cut and the molten area. Additionally, the model helps to get a better understanding on the physical phenomena involved in material processing.

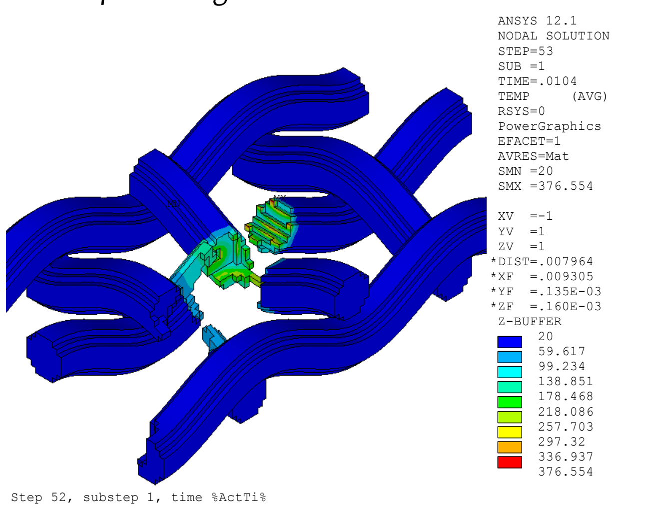

Figure 10 - Temperature field and cut shape. Simulation of polypropylene fiber cutting,; cutting velocity 1 m/s, step of the simulation 53; time 0.0104 sec

Model allows changing the geometry of the textile, material properties of the textile fibers very easily. Additionally, one of the most important benefits of the model consists from the possibility to keep full control over the laser beam – output power, energy distribution. Model even allows adding secondary beam or the change of the beam regime during the operation.

SUMMARY / CONCLUSIONS

First results indicate that a combined cutting and welding process of technical textiles seems possible. After implementation of a combined cutting and welding process in an industrial production environment, an overall increase of productivity could be expected. Especially requirements on storage and logistics as well as intermediate steps in production of technical textiles could be reduced by such a combined process. Nevertheless, additional efforts are required to overcome current limitations of the process. For industrial implementation there is also an extraction system for occurring by-product needed. These by products consist in this case manly in aerosols, formaldehyde, butadiene and acroleine.

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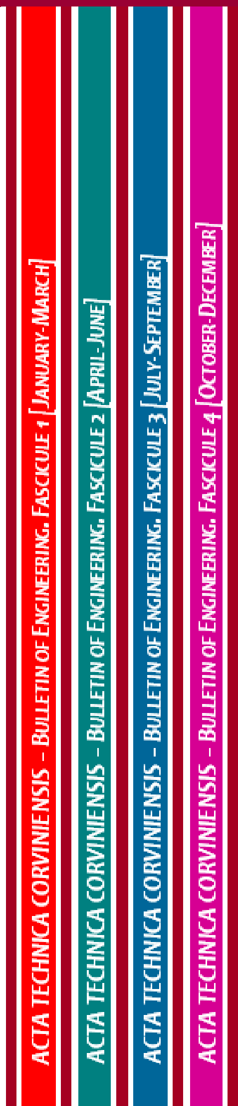

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SERVICE LEVEL AGREEMENT XML SCHEMA FOR SOFTWARE QUALITY ASSURANCE

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ABSTRACT: *In order to assure that the software service levels required by the service consumer are met by the service provider, constant monitoring and verification of the software is required. We propose a new XML schema for defining service level parameters. In documents based on this schema we define parts of application to be monitored, which metric is going to be used and what are expected values. We present the DProf tool for constant monitoring of software performance. The system is implemented in Java, but, with minor modifications, it can be used for .NET applications.*
KEYWORDS: *continuous software monitoring, service management, service level agreement*

INTRODUCTION - SERVICE LEVEL AGREEMENTS

To determine whether the quality of service and service level agreements are on a satisfactory level, it is necessary to monitor software in its operational stage and environment. While new, previously unknown, errors can show up, it is a common phenomenon for software performance and quality of service to degrade over time [16], too. Software testing, debugging, and profiling in development environments hardly allow to detect errors and unpredicted events that can occur after the software is deployed and used in its production environment.

Service level agreement (abr. SLA) [1] is usually a part of an agreement between service consumer and service provider. Based on this document, service provider is obliged not only to provide service, but also to provide certain quality level of the service, too. SLAs specify permanent monitoring and verification of IT service levels. It specifies metrics to be used, service management and reactions to agreement breaches. It also contains time constraints, e.g. period of validity of contract and frequency of measurements.

The life cycle of SLA [13] begins with the agreement definition. It is then passed to the service provider. Within service provider organization, duties are assigned, and monitoring phase can begin. During this phase, SLA parameters are monitored and data is gathered. This data is analyzed and used for 1) detection of violation of SLA and 2) service level improvement. After data analysis, SLA is revised, and the whole process continues from the beginning. Graphic representation of this process' cycle is shown in Figure 1.

To determine how software behaves under production workload, continuous monitoring of that software is a valuable option. Continuous monitoring of software is a technique that provides a picture of the dynamic behavior of software under real usage, but often results in a large amount of data. In the process of the analysis, the obtained data can be used to reconstruct architectural models and perform their visualization (e.g., employing UML).

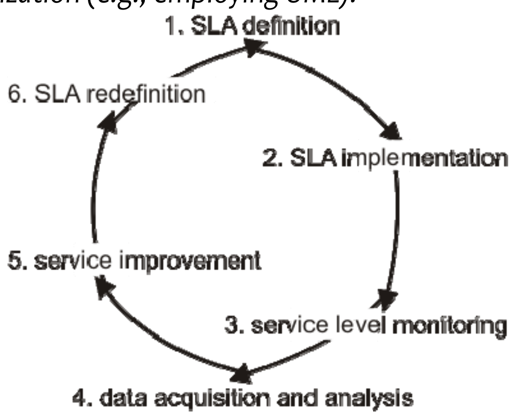

Figure 1. SLA lifecycle

In the development phase, software developers usually utilize tools such as debuggers and profilers. Although they provide a picture of the software behavior, they typically induce a significant performance overhead – something which is unacceptable for production use.

In order to check if software performance is in compliance with SLA, we have developed the DProf system. It performs continuous monitoring of software and analyses gathered data. Based on this data and our DProfSLA XML schema, DProf can find which part of application is not in accordance with SLA. This reduces time needed by developers to identify the source of the problem and to solve it. DProfSLA schema based documents are used to define required service-levels in various metrics. System is extensible so that users can define their own metrics and implement measuring techniques.

The rest of the paper is structured as follows. Chapter 2 presents related work in the field. In chapter 3 we present DProfSLA XML schema, while in chapter 4 we give short description of our DProf system. Fifth *chapter gives an example of how DProf can be used, while chapter 6 provides conclusion and guidelines for future work.*

RELATED WORK - EXISTING SLA STANDARDS

Related work focuses on existing standards for SLA documents definition and monitoring tools.

*In order to automate service level management process, SLAs must be defined in machine-readable format. As shown by Tebbani et al. [15], there are only few formal SLA specification languages. SLAs are usually written in some spoken language. Authors propose GXLA – XML specification for GSLA (**G**eneralized **S**ervice **L**evel **A**greement). GSLA is defined by authors as a contract signed between two or more parties, which is designed to create a measurable common understanding of each party role. A role presents the set of rules which define the minimal service level expectations and obligations the party has. GXLA is a XML schema which implements GSLA information model. GXLA is composed of following sections: schedule (temporal parameters of contract), party (models involved parties), service package (an abstraction used to describe services) and role (as described). Creation and use of GXLA allows automation of service-management process.*

WSLA described in [6] is XML based and it is used to specify service levels for web services. WSLA document defines interested parties, metrics, measuring techniques, responsibilities and courses of action. Authors state that every SLA (and WSLA, too) contain 1) information regarding agreeing parties and their roles, 2) SLA parameters and measurement specification and 3) obligations for each party.

Paschke et al [11] performed categorization scheme for SLA metrics with the goal to support the design and implementation of automatable SLAs.

Standard elements of each SLA are identified and shown in: technical (service descriptions, service objects, metrics and actions), organizational (roles, monitoring parameters, reporting and change management) and legal (legal obligations, payment, additional rights, etc.). Authors categorized service metrics in accordance with standard IT objects: hardware, software, network, help desk and storage. SLAs are grouped according to their intended purpose, scope of application or versatility (using categorization by Binder [2]).

According to this categorization, DProfSLA documents are operation level documents (by intended purpose) to be used in-house (by scope of application). By versatility categorization, they belong to standard agreements. The schema provides subset of elements defined by already existing GXLA or WSLA, and documents can be translated into these schemas using XSLT.

SOFTWARE MONITORING

Study shown in [12] shows that, while service levels and performance of applications are of critical importance in practice, application level monitoring tools are rarely used.

Java application monitoring tools are usually developed using either JVMTI/JVMPI [4, 5] or aspect-oriented programming (AOP) [7].

JVMTI and JVMPI APIs require knowledge of C/C++ in addition to Java, and also yield significant overhead [16].

COMPASS JEEM [10] can be used to monitor JEE applications, but every application layer needs different set of probes. Tools developed by Briand et al. [3] can be used only for UML diagram reconstruction, and it cannot be used for monitoring of web-services.

There are also commercial application monitoring tools, such as DynaTrace and JXInsight.

AOP is used for instrumentation of code. Separation of concerns allows for monitoring code to be separated from application code. There are several monitoring tools based on AOP. The Kieker framework [16] is a framework for continuous monitoring and analysis of all types of Java applications. It uses aspects to define and implement monitoring probes. The HotWave framework [17] tool allows run-time reweaving of aspects and creation of adaptive monitoring scenarios, but it is still in development phase.

The DProf system presented in this work is based on the Kieker framework [1] and the JMX technology [14]. It can be used for adaptive and reconfigurable continuous monitoring of JEE applications, as presented in this paper. Use of Kieker grants low overhead, and separation of monitoring code from application code by using the AOP. JMX is used for controlling of monitoring process at run-time.

Together with DProfSLA schema, DProf system can be used to monitor how SLA is executed and where problems occur.

DProfSLA Xml SCHEMA

Monitoring process goals are defined using a special XML schema – DProfSLA schema. Schema is specified in accordance with categorizations and existing schemas shown in related work.

Root element of this schema is shown in Figure 2.

The root element (DProfSLA) has three sub elements:

- *Parties (parties in the agreement),*
- *Trace (call-traces to be monitored) and*
- *Timing (time constraints of this agreement).*

The Parties element represents interested parties in the agreement. This element is presented in Figure 3.

The Parties element has two sub elements: Provider (representing service provider) and Consumer *(representing service consumer). Both of these sub elements contain contact data regarding service provider and service consumer, respectively – i.e. interested parties in this agreement. Each sub element is represented using the OrganizationType (Figure 4) complex type.*

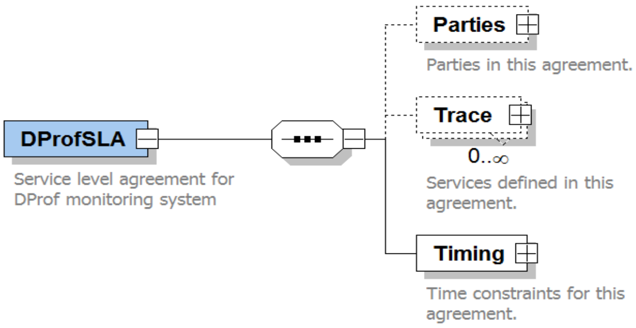

Figure 2 Root element of the DProfSLA schema

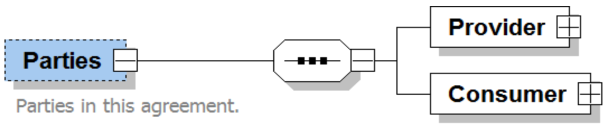

Figure 3. Parties element in the DProfSLA schema

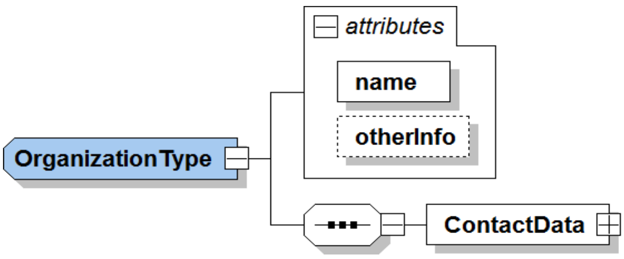

Figure 4. OrganizationType complex type defined in the DProfSLA schema

The OrganizationType element contains the following attributes:

- *name (organization name) and*
- *otherInfo (some other information regarding that organization).*

Contact information for that organization is stated in the ContactData sub element which is presented using the ContactDataType (Figure 5) complex type.

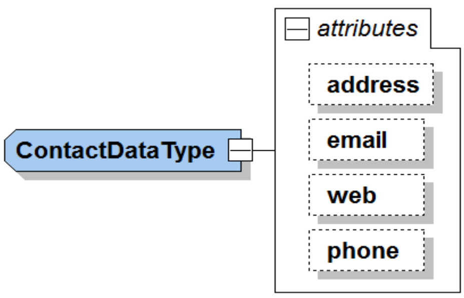

Figure 5. ContactType complex type defined in the DProfSLA schema

ContactDataType contains (optional) attributes for address, e-mail address, web address and contact phone for each interested party in the agreement.

The Trace element (Figure 6) represents performance information for one call trace. It is of the TraceType complex type.

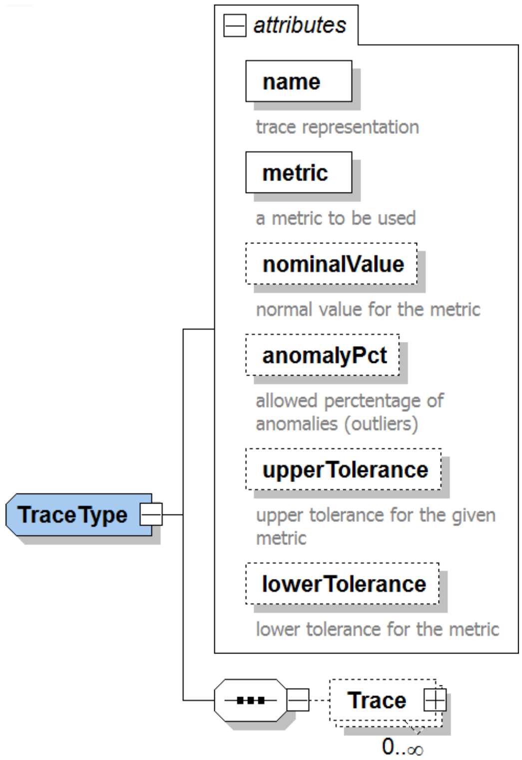

Figure 6. TraceType complex type defined in the DProfSLA schema

The Trace element has two mandatory attributes. The name attribute is used to specify a part of application to be monitored. String representation of a call tree is used for this. The metric attribute specifies which metric is used, i.e. which aspect of application performance is going to be monitored. Sub elements of the Trace element can be other Trace elements, e.g. methods that are invoked from other (parent) method, described in parent Trace element.

Furthermore, there are four optional attributes for specification of expected performance values in designated metric. The nominalValue represents expected average value, while the upperTolerance and lowerTolerance are maximal and minimal average values in designated metric, respectively. The anomalyPct is used to define allowed number of extreme values in obtained results.

The Timing element (Figure 7) is used to specify time constraints for this agreement. Sub elements StartTime and EndTime define period to which this document applies. Both times are in milliseconds (XML schema long values), starting from midnight, January 1, 1970 UTC (as in Java specification).The SamplingPeriod element denotes time (in milliseconds, long values) between two analyses of obtained results.

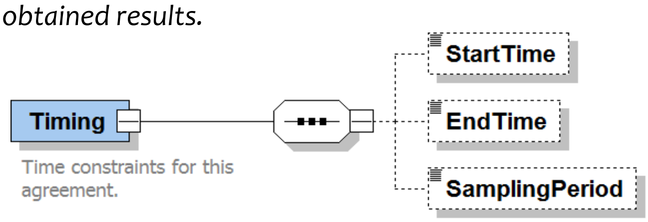

Figure 7. Timing element defined in the DProfSLA schema

DProfSLA MONITORING SYSTEM

In order to continuously monitor software applications we have developed the DProf monitoring system. It is mainly designed for continuous monitoring of JEE applications. With minor modifications it can be used for applications developed for other platforms.

This system is based on Kieker framework for continuous monitoring and analysis of software systems. We have developed additional components in order to allow changing of monitoring parameters while the application is still running.

The Kieker framework consists of the Kieker.Monitoring and the Kieker.Analysis components. The Kieker.Monitoring component collects and stores monitoring data. The Kieker.Analysis component performs analysis and visualization of this monitoring data.

The component diagram of Kieker framework is shown in Figure 8.

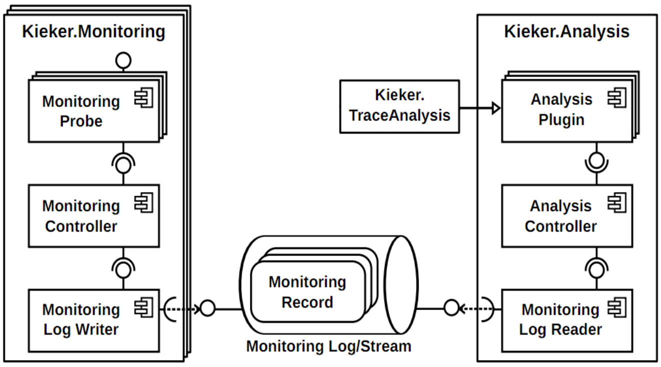

Figure 8. Component diagram of DProf monitoring system

The Kieker.Monitoring component is executed on the same computer where the monitored application is being run. This component collects data during the execution of the monitored applications. The Monitoring Probe component is a software sensor that is inserted into the observed application and takes various measurements. For example, Kieker includes probes to monitor control-flow and timing information of method executions. Probes are most commonly implemented using AOP aspects, and additional probes can be added to support different measurements (e.g. for adding support for new metrics). Monitoring Log Writers store the collected data, in the form of Monitoring Records, in a Monitoring Log. The framework is distributed with Monitoring Log Writers that can store Monitoring Records in file systems, databases, or JMS queues. Additionally, users can implement and use their own writers. The Monitoring Controller component controls the work of this part of the framework.

The data in the Monitoring Log is analyzed by the Kieker.Analysis component. A Monitoring Log Reader reads records from the Monitoring Log and forwards them to Analysis Plugins. Analysis Plugins may, for example, analyze and visualize gathered data. Control of all components in this part of the Kieker framework is performed by the Analysis Controller component.

The DProf system uses Kieker's infrastructure for data acquisition, but with some additional components. Architecture of DProf system and its connection to Kieker is shown on Figure 9.

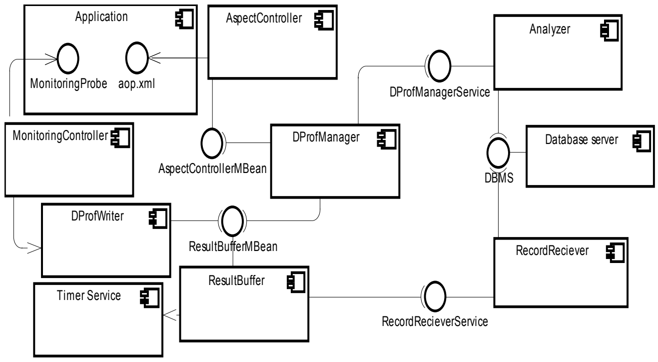

Figure 9. Component diagram of DProf monitoring system

The DProfWriter is the new Monitoring Log Writer. It sends Monitoring Records to the ResultBuffer component. The ResultBuffer sends data (periodically or on demand) to the RecordReceiver component, which, in turn, stores data into the database. This combination of ResultBuffer, RecordReceiver and database plays the role of the Monitoring Log.

Received data is periodically analyzed by the Analyzer component. The Analyzer can create new monitoring parameters (based on data analysis) and send these parameters to the DprofManager component. The DProfManager component passes these parameters to the ResultBuffer component (if the command requires change in data sending period) or to the AspectController component (if the command requires change in aspects or join points).

While using the DProfManager and these additional components we can change monitoring parameters at run-time. This allows us to reduce monitoring overhead by shutting off of monitoring in some parts of software, and obtain more accurate results. Setting of new parameters can be performed either manually, by a person in charge or by the Analyzer component. The Analyzer component, provided with document based on the DProfSLA XML schema, can check if service levels read from gathered data, are not in accordance with SLA and which part of the software causes this.

More detailed information about DProf system and in depth explanation of its architecture can be found in [8].

Since the RecordReceiver component is designed as a web-service, this component can be used for receiving monitoring records from application developed for platforms other then Java/Java EE. In order to use this system with some other platform, such as .NET, all we need is Kieker and DProfManager implementation in

.NET. Although it seems complicated, using existing AOP and JMX implementations for .NET, this can be reduced to rewriting required components in corresponding programming language.

MONITORING AND EVALUATION OF A SAMPLE APPLICATION

The Case study of our solution will be described on the JEE application shown in [9]. It is a simple software configuration management (SCM) application, based on EJB and JAX-WS. The DProf was configured to monitor memory usage during execution of a method that creates organizations (OrganizationFacade.createOrganization(...)) and methods invoked from this method (OrganisationFacade.checkName(...) and City.getId(...) methods). Maximal values for memory usage during executions of these methods are given in the DProfSLA document. Measurement of memory usage in monitoring probes was performed using JMX platform MemoryMXBean.

The analysis of the obtained data will be performed every 12 hours (43200000ms). First, only createOrganization() method is monitored and then, if there is deviation from values in DProfSLA, only methods invoked from this one are monitored. If there is a deviation from SLA values in one of these methods, that particular method needs to be reengineered. If there's no problem with any of them, parent method – createOrganization() – needs reengineering.

Classes from kieker.*, java.* and javax.* packages are not monitored – we only look for problems in this application classes.

Listing 1. shows a part of DProfSLA document.

```
<DProfSLA>
    <Parties>
        <Provider name="...">...</Provider>
        <Consumer name="...">...</Consumer>
    </Parties>
    <Trace metric="memory"
        name="[{OrganisationFacade.createOrganisation,[{
        OrganisationFacade.checkOrgName,[]},
        {City.getId,[]}]" upperTolerance="450000000">
        <Trace metric="memory"
            name="[{Organisation.checkOrgName,[]}]"
            upperTolerance="35000000"/>
        <Trace metric="memory" name="[{City.getId,[]}]"
            upperTolerance="40000000"/>
    </Trace>
    <Timing>
        <SamplingPeriod>43200000</SamplingPeriod>
    </Timing>
</DProfSLA>
```

Listing 1. DProfSLA document for this example

Obtained results were analyzed by the Analyzer, and they show increased memory consumption during the execution of the createOrganization(...) method (averagely 404519341B ≈ 385MB – Figure 10).

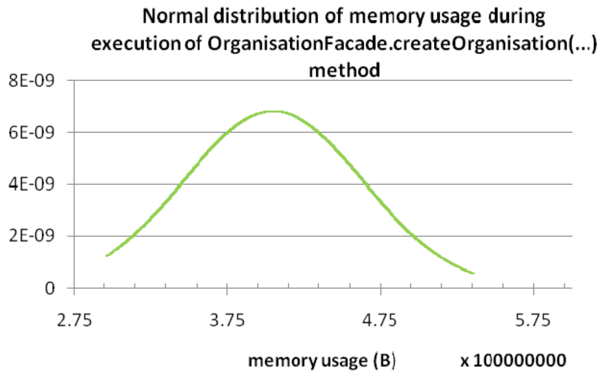

Figure 10. Memory usage during execution of OrganizationFacade.createOrganization(...) method

To find the source of the problem, the Analyzer component changed monitoring parameters and disabled monitoring of createOrganization(...) method. Monitoring of methods invoked from this method was turned on.

New set of data is shown on Figure 11.

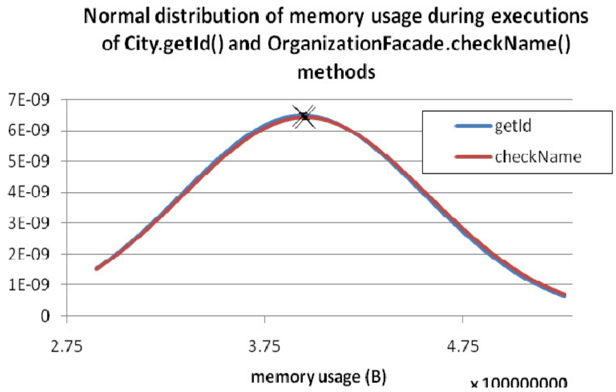

Figure 11. Memory usage during execution of OrganizationFacade.checkName(...) and City.getId() methods

Analysis of gathered data, twelve hours after previous analysis, showed that checkName(...) method consumes more memory then expected by SLA (averagely 394070676B ≈ 375MB).

Based on these results, it can be said that checkName (...) method requires refactoring in order to be optimized and in accordance to the SLA.

CONCLUSIONS

In this paper we presented a XML schema for creating SLA documents and extensible system for continuous monitoring of applications and automatic evaluation of software against expected values, defined in SLA – DProf. Using this system we can search for problems in honoring an agreement between service provider and consumer.

The system can gather data on application execution, compare these results with expected results and find which part of application causes deviations. Expected values are defined in a document based on DProfSLA XML schema. The schema is designed with existing SLA schema standards (such as GXLA and WSLA) and with categorizations of these schemas in mind. Its main use is for standard intra-organizational *agreements, but it can be used for inter-organizational agreements, too. The system supports various metrics and additional metrics can be added as needed.*

As a proof-of-concept, the DProf system was used for monitoring of memory usage of one SCM application based on EJB and web services technologies.

Future work on this system will focus on implementation of the DProf Analyzer component as Kieker.TraceAnalysis module and improvement of integration of the DProf component into the Kieker distribution. We will also work on extending of the system with additional monitoring probes for different and more complex measurements.

ACKNOWLEDGEMENT

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STUDENT'S INTERNSHIP PROGRAM AT POLITECNICO DI TORINO – AUTOMOTIVE ENGINEERING COURSE AS INDISPENSABLE SEGMENT OF TECHNOLOGY TRANSFER IN THE FRAME OF UNIVERSITY EDUCATIONAL PROCESS

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ABSTRACT: *The wider objective of student's internship is the achievement of better interaction between universities and enterprises for timely preparation of the university graduates for labour market. Within the frame of the Automotive Engineering course at Politecnico di Torino, the internship is considered to be an instrument to reduce the distance between the theoretical and methodological knowledge acquired during the academic carrier, and the applicative integrated and systematic knowledge which characterizes the industry. Internship represents an opportunity for the students of their temporary introduction into the industrial community, with the purpose of establishing a first contact with companies, and at the same time, carrying out a training period without the setting of a subordinate work. This paper is presenting the general information about the internship program at the Politecnico di Torino, its understanding, types, philosophy and objectives, benefits and correlation with academic credits, complete organizational structure and collaboration with industrial partner institutions. The applying procedure and activation of an internship, rights and obligations of the parties, and necessary documents relevant to student practice, are also described. Finally, a brief review of internship reports with final evaluation criteria of performed work, and internship evaluation questionnaire is given.*
KEYWORDS: Automotive Engineering course, host company, internship, trainee

INTRODUCTION

The Politecnico di Torino is the one of the most prestigious institutions in technical and scientific field in Italy; it is located in Turin, the capital of Piedmont Region. Thanks to its geographical location, the Politecnico is at the centre of the principal industrial European systems and it is very important factor for industrial, technological and social modernization. The year 2009 is marked as the 150th anniversary of Politecnico di Torino foundation and its long-standing tradition has been the basis for the reputation it enjoys today as one of the leading technical universities in Europe and throughout the world. In fact according to the Jiao Tong University's league table, it holds the 7th place in Europe for engineering studies, and is the first in Italy for internationalization and for technical studies according to league tables compiled by Vision and Censis.

In order to organize and manage its didactic activities, the Politecnico has 5 Faculties (3 of Engineering and 2 of Architecture) and the Scuola di Dottorato (PhD School). There are 18 Departments that manage one or more research fields, promote and coordinate research activities and organize research activities for external bodies. There are nearly 30000 students, of which about 4000 are new enrolments. Students are studying mainly in the Torino campuses but there are other 5 small reference campuses, located all over the Piedmont. PhD students are about 700, new PhD students are more than 240 every year.

The Automotive Engineering courses were initiated at Politecnico di Torino in the academic year 1999/2000, on the occasion of the centenary of the founding of Fiat, with the scope to give a properly conceived response to the demand of that specific courses within the engineering education proposal at the Politecnco. At Politecnico di Torino, it had long been active degree courses devoted to aerospace engineering, while only two streams within the mechanical engineering courses were offered for automotive and transportation engineering. Thus it was lacking an educational proposal completely dedicated to this widespread engineering branch: the automotive engineering, that is of the greatest relevance for the Torino area.

The degree course was established and is managed through an agreement between Fiat and Politecnico di Torino and has an important annual contribution of Fiat. The salient features of the agreement are concerning the content of lessons, joint educational activities, a significant number of non-university teachers (so with a sound industry background) and compulsory internships.

This Automotive Engineering degree stems from the belief that for many decades will be necessary to prepare engineers who are able not only to design and build cars, buses, motor vehicles for the transport of goods, special vehicles for agriculture and construction sites, but also to have sensitivity to problems related to the management of production processes, the mobility of people and things, the green engineering (with particular emphasis on the environmental impact of producing operating and dismissing vehicles), the working place security, the product quality, the business organization, enterprise economics, marketing, the human resources management, relations with the world of automotive components. These high qualified subjects are specifically destined for the competitive development of automotive products, including a marked sensitivity to the technology landscape and the global automotive market. Thus this master degree owner will be prepared to operate in an international context taking into account the deep changes that are taking place in production facilities and in their location all over the world. To meet the competitive needs of the automotive sector, this Master of Science course is divided into three streams that students can freely choose: development of the engine, vehicle and system development, management.

The internship program in Automotive Engineering course seeks to provide students with a worked-based experience that is relevant to their course, together with opportunities to study the various functional areas within real enterprises and to extend the students sense of responsibility and reliability both as an individual and as a member of a team.

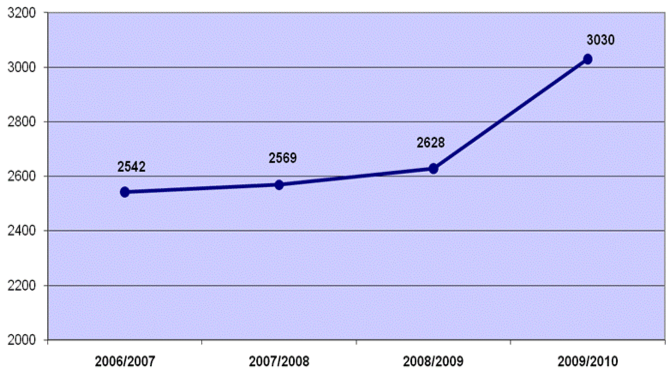

Figure 1. Number of internships performed per academic year

During the internship, students gain a variety of professional skills in employment related to their programme of study, and the ability to apply these to problems in real work situations. Students should be able to relate and apply theoretical and practical experience gained during the studies to their experience during professional training, while giving a full and useful contribution to the activities of the organization that is providing the professional training [1].

According to the analysis of internship projects undertaken at Politecnico di Torino, which scope is to monitor the effectiveness of work experience and perception of the service, the number of internships performed per academic year is increasing constantly (Figure 1). The analyzed data were collected in a database consisted of all training projects started at the beginning of internship. The information is inserted both by Politecnico and companies that are presenting hosting bodies.

UNDERSTANDING THE INTERNSHIP

Due to the Italian university reform, the internship has become an integrating part of the curriculum of engineers who, in this way, can get closer to the business world and obtain an evaluation of the internship activity in university (ECTS) credits. The internship is compulsory for the master degree course. The number of working hours dedicated to the internship is about 500 over about four months that is a quite big effort, and leads to the acquisition of ten academic credits.

According to didactic programme of the Automotive Engineering courses, the internship is introduced during the last semester (term) of Master of Science course. The minimum duration is 4 months, but according to host company needs, it can be prolonged up to 9 months.

The experience gained over years has proved that the value of the internship can be recognized both from the point of view of the student and of the host company [3]:

- The student can experience the real work, he must face true engineering problems and find a solution, all that in cooperation with other people. It is no more the simple "academic" exercise made only by student itself, but it is a team work in company circumstances.
- The host companies consider internships to be both a doorway towards hiring and a moment of integration between academic and operative skills aiming to form professional persons at the end of the academic path. Such experience is important for the company since it allows it to evaluate a possible applicant.

The academic responsible for internships is the director/manager of the Automotive Engineering University course. Complete practical work is handled by the office particularly established for students of this faculty. It is independent body with respect to Politecnico di Torino Stage&Job office, and it has been established with the scope to provide useful information and contacts only in automotive sector. Currently there are three types of internships, established at Automotive Engineering course:

- The internship performed in an automotive company

During this time, the student under the supervision of an engineer who is working in the company and an academic tutor from the Politecnico, has a real work experience. The student will be supported by the engineer in the development of the assigned project, *and also, he will collect all necessary data for the preparation of final thesis. In almost all cases, the internship experience is the preliminary step, which is providing useful information and database for MSc. Thesis.*

- *The internship performed at Politecnico di Torino*

Besides the internship in a company, students can experience the internship at Politecnico di Torino, usually working in the frame of projects that Automotive Engineering Faculty is offering in the collaboration with industry. In particular, Formula SAE and Shell Eco Marathon Competition Vehicles (extremely low fuel consumption and polluting emissions) are projects which are concerning the design and development of auto-cross racing cars with small formula styles and advanced lightweight materials, that are produced in the collaboration with partner enterprises in Turin and successfully demonstrated in several University student racing competitions in Italy and Europe. The production strategy of these cars consists in a concurrent analytical and experimental development, from the initial conceptual design and coupon testing, through the stages of element and subcomponent engineering, to final component manufacturing. In this way, students can follow the complete chain of product genesis – from design to manufacture. Further they gain a strong experience in team working with a very strict product delivery time.

- *The internship performed abroad*

An internship abroad is a great opportunity for student not only to make work experience, but also to develop other types of competences like the improvement of language knowledge, of the culture, and of the lifestyle of the host country. As far as the carrying out abroad of the internship is concerned, the procedure is different with respect to an internship done in Italy, because all the bonds imposed by the host country have to be considered. Mostly all of these internships are performed at foreign European universities, and only small number in foreign companies.

The hosting companies, which are offering positions for internships to Automotive Engineering Faculty, are coming always from automotive sector. In order to propose an internship, the company should contact directly the responsible office. Currently, the Automotive Engineering Faculty is collaborating with about 100 industry partners from Italy and abroad which are offering internships to Automotive Engineering Faculty. The following table contain a list of main of them.

After the initial contact, companies have to provide the internship office of Automotive Engineering Faculty with a list of possible subjects, the related principal engineering areas and the name of possible industrial tutors which will guide trainee during the internship. Since the students of the second year of Master of Science course are subdivided by different specialization streams (power train, body & chassis, vehicle electronics, etc.), it is very useful that company covers at least more than one of the automotive sectors. The example of internship titles and areas proposed by Fiat Automobiles and Fiat Research Centre are shown in the following tables.

Table 1. Industrial partner institutions

FIAT Automobiles	FIAT Power Train	MAGNETI MARELLI	CRF (FIAT Research Center)
CNH (Case New Holland)	IVECO	TEKSID	PININFARINA
BENTELER	BMW	AUDI	ITALDESIGN
MICHELIN	SKF SPA	ROBERT BOSCH	SIEMENS
VOLVO	TOYOTA	General Motors Europe	DUCATI
PIAGGIO	HONDA	AZIMUTH YACHTS	BERTONE SPA
COMAU	FEDERAL MOGUL	TNO - MADYMO	JOHNSON CONTROLS

Table 2. Proposed internship projects of Fiat Group Automobiles

FIAT GROUP AUTOMOBILES – *proposed internships*	
AREA	TITLE
R&D - Chassis	*New solutions of traction control for braking ESC modulators*
Interiors	*Methodologies and innovative technologies to improve the perceived quality of the instrument panel*
Electrical electronics	*Diagnostics of LIN: development services and protocol requirements*
R&D - Body	*The design of the full plastic front-end for high-speed collisions*
Product quality	*Development of the accelerated cycle: reliability test vehicle in customer view*

ACTIVATION PROCEDURE OF AN INTERNSHIP

After the meeting between the company tutor and student, after having decided together the content of the internship, the modality of carrying it out, the timetable and the location, there are some compulsory documents which have to be handled in between Politecnico di Torino and the hosting company/public body before the start of the internship: Convention for the internship and Training project.

With the Convention for the internship, the parties declare their availability of enabling internships, undertaking to respect the rules in force (with specific reference to the aims and the maximum extension of the internship, insurance coverage, final evaluation). Without this agreement, no internship can be started. However once the Convention for the internship is signed, it is absolutely not compulsory for *the enterprise to accept a student for trainee. It is therefore fundamental for the activation of an internship to verify the existence and the validity of a Convention of the internship between student and Politecnico. Then, on the occasion, this should be confirmed and personalised with the specific Training Project.*

Therefore, if the Convention for the internship is the agreement generally stipulated between Politecnico di Torino and the hosting body, the Training project is a document which directly involves the student or the graduate and which contains:

- *The names of the trainee, the Academic Tutor of Politecnico di Torino and the Company Tutor;*
- *The objectives, the modalities of carrying out and the duration of the internship;*
- *The details of the insurance policies stipulated by Politecnico di Torino against the accidents at work and the civil responsibility towards third parties;*
- *Company sector where the internship will be carried out.*

For starting of the internship and filling out of the Training project it is necessary that the student and the company agree on certain points like:

- *The location where the internship will be carried out;*
- *Duration and starting date;*
- *Educational objectives, a short description of which is necessary;*
- *The chosen company tutor (telephone number, fax number, e-mail address, information regarding the position in the company);*
- *Schedule: trainees cannot carry out a number of weekly hours greater than the one assigned by contract to the employees of the same organizational structure. That schedule is also relevant for the insurance coverage that will be given by the Politecnico.*
- *Reimbursement of expenses or benefits.*

The trainee will insert this information in the Training project and will have it checked and signed by the company tutor. The document will be also signed by the trainee and the academic tutor and will have to be handled in to the internship office of Automotive Engineering course at least 7 days before the starting date. The communication of the start of the internship will be done through a letter, sent by the internship office to the company tutor by fax. It will be the company's responsibility to inform the internship by fax in case of any type of variation (temporary transfer, schedule variations, interruptions or temporary suspensions) through the special form which can be downloaded from the Politecnico di Torino web site ("Modify or Interrupt an internship").

At the beginning of the internship the student will be given the internship book which contains:

- *the appointment calendar, in which the student will register the most important contacts which took place between the student, academic tutor and company tutor during the internship;*
- *attendance sheets, which will have to be filled out by following the instructions contained within the internship book itself.*

The internship book has to be returned to the internship office within 10 days after the end of the internship and is considered to be the only official document which accompanies the student during the internship and which certifies its correct carrying out.

INTERNSHIP REPORTS AND EVALUATION CRITERIA

At the end of the internship, students should write the detailed report about activities performed in the company or public body. This report has to be signed both by academic and company tutors for approval. In order to acquire 10 ECTS academic credits, the final evaluation of the internship report and achieved results is performed according to the statement: Satisfied or Not satisfied.

Furthermore, in order to improve and map out a course of internship activities at Automotive Engineering faculty, it is introduced the monitoring of the effectiveness of placements and the perception of the service. The analyzed data are collected in a database containing an evaluation questionnaire, submitted at the end of internship, where students can express their first impressions about the internship just finished.

THE EXAMPLE OF THE INTERNSHIP PERFORMED AT AUTOMOTIVE ENGINEERING COURSE

In this chapter, it is presented the summary of the internship performed at AUDI AG, by an MSc. student of Automotive Engineering course. The student spent 8 months in Ingolstadt, Germany, working on industrial R&D project. The title of the internship report is the influence of packaging hybrid components in the development of new concepts.

The project work deployed has been developed in the Concept Development Department at AUDI AG and under the supervision of the "Institut für Kraftfahrzeuge der RWTH Aachen".

Starting from the understanding of the evolution of the market of Electrical Vehicle in the upcoming future, the analysis focuses on the necessity of developing new power train technologies to reduce CO_2 emissions of vehicles. The new EU regulation introduces CO_2 emission targets that need to be met by OEM car fleets in the new future. Therefore, all OEM are developing Hybrid Vehicle (HEV) as the next step toward a mature electrical mobility.

The analysis then focuses on the development of Plug-In Hybrid, adopting an "Initial EV" strategy, allowing the vehicle to drive in pure electrical mode from start for the driving range set. Such strategy allows the vehicle to obtain 0 g/km of CO_2 in the NEDC homologation cycle, helping to reduce the emissions of the fleet.

Once strategy is defined, the electrical components of a HEV have been analyzed in order to evaluate their size and volume to package. Battery, of course, represents the most important component in the definition of a concept of HEV: the size of the battery pack is variable according to the driving strategy chosen.

Once the Hybrid components have analyzed in terms of volume, a CATIA model has been created in order to understand the influence of packaging them on the car body design at early stages of development. The analysis has been conducted on a mid-size compact sedan.

The main settings of vehicle, such as H-point, ergonomics and dimensions, vary when Hybrid components are installed on board. Using the CATIA model, possible layout of components has been analyzed. The layout mainly depends on the position of the battery pack that must fulfill requirements for dynamics, production and crash performances. The two possible layouts have been defined: one with batteries packaged in the tunnel, the other with batteries packaged in trunk.

Packaging batteries in the tunnel influences the position of the dummy on both the first and second rows. Due to ergonomics reason, the driver results seated in higher position and in a sport position, affecting the comfort and the feeling of the vehicle. Moreover, passengers on the second row have less head room and leg room.

All results have been collected in order to understand strength and weakness of each configuration: on one hand packaging battery in the trunk does not affect the ergonomics of the vehicle, but has important influences on the dynamics, assembly; on the other having batteries in the tunnel allows a better dynamics of the vehicle and offers the opportunity to assemble the electrical components together with the drive train, even if there are limits on the dimensions of the battery. Though the second configuration affects the ergonomics of the vehicle, it offers better chances of improvement. The analysis conducted focuses on influences on the ergonomics: the next step would be the study of influence of Hybrid components on crash performances.

CONCLUSIONS

The internship in Automotive Engineering course has wider objective on achievement of interaction between university and enterprises for timely preparation of the university graduates for labor market. From this final scope, there are two specific objectives stated in the frame of constant internship improvement process.

The first one is oriented on improvement of students internship models in relevant study programs in order to enable students to experience the typical engineer working environment, to gain base professional experience, to develop skills, to explore career fields, and to contribute to the missions and goals of professional organizations, all while earning academic credit.

The second particular objective is to enhance the communication channels through which transfer of know-how from university to enterprises in the particular fields is achieved in order to contribute on improvement of relations and cooperation between Politecnico and enterprises as one of the major pre-request for development of knowledge based economy.

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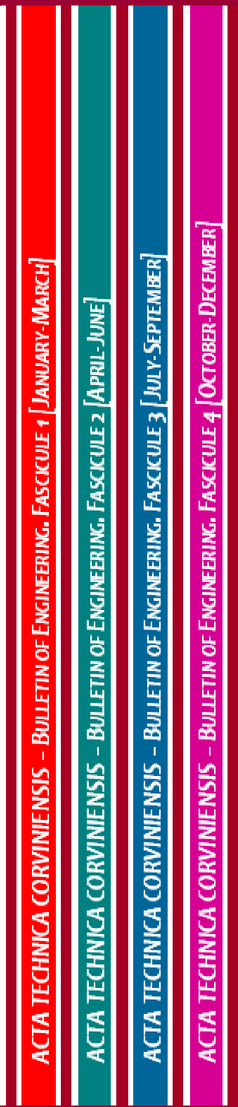

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SUSTAINABLE BUSINESS SOLUTIONS THROUGH LEAN PRODUCT LIFECYCLE MANAGEMENT

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ABSTRACT: *In today's process manufacturing environment, innovation is viewed as critical to sustainable growth and business profitability. While open innovation is regarded as the answer, the companies can effectively measure the return on R&D investment, have acceptable product success rates, achieve acceptable promotional effectiveness, or have visibility into their compliance risks or operational readiness for new product launches. While open innovation is an actual topic, capitalizing on the opportunity requires holistic strategy, not just increased collaboration. Companies must have repeatable, compliant and responsive business processes, global information infrastructure that provides a single source of the truth, alignment across departments and solutions that evolve without coding. With holistic strategy and supporting infrastructure, companies can consistently minimize the time to scale, improve product success rates and promotional effectiveness, and enjoy sustainable and profitable growth. With open innovation providing unlimited opportunities, the company should start to identify the best open innovation opportunity and deliver top and bottom line of the company's benefits. The companies must first focus on the needs of their customer, continually minimize time to scale, eliminate waste, drive out costs and improve. These are core concepts of a Lean strategy. This paper will describe how Lean concept with PLM business strategy can leverage Lean with integrated compliance, continual improvement and other PLM best practices to increase the return on R&D investments and provide sustainable and profitable growth for business processes mainly manufacturing processes. The purpose of this paper is to review PLM approach linked to Lean concepts in order to achieve sustainable and innovative business processes with sustainable and profitable growth.*
KEYWORDS: *PLM, Business solution, Lean PLM, Sustainable business process*

INTRODUCTION

In today's challenging global market, enterprises must innovate to survive. Business innovation must occur in all dimensions—product, process, and organization—to improve competitiveness and business performance. To differentiate themselves, enterprises must capture, manage, and leverage their intellectual assets. This can best be accomplished through proper application of a Product Lifecycle Management (PLM) approach that addresses the needs of the extended enterprise [2,5,6]. PLM is a strategic business approach that helps enterprises achieve its business goals of reducing costs, improving quality, and shortening time to market, while innovating its products, services, and business operations and also, with including the idea of open innovation [2,4,8].

Once implemented, PLM solutions provide benefits that have demonstrated a positive impact on an enterprise's top and bottom lines. PLM solutions can improve business efficiency by providing:

- *Reductions in time and cost of product changes;*
- *Significantly shorter product cycle and lead times;*
- *Decreased scrap and rework during production;*
- *Improved productivity in design engineering.*

In a now-a-day enterprise business solutions, lean concept is high popular. The real means of lean is given according to LEI (Lean Enterprise Institute) [9]: "The core idea is to maximize customer value while minimizing waste. Simply, lean means creating more value for customers with less resource".

A lean organization understands customer value and focuses its key processes to continuously increase it. The ultimate goal is to provide perfect value to the customer through a perfect value creation process that has zero waste.

There for, where is the link between lean and PLM enterprise business solutions? The focus of lean PLM is to address the need of the right amount of product data in different stages of product life cycle to serve the requirement of business intelligence, based on which sound business decisions can be made in a timely fashion [13]. PLM is often global, and/or across multiple business entities, therefore, lean PLM would also address the needs for intelligent, secure and efficient communication across board.

Lean PLM implementation is to apply the lean principles to a PLM implementation to ensure that all ingredients in the implementation is well justified and of value and there is no waste and there is minimum change needs.

BUSINESS CHALLENGES

Businesses today face three on-going challenges: improving customer intimacy, achieving operational excellence, and providing product leadership. Improving customer intimacy requires understanding and responding quickly to current and potential customers, their needs and providing consist, long-term customer value. Achieving operational excellence requires enterprises to focus on operating efficiently, effectively, and flexibly, working with their partners to reduce the cost and time necessary to deliver high-quality products meet their customer's requirements in a timely manner. Providing product leadership means delivering leading edge products and solutions tailored to customer needs.

To meet these challenges, businesses must become more innovative. However, being an innovative business doesn't simply mean creating innovative products.

It also means improving the processes a company uses to produce its products and how it supports its products using innovative approaches to the complete product lifecycle. Today, innovation is recognized as critical for a business to maintain its competitiveness in the marketplace. However, innovation must be achieved while reducing overall product-related costs across development, production, and service.

To be successful in global markets, organizations must develop and apply a diverse set of skills and business processes. Global enterprises must:

- Make effective use of a widely-distributed worldwide organization, creating a virtual value chain with no time, distance, or organizational boundaries.
- Ensure that corporate acquisitions and mergers work together.
- Create and enable virtual product teams composed of people that are spread around the world
- Leverage the intellectual assets in these dispersed teams and organizations
- Enable 24 x 7 development and product support using global teams

These drivers are putting increasing pressure on organizations to invest in solutions that include technologies, methodologies, best practices that can help them improve their ability to focus on product innovation, leverage business partners, and compete more effectively in the global market place.

There has been a continuous evolution of what PLM represents, as illustrated in the figure below, Fig.1. Fifteen years ago, custom implementations focused on precise applications wrapped around primarily engineering design data. In the late 1980's, the major emphasis was on how to manage engineering drawings, with limited solutions primarily sold to managers in engineering departments. Today, the focus is on complete business solutions that address top and bottom line issues. These solutions incorporate best practices to allow organizations to migrate their business processes toward industry standards.

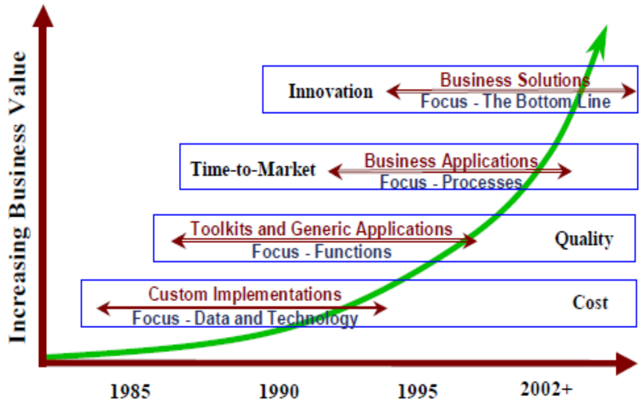

Figure 1. Evolution of PLM idea [1]

BUSINESS APPROACH

PLM is a definition of a business approach to solving the problem of managing the complete set of product definition information— creating that information, managing it through its life and disseminating and using it throughout the lifecycle of the product. PLM is not just a technology, but is an approach in which processes are as important as or more important than data. It is critical to note that PLM is as concerned with "how a business works" as with "what is being created."

Three core or fundamental concepts of PLM are:

1. Universal, secure, managed access and use of product definition information
2. Maintaining the integrity of that product definition and related information throughout the life of the product or plant
3. Managing and maintaining business processes used to create, manage, disseminate, share and use the information.

PLM model describes the technology, management and process components of an enterprise PLM solution. Across the bottom of the model are technology foundation components that are an integral part of any PLM solution. Solution providers use these foundation elements to construct core functions, such as design automation, product structures and Bills of Materials, workflow and process management, and information and content management and vaulting. These core functions are inherent capabilities contained within PLM solutions.

ERP is integrated or interfaced with PLM. ERP has traditionally dealt with the product production lifecycle. Over the last several years, the focus shifted from ERP to other enterprise solutions such as SCM, CRM, and now, PLM. As part of the continuing evolution, new solution providers are beginning to deliver products that combine some ERP and some PLM capabilities into one offering. Other business functions, such as the logistics of supply chain *management, logistics itself, marketing and sales, distribution, HR, and finance are not part of the basic PLM capabilities, but they all interact at multiple points along the product lifecycle or with components of a comprehensive PLM solution.*

The figure below (Fig.2) shows the relationships between these enterprise solutions. Product businesses have at their core the intellectual assets describing their products. Typically, PDM solutions were used to manage product development and design work-in-process. Once a product could be released to manufacturing, ERP took over. Supply chain management was often used by procurement to support the production function. Once the product was in the field, CRM systems helped manage the customer relationship. Today's businesses require enterprise solutions that can integrate all of this disparate information to optimize product development, production, and deployment. CRM data must be used to embody today's customer requirements into the next product generation. To save money, SCM systems must be active from the beginning of the product definition lifecycle, saving procurement time and money while supporting the product development process. Business partners, suppliers, and customers must all have visibility into this information to optimize their decision processes to benefit the enterprise. PLM is becoming the overall view port or portal into such product definition information and processes, providing collaboration and integration functions to synthesize information residing in CRM, SCM, ERP, and other business systems to enable new, complex business solutions.

Figure 2. Relationships among Enterprise Solutions

Additionally, PLM solutions improve an individual's performance by managing not only product definition information, but by guiding and facilitating their tasks through well-defined business processes and workflows.

PLM solutions have a very positive effect on process efficiency and effectiveness by supporting and encouraging work in a more structured manner and providing the right information, at the right time, to the right people.

PLM solutions touch every aspect of an enterprise. The ability to effectively integrate and use product definition information is important to sales and service, marketing, production planning, plant operations, customers and suppliers. All disciplines need detailed, timely knowledge of what products are being designed and produced.

LEAN CONCEPTS COMPLIMENT PLM BEST PRACTICES

□ *Defining Lean*

According to LEI (Lean Enterprise Institute) [9], the core idea of Lean Management (LM) is to maximize customer value while minimizing waste. Simply, lean means creating more value for customers with fewer resources.

A lean organization understands customer value and focuses its key processes to continuously increase it. The ultimate goal is to provide perfect value to the customer through a perfect value creation process that has zero waste.

To accomplish this, lean thinking changes the focus of management from optimizing separate technologies, assets, and vertical departments to optimizing the flow of products and services through entire value streams that flow horizontally across technologies, assets, and departments to customers.

Eliminating waste along entire value streams, instead of at isolated points, creates processes that need less human effort, less space, less capital, and less time to make products and services at far less costs and with much fewer defects, compared with traditional business systems. Companies are able to respond to changing customer desires with high variety, high quality, low cost, and with very fast throughput times.

Lean Manufacturing is the practice of eliminating waste in every area of production including customer relations (sales, delivery, billing, service and product satis-faction), product design, supplier networks, production flow, maintenance, engineering, quality assurance and factory management. Its goal is to utilize less human effort, less inventory, less time to respond to customer demand, less time to develop products and less space to produce top quality products in the most efficient and economical manner possible.

□ *Lean Concept*

When considering the lean concept for Lean Enterprise (Figure 3) [10], defining it must be done within several self contained domains. There are at first the principles of Lean that must be dominant in all aspects of the Lean Enterprises practices (including the subset of Lean implementation principles).Within that concept, there are the characteristics of the operation, the concepts under which the enterprise operates and the tools used in making the lean journey.

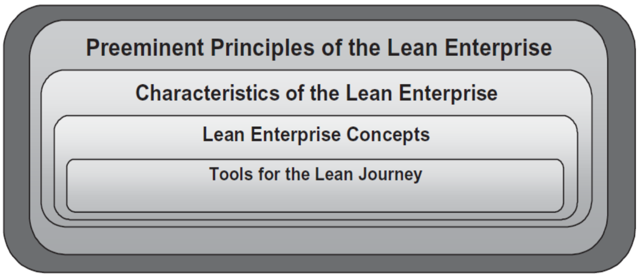

Figure 3. Lean Entreprise

- ***Pre-eminent Principles***
  - *Customer Focused*
  - *Doing More with Less (Waste Elimination)*
  - *Quality at the Source*
- ***Principles of Implementation—a Subset of Pre-eminent Principles***
  - *Specify (value)*
  - *Map (process/value stream)*
  - *Apply (process flow)*
  - *Selectivity (pull)*
  - *Continuous Improvement (perfection)*
- ***Characteristics***
  - *Standardize-Do-Check-Act (SDCA) to Plan-Do-Check-Act (PDCA)*
  - *Next Production Line Process is Your Customer*
  - *Quality the First Time, Every Time*
  - *Market-in vs. Product-out*
  - *Upstream Levelled Management Structure*
  - *Let Data Speak*
  - *Variability Control and Recurrence Prevention*
- ***Concepts***
  - *Waste Reduction*
  - *Integrated Supply Chain*
  - *Enhanced Customer Value*
  - *Value Creating Organization*
  - *Committed Management*
  - *Winning Employee Commitment/Empowering Employees*
  - *Optimized Equipment Reliability*
  - *Measurement (Lean Performance) Systems*
  - *Plant-Wide Lines of Communication*
  - *Making and Sustaining Cultural Change*
- ***Tools***
  - *5-S Process*
  - *Seven Deadly Wastes*
  - *Standardized Work Flow (TAKT Time)*
  - *Value Stream*
  - *Kanban (Pull System & Visual Cues)*
  - *Jidoka (Quality at the Source)*
  - *Poka-Yoke (Mistake [Error] Proofing)*
  - *JIT (Just-in-Time)*
- ***Lean PLM***

The focus of lean PLM is to address the need of the right amount of product data in different stages of product life cycle to serve the requirement of business intelligence, based on which sound business decisions can be made in a timely fashion [10].

PLM is often global, across multiple business entities, therefore, lean PLM would also address the needs for intelligent, secure and efficient communication across board. For small and medium local businesses, lean PLM would address PLM needs in the form of on-demand requirements for on-demand services.

- ***Lean PLM Implementation***

Lean PLM implementation is to apply the lean principles to a PLM implementation to ensure that all ingredients in the implementation is well justified and of value and there is no waste and there is minimum change needs.

According to LEI [9], there are 5 steps in the lean practice:

1. ***Identify value*** *- Specify value from the standpoint of the end customer by product family.*
2. ***Map the value stream*** *- Identify all the steps in the value stream for each product family, eliminating whenever possible those steps that do not create value.*
3. ***Create flow*** *- Make the value-creating steps occur in tight sequence so the product will flow smoothly toward the customer.*
4. ***Establish pull*** *- As flow is introduced, let customers pull value from the next upstream activity.*
5. ***Seek perfection*** *- As value is specified, value streams are identified, wasted steps are removed, and flow and pull are introduced, begin the process again and continue it until a state of perfection is reached in which perfect value is created with no waste.*

- ***Lean PLM collaborating aspects***

A core component of Lean is focusing on the customer. For many production and manufacturing processes, they must need to focus on the consumer or customer, retailer and distribution. To achieve this, collaborating with aspects of the value chain, validating constraints and compliance early and often, continually optimizing portfolio management opportunities, managing knowledge and intellectual property, integrating to the extended enterprise systems, engraining governance into processes and continually improving without coding are standard PLM best practices [12]. These PLM best practices will allow the company to continually minimize time to scale, eliminate waste, and drive out costs.

- ***Focusing on the customers:*** *To drive growth and profitability, companies need to focus on the customer and must identify their unique value propositions for customers and align these with their channel. Defining your critical-to-customer, critical-to-retailer and critical-to-quality* *characteristics is an important first step. With these critical characteristics, R&D costs can be lowered by not designing in non-value added capabilities, time can be reduced by eliminating non-value added iterations, excess material costs and carrying costs can be eliminated, product quality and consistency improved, and regulatory risks reduced. Integrating these into R&D concept, development and commercial applications and providing continual validation will ensure products meet customer expectations and improve product success rates. Additionally, lead times are reduced, waste is eliminated and costs are reduced.*

- ***Collaborating with aspects of the value chain:*** *To improve quality, increase innovation, reduce costs and time, many researches concluded that increased collaboration is essential. Extending collaboration from R&D (research & development) and SCM (supply chain management) to suppliers and retailers will provide increased agility, extend internal capabilities, reduce time, improve quality, lower costs and improve innovation. To identify the best way to optimize profit potential, retailer collaboration can result in better shelf placement, increased revenue, improved turns and lower retailer costs. As part of developing retailer-specific products, the supply chain must be integrated into the process and operational readiness improved. As new capabilities or capacity are required, supplier collaboration and enablement programs can reduce time and costs, improve quality and increase innovation. Further, many companies are increased levels of collaboration, both internally and across the enterprise, in an effort to increase agility and velocity. This results in reduced lead times, lower costs, improved quality and compliance and increased innovation, not to mention sustainable growth and profitability.*
- ***Validating constraints and compliance:*** *As lead times are compressed, participation of additional resources and product complexity increased; early identification of potential issues and timely mitigation is critical. The earlier a project can be stopped or realigned, the less capacity is wasted, the further costs are reduced. At any stage of development, target specifications, product and project costs and projected dates can be validated, and regulatory restrictions by market and product type best-practices guidelines can be checked. In addition to these R&D-oriented validations, supply chain constraints and vendor compliance capabilities that are validated late in the development process can be proactively validated. A supplier's capability matrix rating, social responsibility, sustainability index, enablement status, quality rating, preference status, compliance risk and readiness values can be used to identify the best sustainable source of materials or products.*
- ***Managing knowledge:*** *This is crucial phase of product's realization. Effective reuse of knowledge and intellectual property is keys to reducing time, eliminating waste, reducing costs and improving quality while meeting customer requirements. Ready access to relevant and accurate information can eliminate the need to search for information in multiple systems or offline sources. It will eliminate non-value added, trial-and-error iterations and halt the initiation of dead end projects. To achieve these benefits, information must be effectively captured, categorized, validated, secured, put into global content, referenced to adjacent information, and the relevance status maintained through the lifecycle. Semantic search engines can mine the data and visual-comparison engines can help turn data into relevant and actionable information. When information needs to be provided to the extended value chain, specifications are used to communicate the appropriate information and secure intellectual property.*
- ***Integration to the extended enterprise system:*** *To make, source, distribute and sell products, PLM information must be integrated into extended enterprise systems. For most companies, the PLM system information will not be different from the operational planning systems. Some R&D-oriented or proprietary information will not be integrated to the extended enterprise systems. Items, components, formulas/recipes, routings, products, new vendors, quality specifications and new customers must be sent to the ERP system. To ensure R&D is working with the most current information, costs, quality, sourcing, product or pilot assays and production volumes and status changes must be communicated back into PLM. Collaboration with vendors, customers and retailers via collaborative workspaces or integration can shorten time, reduce costs and improve quality.*

PLM METRICS DEVELOPMENT PROCESS

The questions often asked in business and commerce are how well do we know we're doing, and how do we know what we're doing is working? There is important to find out the metrics process for measuring what is important and meaningful [3,5,7]. The only way to find out answers to these questions is to measure the processes and outcomes of these processes. As PLM transforms the way companies do business, it is important that companies understand how well they are doing. To determine the effectiveness of PLM implementation within any context, PLM processes and outcomes need to be measured. Measurement of PLM requires the development of metrics that are important and meaningful to the process. It is essential that what is identified as a metric is relevant, appropriate and important, since typically what gets measured gets done.

The objective of the metrics development process is to identify, develop, and articulate PLM metrics that would help companies implementing PLM determine the extent to which their PLM efforts are paying off. The PLM assessment process model shown at the Figure 4, conceptually presents the metrics development process.

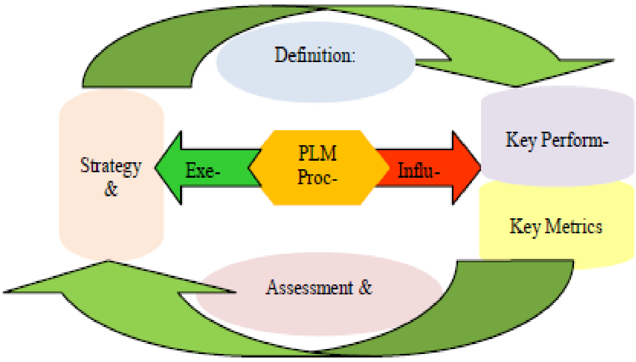

Figure 4. PLM Assessment Model [7]

The PLM processes, including ideation, design, build, service, disposal, and recycling, on one hand influence the determination the key performance indicators of success on the other hand the execution of the strategies and initiatives depends on them. The key performance indicators are directly impacted by the organizational strategies and initiatives. In other words, the organizational goals and objectives define what the organizational considers success which should determine the key performance indicators. Key metrics are derived from the performance indicators. The key metrics measure what is relevant and important to the organization as outlined by the organizational strategic plan. Outcomes of the assessment and analysis using the key metrics impact the organizational strategic plan. These metrics are all tied to business objectives related to growth, revenue, and profitability.

PLM metrics can be applied at various levels of complexity, explained in follow according to [2,6].

- At the very basic Level 1 Input metrics are measured. At this level, the question is whether the organization is applying appropriate resources to the PLM process, i.e. investments.
- At Level 2, metrics are used to determine if the appropriate PLM processes were implemented, e.g., Requirements Management, Sourcing and procurement, Distribution Quote/order generation.
- Level 3 focuses on customers being reached.
- Level 4 and 5 metrics examine the efficiency whether the outputs meet the needs of customers are being met (e.g., requirements traceability, visualization, concepts, design capture & accessibility, change control & change capacity, configuration management, commercial cost of risk, product quality) and effectiveness, if desirable results are being achieved (e.g., generation of new business, software integration, cost performance, market share, cost reduction, design reuse).

At the highest Level 6 metrics are used to measure the impact of the implementation of PLM by measuring the extent to which procedures and controls have been integrated and the return on investment. Level 6 metrics are the most complex and difficult to measure. These include waste reduction, innovation/ new products, continuous improvement, and sustainable green manufacturing.

PLM BUSINESS VALUE

When the enterprise implements the PLM concept in work, than it can move forward strategically while achieving near-term results and can establish a platform for innovation. As the enterprise address specific business issues and builds a solid foundation for future success through PLM platform, it will be able to realize measurable innovation benefits both immediately and over the long term, shown on the Figure 5.

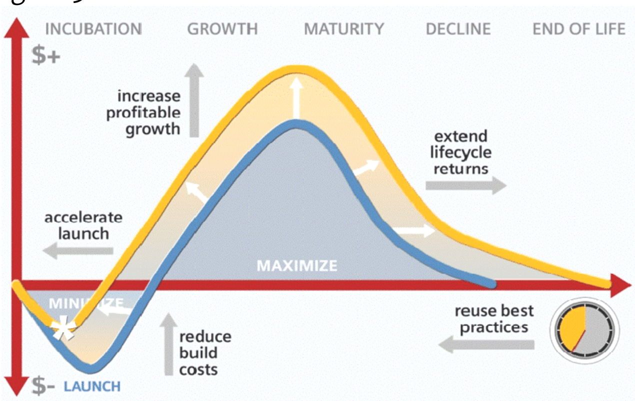

Figure 5. PLM business value

Traditionally, companies brought their products to market in time-consuming serial processes that delayed the participation of downstream contributors, such as suppliers, manufacturing experts and service/maintenance providers. By allowing to the enterprise to execute as many lifecycle tasks as possible in parallel processes, PLM enables to the enterprise to streamline and collapse critical stages in the product lifecycle. PLM delivers aligned, accurate, and highly synchronized product knowledge to multiple disciplines early in product lifecycle – thereby *avoiding the cost and scheduling impact that comes when late suggestions and unexpected concerns arise from downstream players. PLM enables to the enterprise to beat the competition to market with innovative product content that carries first to-market advantages and drives early product sales.*

- ***Increase profitable growth***

PLM allows the enterprise to create, capture and share the product-related requirements, expectations and preferences of targeted customers and markets and align these requirements with specific innovative content that customers want for a price they can afford at the time when it is needed. PLM concept gives new product ideas against quickly rising customer requirements and cost effective manufacturability.

Global cross-functional teams collaborate in real time on the development process, each contributing their unique experience and perspective. Knowledge and "lessons learned" are captured for potential re-use in a process of continual innovation. PLM facilitates mass customization by enabling to rapidly and costs effectively deliver customized product offerings that satisfy the needs of individual customers and targeted market segments. PLM combines the advantages of configuration management with option and variant management. These state-of-the-market capabilities allow the enterprise to perform portfolio planning in as flexible and continuous a process as possible.

- ***Reduce build costs***

PLM allows the enterprise to reduce cost across all of the stages in the product lifecycle – which in turn, enables to minimize the cost of the product offerings that plan, develop, manufacture and support.

For example, by leveraging PLM to understand the time and resource impacts of proposed design changes and requirements changes, the enterprise's team can make decisions that minimize lifecycle and product costs.

By using PLM to catch design flaws up front in the lifecycle, the team can avoid the cascading rework and cost associated with changing the products during the manufacturing stages of the product lifecycle. Also, the enterprise's team can use PLM to incorporate the concerns of the maintenance and service groups into the product designs and minimize warranty costs. By digitally creating and re-using the manufacturing plans, plant information and manufacturing processes, the enterprise can reduce the overall operational costs. The enterprise can also use PLM to implement virtual prototyping that enables to reduce the validation costs associated with physical prototyping.

Implementation of the PLM concept in the enterprise enables to cost effectively deliver product enhancements, derivatives, niche offerings and add-ons that extend the profitable duration of the product lifecycle. PLM facilitates this objective by enabling to create product platforms that accelerate start up processes, minimize take to market cost and maximize the revenue generated by a product's initial release.

PLM enables the enterprise to maximize the re-use of the best-practice processes, intellectual capital, human resources, product plans, production plans, production facilities and value chains across a continuing set of take-to-market programs and complete set of product and production management capabilities.

CONCLUSIONS

PLM is much more than a technology or software product. PLM is a strategic business approach to improve the business, to enable product and process innovation and enhance both top and bottom line business performance. It includes technology, processes, best practices, and other elements that provide a complete solution to business problems.

Although a quite new method with short history PLM has proven itself to be useful for all management levels within the company in both vertical and horizontal organization. In this paper, it is made analysis of using of PLM approach, by those who are doing execution and by decision makers within the organization answering to the rapid changes in the business environment. Firstly, this business approach is based on a method for analysing informal collaborative practices and modelling detailed design processes. Secondly, these processes are implemented by using PLM technologies. PLM workflows are implemented to control progress of design from project management level to document lifecycle management level and connection with lean management is analysed.

To accomplish this, lean thinking changes the focus of management from optimizing separate technologies, assets, and vertical departments to optimizing the flow of products and services through entire value streams that flow horizontally across technologies, assets, and departments to customers.

Eliminating waste along entire value streams, instead of at isolated points, creates processes that need less human effort, less space, less capital, and less time to make products and services at far less costs and with much fewer defects, compared with traditional business systems. Companies are able to respond to changing customer desires with high variety, high quality, low cost, and with very fast throughput times. Also, information management becomes much simpler and more accurate.

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RESEARCHES OF THE IMPACT QUALITY MANAGEMENT PRINCIPLES ON INTEGRATED MANAGEMENT SYSTEM PRACTICES IN SERBIA

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ABSTRACT: *The business is experiencing intense development of standardization in the first decade of the 21st century. So far developed dozens of standards / models and recommendations for management systems, which are now applied separately or integrated with one or more standardized management system. The basis for the development of standardization of business was a series of ISO 9000, which has now reached that stage IV of development. The basis for their development from the year 2000 are pripcipi quality management, their eighth We can also say that they are - the principles of quality management have always been the basis for the development of other models and standardized management system, which in this work and investigated. Namely, to determine what is the relationship between them and the practice of IMS applications in the Serbian economy, which in this paper and in detail and illustrated.*
KEYWORDS: *QM principles, IMS, Practices, Improvement*

INTRODUCTION

Today in world we have more 1 million of QMS certificate and about 25% of them are related on IMS (two or more integrated standardize management systems). If we look history, we can divide the evolution of the quality movement into five distinct eras: (i) inspections, (ii) quality control (QC), (iii) quality assurance (QA), (iv) quality management (QMS), and (v) strategic quality management, which includes TQM / BE and IMS. ISO 9000 standards dominate the world scene of quality practice in the last two decades. Today, the 4th version of ISO 9000 series (ISO 9001:2008) is actual as a model for certification. At the other hand, the quality awards (international, company's, national – there are over 150 different models today in the world) have suffered an intensive changes as well (TQM, BE, E). The whole set of techniques and a tool used for quality improvement and QMS & TQM models integration is also established. For instance the ISO 9004:2009 and other models (up to date analyses shows that over 120 different models are used today). Eight quality management principles on which the quality management system standards of the ISO 9000:2005, ISO 9001:2008 and ISO 9004:2009 series are based. Also, IMS are based on QMS and others standardize management systems, such as ISO 14001, OHSAS 18001, ISO 22001, etc are introduce. Those principles can be used by senior management as a framework to guide their organizations towards improved performance and also building and applied of IMS. This paper show to QM principles / QMS (IMS) analyses and synthesis of theory and QM/IMS practice (of specified modifications of well known models) in the world and in Serbia [31, 43-46].

WORLD'S QM THEORY AND PRACTICE – THE ADVANCED APPROACHES

If we look world's QM/IMS theory and practice today, we can see following thinks: (i) The evolution of QM/IMS model development in praxis, (ii) The new QM/IMS model dimension and it's praxis, (iii) Tools for improvement of QM/IMS praxis, (iv) Modeling and improvement of QM/IMS processes and (v) Measuring and improvement of QM/IMS praxis (benefits).

At the beginning of this paper covers the analyses of following approaches: general approach to the QMS application - against the TQM in EU, analyzed by longitudinal approach and empiric data (continual development and application of QM praxis based on integration and development of QMS and TQM) [6], generic benchmarking as a framework for BE model application in SMEs (BE model for SMEs) [9,35], development of QM models based on benchmarking analysis and organizational learning, by application of many criteria's (QM model based on learning) [10], integrated quality data model (IQDM) for support of all processes, sub processes and quality activities in the life cycle of product [11], quality of product defined as "kind of durability", through the QM process [12], the future TQM model defined based on the "body of knowledge" [35].

The conclusion can be made that the evolution of QM/IMS concept development in praxis (QM/IMS praxis in the world) is based on the new expanded approach for quality knowledge modeling (QMS, TQM / BE, IQDM, body of knowledge for QM/IMS). These approaches and advanced QM models can be used as a paradigm for improvement of good QM praxis in the Serbian economy.

The second part of the paper analyzes the new dimension of QM/IMS model and it's praxis in the world; especially the questions like: how can QMS certification benefit the organization? (production increment, market expansion, better QM model, quality problems decrement, customer satisfaction - global competitiveness) [14], integration of sustainable development as a lever of a business system, application of integrated management system (IMS) which integrates QMS, EMS, OHSAS and CSR [15], QMS certification and it's contribution to improvement of educational and training activities - education for quality (training and development for quality initiatives) [17], the application of Step by Step Programme (SSP) for the quality improvement (QI) in low innovative industries (heavy industry) - QM improvement [21], contingent approach of QM concept development in different structured organizations - contingent QM [23], QMS and TQM, can they be complementary, or not? The analyses show that the simultaneous implementation is the best approach, when organization reaches bigger and better benefits, then in separated implementation - QMS/TQM simultaneous implementation [28], the adoption to changes brought by the new versions of standards and business condition changes, that define the scope of business - gap between organizational changes and QMS models [29], the QM role and it's implication on strategic planning in organization, as a part of the global business - QM as new global competitive strategy [32], T(QM)`s influence on business results from it's competencies angle (customer orientation, continual improvement, focus on employees and the global vision of the organization) - (T)QM as a competitive factor [34] and positive and dominant influence of TQM on product quality and innovation performance - The relationship between TQM practices, quality performance, and innovation performance [36].

The conclusions based on fulfilled analyses can be recapitulated as: (i) The good QM/IMS practice positively influences on different aspects of business performances of an organization (starting with sustainable development and finishing with innovations) and inverse, (ii) the following paradigm of the research has been confirmed - The good QM/IMS practice in Serbia positively influences on overall business performances of an organization.

Quality improvement and effective implementation of good QM practice is based on the use of different engineer techniques of quality (seven old and new QM management tools) and the large number of others.

The short analyses of specific examples, based on overall research results, is given in this paper: audit as an added value of quality and powerful tool for continual improvement, with formed Fuzzy quality teams - ''fuzzy'' auditing [7], audit and self-assessment as a method and tools for QM/IMS model improvement [8], the use of QM tools and techniques in SMEs [26], and causal TQM model and it's influence to the conformity with quality requirements and customer satisfaction [33]. These analyses confirms: (i) Different tools and techniques are developed and implemented in QM improvement process, especially those important for SMEs, and (ii) our paradigm stands - QM tools and techniques are the base for QM praxis improvement in Serbia.

QMS practice is based on process modeling for all quality activities, which was the reason of our detailed analyze in the first place. It shows that different models are used for these purposes: model for analyses (performance measurement) and process re-engineering on the bases of IDEF 3 methodology [37], integrated multidimensional for process improvement methodology (IMPIM) which enables analyses of costs, as well as re-engineering (improvement) of processes [38], statistical engineering method based on variation method and analyze of it`s effects (VMEA), which enables management / improvement of QM processes [39], simulation model for value analyses (VA) by SPC and FMEA methods [40], modeling technique referred as IDEF9000 aimed for analyses and improvement of process – oriented QM systems, published as a methodology for dynamic enterprise process performance evaluation [30], Activity-Based Costing and Activity-Based Management (ABC/ABM) [41] and a Process Oriented Approach to Automated Quality Control [42]. This analyze shows us that progressive tools and techniques are used for modeling of QM processes, and the paradigm stands – There are no, or very few, tools and techniques for processes modeling used in Serbia.

At last, the final part of our analyses is concerned about improvement measurement of QM/IMS practice (benefits). It shows that different approaches are used in this area: examination of the QMS certification effects, by in-depth analyses of different influences, such as: (i) relation between QMS and TQM – Does QMS contribute to TQM improvements, and how much, (ii) QMS benefits perception – Do they overwhelm implementation costs, (iii) relation between QMS and organizational improvements – Does QMS contribute to organizational improvements, (iv) QMS implementation in all kinds and sizes of organization – It's universality for all types and situations, (v) long-term effects of QMS – Does it's application means long-term improvements, and (vi) motivation for QMS application – customer's demands and/or legal requirements are the most important for quality improvement? [1].

This approach shows that QMS certification effects can be analyzed from specific angles: QM/IMS praxis improvement, costs, organizational improvements, universality of application, long-term positive effects and motivation for certification.

The following analyses considers specific relations and effects of QS (ISO 9001/2/3):1994 and QMS certification [2], where interesting indicators were gained: 18 indicators have been analyzed (from supplier relation improvement to employees satisfaction), just 3 QS certificate indicators were better than QMS: time of investment get-back, occupational health and safety, and employee motivation. Comparison of QMS effects with TQM improvements in the same industrial branch (construction) in two countries (USA and Hong Kong) is shown in [3]. Interesting indicators were gained: Hong Kong construction companies prefer QMS certification (with the Government help), while the USA companies use TQM improvements. The same or similar quality engineering techniques for good QM praxis improvement are used. China is the world lieder in QMS certification (around 200.000 certificates for China, and just over 1 million for the entire world). The research shown in [4], analyses this phenomenon, as well as the QM praxis improvement in China by MBNQA criteria's. Interesting indicators were gained: large number of China`s companies fully understands the strategic importance of QMS, and many of them treys to apply TQM concept. The future of quality movement, managers and quality professionals is their lieder role in QM promoting as a strategic concept, as well as the best practice in this scope. Relative effectiveness of QM praxis in Thai (native, American and Japanese companies) was researched by DEA (Data Envelope Analysis) technique [5]. The following results were gained: Relative effectiveness comparison – average effectiveness of Japanese companies is better than Thai`s, or American`s. Return index comparison (of investments, capital, ...) – Thai companies are especially focused on effective and efficient QM activities, Japanese companies have high effectiveness (high level of QM praxis maturity), American companies strive for QM activities implementation with regard to costs. Costs causes – the causes of QM activities costs in American and Japanese companies are the same, but Thai companies cover their costs with lower prices and larger sale.

One interesting analyses is shown in [13], where the influence of QM practice on production system performances is given. The gained results show that the approximate analytic method for assessment of production system performances can be used, which is followed by SPC methods (QM praxis and it`s influence on productivity performances). The research shown in [16], analyses the effects of QMS certification in an interesting way, by inter-relation between five factors and their parameters: the production process improvement (7 parameters – the largest is increment of internal delivery performances (0,76)), company results improvement (4 parameters – the largest is increment of overall sale (0,84)), customer satisfaction (3 parameters – the largest is customer satisfaction index improvement (0,78)), investments (3 parameters – the largest is increment of investment index (0,89)) and personal motivation (3 parameters – the largest is increment of personal qualification index (0,60)). Gained parameters speak for themselves. The new model for prediction of QMS certificates diffusion in EU countries (Italy, UK, Netherlands, Germany, Spain and France) is given in [18]. It shows that benchmarking model of prediction is based on „logistic model”, which shows that phenomenon (QMS certification) limes to saturation. Also, the certificates diffusion depends on specific business macro-structure, and the prediction shows further enlargement of certificate number. Model for measurement of TQM purchase performances [19], integrates following factors: top management responsibility, quality measurement and benchmarking, process management, product design, employees training, purchase management and involvement and satisfactions of customers. There are 45 parameters defined for all factors and they all together gain the „overall TQM level” of the organization.

Model for QM/IMS system performance measurement in praxis, based on defined indicators is given in [20]. The general definition of indicators define it`s metrics, which provides three functions: management, communication and improvement, and also defines it`s mathematical structure. Next example is related to QM practice success analyses (TQM model) in SMEs [22], by the parameter mark, related to: results related to customers, employees and society, as well as the quality performances. This research was done for 85 SMEs organizations, and correlation parameters were gained (for 16 characteristics) and after that „on site“ check for 10 randomly picked organizations was done. The conclusion made out of the research was that specialist quality education can strongly influence on output quality of product. Evaluation of QM praxis in large organizations was done on the basis of 10 years long surveillance. [24]. It was aimed to determine the influence of internal factors on sustainable development and QM in long-term period. By longitudinal approach in research, QM strategies and activities were evaluated by analyzed relevant QM documentation. All factors with long-term influence on QM were exposed, such as influences of: CEO, executive directors, quality foundations and their creation of new quality initiatives, as a motor force for quality improvement on national level, QM model expansion and its integration with other systems (IMS). Other factors encompass audit role and evaluation, customer relation, informational system and creation of solid relation between business plan and QM activities.

One of the key elements of QM/IMS praxis is monitoring and measurement of its performances. The approach given in [25] is the study that evaluates QM praxis in Irish industry, on the bases of its performances. The key element of this research is linear relation with correlation coefficient of 0,694 between QM praxis and industry performances. The research was done by specially designed questionnaire, which was used to gain all relevant information about QM praxis and business results. The Study shown in [27] analyses nine factors of QMS (6 – internal characteristics of QMS and 3 – external characteristics of QMS), HK for metal industry. It shows that quality is the most important factor for sales and marketing performances improvement in an organization. This research also pointed out that good QM practice in organizations builds the basis for decrement of production costs and improvement of organizational effectiveness and efficiency. Foretoken analyses enables us to define following conclusions: (i) different approaches and methodologies are used for QM praxis evaluation. These approaches and methodologies represent annex of ISO 19011 standard, or are complementary with a part of it, and (ii) QM praxis in high developed countries is defined as „the best“.

QM PRAXIS IN SERBIA – SOME RESEARCHES RESULTS

QM/IMS praxis in Serbia can be observed from two different views: (i) quality improvement in business, based on QMS certification, and (ii) development and application of good QM praxis. The first approach can be defined by following facts (May 2011): about 1950 QMS certificates, 8 ISO 16949 certificates, about 190 EMS certificates, about 430 (QMS + EMS) certificates, 270 (QMS + EMS + OHSAS) certificates, 318 HACCP certificates, 44 ISO 22001 certificates, 9 ISO 13485:2003 and 9 ISO 27001 certificates. If we have on mind the fact that there is over 1 million of QMS certificates at this moment on the world, Serbia participates about 2 promiles of overall certificates number. That is extremely small number, because there is 205 countries today in the world, and Serbia holds 104th place in the world by the number of certificates. Considering the level of economic development (BND) and level of technical and technological development, Serbia is on 76th place, it is clear that our country deserves larger number of QMS certificates. In the region of West Balkans, all significant countries have larger number of QMS certificates (some of them, like Hungary have more 17000 QMS certificates, Romania more of 11000, etc). Why is that so?

Here are some reasons: (i) commerce transition process with owner structure change lasts for very long period (almost two decades), so that we have about 100 organizations that lost their certificates – they did not go for recertification, (ii) no consistent Government policy in the scope of macro-economics which are supposed to encourage commercial subjects for QMS certification (there were some palliative measures till now), and (iii) lack of national strategy for long-term quality development in Serbia. Because of all this, YUSQ, as a National Organization for Quality started national programme named: Quality improvement study in Serbia, in cooperation with EOQ and EC. This study is based on following paradigms: (i) good QM praxis has positive influence on business performances and development on organizations (Pharmaceutical industry, „Metalac“ – Gornji Milanovac, Carlsberg – Serbia, Celarevo, „Tigar“ – Pirot, Elektro-Vojvodina, Novi Sad, etc.), (ii) Quality engineering tools and techniques for QM praxis improvement in Serbia (iii) New national strategy for quality improvement based on good QM praxis in EU (UASQ, EOQ and EC Study), (iv) Continual education for quality (UASQ permanent education system for quality) and (v) Education and lieder role of management in good QM praxis in Serbia.

Next part is related on researches of the impact Quality Management Principles on Quality Management Practices in Serbia. We are used questionnaire and Lickert scale model (five level – from 1/low to 5/high). We are formulate companies data base – more 300 (about 30% without (QMS) IMS certificate and about 70% with IMS (QMS) certificate). The organizations were divided into groups according to size and industry type, and each group was divided into IMS (QMS) and non-IMS (QMS) certified organizations. We are received 338 responses (about 62% have such type of IMS) to the 720 survey instruments that were distributed, by e-mail. 16 responses were excluded from the study because they were incomplete. The survey instruments were mailed directly to top and middle managers who were responsible for quality management practices. Table 1 represents the sample by industry type (we are used UN classification system), showing that it comprised 237 manufacturing and service industries. As indicated in the table, most participants in this study were manufacturing companies, representing 66 % of the total sample. These participants were classified into ten categories: (1) oil & gas, (2) basic materials, (3) industrials, (4) consumer goods, (5) health care, (6) consumer services, (7) telecommunications, (8) *utilities, (9) financials and (10) technology. Detailed classification of industrials is given on table 2.*

Table 1. The sample by industry type

Industry	Non-IMS(QMS)	IMS(QMS)	Total
Oil & Gas	2	5	7
Basic Materials	11	35	46
Industrials	15	49	64
Consumer Goods	12	39	51
Health Care	6	1	7
Consumer Services	2	4	6
Telecommunications	1	3	4
Utilities	1	4	5
Financials	5	11	16
Technology	8	28	36
	64	174	238

Table 2. Industrials – detailed classification

Industry	Supersector	Sector
	Construction & Materials	Construction & Materials
	Industrial Goods & Services	Aerospace & Defense
		General Industrials
Industrials		Electronic & Electrical Equipment
		Industrial Engineering
		Industrial Transportation
		Support Services

Table 3 shows the companies grouped in terms of number of employees. Most of the samples were taken from small organizations. The IMS registered organizations in the study tended to have more employees than the non-IMS(QMS) registered organizations.

Table 3. Review analyzing organizations according number of employs

Size	Employees	Non-IMS(QMS)	IMS(QMS)	Total
Small	< 50	26	133	159
Medium	50 - 249	24	43	67
Large	>250	13	9	22
	Total	63	185	**238**

Tables 4 and 5 show the results of descriptive statistics and ANOVA. There were significant differences in all seven QM principles: (1) Customer focused organization, (2) leadership, (3) Involvement of people, (4) Process approach, (5) System approach to management, (6) Continual improvement, (7) Factual approach to decision making, and (8) Mutually beneficial supplier relationships, between non-IMS(QMS) and IMS(QMS) organizations. In addition, the IMS (QMS) organizations had higher mean results in all of the quality management principles. The mean values for QM/IMS principles were the highest for IMS(QMS) organizations had higher mean values than non-IMS(QMS) registered companies. Table 5 show that QM principles (system approach to management) for non-IMS(QMS) organization not have significant level in relation of IMS(QMS) certificated organization.

Table 4. Basic statistics

QM Principles	Non-IMS(QMS)	IMS(QMS)	Average
Customer focused organisation	3.87	4.12	4.02
Leadership	3.53	3.81	3.66
Involvement of people	3.67	3.96	3.84
Process approach	3.31	3.72	3.51
System approach to management	3.53	3.80	3.66
Continual improvement	3.40	3.85	3.65
Factual approach to decision making	3.61	4.13	3.87
Mutually beneficial supplier relationships	3.56	3.97	3.79
Average	3.55	3.92	3.73

** Significant at 0.05 level.*

Table 5. ANOVA analysis results

QM Principles	Non-IMS(QMS)	F-Value	IMS(QMS)
Customer focused organization	3.89	8.05*	4.15
Leadership	3.51	3.27*	3.82
Involvement of people	3.69	7.95*	3.99
Process approach	3.30	15.71*	3.71
System approach to management	3.51	0.24**	3.81
Continual improvement	3.43	12.61*	3.89
Factual approach to decision making	3.63	7.11*	4.11
Mutually beneficial supplier relationships	3.58	7.26*	3.99

** Significant at 0.05 level.*
*** Not Significant at 0.05 level.*

Table 6. Results of Multiple Comparisons between Non-QMS and QMS

QM Principles	Non-IMS (QMS)/ Mean	Mean / Difference	IMS (QMS)	HSD Test	LSD Test
Customer focused organization	3.89	- 0.26	4.15	*	*
Leadership	3.51	- 0.31	3.82	*	*
Involvement of people	3.69	- 0.33	3.99	*	*
Process approach	3.30	- 0.39	3.71	*	*
System approach to management	3.51	- 0.30	3.81	*	*
Continual improvement	3.43	- 0.45	3.89	*	*
Factual approach to decision making	3.63	- 0.38	4.11	*	*
Mutually beneficial supplier relationships	3.58	- 0.41	3.99	*	*

** Significant at 0.05 level.*

As shown in Tables 6 a comparison of the group means for each of the QM principles shows that there are significant differences for all principles between IMS(QMS) and non-IMS(QMS) organizations. To test these differences statistically, a multiple comparison test (HSD and LSD test) was carried out between those organizations.

It could be concluded that the requirements of ISO 9001:2008 standardization made a particular impact on QM principles.

QM/IMS RESEARCH IN SERBIA

Basic research centers in Serbia for quality development and technology are: (i) Mechanical Faculty in Belgrade, Laboratory for production metrology and TQM: (a) research, development and application of good QM/IMS praxis – BE model (business organizations, educational organizations), (b) intelligent and digital quality model for new technology systems generations, and (c) six sigma and Taguchi method for production without waste - research, development and application, (ii) Vinca institutes, Belgrade - development and application of EU directives in Serbia, (iii) Faculty of technical sciences – IIS – ITC, Novi Sad: (a) development and application of good QM and IMS praxis in commerce of Serbia, and (b) education for quality, and (iv) CIM College, Nis: (a) research, development and application of software models for quality engineering techniques, (b) development and application of software model for process modeling in QM and IMS commerce praxis, and (iii) development and application of good QM and IMS praxis in Serbia.

If we compare scope of research mentioned above, with research themes shown in chapter 2 of this paper, the conclusion can be made that Serbia does not lag behind in this area, as it was stated in paragraph 3. This can assure us that the paradigms defined in paragraph above, were defined correctly.

CONCLUSION REMARKS

Talking about QM theory and praxis in the world and in Serbia today, we can make a conclusion that: (i) quality and sustainable development are basic paradigms of commerce in high developed countries, in the first decade of 21st century, and (ii) Serbia has all necessary prerequisites for high achievements in this area, but necessary steps needed for this accomplishment are intensive state changing activities, defined as paradigms in paragraph 3. UASQ with it`s activities has a leading role in those processes, and accomplishes that in some long-term period. This work represents a part of research done in projects (QM/IMS praxis and implementation of EU directives) which is supported by Serbian Ministry of Science and Technology.

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LAYOUT DESIGN OF FLEXIBLE MANUFACTURING SYSTEM

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ABSTRACT: A today trend in manufacturing is characterized by production broadening, innovation cycle shortening, and the products have new shape, material and functions. The production strategy focused to time need change from the traditional functional production structure to production by flexible manufacturing cells and lines. Production by automated manufacturing system (AMS) is a most important manufacturing philosophy in last years. Our main aim of project is building of laboratory, in which will be located flexible manufacturing system consisting of at least two production machines with NC control (milling machines, lathe). These machines will be linked with transport system and they will be served by industrial robots. Within this flexible manufacturing system will be also station for quality control with camera systems and rack warehouse. The design of manufacturing system is a part of production planning. The main determining factors for the manufacturing system design are: the product, the production volume, the used machines, the disposable manpower, the disposable infrastructure and the legislative frame for the specific cases.
KEYWORDS: Paperless manufacturing, flexible manufacturing, robotized manufacturing, material flow

INTRODUCTION

At the end of 2008 our workplace - Department of Production Systems and Applied Mechanics responded to the challenge number: OPVaV-2008/2.2/01-SORO ASFEU Agency and the Ministry of Education has developed a project called "Laboratory of flexible manufacturing systems with robotic handling for environment without drawing production. [2]

The main target of project „OPVaV-2008/2.2/01-SORO – 26220220055" is building the laboratory equipped by flexible manufacturing cell and directly connected to our CAD laboratory. The direct connection between these two laboratories enables realization the jointed design and manufacturing system. The main advance of this system is a possibility of manufacturing fast reaction to design changes without a manufacturing documentation on paper form. This is a model of a new "digital" manufacturing. [1]

The flexible manufacturing system will contain the two CNC controlled machines (milling and lathe machines). These machines will be interconnected by a transport system and operated by industrial robots. This flexible manufacturing system will also include a quality control station including the camera system and shelf storage.

Material flow is an integral part of every production system. In this paper we will focus to material flow suggestions possibilities in the flexible manufacturing system. The material flow is determined by several variants of system layout.

MANUFACTURING SYSTEM DESIGN

The design of manufacturing system is a part of production planning. The main determining factors for the manufacturing system design are: the product, the production volume, the used machines, the disposable manpower, the disposable infrastructure and the legislative frame for the specific cases.

The manufacturing systems design is a fine prepared project which include the several kinds of calculations (capacity, space, manpower,…), material and information flow and others.

In manufacturing system design time are very important the realization of following tasks:

- data collection and analyze methods for manufacturing system analyze,
- methods for measuring and analyzing of tasks,
- manufacturing systems design methodology,
- methodology of manufacturing system controlling,
- computer simulation of designed manufacturing system,
- methodology for a continuously improving of a design team work.

In base of manufacturing systems organization we can design these systems by following profiles:

- technological – machines are fully interchangeable,
- subjective – its characteristic is sequence of the material flow,
- combined – enables variability of material flow,
- virtual – the same machine is associated into several cells on base of actual needs. [3]

The control system of manufacturing system is connected at input side to manufacturing management system of company. This system provides the planning and managing of manufacturing requests and in the connection to control systems of a several manufacturing processes provides the information and material flow integration in the higher level. This means that this management system provide the managing the whole material and information flow on all manufacturing phase.

MATERIAL FLOW PLANNING

In the process of material flow planning, it is necessary to consider the fact that the aim of the plan is not the transport and storage of material as these activities are expensive and do not improve the material value. Current systems for handling, transport and storage provide a great number of possibilities for the application of expensive and complex systems. The optimal design should contain minimum storages, transport and handling. Hence, the suitable way before the elaboration of detailed system solution is to reduce mentioned activities to a minimum. [4]

All features of manufacturing system must be planned considering mutual interactions and verified by a simulation model before the system realization.

From the point of view of manufacturing and material flow, it is talking about mutual connections and formation of material chain. The main aim is the mutual coordination of all material flows and assurance of the efficiency of material flow between individual segments of a chain.

Material flow analysis is one of the main parts of production process analysis. The type, quantity, volume, mass and dimensions of manipulated material have strong influence to possibilities of manipulation, storage, packaging and transport. In time of material flow analysis we observe the important material movements between material incoming and outgoing stations. The methods used for analysis are similar for production processes and for material flow processes too (Sankey diagrams, CRAFT, coordinate methods, networking methods, linear programming, value analysis …). [4]

The general sequence of material flow planning is a following:

- *material flow analyze, volume of transport operations determination,*
- *layout*
- *analyze of existing devices,*
- *design of transport systems variants,*
- *computer simulations and dynamical dimensioning of material transport and handling devices.*

In this time we solve the equations of material flow (Figure 1)

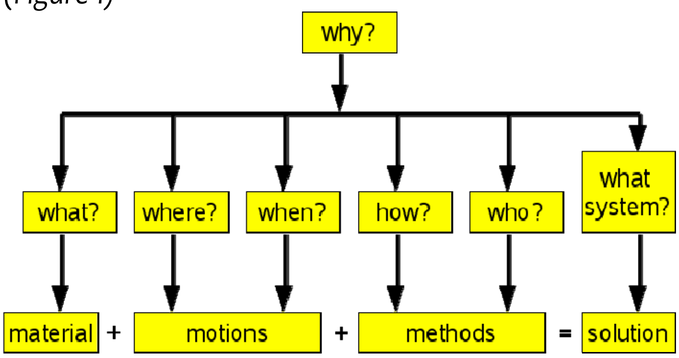

Figure 1. Material flow equation

One of most usual method to material flow representation is a triangle net method. The triangle net of relations (Figure 2) described the factors and relations between workplaces which acting to material flow.

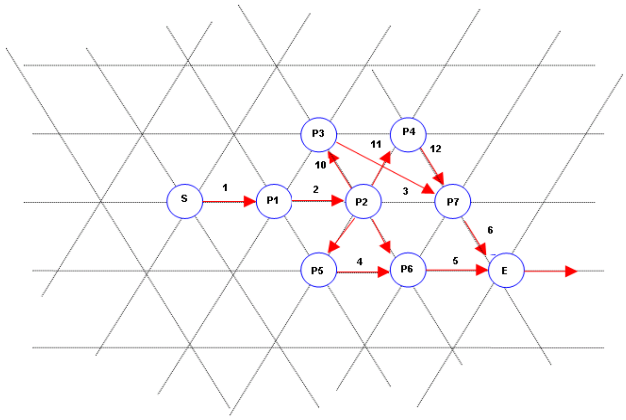

Figure 2: The triangle method

This triangle graph shows all the relationships, the most important factors which are affecting on the material flow. Relations between the deployment or permanent place of work and factors affecting them, as well as between sites and the actors themselves are classified in some way.

The classification of relationship is analytical work requiring detailed knowledge of the situation and many technical aspects.

Assign a classification code corresponds to a specific rule addressing the project deployment. For greater clearness it is recommended to identify the individual classification colors.

This procedure assumes the practical application of this method:

1) *First, we develop checkerboard table transport relations between objects whose spatial situation we want to address,*
2) *Then we determine the order of magnitude of the volume of transported material and the serial number inscribed in the upper right corner of each box in the occupied checkerboard table*
3) *We have to construct a table of transport relations between objects. It consists of a number of columns, there are transshipments, and has 4 lines. In the first is order. In the second row are written symbols selected suppliers, to the third row are written customers. In the last line is given the volume of traffic,*
4) *It is necessary to draw in the triangular network module. With it will solve the entire network.*
5) *We are solved spatial situation so that we in look up the auxiliary table supplier and customer, who are assigned to the first order number. We draw the symbols in any two adjacent vertices in an arbitrary triangle network. To the fourth row we can bring mutual traffic volume above oriented*

segment. By this segment are two points connected. It is necessary to state only serial number. In the next step, we are searching for that point, fourth and further points to the most intense flow into one of those pairs. We proceed to the deployment of all or at least the main objects in the examined area. [2]

THE POSSIBLE VARIANTS OF FLEXIBLE PRODUCTION SYSTEM LAYOUT AT OUR LABORATORY

In Figure 3 are showed the simplest variant of flexible manufacturing system layout. This system contains two machining centers (milling and turning), assembly station, shelf storage with manipulator and industrial robot on rail.

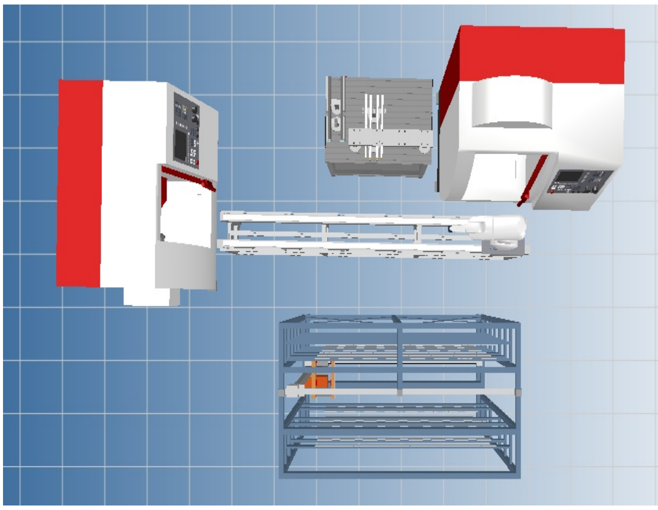

Figure 3: The first variant of production system layout

The other variant of layout is shoved at Figure 4. This variant is a more complex. This flexible manufacturing system contains devices from a previous variant and it is extended by a transport system in a closed loop, quality control station and by a robotized assembly station.

At our institute we would be like realize the second variant of a flexible manufacturing system.

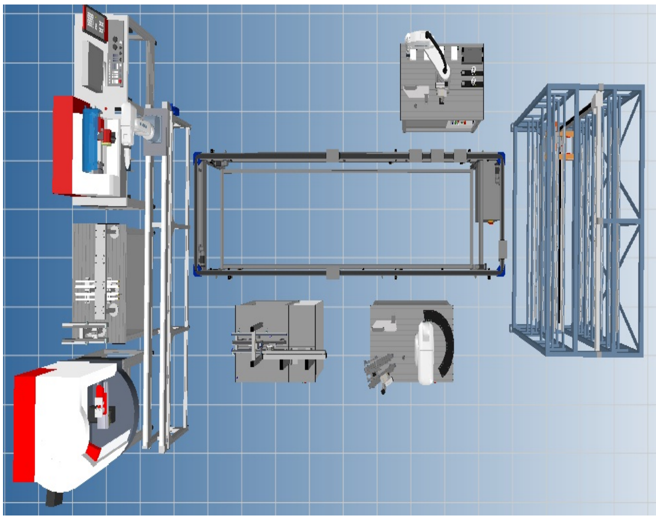

Figure 4: The second variant of production system layout

CONCLUSIONS

Our main aim of project is building of laboratory, in which will be located flexible manufacturing system consisting of at least two production machines with NC control (milling machines, lathe). These machines will be linked with transport system and they will be served by industrial robots. Within this flexible manufacturing system will be also station for quality control with camera systems and rack warehouse.

In the final phase of this project in year 2012, the flexible production system will be linked with the CAD laboratory of our institute and it will arise as "laboratory flexible manufacturing systems with robotic handling for environment of without drawing production.

After termination of the project our Institute will have a fully functional prototype of a flexible manufacturing system with robotic operation of individual production facilities, which will be integrated with CAx laboratories. [2]

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1. Ali NIKKAR, 2. Hamid Reza KHALAJ HEDAYATI, 3. Saeid SOHRABI

BOUNDARY VALUE AND APPLICATION OF CAUCHY'S INTEGRALS ON TWO-DIMENSIONAL ELASTICITY PROBLEM

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ABSTRACT: *In discussing continuation in two-dimensional elasticity it is necessary to use certain results concerning the boundary values of Cauchy integrals. The purpose of this paper is to use the value of Cauchy's Integrals to find the solution problems of two-dimensional elasticity.*
KEYWORDS: *Cauchy's integral, Boundary values, Limit values, Holder condition*

INTRODUCTION

The solution of problems of two-dimensional elasticity by methods using the techniques of the complex variable theory requires the determination from the boundary conditions, of two unknown complex functions, holomorphic at all points in the region of the complex plane occupied by the elastic material [1].

A number of methods of solving these problems have been given by Muskhelishvili (1953) and others. One such method involves the continuation of one or both these unknown functions across the boundary into the region of the complex plane not occupied by elastic material and the expressing the result in terms of Cauchy Integrals. A careful examination of the method and of the results obtained show that a more simple and direct approach may be given. This is the concern of this paper and simply involves the determination of a holomorphic function having a known real part on the boundary. Such a function may be expressed as a Cauchy's Integral [1].

PRELIMINARY DEFINITIONS

Let f (t) be an integral function of t along a line L_o then the function

$$(z) = \frac{1}{2\pi i}\int_L \frac{f(t)dt}{t-z} \qquad (1)$$

Is called the Cauchy Integral of f(t) taken along the line L_o Clearly φ(z) is an analytic function of z throughout the whole complex plane except on the line L_o. Also

$$(z) = O(z^{-1}) \quad \text{at} \quad z=\infty \qquad (2)$$

Further, if the end points A, B of line L are given by t = a, b respectively, then in general [4]

$$(z) = \begin{Bmatrix} O\{\log(z-a)\} & \text{at } z=a \\ O\{\log(z-b)\} & \text{at } z=b \end{Bmatrix} \qquad (3)$$

The line L may consist of more than one segment, so there may be several end points. However it is important to know boundary value of Cauchy's integral when z=t_o, a point on L. When proceeding along L in the positive neighborhood S+ of a point P on it, is that the region to the left of P and the negative neighborhood S_- is that the right of P. If the region is closed line as C, then S_+ is the interior of C and S_- is exterior of C.

Let f (t) be a function defined at points P (t) a line L in the complex plane. The function f (t) is said to satisfy the Holder condition, with constant A and Holder index μ, if it satisfies the inequality

$$| f(t) - f(t_0) | \le AB\, | t - t_0 |\, \mu \qquad (4)$$

where A > 0, 0 < μ ≤ 1 in the neighborhood of a point t_o of L_o [5].

BOUNDARY VALUE OF CAUCHY'S INTEGRALS ON ELASTICITY PROBLEM

However it is important to know Boundary Value of Cauchy's Integral when z=t_o, a point on L_o

Consider the Integral

$$\frac{1}{2\pi i}\int_L \frac{f(t)dt}{t-z} \qquad (5)$$

Let P_1, P_2 be the points t_1, t_2 of L in the neighborhood of t such that

$$| t_1 - t_0 | = | t_2 - t_0 | = \delta . \qquad (6)$$

The principal value at t_o of Cauchy's Integral along L is defined to be:

$$(t_0) = \frac{1}{2\pi i}\lim_{\delta \to 0}\left\{\int_{AP_1} + \int_{P_2B}\right\}\frac{f(t)dt}{t-t_0}. \qquad (7)$$

This may be written

$$(t_0) = \frac{1}{2\pi i}\lim_{\delta \to 0}\left\{\int_{AP_1} + \int_{P_2B}\right\}\left\{\frac{f(t)-f(t_0)}{t-t_0} + \frac{f(t_0)}{t-t_0}\right\}dt . \qquad (8)$$

Now, If f (t) satisfies the Holder Condition [see Appendix], then we will have

$$\frac{f(t)-f(t_0)}{t-t_0} \le \frac{A}{| t - t_0 |^{1-\mu}} \qquad (9)$$

Since 0 ≤1-μ <, 1 then first part of the limit converges. Also

$$\left\{\int_{AP1} + \int_{P2B}\right\}\frac{dt}{t-t_0} = \left[\log(t-t_0)\right]_a^{t_1} + \left[\log(t-t_0)\right]_{t_2}^{b} \qquad (10)$$

where any branch of the logarithmic function may be chosen. It is convenient to choose to connect P_1, P_2 by the arc P_1P_3 P_2 of a circle in S_+, with center P_o and radius as shown in the figure 1.

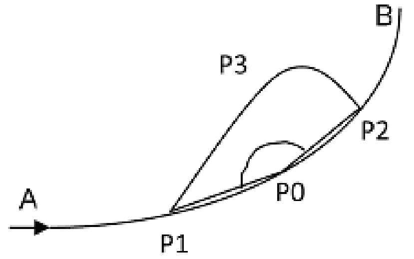

Figure 1.

If $t = a, b$ are the end points A,B respectively of L and the logarithmic function is assumed to change continuously along $A_{P_1P_3P_2}B$, then

$$\lim_{\delta \to 0} \left\{ \int_{AP_1} + \int_{P_2B} \right\} \frac{dt}{t - t_0} = \log \frac{b - t_0}{a - t_0} + \lim_{\delta \to 0} \log \frac{t_1 - t_0}{t_2 - t_0} = \tag{11}$$

$$\log \frac{b - t_0}{a - t_0} + \lim_{\delta \to 0} i\theta = \log \frac{b - t_0}{a - t_0} + \lim_{\delta \to 0} i\pi.$$

So

$$(t_0) = \frac{1}{2} f(t_0) + \frac{1}{2\pi i} f(t_0) \log \frac{b - t_0}{a - t_0} + \frac{1}{2\pi i} \int \frac{f(t) - f(t_0)}{t - t_0} dt. \tag{12}$$

If L is a simple contour C, then a=b and

THE BOUNDARY EQUATION

Consider elastic material with boundary curve C occupying the region S_+ or the complex plane. For homogeneous isotropic elastic material free from body force, the stress and displacement gradient components may be expressed as the real part of certain combinations of unknown function Ω (z), ω (z), and holomorphic at all points z in S_+ and their derivatives. A typical expression of this kind may be written in the form

$$\sum_{r=1}^{n} P_r(z)\Omega_r(z) \tag{14}$$

where Ω_t (z), r=1,2,...,n , denote the unknown holomorphic functions, Ω'_t (z), Ω''_t (z),..., ω'(z), ω''(z) ,... and P_r (z) , r=1,2,...,n , denote certain known non-holomorphic function such as $\bar{z}$, $\frac{z}{\bar{z}}$ ... or constants.

If the real part of such a typical expression is given as f (t) on the boundary C where z=t then it is required to determine the Ω_t (z) such that

$$\mathrm{Re}\left[\sum_{r=1}^{n} P_r(z)\Omega_r(z)\right]_{z=t} = f(t) \tag{15}$$

There being given sufficient condition of this form to enable all the Ω_r (z) to be determined.

This is the problem of two-dimensional elasticity.

Now let π_t (z), r=1,2,...,n , be functions, holomorphic at all points z in S_+ having the same boundary values respectively as P_r (z) , r=1,2,...,n on the boundary z=t . Such that

$$\pi_{r_+}(t) = P_{r_+}(t) \tag{16}$$

The boundary equation (15) may now be written

$$\mathrm{Re}\left[\sum_{r=1}^{n} \pi_r(z)\Omega_r(z)\right]_{z=t} = f(t) \tag{17}$$

Thus the problem has been reduced to that of finding a function, holomorphic at all points z in S_+ which has a known real part on the boundary, z=t . This function may be expressed as a Cauchy Integral.

The requirement of equation (16) that the functions P_r (z), π_r (z) should have the same value on the boundary greatly restricts the functions π_+ (z) which is assumed to exist. In practice the functions involved are very simple and present no difficulties.

THE ELASTIC HALF-PLANE

Now consider elastic material with boundary along the real axis occupying the semi-infinite region S_+, y>0, of the complex plane. The mean cartesian stress components are given by the equations

$$2(\widetilde{xx} + \widetilde{yy}) = \Omega'(z) + \overline{\Omega'(z)} \tag{18}$$

$$2(\widetilde{xx} - \widetilde{yy} + 2i\widetilde{xy}) = -z\Omega''(z) - \overline{\omega''(z)} \tag{19}$$

And the mean Cartesian displacement components by

$$\delta\mu(u + iv) = k\Omega(z) - z\Omega''(z) - \overline{\omega''(z)} \tag{20}$$

where Ω (z), ω (z) are the unknown functions, holomorphic at all points z in S_+ which has to be determined from the boundary conditions.

Equation (18), (19) lead to

$$4\widetilde{yy} = \mathrm{Re}\{2\Omega'(z) + \bar{z}\Omega''(z) + \omega''(z)\} \tag{21}$$

$$4\widetilde{xy} = \mathrm{Re}\ - i\{\bar{z}\Omega''(z) + \omega''(z)\} \tag{22}$$

And equation (20) to

$$-\delta\mu\frac{\partial u}{\partial x} = \mathrm{Re}\{(1 - k)\Omega'(z) + \bar{z}\Omega''(z) + \omega''(z)\} \tag{23}$$

$$-\delta\mu\frac{\partial v}{\partial x} = \mathrm{Re}\ - i\{(1 + k)\Omega'(z) + \bar{z}\Omega''(z) + \omega''(z)\} \tag{24}$$

Suppose the boundary conditions to be given by any two of the equations

$$\begin{Bmatrix} 4(\widetilde{yy})_{y=0} = f_1(t) & 4(\widetilde{xy})_{y=0} = f_2(t) \\ -\delta\mu(\frac{\partial u}{\partial x})_{y=0} = f_3(t) & -\delta\mu(\frac{\partial u}{\partial x})_{y=0} = f_4(t) \end{Bmatrix} \tag{25}$$

Thus it is required to find Ω (z), ω (z) to satisfy any two of the equations

$$\mathrm{Re}\left[\{2\Omega'(z) + \bar{z}\Omega''(z) + \omega''(z)\}\right]_{y=0} = f_1(t) \tag{26}$$

$$\mathrm{Re}\left[-i\{\bar{z}\Omega''(z) + \omega''(z)\}\right]_{y=0} = f_2(t) \tag{27}$$

$$\mathrm{Re}\left[\{(1 - k)\Omega'(z) + \bar{z}\Omega''(z) + \omega''(z)\}\right]_{y=0} = f_3(t) \tag{28}$$

$$\mathrm{Re}\left[i\{(1 + k)\Omega'(z) + \bar{z}\Omega''(z) + \omega''(z)\}\right]_{y=0} = f_4(t) \tag{29}$$

These equations contain the holomorphic functions Ω'_t (z), Ω''_t (z), ω'' (z) and the non-holomorphic function $\bar{z}$. The essential step in the solution of the problem is to replace $\bar{z}$ by z which has the same value on the real axis [4].

The boundary equations now become

$$\mathrm{Re}\left[\{2\Omega'(z) + \bar{z}\Omega''(z) + \omega''(z)\}\right]_{y=0} = f_1(t) \tag{30}$$

$$\mathrm{Re}\left[-i\{\bar{z}\Omega''(z) + \omega''(z)\}\right]_{y=0} = f_2(t) \tag{31}$$

$$\mathrm{Re}\left[\{(1 - k)\Omega'(z) + \bar{z}\Omega''(z) + \omega''(z)\}\right]_{y=0} = f_3(t) \tag{32}$$

$$\mathrm{Re}\left[i\{(1 + k)\Omega'(z) + \bar{z}\Omega''(z) + \omega''(z)\}\right]_{y=0} = f_4(t) \tag{33}$$

And the problem reduces to that of finding functions with known real parts on the boundary. The solution is given in terms of Cauchy Integrals by

$$2\Omega'(z) + \bar{z}\Omega''(z) + \omega''(z) = \frac{1}{\pi i}\int_{-\infty}^{+\infty} f_1(t)\frac{dt}{t - z} + \tau_1(t) \tag{34}$$

$$-i\{\bar{z}\Omega''(z)+\omega''(z)\} = \frac{1}{\pi i}\int_{-\infty}^{+\infty} f_2(t)\frac{dt}{t-z}+\tau_2(t) \quad (35)$$

$$(1-k)\Omega'(z)+\bar{z}\Omega''(z)+\omega''(z) = \frac{1}{\pi i}\int_{-\infty}^{+\infty} f_3(t)\frac{dt}{t-z}+\tau_3(t) \quad (36)$$

$$i\{(1+k)\Omega'(z)+\bar{z}\Omega''(z)+\omega''(z)\} = \frac{1}{\pi i}\int_{-\infty}^{+\infty} f_4(t)\frac{dt}{t-z}+\tau_{41}(t) \quad (37)$$

where $\tau_j(z)$, j=1,2,3,4 are arbitrary functions of z which vanish for stresses that are $o(z^{-1})$ at infinity [6].

Hence if any two of the $f_j(t)$, j=1,2,3,4 are known, the functions Ω (z), ω (z) may be found and the elastic problem solved.

THE ELASTIC PLATE CONTAINING A CIRCULAR HOLE

Consider elastic material occupying the region S_+ lying outside the circle C, $z\bar{z} = a^2$.

The mean polar stress components are given by [6],

$$\breve{rr}+\breve{\theta\theta} = \Omega'(z)+\overline{\Omega'(z)} \quad (38)$$

$$\breve{rr}-\breve{\theta\theta}+2i\breve{r\theta} = -z\Omega''(z)-\overline{\omega''(z)} \quad (39)$$

These equations lead to

$$4\breve{rr} = \mathrm{Re}\left\{2\Omega'(z)+\bar{z}\Omega''(z)+\frac{z}{\bar{z}}\omega''(z)\right\} \quad (40)$$

$$4\breve{r\theta} = \mathrm{Re}\ -i\left\{\bar{z}\Omega''(z)+\frac{z}{\bar{z}}\omega''(z)\right\} \quad (41)$$

And equation (20) to

$$-\frac{\delta\mu i}{z}\frac{\partial}{\partial\theta}(u-iv) = \Omega'(z)-k\overline{\Omega'(z)}-\bar{z}\Omega''(z)-\frac{z}{\bar{z}}\omega''(z) \quad (42)$$

Now let the boundary conditions on the circle C, $z=t=ae^{i\vartheta}$, be given by any two of the functions

$$\left\{\begin{array}{ll} 4(\breve{yy})_{y=0} = f_1(t) & 4(\breve{xy})_{y=0} = f_2(t) \\ \left[-\frac{\delta\mu i}{z}\frac{\partial}{\partial\theta}(u-iv)\right]_{r=a} = f_3(t)-if_4(t) & \end{array}\right\} \quad (43)$$

Then it is required to find Ω (z), ω (z) such that

$$\mathrm{Re}\left[\left\{2\Omega'(z)-\bar{z}\Omega''(z)-\frac{z}{\bar{z}}\omega''(z)\right\}\right]_{r=a} = f_1(t) \quad (44)$$

$$\mathrm{Re}\left[-i\left\{\bar{z}\Omega''(z)+\frac{z}{\bar{z}}\omega''(z)\right\}\right]_{r=a} = f_2(t) \quad (45)$$

$$\mathrm{Re}\left[\left\{(1-k)\Omega'(z)-\bar{z}\Omega''(z)-\frac{z}{\bar{z}}\omega''(z)\right\}\right]_{r=a} = f_3(t) \quad (46)$$

$$\mathrm{Re}\left[i\left\{(1+k)\Omega'(z)-\bar{z}\Omega''(z)-\frac{z}{\bar{z}}\omega''(z)\right\}\right]_{r=a} = f_4(t) \quad (47)$$

In this case it is sufficient to replace the function $\frac{z}{\bar{z}}$ by $\frac{z^2}{a^2}$ which has the same value on the circle $z=t=ae^{i\vartheta}$ [5].

This then leads to the solution

$$2\Omega'(z)-\bar{z}\Omega''(z)-\frac{z^2}{a^2}\omega''(z) = \frac{1}{\pi i}\int_c f_1(t)\frac{dt}{t-z}-\frac{1}{2\pi i}\int_c f_1(t)\frac{dt}{t}+i\lambda_1 \quad (48)$$

$$-i\left\{\bar{z}\Omega''(z)+\frac{z^2}{a^2}\omega''(z)\right\} = \frac{1}{\pi i}\int_c f_2(t)\frac{dt}{t-z}-\frac{1}{2\pi i}\int_c f_2(t)\frac{dt}{t}+i\lambda_2 \quad (49)$$

$$(1-k)\Omega'(z)-\bar{z}\Omega''(z)-\frac{z^2}{a^2}\omega''(z) = \frac{1}{\pi i}\int_c f_3(t)\frac{dt}{t-z}-\frac{1}{2\pi i}\int_c f_3(t)\frac{dt}{t}+i\lambda_3 \quad (50)$$

$$i\left\{(1+k)\Omega'(z)-\bar{z}\Omega''(z)-\frac{z^2}{a^2}\omega''(z)\right\} = \frac{1}{\pi i}\int_c f_4(t)\frac{dt}{t-z}-\frac{1}{2\pi i}\int_c f_4(t)\frac{dt}{t}+i\lambda_4 \quad (51)$$

where λ_j, j=1,2,3,4 are constants to be determined to ensure that the stresses are $o(z^{-1})$ at infinity.

Any two of these equations will enable Ω (z), ω (z) to be determined.

CONCLUSIONS

It has been shown that the solution of the boundary value problem of two-dimensional elasticity may be solved simply and directly by finding holomorphics functions, with known real parts on the boundary, in terms of Cauchy Integrals. The method requires only that simple non-holomorphic functions be replaced by holomorphic functions having the same boundary values and has the advantage that no reference need be made, as in the case of continuation, to those regions of the complex plane not occupied by elastic material. Furthermore this technique provides a straightforward solution to problems in which a combination of any two of the stress or displacement. Components are known on the boundary. In addition the method may be applied to problems which can be solved by conformal transformation.

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Scientific Events in 2012

1. THE 7th INTERNATIONAL SYMPOSIUM – MACHINE AND INDUSTRIAL DESIGN IN MECHANICAL ENGINEERING – KOD 2012
24–26 May 2012, Balatonfüred, HUNGARY

The aim of the symposium is to review the current state of knowledge and present the scope of scientific research and innovation in the field of engineering design, product developing and management.
We kindly invite You to join the 7th International Symposium "KOD 2012" which will take place on 24th and 26th May 2012 in Hotel Marina in Balatonfüred, Hungary. The basic goals of this symposium are:

- to assemble famous investigators and practitioners from faculties, scientific institutes and different enterprises or other organizations,
- to enable presentation of new knowledge and exchange of practical experience in mechanical and graphical engineering, industrial design and shaping, product development and management,
- to propose theoretically developed and practically tested solutions for improving the quality of products in mechanical engineering in order to achieve the highest possible position on the international market

Detailed informations here: http://www.kod.ftn.uns.ac.rs/

2. THE 4th INTERNATIONAL SCIENTIFIC CONFERENCE MANAGEMENT OF TECHNOLOGY STEP TO SUSTAINABLE PRODUCTION – MOTSP 2012
14–16 June 2012, Zadar, CROATIA

International Conference Management of Technology – Step to Sustainable Production (MOTSP 2012), will take place from 14-16 June 2012 in Zadar, Croatia as a joint project organized by the Faculty of Mechanical Engineering and Naval Architecture and Faculty of Graphical Arts both from the University of Zagreb, Croatia, Faculty of Management, University of Primorska, Koper and Faculty of Mechanical Engineering, University of Maribor, Slovenia, Faculty of Mechanical Engineering, Ss. Cyril and Methodius University, Skopje, Macedonia, and Politecnico di Torino, Italy.
The main objective of this Conference is to gather international experts from academic entities, research laboratories and industries related to the field of Management of Technology and Sustainable Production. The Conference will also provide a platform for sharing knowledge, ideas and results between science and industry.
The management of technology, stimulation of innovation and invention and transfer of technology are important challenges of the developed countries and countries in transition. Detailed informations here: http://motsp2012.org/

3. INTERNATIONAL CONFERENCE ON INDUSTRIAL LOGISTICS – ICIL 2012
14–16 June 2012, Zadar, CROATIA

The International Conference on Industrial Logistics (ICIL) 2012 will take place in Croatia, from June 14th to June 16th 2012, hosted by the Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb and International Centre for Innovation and Industrial Logistics (ICIIL).
International Centre for Innovation and Industrial Logistics (ICIIL) is a non-profit professional association which has been developing an integrated view of Industrial Logistics, sharing and exchanging ideas and research results among students, researchers, academics and industrialists. The biannual International Conference on Industrial Logistics (ICIL) is the main mean to attain these objectives worldwide, moving from France 1993 to Brazil 1995, USA 1997, Russia 1999, Okinawa 2001, Finland 2003, Uruguay 2005, Lithuania 2006, Israel 2008, again Brazil 2010 and Croatia 2012.
The conference will feature a multidisciplinary program that will include original research results and contributions to the fields of logistics and supply chain management. Organizing and Scientific Committee gladly invite professionals, academics, students and industrialists to send contributing papers to the Conference.
Detailed informations here: http://icil2012.info/

4. THE 9th INTERNATIONAL CONFERENCE – ELEKTRO 2012
21–22 May 2012, Rajecké Teplice, SLOVAKIA

The conference is the ninth of the international series of conferences which began in 1995 initially as a national conference with international participation. The conference is organizes by the Faculty of Electrical Engineering, University of Žilina, every two years. The purpose of the conference is to provide an international forum for researchers and professionals interested in electrical and electronic engineering as well as boundary areas with the main attention to the conference topics.Detailed informations here: http://www.elektro.uniza.sk

5. THE 2nd CONFERENCE – MAINTENANCE 2012
13–16 June 2012, Zenica, B&H

Faculty of Mechanical Engineering in Zenica and Society of Maintainers in B&H organize the 2nd Conference "Maintenance 2012". Conference objectives are:

- Gathering of people engaged in maintenance funds for the operation of various aspects and their structural organization,
- Communication of the results of research in the field of maintenance, as theoretical and practical,
- Exchange of experiences from practical maintenance activities,
- Transfer of knowledge in the field of maintenance.

The Conference will be performed as follows: plenary session (Key papers concerned global topics), symposium (papers according to the conference topics) and workshops, when needed.
Detailed informations here: http://www.odrzavanje.unze.ba/

6. THE 4th INTERNATIONAL CONFERENCE ON SUSTAINABLE AUTOMOTIVE TECHNOLOGIES – ICSAT 2012
21–23 March 2012, Melbourne, AUSTRALIA

The International Conference on Sustainable Automotive Technologies aims to draw special attention to the research and practice of meeting the challenges to sustainable mobility. In particular, the conference is interested in the technical and scientific advancements that are able to meet social, economic and environmental targets in both local and global context. This is the fourth conference in the series held annually, and alternating between Australia, Germany and US as host countries. We cordially invite you to attend this important international event. Conference program will include Plenary Sessions with invited keynote speakers and panel discussions, as well as Concurrent Technical Sessions involving presentations of accepted peer reviewed papers. Detailed informations here: http://www.icsat2012.com

7. THE 20th ANNUAL INTERNATIONAL CONFERENCE ON COMPOSITES, NANO OR METALS ENGINEERING – ICCE-20
22–28 July 2012, Beijing, CHINA

*The **ICCE** conference is unique in that while it is an engineering conference, it has attracted numerous chemists, physicists and scientists from diverse fields in our efforts to promote interdisciplinary research on composites. Of particular concern is the challenge for materials engineers to understand the wide diversity of length scales ranging from nano to micro to macro and full scale and to question the validity of the theories or models which are known to be valid only in certain length scales. The ICCE is among the first composite materials conferences which take a leading vital role to bridge the gap between nano-chemistry and nano-engineering and attracted hundreds of papers in this existing relatively new field of nano-composites engineering.*

*The **ICCE** conference will provide a forum for the exchange of information and ideas in virtually all areas composite materials research. The goals of the ICCE conference are:*

- *To **BRIDGE THE GAP** between Materials Science, Mechanics and manufacturing of Composite Materials;*
- *To **ENCOURAGE INTERDISCIPLINARY** research bridging the gap between aerospace technology, bio-materials, chemistry, electronics, fluid mechanics, infrastructures, magnetic materials, nanotechnology, physics, powder metallurgy, sensors/actuators, among others and*
- *To **ENCOURAGE LEVERAGING** of composite materials research resources through joint research between participants and writing joint research proposals.*

Detailed informations here: www.icce-nano.org

8. THE 12th INTERNATIONAL MULTIDISCIPLINARY SCIENTIFIC GEO-CONFERENCE AND EXPO – SGEM 2012 (SURVEYING GEOLOGY & MINING ECOLOGY MANAGEMENT) – MODERN MANAGEMENT OF MINE PRODUCING, GEOLOGY AND ENVIRONMENTAL PROTECTION
17–23 June 2012, Albena, BULGARIA

The SGEM GeoConference focuses on the latest findings and technologies in surveying geology and mining, ecology, and management, in order to contribute to the sustainable use of natural resources. In this regards all theoretical, methodological and conceptual reports presenting contemporary geoscience development and problems solving ideas are expecting with a great interest. Special attention will be given to reports, proposing science based ideas for decision-making and adaptation to the new reality of global changes.

The GeoConference will bring together researchers, educators, and practitioners representing research and educational institutions, companies, government agencies and consulting organizations from all over the world to exchange of ideas, to define the research priorities in the above fields and to propose potential solutions of problems related to the global changes. Detailed informations here: http://www.sgem.org

9. INTERNATIONAL CONFERENCE IN SURFACE METROLOGY – ICSM 2012
21–23 March, 2012, Annecy, FRANCE

The aim of the seminar is to discuss the rapidly evolving field of surface metrology, including new methods, solutions, applications, and harwares. Contributions should be at least half about surface metrology, i.e., measurements and analysis, and the remainder on applications.

In many domains the metrology of surfaces brings concrete answers to very diverse requirements. These measures are made possible thanks to devices in constant evolution, which benefit from the latest scientific advances. Hardware and software are progressing hand in hand. It will be interesting to measure this progress through the workshops, the applied sessions and the exhibition. But which prospects will define tomorrow's solutions? The researcher's presentations will try to answer that question.

"Making complexity understandable" could be a subtitle for this conference. Since the more we try to learn about a given surface to better understand its function, the more the measured data can become rich and complex to analyze. Our common stake is to get down towards this complexity in order to abstract/infer a simple analysis, on which a decision can be based. That challenge will be a central topic of the conference.

Detailed informations here: http://www.icsm3.org

10. THE 9th INTERNATIONAL CONGRESS "MACHINES, TECHNOLOGIES, MATERIALS - INNOVATIONS FOR THE INDUSTRY" – MTM'12
19-21 September, 2012, Varna, BULGARIA

We invite you to take part in the 9th International Congress "Machines, Technologies, Materials - Innovations for the Industry", which will be held from 19th till 21st September 2012 again in hotel "Aqua Azur" in the sea resort "St. Konstantin and Elena", region Varna, as a comprehensive scientific-technical manifestation, which includes three main topics. The Congress program includes also five special congress sub-sections which previously were held separately.

We believe that and this time the Congress will be a successful international forum in the field of engineering science. We hope that in this way the Congress MTM'12 will become a bigger innovation mediator between scientific research and industry and we offer you to take advantage of this opportunity. We believe that you will take this opportunity and contribute to the success of the Congress with your researches and experience.

*We would be very grateful to you if you recommend *MTM'12* to colleagues of yours, from your country and abroad, who might have scientific and practical interests in the thematic area of the Congress.*

Short information about the Congress you may find in the attached file and detailed information is available on http://mech-ing.com/mtm/

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MANUSCRIPT PREPARATION – General Guidelines

These instructions are written in a form that satisfies all of the formatting requirements for the author manuscript. Please use them as a template in preparing your manuscript. Authors must take special care to follow these instructions concerning margins. The basic instructions are simple:

- *Manuscript shall be formatted for an A4 size page.*
- *The top and left margins shall be 25 mm.*
- *The bottom and right margins shall be 25 mm.*
- *The text shall have both the left and right margins justified.*

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The manuscript should be organized in the following order: Title of the paper, Authors' names and affiliation, Abstract, Key Words, Introduction, Body of the paper (in sequential headings), Conclusion, Acknowledgements (where applicable), References, and Appendices (where applicable).

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