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We are very pleased to inform that our international scientific journal ***ACTA TECHNICA CORVINIENSIS - Bulletin of Engineering*** *completed its six years of publication successfully [2008 - 2013, Tome I - VI].*

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 all contributors and all collaborators!

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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. Every year, in four online issues (fascicules 1 - 4), ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering [e-ISSN: 2067-3809] 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.

Topical reviews in materials science and engineering, each including:

- *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,*
- *Scientific Papers - concise, high impact original theoretical articles,*
- *Perspectives - commissioned commentaries highlighting the impact and wider implications of research appearing in the journal.*

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.

Mission

ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering is an international and interdisciplinary journal which reports on scientific and technical contributions. The ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering advances the understanding of both the fundamentals of engineering science and its application to the solution of challenges and problems in engineering and management, dedicated to the publication of high quality papers on all aspects of the engineering sciences and the management.

You are invited to contribute review or research papers as well as opinion in the fields of science and technology including engineering. We accept contributions (full papers) in the fields of applied sciences and technology including all branches of engineering and management.

Submission of a paper implies that the work described has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis) that it is not under consideration for publication elsewhere. It is not accepted to submit materials which in any way violate copyrights of third persons or law rights. An author is fully responsible ethically and legally for breaking given conditions or misleading the Editor or the Publisher.

The Editor reserves the right to return papers that do not conform to the instructions for paper preparation and template as well as papers that do not fit the scope of the journal, prior to refereeing. The Editor reserves the right not to accept the paper for print in the case of a negative review made by reviewers and also in the case of not paying the required fees if such will be fixed and in the case time of waiting for the publication of the paper would extend the period fixed by the Editor as a result of too big number of papers waiting for print. The decision of the Editor in that matter is irrevocable and their aim is care about the high content-related level of that journal.

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We strongly believe that the open access model will spur research across the world especially as researchers gain unrestricted access to high quality research articles. Being an Open Access Publisher, Academic Journals does not receive payment for subscription as the journals are freely accessible over the internet.

General Topics

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- ☐ Mechanical Engineering
- ☐ Metallurgical Engineering
- ☐ Agricultural Engineering
- ☐ Control Engineering
- ☐ Electrical Engineering
- ☐ Civil Engineering
- ☐ Biomedical Engineering
- ☐ Transport Engineering
- ☐ Nanoengineering

CHEMISTRY
- ☐ General Chemistry
- ☐ Analytical Chemistry
- ☐ Inorganic Chemistry
- ☐ Materials Science & Metallography
- ☐ Polymer Chemistry
- ☐ Spectroscopy
- ☐ Thermo-chemistry

ECONOMICS
- ☐ Agricultural Economics
- ☐ Development Economics
- ☐ Environmental Economics
- ☐ Industrial Organization
- ☐ Mathematical Economics
- ☐ Monetary Economics
- ☐ Resource Economics
- ☐ Transport Economics
- ☐ General Management
- ☐ Managerial Economics
- ☐ Logistics

AGRICULTURE
- ☐ Agricultural & Biological Engineering
- ☐ Food Science & Engineering
- ☐ Horticulture

COMPUTER & INFORMATION SCIENCES
- ☐ Computer Science
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- ☐ Geodesy
- ☐ Geology
- ☐ Hydrology
- ☐ Seismology
- ☐ Soil science

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- ☐ Environmental Chemistry
- ☐ Environmental Science & Ecology
- ☐ Environmental Soil Science
- ☐ Environmental Health

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- ☐ Biomechanics
- ☐ Biotechnology
- ☐ Biomaterials

MATHEMATICS
- ☐ Applied mathematics
- ☐ Modeling & Optimization
- ☐ Foundations & methods

History

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. Now, the ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering is a free-access, online, international and multidisciplinary publication of the Faculty of Engineering Hunedoara.

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

Invitation

We are looking forward to a fruitful collaboration and we welcome you to publish in our ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering. You are invited to contribute review or research papers as well as opinion in the fields of science and technology including engineering. We accept contributions (full papers) in the fields of applied sciences and technology including all branches of engineering and management.

ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING publishes invited review papers covering the full spectrum of engineering and management. 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.

Submission of a paper implies that the work described has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis) that it is not under consideration for publication elsewhere. It is not accepted to submit materials which in any way violate copyrights of third persons or law rights. An author is fully responsible ethically and legally for breaking given conditions or misleading the Editor or the Publisher.

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Review process & Editorial Policy

ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering is dedicated to publishing material of the highest engineering interest, and to this end we have assembled a distinguished Editorial Board and Scientific Committee of academics, professors and researchers. 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. 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.
ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering accept for publication unpublished manuscripts on the understanding that the same manuscript is not under simultaneous consideration of other journals. Publication of a part of the data as the abstract of conference proceedings is exempted.
Manuscripts submitted (original articles, technical notes, brief communications and case studies) will be subject to peer review by the members of the Editorial Board or by qualified outside reviewers. Only papers of high scientific quality will be accepted for publication. Manuscripts are accepted for review only when they report unpublished work that is not being considered for publication elsewhere. The evaluated paper may be recommended for:

- *Acceptance without any changes – in that case the authors will be asked to send the paper electronically in the required .doc format according to authors' instructions;*
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- *Acceptance with major changes – if the authors follow completely the conditions imposed by referees the paper will be sent in the required .doc format;*
- *Rejection – in that case the reasons for rejection will be transmitted to authors along with some suggestions for future improvements (if that will be considered necessary).*

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

All the authors and the corresponding author in particular take the responsibility to ensure that the text of the article does not contain portions copied from any other published material which amounts to plagiarism. We also request the authors to familiarize themselves with the good publication ethics principles before finalizing their manuscripts.

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The Editor and editorial board members do not receive any remuneration. These positions are voluntary.
We are very pleased to inform that our journal ACTA TECHNICA CORVINIENSIS – BULLETIN of ENGINEERING is going to complete its six 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.
The members of the Editorial Board may serve as scientific reviewers.
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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CONTENTS of Tome VII [2014] Fascicule 2 [April – June]

Abstract: *Intelligent systems such as industrial robots are the basis of CIM (Computer Integrated Manufacturing) systems and are increasingly used in the most demanding applications. There are several reasons for implementing the industrial robots in food processing industry. They can replace humans in physically demanding environments and enable continous operation without stopping and with high precision. All of the above reasons are the criteria for their efficiency. The food industry demands high precision robots for packaging transport and stacking of sensitive products such as dairy products. This article presents the automation of the milk transport line, the industrial robot type MOTOMAN EPL 80 which enables high speed rotation around 5 axes and is used for movement, positioning and rotation of the milk box which is then further transported and packed. The criteria for evaluation of the work on the robot is it's precision, speed and accuracy.*

Abstract: *In this paper, measurements of mechanical vibrations are carried out at different working conditions by using different tools. Measurements were committed with a 4447-type Human vibration analyzer, with vibrations measured from the source to the receiver. Measurements are made in real time, by using a specific tool, and worker for whom minimization of vibrations at work is needed. Vibrations which can vary in large measure regarding the excitation frequencies and levels, can also depend from the employee's weight and conduct. The time of exposure to vibrations can be determined with proper measurement in real terms, which is one of the most important factors in preserving the health of the employee.*

Abstract: *This paper presents the aplication of a feature-based design features within simulation model development procedure. Based on a review of the feature technology and previous research work, paper focuses on the modeling of intricate relations among features of different design aspects. An example is provided to demonstrate our approach and to show its effectiveness in the integration of the modules. The authors propose a set of CAD-CAE features that are oriented to both the design and analysis processes in the developed an integrated CAD/CAE mold design system.*

Abstract: *In the presented report, through in-depth study of international researches, the importance of standards in all areas of life and pressing need to deepen the study of standards in the higher engineering education has been reasoned. Results of a questionnaire survey have been stooped, with respondents - engineering students, confirming their awareness that enhanced study in the field of standardization is needed. Education about standards and up to date information about them is condition for improving the quality and effectiveness of their study. The authors propose a comprehensive approach to education about standards, which includes complementing of the curriculum of technical subjects and creation of new discipline that studies standards used in the particular specialty and those found in everyday life. Positive contribution to the creation of good qualified engineers has access to updated information about standards, which would be achieved through the establishment of an Information Centre at campus in constant contact with Standardization Institute.*

Abstract: *The recycling of used materials is now very common all over the world, in order to save the environment from pollution. This paper looked into how used-polyethylene material can be effectively recycled for construction purposes and the effect of temperature on the end products. The used polyethylene sachets were converted to 6mm diameter polymer rod under controlled temperature and pressure. Two sets of five samples concrete façade of size 500 x 300 x 30 mm was cast using the polymer rod and steel respectively. Some of the slabs were exposed to a temperature of 50^0C for six hours, after which they were subjected to loading until failure occurred. At ambient temperature, crack width, was 0.40mm and 0.30 mm; maximum deflection, 5.99mm and 12.25 mm; and ultimate failure load, 2.50 kN and 2.70 kN for steel and polymer rod slabs respectively. While at 50^0 C, crack width was 0.7mm and 1.3mm, deflection, 11.2mm and 12.72 mm, and ultimate failure load, 5.3 kN and 3.00 kN for steel and polymer respectively. Polyethylene (polymer) rod could be a very good substitute in slender concrete structures like façade because of its low crack width, non-corrosive nature and it low thermal conductivity.*

Abstract: *The riser must be adequate to satisfy the liquid and solidification shrinkage requirements of the casting. In addition, the riser itself will be solidifying, so the total shrinkage requirement to be met will be for the riser/casting combination. The total feeding requirement will depend on the specific alloy, the amount of superheat, the casting geometry, and the molding medium. The shape of a casting will affect the size of the riser needed to meet its feed requirements for the obvious reason that the longer the casting takes to solidify, the longer the riser must maintain a reservoir of liquid metal. A variety of methods have been devised to calculate the riser size (shape factor method, geometric method, the modulus method) needed to ensure that liquid feed metal will be available for as long as the solidifying casting requires. In this research has been calculated the riser geometry by different methods for a piece type wheel and the simulation has been used to determine which of the methods it is more efficient.*

Abstract: *The purpose of this paper is to make an analysis of a system of piston mechanism and of its kinematic analysis on the one hand, and modeling and computer-aided design on the other hand. The paper uses kinematic analysis of a mechanism which is made in three methods – analytical, graphic and computer-aided which can also be successfully used in teaching engineers of technical sciences in higher education. Modern computer-aided methods are supported by a special software for analysis of treatment which can simulate not only movement of the mechanism, but it can also determine the position, velocity, acceleration, forces, moments and other parameters in every moment of time; however, control and application of mechanical laws are necessary. Some basic approaches, advantages and disadvantages of presented solutions are described.*

Abstract: *This research is initiated with the objective of investigating the behavior of light weight reinforced concrete columns under elevated temperature. Light weight concrete is achieved by using light weight expanded clay aggregate (LECA) as partial replacement (by volume) to normal weight aggregate. Four specimens were tested experimentally where they were subjected to elevated temperature, and under axial load. Experimentally tested specimens are used to verify a numerical model established by a commercial finite element modeling package ANSYS 13.0. Experimental measurements and numerical results showed a good agreement. Numerical model is then used to cover a wider range of concrete characteristic strengths and with different heating scenarios. Results showed that a slight reduction in the load carrying capacity, stiffness and toughness in unheated light weight columns when compared to the normal-weight concrete columns. Contrarily, an enhancement in the load carrying capacity after subjecting to elevated temperature is obtained.*

Abstract: *The geometric modeling of a folded composite membrane using method of approximation of a folded composite membrane by a developable surface with parabolic guidelines of any order is an aim of this work. This approach is carried out on a one-way expandable composite membrane with thermosetting polyester matrix reinforced by fiberglass. The geometric model is done in two steps: first one replaces the membrane of reference by a system of developable membranes from which then plane quadrilaterals arranged in a well-defined manner are constructed. This need the establishment of mono parametric equation of the family of the plans and the equation of the cuspidal edge of the developable surface basing on which it is carried out the development of algorithms for the construction of the folded composite membrane and that of the developed of the twisted membrane.*

Abstract: *The arsenic polluted sprinkling water might appear in the southern regions of Hungary. Arsenic levels sometimes exceed the 200 µg/l limit, allowed in underground water in Hungary. In the teamwork of Soil and Plant Testing Laboratory and the Institute of Vegetable Growing (Kecskemét College, Faculty of Horticulture) we studied some of the effects of sprinkling water containing arsenic pollution on different vegetables since 2006. In this work, lettuce in hydro-culture was used as an indicator plant. The aim of our examination was to clear up the effect of arsenic on the degree of arsenic accumulation. We used 25, 50, 75, 100, 200, 400 and 600 µg/l arsenic pollution doses.*

Abstract: *Erosion and transporting the separated bed materials by flow is called scouring. One of the main reasons for destruction of bridges, especially in flood events, is the local scouring around the bridge piers. Depth of local scouring around the bridge piers plays an important role to design the bridges against this destructive phenomenon. Therefore, the methods of controlling and reducing this phenomenon are important. Collar and slot can be modeled by SSIIM while it is the three–dimensional software regarding time, as well as the scouring depth and its reduction can be evaluated. Finally, collar and slot have been tangible impact to reduce the scouring depth and there is no notable difference between the results of numerical modeling and the experimental model.*

Abstract: *In our study we intend to discuss the role of education in economy and the relationship between education and the current state of Hungarian labour market. The aim of our thesis is the comprehensive examination of the phenomenon why employees leave their work. In order to fulfill this investigation we have mainly focused on the data of different studies and statistics. Beyond this we have relied on our own inquiry: assumptions, consequences and suggestions have been composed based on the questionnaire filled in by a group of 128 employees. The result from the viewpoint of assumptions, suggesting that the main reason for leaving work is the question of financial matters, is not correct nowadays. The reason why employees leave work today is the modification of their interests or some other motifs. Natural curiosity plays a significant role and ultimately the problems of cost of living and the devaluation of the jobs' prestige (in the major case of qualified workers, but similarly in the case of medical employees or engineers). Decision-makers of Hungary would be suggested that circumstances should be established urging employees to stay in the country. The practice of life guidance, temporary agency, personnel placement and supply services as well as mobility should be proposed to and accepted by a wider range of society. During my work I also call the employers' attention to the extension of part-time employment since the results of my thesis confirm this need especially in the case of some groups of women.*

Abstract: *Casting dynamics such as electromagnetic stirring, stirring in gaseous atmosphere, high energy ultra-sound and mechanical vibration when applied during pouring may improve the mechanical properties of Aluminum-silicon alloy. In this work, mechanical vibration was applied to the mold during solidification varying the applied frequencies. Test samples were made, 3 were vibrated vibrated and 1 was not vibrated(As-Cast) Analysis of results obtained shows that the specimen vibrated at 5 Hz has the ability to absorb energy and to resist load and shock within its elastic limit hence it is resilient. This specimen presents all the properties required for a piston alloy .The results obtained practically shows that there would be improved mechanical properties with an increment in the frequency of vibration.*

Abstract: *The paper presents an efficient approach for determining the equivalent circuit parameters of squirrel cage induction motors by genetic algorithms. A T80B4AB3 type squirrel cage induction motor is analyzed. The T-shaped equivalent circuit is utilized. There are five unknowns in the equivalent circuit, namely: stator resistance and stator leakage reactance, rotor resistance and rotor leakage reactance, and magnetizing reactance. The known quantities from measurement are the input voltage, input current, power factor and slip. Genetic algorithms are used for determining the induction motor parameters. The results are compared by using one, two and three sets of measured data. The accuracy of the proposed approach is verified by determining the relative error in the parameters, obtained by genetic algorithms with regard to analytical values. It is shown that the presented approach needs only two points from the induction motor load curve. In contrast, the standard approach requires at least three points from the motor load curve to obtain relative error less than 1%.*

Abstract: *Development of local communities dependent on the actions of development agencies, and particularly the effects of regional and local development agencies. Percent have data available that are potentially exploitable resources, can directly encourage the establishment of small and micro enterprises, and thereby facilitate and achieve sustainable development in all economic regions and local communities. Therefore it is necessary to form a regional development agency.*

Abstract: *In an attempt to improve the wear resistance of a failed automobile brake disc, different type of heat treatment operation was carried out on the samples of the disc. The samples were heated to 840°C 860°C and 880°C in a muffle furnace, and quenched in water, palm oil and air, separately. Water and oil quenched samples were later tempered at 200°C. The chemical composition of the failed brake disc was obtained by an optical emission spectrometer (OES), while the hardness value was measured using Brinell hardness testing machine. The highest Brinell hardness value of 331 BHN was obtained from the water-quenched sample heated to 880°C. The hardness values of the oil-quenched samples surpass that of air-quenched samples. The tempered samples displayed lower hardness values compared with the hardened samples, although the sample heat treated at 880°C, water-quenched and tempered still possesses high hardness value. The reduction in hardness of most of the samples after tempering suggests possible increase in ductility and toughness. As a result of the heat treatment and subsequent quenching, the retained austenite in the samples transforms to martensite, while the ferrite, flakes of graphite, and cementite were restructured. This shows that the brake disc could be hardened and tempered to obtain optimum hardness with improved ductility and toughness. This will result in better wear resistance, increase service life, and thus reduce brake failure and other related transportation hazard.*

Abstract: *Aircraft industry faces many challenges to reduce both operational and maintenance cost. One of the possible ways for reducing these costs is the introduction of wireless sensor networks (WSNs). WSNs are already finding a variety of applications for both safety-critical and non-safety critical distributed systems. This paper deals with the application of WSNs for aircraft structural health monitoring. Special attention has been given to the WSNs design issues using available components on the market.*

Abstract: *The possibilities and ways for data protection in microcomputer systems and their networks are considered and described in the paper. The overview of the most important threats and attacks on security of microcomputer systems and networks is given first. Then, the possibilities and ways for protection of those systems and data are described. Finally, the paper provides a detailed description of one actual practically implemented system of cryptographic protection of data on personal computers which represents the combination of hardware and software protection.*

Abstract: *In this paper we will present the newest achievements using RFID (Radio Frequency Identification) technology in relation to brand protection in today's industry. At the beginning, our presentation of the paper will go to the explanation of RFID technology as a modern industrial concept and later moved on the details about brand protection in manufacturing. Today, machine builders around the world put great emphasis and at the same time devote attention on the quality of their products such as machine uptime, productivity so flexibility is important selling detail. RFID solutions can make big contributions and provide valuable scale compared to reverse-engineered copies from low-quality competitors which produce cheap spare parts or simply parts.*

Abstract: *Obtaining of all acceptable locations is one of the main tasks for siting of wind turbines. The main goal of this paper was to estimate wind potentials in Vlasina region, mainly on Strešer and Besna Kobila mountains. Finally, 231 locations are accepted, which covers the most of the area of the south of Vlasina lake, until the borders with FYR Macedonia and Bulgaria, respectively. The estimations were obtained using the WAsP simulation software. Final results are compared by means of the quality and quantity of the wind data and capacity factor. Finally, the economical analysis of the acceptabillity of the installing of wind turbines was done. This paper is concerned by the National Program of Energy Efficiency, project number: TR33036, funded by the Government of Republic of Serbia.*

Abstract: *For decades, discussions on road traffic have been followed by forecasts on limited reserves of mineral oil and other fossil fuels, by increased demands regarding the vehicle's economy and by more and more severe legislations regarding reduction of CO_2 emission and noxious components in exhaust gases. The question of which power units will drive the automobiles of the future or which will replace the internal combustion piston engine in the next 10 to 15 years, has not lost its actuality even after 130 years of engine development. Energy supply has the key role in answering this question. Forecasts that the known reserves of mineral oil will be spent in the next 30 to 40 years and that the four-stroke piston engine will be replaced by better power units have been repeated for several decades.*

The ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering, Fascicule 2/2014 [April-June/2014] includes scientific papers presented in the sections of Conference on:

- *The 7th INTERNATIONAL CONFERENCE for YOUNG RESEARCHERS and Ph.D. STUDENTS – Education, Research, INnovation 2013 – ERIN 2013 (15 – 17 May, 2013), hosted by Slovak University of Technology in Bratislava, in Častá-Papiernička, SLOVAKIA. The new current identification numbers of the papers are # 1 – 3, according to the present contents list.*
- *The 11th INTERNATIONAL CONFERENCE on ACCOMPLISHMENTS in ELECTRICAL and MECHANICAL ENGINEERING and INFORMATION TECHNOLOGY – DEMI 2013, organized in Banja Luka, BOSNIA & HERZEGOVINA (30 May – 1 June, 2013), jointly by the Faculty of Mechanical Engineering, University of East Sarajevo. The new current identification number of the papers are # 4 – 7 and # 21 – 25, according to the present contents list.*

Also, the ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering, Fascicule 2/2014 [April-June/2014] includes, also, original papers submitted to the Editorial Board, directly by authors or by the regional collaborators of the Journal.

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COMPUTER AIDED GENERATIVE DESIGN OF AUTOMOTIVE SHAPED COMPONENTS

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Abstract: *Generative design as a new method of product development and innovation has become very important in the automotive industry at present. The reason for the introduction of this method into the process of development tasks solution is simple. This approach to car innovation leads to a reduction in the time spent developing prototypes. CAD software allows an approximate design to be used initially, with the ability to make subsequent changes to the aerodynamic properties and other attributes, according to the market needs. When the shape of a car is complete, styling is not closed and can be modified until the time of the final design confirmation. Now that the most important features are no longer just safety and driveability, the car's design and its saleability have become equally essential facets of the overall design process. The underlying assumption for innovation in this field is simplicity, and especially time–saving, during the development of the prototype. Since the early days of using intelligent design systems, opportunities for automotive design have expanded far beyond the boundaries of austere block shapes. These only made use of radiuses in the bending areas that were purely functional. By contrast one of the most important goals of modern car design is the shape of reflection lines. It is necessary to generate gentle and smooth curves of the car body which, under lighting, will catch the eye. Other goals include the drag coefficient, aerodynamic sound, and passive safety. Depending on the complexity of the body shell, it is possible to describe this shape by using more or fewer mathematical formulas. All these formulas are included in the special algorithm which controls the whole process. In this way, constraints can finally be generated automatically.*
Keywords: *CAD, Generative design method, Cloud of points*

INTRODUCTION

Even though they may appear similar, the fundamentals of generative design are in principle not the same as parametrical modelling. Parametric models are numerically controlled representations of design solutions which result in a new product with similar geometrical values (quantity indicators such as dimensions, weight etc.) but dissimilar in quality (e.g. aesthetic indicators, subjective user requirements, and needs). This means that generative design in new product development and innovation offers more than a geometric model. It offers the whole complex of information about a new product which has not only a deterministic, but also heuristic nature.

Practical application of generative design is part of the private policy of automotive companies. Even though it is so beneficial, they do not use it much in practice. The important role of this method is based on its time saving opportunities. A few years back it took about 4 to 5 years to start a new model production. If designers use generative developing of a new prototype, it will cut the development time to 1 to 2 years. The most important step is to reduce the routine phase during that process but also to improve the quality of the final result.

ESSENTIALS OF GENERATIVE DESIGN

The basic scheme of the generative design process is shown on Figure 1. It shows the cooperation during the prototype development.

In the first level of the development process there is just the designer, who has to make the initial design. When the draft of the shape is done, engineers start to invent the functional elements. These are in interference with all the exterior surfaces. The clay model can be checked for its aerodynamic properties, passive safety, and so on. After that, the surface is scanned by the 3D

scanning device. The output is an ASCII text file with coordinate points. A special algorithm selects, filters, and orders the points. The cloud of points is interpolated by a mesh which can be transformed into a surface. This process can be seen in Figure 2.

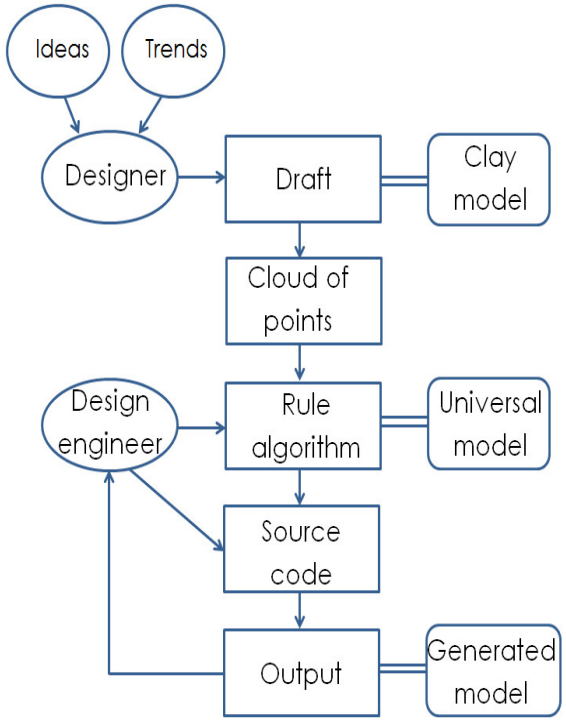

Figure 1. Basic scheme of generative developing process of an automotive prototype

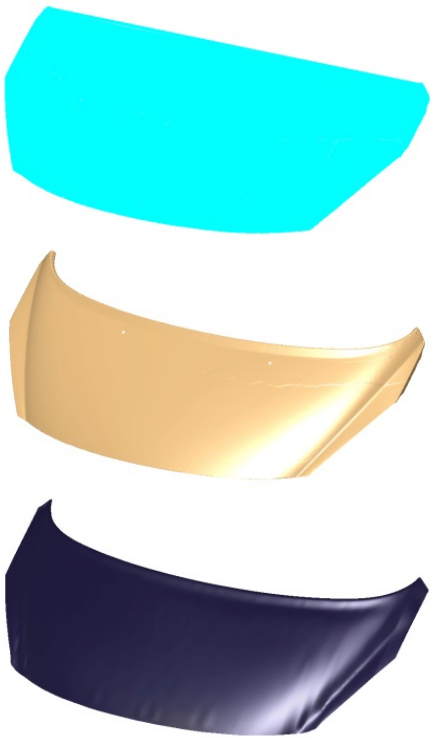

Figure 2. Process of transforming cloud of points into surface using example of a car's bonnet

This surface is then provided by the source code for the interferences between inner and outer parts. The results of the algorithms, rules, and source codes results in a generated model. In case of the draft being changed, the CAD system drives it through the process, and generates a new model.

At the beginning of a new method of development research some new terms were employed. They are important to describe this recent process. This paper uses the terminology from [1] which represents these words:

- *Genotype – generic parametric CAD model*
- *Phenotype – specified CAD data, including tree history, parameters, relations*
- *Exploration envelope – a boundary of space within which the model is generated, determined by maximum and minimum parameters*
- *Rule/algorithm – routine defining usable section from a cloud of points, the software fits the surface through this section, and then the resulting output is a universal model*
- *Source code – routine for the functional parts, based on the components interfaces and defined by the exploration envelope*

CRITERION FOR SHAPE COMPONENTS

This paper focuses especially on the generative design of automotive bodywork. Saleability is influenced by the smoothness of the shape. It is not just because of the nice curves of the body shell. Another criterion is the shape of objects reflected on the surface.

In software applications parametric equations from [2] are used. If there is a closed interval I it is possible to describe a 3D curve by the parametric relation (1).

$$K(u) = [x(u), y(u), z(u)], u \in I \qquad (1)$$

Firstly, the surface is as smooth as the derivation level of the curve at any point. The continuity between two curves or two segments of a curve is in (2). Here k represents the level of smoothness.

$$K^{i}(u) = N^{i}(v), i = 0,1\ldots.k \qquad (2)$$

If there are curves with C^0 continuity this is called 'point continuity' and there is no smoothness. Using C^1 there is a 'tangent continuity'. A

minimum of C^2 continuity is necessary in order to produce a smooth surface. This is called 'curvature continuity' and using it avoids any bad edges. For the aerodynamic properties and passive safety C^2 continuity of surface in every segment is best. Of course, curves can, in principle, also be described by higher degree polynomial functions (n). In this case, it is very advantageous to change the shape of the profiles and change their aesthetic outcome by using higher derivatives order (C^{n-1}) continuity.

Secondly, there must be a compromise between the engineer's model and the designer's draft. This is because innovation sells new products. On bodywork in particular aesthetic lines are used. In rule/algorithm there must be steps which recognize the required lines with a proper shape.

After categorization of the smoothness or lines comes a curve fitting algorithm. Splines describing the preliminary surface are used to represent the curves. After generating the surface there must be a final check. Curvature analyses are used in CAD software for the control of aesthetics, inflection lines, reflection lines etc. An example of inflection lines (red) and reflection lines (green) can be seen in Figure 3.

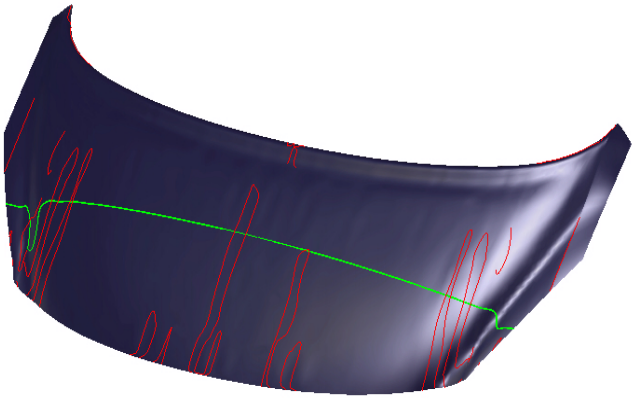

Figure 3. Car's bonnet model with analysis of reflection and inflection lines

CONNECTION BETWEEN CLASS A SURFACE AND CLASS B SURFACE

It is necessary for the assembly to fulfil certain functional relations. An A surface represents the shape, whilst a B surface represents proper position and function. Using the example of a bonnet, this means the need to fit braces, holes and other interior parts (in a broader sense to the whole car "body in white" structure). The scheme of connections in the CAD software can be seen in Figure 4. This is an example of how the source code can work to generate B surfaces. After updating the CAS (Computer Aided Style) or A surface by scanning this algorithm, B surfaces proceed to assimilate this change. This is the reason why an engineer has to prescribe the interfaces between A surface and B surface.

REASONS FOR USING GENERATIVE DESIGN IN THE AUTOMOTIVE INDUSTRY

In the past it was common for engineers to frozen the model after completing the design task. Consequently, no further changes were possible on A class surfaces after this point. In practice, generative design, based on the scheme in Figure 1, could open new possibilities in the design process. Exterior shape is active during almost the entire time of developing the new prototype.

The generative design method can also be advantageously applied to the process of automotive mechanical parts development. Here it is useful to also incorporate into the whole process the knowledge in the form of a special system. Using this method it is possible to solve problems connected with the assembly structure of complete mechanisms (changing and selecting the standardized or predevelopment parts stored in the design database), Additionally, the calculation and optimization tasks relating to the geometry and load capacity requirements can also be solved using this method. Such a task has been addressed in the design of automotive hybrid drives, where HCR gearing is used.

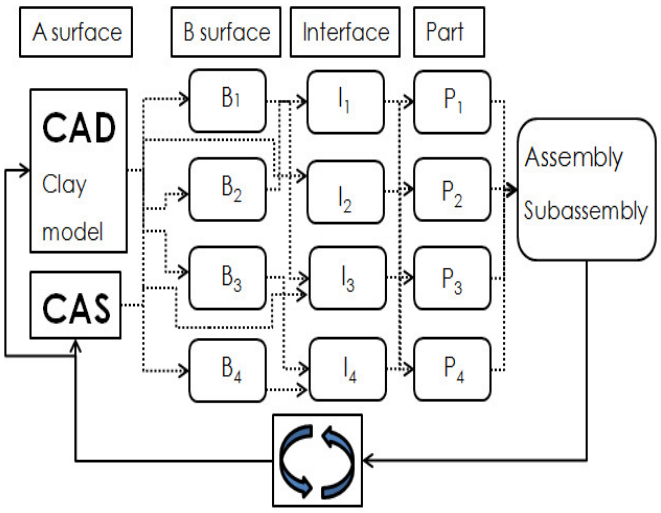

Figure 4. Scheme of CAD relations for functional parts

Finally, it is important to mention how working procedures are distributed in companies. The trend is to distribute work not just among workplaces in one firm, but also among workplaces all over the world in international concerns. Professional communication has changed from personal contact to internet connections across national boundaries. This offers employees the possibility of working in more than one place at any one time. That is why generative design is gaining ground in the automotive industry (as the next element of Concurrent or Parallel Engineering).

In conclusion, the future offers the possibility of working with simple adaptations of a model to produce changes without time-consuming procedures.

Acknowledgement

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References

[1.] *Krish, Sivam. A practical generative design method. Computer-Aided Design. 2011, 43.*

[2.] *Linkeová, Ivana. NURBS křivky. Praha : Nakladatelství ČVUT, 2007.*

[3.] *M. Sevaux, Y. Mineur. A curve-fitting genetic algorithm for a styling application. European Journal of Operational Research. 2005.*

[4.] *Xiuzi, Ye, et al., et al. Reverse innovative design – an integrated product design methodology. Computer-Aided Design. 2008.*

[5.] *Skarka, Wojciech. Application of MOKA methodology in generative model. Engineering Applications of Artificial Intelligence. 2007*

[6.] *Morello, Lorenzo, et al., et al. The Automotive Body, Volume I: Components Design. Dordrecht, Heidelberg, London, New York : Springer, 2011. ISBN 978-94-007-0512-8.*

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THE INVESTIGATION OF NEW POLYMERIC COMPOUNDS FOR LEATHER TREATMENT

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Abstract: *Physical and chemical properties of modern polymeric compounds have been investigated. The influence of polymers on the properties of collagen containing materials – gelatin, chrome leather and leather semi-finished item has been examined. Presumptive nature of the interaction between polymeric compounds and collagen has been ascertained. Reasonability of their usage for leather processing before dyeing has been shown. Implementation of research results in the production will help to get a leather product of high quality and to make rational use of material resources.*
Keywords: *modern polymeric compounds, physical and chemical properties*

INTRODUCTION

In the conditions of the market economy only high quality items with high consumer properties are in great demand and all these properties are defined by the state of raw materials treatment and the efficiency of applied chemical materials, especially in tanning and after tanning processes. So the actual problem to the branch is searching and motivated using of modern chemical materials for natural leather production from available raw materials. Taking into account the above mentioned the main our investigation concept is the improvement of leather treatment with the application of modern materials in order to simplify technological schemes and decrease material capacity while providing with finished goods of high quality [1-3]. The literature analysis and the practical experience of the work of leather industry enterprises testify about promising application of polymeric compounds of a new generation that impart to derma the desired properties [4-6].

This work is continuation of investigation of modern polymeric compounds properties, their influence on the collagen of derma to ascertain the efficiency of these materials usage in leather production.

The following objectives have been formulated to achieve this goal: to investigate the physicochemical properties of new polymeric compounds and compare them with the results of previous studies, to determine the effect of these materials on the properties of leather; to ascertain the nature of polymers interaction with collagen, to show the reasonability of their usage for leather treatment.

Liquid leather finishing using modern polymeric compounds has been chosen as the object of research; as a subject of research new polymeric compounds in the form of derivatives of unsaturated maleic acid (product Kro), acrylic acid (product CP) and its derivatives (product TP) have been taken, as well as the properties of collagen after treatment with these materials.

The scientific novelty of this research consists in determination of the influence of the kind and flow of polymeric compounds on the isoelectric point of gelatin and collagen thermal stability, establishing a possible mechanism of interaction between these materials and protein.

The practical meaning of the work is the experimental confirmation of the efficiency of new polymeric compounds for leather treatment.

EXPERIMENT

We have used both common in leather and fur production and modern research methods: viscometric, fusiometric, photometric, potentiometric, infrared spectroscopy and microscopic, mathematical statistics.

For establishing viscosity of investigated polymers Ostwald viscometer was applied (relative error ± 1 %), choosing its diameter so that obtained data have been the most trustworthy. Surface tension was defined with the help of stalogmometer CT-2 (Corund-Chem, Russia) (absolute error ± 0.06 mN/m); density – areometer AOH-1 (Steklopribor, Ukraine) (absolute error ± 0.01 g/cm^3); pH – pH meter HI 2210 (Hanna Instruments, Great Britain) (absolute error ± 0.1 pH); dry residue – by weight method. Resistance to electrolytes was determined after coagulation threshold at adding to polymers, wide-spread in leather production, electrolytes (sodium chloride, ammonium hydroxide, acetic and salt acids and others).

For measuring polymer particle size laser correlation analyzer – spectrometer Zeta Sizer Nano (Malvern Instruments, Great Britain) was used. As to the advantages of the device the range of material measurement from 0.02 μm to 2000 μm can be attributed; wide spectrum of samples types (it is possible to measure emulsions, suspensions, dispersions, powder); convenience in usage; full reconstruction of obtained data; high exactness of measurement (relative error ± 1 %).

The influence of temperature on derma collagen and its derivative – gelatin was defined according to the melting temperature 10 % gels of gelatin at fusiometer [7] (absolute error ± 0.1 °C) at corresponding apparatus [8] (absolute error ± 1 °C). In order to define isoelectric point of protein photometer (Econix Expert, Russia) was used (absolute error – 0.005) and pH meter HI 2210 (Hanna Instruments, Great Britain) (absolute error ± 0.1 pH).

Spectral analysis has been holding on spectrophotometer TENSOR 37 (Brucer, Germany). Belonging of the absorption bands on the spectra to materials under test of the different types of compounds (groups of atoms) was ascertained on the basis of numerous publications in the field of infrared spectroscopy [9-10]. The resulting absorption spectrogram in the range of 400-4000 cm^{-1} was treated by the methods of «baseline» and «internal standard» [2]. For the internal standard bands with frequencies in 2930 and 1337 cm^{-1} was chosen (deformative vibrations of CH_3 and CH_2 groups correspond to the valent), since at these frequencies the optical density of substances under test is changed insignificantly.

Chemical and physico-mechanical tests of chrome leather were carried out according to standard methods [8] with the use of modern equipment: tearing machine PT 250M; drying cabinet SNOL 24/200 (Umega, Lithuania); thickness gauge SGM (Filetta, Netherland); microscope L1500A 600x (Paralux, France). The uniformity of dyeing of leather semi-finished item in modern photometer of whiteness and colour characteristics «Kolir» (Trigla, Ukraine) was determined under such conditions as: measurement geometry/ observation – D/65; regime: a) colour distinction; b) source – A; c) observer – 2°; error according to coordinate of colour – not more than ± 0.02.

Accuracy of the results, the validity of the ascertained regularities and the assumptions are provided by sufficient quantity of the conducted experiments, the use of modern exact methods, of computer technologies to attain the objective.

RESULTS AND DISCUSSION

The results of physicochemical studies of new polymeric compounds indicate their anionic nature and such valuable properties as non-toxicity, complete water solubility, stability to electrolytes (Table 1).

Table 1. The main physical and chemical properties of investigated polymers

Index	Polymer		
	Kro	TP	CP
Component (acid) derivative of	maleic acid	acrylic acid	acrylic acid
Activity, %	15.0±5.0	17.0±3.0	29.0±3.0
Solubility in water	complete	complete	complete
Resistance to electrolytes	high	high	high
pH (10 % solution)	7.6±0.5	5.7±0.5	5.5±1.0
Dry residue, %	21.5	13.5	32.5
Density, g/cm^3	1.015	1.011	1.040
Surface tension, mN/m	54.09	76.59	76.88
Relative viscosity (20 % solution)	1.14	3.40	14.90
Intrinsic viscosity	0.700	1.472	2.507
Molecular weight	11599	33538	71756

It was ascertained by the method of laser correlation spectroscopy that average size of maleate particle is 17 nm, while particles of acrylates are larger in 4.6-252.4 times. On the basis of the results of viscometric study polymer solutions of different concentrations (0.3-5.0 g/l) their molecular weight was defined according to the equation of Mark-Houwink (Table 1). Depending on the molecular weight the investigated compounds can be arranged in the sequence of CP > TP > Kro, which is quite correlated with the particles size. The effect of polymeric compounds on the properties of collagen, using gelatin as an example, leather semi-finished item and leather has been defined. It is ascertained that after treatment with polymers melting temperature of 10 % gelatin gels increases by 3-4 °C (Fig. 1).

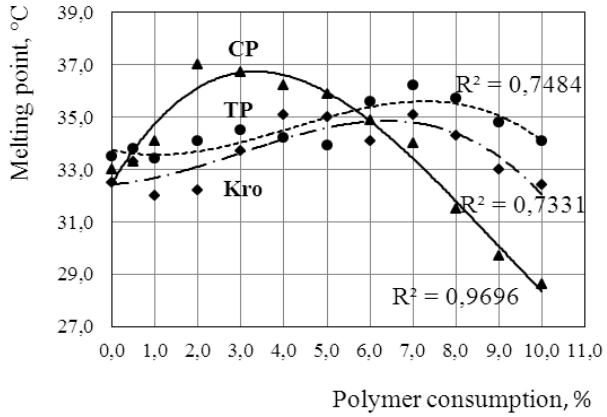

Figure 1. Influence of polymeric compounds on the melting point of gelatin gels

It is fully consistent with hydrothermal stability index – the shrinking temperature of collagen of untanned leather semi-finished item from cow hides. The index increases after treatment with the products Kro and CP at 5-10 °C [3]. It indicates the formation of some, though not very strong, bonds in the structure of the derma.

With the help of potentiometric and photocolorimetric methods it has been ascertained that gelatin treatment by investigated polymer shift the isoelectric point of protein from a position of 4.89 to the lower pH by 0.16-0.53 units: for product Kro – to 4.73, for product TR - to 4.55, for product CP – to 4.6.

The shift of the isoelectric point of gelatin to more acidic area indicates the presence in polymeric compounds of active mainly unbound carboxyl groups, which are inclined to interact with the basic and the other nitrogen-containing groups of collagen. The above stated is confirmed by spectral analysis of gelatin films treated by polymers (Table 2).

Table 2. Change of gelatin optical density after treatment by polymers

λ, cm^{-1}	Connection type, group	Z*		
		Kro	TP	CP
1554	Amide II (CN; NH); Carboxylic acids (COO^-)	1.05	1.05	0.95
1405	Alcohols, phenols (OH); Carboxylic acids (CO; OH) Primary amides (CN)	1.35	1.42	1.33
1280	Amines secondary, tertiary (CN); Esters (COC)	1.01	1.01	1.50
1240	Amide III (CO; CN; NH; O = CN) Amines secondary, tertiary (CN); Esters (COC)	1.01	1.06	1.00

** Ratio of adducing optical density of the initial gelatin to adducing optical density of gelatin after treatment by polymer*

After polymer treatment of gelatin index Z, which characterizes the decrease of the intensity of the gelatin absorption bands on the IR spectrograms, increases at frequency 1405 cm^{-1}; after treatment with some of them – at frequencies 1554, 1280 and 1240 cm^{-1}. This can be explained by the interaction between polymeric compounds and nitrogen (Amide II – 1554 cm^{-1}, amines secondary, tertiary – 1240-1280 cm^{-1}) and hydroxyl (1405 cm^{-1}) protein groups (Table 2). Results of kinetic research of the system «polymer-gelatin» indicate the chemical nature of the interaction between polymers and collagen: for all products under test the activation energy is not less than 125 KJ [2].

Expediency of polymeric compounds use in leather processing has been studied at the stage of dyeing and fatliquoring processes an example of maleic acid derivative. Processing scheme of shaved semi-finished item of cow hide has been chosen by according to the standard method of chrome-tanned leather production for the upper of shoes, from cattle hides [11]: washing – neutralization – washing – dyeing – fatting – vegetable tanning agents retannage – washing.

The difference in processing of the investigated leathers consisted in the application of polymer before dyeing (a product Kro) in the amount of 6.0 % of weight of shaved semi-finished item, reducing the consumption of tannins and dye in 2 times as

compared with control ones (2.0 and 1.0 % respectively). As a vegetable tanning agents quebracho tannins have been used as a dye – brown anionic Y. Polymer processing and dyeing temperature was at 36 °C, the duration of each of these processes – 1 hour, consumption of water – 200 %. Control leathers have not been treated by polymers. No complications due to polymer processing have not occurred, the finished product was dyed uniformly, it was soft and filled to the touch, had a nice grain. As a result of leather physical and chemical testing it has been found (Table 3) that the use of maleate promotes the obtainment of quality leather goods, which is characterized by high hydrothermal stability, the strength of leather as a whole and its grain (σ_g, σ_s), good fullness (yield in thickness), good elastic and plastic properties (elongation at 10 MPa L10). Increase of distribution uniformity of the strength and elongation indices by 10-17 %, the yield in area by 1.5 %, reducing the consumption of tannins and dye by 50 % indicates a more rational use of scarce raw stock and chemical materials.

Table 3. Indices of chrome leathers

Index		Value	
		Investigated leather	Control leather
Temperature of shrinkage,°C		126.1	123.3
Limit tensile strength σ_g, MPa		22.0	21.6
The strength of grain layer σ_s, MPa		16.7	16.2
$\Delta\sigma = \sigma_g - \sigma_s$, MPa		5.3	10.4
Elongation at stress 10 MPa L_{10}, %		41.5	40.0
Uniformity of distribution of indices to directions of leather	$K\sigma_g$	0.80	0.72
	$K\sigma_s$	0.69	0.59
	K_{L10}	0.90	0.75
Porosity, %		54.0	42.1
Vapour permeability, %		85.2	69.5
Yield in thickness, %		92.0	92.1
Yield in area, %		94.7	93.3
Volume yield, cm^3/100 g protein		233.0	231.3
Penetration level of dye, %		76.2	66.6
Uniformity of colouring $\Delta E(D65)$		2.51	7.45

CONCLUSIONS

On the basis of the research of new polymeric compounds − derivatives of unsaturated maleic and acrylic acids − it has been suggested that due to the peculiarities of their structure and properties (definite particle size, presence of active groups and bonds, reaction to the action of water and electrolytes) investigated polymers can not only be sorbe by derma, filling the space between its structural elements, but also to interact with the active (amine, imine, peptide, hydroxyl) groups of collagen and to impart to the natural leather high consumer, health, aesthetic and cutting-out properties. The introductions of research results into the manufacture give the possibilities to get a high quality leather item with more rational use of material resources.

REFERENCES

[1.] *GORBACHEV, A., KERNER, S., ANDREYEVA, O., ORLOVA, O.: Bases of creation of modern production of leather and fur technology, KNUTD Kyiv, 2007 (in Ukrainian).*

[2.] *LUKIANETS, L., ANDREYEVA, O.: Investigation of characteristics of new polymeric materials for leather and fur production. Message 1, Visnyk KhNU, 2009, Volume 4, pp. 208-211 (in Ukrainian).*

[3.] *LUKIANETS, L., ANDREYEVA, O.: Production of high quality leather by application of modern polymeric compounds, Visnyk KNUTD, 2010, Volume 4, pp. 246-250 (in Ukrainian).*

[4.] *BIENTINESI, G., D'ELIA, A., SEGGIANI, M.: A practical evaluation of acrylic resins and the development of a materials evaluation method. W. Leather, 2005, Volume 4, pp. 31−35.*

[5.] *JIANZHONG, M., HUA, L.: The study of elasticity of the skin, retanning by different types of acrylic polymers. J. Amer. Leather Chem. Assoc., 2008, Volume 11, pp. 363−369.*

[6.] *TYSOE, C.: Zero formaldehyde resin retanning agents. W. Leather, 2007, Volume 20, 2, p. 36.*

[7.] *BABLOYAN, O., RADKEVICH, D., TIMOKHIN N.: Manufacture of glue and gelatin in tanneries, Legk. Industriya Moscow, 1972 (in Russian).*

[8.] **** Chrome leather for the uppers of shoes. Methods of tests, Legprom Moscow, 1972 (in Russian).*

[9.] *VASILIEV, A., GRINENKO, E., SCHUKIN, A., FEDULINA, T.: Infrared spectroscopy of organic and natural compounds, SPbGLTA St. Petersburg, 2007 (in Russian).*

[10.] *DEHANT, I., KIMMER, V., DANTS, R., SHMOLKE, R.: Infrared spectroscopy of polymers, Himiya Moscow, 1976 (in Russian).*

[11.] *BALBEROVA, N., MIKHAYLOV, A. and others: Directory of tanner (Technology), Legprombytizdat Moscow, 1986 (in Russian).*

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HEAT TRANSPORT DYNAMICS OF VARIOUS WORKING FLUIDS IN HEAT PIPES

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Abstract: *A heat pipe is a hermetically closed pipe, filled with working fluid. The heat transport in heat pipe is procured by the change of the working fluid state from liquid to vapor and vice-versa and thus is able the heat transfer several times more such by heat conduction. Phases change depends on the hydrodynamic and thermal processes in the pipe. This paper observes the impact of these processes at startup of heat pipes with various working fluids scanning the surface temperatures of heat pipes by thermovision camera. According thermo vision record of heat pipe operating is possible identify the dynamics of heat pipe working fluid and if the heat pipe operate correct.*

Keywords: *heat pipes, working fluids, heat transport, thermovision camera*

INTRODUCTION

The heat pipe is a hermetically closed pipe which is filled with working fluid. Heating the evaporation section of the heat pipe the working fluid starts to evaporate and flows through to the opposite side of the pipe. Here the vapour condensate and in the form of condensate flow down the walls of the pipe as a result of gravity or the condensate is transported back to the evaporation section of the pipe through the capillary system. The transport of latent heat procured in this way significantly increases the effectiveness of transporting heat by compared to transporting heat by standard pipe. The heat flow transported by the heat pipe depends on the material of the pipe, working substance and their mutual compatibility. In the wick heat pipes maximal possible transport of heat flow depends to capillary system too, but mainly it depends to hydrodynamic and heat processes taking place during function of heat pipe [1, 2].

METHOD OF ANALYSIS

During the functioning of the heat pipe a phase change of liquid state to vapuor state and via versa occurs. This work is oriented at observing the hydrodynamic and heat processes which occur inside the pipe and affect the overall transport of heat by heat pipe. Thermography is one of the ways with which it is possible to monitor these processes. Thermography is a method which allows us to observe these processes using an infrared sensor which measure surface temperature without contact of objects and consecutively digitally shows the temperature fields of the objects. The function of hermovision camera is based on this principle. Using thermovision camera was scanning the surface temperatures of the wick heat pipes related to time [3]. This method of monitoring heat pipe surface temperatures can be used to verify and test their correct functioning.

EXPERIMENTAL TECHNIQUES

Experiment of monitoring heat transport dynamics was realized on heat pipes with mesh screen capillary structure. Mesh screen capillary structures are one from the most applied structures in heat pipe. For manufacture of heat pipes are use a finely mesh screens from stainless steel with mesh 200. Piece of screen is rolled and inserted in to the pipe, thus is rolled screen by acting expansive forces stable placed in inner surface of pipe. The container material is copper and overall length of heat pipes is 0,5 m. The working mediums in heat pipes were used distilled water, acetone and ethanol [4, 5]. On figure 1 is shown monitoring method of heat pipes by thermocamera.

Experiment was realized in laboratory on our department. Heat pipes were placed in to the thermal isolated container with liquid medium and constantly heated from 20°C to 90°C. For better visualization was surface of heat pipes painted with white matt colour before the scanning.

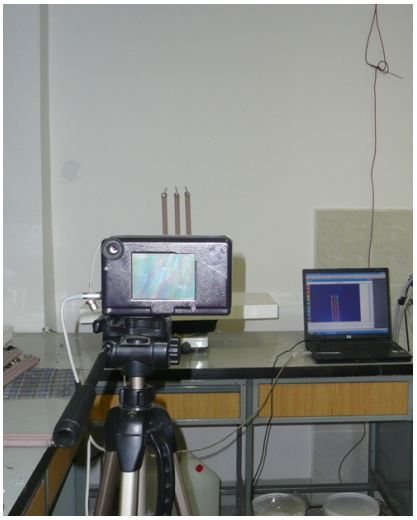
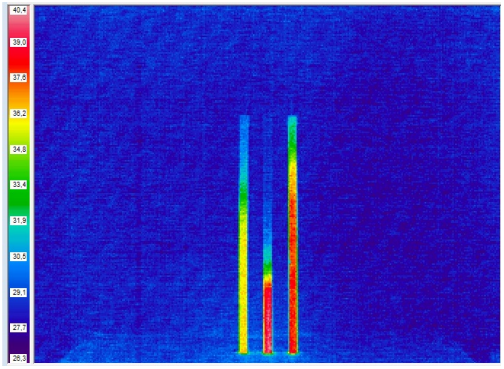


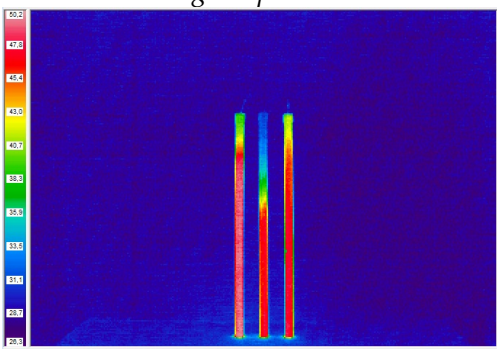
Figure 1. Monitoring of heat pipes by thermocamera

RESULTS

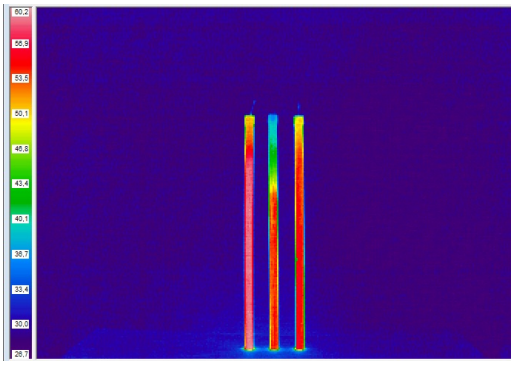
Thermovision photos show the heat transport dynamics of heat pipes with working fluids of acetone, ethanol and water at the same working temperature condition. In Figure 2 are six thermovision pictures of heat pipes according working temperature conditions from 40 to 90 °C.



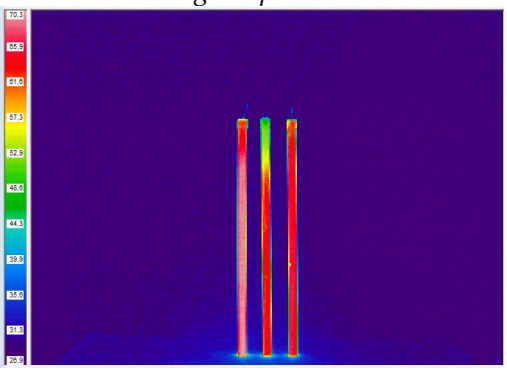
1. Working temperature 40°C



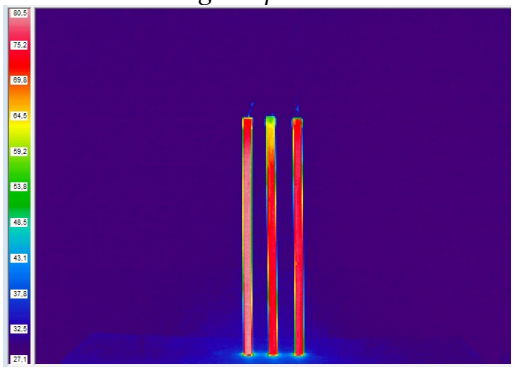
2. Working temperature 50°C



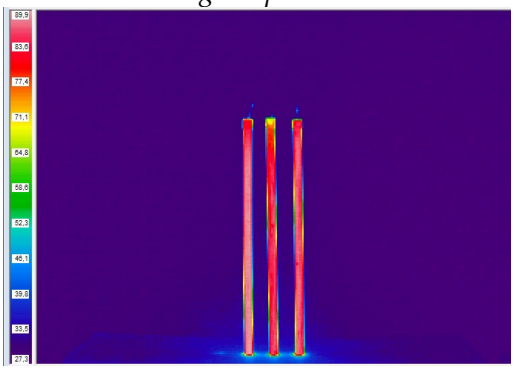
3. Working temperature 60°C



4. Working temperature 70°C



5. Working temperature 80°C



6. Working temperature 90°C

Figure 2. Thermovision visualization of screen mesh wick heat pipes with working fluids acetone, water and ethanol

On the thermovission photos scanned by thermocamera is clearly to see increase of temperature on the surface of the heat pipes depending from heat source temperature. Multicollor scales on the left side of the photos

determine scaned surface temperature. Blue and green collor are low temperatures, yellow and red collors are high temperatures equivalent to heat source temperature. Heat pipe visualization by thermovission camera imagine thermal and hydrodinamical phenomenon inside the heat pipe. Colouring of the scaning surface plane displays speed of the working fluid vapour flow and volume of the mas flow transfer from evaporation to the condensation section of the heat pipe.

On the Figure 2 where heat source temperature increase form 40 to 80 °C is to see on heat pipe no. 1 filled with ethanol and no. 3 filled with acetone better and faster heat transport reaction than on heat pipe no. 2 filled with water. The slower reaction of the water heat pipe at startup cause different thermophysical properties of the water than acetone and ethanol. On the last photograph at working conditions 90°C every three heat pipes achieve uniform temperature along the length and have a single colour.

This experiment achieve that acetone and ethanol heat pipe operate at lower temperature better than water heat pipe but at higher temperature water heat pipe operate as well as acetone and ethanol heat pipe. Results of scanning surface temperature of the heat pipes by thermovision camera are show how does work heat pipes on the start up, how it does influence their heat transfer ability and if operate correct.

CONCLUSION

Experiment show that the one of the factors, which is influencing on performance of wick heat pipe is choice of the working fluid, because each liquid have different thermo physical properties at equal ambient conditions. The effect of this factor on the dynamics of the heat transfer by heat pipes can be easily identified by thermovision scanning surface temperature of the heat pipes. Photographs scanned by thermovision camera show different behaviour of the heat pipes, which is caused by various working fluids. The fastest start of functioning was monitored in heat pipe with acetone, the slower start has heat pipe with ethanol and the slowest start has heat pipe with water. Even though that the water heat pipe has slowest start, at higher working temperature achieve uniform temperature along the length as well as acetone and ethanol heat pipes and all heat pipes work correct.

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REFERENCES

[1.] *NEMEC, P., ČAJA, A., MALCHO, M.: Mathematical model for heat transfer limitations of heat pipe, Mathematical and Computer Modelling, 2013, Volume 57, pp. 126-136.*

[2.] *NEMEC, P., ČAJA, A.: Intenzifikácia transportu tepla pomocou tepelných trubíc, Acta Metallurgica Slovaca, 2009, Vol. 15, SI no. 1, p. 215-220.*

[3.] *NEMEC, P., ČAJA, A., LENHARD, R.: Visualization of heat transport in heat pipes using thermocamera, Archives of thermodynamics, 2010, Vol. 31, No. 4, pp. 125-132.*

[4.] *KAPJOR, A., KOSECOVÁ, A., PAPUČÍK, Š.: Influence of construction parameters to heat output of floor convector, Proceedings of the TRANSCOM, 2005, pp. 69-72.*

[5.] *LENHARD, R.: Numerical simulation device for the transport of geothermal heat with forced circulation of media, Proceedings of the Power control and optimization, 2010, pp. 13*

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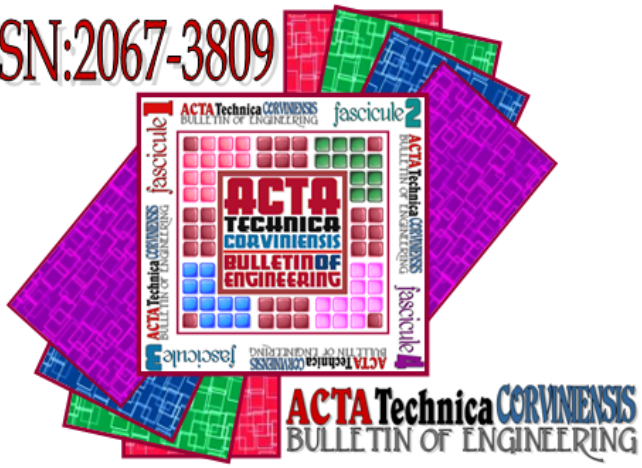

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PIONEER 3-DX DISTANCE CONTROL USING DIFFERENT TYPE OF SENSORS

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Abstract: *In mechatronics education accuracy of sensors used in systems control is very important, as students should have to study on adequate examples. Demonstration of control algorithms is the most effective on simpler laboratory setups, or mobile robots, in comparison with simulation realizations of controlled system. As one of the problems of this concept are imperfect sensors used for feedback information. Mobile robot should be aware of its position in every moment, meaning that it should have correct information about the distance from a wall or obstacle. For example, if one wants to demonstrate P controller on a problem of keeping uniform distance from obstacle, sensor choice have influence on final results. This paper presents mentioned problem on distance control of Pioneer 3-DX mobile robot. It deals with problem using two different types of sensors. One is ultrasonic, as 3-DX has these types of sensors by default, and handmade photo sensor. Advantages and disadvantages of both types are presented on experimental results of distance task in different environmental conditions.*

Keywords: *mobile robot, ultrasonic sensors, photo sensors, SoaR*

INTRODUCTION

The main part of engineering education is laboratory work. It requires human, organisational and material resources [1-2]. Evendough it is practically inevitable, in Serbia is not well developed. Important segments of every good laboratory setup are accurate parts. If setup is not well-planed, measuring errors will appear during experiments. Laboratory for automation control at Faculty of Engineering at University of Kragujevac is equipped with various test-benches for student learning process.

One of the most used is Pioneer 3-DX mobile robot. The robot has two wheels drive, and eight ultrasonic sensors for measuring distance from obstacles. As its' sensors are not very accurate, additional part with photo-resistors is made, in order to make measurement more accurate. In this paper we will present performances of both types of sensors. Objective is to make useful comparison for future usage of robots in different environmental conditions. Second section will give robot structure, hardware and software communication. In third section measurement and experimental results will be presented, for maintaining the constant distance from the wall. In the last section focus will be on comparing results from different sensor types.

PIONEER 3-DX STRUCTURE

Mobile robot Pioneer 3-DX is commercial product, designed for educational and research purposes.

Figure 1. Pioneer 3-DX mobile robot

Robot drive is achieved by two separately controlled electromotors. It has two wheels attached to motors, and third which is just for balance. Maximum speed is 1.2 m/s, and it can carry up to 17 kg. Eight ultrasonic sensors are placed in front and overside the robot (Figure 1). On the main board it has additional AD and DA convertors for optional sensors and actuators. Communication is accomplished by serial RS-232 port, over SIP (Status Information Packets) protocol.

In order to achieve greater autonomy, beside the standard serial cable, WiFiRS-232 adapter is added. In that way user can control the robot over the computer with wireless connection.

Robot sensors can make errors during the runtime, so we have integrated the robot "head" with photoresistors as sensors (Figure 2), in order to see

which sensor will give better results. Video demonstration of driving robot over this type of sensor can be found at [3-4]. The "head" has role to lead the robot according to light which is driven to resistors. Analog outputs from robot's head, which are in range from zero to ten volts, are converted over the adequate electronics to range from zero to five volts, which is the adequate range for robot's AD convertor.

Manufacturer made detailed description of SIP, so the communication is made much easier. Software packet SoaR developed at MIT (Massachusetts Institute of Technology) is used for simulation, programming and monitoring the robot movement. Base for SoaR are Python and Tcl, and supported operating systems are Linux, Windows and Mac. Software is given in source code, so a user can make changes and add new types of robots.

In SoaR one can simulate robot's behaviour, or directly control the robot. Test environment („world") for robot can be selected from existing ones, or created by user, giving the coordinates of obstacles in „world".

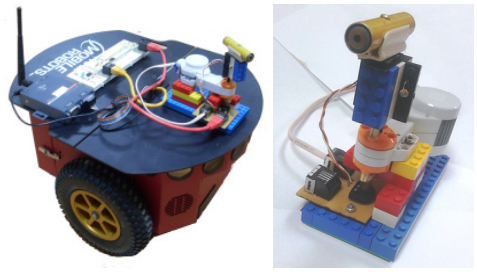

Figure 2. Robot with integrated "head"

EXPERIMENTAL RESULTS

As test example for distance sensors for Pioneer robot first we made simulation in SoaR for keeping the distance from a wall at 50 cm. SoaR environment is given on Figure 3. As the simulation is working with sonars (Figure 3), we run the same program on real system. Control algorithm was simple P controller, because there was no need for more complicated one in this type of testing. Results were different with every execution. Here we show the comparison between simulation results, and two real tests: one faulty, which has the error in measurement so big that the robot hit the wall, and the other one which shows values varying around desired position, with steady-state error because of P controller applied (Figure 4). For second type of sensors we could not use simulation, so we run the program separately for maintaining the same distance, but from the light source, as the sensors are based on photoresistors (Figure 5).

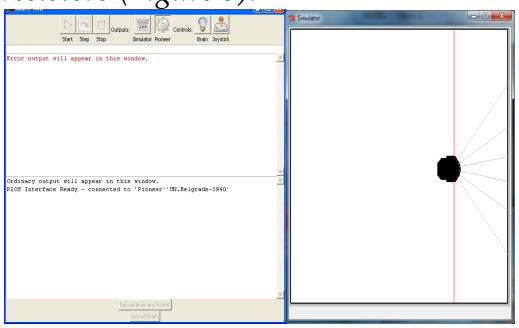

Figure 3. SoaR environment and simulation

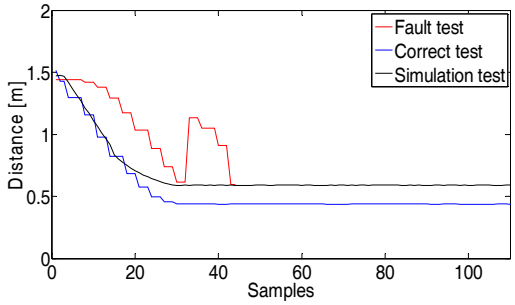

Figure 4. Testing the distance maintaining using sonars

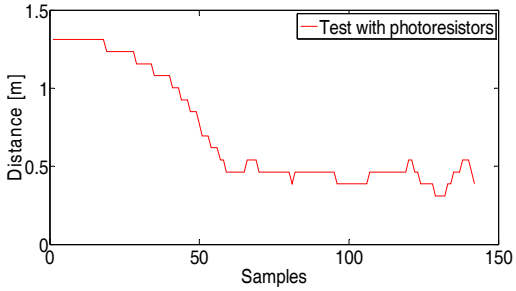

Figure 5. Testing the distance maintaining using photo-sensors

CONCLUSION

As one can see, non of these sensors have completely accurate measurements. Sometimes robot hits the obstacle when the error is too big. As for the photo-sensor, it depends from surrounding light, as well as from the source one. It requires additional tuning of parameters depending on environment. For more complex tasks the difference would be more obvious.

REFERENCES

[1.] *Kostulski, T., Murray, S., (2010). The National Engineering Laboratory Survey.Sydney: Labshare.*

[2.] *Feisel, L.D., Rosa, A.J., (2005). The role of the laboratory in undegraduate engineering education.Journal of Engineering Education, pp. 121.-130.*

[3.] *http://www.youtube.com/watch?v=QgzGUVxm4ck*

[4.] *http://www.youtube.com/watch?v=vUljEj6bp-g*

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AUTOMATION OF CONVEYOR LINES IN THE MILK TREATMENT INDUSTRY

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Abstract: *Intelligent systems such as industrial robots are the basis of CIM (Computer Integrated Manufacturing) systems and are increasingly used in the most demanding applications. There are several reasons for implementing the industrial robots in food processing industry. They can replace humans in physically demanding environments and enable continous operation without stopping and with high precision. All of the above reasons are the criteria for their efficiency. The food industry demands high precision robots for packaging transport and stacking of sensitive products such as dairy products. This article presents the automation of the milk transport line, the industrial robot type MOTOMAN EPL 80 which enables high speed rotation around 5 axes and is used for movement, positioning and rotation of the milk box which is then further transported and packed. The criteria for evaluation of the work on the robot is it's precision, speed and accuracy.*
Keywords: *Automation, transport, robotic process industry, economy*

INTRODUCTION

The automatization of processes has its application primarily in the processes of production and operating machines [4]. Industrial robots are automatized systems which use computers as an intelligent part of operating [1]. A robot means a machine that is consisted of mechanisms with different ways of independent movement, which is capable of using a tool or a working object [2]. The automatization of a transport line can include one or more industrial robots at the same time, depending on the complexity and level of the operations carried out by the robot. The industrial robots are equally perfect for monotonous and more difficult tasks [3]. As you can see on the pictures, the robot is a part of an automatized process and its task is to move, position and turn the packages of milk, while the task of other segments of the automatized process is transport and piling packages of milk. Regarding bigger and more demanding capacities, the robots which can move and turn objects faster are developed. Thus, for example, the robot MOTOMAN EPL 80 has a maximum speed of rotation on its axis T of 350^0 per second [7].

THE AUTOMATIZATION OF A TRANSPORT LINE IN THE PROCESS INDUSTRY OF MILK

The figure 1 shows an automatized line for the transport and piling packages of milk. The automatized line for transport in the process industry of milk, as it is shown on the figure 1, is consisted of transport lines in several segments, which are used for transporting packages of milk separated by independent machines, a robot which turns and positions the packages, a machine which prepares the layers of packages and a one-pole machine which piles the layers. Apart from these machines, it is important to say that the process of automatization also includes sensors which signal when and how the mentioned machines in the automatized line will activatepower, improved dynamic indicators and advanced managing algorithms.

The process of the automatized transport line in the process industry of milk is usually described from the end towards the beginning since it is easier to understand the logic of its order this way. The one-pole machine for piling layers, which is used for piling layers of packages for further transport to

the warehouse, has a built-in sensor S8 which controls the height of a pile.

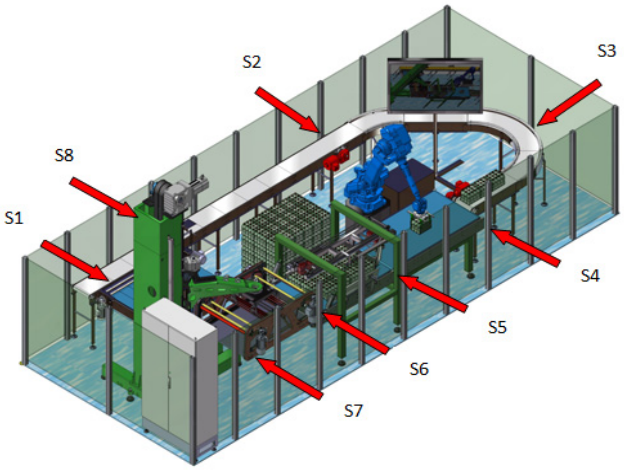

Figure 1. The automatization of the transport line for packaging milk [8]

Figure 2. Paletizer for for piling packages [8]

That means, when a certain number of layers is piled, the sensor S8 signals that the machine for piling layers should be temporarily stopped and quit piling further layers until the piled packages are transported from the place of piling layers to another pile and until another pile is positioned in the right place where we should get the signal from the sensor S1. As soon as the sensor S1 signals that the empty pile holder is positioned, the process of piling continues to be carried out by the machine for piling layers.

Figure 3. Transport rollers for transporting piles with sensors [8]

The layer of packages is taken from the transporter which is used for delivering layers as soon as the machine for piling packages gets a signal from the sensor S7 showing that the layer is ready to be taken. There is the built-in sensor S6 on the transporter for preparing the layers of packages, which, followed by the sensor S5, signals to the robot where and how the package should be positioned. On the transporter for preparing the layers, the packages are positioned according to the logic and order of an imaginary layer of packages. Moving a prepared layer of packages from the transporter for preparing layers onto the transporter for delivering layers, is signalled by the sensor S6 which should get a signal from the sensor S5 that the layer is ready to be delivered as well as a signal from the sensor S7 that there is an empty space on the transporter for delivering layers. When these conditions are fulfilled, a layer can be positioned on the transporter for delivering layers of packages.

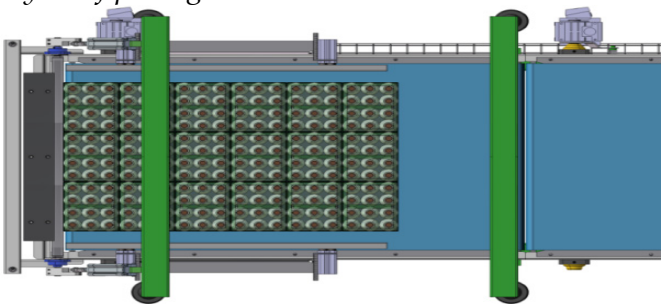

Figure 4. A prepared layer of packages on the transporter for preparing packages [8]

In case that the sensor S7 signals that the transporter for delivering layers of packages is not empty because there is a layer of packages still positioned on the transporter for delivering layers of packages, the process will be automatically stopped temporarily until there is a signal that it can be restarted. Working of the robot, and that is positioning and, if necessary, turning packages towards one of the three possible positions, regarding that a layer is consisted of three rows, depends on getting a signal from the sensors S5 and S4. Having positioned one carton, the robot comes back to its zero position from which it starts to move in order to turn or move another package. This zero position is usually near the place where the packages are taken, especially when they are big, and then it is essential not to waste time and energy. If the robot gets a signal from the sensor

S5, that means that the line from the robot onwards is full. At that point, the robot is stopped and waits for the next information. Of course, in that case, the transporters for delivering packages are also stopped. The robot is in its zero point until the moment when it gets a signal that the line is empty and that the package can be positioned.

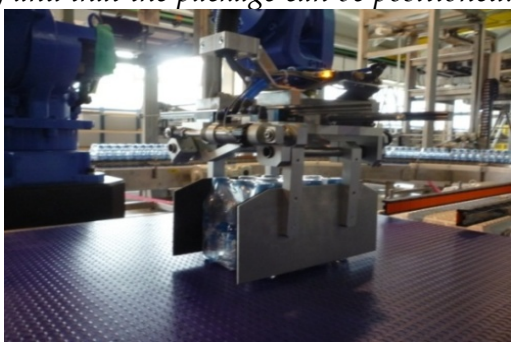

Figure 5. A robot with package holder is positioning a package on one of the three possible positions [8]

The robot takes packages from the delivering transport line which moves when there is a signal from the sensor S4 that the packages can be put on the transporter for positioning of packages. Sensor S4 is also used for counting packages which means that firstly the value of needed capacity should be typed in and then, after a number of packages is counted by a shaft of light of the sensor S4, the delivering transporters are stopped since they get a signal that the capacity has been achieved. In case that the sensor S5 signals that the prepared layer of packages on the transporter for preparing layers is full, the sensor S4 signals that the transporter for positioning packages should be stopped. The delivering transporter for packages keeps working and the packages are gathered for the so called layer reserve until the number of packages needed for the layer reserve is achieved. Then, the sensor S3 signals that the layer reserve is made and then the delivering transporter is stopped.

Figure 6. Transport and the prepared reserves of layers of packages [8]

After getting a signal from the sensor S3 that the layer reserve of packages is full, the transport line in front of it is automatically stopped and there the sensor S2 gets a signal and forwards it requesting stopping transport of packages. Electro motor powers of the transport lines and all other machines of the automatized lines are also equipped with frequency transformators which are used to control achieving capacity (by increasing and decreasing frequency from the standard 50 Hz) and to lessen sudden stopping and moving of the transport lines and other machines, which is very important for transport and piling milk and dairy products. We can notice that all the commands for the machines in the automatic line are signalled by sensors. Here, the indirect optical sensor SICK is used and its working is based on reflection beams. That means that a sensor is put on one side of the transport line and a reflection mirror is put on the other side. By activating the sensor, it casts a shaft of light on the mirror and gets back another shaft and that is the way it functions. When a package comes and cuts the shaft of light, the sensor gets a signal and forwards it as a signal that it has got a package. When the package passes, the shaft of light between the sensor and the reflection mirror is restored again waiting for another package.

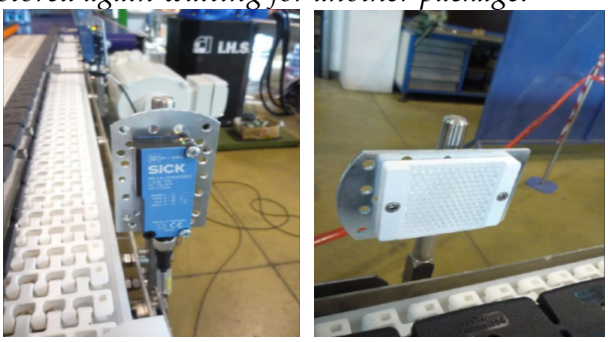

Figure 7. The sensor SICK WL 11-2F2430S04 and a reflection mirror [8]

One of the most demanding tasks on this automatic line is the one of the robot. Its task is to achieve the capacity, and that is to manage to position and turn the packages and to adopt to the type of layer. The picture 4 shows a type of layer, but any other layer is piled in different way so that the piled packages don't break up during the transport. That means that the packages on other layers are turned 90° in relation to the layer shown on the picture 4 in order to get more stable pile of packages by covering them. For bigger capacities, e.g. 3600

packages/h or even more, the robots are necessary. That is because they are tireless machines which react to the signal while performing their tasks. On this example, we can see that a package after package is taken and positioned. However, for bigger capacities, the layers are combined so that the robot positions two or more packages at the same time, depending on the size and shape of the package.

CONCLUSION

Considering all this, we can say that robots today are necessary for performing demanding tasks, such as achieving big capacities in piling packages in the process industry of milk, piling units up in packages and other difficult tasks (4). The automatization means transfering human's job to the machines, usually through a technical advance (5). The main advantage of robots over a human is their tireless and precise working, not depending on time, while a human is capable of working precisely only for some time, and after that he loses his concentration and precision and gets tired both physically and mentally (6). When choosing robots, we should take care to choose a suitable and optimal robot considering its capacity, speed, using energy, etc. Nowadays, there is a tendency towards optimizing processes and that is where robots have advantage and usefulness. There is a constant need for increasing exploitation of machines and profit as well as decreasing expenses, or better to say, for making economies. The robot we were talking about has a very demanding task and that is positioning packages in one of the three possible positions and turning them when necessary. Regarding its precision, it fulfills the field of tolerance in piling packages. For the lines like these, it is common to align all sides of the layer on the transporter for preparing layers before putting it on the transporter for delivering layers. This alignment is done by pneumatic boards on all the sides at the same time. In this way, the layer is in ideal position for further process.

REFERENCES

[1] *V. Doleček; I. Karabegović, Robotika, Univerzitetska knjiga, Bihać 2002.pp.201-238.*

[2] *V. Doleček; I. Karabegović, Roboti u industriji, Univerzitetska knjiga, Bihać 2008.pp.73-125.*

[3] *Zdenko Kovačić, Stjepan Bogdan, Elementi sustava automatizacije, Zavod za automatiku i računalno inženjerstvo, Sveučilište u Zagrebu, Fakultet elektrotehnike i računarstva, Zagreb 2008.pp.30-37.*

[4] *W. Rone, B., Pinhas,Mapping, localization and motion planning in mobile multi-robotic systems, Robotics and Mechatronics Laboratory, Department of Mechanical and Aerospace Engineering, The George Washington University, Washington, ISSN:02635747 Vol.31 Issue1, pp.1-23.*

[5] *Zoran Kalinić, Osnove automatizacije, Zagreb 2012.pp.46-64.*

[6] *www.motoman.de 15.02.2009.*

[7] *www.robotik.de 18.02.2009.*

[8] *IHS d.o.o., baza podatatka, 19.02.2009.*

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HUMAN VIBRATIONS EFFECTS, MEASUREMENT AND PROTECTION

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Abstract: *In this paper, measurements of mechanical vibrations are carried out at different working conditions by using different tools. Measurements were committed with a 4447-type Human vibration analyzer, with vibrations measured from the source to the receiver. Measurements are made in real time, by using a specific tool, and worker for whom minimization of vibrations at work is needed. Vibrations which can vary in large measure regarding the excitation frequencies and levels, can also depend from the employee's weight and conduct. The time of exposure to vibrations can be determined with proper measurement in real terms, which is one of the most important factors in preserving the health of the employee.*

Keywords: *human vibrations, measurement, protection*

INTRODUCTION

Man, throughout his life is often influenced by mechanical vibration. Prolonged exposure to high levels of vibration of the body leading to premature fatigue and lower productivity, and often the incidence of occupational diseases.

In numerous studies that have been done for the assessment of human vibration, especially for vibrations that occur in the work environment are observed international standard values used for evaluating the allowable vibration. European Directive EU 2002/44/EC introduced the minimum health and safety requirements for workers to protect them from possible exposure to vibration in their work activity. Standard applications include measurement of whole-body vibration and the vibration of the upper limbs in humans, with an instrument that meets the standard requirements.

INDUSTRIAL VIBRATION

Industrial vibration with its physical characteristics has complex classification. Vibration depending on the nature of contact with the source of vibration is divided into:

- *Vibration, which people are exposed through the support surface (the surface on which a person stands, sits or lies) that have an effect on the whole body and are called general. This whole-body vibration and occur in all types of transport and industrial zones.*
- *Vibration, affecting only part of the body are called local. The transfer of vibration is usually of the hands (fingers) and occur where the vibrating tool.*

Vibrations often occur in combination of local and general vibration. Table 1 presents the two types of vibration: hand-arm vibration and vibration transmitted to the whole body, with their meaning and implications. Table 2 shows the limits of exposure to vibration according to Regulation for Safety and Health of Employees at risk of mechanical vibrations (Official Journal of R.M. No. 26/2008).

Table 1. Division of vibration during exposure

Terms	*Meaning*
1. Hand-arm Vibration	*Mechanical vibration which when transmitted to the human hand-arm system, causing risks to health and safety of employees (vascular, bone or joint, neurological or muscular disorders)*
2. Whole-body vibration	*Mechanical vibration which when transmitted to the whole body, causing risks to health and safety of employees, especially of immobility lower of the back, and damage to the spine*

Table 2. Allowed limits of exposure to vibration

Limits of exposure and values at work	
1. Hand-arm Vibration	*- Limit value of daily exposure at work, the default for a period of 8 hours is* ***5m/s²****.* *- The value of daily exposure at work, the default for a period of 8 hours is* ***2,5 m/ s².***
2. Whole-body vibration	*- Limit value of daily exposure at work, the default for a period of 8 hours is* ***1,15m/ s².*** *- The value of daily exposure at work, the default for a period of 8 hours is* ***0,5 m/ s²***

METHOD AND METHODOLOGY FOR MEASURING THE VIBRATION OF HAND-ARM SYSTEM

Today, the intensity of vibration is measured objectively using appropriate encoders (sensors) and additional testing equipment. Encoders are used for measuring vibrations: for measurement of displacement (contact and without contact), to measure the speed and accelerate measurement.

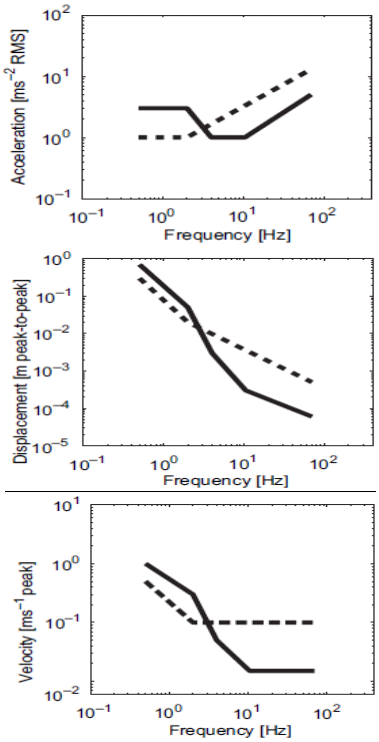

Figure 1. Vibration can be expressed through acceleration (left), velocity (right) and feed (center) [1]

According to ISO 5349:2001, values of human vibration are acceleration (a), indicated as RMS (mean square value of vibration acceleration). Results of the measurements are expressed in m/s².

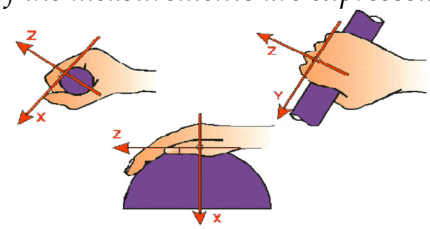

Figure 2. The principle of measurement, location and axial-orientation of hand system

The standard ISO 5349 1:2001 recommends setting the frequency in three directions: the axis direction of the arm and two other axes in the plane between the hand and the tool (Figure 2). The best solution is using a miniature triaxial accelerometer, which receives vibrations from all three directions at one point. Frequency range of the analysis is 8-1000 Hz. Weight factor of frequency, Wh, (Figure 3) is used for all three axes, although anatomy, sensitivity along the arm and in transverse direction are different.

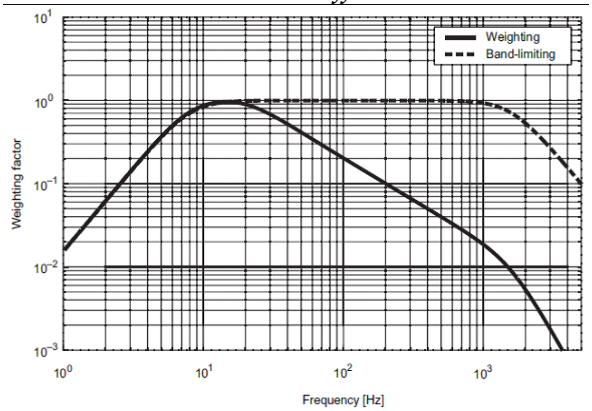

Figure 3. The size of the frequency weighting factor according to ISO 53491 or ISO 8041 [1]

The three components of frequency of acceleration are marked with a_{hwx}, a_{hwy} and a_{hwz} while the root of the sum of their squares give total vibration a_{hv}:

$$a_{hv} = \sqrt{(\text{kxa}_{\text{hwx}})^2 + (\text{kya}_{\text{hwy}})^2 + (\text{kza}_{\text{hwz}})^2} \qquad (1)$$

Calculation of daily vibration exposure A (8), for one worker during 8 hours will be:

$$A(8) = a_{hv}\sqrt{\frac{T_{exp}}{T_0}} \qquad (2)$$

where T_0 is the reference time of 8 hours, T_{exp} duration of exposure to vibration or the duration of the operation, including breaks, depending on the measurement approach.

MODERN MEASUREMENT SYSTEMS FOR MEASURING VIBRATION

The principle of operation of modern equipment for measuring and analysis of vibration will be shown to the device- Human vibration analyzer - type 4447 of Bruel&Kjaer.[1]

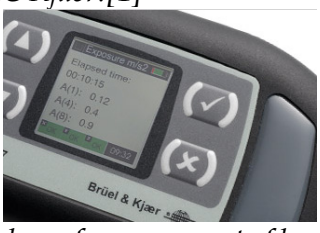

Figure 4. Analyzer for assessment of human vibration Type 4447, Bruel & Kjaer [1]

Analyzer - Type 4447 is portable systems designed to control and eliminate potential vibration in accordance with EU Directive 2002/44/EC. [3]

Type 4447 - Bruel & Kjaer, provides integrated solutions for measuring and analyzing vibration.

The graphic display (figure 4) of 124x124 pixels provides continuous, detailed feedback on exposure to vibration and allows assessment of the measurement immediately.

MEASUREMENTS OF VIBRATION

In this paper, measurements are performed of exposure to vibration, of the employee who works with Hand Drilling Machine Φ5 in concrete MB30 (Machine A and B) and Cordless Drill Driver, in wood (Machine C). Measurements were performed in accordance with recommendation of the International Standard ISO 5349:2001 (local vibration, hand-arm).

Figure 5. Equipment that was made measurement: type 4447 analyzer and computer processing of measurements in 4447 Vibration Explorer-software

The main accent in the measurement is the position of the Z axis, set as vertical and horizontal component when measuring.

Results of measurement 1

Figure 6. Machine A- Large Hand Drill (Φ5) Measuring exposure to vibration in the horizontal and vertical position when working in concrete

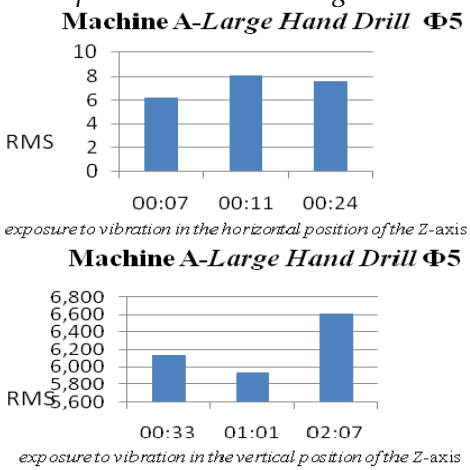

Figure 7. Machine A- Large Hand Drill (Φ5) Displaying RMS vs. time of exposure, at horizontal (left) and vertical (right) posicion of the Z-axis

The measured vibration exposures of Large Hand Drill, the results show a daily average exposure of 6,738 (RMS). Relying on allowable limit values [6], the exposure of this machine is reduced to 6 hours in accordance with ISO 5349-1/2 [7] [8].

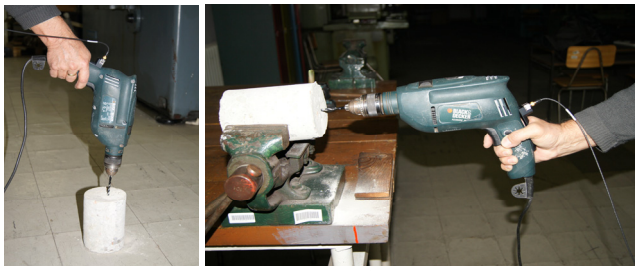

Figure 8. Machine B- Small Hand Drill (Φ5) Working with Small Hand Drill Machine in vertical and horizontal positions

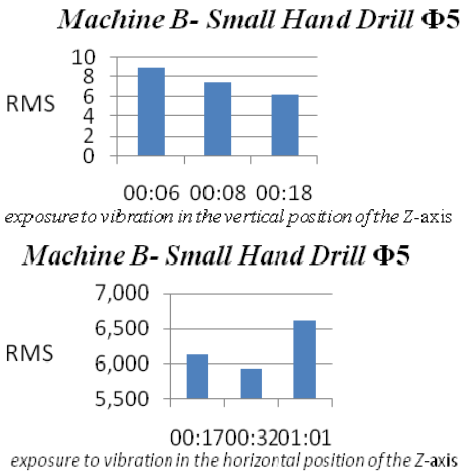

Figure 9. Machine B- Small Hand Drill (Φ5) Displaying RMS vs. time of exposure, at horizontal (right) and vertical (left) position of the Z-axis

Results for Little Hand Drill Machine for daily exposure A (8), according to measurements of exposure to vibration, shows the average value of 8,341 (RMS), and for overcoming the limit value, time of work optimize up to 5 hours.

Results of measurement 2

Figure 10. Machine C- Cordless Drill Driver (Φ5) Working with Cordless Drill Driver in vertical and horizontal positions

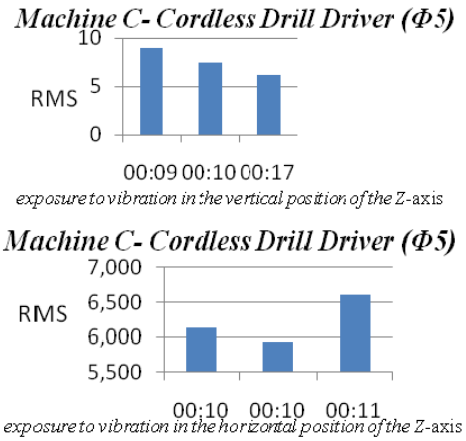

Figure 11. Machine C- Cordless Drill Driver (Φ5) Displaying RMS vs. time of exposure, at horizontal (right) and vertical (left) position of Z-axis

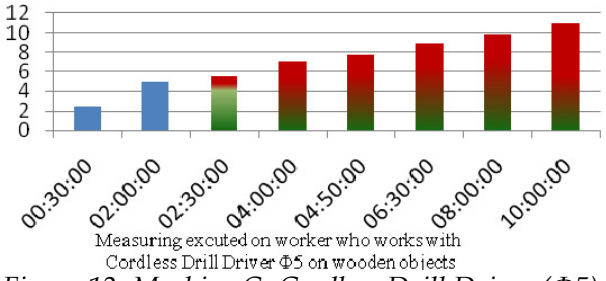

Figure 12. Machine C- Cordless Drill Driver (Φ5) Displaying RMS vs. time of exposure at horizontal position of Z-axis (No.7-2HOR)

According to the exposure limit values (Figure 12), allowable working action with this machine is 4 hours. Any continuously overcoming above the daily exposure can lead to professional illness.

	Color	Action value EAV (2,5m/s²)	Limit value ELV (5m/s²)
0 to 5 m/s²	Green	More than 2 hours	More than 8 hours
5 to 10 m/s²	Amber	30 minutes to 2 hours	2 to 8 hours
>10 m/s²	Red	Less than 30 mins	Less than 2 hours

Figure 13. Allowed Maximum exposure by the hand-arm vibration (ISO 5349)

Note in respect of position in which the worker is exposed. The vertical component of the vibration is unfavorable for people who work in a sitting position, and the horizontal component of the standing working position of.

VIBRATION PROTECTION & CONCLUSION

It can be concluded that the full elimination of vibrations from the environment in general, is not possible. In any case, employees should not be exposed above the exposure limit value. There are several methods used to prevent vibration. Action for preventing vibrations [4], [5]:

- *Elimination;*
- *Replacement;*
- *Isolation;*
- *Engineering controls (the source of vibration and their progress);*
- *Administrative control (exposure to vibration and training);*
- *Regular health checkups and*
- *Supply of personal protective equipment.*

References

[1.] *Human Vibration Analyzer Type 4447-User Manual, Good Practice Hand Arm, Good Practice Whole body*

[2.] *CEN Technical Report - "Notes on the assessment of exposure to vibration based on information supplied by the manufacturer of the machine"*

[3.] *Reaction of human to vibration (ISO 8041:2005)*

[4.] *GOST 12.4.002-74 "Hand protection from vibration-General requirements."*

[5.] *GOST 12.4.024-76 "Shoes for protection against vibration"*

[6.] *Regulation on Safety and Health at Work of employees at risk of mechanical vibrations (Official Journal of R.M. No. 26/2008).*

[7.] *ISO 5349-1 Mechanical vibration. Measurement and evaluation of vibration exposure in man hand. Part 1: General requirements*

[8.] *ISO 5349-2 Mechanical vibration. Measurement and evaluation of vibration exposure in man hand. Part 2: Practical Guide for measuring workplace*

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PRACTICAL ASPECTS OF INTEGRATION IN THE DEVELOPED MOLD DESIGN SYSTEM

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Abstract: This paper presents the aplication of a feature-based design features within simulation model development procedure. Based on a review of the feature technology and previous research work, paper focuses on the modeling of intricate relations among features of different design aspects. An example is provided to demonstrate our approach and to show its effectiveness in the integration of the modules. The authors propose a set of CAD-CAE features that are oriented to both the design and analysis processes in the developed an integrated CAD/CAE mold design system.
Keywords: mold design, numerical simulation, DB, CAD/CAE features

INTRODUCTION

Injection molding process is the most common molding process for plastic parts manufacturing. Plastic injection molding design includes plastic product design, mold design, and injection molding process design, all of which contribute to the quality of the molded product as well as production efficiency. The creation of feature geometry is dependent on the functionality of the CAx. If a CAD system supports feature-based modeling, as is the case, geometry will be referred to as 'CAD features'. However, these features are CAM-oriented too, but, in general, cannot be directly mapped into CAE-oriented features. These CAD features provide the geometry for the developed proposed CAD/CAE features. CAD/CAE system consists of four main modules [2, 4, 5, 6] such as CAD/I module for CAD modeling of the part, CAE/I module for numerical simulation of injection molding process, CAE/II module for mold design calculation and selection and CAD/II Module for mold modeling (core and cavity design and design all residual mold components).

The developed mold design system makes possible to perform: [2, 4]

- 3D modeling of the parts, analysis of part design and simulation model design,
- numerical simulation of injection molding and
- mold design with required calculations.

CAD/I Module

CAD/I module is used for generating CAD model of the plastic product and appropriate simulation model. The result of this module is solid model of plastic part with all necessary geometrical and precision specifications. Proposed precision specifications are: project name, number, feature ID, feature name, position of base point, code number of simulation annealing, trade material name, material grade, machine specification (name, clamping force, and maximal pressure). If geometrical and precision specification is specified (given) with product model, the same are used as input to the next module, while this module is used only to generate the simulation model.

CAE/I Module

Module CAE/I is used for numerical simulation of injection molding process. User implements an iterative simulation process for determining the moldability parameters of injection molding and simulation model specification.

INTEGRATION OF CAD/CAE

The authors propose a set of CAD/CAE features that are oriented to both the design and analysis processes. These include a part feature and a collection of wall, hole, rib, or slot features. These features can be decomposed into a number of sub-features because designers may need to specify

different non-geometrical information over different parts of a feature. The part feature contains the overall information of a plastic part. At the top of the feature tree is the part feature then simulation model features. The second level of the tree contains collections of non-geometric features and development simulation model features. The third level contains UDF with CAE text information. UDF contains design and analysis related data, which are called feature attributes. All features have a reference base point attribute, which describes the relationship between them. All design parameters have to be collected and managed in to model tree. With such conceptual features being specified by suitable parameters and values, the degree of uncertainty in the design problem will be reduced progressively in iterations. Finally, a well-defined simulation model, together with its important and influential features as well as potential options and configurations, is established and transferred to the next step of design. Next, along the stages of evolvement of detailing parametrically in the feature-based design approach, conceptual features are gradually enriched; and detailed features in individual components are constructed. Among these features, a hierarchical system of feature parameter maps can then be worked out. Further, the engineering analysis programming effort, with the support of a spreadsheet or a DB, can be carried out. After the previous steps of analysis, the design output parameters are defined into Pro/Table, and parameters are explicitly associated to important product modeling aspects and their relevant implementation features. In such a feature-enabled design environment, the product's geometry modeling makes use of those parameters of features calculated in the previous module as the input. In addition, at the CAD modeling, geometric constraints are imposed because component features are often affiliated to other advanced features, like conceptual features and assembly features are associated to the product design. Eventually, the final product is developed with all the detailed model features in to CAE/II and CAD/II module. In addition to engineering design equations and solutions, models, and documents, the useful information chains defined as design output 3D model. Within the design process, a constraint-driven design method can be applied, and at the same time, design can make full use of the advantages of feature-based technology. The potential goal is to achieve the information synchronization by production rules at different design stages such as concept design, detail design, or redesign. Flowchart of the integrated CAD/CAE features between module CAD/I and CAE/I is shown in Figure 1.

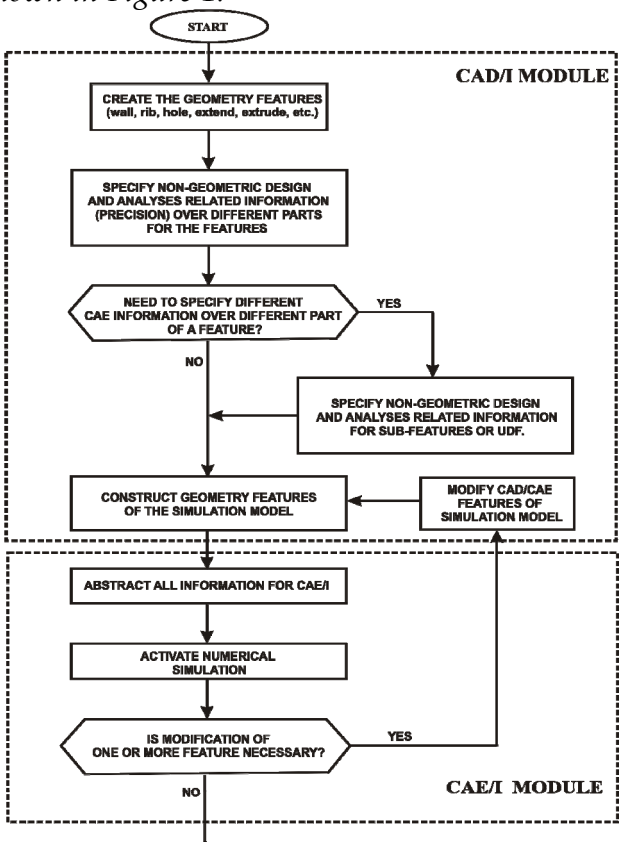

Figure 1. Flowchart of the integrated CAD/CAE features

CREATE CAD/CAE FEATURES

Assignment of CAD geometry to a CAD/CAE feature may involve selection of a complete CAD feature, combining several features, and/or decomposing a feature so part of it can be selected. After the geometry has been defined non-geometric as well as precision information can be added [2, 4, 5, 6]. Its geometry is assigned through the assignment of the constituent `optimal wall feature` in mechanical calculation (CAE/II module). Overall product information relating to design and analysis can be specified the simulation model and mold design approach. The abstraction process involves abstracting a geometric model as well as non-geometric analysis information, such

as material type, boundary conditions, several processing conditions and constraint information. With all of the information is available, the CAE/I system can be activated to conduct numerical simulation of injection molding process. The analysis results are then examined to check whether any of the pre-defined criteria – which are in the form of part feature constraints in the simulation model – are violated. If they are, then the CAD/CAE features need to be modified. After modification, a new model will be constructed and an analysis model abstracted, so that another CAE/I analysis can be activated. The process iterates until rules have been satisfied and simulation model is acceptable. The exact definition of thickness depends on the size and shape of the part. The following rules give satisfactory results:

- *Consider the average of the length and width of a local region, and average wall thickness So < 1/4 of average of the length and width of a local region.*
- *Ensure the thickness is less than one quarter of this average.*

Off course for real parts, it is time-consuming to apply the above rule to each wall. However, it is often possible to look at the entire part or simulation model and decide whether or not it is suitable to be taken through the CAE/I module.

RESULTS OF CAE/I MODULE

Our research team used well known simulation model [2, 4, 5, 6], as concrete example to demonstrate the power of the first integration of the CAD/CAE integrated design system for mold design. The Gate Location analysis indicates a suitable location if the flow of material is balanced. Therefore, a blue region is shown in Figure 2. Dark blue indicates the best location to inject the material. The Confidence of Fill result is shown displays the probability of a region within the cavity filling with material. The Quality Prediction result measures the expected quality of the simulation model's appearance and its mechanical properties. The Fill Time result shows the flow path of the plastic through the simulation model. The Pressure Drop result displays the drop in pressure from the injection point to the selected point, at the moment that point was filled. The Injection Pressure result displays the pressure at the injection point at the moment each point was filled and the Flow Front Temperature result displays the material melt temperature at each point at the time it was filled. Sink mark estimate of the simulation model is also shown in Figure 2. The Confidence of Fill and the Quality Prediction results are good starting points when checking developed features. They will show designer where there may be problems. Table 1 presents some of expressions must be acceptable. An area of the Quality prediction result is green if all of these expressions are true.

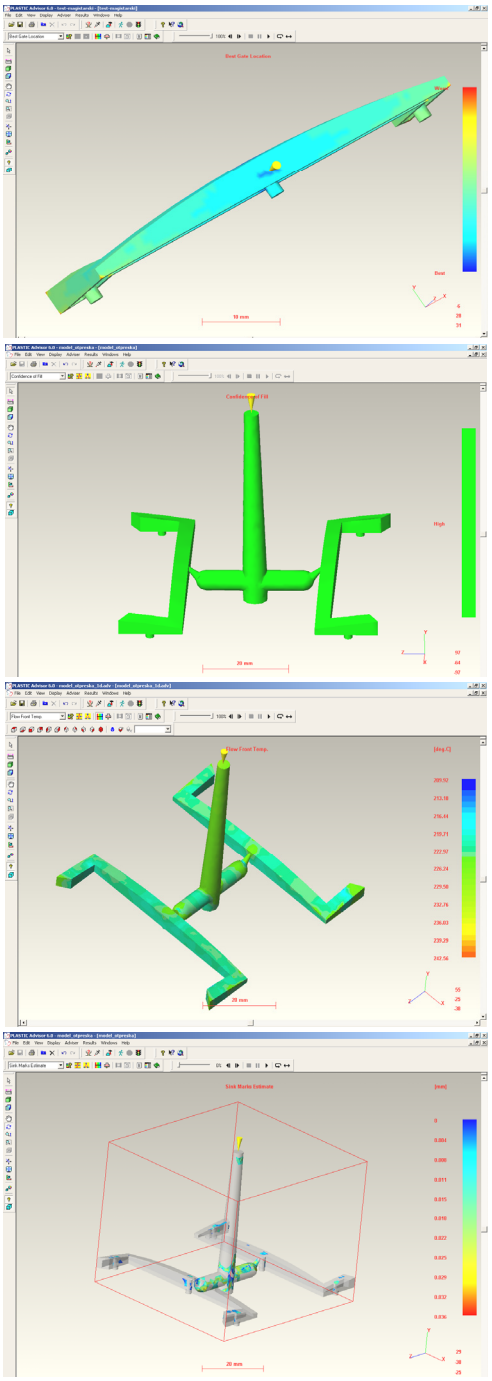

Figure 2. Few results of numerical simulation

Table 1. Expressions for green quality prediction

Description	Equation
The flow front temperature (T) is between the minimum (T_{min}) and maximum (T_{max}) recommended temperatures for the material in the DB.	$T_{min} < T < T_{max}$
The pressure drop (p_{drop}) is in the range between 0% and 80% of the maximum injection pressure (p_{max}).	$p_{drop} < 0.8\ p_{max}$
The cooling time (t) is less than 1.5 times the average cooling time for the part (t_{av})	$t < 1.5t_{av}$
The shear rate (τ) is less than the maximum recommended shear rate in the material record (τ_{max}).	$\tau < \tau_{max}$
The shear stress (σ) is less than the maximum recommended shear stress in the material record (σ_{max}).	$\sigma < \sigma_{max}$

The Quality is derived from combinations of the five results listed below. The five results are: Flow front temperature, Pressure drop, Cooling time, Shear rate and Shear stress. Only if all five results in an area are acceptable, the area is green.

CONCLUSION

Integration is achieved through a feature-based integration model and an iterative design-analysis process. The integration model consists of a number of CAD/CAE features and the relationships between them. The features capture both geometric and non-geometric information essential for CAE/I analysis and mold design in CAE/II module. By using existing software, development effort is reduced considerably and full advantage can be taken of the functionality of this software. A number of tools have been developed to assist in the integrated design-simulation process. With this model, designers can specify not only design information, but also CAE information. This is especially useful when a designer needs to specify mold design parameters intentions that are analysis-related, such as gate location constraints estimate in module CAE/I and for example „measuring wall distance" in module CAE/II. The case study also shows that the developed system supports iterative design-analysis process. The results of this research are limited to Creo Parametric and MPA. The future can be developing the integration model can be applied to other CAD and to other CAE/I software, if Serbian industry explicit need that. R&D of the integration process will continue in the future, especially interference engine using VBA and actual KBE techniques.

REFERENCES

[1.] *Deng, Y.M., Lam, Y. C., Tor, S. B., Britton, G.A. (2002).: A CAD/CAE Integrated Injection Molding Design System, Engineering with Computers Vol. 18, pp. 80–92.*

[2.] *Hodolic, J., Matin, I., Hadzistevic, M., Vukelic, Dj. (2009). Development of Integrated CAD/CAE System of Mold Design for Plastic Injection Molding. Materiale Plastice. Vol. 46, No. 3, pp. 236-242.*

[3.] *Kennedy, P. (2008). Practical and Scientific Aspects of Injection Molding Simulation. University Press Facilities-Eindhoven, ISBN 978-90-386-1275-1.*

[4.] *Matin, I., Hadzistevic, M., Hodolic, J., Vukelic, Dj., Tadic, B. (2010) Development CAD/CAE system for mold design, Journal of Production Engineering, Vol.12, No 1, pp. 222-225.*

[5.] *Matin, I., Hadzistevic, M., Hodolic, J., Vukelic, Dj. (2011). An Interactive CAE/CAE System for Mold Design. Proceedings of 34th International Conference on Production Engineering, p.213-216.*

[6.] *Matin, I., Hadzistevic, M., Hodolic, J., Vukelic, Dj., Lukic, D. (2012). A CAD/CAE Integrated Injection Mold Design System for Plastic Products., International Journal of Advanced Manufacturing Technology Vol. 63, No. 5-8, pp. 595-607.*

[7.] *Nardin B, Kuzman K, Kampus Z (2002) Injection moulding simulation results as an input to the injection moulding process. International Journal of Material Processing Technology Vol. 130-131, pp. 310-314.*

[8.] *Zhou, H., Shi, S., Ma, B.: Virtual Injection Molding System Based on Numerical Simulation. International Journal of Advanced Manufacturing Technology, Vol.40, No.3-4, pp. 297-306, 2009.*

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TEACHING STANDARDS IN HIGHER ENGINEERING EDUCATION – NECESSITY, OBJECTIVES AND APPROACHES

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Abstract: *In the presented report, through in-depth study of international researches, the importance of standards in all areas of life and pressing need to deepen the study of standards in the higher engineering education has been reasoned. Results of a questionnaire survey have been stooped, with respondents - engineering students, confirming their awareness that enhanced study in the field of standardization is needed. Education about standards and up to date information about them is condition for improving the quality and effectiveness of their study. The authors propose a comprehensive approach to education about standards, which includes complementing of the curriculum of technical subjects and creation of new discipline that studies standards used in the particular specialty and those found in everyday life. Positive contribution to the creation of good qualified engineers has access to updated information about standards, which would be achieved through the establishment of an Information Centre at campus in constant contact with Standardization Institute.*
Keywords: *Standardization, higher education, engineering education, teaching program, survey*

REVIEW OF THE PROBLEM

Standardization is a key factor for the integration of a national economy into the world market, which ensures uniformity of product requirements, production conditions and procedures for assessing compliance, thus achieving free movement of goods, people, capital and services worldwide. Compliance with endorsed norms and standards results in improved living conditions through the provision of security products and services, protection of health and life of humans, animals and protection of the environment. Therefore, for proper realization of young people in a market economy, it is essential that in the learning process at all levels information about standardization and training, which creates knowledge and skills to work with standards, is included.

This concerns even more engineering students because most of the technical knowledge is regulated and standardized. Understanding the local, national, European and international technical standards and information for their update, is imperative to improve the quality and effectiveness of engineering education. As future professionals, producers and consumers students should realize the social significance and role of standards. Future engineers have to be aware that applying standardization would improve the quality of their product or service. High quality is always a very strong argument for the production sale and it is one of the best ways to create permanent customers. To attract new customers, standards are one of the most effective methods of persuading consumers because the product meets the highest and most common requirements for quality, safety and security. Protecting the safety, health and welfare of the public is part of the Code of Ethics for Engineers. The application of standards plays a major role in satisfying this.

The application of standards enhances competitiveness by offering high quality product of labour. The young engineer should know that the application of technical standards ensure its competitiveness, maximize the potential market and is an advantage in export of products. Although standards are voluntary and not required by law in some markets the output will be accessible, unless it meets certain criteria of quality and safety. The application of certain standards as related to environmental protection, help to build a reputation in the community.

Standards provide young professionals a safe starting point, which reduces the risk of mistakes and misunderstandings and this good practice decreases wasted time and money to develop products that do not meet the necessary quality requirements. Application of technical standards reduces costs for research and development [3, 4].

Young specialists have not only to learn the benefits of applying the standards during their higher education, but also how to access them. They have to become familiar with the activities of the standardization institutes in the country, in Europe and worldwide. They have to learn how to receive timely information on new introduced, changed or updated standards.

PERSPECTIVE OF BOTH EDUCATORS AND BUSINESS REPRESENTATIVES

In this part of the report, the authors reviewed the research and publications on the subject matter of standardization institutes, universities and industry from different countries.

For example, in 2005, US Congress estimated that private sector standards and government technical regulations directly affected at least $7 trillion (US) of world trade in 2003. In UK National Standards Strategy (2003) is written- Standards influence everything we do. Standards control markets (German National Standards Strategy (2005)).According French Standardization Strategy (2006) - Standardization is one of the most powerful sources of competitive economic intelligence available.

In American Society of Mechanical Engineers they believe that standards must be integrated into engineering and engineering technology courses, be a part of design and manufacturing-oriented competitions, and be embraced by faculty as important to preparing students as practitioners. The course exposure must include both national and international standards such as those from ISO, IEC, and ASME, because of the global nature of engineering.

BSI British Standards states that the continued success and development of the UK economy has a need for students to understand the significance of standards within it. Standards form a common language, a dialogue in which all can participate and from which all can benefit. The key benefits of developing a strategic education plan, nationally or internationally, are numerous: raising awareness from a young age of the benefits and uses of standards; influencing future participants in standards creation and future purchasers of standards; furthering the research base on the impact of standards.

Like industry representatives, CSK Holdings Corporation note that the effect of the quality and quantity of the output of an education program is profound and wide, and its results may affect the society and its economy for many years. They say that standards, especially global standards have strategic value in the sense that they affect not only the current marketplace or product/service production, but also the industry and government planning because they will promote the specific lines of products/services that conform to the standards.

The Institute of Electrical and Electronics Engineers expose the opinion that technical standards are consensus documents that define the solution of complex technical problems taking into account economic, ethical, and societal constraints. A large part of the world's trade today involves products that comply with one or more standards. This has made education about standards, both at the college level and among the workforce, of significant importance. At the same time education about standards faces significant challenges. These challenges include increasing technology complexity and rapid evolution of standards.

While the critical role of standards is generally recognized, surprisingly little has been reported about the critical role of standards education. Not only are standards of critical importance, but standards education is of strategic value to industry and the society.

Behind a winning standards strategy there are well-trained and experienced technologists and marketers who have mastered the art and science of standards in industry. Most often, these employees have learned the practice of standards at best, from a company mentor or at worst, by trial and error. It can take many years of "on-the-job training" for a professional who is unfamiliar with standards to become fully proficient.

Standards education programs are handicapped. As of today, in most countries standards education programs do not have solid departments or institutes to provide educators a framework within the educational institutes. Stand-alone courses in standards exist in a few universities, but the occurrence is rare [1, 2, 5, 7].

Lecturers in engineering fields reported that engineering knowledge has normative component that lacks in pure scientific field and that is why students studying engineering are in need of studying and knowledge about standards and other normative documents as an integrated part of the education that future engineers and technologists are expected to receive.

It is recognized that this complex issue is not resolved in the present education and there are not adequate curriculum that includes training in standardization.

EXPLORATION OF STUDENTS' OPINION about their training in the field of standardization system and standards

At the beginning of their engineering studies students face standards. A large part of the learning content of the fundamental subjects in the basic module is standardized. The authors aim to investigate, through inquiry, the opinion of students on obtained knowledge in the field of standards and the need for their expansion.

University of Ruse (RU) follows the standards and guidelines for quality assurance in the European Higher Education Area. Traditional practice in the University is to seek feedback from students through surveys. This is an effective tool for managing the quality of education. The report provides the results of a survey conducted at the Department of Mechanics, Machine Elements and of Engineering Graphics in RU. The purpose of the questionnaire is to receive updated information about the students` perspective on the need to enhance their culture and awareness in the field of standards and the structure of the standardization system in Bulgaria.

□ *Structure and content of the survey*

When developing the survey authors draw on their previous experience in conducting surveys among students, and on the practice of other universities abroad. The survey is structured in three parts.

The first part is introductory and provides information on the location, timing and the respondent.

The second part is the essence of the inquiry. The proposed questions covered some main topics:

- *knowledge about the standardization system obtained in previous education;*
- *their experience in searching and using the required standards in their education and practice;*
- *availability of information related to standards;*
- *their appraisal of the need to introduce;*
- *adding topics in their training program and set up a complete course of a discipline that acquaint them to the standardization system and required standards.*

In the third part is given place where students could expose their comments and recommendations on the subject of the inquiry.

□ *Carrying out the survey*

The survey was conducted with students from the fields - Mechanical Engineering, Transport and Agricultural equipment, taking courses at the Department of Mechanics, Machine Elements and Engineering Graphics at the University of Ruse.

Students- participants show interest in the topic and willingness to answer questions because they realize that they can help to improve the learning process.

□ *Survey results*

The responses in the survey show that students have met standards both in training and in practice.

38% of respondents are aware of insufficient information about existing standardization system and current standards. They appreciate that in the already attended courses at Ruse University attempt to give full and updated acquaintance with standards related to specific subjects.

However, 80% of them think that, broad and in-depth information about standards in each discipline is needed.

84% of students - participants are likely to choose attending of a separate subject giving them a wider culture and deeper information about standardization system and guidance how to access it.

Over 90% of students want the existence of an information centre at the University, connected with Bulgarian Institute for Standardization (BIS), which will give regulated access to standards related to their specialty.

Following the analysis of the results of the questionnaire, the authors propose a new approach to training in the field of standards in higher engineering education.

A NEW APPROACH TO TEACHING STANDARDS IN HIGHER EDUCATION

From the publications and research review of different international institutions on standards, and the opinion of engineering students the authors came to the conclusion of the pressing need for new approach and new curriculum includes topics for standardization system, standards and how to access.

Up to 90`s the structure of the standardization system in Bulgaria is nationally oriented and closed. At that time standards are distributed only on paper, though information about them entered regularly all institutions. Each department at the university maintains a library with standards in the related field. Gathering data from a large number of standards in reference books is useful practice for industry and students.

Nowadays, after the changes in the bodies responsible for standardization a shortage and difficult access to new and updated standards is perceptible. Although today the standards are not mandatory and BIS is not a state institution the need for better information about standards and better access to them is recognized by higher education and in particular in Ruse University. Therefore, it is essential to find the right form and to create a curriculum to give students about standards and about the positives of their knowledge and application.

For now the most common practice is to introduce the teaching content that includes standardized information, without students to be aware that these rules and requirements are imposed by the standard.

The authors of this report propose a more comprehensive approach to the teaching content associated with standardization.

Complementing the teaching content with exact information about related standards

As a first step, to each discipline associated with standardized content to provide clear and accurate information and if it is possible to cite the standard and to provide information for its relevance to older and harmonized standards.

In this way students will realize that this learning content is standardized and this rules and requirements is important to be followed.

In each discipline curriculum there should be at list a topic associated with the relevant standards for the contents of the course.

Good practice is the teacher to prepare reference material with excerpts from the relevant standards applicable in the course. This will help students to develop skills to work with standardized information and apply them to solve complex technical problems [6, 8].

New subject concerning standards

The authors propose establishment of a new subject related to the education about standardization. This subject will be placed in the curriculum at the beginning of the base module. The syllabus of this subject will provide content which includes some main themes, listed and described below.

In the course students' attention will be drawn to the fact that standards are all around us. In everyday life, we encounter this phenomenon when we use products and services without even realizing it.

In the introductory theme will be highlighted the social importance and role of standards and will justify the need of knowledge about them and their application. This will be explained with clear and motivating examples.

The new subject will provide information about standardization system, BIS, different types of standards – national (BDS, DIN), regional, European (EN) and international (ISO). Students will be taught how to access standards and relevant institutions and about the reference books available.

Students will examine the theoretical basis of creating standards, from the occurrence of the need for establishing standards to their adoption and implementation. They will learn what the national

and European institutions for standardization are responsible for and about the links between them.

It is important that students will get acquainted with national and regional policies and standards. Markets are increasingly becoming international, reflecting the globalization of world economy. Regional and international standards support globalization by facilitating entry into international markets through compliance of their requirements. They increase accessibility to the market and remove barriers to trade by showing that local requirements are met. Harmonized standards provide greater opportunities for companies to sell internationally.

The next issue is devoted to the use of specific widely used standards. For example:

- *Quality management systems - Requirements (ISO 9001:2008)*
- *Environmental management systems - Requirements with guidance for use (ISO 14001:2004)*
- *Guidance on social responsibility (ISO 26000:2010)*

The new subject will provide specific information about standards relating to the studied specialty. Students will become acquainted with the specific standards concerning themes chosen by the companies requiring specialized training.

Segmented in this way the teaching program for the new subject will provide a full knowledge about standards and their application and would be extremely useful addition to their higher education.

Establishment of an information centre - a direct link between the university and standardization institute

BIS follows trends in the European standards institutions in realization of closer links with universities. [10]

This strategic objective of BIS will be fulfilled by creation of an information center linked and accessed over Internet with regulated access for students and teachers. The center will allow controlled information about standards related to the scientific areas covered in the university. The system developed will be from a great help to students, graduates and faculty, and to the needs of the public.

Some universities, including the University of Ruse stated their desire to build such a center [9]. The first contacts are made and actions have been carried out.

CONCLUSION

An analysis of the problem for the training about standards in the higher technical school has been made by investigating the opinion of international institutions (standardization institutes, universities and companies) and the need to strengthen and systematize the curriculum for studding the standardization system and learning specific standards linked to the respective scientific field has been revealed.

A survey has been conducted with participants-students at the University, which allows the conclusion that they realize the importance of standards, both in their education and practice and are willing to expand their knowledge in this area.

Based on these studies and on their personal experience the authors propose a new approach to the study of standards and standardization, developed on three levels:

- *Implement further topics for standardization in each subject;*
- *Introduction of a subject about standardization system, standards applicable in everyday life, as well as specialized information on standards related to a particular scientific field;*
- *Establishment of an information center for a direct connection between the university and the standardization institute. The center will offer updated information on standards.*

Awareness of the importance of standards and of the need to include learning content about standards in higher education requires an appropriate approach. It is necessary to facilitate access to standards and to the timely information about their renewal.

Very useful would be if the relations between universities and standardization institutions deepen. It could be managed through creation of information centers for permanent connection on campus as well as regular receiving bulletins for news about standards related with the certain scientific field. Good practice would be implementing reference books concerning such standards.

BIBLIOGRAPHY

[1.] *Bakker D., Masterplan to improve education about standardization: the challenges ahead, ESO Event on Education about Standardization: Strategic importance of education about standardization – a dialogue with academia and industry, Brussels, 2012*

[2.] *Choi D., Education about Standardization: how is it dealt with outside Europe?, ESO Event on Education about Standardization: Strategic importance of education about standardization – a dialogue with academia and industry, Brussels, 2012*

[3.] *Dianne Q. Nguyen, Zenon J. Pudlowski, The Design and Standardisation of Engineering Curricula in the Context of Globalisation, Global Journal of Engineering Education., Vol.10, No.2, Published in Australia, UICEE, 2006*

[4.] *Dong Geun Choi, Henk J. de Vries, Standardization as emerging content in technology education at all levels of education, International Journal of Technology and Design (2011) 21:111–135*

[5.] *Purcell D., The Strategic Value of Standards Education, A Global Survey conducted by The Center for Global Standards Analysis, 2008.r*

[6.] *Ronkova V., V. Haralanova, Model for student course in subject "Applied Geometry and Engineering Graphics". Turkish – Bulgarian youth international scientific conference "Technology and innovative solutions 2011", 16-18.12. Edirne, Turkey, 2011, Сборник научни доклади - част първа, Печатна база Авангард принт ЕООД, Русе, 2011, pp 668-673ISBN 978-954-337-163-1*

[7.] *Vanselow M., The importance of education and training on standardization for industry, ESO Event on Education about Standardization: Strategic importance of education about standardization – a dialogue with academia and industry, Brussels, 2012*

[8.] *Ронкова, В., В. Хараланова,. Стандартите и мястото им в учебния процес на инженерното образование, "SCIENCE & TECHNOLOGIES", 2012, брой II - 4, стр. 114-118, ISSN 1314-4111*

[9.] *Русев, Д., Й. Николова, Използване на информационна система за изработване на техническа документация, Годишник на университет „Проф. Асен Златаров", Том XXXIX, Бургас, 2010.*

[10.]*http://www.bds bg.org*

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STRUCTURAL RESPONSE OF HEATED POLYMER REINFORCED CONCRETE FAÇADE TO LOADING

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Abstract: *The recycling of used materials is now very common all over the world, in order to save the environment from pollution. This paper looked into how used-polyethylene material can be effectively recycled for construction purposes and the effect of temperature on the end products. The used polyethylene sachets were converted to 6mm diameter polymer rod under controlled temperature and pressure. Two sets of five samples concrete façade of size 500 x 300 x 30 mm was cast using the polymer rod and steel respectively. Some of the slabs were exposed to a temperature of 50^{0}C for six hours, after which they were subjected to loading until failure occurred. At ambient temperature, crack width, was 0.40mm and 0.30 mm; maximum deflection, 5.99mm and 12.25 mm; and ultimate failure load, 2.50 kN and 2.70 kN for steel and polymer rod slabs respectively. While at 50^0 C, crack width was 0.7mm and 1.3mm, deflection, 11.2mm and 12.72 mm, and ultimate failure load, 5.3 kN and 3.00 kN for steel and polymer respectively. Polyethylene (polymer) rod could be a very good substitute in slender concrete structures like façade because of its low crack width, non-corrosive nature and it low thermal conductivity.*

Keywords: *Polyethylene sachet, Concrete Façade, Polymer rod, Deflection, Crack width*

INTRODUCTION

Concrete reinforced with fibre reinforced polymer (FRP) materials has been under investigation since the 1960's. Unstressed FRP reinforcement has been developed in a number of forms including ribbed FRP rod similar in appearance to deformed steel reinforcing bar, un-deformed E-glass and carbon fibre bar bound with polyester, vinylester or epoxy resin, E-glass mesh made from flat FRP bars and prefabricated reinforcing cages using flat bars and box sections (Gowripalan,1999). Stressed FRP reinforcement is also available, usually consisting of bundles of rods or strands of fibre-reinforced polymer running parallel to the axis of the tendon. These are used in a similar fashion to conventional steel tendons (Gowripalan, 2000). The durability performance of FRP reinforcements is considered by some (Gowripalan, 1999, Ko, 1997) to offer a possible solution to the problem of corrosion of steel reinforcement, a primary factor in reduced durability of concrete structures. Other reported advantages of FRP rebar include enhanced erection and handling speeds (Karbhari and Zhang, 1999) and suitability to applications which are sensitive to materials which impede radio wave propagation and disturb electromagnetic fields.

A polymer is a large molecule (macromolecule) composed of repeating structural units typically connected by covalent chemical bonds. Whereas the term polymer is sometimes taken to refer to plastics, it actually encompasses a large class of natural and synthetic materials with a wide variety of properties.

Natural polymeric materials such as shellac, amber, and natural rubber have been used for centuries. A variety of other natural polymers exist, such as cellulose, which is the main constituent of wood and paper. The list of synthetic polymers includes synthetic rubber, Bakelite, neoprene, nylon, PVC, polystyrene, polyethylene and many more (Wikipedia, 2011). The attractive forces between polymer chains play a large part in determining a polymer's properties. Because polymer chains are so long, these inter-chain forces are amplified far beyond the attractions between conventional molecules. Different side groups on the polymer can lend the polymer to ionic bonding or hygrogen bonding between its own chains. These stronger forces typically result in higher

tensile strength and higher crystalline melting points (Omnexus.com, 2011).

The intermolecular forces in polymers can be affected by dipoles in the monomer units. Polymers containing amide or carbonyl groups can form hydrogen bond between adjacent chains; the partially positively charged hydrogen atoms in N-H groups of one chain are strongly attracted to the partially negatively charged oxygen atoms in C=O groups on another. These strong hydrogen bonds, for example, result in the high tensile strength and melting point of polymers containing urethane or urea linkages (Omnexus.com, 2011).

Over the last decades, used water sachet that is made of polyethylene materials have become nuisance to the environment because of it non-biodegradable property. Several times when the water in the sachet is used up, the waste sachet is found in drains and other water ways which has led to flooding.

Many works have gone into the use of Fibre Reinforced Polymer (FRP) by Sivagamasundari and Kumaran (2008). Also Hegger et al (2010) investigated the advantages of textile reinforced concrete applied to a pedestrian bridge in Germany, and the results concluded that it is possible to design slender and light weight concrete members by using technical textiles instead of steel as reinforcement. A small number of new loads bearing civil engineering structures have been made predominantly from FRP materials over the last three decades. These include compound curved roofs (Hollaway, 2002), pedestrian and vehicle bridges and bridge decks, energy absorbing roadside guardrails (Bank and Gentry, 2000), building systems, modular rooftop cooling towers (Barbero and GangaRao, 1991), access platforms for industrial, chemical and offshore (Hale, 1997), electricity transmission towers, power poles, power pole cross-arms and light poles and marine structures such as seawalls and fenders (Weaver, 1999).

Some codes like the ACI code and CAN/CSA code allow the use of Glass Fibre Reinforced Polymer (GFRP) bars as main reinforcement for concrete structures such as bridge decks, floor slabs and wall type structures. (ACI committee, 1996, CAN/CSA-S6-02, 2002).

The aim of this research work is to use polyethylene sachets used in the packaging of water as an alternative reinforcement in concrete façade. And the objective is to determine the flexural behavior of reinforced concrete façade at both ambient and elevated temperature.

MECHANICAL PROPERTIES OF POLYMER

The tensile strength of a material quantifies how much stress the material will endure before suffering permanent deformation (Ashby and David, 1996, Meyers and Chawla, 1999). This is very important in applications that rely upon a polymer's physical strength or durability. For example, a rubber band with a higher tensile strength will hold a greater weight before snapping. In general, tensile strength increases with polymer chain length and cross-linking of polymer chains. A High Density Polyethylene HDPE has a strength between 25-30mpa and a Low Density Polyethylene LDPE has a strength of between 10-20mpa (omnexus.com, 2011).

Young's modulus quantifies the elasticity of the polymer. It is defined, for small strains, as the ratio of rate of change of stress to strain. Like tensile strength, this is highly relevant in polymer applications involving the physical properties of polymers, such as rubber bands. The modulus is strongly dependent on temperature (Ashby and David, 1996, Meyers and Chawla, 1999). Table 1 showed the mechanical properties of each reinforcement.

Table 1: Properties of reinforcement

No	Reinforcement type	f (N/mm^2)	E_s (N/mm^2)	$D_{f\,(mm)}$	Strain ε	No. of reinforcements
1	Polyethylene	30	1,110	6	0.02703	18 bottom
2	Steel rod	250	200, 000	6	0.00125	4 bottom

where: f = Tensile strength of reinforcement, E_s = Modulus of elasticity of Reinforcement, D_f = diameter of reinforcement, ε = Strain of reinforcement at ultimate load.

MATERIALS AND METHOD - POLYETHYLENE ROD PRODUCTION

The polyethylene rods were made from sachets water packs. The packs were gathered in large amount, washed and spread to drain the water

from it. After the water had been drained, they were taken in a bag to a polyethylene bag manufacturing company in Lagos Nigeria.

The sachets were introduced into intake of the extrusion machine after the temperature and the pressure for the melting had been set on the control panel of the extrusion machine. As the sachets were introduced into the intake, the sachets start melting and then came out from the mould at the mouth of the extrusion machine in rod form of 6mm diameter.

As the rods come out, a water bath is provided where the rods were made to go through so as to cool off the temperature and make it harden. Figures 1-2 showed the process.

Figure 1: Polyethylene rod coming out of the machine

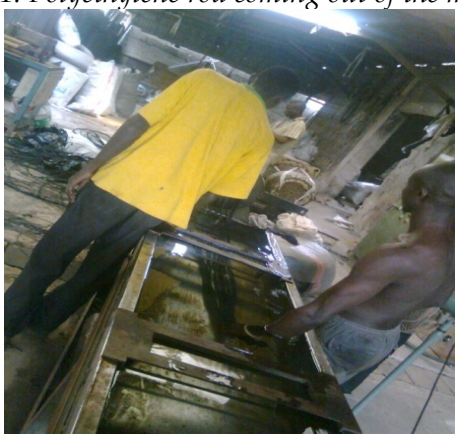

Figure 2: The Polyethylene rod in water bath.

PRODUCTION OF REINFORCED CONCRETE FAÇADE

The façade were designed based on the tensile strength of the reinforcing materials, mild steel rod with strength of 250 N/mm² and polyethylene rod of 20 N/mm² were used for the design of the slab prototypes. Both the steel and the polyethylene rods were arranged based on the design specifications which gave the diameter of the material and the spacing, for the polyethylene rod, 18 number 6 mm rod was used at a spacing of 25 mm for both ways, while for steel rod 4 number 6 mm rod at 125 mm spacing was applied at both ways. The reinforcing materials were then placed into the wooden mould (i.e. form work). These formworks are 500 mm by 300 mm by 30 mm in to in. There were a total of ten (10) number concrete façade produced from the experiment, five number each for the Steel and polyethylene rods respectively. The concrete mix used was 1:2:4 i.e. the proportion of 1 part of cement to 2 parts of fine aggregate and to 4 parts of coarse aggregate while the water-cement ratio (the w/c ratio) was 0.5 i.e. 1 part of water to 2 parts of cement by weight.

The concrete was well mixed, the cement, fine and coarse aggregate were measured through the use of weighing balance i.e. batching was by weigh. Ordinary Portland cement was used and the fine aggregate was the sharp sand. The size of the coarse aggregate used was half an inch (12 mm).

The moulds were lubricated with oil before concrete was poured into it to allow easy removal of the slab specimens after it is set. After the preparation of thoroughly mixed concrete, it was then poured into the moulds and then compacted or vibrated manually by shaking the moulds. The slab specimens were removed from the mould after it has been allowed to set for 24 hrs. The slabs were then cured to gain full strength by pouring water on it everyday. After 28 days, the slab specimens were put into test.

It is possible for stresses to be induced by temperature changes in composite members which are additional to those produced by applied loads. These stresses arise when the components of a composite member have different rate of thermal expansion. Two samples each from the steel and polymer reinforced facades were exposed to a temperature of 50 ^{0}C (an average temperature for a desert area) for about six hours before crushing, while others were left at room temperature, the specimens were placed in a testing machine in such a manner that the load was applied at the top surface and supported on all four sides. The axis of the specimen was carefully aligned with the axis of loading device. The digital dial gauge attached to the retort stand was placed on the slab close to loading point to measure the deflection due to the

applied load and load was also gradually increased by the adjusting knob at an interval and the corresponding deflection was recorded. The specimen was loaded until it failed, the ultimate failure load was recorded and the crack width was measured at failure load.

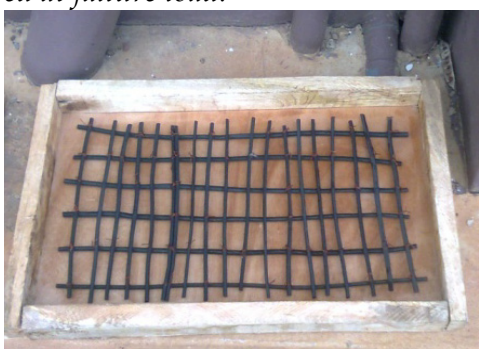

Figure 3: Polyethylene rod in mould

RESULTS

At room temperature of 25 ^{0} C, it was observed in the steel reinforced façade that the cracks started from the centre which was the point of loading and gradually moved toward the corner edges of the slabs as the load was increasing, the crack width at failure load was 0.40 mm. The deflection of the slabs in this group increases slowly as the load increases and the elastic limit was exceeded when the load got to 2.30 kN and finally failed at 2.50 kN. Figure 4 showed the graph.

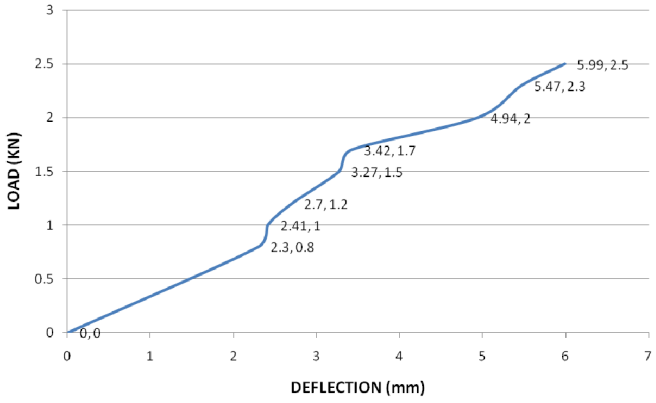

Figure 4: Deflection for Steel reinforced façade at room temperature

The results for the slab reinforced with polyethylene showed that the failure occurred at the centre which has the point of load and the crack pattern is very similar to that of the slab reinforced with steel but with a crack width of 0.30 mm. The deflection of the slabs in this group increases rapidly as the load increases forming a curve but there was a sharp change of direction at 1.90 kN while the elastic limit was exceeded at 2.25 kN, the gradual curve continues until it finally failed at 2.70 kN. Figure 5 showed the deflection pattern.

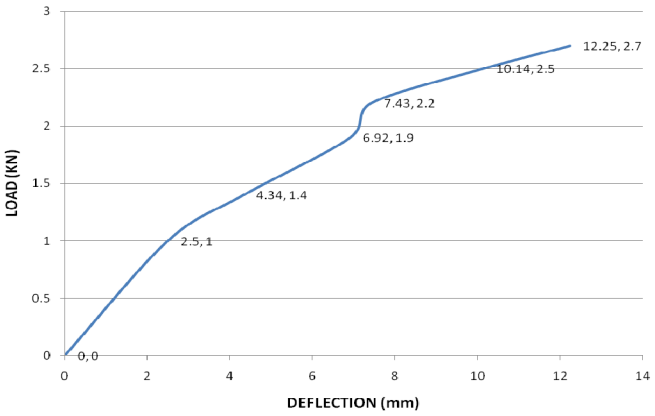

Figure 5: Defelction for Polyethylene rod façade at room temperature

At higher temperature of 50 ^{0}C after six hours, the crack width for steel reinforced facades was 0.70 mm, the deflection was 11.20 mm while the slab failed at 5.30 kN load. Figure 6 showed the graph of load against deflections.

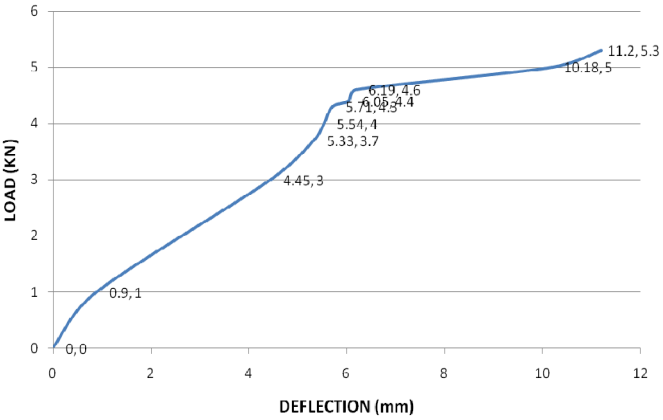

Figure 6: deflection of Steel façade at 50 ^{0}C

For the polymer reinforced slab, crack width was 1.30 mm, deflection was 12.72 mm and failure load was 3.00 kN. The graph is showed in Figure 7. The above results showed that increasing the temperature of slabs has effect on its properties, the failure load for both type of slab increased with temperature, with that of steel reinforced façade increasing by over 100%, which implies that the increment in temperature corresponds to the increase in the strength of the reinforced concrete as far as the melting point of the concrete material is not reached, this is a confirmation that the older the concrete, the stronger it becomes. This theory is based on the facts that the water content in the concrete is reduced as the temperature increases, and this will lead to the increment in the bonding

between all the aggregates that made up the concrete.

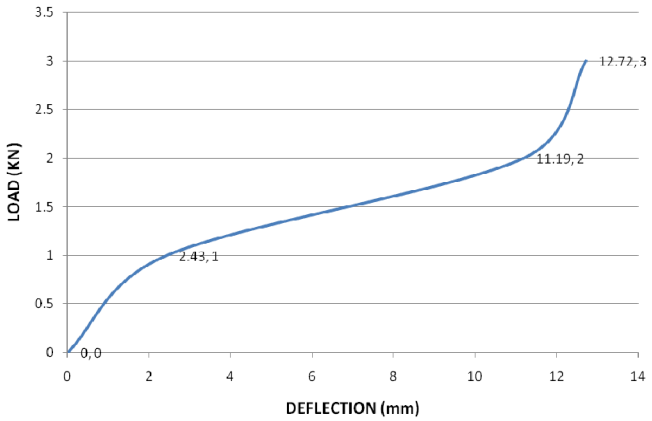

Figure 7: Deflection of Polymer rod façade at 50 ^{0}C

The increment in temperature led to increase in deflections and crack widths; these can be traced to the reinforcement used in both type of slabs. Steel exhibit weakness when exposed to temperature, and this is as a result of it higher thermal conductivity, that was why the deflection in steel reinforced façade increased by 87%, when compared with polymer reinforced façade which increased by a marginal 4 %.

CONCLUSIONS

At ultimate load, the polyethylene rod slab has a lower crack width when compared with steel reinforced slab at room temperature; this is a good advantage when considering the effect of water ingress that may cause corrosion in the slab element, also the resistance of polyethylene to water also gave it advantage over steel. There was no rupture in any of the two types of reinforcement used but they both failed at different yield point, with the steel reinforced slab failing earlier than the polyethylene rod slab at room temperature, this must have been due to the number and spacing of reinforcement used for each type of slab. The impact of temperature increase affected the performance of steel reinforced façade, with the fact that steel has a higher thermal conductivity than the polymer rod. The steel reinforced facade deflected more than it corresponding polymer façade, this is a disadvantage, because deflection can lead to excessive cracking, which will encourage the ingress of moisture into the concrete material, and by this action, corrosion will quickly set in and it will reduce the life span of the façade. Based on this study and the performance of polyethylene reinforced slab, the new material can be a good substitute to steel in slender structures like concrete façade. The low tensile property of the polyethylene rod can be improved upon in the nearest future through the use of nanotechnology.

REFERENCES

[1.] *ACI Committee 440 R-96, (1996) State-of-the-Art Report on Fibre Reinforced Plastic (FRP) Reinforcement for concrete structures.*

[2.] *Ashby, Michael and Jones, David (1996). Engineering Materials (2nd ed.). Butterworth-Heinermann*

[3.] *Bank, L.C. and T. R. Gentry, (2000) "Composite Materials for Roadside Safety Structures", Proceedings of ACUN-II International Composites Conference, University Of New South Wales, Australia*

[4.] *Barbero, E. and H.V.S. Ganga Rao, (1991) "Structural Applications of Composites in Infrastructure", SAMPE Journal, Vol 27, No 6, SAMPE, USA.*

[5.] *CAN/CSA-S6-02 (2002), "Design and Construction of building components with Fibre Reinforcement Polymers", Canadian Standards Association, Toronto, Ontario, Canada.*

[6.] *Gowripalan N., (1999) "Fibre reinforced Polymer (FRP) Applications for Prestressed Concrete Bridges", Proceedings of ACUN 1 Conference Composites: Innovations and Structural Applications, UNSW, Australia*

[7.] *Gowripalan, N., (2000) "Design Considerations for Prestressed Concrete Beams with Fibre Reinforced Polymer (FRP) Tendons", Fibre Composites: Who Needs Them?, A Workshop for Civil and Structural Engineers, University of Southern Queensland, Australia.*

[8.] *Hale, J. M., (1997) "Strength Reduction of GRP Composites Exposed to High Temperature Marine Environments", Proceedings of ICCM11 International Conference on Composite Materials, Australian Composites Structures Society, Australia*

[9.] *Hegger J., Kulas C., Goralski C. (2010) "Advantages of textile reinforced concrete applied to a pedestrian bridge". Advances and Trends in Structural Engineering, Mechanics and Computation, Taylor and Francis Group, London. Pp 215.*

[10.] *Hollaway, L., (2002) "The Development and the Future of Advanced Polymer Composites in the Civil Infrastructure", Proceedings of the International Conference on Advanced*

Composites in Construction, University of Southampton, Available November 2002.

[11.] *Karbhari V.M. and S. Zhang, (1999) "Durability of Fibre Reinforced Composites in Civil Infrastructure – Issues, Results and Implications", Developments in Design Standards for Advanced Composites in Infrastructure Applications, CRC-ACS, Australia*

[12.] *Ko, K., (1997) "Fibre Architecture Based Design of Ductile Composite Rebar for Concrete Structures", Proceedings of ICCM-11: International Conference on Composite Materials, Australian Composites Structures Society, Australia.*

[13.] *Meyers, M. A. and K. K. Chawla (1999). Mechanical Behavior of Materials, Cambridge University Press. Omnexus.com. Accessed (May 2011).*

[14.] *Sivagamasundari, R and Kumara, G. (2008) "A comparative study on the flexural behaviour of one-way concrete slabs reinforced with GFRP reinforcements and conventional reinforcements when subjected to monotonic and repeated loading". The open Civil Engineering Journal, Vol. 2. pp 24-34.*

[15.] *Weaver, A., 1999, "Composites: Worldwide Markets and Opportunities", Materials Today.*

[16.] *Wikipedia.com, Accessed (May, 2011)*

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THE SIMULATION AS PREDICTION TOOL TO DETERMINE THE METHOD OF RISER CALCULATION MORE EFFICIENT

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Abstract: The riser must be adequate to satisfy the liquid and solidification shrinkage requirements of the casting. In addition, the riser itself will be solidifying, so the total shrinkage requirement to be met will be for the riser/casting combination. The total feeding requirement will depend on the specific alloy, the amount of superheat, the casting geometry, and the molding medium. The shape of a casting will affect the size of the riser needed to meet its feed requirements for the obvious reason that the longer the casting takes to solidify, the longer the riser must maintain a reservoir of liquid metal. A variety of methods have been devised to calculate the riser size (shape factor method, geometric method, the modulus method) needed to ensure that liquid feed metal will be available for as long as the solidifying casting requires. In this research has been calculated the riser geometry by different methods for a piece type wheel and the simulation has been used to determine which of the methods it is more efficient.
Keywords: Simulation casting, quality, risers design

INTRODUCTION

The consequences of a low casting yield are well known in the foundry industry: lower profits due to increased production costs and decreased capacity. Additional melted metal and heats, as well as the increased labor and materials costs required for production, are the primary reasons for the increased costs. Furthermore, it is recognized that a higher casting yield has the side benefit of lowering casting cleaning costs. Essentially, when a foundry achieves the highest possible yield, it can operate at maximum capacity, maximizing its revenues [1]. Casting is a very simple process; apparently, melting, pouring and made the mold is only, but each one has other processes more complex [2]. Green sand casting process involves many process parameters which affect the quality of the casting produced [3]. The rigorous control of the scrap, the use of molding sands appropriate, the correct production of the molds, the good design of the gates and risers systems, among other, they are some of the processes that it is necessary to keep in mind to achieve a maximum quality of the cast pieces. If to that said previously it is added that the optimization of anyone of them, choosing in those cases where it exists more than a way for their determination the best and more economic, it guarantees that the process is efficient and it can guarantee himself the time that delays a product in arriving again at the market is smaller. The main objective of this paper is improvement the efficiency of the sand casting process; to guarantee that it has been divided in three steps: first, to determine the main factors that influence in the final quality of the product, second, to carry out an analysis using the simulation for determines the action of the main factor and to optimize the results obtained in the simulation.

A survey applied experts in foundry and that reflects the main parameters that affect the final quality of the cast piece (see figure 1), provides an evaluation and a vision of those that more affect the productive process, one of them is the pouring process and the design the gate and riser system, the results can see in the figure 2. In these graphics two ways of analysis of the results are presented, the average of points confers by the experts in each variable and the frequency with which a certain valuation appears for the certain ones as more influential.

	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5
Design of Foundry technology					
Personal qualification	9	5	9	8	4
Method applied to obtain the solution	9	1	9	6	4
Preparación de la mezcla de moldeo y machos					
The use of the right sand	9	10	8	9	8
The use of the right clay	9	10	9	9	8
Additives	9	1	9	9	8
Right control in laboratory	10	5	9	8	6
Personal qualification	8	6	7	7	9
Preparación de modelos y cajas de macho					
Quality of the flask	8	1	8	4	8
Quality of the tools for molding	8	5	7	6	7
Molding method	8	5	7	7	7
Personal qualification	9	5	6	8	8

Figure 1. Part of the survey applied to experts

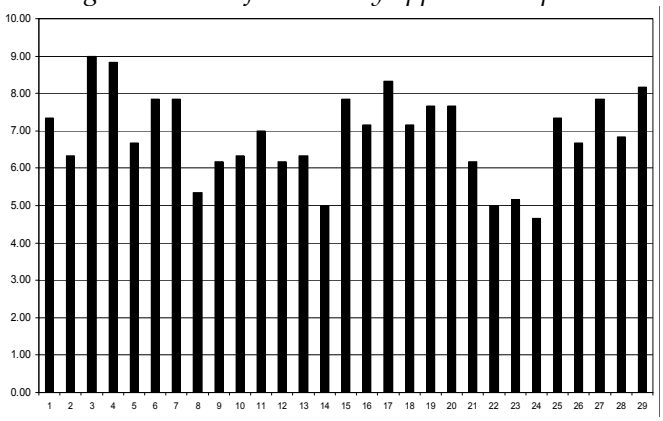


Figure 2. Average of points confer by the experts in each variable

The gating and risering systems as one of the main factors for their effect in the quality of the casting is identified, a brief study is pointed out on the same ones and it is determined for wheel of AISI 1045 which is the effective feeding distance depending on the geometric characteristics of the cast.

Table 1. Data of the risering dimension calculate for different ways

Method	D_R (mm)	H_R (mm)	Neck (mm)	Volume (dm^3)	Weight Riser (kg) 1 Riser	Weight Casting (kg)	Weight Riser-Casting (kg) 4 Riser
Moduli method	100	100	15	3.33	26.16	104.08	208.71
Heuvers method	90.55	142	15	3.50	27.6	104.08	214.48

According to the results, it can say that the difference between methods is significant. Maximizing casting yield, which is defined as the weight of a casting divided by the weight of the metal poured to produce the casting (i.e., including metal that solidifies in the risers, gating, downsprue, etc.), is an important consideration in the steel casting industry [1]. An increase in casting yield decreases production costs; with increased yield, production of the same number of castings requires less melted metal and fewer heats, as well as reduced labor and material costs required for production. Also, higher yield usually has the side benefit of lower casting cleaning costs. One effective way to improve casting yield is through riser optimization, where "optimized" means (1) the riser has the minimum possible volume to provide sufficient feed metal to the casting, without the riser pipe extending into the casting; and (2) the smallest number of risers are used, while still ensuring that the risers are close enough to each other to produce a sufficiently sound casting. Computer simulation of the casting process is becoming an indispensable tool in the effort to increase casting yield. Through the use of simulation, foundries are able to evaluate modifications to casting designs without having to actually produce the casting, thus saving time, material resources, and manpower. However, computer simulation must be applied on a case-by-case basis, and its effective use requires expertise as well as accurate data for many process variables [10].

SIMULATION IN CASTING PROCESS

The replacement of physical experiments with software simulations is increasingly common in many sections of the industry today. Some numerical experiments are carried out in order that optimal tooling and process parameters are selected to get products right first time-avoiding time-consuming and costly physical experimentation. Other studies aim to obtain a deeper understanding of the effect of varying process parameters (sensitivity studies) towards optimizing a process [13]. However, numerical experiments that were based on the DOE method are rare in the open literature. The fact that workers are only just starting to consider such a combination for casting related simulations is apparent from a recent paper [14] where the DOE method is applied to numerical simulations of aluminum permanent mold casting. The aim of their investigation was determinate what is the

best method for optimal riser design, in sand casting process. In summary, whilst DOE methods and the use of computer simulations are no longer new to the manufacturing industry, instances of combining the two for achieving significant increases in productivity during a problem solving exercise are relatively scarce and the effectiveness of this strategy therefore remains to be investigated.

Simulation studies, when used in several areas of investigation, are quite useful to study the behavior of some phenomena in which different virtual situations are generated by the researcher using some specialized software. Robustness studies are rather common in statistic research; many of them are used to observe the behavior of an estimator under several hypothetical situations that could happen in practice [15].

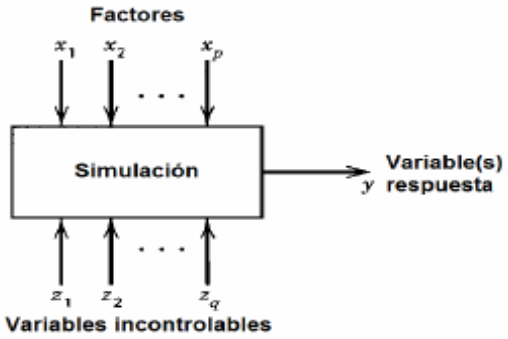


Figure 3. General scheme of a simulation study, adapted from a scheme presented in [15]

Simulation studies, when used in several areas of investigation, are quite useful to study the behavior of some phenomena in which different virtual situations are generated by the researcher using some specialized software. Robustness studies are rather common in statistic research; many of them are used to observe the behavior of an estimator under several hypothetical situations that could happen in practice.

DATA FOR SIMULATION

The filling and cooling simulation was made under the following condition:

Data of the Mold

- ✓ *The mold was made with a mixture of silica sand and clay.*
- ✓ *The mold temperatura was 30^{0}C*

Data of the metal

- ✓ *AISI 1045, is important say that the software ProCAST [5] don't have data for this material.*
- ✓ *Pouring temperature 1540 C*
- ✓ *Pouring velocity 287 mm/s (0.287 m/s)*
- ✓ *Pouring time 25 s*

The first step is to carry out a simulation of the casting without risers, for to determine, in accordance with the results, the best risers location [6].

In the picture 4 are shown the places of the casting with more modulus, according to Chvorinov equation, this means that, the best location of the riser.

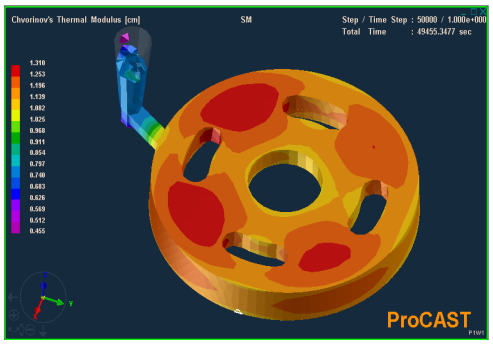


Figure 4. Chvorinov's thermal modulus representation

A sample of that, is the picture 5, where the formation of << hot spots >> is observed and its relationship with the shrinkage porosity [7].

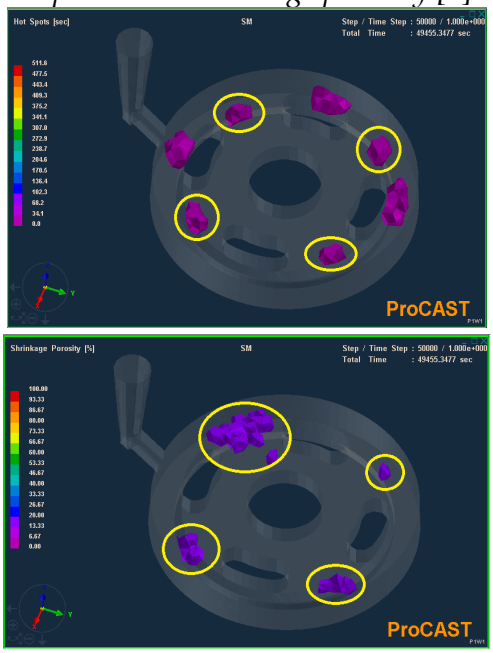


Figure 5. Relation between the hot spots formation and the shrinkage porosity

As second step the calculations to determine the riser geometry are carried out, in an analytic way, through the well-known methods and at the end the simulation of each method.

In the picture 6 the distribution of temperatures is observed, for the 2 methods, after 14 hours, in the

cooling process. If, the parameters of pouring temperature, fill velocity and fill time, stay constant in the three cases, it is observed how the cooling, of both geometries, is different.

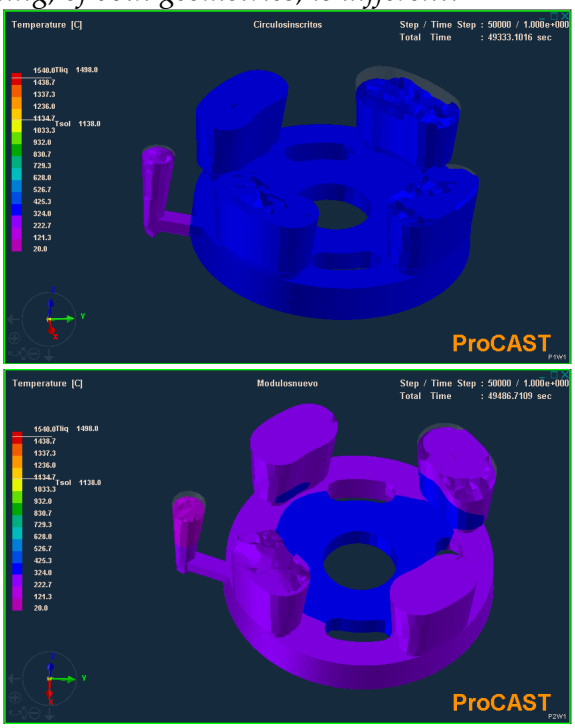
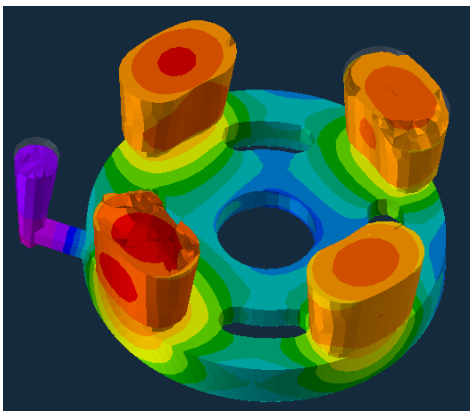


Figure 6. Representation of temperatures distribution for 14 hours by the Heuver's method and Modulus method



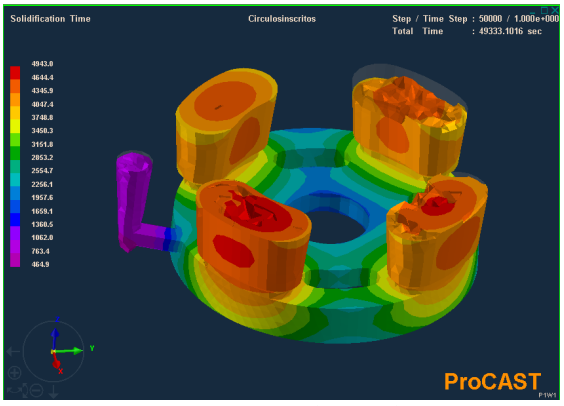
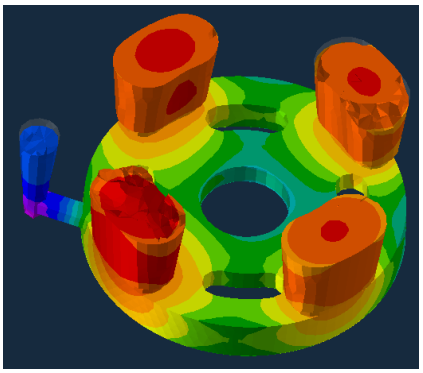


Figure 7. Representation of solidification time by the Heuver's method and Modulus method



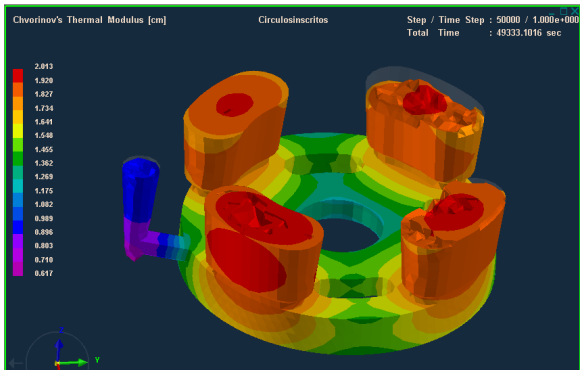


Figure 8. Thermal Modulus determined by the Heuver's method and Modulus method

In the picture 9 the simulation shows some porosities in the surface of the casting, change of coloration, in the Modulus method.

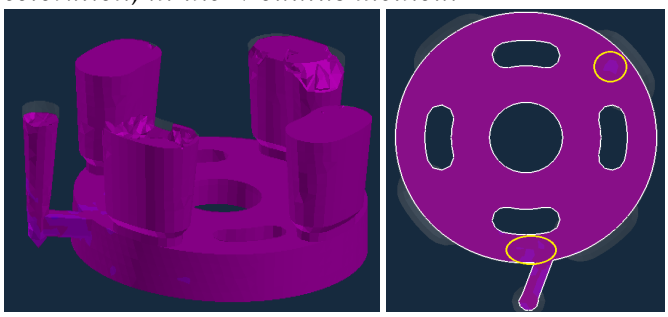


Figure 9. Shrinkage porosities in the surface in the Modulus method

Also, is possible to appreciate, through the simulation, the shrinkage porosities inside of the casting.

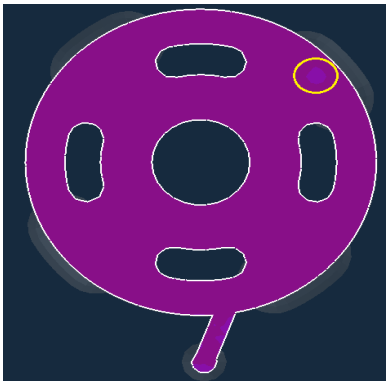


Figure 10. Inside shrinkage porosities in the modulus method

In the case of Heuver's method, the result of shrinkage porosities, are shown in the picture 11.

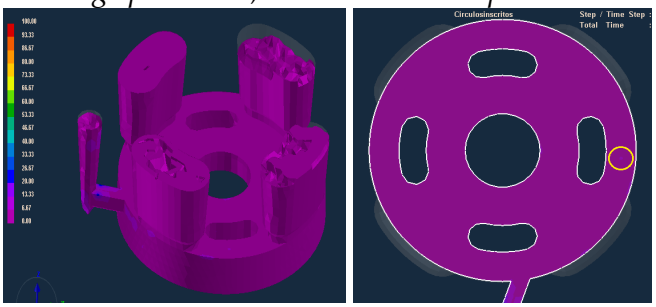


Figure 11. Shrinkage porosities in the surface in the Heuver's method

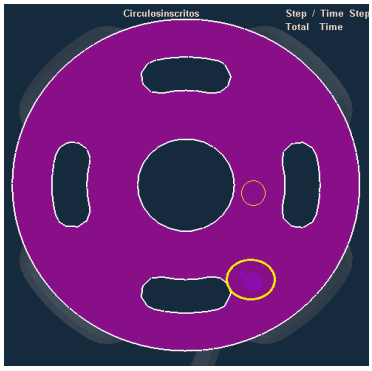
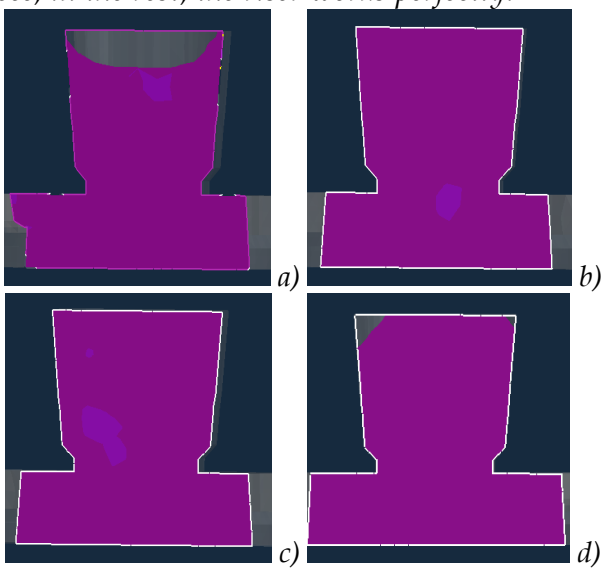


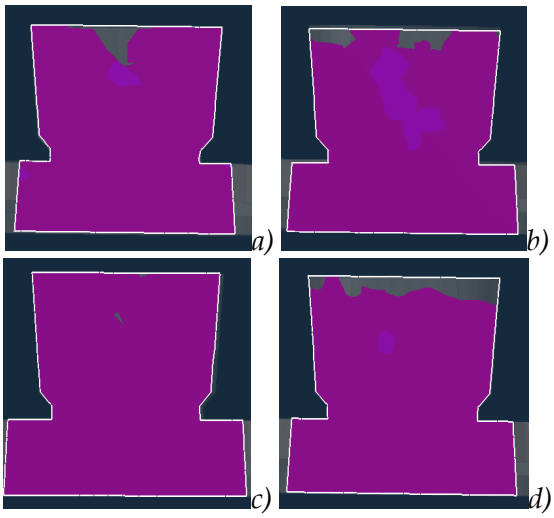
Figure 12. Inside shrinkage porosities in the Heuver's method.

In the pictures 13 and 14 the action of the risers is observed in both methods. In all the cases, the riser carried out their work, assuming the shrinkage porosities in their interior, only one of the riser, of the Modulus method, where the porosity is in the piece, in the rest, the riser works perfectly.



a) b) c) d)

Figure 13. Inside view of risers by the Modulus method. a) riser more near to the metal entrance, b) riser far away for the right, c) riser more fences for the left, d) riser far away for the left



a) b) c) d)

Figure 14. Inside view of risers by the Heuver's method. a) riser more near to the metal entrance, b) riser far away for the right, c) riser more fences for the left, d) riser far away for the left

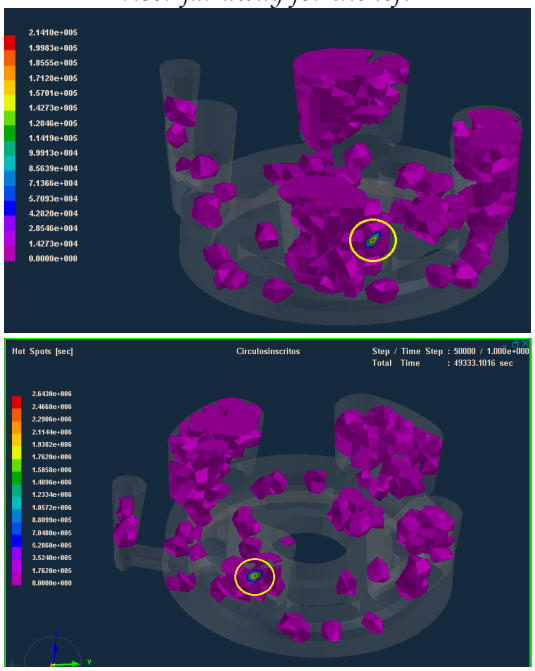


Figure 15. The phenomenon of the Hot Spot can be seen in the simulation by the Modulus method and the Heuver's method.

A foundry was made with the calculated data and the results obtained are shown in the pictures 16 and 17.

Figure 16. Real inside view of risers by the Modulus method

Figure 17. External surface of the real casting without shrinkage porosities

CONCLUSIONS

- ✓ *The foundry process has a great complexity due to the great quantity of variables that intervene in the process, subjective many of them.*
- ✓ *Through the survey carried out experts it can be proven that one of the main parameters that affects the quality of the pieces is the filling of the same ones, influencing the geometry and the calculate method of the risers.*
- ✓ *The obtained results and shown in the pictures shown that the used methods include a safety coefficient very high, this causes that the riser geometry, be very big.*
- ✓ *The application of the Modulus method contributes to obtain better quality in the analyze casting, if one keeps fundamentally in mind the appearance of defects of shrinkage porosities, eliminating unnecessary operations and not anticipate expenses.*
- ✓ *If the Modulus method is applied, a saving is achieved until of 5% in weight of the riser, representing the obtained result, in the total weight until 3%, that is to say 5 kg of metal was saved in a single piece.*

Acknowledgment

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References

[1.] *Beckermann, C., O. Shouzhu, and K.D. Carlson, Feeding and risering of high-alloy steel castings. Metallurgical and materials transactions B, 2005. 36B(97).*

[2.] *Engels, G. and Wubbenhorst, 5000 Jahre giessen von metallen, ed. Giesserei and Verlag. 1994, Dusseldorf.*

[3.] *Singaram, L., Improving quality of sand casting using Taguchi method and ANN analysis International journal on desing and manufacturing technologies, 2010. 4(1).*

[4.] *Sandell, P.K., Feeding of hollow cylindrical castings, in 68th WFC-World Foundry Congress. 2008: Chennai, India.*

[5.] *ASM, ASM Metal Handbook-Casting. 1988.*

[6.] *Ri, L., et al., Application of Layer-by-Layer Solidification Principle to Optimization of Large Chain Wheel Foundry Technology. Journal of Shanghai University, 2003. 7(3): p. 294-300.*

[7.] *Kondic, V., Metallurgical Principles of Founding ed. E.A. Pub. 1968.*

[8.] *Wloadawer, R., Directional Solidification of Steel Castings ed. P. Press. 1966.*

[9.] *Beckermann, C., et al., Development of New Feeding-Distance Rules Using Casting Simulation: Part I. Methodology. Metallurgical and Materials transactions B, 2002. 33B.*

[10.] *Tavakoli, R. and P. Davami, Optimal riser design in sand casting process by topology optimization with SIMP method I: Poisson approximation of nonlinear heat transfer equation. Struct Multidisc Optim, 2008. 36: p. 193-202.*

[11.] *Gunasegaram, D.R. and B.J. Smith. MAGMASOFT helps assure quality in a progressive Australian iron foundry. in 32nd National Convention of the Australian Foundry Institute. 2001. Fremantle, Australia.*

[12.] *Coello Machado, N.I. and L.H. Suárez Lisca. Casting parts quality improvement using forecast and control process parameters. in 5th International doctoral students workshop on logistics. 2012. Magdeburg, Germany: Prof. Dr. -Ing. habil. Prof. E. h. Dr. h. c. mult. Michael Schenk.*

[13.] *Gupta, A., et al., Optimal parameter selection for electronic packaging using sequential computer simulations. J. Manuf. Sci. E-Trans, 2006. ASME 128: p. 705-715.*

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VARIOUS APPROACHES TO KINEMATIC ANALYSIS IN THE PROCESS OF DESIGN OF PISTON MECHANISMS

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Abstract: *The purpose of this paper is to make an analysis of a system of piston mechanism and of its kinematic analysis on the one hand, and modeling and computer-aided design on the other hand. The paper uses kinematic analysis of a mechanism which is made in three methods – analytical, graphic and computer-aided which can also be successfully used in teaching engineers of technical sciences in higher education. Modern computer-aided methods are supported by a special software for analysis of treatment which can simulate not only movement of the mechanism, but it can also determine the position, velocity, acceleration, forces, moments and other parameters in every moment of time; however, control and application of mechanical laws are necessary. Some basic approaches, advantages and disadvantages of presented solutions are described.*
Keywords: *piston mechanism, kinematic analysis, computer aided solution, piston velocity*

INTRODUCTION

A piston mechanism is a kinematic chain which includes three components: crank, connecting rod and crosshead with a slipper whose purpose is to convert straight line motion to rotary motion and vice versa. The use of this mechanism is frequent especially in vehicles with internal combustion engines. A crankshaft, a piston, connecting rod and a cylinder (figures 1, 2 and 3) are parts of piston mechanism. Rotary motion of the crank is transferred to other systems of a vehicle via other parts of the engine, thus ensuring the geometric, kinematic and dynamic accuracy of the vehicle. It is a well known fact that there is a high degree of disturbance of the work of the crankshaft and the connecting rod.

To identify these problems it is necessary to completely examine all parts of the mechanism to avoid high price of repair and maintenance, especially of the cylinder and the piston. The results of some researches show that the cause of damages in these parts lies in the "number of shifts of transmission during a drive, particularly when switching to the lower gear". [1], [13]

The mechanism has to convert straight line oscillating motion of the piston to a rotary motion of the crankshaft. This enables the work performed by releasing of heat from the fuel in the piston crown to be transferred as turning moment to the crankshaft. [5], [6]

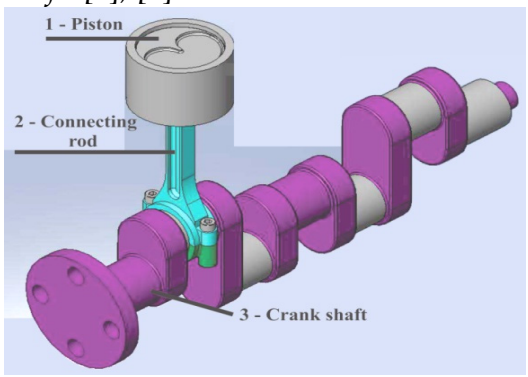


Figure 1. Piston mechanism:
1- piston , 2- connecting rod, 3- crankshaft

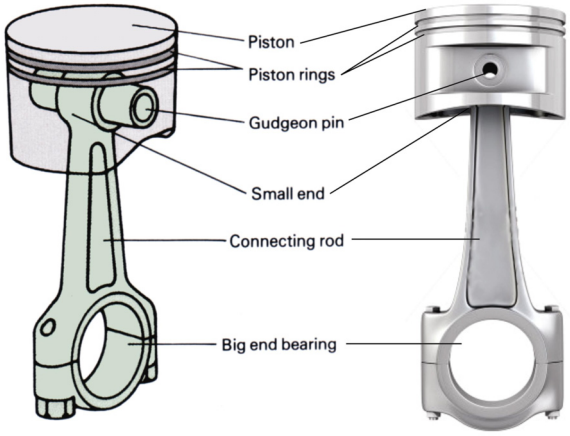


Figure 2. Parts of piston

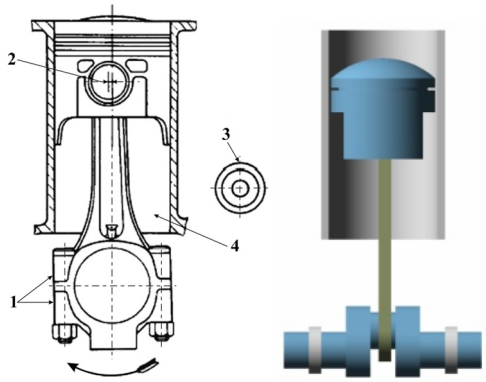


Figure 3. Cylinder of mechanism

The most common mechanisms used are so called simple mechanisms which consist of a piston, a connecting rod and a crankshaft. The complex ones include more elements (crank mechanism with crosshead). [4]

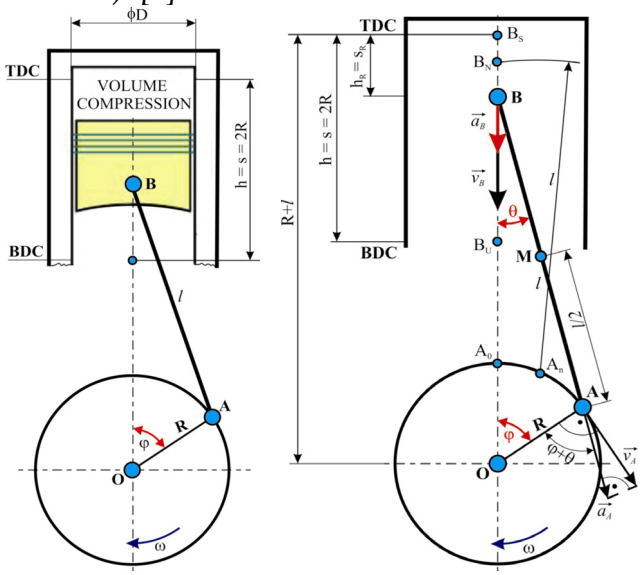


Figure 4. Kinematic scheme of mechanism

The crosshead B produces oscillating straight line motion (Figure 4). The crosshead B is fitted to one end of the connecting rod. It is connected to the piston which moves in a straight line and therefore its motion is also in a straight line. The crank journal A rotates. The position of point A is defined by angle φ which the crank covers with horizontal path of the crosshead (Figure 4). When the point A is in the position ($\varphi = 0$) A_0 ($\varphi = 0$), the crosshead B is in the position B_s (external deadlock). When the point A is in the position that corresponds to the angle $\varphi = 180^0$, the crosshead B is in the position B_u (internal deadlock). The crosshead B oscillates between positions B_s and B_u. The distance between B_s and B_u is called the crosshead stroke and is equal to double length of crank 2R.

KINEMATIC ANALYSIS APPROACHES

The task of kinematic analysis is to determine grafically, analytically or in a computer-aided manner: [5], [6]

1. The position of the crosshead piston of the mechanism for a given position of a driving member or of all driving members (s),
2. The velocity of the crosshead piston of the mechanism (v),
3. Acceleration of the crosshead piston of the mechanism (a) and
4. Kinematic diagrams of piston mechanism (v,s), (a,s), (s,t), (v,t) and (a,t).

The comparison between analytic, graphic and computer-aided solutions of kinematic analysis in this paper was made on the piston mechanism used as a basis to convert rotary motion to a straight line motion in pumps as well as in internal combustion engines in practice. Since the calculations are complex, only determination of the piston velocity will be shown.

Figure 5 shows a mechanism with real behavior in practice (the values of parameters of this mechanism are given only for the case of a specific vehicle movement and are valid only for this movement of the system).

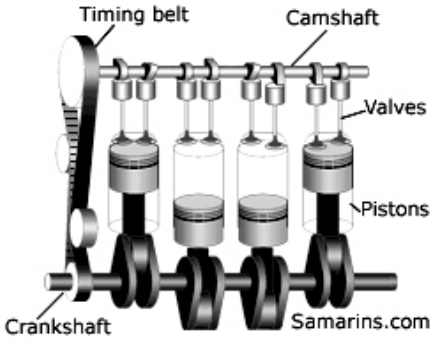


Figure 5. Physical model of mechanism

The simple presentation of real mechanism which serves as a basis for calculation is a kinematic scheme. The kinematic scheme of the mechanism is based on the real mechanism and is shown in figure 4. Individual components of the mechanism in this scheme are given with standard designations to provide simpler calculation. The input values of the given mechanism shown in figures 4 and 5 are: Cylinder diameter Φ80.5 mm, piston stroke $h = s =$ 67.4 mm, number of rotations of the crankshaft at maximal power $n = 6000$ min^{-1}, maximal turning moment of the engine $M_{max} = 106$ Nm, number of

turnings of the crankshaft n = 2900/min, radius of the crank r = h/2, r = 67.4 / 2 = 33.7 mm, radius of piston attaching end d_1 = 22 mm, radius of the crankshaft attaching end d_2 = 48.6 mm, radius of the crankshaft R = 24.3 mm, radius of the piston D = 80.48 mm, length of the crank l = 130 mm.

Engineering design and analysis in teaching

Computer technology equipped with suitable software is advantageously used in various branches of practice at present time. [13] Education of mechanical engineers is a process that has to provide knowledge of related natural science, social and technical disciplines, training in using and applying specific methods and development of creativity. CAD (Computer Aided Design) is just one of the methods in design and the software which can be applied in teaching design to encourage development of creative abilities of students. [2], [3]

At the Technical faculty "Mihajlo Pupin" in Zrenjanin the students are taught the said topics in two courses Mechanics and Mechanisms and Computer-aided Design.

The course objective of Mechanics and Mechanisms is to offer the students the basic knowledge in this field. The course is organized in one semester and comprises lectures, practical exercises and calculation exercises. Beside acquisition of necessary theoretical knowledge, it is necessary for the students to learn to solve complex problems of statistics, kinematics and dynamics. At the end of the course the students will be able to use certain theoretical knowledge in designing and calculating and in solving problems related to structure, kinematics and dynamics of certain types of mechanisms. In order to keep pace with development of new technologies, fast and effective learning in as short a time as possible is necessary while at the same time permanent education is a must.

One of the objectives of the course Computer-aided Design is to update the general technical knowledge of the students – future creative professionals: designers and managers, especially in the area of developmental engineering. The objectives also include learning the basic algorithms of new methods in 2D and 3D computer-aided design.

The course Computer-aided Design or CAD/CAM technology includes the following topics: Dimensioning and tolerancing, Machine materials, Design of rotating machine parts, Twisting joints design, Standard profiles and rivets, Axles and springs, Chain and belt drives, Ball and roller bearings, Calculation of shaft and axle load, Gear drives, Mechanisms, etc.

Analytical determination of piston velocity

Velocity projections of two points of rod onto rod direction are equal (figure 6), thus:

$$\overline{Aa'} = \overline{Bb'} \Rightarrow v_A \cdot \cos\left[90^\circ - (\varphi + \theta)\right] = v_B \cos\theta \qquad [1]$$

Transformation of the previous equation gives:

$$v_A \sin(\varphi + \theta) = v_B \cos\theta\,, \qquad [2]$$

$$v_B = v_A \frac{\sin(\varphi + \theta)}{\cos\theta} \qquad [3]$$

To determine the velocity v_B in terms of the angle φ, we use the links:

$$\sin(\varphi + \theta) = \sin\varphi\cos\theta + \cos\varphi\sin\theta\,,$$

$$tg\,\theta = \frac{\sin\theta}{\cos\theta} \approx \sin\theta\,, \qquad [4]$$

because $\cos\theta \approx 1$ is for small angles θ,

$$\sin\theta = \lambda\sin\varphi\,,\ \ \sin 2\varphi = 2\sin\varphi\cos\varphi\,. \qquad [5]$$

The final equation for calculation of piston velocity is:

$$v_B = R\omega\left(\sin\varphi \pm \frac{1}{2}\lambda\sin 2\varphi\right) \qquad [6]$$

The sign "+" is used for forward stroke and the sign "-" is used for backward stroke.

The velocity v_B equals zero for angles φ = 0 and φ = 180, i.e. when the piston is in position B_s and B_u. The velocity v_B has its greatest value when the direction AB touches the curve of the point A (crank journal).

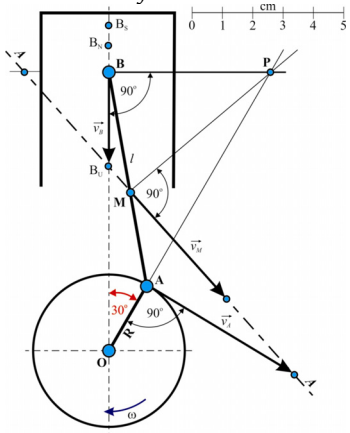
The average velocity of the piston is a very important indication of strength of the assembly piston-ring-cylinder and is calculated according to the term (h – piston stroke, n – velocity of the crankshaft, 1/s): Y_{sred} = 2hn.

Graphic methods for determination of the piston velocity [5], [6]

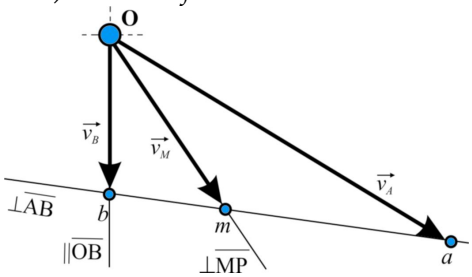
The piston velocity may be determined by graphic means using the method of rotational velocities and the velocity planning method. For both methods it is necessary first to calculate the velocity of crank journal on the basis of values: $v_a = \overline{O'A} \cdot \omega = R \cdot \omega$.

*a) **Method of rotational velocities***

In the method of rotational velocities the given piston mechanism is drawn in proportion U_L (Figure 6-a). In the point A the velocity vector of the point A perpendicular to $\overline{O'A}$, v_A is drawn in a corresponding proportion. The position of momentary pole of velocity P is determined by rotating the direction of velocities v_A and v_B by 90^0.



a) Method of rotational velocities



b) Velocity planning method

Figure 6: Graphic methods for determination of crosshead piston velocity

The direction of v_B is horizontal, e.i. it concurs with the direction $\overline{O'B}$, and direction v_A is perpendicular to $\overline{O'A}$. The vector v_A rotates by 90^0. From the ultimate point of the rotational velocity v_A, the point A_1, a parallel line in the direction $\overline{AB}$ is drawn. On the direction $\overline{BP}$ is produced the point B_1. The line $\overline{BB_1}$ is a graphic representation of rotated velocity v_B. The position v_B is produced by rotating $\overline{BB_1}$ in the opposite direction by 90^0. The value of velocity of the point B is: $v_B = U_v \cdot \overline{BB_1}$.

*b) **Velocity planning method***

In this method the given piston mechanism is also drawn in proportion U_L (Figure 6-a). In point A the vector v_A is drawn in proportion U_v. The velocity v_A is parallelly transferred to the point O_1 and drawn in proportion. In the point O_1 the velocity direction v_B is parallelly transferred, in to the point A_2 (ultimate point v_A) the direction of relative velocity v_B^A is parallelly transferred and is perpendicular to $\overline{AB}$. A triangle $O_1A_2B_2$ is formed according to the equation: $\overline{v_B} = \overline{v_A} + \overline{v_B^A}$. The line $\overline{O_1B_2}$ in velocity planning (Figure6-b) graphically represents the velocity v_B whose intensity is: $v_B = U_v \cdot \overline{O_1B_2}$. The velocity slope is made by connecting the ultimate points of the velocity vectors v_A and v_B (Figure 6-a).

Computed-aided design of piston mechanisms

Computer-aided design of mechanisms will be shown on the example of the piston mechanism of the engine, if it is a high-speed engine where the piston motion cycle becomes very short at high rotation speeds of crankshaft (Figure 7). In this case the influence of inertia forces generated during motion dominates in reference to the force generated as a result of fuel mixture expansion in the cylinder. [10]

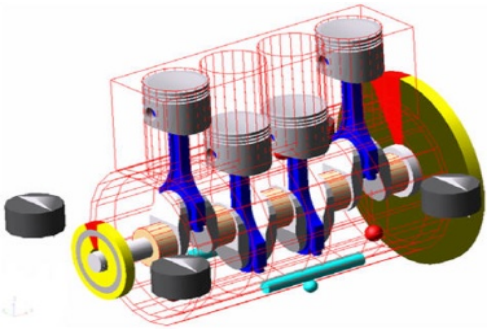


Figure 7. Virtual model of mechanism

A virtual model of the mechanism shown in figure 7 is made using Catia V5 software based on the kinematic scheme (figure 4). The software comprises the simulation of Catia tools suitable for analysis and control of rationalization of complex processes. It helps engineers make kinematic simulations of motions and behavior during the product development process; it enables them to have an insight into the system through a simple definition and animation of links, such as piston and connecting rod, crankshaft, and other. [14]

During the modeling process and since it is the software which allows parameter modeling, the necessary links and relations between specific geometric characteristics are made. This enables the preset relations of geometric structure and what is most important, the initial concept of modeling to be retained when some dimensions are subsequently changed, e.g. during optimization.

The necessary limitations in movement of members are inserted, i.e. movable and unmovable members are defined, joints are visualized and thus a kinematic chain of the piston mechanism is formed as a movable assembly which is further used as a virtual prototype in examination and analysis. [9] The view of modeled 3D mechanism is shown in figure 8b. This mechanism model is further used for visual animations.

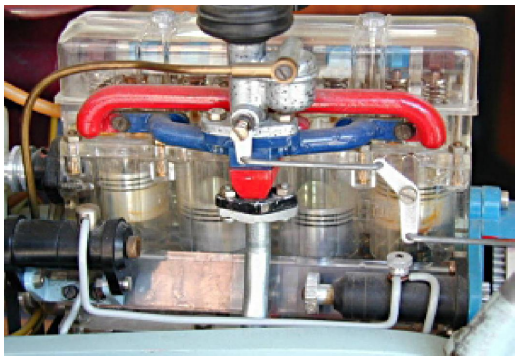


Figure 8. Snapshot of automobile pistons work (simulation)

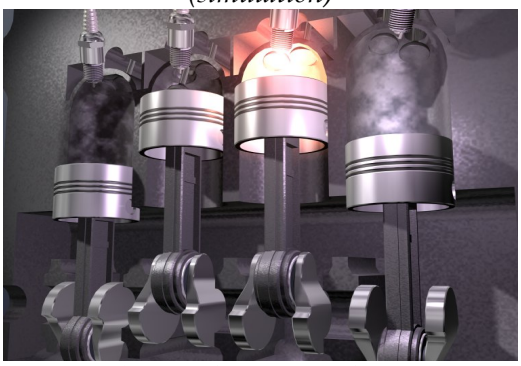


Figure 9. Simulation of the work of automobile pistons

The figures 8 and 9 show the simulation of the automobile pistons work. It helps not only the professionals and engineers in this area, but also drivers to simulate engines and actuators. It is a powerful tool which provides the best mechanism design in industry, enables the best purpose in mechanism of assemblies and subassemblies to be achieved by means of the software. [10]

A VIEW TO THE DESCRIBED KINEMATIC ANALYSIS

The comparison between analytical, graphic and computer-aided kinematic analysis are made on the mechanism which is usually used as a basis for machines and internal combustion engines design in practice. Engineers and mechanical engineering students may easily understand the application and importance of physical behavior of the mechanism model which is analyzed by calculation, modeling and behavior simulation (based on the real mechanism) [11], [14]

Analytical solution

The advantages of this method include minimal cost for its realization and the possibility to use the table applications for obtaining mathematical function. The disadvantages: mathematical equations terms are long-term; they require an excellent mathematical knowledge of the operator.

Graphical solution

The advantages of this method are: minimal cost for its realization, possibility to use graphical software, relatively quick solution of obtaining output values for one concrete combination of defined input parameters. The disadvantages: every change of input values requires processing, a new graphic solution; inaccuracy of results due to impreciseness.

Computer aided solution

Today, there are interactive and useful 3D software solutions which can be used to model very complex models [7], [8]. The advantages of this method are: visualization of motion mechanism with its details; fast data processing and output; possibility of variable combinations of input values; possibility to use output data for other purposes; direct transfer to dynamic analysis. The disadvantages are: expensive software and hardware, only engineers who are familiar with the work on this equipment may be engaged.

The final decision about which method will be used depends only on the researchers and their abilities. If they are good at mathematics, they will choose analytical and graphic method, but if they use software and hardware, they will choose computer-aided method. In all three cases they must know the basic principles of mechanics (kinematics and dynamics).

CONLUSIONS

Mechanism design is thought to be one of the most fascinating topics in mechanical engineering. In every modern plant there is a series of automatic operations connected to the production, assembly, transportation of parts, which need the use of mechanisms. The development of robotics and mechatronics is impossible without any knowledge of mechanism design. Therefore mechanism design

is of wider importance for everyday practice as well as for modern technology.

Computer using in designing and constructing is not news any more, but inevitability. Introducing the computer technology in designing and constructing process changes a character of user's work and changes his professional preparation. There are plenty of techniques of governing the application of corresponding program packages for the designing process. Designing with its requests includes needs for simulations of real conditions as well as analysis of interaction of models with the surroundings.

The machine or mechanism design always starts with kinematics consideration. Kinematics is the study of geometry of motion, i.e. of relations between linked parts and their motion in relation to each other. Insufficient knowledge of kinematics may result in a design of a system with failures, with no optimal effect and/or with insufficient reliability. Very powerful personal computers are available today with software products which enable kinematic analysis and synthesis that were not easily, efficiently and cheaply made before. Availability of such complex and expensive computers stimulate defining kinematic principles in design.

It could be said that mechanisms, along with other disciplines, are an area which both a designer and a user of machines must know well. This gives them confidence in solving tasks, designing mechanisms or adjusting them to conditions of use, which will satisfy all necessary requirements. The prerequisite for this is certainly a good knowledge of modern software tools.

REFERENCES

[1.] *Bilek, O., Lukovics, I., Finite Element Model of Dynamics within Highspeed Grinding Process, Academic Journal of Manufacturing Engineering, pp. 6-11, 2009.*

[2.] *Desnica, E., Letić, D., Advancing machine elements teaching in technical fields at university level education, Journal „Machine design", pp.45-48, 2007.*

[3.] *Desnica, E., Letić, D., Gligorić, R., Navalušić, S., The importance of improving education for successful performance of engineering tasks, International Symposium KOD 2012 - Machine and industrial design in mechanical engineering, pp. 91-96, 2012.*

[4.] *Eckhardt, Homer D., Kinematic design of machines and Mechanisms, McGraw-Hill Companies,, pp.11-24, 1998.*

[5.] *Gligorić, R., Mechanisms of agricultural machinery, Faculty of Agriculture, Novi Sad, 2005.*

[6.] *Husnjak, M., Mehanizmi, Teorija mehanizama, Zagreb, 2010.*

[7.] *Letić, D., Desnica, E., Engineering Graphics I and II, Technical faculty "Mihajlo Pupin", Zrenjanin, 2011.*

[8.] *Mikić, D., Ašonja, A., Gligorić, R., Savin, L., Tomić, M., Dynamic Solving of Rotational Transformation Matrix Using the D'ALAMBER Principle, Journal TTEM, Vol.7, No.3, pp.1187-1195, 2012.*

[9.] *Mikić D., Desnica, E., Aleksandar, A., Adamović, Ž., Mechanical modeling of industrial machines, II International Conference – Industrial Engineering And Environmental Protection (IIZS 2012), Zrenjanin, october 2012.*

[10.] *Mikić, D., Modeliranje mašinskih elemenata i konstrukcija u obrazovanju primenom softverskog paketa Catia", Internacionalna konferencija Tehnika i informatika u obrazovanju, str.552-559, 2010.*

[11.] *Monkova, K., Monka, P., Hloch, S., Valíček, J., Kinematic analysis of quick-return mechanism in three various approaches, Technical Gazette 18, 2(2011), pp. 295-299, 2011.*

[12.] *Novak-Marcincin, J., Computer modelling and simulation of automated manufacturing systems, Annals of Faculty Engineering Hunedoara – International Journal of Engineering, Tome XI, fascicule 2, pp.23-26, 2013.*

[13.] *Rao, J. S., Dukkipati, R. V., Mechanism and Machine Theory, New Age International Ltd. Publisher, pp. 22-71. 1992.*

[14.] *http://www.autopedija.com/index.php/2008112265/konfiguracije-motora.html*

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STRUCTURAL ANALYSIS FOR CONCRETE COLUMNS SUBJECTED TO TEMPERATURE

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Abstract: This research is initiated with the objective of investigating the behavior of light weight reinforced concrete columns under elevated temperature. Light weight concrete is achieved by using light weight expanded clay aggregate (LECA) as partial replacement (by volume) to normal weight aggregate. Four specimens were tested experimentally where they were subjected to elevated temperature, and under axial load. Experimentally tested specimens are used to verify a numerical model established by a commercial finite element modeling package ANSYS 13.0. Experimental measurements and numerical results showed a good agreement. Numerical model is then used to cover a wider range of concrete characteristic strengths and with different heating scenarios. Results showed that a slight reduction in the load carrying capacity, stiffness and toughness in unheated light weight columns when compared to the normal-weight concrete columns. Contrarily, an enhancement in the load carrying capacity after subjecting to elevated temperature is obtained.

Keywords: Reinforced concrete columns, Elevated temperatures, Light-weight concrete (LWC), Finite element analysis, Failure modde, Ultimate load

INTRODUCTION

Collapsing of structural elements subjected to fire is worldwide documented. Likewise, it is the case in Egypt. Structural elements when subjected to fire usually fail to resist it and the whole structure collapses. This is considered a big investment economical loss. This occurs persistently in developing countries (i.e. where many illiterate people live) and in hot zones (i.e. where the weather warmth makes the ignition point of materials to be reached easily). The influence of elevated temperatures on the concrete strength was studied by many researchers. Generally, concrete loses most of its strength (i.e. 70% to 80% of its original strength at room temperature) if exposed to 500 – 600 ℃ for a long time [1]. This sharp drop in the concrete strength occurs due to the complete decomposition of the cement hydrates with appearance of several microcracks [2]. Sait and Turan [3] found that at 900 ℃ concrete lost almost all of its strength. Also, Abd El-Razek et al [4] studied experimentally the reduction in the ultimate capacities of axially loaded reinforced concrete rectangular columns after the exposure to elevated temperatures while others [5] investigated the effect of the exposure to direct fire on the behavior of high strength concrete columns.

Each of them concluded that the exposure to either elevated temperature or fire causes severe reduction in the ultimate capacity of the tested columns. Khafaga [6] reported that exposure to 550 ℃ elevated temperatures adversely affected the structural behavior of the tested columns under uni-axial bending moment in terms of residual capacity, serviceability performance, stiffness and toughness.

On the other hand, in concrete structures, the concrete imposes a huge amount of the total load of the structure. Lighter concrete offers design flexibility and substantial cost saving by providing less dead load, improved seismic structural response, low heat conductivity and lower foundation cost when applied to structures. In recent years, due to these advantages, there is an interest in production and investigation of the light or reduced-weight concrete. Demirbog, [7], studied the mechanical properties, durability and thermal conductivity of the lightweight concrete. Kayali, [8], used fly ash light weight aggregate to produce light-weight high performance concrete. He

reported that, concrete produced using these aggregates is around 22% lighter and at the same time 20% stronger than normal weight aggregate concrete. Also, drying shrinkage is around 33% less than that of normal weight concrete. On the other hand, Choi et al, [9], reported that the range of elastic modulus has come out as 24 – 33 GPa, for light-weight concrete (LWC) with compressive strength more than 40 MPa, comparably lower than the normal concrete which possessed the same compressive strength. In addition, for LWC, different researchers, have proposed different relationships to estimate modulus of elasticity value from compressive strength and unit weight. However, these relationships depend on the type and source of the light-weight aggregate, since the light-weight aggregates are porous and have modulus of elasticity values lower than that of natural aggregate. On the other hand, Haque et al [10], carried out an experimental study and found that replacement of Light weight fine aggregate with normal weight sand produces a concrete that is some now more durable as indicated by their water penetrability and depth of carbonation when concretes are of equal strength.

However, although it was found that light-weight concrete (LWC) has good insulation and mechanical properties; it still needs further investigations of its structural behavior for use as structural members. Also Khafaga, [11], observed enhancement in ultimate carrying capacity of the reduced weight-concrete beams due to the increase in the concrete grade was lower than that of the normal-weight concrete beams and also reported that increasing the shear span to depth ratio promoted the beam action, decreased the cracking and ultimate loads and stiffness and increased the ductility of the reduced-weight concrete beams.

Nevertheless; there is a lack in knowledge about the structural behavior of the light-weight concrete when used in structural members. Previous researches indicated also that the properties of light-weight concrete depend on the type of its lightweight aggregates. Therefore, the structural behavior of light-weight concrete members may vary according to the type of the used light-weight aggregates.

The current research aims to investigate the effect of elevated temperature on the behavior of reinforced light weight concrete columns made of light-weight expanded clay aggregate (LECA) as a partial replacement (by volume) to the normal-weight aggregates. This is one of the widespread light-weight aggregates. Four reinforced concrete columns were fabricated and tested under axial load in compression machine of 5000 kN capacity. The effects of several variables such as type of concrete according to its weight, concrete grade and the effect of exposure duration were numerically investigated. The behavior of the tested columns was analyzed in terms of mode of failure, load-strains response, ultimate carrying capacity, stiffness and toughness. The test results are analyzed to demonstrate the effects of these considered variables on the tested light weight concrete columns as well as the normal-weight concrete columns.

However, due to the financial reasons, was obtaining the results from experiments, was not possible. Finite element method supplied a new way to study the behavior of light weight concrete columns subjected elevated temperature by computer, which can help the researcher to analyze and complete the experimental results and have a better understanding of it.

In recent years, using ANSYS as a finite element modeling software in many research works have been done successfully to simulate the numerical model for axial loaded concrete elements [12]. This software has plentiful element types and offers some default parameters, which makes it easy to develop a finite element model (FEM) to simulate the interactive behavior between concrete and other materials. In this study ANSYS 13 was used to implement the numerical study on the behavior of lightweight reinforced concrete columns subjected to elevated temperature.

Current research results are expected to assist engineers in design of fire resisting structures. Moreover, recommendations are going be added to the Egyptian Code of Practice (ECP).

EXPERIMENTAL PROGRAM

The experimental program consisted of fabricating and testing four reinforced concrete columns. Two of these reinforced concrete columns contained

light-weight expanded clay aggregates (LECA) as a partial replacement (by volume) to the normal weight coarse and fine aggregates with a percentage equals 50%. The unit weight of this type of concrete ranged between 1830 and 1890 kg/m³. The other two columns were cast with normal-weight concrete which contained normal-weight coarse and fine natural aggregates to be used as control specimens.

Materials and Concrete Mixes

Two concrete mixes were used in the current research. Mix No. I possessed normal unit weights (control mixes) and mix No. II possessed reduced unit weights. The intended compressive strengths is 30 MPa. Table (1) shows the details of these two mixes.

Table (1) Proportions of Concrete mixes {for Concrete Strength 30 (N/mm²)}

Mix No.	Type of Concrete	Cement (Kg/m³)	Silica Fume (Kg/m³)	Coarse Agg. (Kg/m³) Dolomite	LECA
I	Normal weight	350	---	1224	---
II	Light weight	315	35	612	204
Mix No.	Type of Concrete	Fine Agg. (Kg/m³) Sand	LECA	Water (Lit/m³)	Admix. (Kg/m³)
I	Normal weight	612	---	195	---
II	Light weight	306	184	185	7.0

Details of the Test Columns

The four tested columns have the same concrete dimensions, (i.e. 200 x 200 mm² in cross sectional area and length 1500 mm) Figure (1-a).

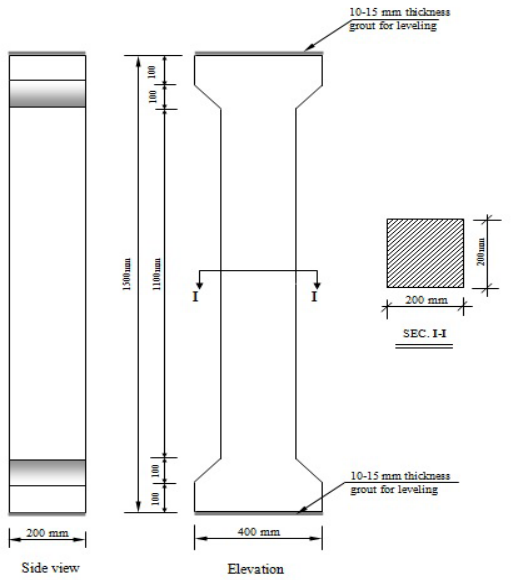

Figure (1-a) Concrete Dimensions of Typical Test Columns (200x200 mm²)

Table (2) presents the group number, column identification number, main characteristic values and the duration of elevated temperature.

Table (2) Column test results

Group	Column ident.	Type of Concrete	Exposure Duration (hrs)	Notes
I	$C1_{exp}$	Normal Weight	-------	Control specimen
	$C2_{exp}$		1.5	-------
II	$C4_{exp}$	Light weight	-------	Control specimen
	$C5_{exp}$		1.5	-------

The percentage of reinforcement (μ=1.13%) was used for all columns in the current study. Columns C1 and C4 were not exposed to elevated temperature.Therefore they were used as control specimens while the remaining two columns were exposed to a target temperature of 550℃ for 90 minutes. Allheated columns were cooled gradually in air for 24 hours before testing.

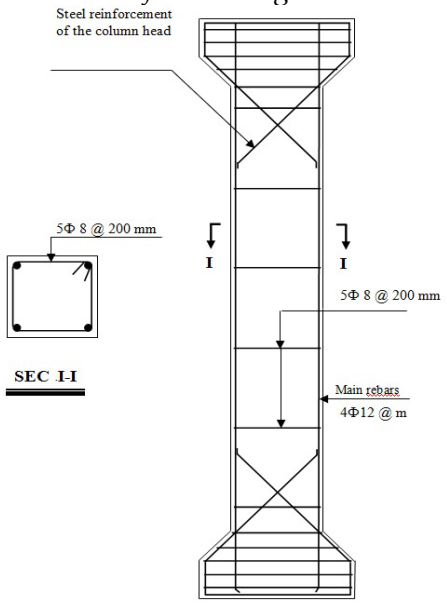

Figure (1-b) Typical Reinforcement Detailing Test Columns

Figure (1-b) shows the general reinforcement details for the tested columns. The main reinforcing bars were 4 Ø12 (high tensile steel 400/600) for columns of all groups. Stirrups with diameter 8 mm (mild steel 280/420) were detailed to keep the thickness of the concrete cover of the tested columns to be 25 mm which is the minimum thickness that achieve the requirements of the fire resistance of reinforced concrete columns according to the Egyptian Code ofPractice (ECP – 203) [13]. The main properties of the used steel bars are listed in table (3). Also, the column heads were designed

to avoid failureduring loading by adding additional reinforcement for strengthening the column heads.

Table (3) Properties of Steel Reinforcement

Type Size	Mild Steel	High Tensile Steel
Diameter (mm)	8	12
Actual Cross Sectional Area (mm^2)	50.80	112.4
Weight / Unit Length (kg/m')	0. 399	0.882
Yield Strength (N/mm^2)	307.7	443.6
Ultimate Strength (N/mm^2)	437.7	676.4
Elongation (%)	28.9	13.2

Elevated Temperature Setup

Two of the tested columns were subjected to an elevated temperature of 550℃ from four sides for 90 minutes. The tested columns were heated under the application of concentric constant vertical load equals 1/3 of the ultimate loads determined from testing the comparative control (unheated) columns, $C1_{exp}$ and $C4_{exp}$, respectively. The tested columns and the furnace were mounted, during the exposure periods, in the loading testing machine which applies the concentricvertical load, figure (2).

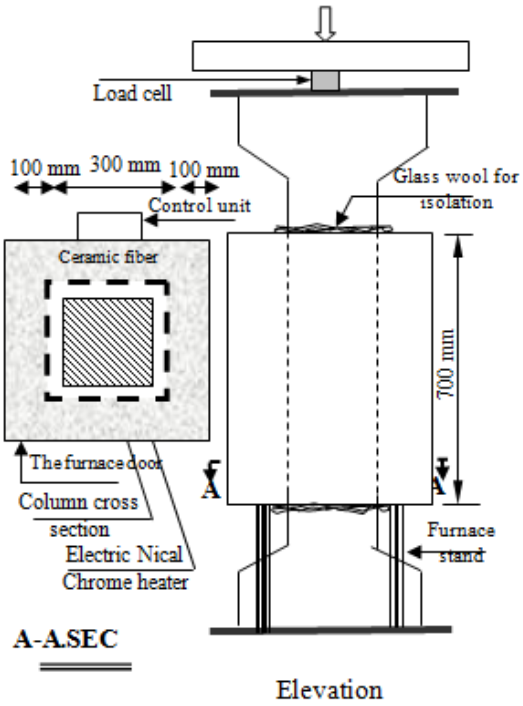

Figure (2) Setup of the exposure of elevated temperature from the four faces of the tested columns

Instrumentation and Test Setup

All columns are loaded up to failure. The control sample and the heated columns are loaded by a 5000 kN hydraulic compression machine. A load cell 2000 kN was used to measure the applied load and the readings were recorded automatically by means of a data acquisition system. Each of the tested columns was acted upon by a concentric vertical load.

Strains were measured at two sides of each tested column by attached linear variable displacement transducers (LVDT) which were connected to the data acquisition system. The LVDT measurements were determined on pegs mounted on the column sides at 700 mm spacing. Figure (3) illustrates a schematic of the loading setup and instrumentation of the tested columns.

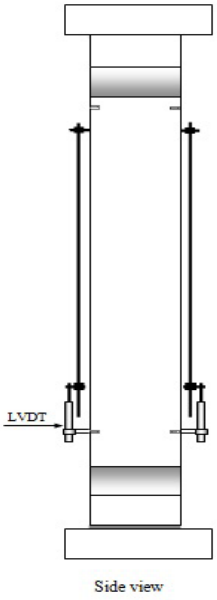

Figure (3) Instrumentation layout of the Test Columns.

Modes of Failure

For columns of group I ($C1_{exp}$, and $C2_{exp}$) of normal weight concrete, when the load increased beyond the point at which the peak load, the concrete crushed and the longitudinal reinforcement bars buckled. Then, a failure plane or a crushed zone was developed where the cover had pulled off. The failure of $C1_{exp}$ (unheated normal concrete column), occurred at sections at a certain height from the upper end. This is due to the effect of stress concentration at the column ends and the large sections chosen for the column heads. For column (heated normal concrete column), $C2_{exp}$ after the exposure to the 550℃ elevated temperature, the crushing of concrete took place at the mid height of the simulated columns, After the yielding point, cracks which were experienced at all sides, widen more. Upon further loading, concrete crushing occurred and larger deformations took place.

On the other hand, the failure modes of the light weight tested columns of the group II ($C4_{exp}$, and $C5_{exp}$), it was observed that light-weight aggregate concretes experience greater spalling when compared to normal-weight concretes. Thus, the lightweight aggregate concretes structures will only have potentially higher fire resistance than normal concrete structures if no spalling occurs.
The failure shape of the analysis column after loading is presented in figure (4).

Figure(4) Failure mode of column (Experimental)

FINITE ELEMENT ANALYSIS BY ANSYS

Finite element modeling in Ansys is considered perfectly performed if four main preprocessors activity is done. Finite element modeling is performed when element types selection, material modeling, geometrical modeling, and definition of loading schemes are completely done.

a. Element type selection

In Ansys, reinforced concrete behavior is achieved by combining two types of elements, namely, Solid65 and Link 8. SOLID 65 is an eight-node solid element, which is used to model the concrete cracking and crushing criterion. On the other hand, Link8 is a 3D spar element which is used to model reinforcing steel bars.

b. Material modeling

Two types of materials are modeled, concrete and steel materials. Concrete material is required to be capable of cracking in tension and crushing in compression. Despite the great advances achieved in the fields of plasticity, damage theory and fracture mechanics, unique and complete constitutive model for reinforced concrete is still lacking. Recently, researchers agreed to model concrete material in Ansys in both elastic and plastic loading stages. Concrete elastic behavior is well defined by both young's modulus (E_c) and Poisson's ratio (ν_c). Numerically E_c is dependent on concrete characteristic strength as will be discussed later and ν_c is assumed to be 0.2. On the other hand, concrete plastic behavior needs to be defined by multiple failure surfaces to capture concrete cracking, crushing, and large deformations during loading scenario.
By nature of material homogeneity, modeling of steel material is much simpler than concrete material. To satisfy the assumption that strain in steel and concrete at the same level is equal, steel material behavior should be defined in both elastic and plastic stress ranges. Steel elastic behavior is defined similar to concrete elastic behavior by both young's modulus (E_s) and Poisson's ratio (ν_s). Numerically, E_s and ν_s are assumed to be 210 GPa, and 0.2, respectively. 10% strain hardening is taken into considerations in steel plastic range rather than plateau behavior.

b.1. Concrete material non-linearity

Two failure surfaces are used to model the concrete plastic behavior, namely, concrete (CONC) and multi-linear isotropic (MISO) material models. Concrete material model predicts the mechanical failure of brittle materials, applied to a three dimensional solid element.
Consequently, CONC material model is capable of cracking in tension and crushing in compression. It can also undergo plastic deformation and creep. Mainly, two types of mechanical behavior data are defined to fill in CONC data table, uniaxial failure data (either in compression (f_c) or in tension (f_t)) and shear cracking parameters (β_t and β_c). The two input strength parameters, ultimate uniaxial tensile (f_t) and compressive strength (f_c), were defined to be 3MPa and 38 MPa, respectively. In this study, shear transfer coefficient of open crack β_t=0.5 and shear transfer coefficient of closed crackβ_c =0.8.
MISO yield surface is considered well defined by the definition of discrete points representing the numerical relation between applied stresses and corresponding strain values.
As per literature, numerical expression (1) is used to construct the uniaxial compressive stress-strain

curve for lightweight concrete in this study. Figure (5), shows the graphical representation of stresses and corresponding strains obtained from equation (1).

$$f_c = (2\beta - 3)\left\{\frac{\varepsilon_c}{\varepsilon_o}\right\}^4 + (4 - 3\beta)\left\{\frac{\varepsilon_c}{\varepsilon_o}\right\}^3 + \beta\left\{\frac{\varepsilon_c}{\varepsilon_o}\right\} \quad (1)$$

where, f_c : is the concrete stress, ε_C: is the concrete strain

$$\beta = E_{itm}\frac{\varepsilon_o}{f_c'}$$

For lightweight concrete, Wang et al [14] proposed eqn. (2) to estimate E_{itm}

$$E_{itm} = 2.1684\ f_c'^{0.535} \quad (2)$$

where, f'_c: is the concrete compressive strength, ε_0: is the concrete strain at peak stress, in case of lightweight aggregate concrete, and it is proposed by Almusallam and Alsayed [15] to be calculated by eqn. (3),

$$\varepsilon_o = (65.57 f_c'^{0.44} - 6.748)\times 10^{-5} \quad (3)$$

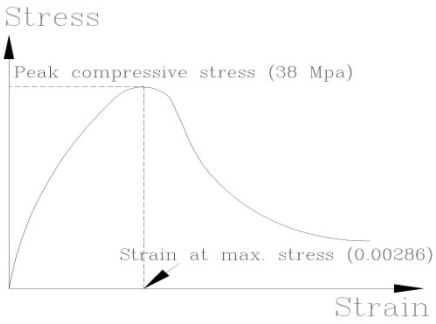

Figure (5) Compressive stress-strain curve for lightweight concrete used in ANSYS model

b.2. Reinforcement material non-linearity

The bilinear kinematic hardening model (BKIN) Constitutive model is sufficiently used to define steel bars material non-linearity (Werasak Raongjant, and Meng Jing [12]).

Bond between concrete and reinforcement is assumed to be perfect and modeling of bond itself is undertaken in this study through shared joints between both Solid65 and Link8 elements.

The bilinear kinematic hardening model (BKIN) was used. Constitutive law for steel behaviour is calculated by Werasak Raongjant, and Meng Jing models [16] shown in eqn. (4).

$$\text{[illegible]} = \begin{cases} E_s\varepsilon_s, & \varepsilon_s \le \varepsilon_y \\ f_y + E_s'\varepsilon_s, & \varepsilon_s \succ \varepsilon_y \end{cases} \quad (4)$$

In which δ_s is the steel stress; ε_s is the steel strain; E_s is the elastic modulus of steel; E'_s is the tangent modulus of steel after yielding, E'_s = 0.01 Es; f_y and ε_y is the yielding stress and strain of steel, respectively.

c. Geometrical modeling and finite element meshing

*Numerically modeled columns are typical to those experimentally tested in lab to verify the FEM accuracy. Numerically studied samples are 200 * 200 mm² in cross sectional area and 1500 mm high.Concrete solid continuums are meshed with cubic solid elements having and element size of 20 mm. Similarly, reinforcing bars are 20 mm long link elements, as shown in Figure (6).*

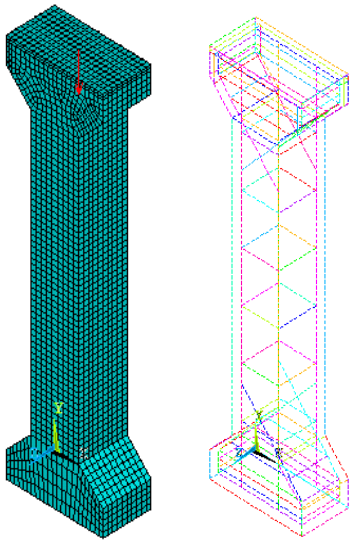

Figure (6.a) Concrete Model Figure (6.b) ReinforcedModel

d. Loading schemes

Two types of loads are considered during analysis. Control specimen is loaded using ramped axial load till failure with a uniform distribution over column cross section. Other specimens are investigated under both ramped axial load till failure simultaneously with an increasing external temperature over time.

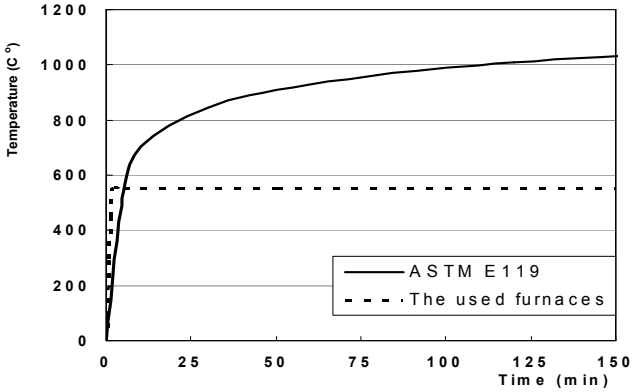

Figure 7. Effective Temperature – time curve

Temperature loading overtime is shown in Figure (7) which is in agreement with ASTM E119 [17]. In both types of specimens, axial loads are applied slowly to the numerical model in order to avoid hardening effect due to rapid loading. In addition, automatic time stepping is enabled to change rate of load application near failure load.

ANSYS supports two types of thermal analysis:

1. *A steady-state thermal analysis determines the temperature distribution and other thermal quantities under steady-state loading conditions. A steady-state loading condition is a situation where heat storage effects varying over a period of time can be ignored.*
2. *A transient thermal analysis determines the temperature distribution and other thermal quantities under conditions that vary over a period of time.*

Thermal analysis in Ansys calculates the temperature distribution and related thermal quantities. Typical thermal quantities of interest are: the temperature distributions, the amount of heat lost or gained, thermal gradients, and thermal fluxes.

Ansys Multiphysics module is used to perform such FE analysis during thermal loading. The basis of thermal analysis in Ansys Multiphysics is the heat balance equation obtained from the principle of conservation of energy.

VERIFICATION OF THE NUMERICAL MODEL

The tested and the ANSYS results of load – concrete strain curves of the four specimens are presented in Figure (8 to 11). Finite element analysis results showed similar trends to the tested results with a deviation nearly about 9% which recommended the proposed numerical model.

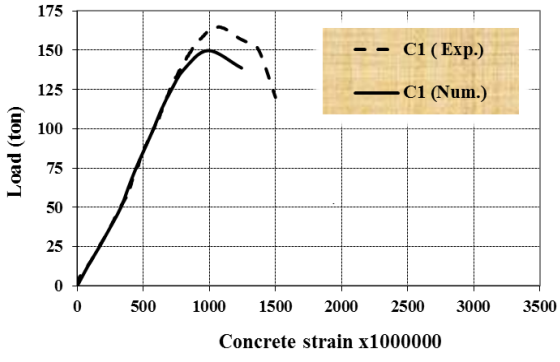

Figure (8) Load – Strain Relationship For Column (C1)

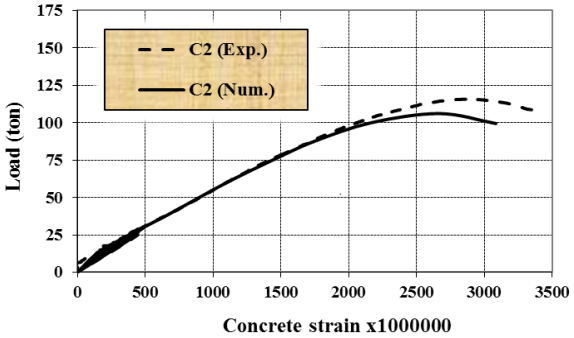

Figure (9) Load – Strain Relationship For Column (C2)

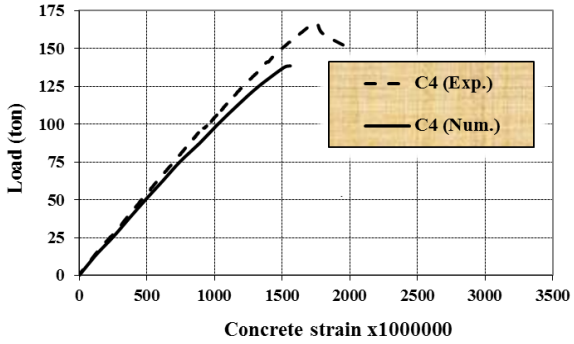

Figure (10) Load – Strain Relationship For Column (C4)

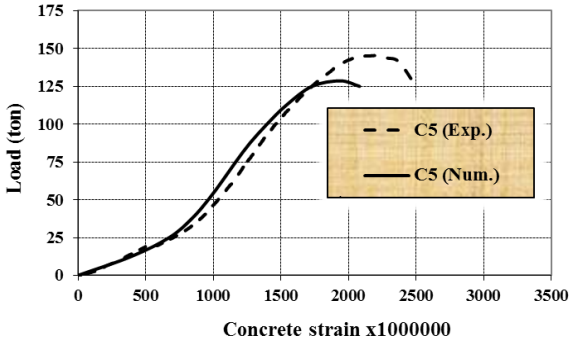

Figure (11) Load – Strain Relationship For Column (C5)

ANALYSIS PROCEDURE (numerical examples)

*A total number of twelve reinforced columns were fabricated and simulated by ANSYS in the current study. Groups A and B consist of columns $C1_{num}$ to $C6_{num}$ with intended concrete compressive strength 30 MPa, while groups B and D consist of columns $C7_{num}$ to $C12_{num}$ with intended concrete compressive strength 40 MPa. All analysis columns in this study were of the same concrete dimensions; 200 * 200 mm² in cross sectional area and length 1500 mmas shown in Figure (1).*

The percentage of reinforcement (μ=1.13%) was used for all columns in the current study. Columns $C1_{num}$, $C4_{num}$, $C7_{num}$ and $C10_{num}$were not exposed to elevated temperature, therefore they were used as control specimens while the remaining eight

columns were exposed to a target temperature of 550℃ for either 90 or 180 minutes. Figure (1) shows the general reinforcement details for the simulated columns.

The main reinforcing bars were 4 Ø12 (high tensile steel 400/600) for columns of all groups. Stirrups with diameter 8 mm (mild steel 280/420) were detailed to keep the thickness of the concrete cover of the tested columns to be 25 mm which is the minimum thickness that achieve the requirements of the fire resistance of reinforced concrete columns according to the Egyptian code for design and construction of concrete structures (ECP – 203) [13]. The main properties of the used steel bars were listed in Table (2). Table (4) presents the group number, column identification number, main characteristic values, type of concrete and the duration of elevated temperature.

Table (4) Major analysis results

Group	Column ident.	Ultimate load, P_u, (KN)	Stiffness (KN/m)	Toughness (KN mm/mm)	Exposure Duration (hrs)
A	$C1_{num}$	1490	1.059	0.450	----
	$C2_{num}$	1040	0.284	0.120	1.5
	$C3_{num}$	960	0.252	0.107	3.0
B	$C4_{num}$	1380	0.619	0.263	----
	$C5_{num}$	1280	0.493	0.209	1.5
	$C6_{num}$	1410	0.39	0.165	3.0
C	$C7_{num}$	1730	0.80	0.340	----
	$C8_{num}$	980	0.289	0.123	1.5
	$C9_{num}$	890	0.221	0.094	3.0
D	$C10_{num}$	1480	0.684	0.290	----
	$C11_{num}$	1170	0.278	0.118	1.5
	$C12_{num}$	960	0.489	0.207	3.0

ANALYTICAL RESULTS and DISCUSSION

Results of the simulated columns are presented, analyzed and discussed in this section. Topics to be covered include the mode of failure, the load-strain relationships, the ultimate load, the stiffness and toughness of the analysis columns. Table (4) lists the ultimate loads, stiffness and toughness of the simulatedcolumns. The analysis columns showed different structural behavior according to the studied key variables.

□ Stiffness and Toughness

The stiffness of the analysis columns can be calculated as the average slope of the ascending part of the load – Longitudinal strain curves. It can be noted from figures (12) to (25) that the slope of the curves is not constant and it decreases 40% to 70% of the ultimate loads of the simulated columns. This stiffness degradation occurs due to the micro-cracking of concrete. Table (4) presented the initial stiffness values of the whole analysis columns. It can be observed that the initial stiffness of the columns of group A ranged between 0.252 kN/m for $C3_{num}$ and 1.059 kN/m for the unheated column, $C1_{num}$. This means that the occurring reduction in the initial stiffness in this group reached 73.2% due to the exposure to elevated temperature for 3hrs of normal strength concrete 30 N/mm². On the other hand, the initial stiffness of the light weight columns of the same strength (group B) ranged between 0.39 kN/m for $C6_{num}$ and 0.619 kN/m for the unheated column, $C4_{num}$, i.e. the reduction percentage of the initial stiffness induced by the exposure to 550℃ elevated temperature reached 36.9% in this group and due to the high fire resistance of light weight concrete Moreover, referring to Table (4).

Also, it can be observed that the initial stiffness of the columns of group C ranged between 0.221 kN/m for $C9_{num}$ and 0.80 kN/m for the control column, C7num. This means that the occurring reduction in the initial stiffness in this group reached 72.4% due to the exposure to elevated temperature for 3hrs at normal strength 40 N/mm². On the other hand, the initial stiffness of the light weight columns with the strength of group D ranged from 0.490 kN/m for $C12_{num}$ to 0.684 kN/m for the control column, $C10_{num}$, i.e. the reduction percentage of the initial stiffness induced by the exposure to 550 ℃ elevated temperature for 3 hrs reached 28.3% in this group. And this can be explained by the high fire resistance of light weight concrete. Moreover, it is noticed that as the concrete type changed from normal to light weight concrete at the same concrete strength, the rate of loss in stiffness decreased.

Toughness of the analysis columns, which is the ability to absorb the energy through their deformations, is one of the main important characteristics of the structural behavior of the concrete elements. The toughness values can be represented by the total area under the load – compressive strain curves that were calculated numerically. Table (4) presents the toughness values of the analysis columns. Comparing the values given in Table (4), it can be noted that the occurring reduction ranged from 63.9-76.2% in

the toughness after analysis of the heated columns as the time of exposure to elevated temperature increased from 1.5 hrs to 3 hrs for groups A and C (normal weight concrete, at strength 30 N/mm² and 40 N/mm²), while the reduction in toughness decreased ranged between 20.5% to 59% in light weight concrete as the time of exposure to elevated temperature increased from 1.5 hrs to 3 hrs for groups B and D at strength 30 N/mm² and 40 N/mm².

□ ***Load – Strain Records***

√ ***Effect of Concrete Grade***

Figures (12) and (13) illustrate the load- strain relationships of the analysis unheated columns ($C1_{num}$, $C7_{num}$) and ($C4_{num}$, $C10_{num}$) for normal-weight and light weight concrete respectively. In general, for unheated tested columns, it was noticed that the ultimate failure load increased by 13.4% for normal strength concrete ($C1_{num}$ and $C7_{num}$) and 6.75% for light weight concrete ($C4_{num}$ and $C10_{num}$) as the concrete strength increased from 30 N/mm² to 40 N/mm², respectively. This means that normal-weight concrete columns were more sensitive to concrete strength than the light weight concrete columns.

For heated columns at 550℃ for 1.5 hrs, figure (14), it is noticed that the ultimate failure load decreased by 30.2% for normal strength concrete column ($C2_{num}$) comparing with unheated control specimen ($C1_{num}$) at concrete strength 30 N/mm², while it decreased by 43.3% for normal strength concrete column ($C8_{num}$) comparing with unheated control specimen ($C7_{num}$) at concrete strength 40 N/mm². While for heated analysis columns at 550℃ for 1.5 hrs, figure (15). It was noticed that the ultimate failure load decreased by 7.2% for light weight concrete column ($C5_{num}$) compared to unheated control specimen ($C4_{num}$) at concrete strength 30 N/mm², while it decreased by 20.9% for normal strength concrete column ($C11_{num}$) comparing with unheated control specimen ($C10_{num}$) at concrete strength 40 N/mm².

While at 3 hrs exposure duration at 550℃, Figure (16), the ultimate failure load decreased by 35.5% at concrete strength 30 N/mm² to for normal weight concrete comparing with (the unheated control column). While it decreased by 48.5% at concrete strength 40 N/mm² for the same type of concrete.

So it can be noted that, in general the rate of reduction of ultimate failure load of specimens subjected to elevated temperature increased as concrete grade increased from 30 N/mm² to 40 N/mm².

Moreover, from the figures, the rate of loss in stiffness was increased as the exposure duration increased from 1.5 hrs to 3 hrs as the concrete strength increased from 30 N/mm² to 40 N/mm² for normal strength concrete.

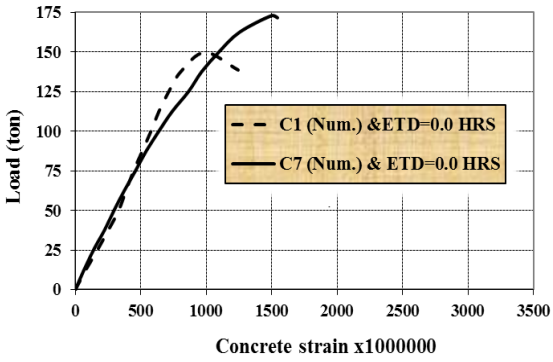

Figure (12) Effect of Concrete Grade on Load –Strain Relationship for Unheated Columns (NWC)

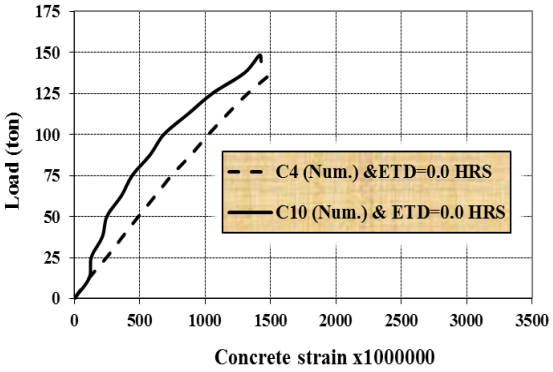

Figure (13) Effect of Concrete Grade on Load –Strain Relationship for Unheated Columns (NWC)

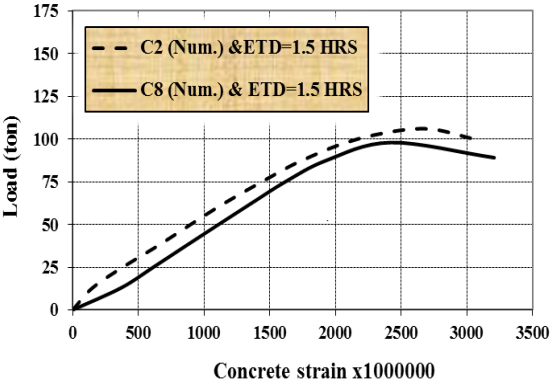

Figure (14) Effect of Concrete Grade on Load –Strain Relationship for Heated Columns (NWC) at 1.5 hrs

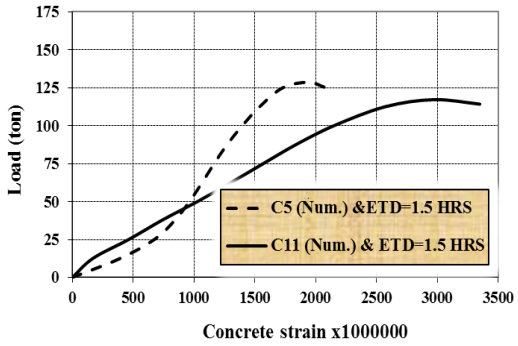

Figure (15) Effect of Concrete Grade on Load – Strain Relationship for Heated Columns (LWC) at 1.5 hrs

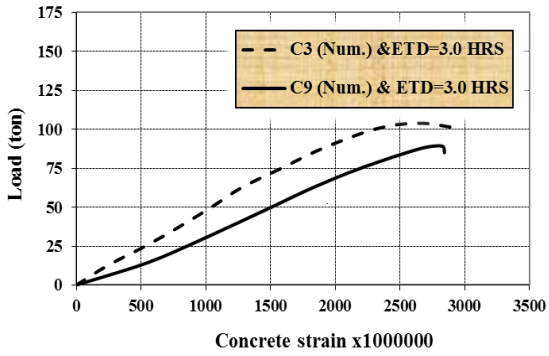

Figure (16) Effect of Concrete Grade on Load - Strain Relationship for Heated Columns (NWC) at 3 hrs

√ ***Effect of Concrete Type***

Figures (17 to 18) illustrate the load- strain relationships of ($C1_{num}$, $C4_{num}$), and ($C7_{num}$, $C10_{num}$) unheated tested columns. It can be noticed that the ultimate load decreased by 7.4% as the concrete type changed from normal weight to light weight concrete at compressive strength 30 N/mm² while it decreased by 14.4% as the concrete type changed from normal weight to light weight concrete at compressive strength 40 N/mm². It can be noted also that, in general, the recorded values of compressive strains for normal weight concrete and low density concrete increased as compressive strength 30 N/mm² to 40 N/mm², respectively.

Figures (19 to 20) illustrate the load- strain relationships of analysis heated columns ($C2_{num}$ and $C5_{num}$) and ($C8_{num}$ and $C11_{num}$) at 550 ℃ for 1.5 hrs, respectively. It can be noticed that the ultimate load decreased from 30.2% to 7.2% compared to unheated analysis columns as concrete type changed from normal weight to light weight concrete respectively, at compressive strength 30 N/mm², while the ultimate load decreased from 43.3% to 20.9% as the concrete type changed from normal weight to low density concrete at compressive strength 40 N/mm².

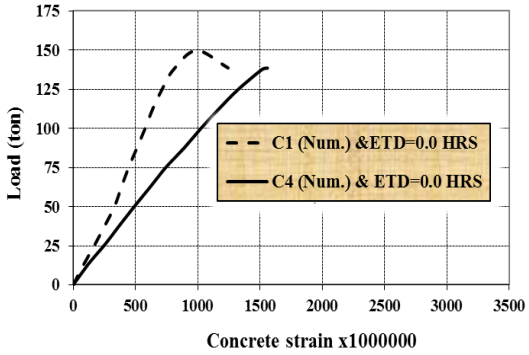

Figure (17) Effect of Concrete Type on Load – Strain Relationship for Unheated Columns at Concrete Strength 30N/mm²

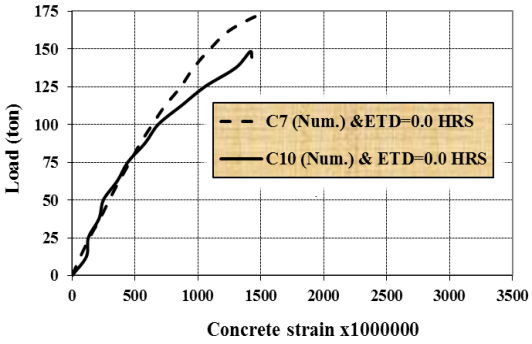

Figure (18) Effect of Concrete Type on Load – Strain Relationship for Unheated Columns at Concrete Strength 40N/mm²

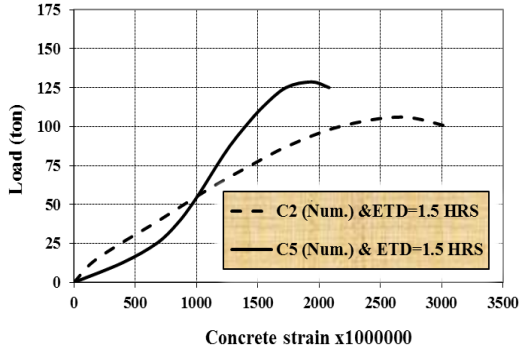

Figure (19) Effect of Concrete Type on Load – Strain Relationship for Heated Columns at 1.5 hrs at Concrete Strength 30 N/mm²

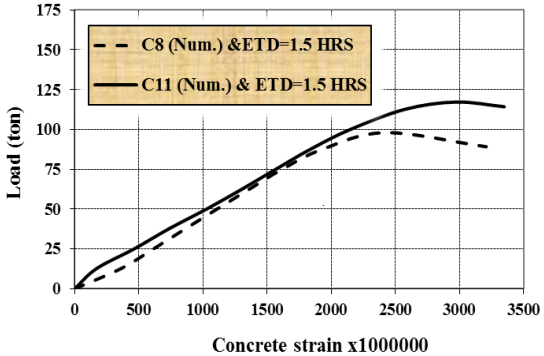

Figure (20) Effect of Concrete Type on Load – Strain Relationship for Heated Columns at 1.5 hrs at Concrete Strength 40 N/mm²

Figure (21) illustratethe load- strain relationships of analysis heated columns ($C9_{num}$ and $C12_{num}$) at 550 ℃ for 3 hrs. It can be noticed that the ultimate load decreased from 48.5% to 35% compared to unheated analysis columns as the concrete type changed from normal weight to light weight concrete respectively, at compressive strength 40 N/mm².

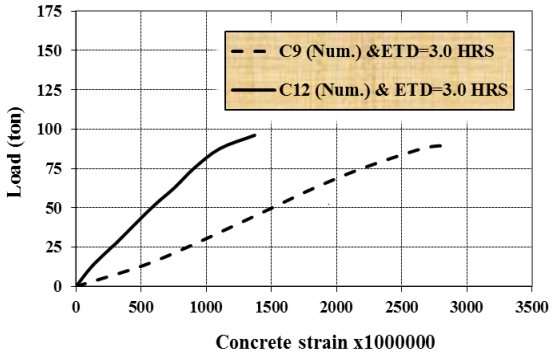

Figure (21) Effect of Concrete Type on Load – Strain Relationship for Heated Columns at 3 hrs at Concrete Strength 40N/mm²

Based on the results, it is noted that the unheated normal weight concrete columns showed larger ultimate loads when compared to the light weight concrete columns thatpossessed the same compressive strength.

On the contrary, the heated low density concrete columns showed larger ultimate loads when compared to the normal weight concrete columns possessed the compressive strength.

Also comparisons between the results of columns of normal-weight concrete and columns of light weight concrete were executed. It can be seen that the percentage of reduction in the ultimate capacity of analysis (unheated) columns increased as the concrete type changed from normal to light weight concrete as the concrete strength increased from 30 N/mm² to 40 N/mm², while the percentage of reduction in the ultimate capacity of analysis (heated) columns was decreased as the concrete type changed from normal to light weight concrete as the concrete strength increased from 30 N/mm² to 40 N/mm².

Also it was observed that the stiffness (the slope of the ascending part of the load–longitudinal strain curve) of the light weight concrete columns decreased compared to the normal weight concrete columns forconcrete strength 30 kN/mm².

√ ***Effect of Exposure Period***

Figures (22) to (25) illustrate the load- strain relationships of analysis columns of groups A, B, C and D, respectively. From Figure (22), the ultimate failure load decreased by (30% to 35.5%) as the exposure duration increased from 1.5 hours to 3 hours at 550°C, at concrete strength 30 N/mm². Also it was observed that the rate of reduction of stiffness increased as the exposure duration increased. Also, Figure (23) indicated that the ultimate failure load decreased by (7.2%) compared to unheated analysis column $C4_{num}$ after exposed to elevated temperature for 1.5 hrs at light weight concrete at compressive strength 30 N/mm². While from Figure (24) and (25), it can be noticed that the ultimate failure load decreased by (43.3% to 48.5%) and (21% to 35.2%) as the exposure duration increased from 1.5 hours to 3 hours at 550°C, as the concrete type changed from normal weight concrete to light weight concrete at the same compressive strength 40 N/mm², respectively.

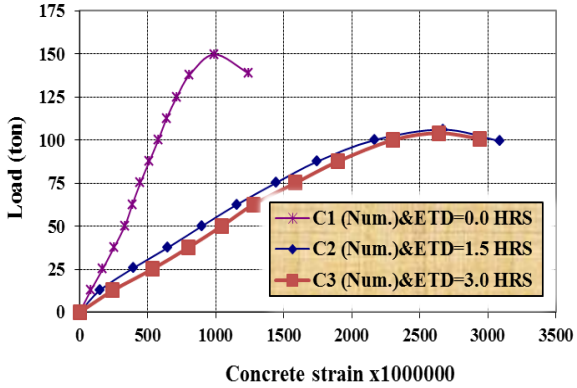

Figure (22) Effect of Exposure Duration on Load – Strain Relationship for (NWC) Columns using Concrete Strength 30 N/mm²

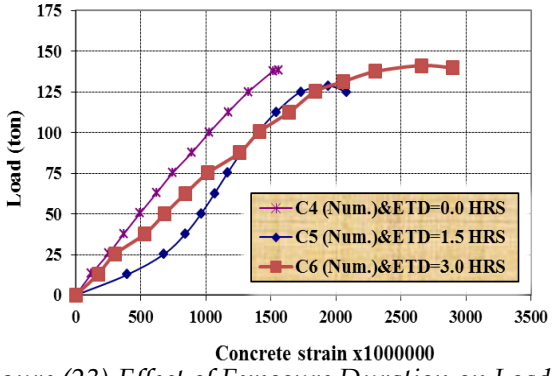

Figure (23) Effect of Exposure Duration on Load – Strain Relationship for (LWC) Columns using Concrete Strength 30 N/mm²

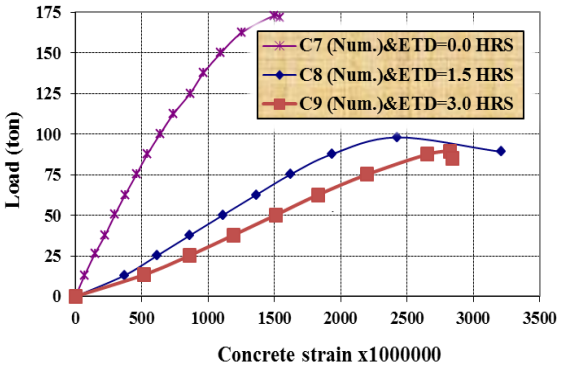

Figure (24) Effect of Exposure Duration on Load – Strain Relationship for (NWC) Columns using Concrete Strength 40 N/mm²

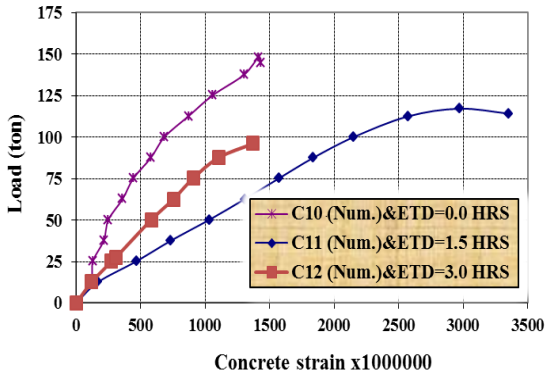

Figure (25) Effect of Exposure Duration on Load – strain Relationship for (LWC) Columns using Concrete Strength 40 N/mm²

CONCLUSIONS

Based on the results the following conclusions could be drawn:

1. *The unheated light weight columns showed a slight reduction in the load carrying capacity, stiffness and toughness when compared to the normal-weight concrete columns.*
2. *The percentage of reduction in the ultimate capacity of analysis (unheated) columns increased from 13.4% in normal weight concrete to 6.75% in light weight concrete as the concrete strength increased from 30 N/mm² to 40 N/ mm².*
3. *The percentage of reduction in the ultimate capacity of analysis (heated) columns at 1.5 hrs decreased as the concrete type changed from normal to light weight concrete.*
4. *For the same grade of strength, the rate of reduction in ultimate capacity of the heated columns was decreased as the concrete type changed from normal weight concrete to light weight concrete.*
5. *The rate of loss in stiffness increased as the exposure duration increased from 1.5 hrs to 3 hrs as the concrete strength increased from 30 N/mm² to 40 N/mm² for normal strength concrete, while in light weight concrete the rate of loss in stiffness decreased.*

REFERENCES

[1.] *Abu Al-magd, S., and Hosny, H., „Fires in Concrete Structures", Egypt, No. 1514, 1994.*

[2.] *Saad, M.; Abo El-Enien, S. A.; Hanna, G. B. and Kotkata, M. F., „Effect of Silica Fume on the Phase Composition and Microstructure of Thermally Treated Concrete", Cement and Concrete Research, Vol. 26, 1996.*

[3.] *Sait, M. and Turan, O., „Effect of Elevated Temperature on the Residual Mechanical Properties of High Performance Mortar", Cement and Concrete Research, Vol. 32, 2002.*

[4.] *Abd El-Razek, M. M.; Hodhod, H. A.; Ragab, A. M. and Rashad, A. M., „Size and Concrete Cover Effect on the Residual Capacity of Loaded Rectangular Short RC Column Models Exposed to Elevated Temperature", Proceeding of International Conference on Future Vision and Challenges for Urban Development, Egypt, December, 2004.*

[5.] *Issa, M. S. and Anwar, H., „Structural Behavior of High Strength Reinforced Concrete Columns Exposed to Direct Fire", Proceeding of International Conference on Future Vision and Challenges for Urban Development, Egypt, December, 2004.*

[6.] *Mohamed A. Khafaga, „ A Novel Approach to Evaluate the Effect of Elevated Temperatures on the Behavior of Reinforced Concrete Columns Subjected to Uni-axial Bending". Engineering Research, Faculty of Engineering, Helwan University, Vol (109), Febrary 2007.*

[7.] *Demirbog, R. and Gu, R., (2003), „The effects of expanded perlite aggregate, silica fume and fly ash on the thermal conductivity of lightweight concrete", Cement and Concrete Research, 33, pp.723 –727.*

[8.] *Kayali, O., (2008), „Fly ash lightweight aggregates in high performance concrete", Construction and Building Materials, 22, pp. 2393 – 2399.*

[9.] *Choi, Y. W., Kilm, Y., J., Shin, H. C. and Moon, H. Y., (2006), „An experimental research on the fluidity and mechanical properties of high-strength lightweight self-compacting concrete", Cement and Concrete Research, 36, pp. 1595 – 1602.*

[10.] Haque, M. N., Al- Khaiat H. and Kayali, O., (2004), „Strength and durability of lightweight concrete", Cement and Concrete Composites, 26, pp. 307 – 314.
[11.] Mohamed A. Khafaga, „Shear Behavior of Reduced Weight Reinforced Concrete Beams". Journal of Engineering Science, JES, Faculty of Engineering, Assuit University, Vol (40), No. (1), January 2012.
[12.] Werasak Raongjant, Meng Jing "Analysis Modelling of Seismic Behaviour of Lightweight Concrete Shear Walls" Proceedings of the International Multi Conference of Engineers and Computer Scientists 2009 vol II IMECS 2009, March 18-20, 2009, Hong Kong.
[13.] Egyptian Code for Design and Construction of Concrete Structures (ECP 203), Housing and Building Research Center, Egypt, 2007.
[14.] Wang P.T. Shah S.P. Naaman A.E., "Stress-strain curve for normal and lightweight concrete in compression". American Concrete Ins. J. Proceeding, 75(`11), 1978. Pp. 603-614
[15.] Almusallam T.H., Alsayed H., "Stress-strain relationship of normal, high-strength and lightweight concrete". Magazine of concrete research, 47 (169), 1995, pp. 39-43.
[16.] Werasak Raongjant, and Meng Jing, "Analysis Modelling of Seismic Behaviors of Lightweight Concrete Shear Walls" International Multi Conference of Engineers and computer Scientists 2009 Vol II IMECS 2009, March 18-20, 2009, Hong Kong.
[17.] ASTM E119, „Standard Method for Fire Tests of Building Construction and Materials", American Society for Testing and Materials, Philadelphia, 2000.

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DESIGNING OF A COMPOSITE FOLDED MEMBRANE BY A DEVELOPABLE MEMBRANE WITH PARABOLIC GUIDELINES OF ANY ORDER

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Abstract: The geometric modeling of a folded composite membrane using method of approximation of a folded composite membrane by a developable surface with parabolic guidelines of any order is an aim of this work. This approach is carried out on a one-way expandable composite membrane with thermosetting polyester matrix reinforced by fiberglass. The geometric model is done in two steps: first one replaces the membrane of reference by a system of developable membranes from which then plane quadrilaterals arranged in a well-defined manner are constructed. This need the establishment of mono parametric equation of the family of the plans and the equation of the cuspidal edge of the developable surface basing on which it is carried out the development of algorithms for the construction of the folded composite membrane and that of the developed of the twisted membrane.
Keywords: twisted membranes, folded composite membrane, developable surface

INTRODUCTION

The twisted membranes belong to the family of developable surfaces whose principal advantage as one knows it resides in their capacity to be spread on a plan without distortion lengths, tearing and crumpling. The applications of developable surfaces in industrial circle are varied. Indeed, the structures whose surface is developable are simply manufactured by folding of their developed form, cut out in a sheet of material. This process is used for example in shipbuilding for the manufacture of the hulls of boat [1]. In the field of the civil engineering and architecture, developable surfaces are generally regarded as a technical method for realization of complex forms. However, the study suggested in [2] show that they can be used like aesthetic tools with whole share.

The current evolution of technology brings to carry out increasingly complex projects, expensive and subjected to increasingly severe constraints of safety. The thin hull belongs to the family of structural surfaces which includes the membranes, folded surfaces and hulls. The hulls with simple or S curve are of everyday usage in structural engineering (engineering mechanical, civil, shipbuilding, aeronautical, etc).Vis-a-vis the geometrical complication of the majority of the structures membrane, the recourse to models more innovating, robust and fulfilling the requirements of reliable simulation as well as possible, proves to be paramount. The recourse to the material concrete to build 3D surfaces a little lost today with the profit of other materials the such composites. In addition, a complete modeling 3D with voluminal finite elements causes costs of prohibitory calculations as well as numerical problems of blockings for the mean structures.

An alternative resides in the development of a macroscopic model which consists in replacing a developable composite membrane by a system of plane quadrilateral elements i.e. a curved membrane by a folded surface. This approach is justified especially for developable surfaces bus by definition they are made of a mono parametric family of tangent plans on these surfaces according to the right generatrixes.

FORMULATION OF THE PROBLEM AND METHOD

In this work, one proposes a macroscopic model allowing the simulation of working of a composite

on a macroscopic scale by using a geometrical modeling much simpler than those of the literature like that proposed in [3].This model suggested is based on a method of approximation of a composite folded membrane by a twisted surface with parabolic guidelines of any order.

MATHEMATICAL ASPECTS

The modeling of developable surfaces is a complicated problem, especially if one does not force the surface to be regular of class C^2. Developable surfaces are isometric surfaces in the plan. The theorem of Minding states that two surfaces having even constant Gaussian curve are isometric. In this case, the theorem egregium indicates that the curve of Gauss of a developable surface is inevitably null in any point.

In general, it is more convenient to define a developable surface by a vector equation set of the shape:

$$\vec{r} = \vec{r}(u,v) = x(u,v)\,\vec{i} + y(u,v)\,\vec{j} + z(u,v)\,\vec{k} \quad (1)$$

or by parameterized form: x=x(u,v), y=y(u,v), z=z(u,v) which may be one of the types:

$$z = z(u, v), \quad (2)$$

$$M(x, y, z) = 0, \quad (3)$$

The expression (2) defines the coordinate z as a direct parameterization and the expression (3) as a dual parameterization where not all the plans are parallel and the family of plans does not form a beam, that is, there is not a right common to all these plans.

Discretization: There is not discrete equivalent of the Gaussian curve, several expressions were proposed besides [4,5,6]. Consequently, there is not single solution to discretize a developable surface. The method described in [7] for example is based on the representation of tangent developable surfaces. The cuspidal edge is discretized and becomes a polygon.

Another solution consists in defining a developable surface as a surface being able to be put flat without being stretched. While following this step, the models of the type "band" were proposed. They consist of an articulated assembly of plane elementary forms forming a band. In [8], the elementary forms are triangles. It is then possible to obtain developable approximations of surfaces which are not it. Same manner one can choose plane quadrilaterals to compose a band. This process is used for example in [9]. Limiting surface obtained is then developable.

GEOMETRICAL MODEL SUGGESTED

Let us consider a twisted surface whose curved generatrixes are plane parabolas of order m and n:

$$x = 0, \quad x = l, \qquad y = a z^n \text{ and } y = b z^m. \quad (4)$$

In this case, the parametric mono equation of the family of the plans will have the following form:

$$M = (n-1)(l-x)\beta^n + n\beta^{n-1}(x\gamma - zl) + \frac{1}{a}(ly - bx\gamma^m) = 0 \quad (5)$$

Where β=z, parameter of the parabola of the plan x=0 and y=z, parameter of the other parabola. The parameters β and γ are bound by the following relation [10]:

$$\gamma^{m-1} = \frac{an\beta^{n-1}}{bm} \quad (6)$$

By introducing the formula (6) into the equation (5) we will have:

$$M = M(x, y, z, \beta) = 0.$$

The right generatrix of the twist passes by the point β=z of parabola of order n and by the corresponding point γ =z of parabola of order m. A twisted surface is completely given by its cuspidal edge whose definition is sufficient for the construction of its developed and that of the folded surface built starting from twisted surface [11].

For considered twisted surface, when m=n, we obtain the equation of the cusp edge in the form:

$$z = 0, \; y = 0, \; x = \frac{l}{(1 - \sqrt[n-1]{a/b})},$$

I.e. we have a cone if a≠b or a cylinder if a=b. When m ≠ n, we obtain the equation of the cuspidal edge by the resolution of the following system:

$$M = 0, \; \frac{\partial M}{\partial \beta} = 0, \; \frac{\partial^2 M}{\partial \beta^2} = 0,$$

For example for m=2, n=4 we find:

$$x = \frac{bl}{b - 6a\beta^2}, \; y = -\frac{2a^2\beta^6}{b - 6a\beta^2}, \; z = -\frac{4a\beta^3}{b - 6a\beta^2} \quad (7)$$

Let's assume that: a=0.5; b=1; l=5; m=2; n=4. The formula (2) will take the following form:

$$M = (2\beta^6 - 3\beta^4)x + 10y - 20\beta^3 z + 15\beta^4 = 0, \quad (8)$$

and of the relation (6) we will have $\gamma = \beta^3$.

RESULTS AND DISCUSSIONS

The twisted surface with parabolic guidelines of order m=2, n=4 and its corresponding cuspidal edge are shown in figure 1. From equation (7) one can determine the coordinates of the remarkable point for (not of return): $\beta = 0,\ x = l,\ y = z = 0;$ *for* $\beta = \sqrt{b/6a}$ *there is a rupture of the cuspidal edge.*

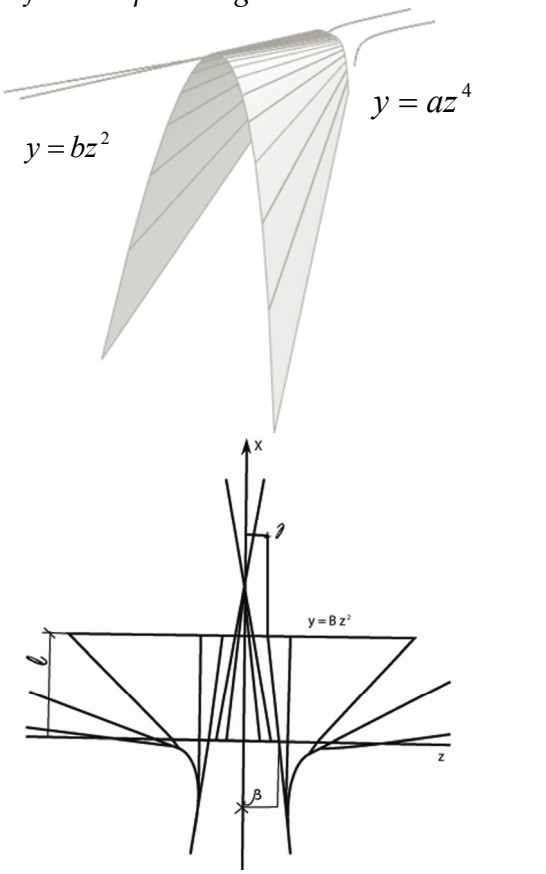

Figure 1. Developable surface and its cuspidal edge

ALGORITHM OF CONSTRUCTION OF FOLDED SURFACE

The algorithm of construction of the folded surface on the basis of given twisted surface is studied in [12]. Let us build the developed of the folded surface (figure 2), tangent to the given twist according to the right generatrix when $\beta = 0;\ \beta = 0.5;\ \beta = 1;\ \beta = 1.5.$

We obtain the coordinates of the angular points of the folded surface as being the components of the points of intersection of three plans. Two plans will be given by two sides close to the folded surface which one can obtain by the mono parametric equation of the family of the plans (5) by fixing two parameters β *.The third plan will be that to which belongs the corresponding curved guideline of the twist, for example the plan x=0 or the plan x=l=5. So, we shall have:*

$$M(\beta = 0) = 10y = 0,$$
$$M(\beta = 0.5) = -0.15625x + 10y - 2.5z + 0.9375 = 0,$$
$$x = 0,$$

$$A(x, y, z) = A(0\ ;\ 0\ ;\ 0.375),$$

$$M(\beta = 0) = 10y = 0,$$
$$M(\beta = 0.5) = -0.15625x + 10y - 2.5z + 0.9375 = 0,$$
$$x = 5,$$

$$A'(x, y, z) = A'(5\ ;\ 0\ ;\ 0.062),$$

$$M(\beta = 0.5) = -0.15625x + 10y - 2.5z + 0.9375 = 0,$$
$$M(\beta = 1) = -x + 10y - 20z + 15 = 0,$$
$$x = 0,$$

$$B(x, y, z) = B(0\ ;\ 0.107\ ;\ 0.8)$$

$$M(\beta = 0.5) = -0.15625x + 10y - 2.5z + 0.9375 = 0,$$
$$M(\beta = 1) = -x + 10y - 20z + 15 = 0,$$
$$x = 5,$$

$$B'(x, y, z) = B'(5\ ;\ 0.12\ ;\ 0.56)$$

$$M(\beta = 1) = x + 10y - 20z + 15 = 0,$$
$$M(\beta = 1.5) = 7.59x + 10y - 67.5z + 75.94 = 0,$$
$$x = 0$$

$$C(x, y, z) = C(0\ ;\ 1.04\ ;\ 1.28)$$

$$M(\beta = 1) = 0;\ M(\beta = 1.5) = 0;\ x = 5,\quad C'(5;3.32;\ 2.18).$$

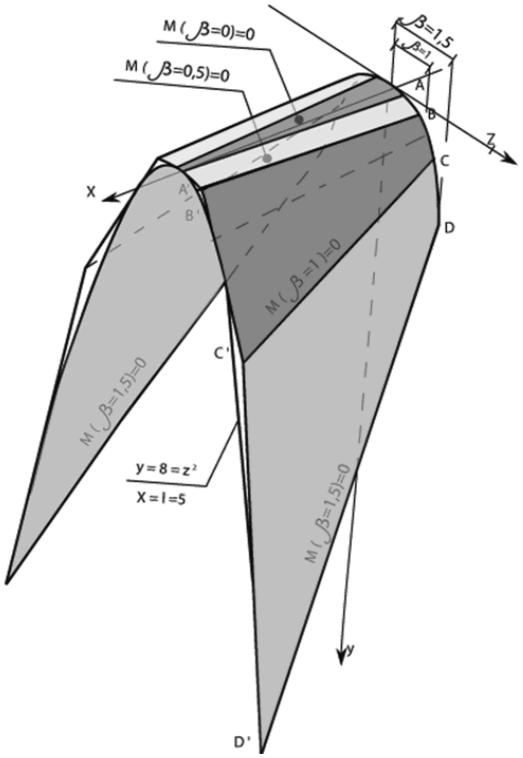

Figure 2. Folded surface obtained from the developable surface

In figure 2 one shows obtained folded surface. The side DD′ is formed by the right generatrix of the twist when $\beta = 1.5,\ \gamma = \beta^3 = 3.375,$ *thus coordinates*

of the point D′ will be $D'(5;\ 11.39;\ 3.375)$ *and those of the point D will be* $D(0;\ 2.53;\ 1.5)$.

Having determined the coordinates of the angular points of folded surface,it is easy to calculate the linear and angular values necessary to construction of developed folded surface (figure 3).

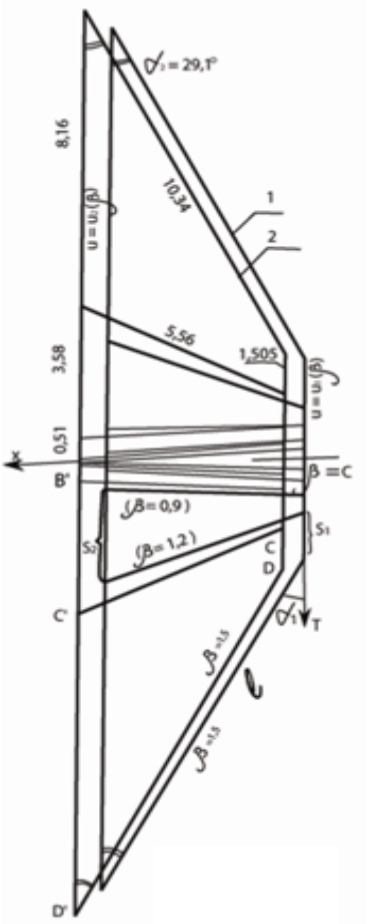

Figure 3. Developed folded surface. 1-Developed of the twist; 2-Developed of the folded surface

ALGORITH OF CONSTRUCTION OF DEVELOPED TWIST

Let us build considered developed twist by the method suggested in [11]. Knowing that the vectorial equation of a twisted surface is written in the following form:

$$\vec{r}(u,\beta) = x\vec{i} + y\vec{j} + z\vec{k} + u\frac{x'\vec{i} + y'\vec{j} + z'\vec{k}}{\sqrt{x'^2 + y'^2 + z'^2}},$$

with $x = x(\beta), y = y\beta), z = z(\beta)$ *- parametric equation of the cuspidal edge (4) and u,* β*-curvilinear coordinates of the twist,* $|u|$*-the distance between the cuspidal edge and any point parallel to taken the tangent with the cuspidal edge, we obtain the equations of the guideline parabolas:*

$$u_1 = \frac{1}{b-6a\beta^2}\sqrt{b^2l^2 + (ab\beta^4 - 4a^2\beta^6)^2 + (b\beta - 2a\beta^3)^2},$$

$$u_2 = \frac{1}{b-6a\beta^2}\sqrt{36a^2l^2\beta^4 + (6a^2\beta^6 - \frac{24a^3}{b}\beta^3)^2 + (6a\beta^3 - \frac{12a^2\beta^3}{b})^2}$$

where $u_1 = u_1(\beta)$ *- equation of the parabola of order n=4,* $u_2 = u_2(\beta)$ *- equation of the parabola of order m=2.*

The length of the right generatrix between the guideline parabolas is determined by the following formula:

$$t = u_2 - u_1.$$

The angle formed by the parabola and the right generator can be calculated by the following formula:

$$\cos\alpha_i = \frac{F + u_i'}{\left[u_i'^2 + 2Fu_i' + B_i^2\right]^{1/2}} \text{ with i=1;2.}$$

The lengths of the extreme curves between the corresponding right generators are determined by the formula:

$$S_i = \int_{\beta_1}^{\beta_2}\sqrt{u_i'^2 + 2Fu_i' + B_i^2}\,d\beta, \text{ with i= 1 ; 2.}$$

In the two last formulas expressions $F = \bar{r}_u\bar{r}_\beta$, $B^2 = \bar{r}_\beta\bar{r}_\beta$ *[11] are the coefficients of the first quadratic form of a surface. The subscripts of B indicate that these coefficients must be taken with* $u = u_i$ *(I=1 ; 2).*

Let us build developed twisted surface for which the mono parametric equation of the family of the plans is obtained in the form (8)). The values of t, a_i, S_i *will be given in the interval* $0\le\beta\le1.5$ *with spacing* $\Delta\beta=0.3$. *It is easy to execute these calculations on computer. The results of calculations are reported to table 1.*

Developed twisted surface is shown in figure 3.One can notice that for the determination lengths of the extreme curves between the corresponding right generatrixes, one uses the following formula of analytical geometry [13]:

$$S = \int_z^{z+\Delta z}\sqrt{1 + (\frac{dy}{dz})^2}dz,$$

For our case where n=4, m=2 (see formula (4)), it takes the form:

$$S_1 = \int_z^{z_1+\Delta z_1}\sqrt{1 + 16a^2z^6}\,dz, \quad z_1 = \beta, (n=4)$$

$$S_2 = \frac{z}{2}\sqrt{1 + 4b^2z^2} + \frac{1}{8b^2}\ln\left|z + \frac{1}{2b}\sqrt{1 + 4b^2z^2}\right|_{z_2}^{z_2+\Delta z_2} \text{ (m=2).}$$

Table 1. Results of calculation of the lengths of the extreme curves

β	$\gamma=\beta^3$	t	α_1	α_2	S_1	S_2
0	0	5.0	90°	90°	0.3000	0.0203
0.3	0.027	5.01	-86.88°	-86.88°	0.3077	0.1498
0.6	0.216	5.01	-86.95°	-86.95°	0.4046	0.6207
0.9	0.729	5.01	89.19°	89.19°	0.7726	2.5618
1.2	1.728	5.39	68.01°	68.01°	1.5253	8.4883
1.5	3.375	10.34	29.10°	29.10°		

The results obtained show that the method of approximation proposed as part of this work can be used to get a complete and relevant solution with a time of calculation on computer, by far much lower than the finite element method. Developable composite membranes' modeling is a complicated problem and sometimes inextricable therefore that it does not impose on the surface to be of certain regularity. So, the possibility of the replacement of a developable composite surface by a folded surface lets you extend the fields of application of these membranes because with the increase in the number of edges (boundaries), one could get a folded structure identical to the expandable membrane of reference. This offers new perspectives to the design of a new variety of folded composite structures.

The theory concerning working of the composite structures with developable form was the subject of a number of studies for example in [14]. In a general way, concerning the composites, for the production of developable forms one often uses thermo-hardening resins whose reinforcements are presented in the form of continuous chechmates i.e. distributed tablecloths in a one-way way. Indeed, the composite membrane object of our study is reinforced resin polyester with one-way fiberglass bus today, only the macroscopic approaches make it possible to simulate working of the composite membranes of this class. The lower scale models make it possible as for them studied the behavior of a reinforcement starting from the assembly of its elementary components. However, the macroscopic scale considers the reinforcement as a continuous material whose behavior is closely related to its internal structure but this one does not appear in an explicit way in modeling. The majority of the digital simulations on this scale use a continue approach [15, 16].

CONCLUSIONS

In this work we can retain the following:

- *It's proceeded to the study of developable composite membrane with parabolic guidelines as two plan parables of order m and n: $x=0$, $y=az^n$ and $x=l$, $y=bz^m$. This developable membrane, it is established the mono parametric equation of family plans and the equation of the cuspidal edge. The cuspidal edge of the developable surface with parabolic guidelines of order $n=4$, $m=2$ presents a singular point ($x=l$, $y=z=0$).*

When $z=\sqrt{\frac{b}{6a}}$, *it has a break from the cuspidal edge.*

- *It is built the developed of the folded membrane tangent to the developable membrane following four straight generatrixes (figure 2; figure 3).*

A method for the construction of the developed of the twisted membrane is developed. Through this approach, we see that with the increase in the number of edges of the folded surface, the dimensions of its developed approximately are very close to those of the corresponding developable membrane. This offers a considerable interest of practical application for the formatting of folded composite membranes.

REFERENCES

[1.] *Chu, C. and J.T. Chen, 2007. Characterizing degrees of freedom for geometric design of developable composite Bezier surfaces. Rob. and Computer-Integr. Manuf., 23:116-125*

[2.] *Glaser, G. and F. Gruber, 2007. Developable surfaces in contemporary architecture. J. Math. and the Arts, 01:59-71*

[3.] *Hivet, G., P. Boisse, 2005. Consistent 3D geometrical model of fabric elementary cell. Application to a meshing preprocessor for 3D finite element analysis. Finite Element in Analysis and Design, 42(1):25-4*

[4.] *Sullivan, J.M., 2008. Curvatures of smooth and discrete surfaces. Springer, Discrete Differential Geometry, 38 :175-188*

[5.] *Wang, C. and Tang K., 2004. Achieving develop ability of polygonal surface by minimum deformation: a study of global and local optimization approaches. The visual computer. Int. J. Comp. Graph., 20:521-539*

[6.] Yamauchi, H., S. Gumhold, R. Zayer and H.P. Seidel, 2005. Mesh segmentation driven by Gaussian curvature. Visual Computer, 21:649-658
[7.] Pottmann and J.Wallner, 2001. Computational line Geometry, Springer, ISBN 3-540-42058-4, pp.565
[8.] Wang, C. and Tang K., 2005. Developable triangulations of strip. Computer-Aid Design & App., 2:233-242
[9.] Liu, Y., H. Pottmann, J. Wallner, Y.L. Yang and W. Wang, 2006.Geometric modeling with conical meshes and developable surfaces. ACM Trans. Graph., 25:681-689
[10.] Krivoshapko,S.N., 1982. Construction, calculation and application of the developed membranes in the thin-walled structures. Calculation of the thin walled structures, Edns. Russian Friendship University, pp. 54-66 (in Russian)
[11.] Krivoshapko, S.N., 1983.The application of developable surfaces in shipbuilding. Shipbuilding, 7:5-7 (in Russian)
[12.] Krivoshapko, S.N., A.G. Shtykov and V.P. Shabanov, 1982. Replacement of the twisted membranes by plane elements. Bul. Mil. Eng., 2 : 18-21 (in Russian)
[13.] Badjoria, G.C., 1984. On a method of construction of the developed of a twisted surface. Shipbuilding, 9: 37-38 (in Russian)
[14.] Cheruet, A., 2001. Analyse et simulation de la mise en forme de composites thermodurcissables. Thèse de doctorat Université d'Orléans
[15.] Peng, X.Q., J. Cao, 2005.A continuum mechanics-based non orthogonal constitutive model for woven composite fabrics. Composites Part A, 36(6):859-874
[16.] Thije Ten, R.H.W., R. Akkerman and J. Huétink, 2007. Large deformation simulation of anisotropic material using an update Lagrangian finite element method, Computer Method in Applied Mechanics and Engineering, 196(33-34):3141-3150

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THE ARSENIC ACCUMULATING CAPACITY OF LETTUCE GROWING IN AGGREGATE HYDROPONICS UNDER THE INFLUENCE OF ARSENIC POLLUTED NUTRIENT SOLUTION

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Abstract: The arsenic polluted sprinkling water might appear in the southern regions of Hungary. Arsenic levels sometimes exceed the 200 µg/l limit, allowed in underground water in Hungary. In the teamwork of Soil and Plant Testing Laboratory and the Institute of Vegetable Growing (Kecskemét College, Faculty of Horticulture) we studied some of the effects of sprinkling water containing arsenic pollution on different vegetables since 2006. In this work, lettuce in hydro-culture was used as an indicator plant. The aim of our examination was to clear up the effect of arsenic on the degree of arsenic accumulation. We used 25, 50, 75, 100, 200, 400 and 600 µg/l arsenic pollution doses.
Keywords: arsenic pollution, lettuce, greenhouse, hydro-culture, hidroponically, ICP-AES

INTRODUCTION

Arsenic is a well known toxic element can be found in some waters and foods. High arsenic levels contribute to the development of serious disorders. According to laws in Hungary, drinking water may contain 10 µg/l arsenic [1], whereas our food is able to have 200 µg/kg maximal arsenic concentration [2].

Arsenic polluted drinking and sprinkling water appears at the southern parts of the country, in counties Bács-Kiskun, Békés, Csongrád and Szolnok. In these areas plants can accumulate arsenic easily and in high quantity. Based on the teamwork of faculty, we studied the effects of nutrient solution containing arsenic pollution on the growing of lettuce in hydro-culture.

Arsenic (As) is a well known toxic element found in Hungarian well waters due to natural geological conditions (3). The underground waters in the southern and south-eastern parts of the Great Plain are polluted with 30-150 µg/l arsenic concentration [4].

Due to these measures the impact of polluted water on the population can be reduced, but it must not be forgotten, that in the southern and south-eastern parts of the country fresh vegetables irrigated with arsenic water can threaten the consumers directly.

It is clearly known from geological research [4], that the southern and south-eastern parts of the Great Plain contain high arsenic water concentration. This area represents 80% of the irrigated vegetables territory.

The inorganic forms of arsenic are dangerous poisons noxious to the whole human body, reducing the activity of the nervous system, kidneys, respiratory organs and the liver, also resulting in reproductive and genetically anomalies and cancer [5].

Trial series were started in cooperation between the Ornamental Plant and Vegetable Crops Institute and Soil and Plant Analysis Laboratory of the College for Horticulture (Hungary, Kecskemét) to determine the concentration of this toxic element in some important vegetables irrigated with polluted water. Leaf-vegetables, pepper, tomato, carrot and parsley have been tested from 2006 onwards followed by hydropone lettuce in 2009 and 2010. Lettuce is grown on about 2000 ha, half in the open and half in forcing. The water used for irrigation or for nutrient solutions is obtained from wells, 30-100 m deep [6].

Trial series aimed at finding out the effect of arsenic water characteristic of the region on the arsenic content of lettuce leaves grown in hydroculture when polluted water is used for the

nutrient solution. Arsenic doses of 25, 50, 75, 100, 200, 400, 600 µg/l were tested. The first five doses represent concentrations found in nature, the extreme values (400-600 µg/l) served for scientific observations or modeled extreme conditions.

MATERIAL AND METHOD

Trials included lettuce in hydropone culture in the greenhouse of the Ornamental Plant and Vegetable Crops Institute. There were three tables each containing three nutrient channels made of plastic plates, 4.3 m long, 15 cm high and 30 cm large (Figure 1).

Figure 1. Hydroculture with nutrient channels

In each channel 25 l standard solution was circulated by a pump controlled by a time switch. An upper container (feeder) and a bottom container (collecting) facilitated the storage of the solution. The slight sloping of the channels furthered the solution flow. In the hydroculture roots developed in the solution and plants were fixed in a neutral agent, rock-wool, and cubes. Figure 2 shows the cross section of the nutrient channel.

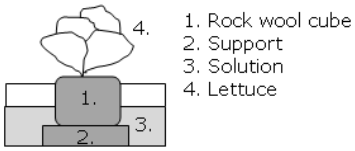

Figure 2. Cross section of the nutrient channel

The nutrient solution was prepared according to a recipe of the Ornamental Plants and Vegetable Crops Institute consisting of Ferticare IV fertilizer complex with 1.6-1.8 mS/cm EC-values and pH 5.5-6.5.

The arsenic solution used in the trials consisted of an arsenic stock solution and the nutrient solution describe above, in 250 mg/l concentration in the stock solution. The stock solution was prepared under laboratory conditions of the Soil and Plant Analysis Laboratory. Increasing doses of the stock solution (2.5; 5; 7.5; 10; 20; 40; 60 ml) were added to the containers (25 l).

The initial compound, arsenic acid (H_3AsO_4) was made of arsenic trioxide. Thus, after dilution arsenic was present in the solution in form of arsenate (H_2AsO_4-). In the naturally polluted waters of the concentrated regions the same ion forms are found.

The hydroculture started 1st September 2009 and 29th March 2010. Two-four leaf lettuce was pricked into rock-wool cubes. The growing period lasted 6 weeks in both years. The nutrient solution was changed once a week. When adding the fresh solution great care was taken of precise dosing.

Evaporation required the replacement of the solution even during the weeks; great care was taken to maintain the initial concentration. Samples were taken and checked by the Laboratory.

At the end of the trial period the lettuce heads were removed from rock-wool cubes and weighed. Random samples were taken on the whole length of each channel (total 17 heads), fully developed healthy leaves were taken from the middle of the heads in four repetitions.

Root samples were also collected by lifting the rock-wool cubes and disentangling the roots carefully.

Figure 3. Rock-wool cube lifted at the end of the trial

The solids content in leaves and roots were determined by drying (70^{0}C) and homogenizing samples in a mill in air dry stage.

Samples were digested in a microwave device by means of concentrated nitric acid and hydrogen peroxide using high pressure teflon bombs at 40-60 bar pressure, at 210^{0}C for 20 minutes. For dilution pure, ion-free water was used and samples were filtered through quantitative filter paper.

Element contents were evaluated in an ICP-AES spectrometer, with radial plasma set, 12 l/min argon flow, 1000 W generator output, at 193.695 nm wavelength, 1 ml/min samples flow. Detector: High Dynamic Detection System (HDD). Limit of quantification: 0.300 mg/kg arsenic referring to samples solids. For quality control all samples were run in duplicates with blanks and certified IPE plant (International Plant Analytical Exchange, Wageningen University). Results from the certified samples were within ± 10% of the known value.

RESULTS

According to classical analytical methods the arsenic content of samples was determined from the solids content. It must not be forgotten, however, that parts of vegetables (in lettuce the whole foliage) have very high water content. In our solids calculations the solids content of the samples varied between 3.05 and 5.82 m/m% with an average of 4.06 m/m%.

Relevant rules [2] allow 0.200 mg/kg arsenic in vegetables for fresh consumption at original water content. The value of arsenic concentration measured in lettuce solids should be divided by 25 to obtain the arsenic concentration of the plant at original water level.

The following two Figures represent arsenic concentrations in the two years and average of repetitions.

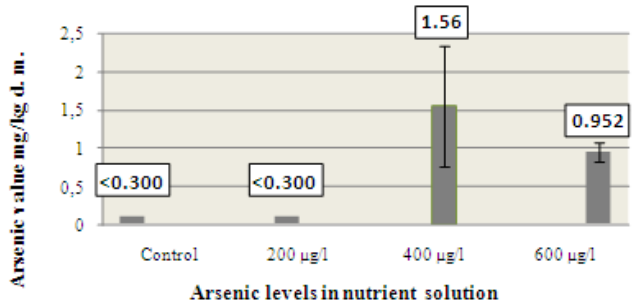

Figure 5. Arsenic levels in leaves referring to solids mg/kg (2009)

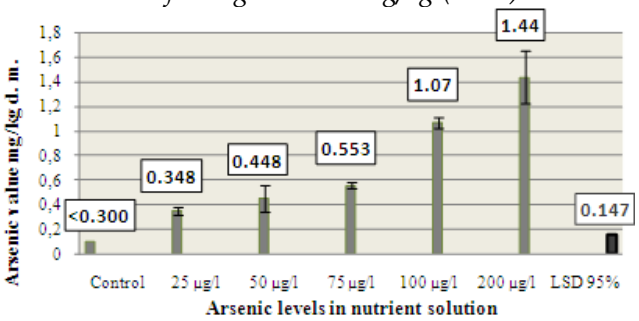

Figure. 6. As levels in leaves referring to solids, mg/kg (2010)

As shown by Figure 5 the 200 µg/l dose in 2009 did not result in measureable As-content in lettuce leaves. Doses 400 and 600 µg/l increased As-content in leaves referring to control and the 200 µg/l dose. Scattering among repetitions is high. The highest As value – 2.67 mg/kg - was found in the third repetition of the 400 µg/l dose. Repetition averages in 400 and 600 µg/l doses were contradictory as the mean of the 400 µg/l dose surpassed that of the 600 µg/l dose (1.56 and 0.952 mg/kg, respectively).

According to valid food decrees [2] the As content of vegetables with original water content can, at most, be as high as 0.200 mg/kg. Due to causes mentioned above the arsenic values of solids are to be divided by 25 to obtain the arsenic concentration of a sample with the original water content. When the measured highest value, 2.67 mg/kg was divided by 25 we got the value 0.107 mg/kg which was nearly 50% lower than 0.200 mg/kg. That is, even the highest applied doses did not surpass the limit.

Figure 6 shows our results in 2010. Repetitions showed much less scattering than in 2009. Trials in 2010 indicated a more precise execution of trials. Between the same doses of the two years (200µg/l) there was considerable difference despite similar conditions. To clear up the situation trial is going to continue in 2011 involving all the doses.

In 2010 increasing doses increased arsenic concentration in the leaves. Variance analysis [7] showed significant As content increase when applying 100 and 200 µg/l doses referring to control and doses below 100 µg/l. They also differed significantly from each other LSD 95% (Figure 6).

The highest value was measured in the first repetition of the 200 µg/l dose (1.62 mg/kg). When it was calculated back to the original samples the value of 0.1 mg/kg did not reach half of the limit.

Similar trends were observed in the increase of As content in roots in both years. Figure 7 and Figure 8 represent As values in root samples.

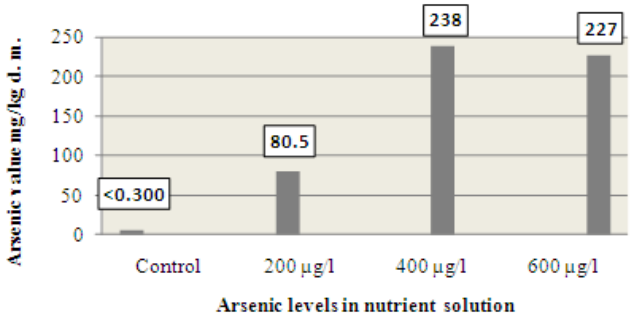

Figure 7. As levels in roots referring to solids (2009)

Increasing As doses increased As concentration in the roots, the low quantities of root samples did not allow repetitions and statistical analysis, yet the physiological filtration effect of the roots is well expressed.

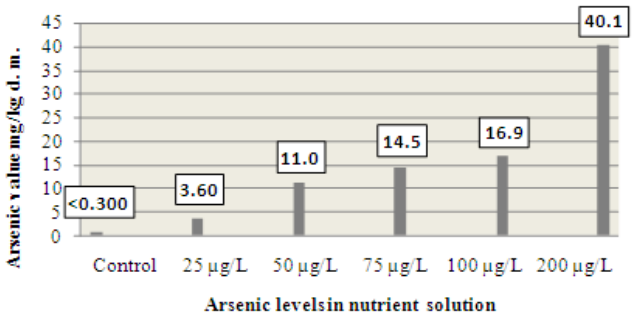

Figure 8. As levels in roots referring to solids (2010)

The ratio of As concentration between roots and foliage as affected by increasing doses was: 10.3; 24.6; 26.2; 15.8; 27.8; 152.6; 238.4. The widening As ratio may indicate the important accumulation function of the roots as affected by high doses of toxic elements. The As content in roots increased more rigidly than in leaves.

The accumulation rate in roots is also expressed by the As concentration in root solids which was 100-600 times higher than in the nutrient solution.

CONCLUSIONS

Trials show that the arsenic concentration of the nutrient solution affects the As content in the vegetative parts of lettuce. Even slight doses (200µg/l) increased As level in the test plant.

According to [8] As poisoning symptoms in plants are as follow: Reddish-brown, necrotic spots on older leaves, brown discoloration on roots, developmental anomalies in the whole plant. In our trials no such symptoms could be observed. They might have been caused by higher doses than those applied by us.

[9] stated that in nutrient solutions As belonged to the moderately toxic elements, hindering plant development between 1 and 100 mg/l concentration. The As doses applied in our trials increased As concentration in lettuce leaves significantly from 75 µg/l upwards. The highest As concentration, 2.67 mg/kg in the leaf solids was caused by the 400 µg/l dose.

Increasing As doses increased As concentration in the roots as well but the accumulation was more accentuated. In some doses As content in roots was 10-238 times higher than in leaves. Results are parallel to those of [10] who found 30 mg/kg in roots and 1-5 mg/kg in stems and leaves of the test plants, as affected by As doses.

[11] proved in different phytoremediation trials that when comparing plant parts the highest As concentration was found in the roots both in soil and soilless cultures. They also found values between 200-600 mg/kg As in roots of test plants. Our trials confirmed the importance of roots in filtering toxic elements.

[12] also studied lettuce in hydroculture adding 2 mg/l arsenic concentration to the nutrient solution. They found 278 µg/kg As in the roots and 3.18 mg/kg in the leaves of the test plant which agrees with our results.

Summarizing it can be stated that the arsenic content of lettuce of original water content, grown in hydroculture, increases as affected by As application but it does not surpass the 0.2 mg/kg limit. According to our results even three times higher values than 200 µg/l found in natural well water do not increase the As level above the limit in lettuce.

REFERENCES

[1.] 201/2001. (X. 25.) Korm. rendelet az ivóvíz minőségi követelményeiről és az ellenőrzés rendjéről.
[2.] 17/1999. (VI. 16.) EüM rendelet az élelmiszerek vegyi szennyezettségének megengedhető mértékéről.
[3.] Fügedi, U., Szurkos, G., and Vermes, J., 2004. Éghajlatváltozások geokémiai hatásai Magyarország középső és keleti részén. In A Magyar Állami Földtani Intézet Évi Jelentése. Budapest, Hungary.
[4.] Bartha, A. 2004. Geokémia és geoanalitika: Ritkaelemek, víz és környezetgeokémia. In Magyar Állami Földtani Intézet. Budapest, Hungary.
[5.] Fergusson, J. E. 1991. The Heavy Elements: Chemistry, Environmental Impact and Health Effects. Pergamon Press. Oxford–New York–Seoul–Tokyo.
[6.] Balázs, S. 1994. Zöldségtermesztők kézikönyve. Budapest, Hungary: Széchenyi Press.
[7.] Sváb, J. 1973. Biometriai módszerek a kutatásban. Budapest, Hungary: Mezőgazdasági Press.
[8.] Kabata-Pendias, A., and Pendias, H. 1984. Trace elements in soil and plants. Florida, USA: CRC Press.
[9.] Bowen, H. J. M. 1966. Trace elements in biochemistry. New York, USA: Academic Press.
[10.] Kádár, I. 1993. Talajaink mikroelem ellátottságának környezeti összefüggései. In MTA Agrártudományi Osztály Tájékoztatója. Budapest, Hungary: Academic Press. 102-106.
[11.] Rofkar, J., Dwyer, D., and Frantz, J. 2007. Analysis of Arsenic Uptake by Plant Species Selected for Growth in Northwest Ohio by ICP-OES. Communications in Soil Science and Plant Analysis. 38: 2505-2517.
[12.] Smith, E., Juhasz, A. L., and Weber, J. 2008. Arsenic uptake and speciation in vegetables grown under greenhouse conditions. Environmental Geochemistry and Health 31, Supplement 1, 125-132.

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ANALYZING THE PERFORMANCE OF COLLAR AND SLOT IN REDUCTION OF SCOURING THE BRIDGE PIERS WITH SOFTWARE SSIIM

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Abstract: *Erosion and transporting the separated bed materials by flow is called scouring. One of the main reasons for destruction of bridges, especially in flood events, is the local scouring around the bridge piers. Depth of local scouring around the bridge piers plays an important role to design the bridges against this destructive phenomenon. Therefore, the methods of controlling and reducing this phenomenon are important. Collar and slot can be modeled by SSIIM while it is the three–dimensional software regarding time, as well as the scouring depth and its reduction can be evaluated. Finally, collar and slot have been tangible impact to reduce the scouring depth and there is no notable difference between the results of numerical modeling and the experimental model.*
Keywords: *Scouring depth, Collar, Slot, Software SSIIM*

INTRODUCTION

Flow in open channels and ducts with moving bed cause the sediment transport. Scouring is usually occurs by changes of the flow characteristics in channel or by the human activities and actions on the river system. Activities such as building structures in the channel s or removal of materials from the riverbed are defined the scouring as the riverbed sediment erosion around an obstacle in the flow field. Bridges, as key roads, are the most important and busiest river structures. Every year, many of these bridges are destroyed because of flood occurrence in the river, just when they are most needed (Tahmasby, 2009). In most cases, breaking the bridges is often occurs in condition of flood flow due to the erosion of bed materials around the pier and foundation of bridges. Erosion mechanism has sufficient potential to threaten the integrity of the hydraulic structures and bridges in which it is caused to full breakage of structures after the foundation of structures and substructures are destroyed completely.

Because of expanding the erosion pit threatens the stability of bridge structure, predicting the sunken size and adopting the necessary measures to suppress it are considered the common engineering practices in the field of river engineering, so the scientists of hydraulic and river engineering focus on it specially. Regular and smooth flow of the river is changed after hitting the bridge pier and it is created due to the diversion of flow lines and formation of boundary layer in high pressure region in the upstream pier and low pressure region in the downstream pier. This intensifies the pressure gradient and creates a kind of secondary flow around the bridge pier that is known so–called horseshoe vortex.

The phenomenon results of speed distribution and its reduction around the bed in smooth flow of upstream in which in turn leads to an imbalance in the dynamic pressure. Horseshoe vortex is another important part of flow field around the bridge pier. The torsional power flow is a three–dimensional in which the downstream flow as well as the eddy fields on the main flow (upstream smooth flow) is effective to form it.

In the figure 1, the flow field around the bridge pier is formed of three distinct regions. The upper part of flow is diverted to the down after hitting the bridge frontal and formed a downstream flow region.

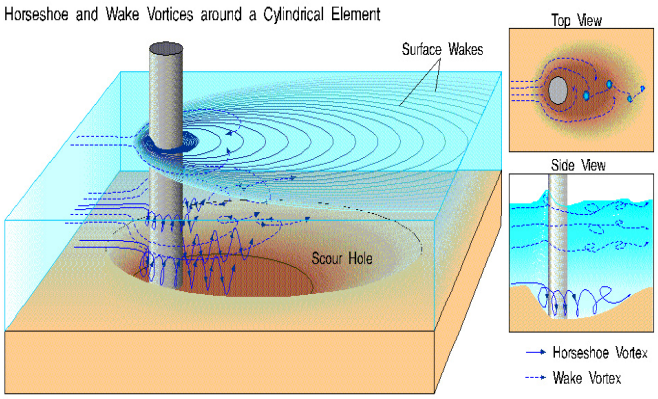

Figure 1 – Three–dimensional model of flow around the bridge pier

Flow pattern and scouring mechanism around a bridge pier and anchor is a complex phenomenon that is result of a power reaction between the three–dimensional turbulent flow around the bridge pier and the floor can be erosion. Local scouring around the bridge piers is caused by under flow and horseshoe vortex.

Radkivy Vatma (2004) has described some parameters affecting the scouring such as flow rate, flow depth, width or diameter of the pier, gravity velocity, the length of pier if the pier has an angle basis of the flow, the size of bed particle grading, flow angle to the pier, the pier shape and the effect of floating materials (ices and trashes (Alabi, 2006).

Shafai Bajestani (2005) was classified the stated parameters in four groups as follows:

1. *Hydraulic parameters: intensity and flow depth, shear velocity, mean velocity, and roughness coefficient.*
2. *Geometric parameters: the size of pier, the shape of pier, the axis angle of bridge with the flow direction, the distance of piers.*
3. *Sediment parameters: grading distribution, sediment density, particles' shape, stagnation angle of particles.*
4. *Fluid parameters: the mass per unit volume, gravity velocity, kinematic viscosity.*

Kochakzadeh et al (2002), using the available data, have examined the feasibility of using artificial neural networks to estimate the scouring depth. The results shown that there was good agreement between the network and measurements and it was even better than the linear multivariable regression. Also sensitivity analysis on the parameters affecting the phenomenon showed that the geometric standard deviation of bed particles has the greatest impact on the results and other influential factors, such as flow speed, average diameter of particles, pier diameter and the flow depth were studied in next times.

Oronghi et al (2009), using a rectangular collar at the cylinder pier, observed that the collar decreases the speed of scouring and depth of scouring hole around the bridge pier, and the collar's dimensions have an important role to decrease the scouring around the bridge pier. Collar length in upstream and downstream of the bridge pier model and the collar width has studied too. The proper values of rectangle collar length in upstream and downstream that were measured than the foundation of bridge pier model, were determined 0.92 and 1.42 by the pier diameter, respectively. Since, the proper width of collar was estimated 3 times than the bridge pier; so after 62 hours, the little scouring was observed around the bridge pier.

Oronghi et al (2008) have studied the temporal variation of scouring depth around the bridge pier in the conditions of clear water scouring. Experiments showed that more than 80% of the scouring depth was done in the first hours and then the rate of scouring is decreased sharply. There is a definition for the time of equilibrium of scouring depth, and then it was compared with the proposed definitions by researchers.

The results showed that the definitions of researchers are often express less time for the equilibrium of scouring depth. The equilibrium scouring depth was extracted in different states and compared with the proposed relations of researchers along with a good agreement. There was an experimental correlation for the temporal variation of scouring depth and also comparing the relation with the available correlations showed the acceptable results.

Radkivy Vatma (2004) has described the parameters such as flow rate, flow depth, width or diameter of the pier, gravity velocity, the length of pier (if the pier has an angle basis of the flow), the size of bed particle grading, flow angle to the pier, the pier shape and the effect of floating materials (ices and trashes on the flow.

Tayeb Zadeh et al (2005) have used the SSIIM numerical model to measure the equilibrium

scouring depth around the bridge piers with circular cross.Their research results indicated the high accuracy of the model by calculating the scouring depth in the conditions of permanent flow.

Esmaeili et al (2009) have simulated the depth of scouring hole during the various hydrographs around the cylindrical piers by SSIIM numerical model. The results of numerical model were compared with available experimental data. However, the numerical results are in very good condition in the Ascending branch of the hydrographs but the accuracy of numerical results in the descending branch is dependent on the kind of hydrographs. This is while the major part of scouring occurs in the bridge pier in the ascending branch.

Sayyadi (2008) has provided the mathematical modeling of two–dimensional simulation to calculate the local scouring around the bridge piers. Navier – Stokes equation is used as an equation to simulate the velocity field. At first, Navier – Stokes equation was solved and then the velocity field was obtained. The velocities obtained in the horizontal plane, as input data to solve the sediment moving equation and the method of Galerkin residual weighted criterion, were used for sorting the Navier – Stokes equations. The studied scope was divided into eight group units and also the second–order functions were applied for velocities and linear pressure.

METHODS OF CONTROL AND DECREASE THE SCOURING

Researchers have provided several methods to prevent and decrease the scouring around the bridge piers in which the most important methods can be included the use of stile, submerged plates, protective candles, slot and collar.

In most studies, the methods of laboratory modeling and field observations have been used for the effect of using the collar and slot to control and decrease the scouring around the bridge pier. So the research is investigated the performance of collar and slot to decrease the scouring around the bridge pier using the numerical three–dimensional simulation. SSIIM three–dimensional software is used for modeling and analysis; and also the performance of simultaneous usage of collar and slot is investigated to decrease the scouring.

Using the Collar to Control the Scouring

Collars are the tools that are parallel to the river floor and be mounted perpendicular to the pier and they can prevent the downstream flow in the upstream cape of the pier as well as hinder the scouring pit. A collar that is mounted on the surface than a bed, divided the flow into two regions up and down. Top of the collar acts as a barrier against the downward flow and reduces the downward power by hitting the collar. At the bottom of the collar, downward power reduces by the horseshoe vortex (Chew, 1992).

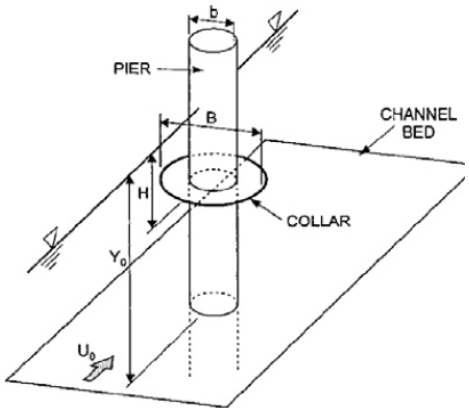

Figure 2 – Install the collar on pier

Using the Slot to Control the Scouring around Bridge Pier

Chiu (1992) at first uses the slot (hole into the pier) as one of the preventive methods and reducing the scouring. He stated that if the slot is close to the bed with a horizontal flow, the downward flow that is the main factor of horseshoe vortex and erosion around the pier would be diverted far away from the pier and reduces the scouring depth. The slot near the water surface reduces the effective depth of flow as well as the pressure gradient, thus it also reduces the downward flow and the scouring depth.

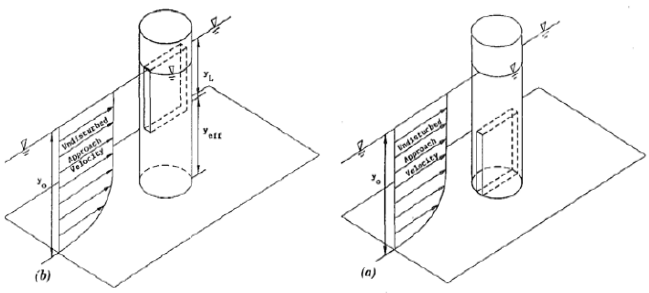

Figure 3 – (a) slot near the bed, (b) slot near the water surface (Chiu, 1992)

MATERIALS AND METHODS

The large number of parameters influencing the scouring effect can increase its complexity. Thus, a numerical model is needed that the use of discrete equations governing the flow field and sediment equations and applying some simplifying assumptions, has changed the complex relationships in this phenomenon into the solvable and simple equations. SSIIM three–dimensional numerical code can satisfy most of the requirements in various fields such as hydraulic scouring around the bridge piers.

Three–dimensional flow pattern and scouring under clear water conditions around a pile group were simulated using the SSIIM numerical model. Numerical model can solve the three–dimensional Navier – Stokes equations for the flow along with k–ε turbulence model.

Shear stress in the bed was used to calculate the near–bed sediment concentration and to solve the equation of transport – distribution of sediments. There are changes in the bed by solving the continuity equation for cells near the bed. By considering the state of convection flow and simultaneous solving the flow and sediment calculations, we can model the scouring around the pile group. Modeling is done for both fixed and moving state around the pile group. In the first case, the flow pattern clearly showed the dominant mechanisms on the scouring around the pile group. In the latter, the changes of bed, scouring and maximum depth of scouring can be modeled and the results were compared with experimental values. There was a good agreement between the shape and depth of scouring by the numerical model with the laboratory results. (Beheshti and Ataee Ashtiani, 2008).

Sayyadi (2008) has provided the two–dimensional mathematical simulation to calculate the local scouring around the bridge pier. Navier – Stokes equation was used as an equation that simulated the velocity field. At first, Navier – Stokes equation is solved and the velocity field is also obtained. Then the velocities obtained in the horizontal plane were used as input data to solve the sediment transport equation and the method of Galerkin residual weighted criterion for sorting the changes of Navier – Stokes equations. The studied scope was divided into eight group units and also the second–order functions were applied for velocities and linear pressure.

After solving the sediment transport equation with initial and final concentrations, the scouring depth and similar responses were compared with the laboratory measured values based on simulations that obtained by solving the Laplace equation with the finite difference method. In practice, the results showed a good agreement with the measured values. Finally, the effect of various factors such as flow depth, riverbed slope, and mean particle size on the depth of scouring was investigated. Graphs for investigating the effect of various factors with the scouring depth on the flow depth and their compare with the results obtained by the above equation using the finite difference method and the determined values have shown a good agreement.

In most studies, the methods of laboratory modeling and field observations have been used for the effect of a collar and slot to control and decrease the scouring around the bridge pier, therefore, this study examines the performance of collar and slot to reduce the scouring of bridge pier using three–dimensional numerical simulation. SSIIM three–dimensional software is used for modeling and analyzing, also the performance of synchronous usage of collar and slot was investigated to decrease the scouring. In this study, the phenomenon of local scouring and its reduction by helping the collar and slot will be investigated using a computer model, and the combination of collar and slot is used to reduce the local scouring depth. This project shows that what a performance is by reducing or increasing the collar and for reduction of scouring.

In the present study, a series of relevant data was provided using the principles of hydraulic scouring around the bridge pier and the studies by other researchers in the field of use of collar and slot in scouring and then the synchronous performance of two methods will be analyzed using SSIIM three–dimensional model. The accuracy of model will be examined by analyzing the modeling results using the statistical indicators such as Correlation Coefficient, Sensitivity Coefficient, Root Mean Square Error and Absolute Error and then they analyzed the results by the graphical tests. The

statistical indicators used in the study include the correlation coefficient (R2):

$$R = \frac{\left(\sum_{i=1}^{n}(O_i - \overline{O})(P_i - \overline{P})\right)^2}{\left[\sum_{i=1}^{n}(O_i - \overline{O})\right]\left[\sum_{i=1}^{n}(P_i - \overline{P})\right]} \quad (1)$$

To calculate the root mean square error (RMSE), the following formula is used:

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(O_i - P_i)^2} \quad (2)$$

Also, to calculate the mean absolute percent error (MAPE), the following formula is used:

$$MAPRE = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{|O_i - P_i|}{O_i}\right)100 \quad (3)$$

where O(i) is the observed value and P(i) is the estimated value, $\overline{O}$ and $\overline{P}$ are the observed and estimated values, respectively, and n is the used data. RMSE indicator is a unit equal to the variable unit and also is a criterion to measure the output error values of model than the observed values. RMSE index represents the square errors, as a result it has more sensitive to the error distribution and the gross errors affect more on the indices and the optimal values of this index is equal zero. MAPE index represents the percentage relative error and mean relative error and its optimum value is zero.

RESEARCH MATHEMATICAL MODEL

In this study, SSIIM model will be used to simulate the flow field that is a three–dimensional model for simulating the flow field and sediment transport using the various turbulence models. Evaluation of model results will be done using the measured data.

In this section, three–dimensional equations of flow and sediment transport will be presented that they solve in a three–dimensional numerical model as well as their numerical solutions are presented. Three–dimensional mathematical model used in this study is SSIIM model. Preliminary version of the model has been prepared by Melaaen Olsen in the Norwegian Institute of Technology in 1990 – 91 and has been developed in different years (Olsen, 2010). Navier–Stokes equations and turbulence models can be solved using a non–orthogonal three–dimensional grid. The control volume method is used for discretization. SIMPLE method is applied for relation of velocity and pressure term. The velocity field is calculated using the method of implicit solving, and also the velocity components are used to solve transmission and distribution equations for different sizes of sediment. SSIIM is used both structured grid in SSIIM1 model and unstructured grid in SSIIM2 model to solve the equations that is formed by two infrastructures of numerical solution and graphical schema. The flow equations in the software are the Navier– Stokes averaged temporal equations called Reynolds equations (RANS). The whole form of this equation is a continuity equation and three momentum equations in three directions that they will be presented after introduction of governing assumptions the model.

Governing Equations and their Numerical Solution in Three–Dimensional Model

Due to the above assumptions, the governing equations used in a three–dimensional model are written as follows (Olsen, 2010):

Correlation:

$$\frac{\partial U_i}{\partial x_i} = 0 \qquad i = 1,2,3 \quad (4)$$

Momentum:

$$\frac{\partial U_i}{\partial t} + U_j\frac{\partial U_i}{\partial x_j} = \frac{1}{\rho}\frac{\partial}{\partial x_j}(-P\delta_{ij} - \rho\overline{u_i u_j}) \qquad i,j = 1,2,3 \quad (5)$$

In these equations, Ui is the temporal average of flow velocity in three directions, x coordinate position, t the time, P the pressure, δ Kronecker delta (Kronecker delta is 1 when i = j and otherwise zero), u velocity fluctuation than the time during a time frame Δt. The first term on the left momentum equation is a non–permanent term; the second term on the left is the convection term, the first term on the right is the pressure term and the second term on the right is the turbulence term that is capable to model using various turbulence models such as $\kappa - \varepsilon$ and $\kappa - \omega$. In the present numerical model, the method of solving equations based on the finite volume method is an implicit method and SIMPLC and SIMPLE methods are used for coupling the pressure and velocity fields. Convection terms can be modeled using the second order upstream difference methods or potential pattern, and Rhie and Chow pattern is used for interpolation. Reynolds turbulence stress term is

determined using the concept of eddy viscosity and Bosinski hypothesis.

Turbulence Modeling

Laminar flow can be simulated using the correlation and Navier – Stokes equations completely. But if the Reynolds number of flow is high so the flow becomes turbulent in which the velocity and pressure will constantly and randomly changed over time, and the velocity fluctuations will increase the stress on the fluid. In this case, the irregular and stochastic behavior of the flow causes a non–permanent and three–dimensional flow. Such flows can be analyzed by entering the temporal fluctuations of the turbulent flow profile into the Navier – Stokes and correlation equations in which in this case, in addition to the four unknown components of velocity and pressure, the other six unknowns called Reynolds stress are also enter the system of equations. The number of equations is less than the number of variables, and closing the system of equations and calculating the unknowns needed to additional equations for Reynolds stress. The additional equations are known as turbulence models. $\overline{u_i u_j}$ *term in momentum equation (Equation 3–4) shows the fluctuation of turbulent flow and transfers the turbulent momentum called Reynolds stresses, and additional equations needed for calculating the unknowns in which Bosinski hypothesis is used for the reason. In this theory, like Newton's Second Law, the turbulent stresses are assumed proportional to the velocity gradient (Olsen, 2010):*

$$-\overline{u_i u_j} = \nu_t\left(\frac{\partial U_j}{\partial x_i} + \frac{\partial U_i}{\partial x_j}\right) + \frac{2}{3}\kappa\delta_{ij} \qquad (6)$$

In this equation, the eddy viscosity ν_t *(x, y, z, t) is not constant property of fluid, but the function of time and position of flow field, it is necessary to determine* ν_t *distribution throughout the flow field in all calculations. Turbulence models are used to determine the eddy viscosity. Turbulence models are calculated the Reynolds stresses based on the concept of eddy viscosity (Bosinski hypothesis) or directly to calculate the Reynolds stresses. Turbulence models based on the eddy viscosity are divided into the zero–equation, one–equation and two–equation models. The most important models are presented below.*

Law of the Wall and Bed Form Roughness

The public law of the wall is used for strong velocity gradient adjacent to the boundaries in the numerical model as follows (Olsen, 2009):

$$\frac{u}{u_*} = \frac{1}{\kappa}\ln\left(\frac{30y}{k_s}\right) \qquad (7)$$

Where k_s *is the roughness of wall or bed and assumes a coefficient of particle size or bed form dimensions. Van Rijn relationship (1993) is used to determine the default dimensions of bed form in the model:*

$$k_s = 3.0d_{90} + 1.1\Delta\left(1.0 - e^{\left(\frac{-25\Delta}{7.3y}\right)}\right) \qquad (8)$$

$$\frac{\Delta}{y} = 0.11\left(\frac{d_{50}}{y}\right)^{0.3}\left(1 - e^{-0.5\left(\frac{\tau-\tau_{c,s}}{\tau_{c,s}}\right)}\right)\left(25 - \left(\frac{\tau-\tau_{c,s}}{\tau_{c,s}}\right)\right)$$

Δ *is the bed form height,* t_c*, s is the critical shear stress for s particle size.*

Three–Dimensional Sediment Transport Equations

Sediment transport is calculated as suspended load and bed load and separately in SSIIM numerical model and then the changes in bed level are simulated using the whole transmitted sediments, (Olsen, 2009).

Suspended Load Transport Equation

The suspended load is calculated using the three–dimensional equation numerical solution of transport – distribution (Olsen, 2010):

$$\frac{\partial c}{\partial t} + U_j\frac{\partial c}{\partial x_j} + w\frac{\partial c}{\partial z} = \frac{\partial}{\partial x_j}\left(\Gamma_t\frac{\partial c}{\partial x_j}\right) \qquad (9)$$

Where c is the concentration of suspended sediment; w the fall velocity; x_j *the coordinate position; z the vertical position;* U_j *the velocity of* x_j *direction and* Γt *the distribution coefficient that is called dispersion coefficient in the one–dimensional models. A transport phenomenon occurs by the effect of flow velocity and the diffusion phenomenon occurs also in the effect of density gradient and turbulent mixing. The boundary condition is needed for solving the equation that is done at the inlet boundary of a given concentration, and the symmetry boundary conditions (zero gradient) is used in downstream*

borders, outlet and sides, and the concentration of water surface equals to zero. There is two ways to introduce the bed boundary condition in diffusion–transport equation: one, a source term adds for the bed's cells in which the removal rate of sediments is determined according to it and the other, the Fan Rhine equilibrium concentration relation is used for the model. According to the Fan Rhine equilibrium relation, the following equation is satisfied in the volume controls adjacent to the bed (Ruther, 2006):

$$c_{b,suspendedload,i} = 0.015 \frac{d_i \left[\frac{\tau - \tau_{c,i}}{\tau_{c,i}} \right]^{1.5}}{a D_i^{0.3} \left[\frac{(\rho_s - \rho)g}{\rho v^2} \right]^{0.1}} \qquad (10)$$

In the equation, di is the sediment size, υ the fluid cinematic viscosity, ρ_s the specific weight of sediments, ρ the special density of water, $\tau_{c,i}$ the particle shear stress per sediment size based on Shields curve and τ the shear stress. a is the base height and equals to the roughness height. Sediment concentrations calculated from the above equation is used for volume control adjacent to the bed, and the concentration is calculated to solve the three–dimensional numerical equation (3–21) for the upper level of control volume.

Bed Load Calculations

In most methods for calculating the bed load, the flow is uniform and the flow depth is showed as one of the parameters. The secondary flow in three–dimensional flows is effective and due to the lack of credit in logarithmic distribution of velocity, most equations of bed load are not usable and the equations of bed load included the relevant parameters to the bed: sediment characteristics, shear stresses of bed and turbulence. However, Fan Rhine offered the equation of dimensionless bed load with Shields parameters and particle size. The calculation process of sediments in the field of three–dimensional numerical model is based on figure 1–3. The volume of white and shaded controls (two upper layers) represents the real computational field. The suspended sediment transport and bed load transport occur in the volume of white and shaded control respectively. The volume of shaded controls is divided into two sediment transport layers of active and passive, and then formed a virtual computational field together (Ruther, 2006).

The bed load transport occurs in the shaded area where cells are adjacent to the bed, in which the volume of bed load in the layer is calculated using the Fan Rhine equation in the three–dimensional model. In computational model of bed load, qb is calculated for each particle size using the Fan Rhine equation as follows (Ruther, 2006):

$$\frac{q_{b,i}}{d_i^{1.5}\sqrt{\frac{(\rho_s - \rho)g}{\rho}}} = 0.053 \frac{\left[\frac{\tau - \tau_{c,i}}{\tau_{c,i}} \right]^{2.1}}{d_i^{0.3} \left[\frac{(\rho_s - \rho)g}{\rho v^2} \right]^{0.1}} \qquad (11)$$

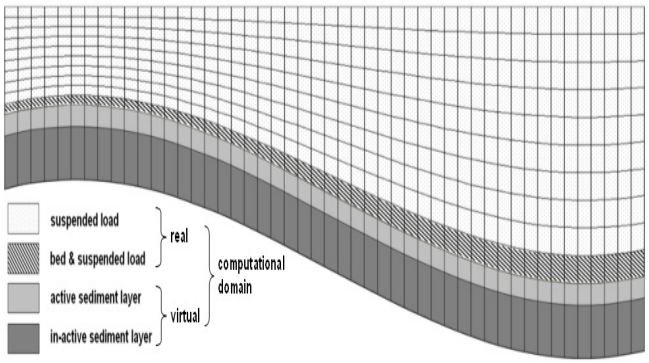

Figure 4 – Longitudinal view of computational field for sediments (Ruther, 2006)

The model is used the Fan Rhine equation to calculate the effective height of the bed form and roughness. The critical shear stress and shear stress are determined according to the Shields critical shear rate and shear rate respectively (Olsen, 2009):

$$\tau = u_*'^2, \qquad \tau_{c,i} = u_{c,i}^2 \qquad (12)$$

Once the model using the above equation can be calculated any size of bed load, it is converted to concentration using the following equation (Olsen, 2009):

$$c_{bed,bedload,i} = \frac{q_{b,i}}{a U_b} \qquad (13)$$

Where a is the base height and equals to the half of height in the first control volume, and U_b is the velocity in the first control volume adjacent to the bed.

Calculate the Shear Stress for Bed

Given the rate of bed cell, height of bed cell and roughness; the shear stress for bed is determined using the law of wall (Olsen, 2000):

$$\tau_{bed} = \rho U_*^2 = \frac{\kappa U_{bed}}{\ln(\frac{30\delta n}{k_s})} \qquad (14)$$

Where δ_n is the vertical distance between the wall and center of boundary cell, and k is the Carmen constant. If k_e turbulence model is used, assuming that the production and dissipation of turbulence is in equilibrium state near the wall, the amount of shear stress is determined due to the given κ in the first center of control volume adjacent to the bed as follows (Khosronejad, 2005; Olsen, 2000):

$$\tau_{bed} = \sqrt{c_\rho}\,\rho\kappa = 300\kappa \qquad (15)$$

Note that T_{bed} is special density of water and equals to 1000, Cp is a constant quals to 0/09 and k is the turbulent kinetic energy in the first center of cell adjacent to the bed where the turbulence model has been calculated, and the above equation can be obtained where the placement of values in the boundary conditions represents the turbulent kinetic energy in the first control volume adjacent to the bed (Khosronejad, 2005).

Calculate the Critical Shear Stress

The critical shear stress for sediment particle movement is determined basis on the Shields curve as follows (Olsen, 2000):

$$\begin{aligned} &For \quad R_* > 500 \quad \tau_{*c} \\ &For \quad R_* < 500 \quad \log(\tau_{*c}) = a\log R_* + b(\log R_*)^2 + c(\log R_*)^3 + d(\log R_*)^4 \\ &a = -0.9986612 \quad b = -0.9253986 \quad c = 0.5428363 \quad d = -0.0848406 \qquad (16) \\ &R_* = \frac{U_* d_s}{\nu} \quad \tau_* = \frac{\tau_c}{g(\rho_s - \rho_w)d_s} \end{aligned}$$

Experimental Data Set Used in the Study

The experimental channel has length 10 m, width 30 cm and height 50 cm. The Flow can be seen from the wall of glass channel while its floor made of metal. Maximum capacity for the supply source of a pump is 24 liters per second. The closed–circuit system of flow can provide a long opportunity to continue the experiments. The Flow control is done by a valve on the drift tube of pumping system. Flow rate was measured by an overflow edge.

Since the sediments have about 16 cm height in experimental range, the part of upstream and downstream of the experimental range due to the materials thickness was brought up about 16 cm using the Plexiglas plates. The floor aquarium glue was used for sealing plates mounted with the walls of channel and thus the floor height was brought up 16 cm in channel length. The height of the new channel in downstream reduces with a medium gradient to the outlet area and behind the control valve on lower level and then upper level of upstream and downstream regions was coarse by the used particles in the experimental range. In order to complete development, the flow of experimental range is considered with 5/1 m length at 5 m distance.

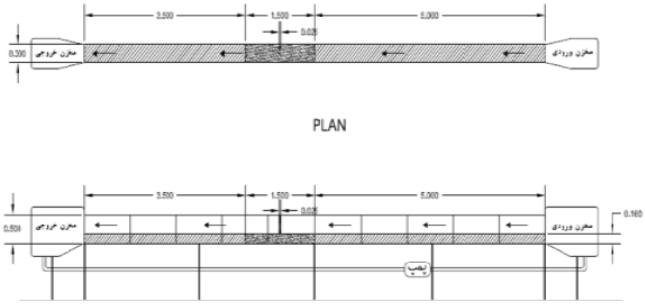

Figure 5 – Plan and view of the laboratory flume

ANALYSIS OF RESULTS

The first and most important step in preparing the input data required for SSIIIM model is the building of computational network. The size and direction of the computational cells have a significant effect on the accuracy of the model results and also the convergence and computational time for the model is built as a function of network characteristics. It is necessary that the computational network around and adjacent to the bridge pier should be finer than farther regions in order to achieve the desired accuracy and better results. Therefore, in this study, the upstream and downstream regions are simulated with coarse mesh to 5/3 m length and 2 m length, respectively. The region near the bridge pier (two sides of the bridge pier with 5/1 m length) is simulated using the finer mesh; also the region around the bridge pier with 5/1 m length and 16 cm in thickness where there are sediments is modeled with smaller mesh.

Mesh dimensions in upstream and downstream regions of the bridge pier are 10 cm in longitudinal direction and 1 cm in transverse direction. The finer mesh is used with 5 cm in longitudinal direction and 1 cm in transverse direction around the regions adjacent to the bridge pier, and the mesh dimensions is 5/2 × 5/0 cm around the bridge.

Finally, the computational mesh for total regions is obtained by connection the three computational meshes shown in previous figures together and along the downstream end of the flume that is obtained in the face.

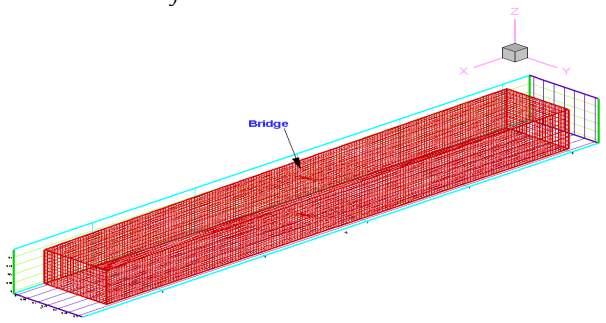

Figure 6 – The generated mesh around the bridge pier

Results of Scouring the Bridge Pier without Collar and Slot

This section is provided the results of scouring around the bridge pier and in the absence of collar and slot. The experimental range is considered with 1/5 m length far away 5 m from the top of the channel in order to complete the development for the flow.

The deposits fallen in experimental range was 16 cm in thickness. Therefore, the floor level of channel was brought up about 16 cm in the upstream and downstream regions. To avoid the wall effects on the rate of scouring as Chiu and Melville told, the maximum pier diameter should be 10% of the channel width, and according to a theory by Radkivy Vatma, the ratio of channel width to the pier diameter should be larger than 6/25. Thus, a Teflon plastic cylinder with 25 mm in diameter was used to model the pier.

To prevent the formation of bed form (Ripple), the average diameter of particles should be larger than 0/7 mm. Also, D/d_{50}> 20–25 needed to removal of the effect of the sediments on scouring depth. D is the pier diameter and d50 is an average particle size of sediment. Therefore, the deposits with d_{50} =0/8 mm is used. On the other hand, there is no effect on the scouring volume if the flow depth is larger 3/5 times than the pier diameter.

The topography of scouring hole created around the pier is shown that the scouring pattern is almost symmetric, and maximum scouring depth is equal to the obtained value in numerical model in which the value is 53 mm in laboratory model, and similar results is obtained with SSIIM model after calibration with the experimental data. Note that for calibrating the numerical model in study, the roughness coefficient and time pace are changed in deposit calculations and adjusted as there was the highest correlation between the results of numerical modeling and experimental modeling in which These values for the bridge pier without a collar and slot can obtained with the roughness coefficient 015296/0 and time pace 60 seconds

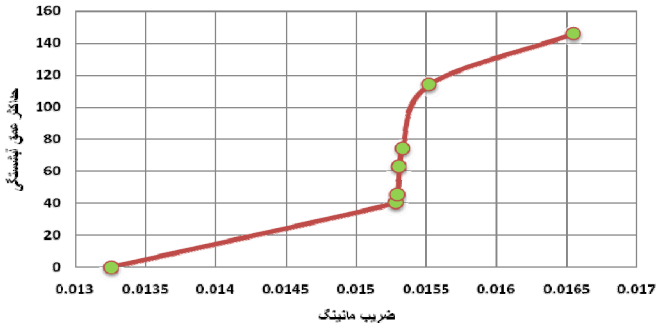

Figure 7 – Maximum changes for scouring depth around the bridge pier against the roughness coefficient in calibration stage of SSIIM model

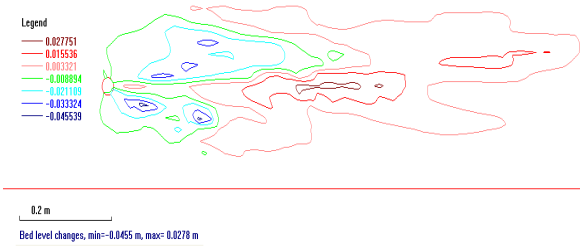

Figure 8 – Scouring around the bridge pier after seven hours in SSIIM calibrated model

Three–Dimensional Modeling for the Effect of Collar on Scouring the Bridge Pier

Geometry schema of channel, dimensions of pier, sediment characteristics and flow field is the same as previous state, and the square collar around the pier is just introduced in this part and the scouring is re–modeled. The square collar around the pier has 25/6 cm length as the results are presented in following figures. The collar is placed on the bed.

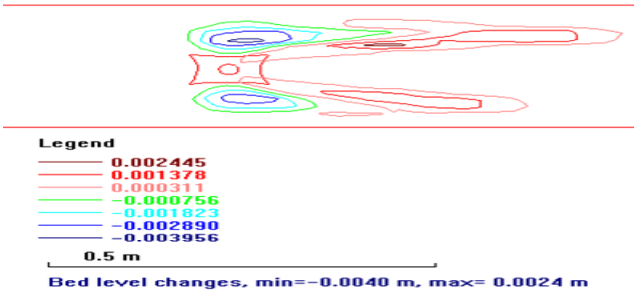

Figure 9 – Erosion of bridge pier after seven hours (Square collar 25/6 cm)

Three–Dimensional Modeling for the Effect of Slot on Scouring the Bridge Pier

A slot was added to the pier and its impact was simulated for reduction of the scouring around the pier using the three–dimensional numerical model. The slot is created with a width by a quarter in diameter of pier (25/ mm) and a length twice the diameter of pier (50 mm) on the model. Once the slot is the adjacent to the bed, and once is near the water surface, and its effect on the pier scouring is investigated too.

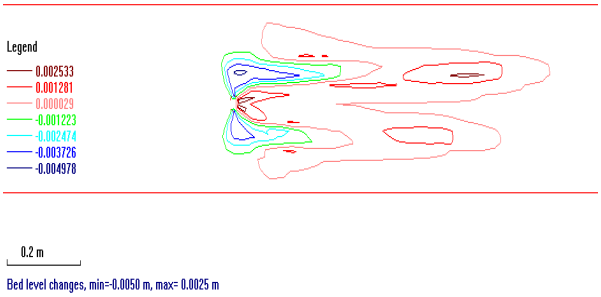

Figure 10 – Erosion of bridge pier after seven hours (slot adjacent to the water surface)

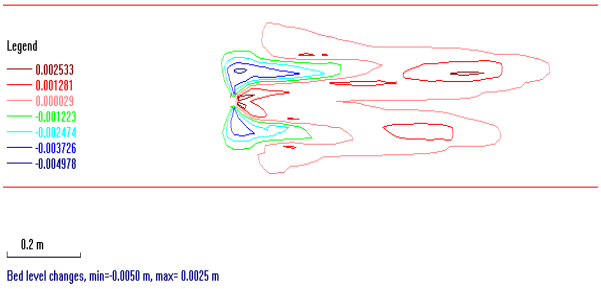

Figure 11 – Erosion of bridge pier after seven hours (slot adjacent the water surface)

Using the slot near the water surface, the scouring and erosion volume is much less than where the slot is in the vicinity of bed, and the slot efficiency near the water surface is better than the slot near the bed. So the next part will reviewed the effect of synchronous usage of collar and slot on the flow pattern and scouring around the pier, and their effectiveness has been analyzed to decrease and control the scouring.

Results of Three–Dimensional Modeling for the Effect of Synchronous Usage of Collar and Slot on the Pier Scouring

The effect of synchronous placement of collar around the pier and slot near the water surface on the results of flow pattern and scouring have been reviewed in this part, and also their performance has been evaluated to decrease the scouring depth.

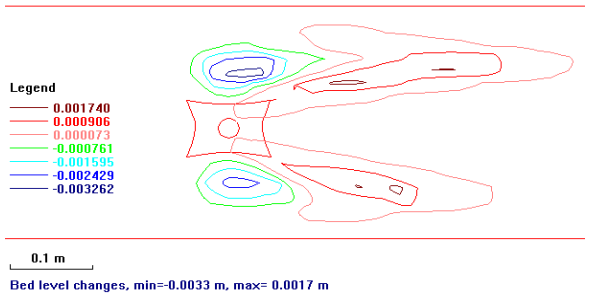

Figure 12 – Erosion of bridge pier after seven hours (collar and slot)

According to the results of numerical models, a dramatic reduction will be observed in scouring the pier at the first use of collar and slot. Finally, comparing the results obtained from the numerical model and laboratory model is shown a maximum difference 20 to 25% in different states.

CONCLUSION

The study of scouring phenomena and erosion of piers and foundations is one of the important considerations for designing the bridge pier of rivers. In past chapters, the erosion mechanism and methods to reduce and controlling this phenomenon was studied and the results of numerical modeling were presented graphically. Overall the obtained analyses and results are listed and finally suggestions are made to complement and enhance the design. Due to the limitations of physical models, it is inevitable to use the three–dimensional numerical model in complex problems of river engineering. However, the performance of three–dimensional numerical model is needed to consider the accuracy for calculations and approximations on different issues due to the existent assumptions and the required time to perform and non–convergence possibility. This thesis has been used the SSIIM three–dimensional numerical models of flow and sediment transport for a number of complex problems of river engineering.

- √ *The results of this thesis show that the used numerical models, one of the available three–dimensional models for engineers, can be predicted the acceptable values by simulating the flow and calculating the free level and changes of bed topography in rivers, and the acceleration error can be high in some points where there are strong rotational flows, but the model is capable to model the rotational flows and acceleration distribution.*

- √ *Applying the collar around the bridge pier can reduce the depth of local scouring by weakening the downward flow and horseshoe vortex.*
- √ *The results showed that the use of a square collar plays a significant role to reduce the scouring depth.*
- √ *The slot with creating the horizontal flow can divert the downward flows in front of the pier farther away and reduces the scouring depth.*
- √ *The combination of both collar and slot on the pier can further reduce the scouring depth.*

According to the mentioned notes, we can say that the accuracy of three–dimensional numerical models such the used model in the thesis is acceptable due to the required accuracy in engineering works, and in most cases it can be used to solve the issues of the river engineering.

SUGGESTIONS

- √ *Analysis of experimental results for the effect of collar and slot in various states and its modeling using SSIIM software*
- √ *Other methods of numerical modeling for reduction of scouring depth and its performance*
- √ *Further study and research is done in order to find new ways to reduce the scouring depth.*
- √ *Further study and modeling should be done to evaluate the effect of collar and slot on a single–pier and multiple–piers with different forms of pier.*
- √ *Other mixing methods should be done to reduce the scouring depth and also their performance to reduce the scouring depth should be examined using different study and modeling.*

Parameters

K: kinetic energy of turbulence
ε: loss of kinetic energy of turbulence
U: velocity component
p: fluid density
P: total pressure
$-p\overrightarrow{u_i}\overrightarrow{u_j}$ *: Reynolds stress term*
W: fall velocity of particle
Γ_T *: Distribution Coefficient*
Sc: Schmitt Number
d: diameter of sediment particles
a: reference level due to the roughness height
τ: shear stress of bed
τ_c*: Critical shear stress of bed for replacing the sediment particles due to the Shields diagram*
p_w*: water density*
p_s*: sediment density*
u: viscosity of water
g: acceleration of gravity
α: Angle between the flow direction and a line perpendicular to bed
φ: Angle of bed slope
θ: Slope Parameter

References

[1.] *Alabi, P.D. (2006). Time development of local scour at bridge pier fitted with a collar. Msc Thesis, University of Saskatchewan, Canada.*

[2.] *Beheshti, A. and Ataeei Ashtiani, B. (2008). Numerical study of flow pattern and scouring around a pile group. Fourth National Congress on Civil Engineering, Tehran University, May.*

[3.] *Breusers, H.N.C., Niccollet, G. and Shen, H. W. (1977). Local scour around cylindrical piles. J. Hyd. Res., 15(3): 211–252.*

[4.] *Chiew, Y. (1992). Scour protection at bridge piers. Journal of Hydraulic Engineering,118(9)1260–1269.*

[5.] *Elahi, M., Sanei, M. and Farhoodi, J. (2008). Reviewing the Scouring of cohesive material in downstream of perpendicular overflows. M.A. Thesis, Department of Irrigation and Drainage, Tehran University, Faculty of Agriculture.*

[6.] *Hadidi, H., Sanei, M. and Bani Hashemi, M. A. (2008). Effect of geometry and hole dimensions on the downstream scouring for the falling jets using the physical models. M.A. Thesis, Civil Engineering, Tehran University, Faculty of Engineering.*

[7.] *Hamidifar, H., Omid, M. H. and Raisi, A. (2009). Effect of adhesion on local scouring caused by horizontal jet. M.A. Thesis, Department of Irrigation and Reclamation, Tehran University, Faculty of Agriculture.*

[8.] *Heidarpour, M., Afzalimehr, H. and Khodarahmi, Z. (2007). Preserving the cylinder pier of bridge against the local scouring using a slot. Journal of Agricultural Sciences and Natural Resources, Volume 14.*

[9.] *Heidarpour, M., Afzalimehr, H. and Naderi Beni, M. (2003). Control and Reduction of local scouring at bridge piers with rectangular sections using the slot. Journal of Science and Technology of Agriculture and Natural Resources, 13–28: 7.*

[10.] *Heidarpour, M. (2002). Control and reduction of local scour at bridge piers by using slot, Proc.International Conf. on Fluvial Hydraulics, 3–6 Sept., Louvain–la–Neuve, Belgium. 2:1069–1072.*

[11.] *Ismaili, T., Kharqany, S. and Dehghani, A.A. (2009). Three–dimensional numerical study of scouring around the bridge piers under unstable flows. Water Science Research, 19–29: 1.*

[12.] *Graf, W. H. (1996). Fluvial Hydraulics, John Wiley &Sons, N.Y.*

[13.] *Khodashenas, S. R., Ismaili, K. and Shariati, H. (2009). Performance study of collar and slot for reduction of*

scouring the bridge pier. Research Committee of Regional Water Board in Khorasan, p 110.

[14.] Koochakzadeh, S., Liyaghat, A. and Sheikh Shamayel, H. (2002). Estimating the depth of local scouring around the piers located in the main channel s using the artificial neural networks. Iranian Journal of Agriculture Science, 617–626: 33.

[15.] Kothyari, U. C. and Ranga Raju, K. G. (2001). Scour Around Spur Dikes and Bridge Abutments. J. of Hydr. Research, 39:367–374.

[16.] Kumar, V., Raja, K. and Vittal, N. (1999). Reduction of local scour around bridge piers using slots and collars. Journal of Hydraulic Engineering, 125(12):1302–1305 .

[17.] Mokalef Sarband, A., Mashahir, M. and Zeraty, A. (2006). Developing the hole of local scouring around a rectangular pier along with collar. Seventh International Congress on Civil Engineering, Tarbiat Modarres University, Tehran.

[18.] Ministry of Power. (2007). Guide to computational procedures for local scouring. Publication No. 318, Publication of Management and Planning Organization.

[19.] Mashahiri, M.B., Zarrati, A.R. and Rezayi, A.R. (2004). Time development of scouring around a bridge pier proteted by collar. 2nd International Conference on Scour and Erosion, ICSE–2, Singapore.

[20.] Masjedi, A., Shafaei Bejestan, M., Moti, A. and Taeedi, A. (2010). Time development of local scour at a bridge pier using square collar in a 180 degree flume bend. American Science, 6: 188–195.

[21.] Melville, B. W. and Coleman, S. E. (2000). Bridge scour. Water Resources Publications, Colo.

[22.] Moncada–M, A.T., Aguirre–PE, J., Bolivar, J.C. and Flores, E.J. (2009). Scour protection of circular bridge piers with collars and slots. Journal of Hydraulic Research, 47(1):119–126.

[23.] Oronghi, H, Hosseinzadeh Dalir, A., Farsadizadeh, D. and Fakheri Fard, (2008). Temporal changes of scouring depth around bridge pier and its empirical relation. Journal of Agricultural Knowledge, 1–10: 18.

[24.] Oronghi, H, Hosseinzadeh Dalir, A., Farsadizadeh, D. and Fakheri Fard, (2008). Determining the proper dimensions for a rectangle collar to reduction of scouring the bridge pier. Journal of Soil and Water, 51–64: 19.

[25.] Raudkivi, A. and Ettema, R. (1983). Clear–water scour at cylindrical piers. Journal of Hydraulic Engineering, 109(3): 338–350.

[26.] Richardson, E.V. and Davis, S.R. (2001). Evaluating Scour at Bridges. Hydraulic Engineering Circular, No.18 (HEC−18), 4rd Ed., Rep. No. FHWA NHI 01–001, Federal Highway Administration, Washington, D.C.

[27.] Sayadi, A. (2008). Solving the equations of flow field and sediment transport around the bridge piers and calculating the depth of local scouring using the finite elements. Journal of Water Engineering, 77–87: 1.

[28.] Shafai Bajestan, M. (2005). Deposition hydraulic. Third Edition, Publication of Shahid Chamran University of Ahwaz.

[29.] Sheppard, D. M., Mufeed, O. and Tom, G. (2004). Large Scale Clear–Water Local Pier Scour Experiments. J. Hydr. Eng., ASCE, 130(10): 957–963.

[30.] Singh, C. P., Setia, B. and Verma, D. V. S. (2001). Collar–Sleeve Combination as a Scour Protection Device Around a Circular Pier. XXIX IAHR Congress Proceedings, Beijing, China, 2: 202–210.

[31.] Yazdandoost, F. and Haideri, M. (2009). Management of sedimentation–washing for reservoirs of dikes using SSIIM three–dimensional model and GIS. Eighth International Congress on Civil Engineering.

[32.] Zarrati, A.R., Gholami, H. and Mashahir, M.B. (2004). Aplication of collar to control scouring around rectangular bridge piers. Journal of Hydraulic Research, 42(1): 97–103.

[33.] Zarrati, A.R., Gholami, H. and Mashahir, M.B. (2004). Application of collar to control scouring around rectangular bridge piers. Hydraulic Research, 42: 97–103.

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EDUCATION AND WORKING LIFE IN HUNGARY

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Abstract: *In our study we intend to discuss the role of education in economy and the relationship between education and the current state of Hungarian labour market. The aim of our thesis is the comprehensive examination of the phenomenon why employees leave their work. In order to fulfill this investigation we have mainly focused on the data of different studies and statistics. Beyond this we have relied on our own inquiry: assumptions, consequences and suggestions have been composed based on the questionnaire filled in by a group of 128 employees. The result from the viewpoint of assumptions, suggesting that the main reason for leaving work is the question of financial matters, is not correct nowadays. The reason why employees leave work today is the modification of their interests or some other motifs. Natural curiosity plays a significant role and ultimately the problems of cost of living and the devaluation of the jobs' prestige (in the major case of qualified workers, but similarly in the case of medical employees or engineers). Decision-makers of Hungary would be suggested that circumstances should be established urging employees to stay in the country. The practice of life guidance, temporary agency, personnel placement and supply services as well as mobility should be proposed to and accepted by a wider range of society. During my work I also call the employers' attention to the extension of part-time employment since the results of my thesis confirm this need especially in the case of some groups of women.*
Keywords: *education, working life*

INTRODUCTION

Education became one of the largest sub-system of modern societies in the past century. The role of education is no longer interpreted only as the conveyor of culture, knowledge and values, but it is also attributed a significant role in its contribution to economic development and the promotion of social integration.

Nowadays investments in human capital development are seen as the most important part of economical and social status development of both the individual and the society, too. The level of the reached education and required abilities and the position on the labour market reflect on the height of earnings and the quality of the life pro rate (Bitterva – Hajós, 2009).

The correlation between vocational education and the labour market was given priority as early as the time of the system change.

Unemployment turned up in Hungary in the nineties and it exceeds 8% at present. It affects the younger generations and those starting their career more than the totality of the population able to work. This tendency is general in developed countries globally. According to Kutas (1996), the reason of the high proportion of young unemployed people lies in our education system. Therefore, one of the most important goals of employment politics in the opinion of Pulay (1996) is to create a closer relationship between education and employment. The key of reducing unemployment among the youth is to make education serve demands of the labour market better.

The establishment of market economy is a challenge for education. Education of the youth is not a short-term investment. The professional yield of this investment may not be evaluated exclusively from the point of view of cost yield. The optimal situation is when a school knows up-to-date what are current requirements of the labour market and what professionals to train (Cseh Papp, 2010). Numberless researches were carried out in this

area, from the work Vincze, 2009; Veroszta, 2010; Varga, 2010; Polónyi, 2010, 2011, 2012; Mocanu –Zamfir –Lungu –Militaru, 2012; Csernovitz – Szegedi, 2012.

Changes in the horizontal structure of the public educational system was primarily compelled by the expansion of secondary school education. Rapid increase of the number of students attending secondary schools in full-time began in the second half of the eighties. The number of those receiving further education in secondary schools increased from 60000 to 80000 between 1985 and 1990. By the end of the nineties, 70% of applicants within each generation chose secondary schools. As a whole, the offer of educational programmes in secondary vocational schools is in accordance with labour market demand but its professional composition does not follow labour market requirements dynamically enough, rather it reproduces the existing - and often obsolete - profession structure.

Numberless researches were carried out in this area. The experiences of these degrees are:

- *Students prefer professions considered popular by society to traditional professions. They had little knowledge concerning what time arrangement, working conditions, work environment and compensations to expect for various jobs.*
- *Investigation of the interest of young persons demonstrated that the directing-innovating and innovating-social interest pairs were the most frequent. The social-methodical and subjective-methodical interest pairs were insignificant. This justifies the fact that the youth dislike professions where they work with tools and machines. Rather, they want professions – and later jobs – where they can make decisions and they are independent during their job.*
- *One third of the students of vocational schools were not trained in the profession for which they first applied.*
- *These days, the quality and contents of education has also become important.*
- *Today, the demand is highest for well trained workers with real professional skills.*
- *The majority of youngsters with a profession looks for a job in accordance with their professional training.*

RESULTS AND DISCUSSION

□ *Research results*

The examination described in the paper is only one component of a comprehensive research.

Based on a survey made with questionnaires, the research outlines the circumstances under which those with secondary-school qualifications leave their trade or career. The paper also drafts the factors affecting the decision starting from the way of choosing school, through the successes (or failures) in studies to the trial/admission phase at the workplace. The paper lists those pressing conditions which lead to the decision of career modification and those aspects and features on the basis of which new career or craft is chosen by the individual. The survey sample consists of 128 persons from Gödöllő region, all of them with trade school qualifications, who changed their careers.

The social-economic changes in Hungary from the middle of the 1990s have required a new approach from employees. One of the priorities is the quick adaptation to the changes of the labour market, considering also the requirements and needs of the person. Career modification is one of the ways of adaptation.

According to the hypothesis of the research, those who choose career and also those employees who change their career do not possess all the necessary information for making good decision and do not know the whole range of possibilities.

Many of them are not aware of their own qualities, interests, others have difficulties to see through the labour market, jobs, trades and retraining courses. Good decision can be made only on the basis of adequate information and often external support and assistance is needed.

This hypothesis was confirmed by the result of the examination. The result from the viewpoint of assumptions, suggesting that the main reason for leaving work is the question of financial matters, is not correct nowadays.

□ *Research sample*

59 women and 69 men completed the questionnaire in Table 1.

Table 1: Distribution of the respondents according to genders (head, %)

Gender	head	ratio %
Man	69	54
Woman	59	46
Total:	128	100

It can be seen from the composition of respondents according to age that the different generations are represented equally, there is a small peak only in case of age group of 30-39 years (Table 2)

Table 2: Distribution of respondents according to age groups (head, %)

Age group	head	ratio %
between 20-29 years	31	24
between 30-39 years	37	29
between 40-49 years	31	24
above 50 years	29	23
Total:	128	100

Defining the composition of respondents according to this aspect is important because, in my opinion, the age differences affect the factors influencing the employees and their preferred values.

Hereinafter I list the most interesting conclusions that can be cautiously drawn from the examination:

The table demonstrates that more than 60% of respondents choose their first craft (school) on the basis of own decision, 20% of the sample listened to the parents. The others made decisions either on the basis of their study achievement or on advice from friends. It can be presumed that some of those people who defined the career selection as their own decision, were also influenced by their parents, but later identified with the idea – if it was not too far from them – and accepted the decision as their own (Table 3).

Table 3: Distribution of respondents according to the way of first career selection (%)

I chose	61
My parents suggested	20
Friends suggested	7
I was admitted there	10
Other	2
Total	100

As regards the quality of the knowledge obtained in the school, the interviewees judged themselves rather negatively. Less than half of the respondents felt that he/she adequately acquired the skills of the given trade. The tendency of undervaluation, mentioned often in the literature, can have a part in it, as well as the school experiences, when one evaluates himself or herself on the basis of the marks received in school. The ratio of replies given to the question explains why the respondents modified their career path (Table 4)

Table 4: Distribution of respondents according to their presumed level of knowledge of their own trade (%)

Very good	47
Average	48
Not at all	5
reason: too much theory	4
was not interested	1
Total	100

Following the vocational training at the trade schools, only about two-third of the respondents found jobs in the acquired profession. The ratio of those who continued studies, was relatively high due perhaps to family expectations, but sometimes they wanted to delay the beginning of employment. It is interesting, that there were some people who started retraining right after finishing the school (Table 5).

Table 5: Distribution of respondents according to the way of original trade selection (%)

I found job in the trade	60
Continued my studies	15
Started retraining	6
Started an enterprise	1
Joined the family enterprise	1
Became jobless	12
Other (I found job in another trade)	5
Total	100

Less than half of the total respondents did not work even a year in the original trade, including those who continued studies or found job in another trade. One-fifth of respondents worked for more than 10 years in their first job (Table 6).

Table 6: Distribution of respondents according to the time spent in the original trade (%)

Less than 1 year	40
1-2 years	14
2-5 years	18
5-10 years	9
more than 1 years	19
Total	100

It is easy to understand that the results correlate with the time of leaving the career and the esteem of the given trade, as well as the time of leaving the

career and the satisfaction with the income from the career.

Those who were satisfied with their salary spent more time in the trade before they changed career. It was typical for the young and the older people. Except for the generation above 50, where 50% of the respondents claimed good salaries, the number of those who were not satisfied with their income was higher in all age groups (Table 7).

Table 7: Distribution of respondents according to their satisfaction with the salary, divided by age groups (%)

	Between 20-29 (%)	Between 30-39 (%)	Between 40-49 (%)	Above 50 (%)
Yes	36	23	20	50
No	64	77	80	50
Total:	100	100	100	100

Those employees who felt esteemed connected with their professional activities, remained within the given career at significantly higher proportion. At this question, only the age group of those older than 50 indicated satisfaction in their reply (Table 8).

Table 8: Distribution of respondents according to the professional esteem, divided by age groups (%)

	Between 20-29	Between 30-39	Between 40-49	Above 50
Yes	45	40	50	80
No	55	60	50	20
Total:	100	100	100	100

In contrary to the above, only a few people indicated the dissatisfaction felt the lack of financial and professional appreciation as a primary reason for leaving the career. Examining the factors which led to leaving the original trade it has become clear that the internal factors were more important in making the decision. Those responses belong to the inner reasons which are related to one of the qualities of the personality (money, negative or positive feelings towards the profession, intent to continue studies, interest in other profession, total lack of interest in the given profession). The external factors included the economic, regional and social conditions (health reasons, winding up of workplace, regular military service, firing after maternity leave, etc.)

According to the results, continuing of studies or learning another profession, or the salary conditions are very important factors in leaving the trade. Less important whether one is employed in black labour or needs to be more mobile owing to the work (Table 9).

Table 9: Distribution of respondents according to the reasons of leaving the original trade (%)

Due to health reasons	9
I could not find job	10
I could find only black job	5
I would earn less with much work	20
I did not like my occupation	8
There is no adequate job around my home, I do not want to commute	7
I wanted to continue studying (high school certificate, college, etc.)	15
I wanted to learn other profession in order to stand on more legs	22
Other	4
Total	100

Aspects of choosing the new profession further enforced the influence of internal factors on modifying the career. Those respondents were in the greatest majority who changed profession because their interests changed. It is very positive, because interest – as one of the most important characteristics in choosing profession and finding job – can change year by year. If the personality cannot follow this change in the career, it can lead to professional dissatisfaction and the deterioration of work performance. Those, who chose the second job close to their original qualifications, aimed to reach a certain level of safety, because they did not have to meet the requirements of a completely new career, the professional experience collected and the acquired skills supported their adaptation to the career. On the other hand, in this case they are not forced to modify their career by the interest change or other factor connected with some personal feature, they have to adapt „only" to the changing labour market.

Only a few people chose a new occupation by considering the professions demanded on the labour market and ensuring the best employment possibilities and salaries. While the reason connected with commuting and mobility was less important regarding the career leaving decision, it was more important feature in choosing new profession that the workplace is closer to the home (Table 10).

Table 10: Distribution of respondents according to the aspects of choosing new occupation (%)

I heard that it is in demand, easy to find job	4
The employment agency offered a course in this line	11
One can earn a lot with it	9
I am more interested in that line of work	33
I did not have any sense of achievement in my original craft	6
It is close to my original craft	13
There were open jobs in that line within my home area	13
There are job opportunities abroad	3
Due to my illness I was fit for this	2
Other	6
Total	100

By reviewing the chosen crafts according to the sectors of the national economy, it is obvious that the employees are increasingly oriented towards the service sector regarding their original occupation and after the career modification, too. The greater proportion in service sector is due mainly to the foreign capital flowing in the country after the social-economic transition and the improvement of transportation-communication network. As regards the second chosen profession, the popularity of industrial trades is decreasing. It can be explained with the considerable reduction of Hungarian industrial production and the globalization impact that is the force to adapt to international economic impacts. There have already been very few people in the primary sector but the selection value of the new occupation well demonstrates the considerable reduction of agricultural employment (Table 11).

Table 11: Distribution of respondents according to the national economy sector of their profession (%)

	Agriculture (%)	Industry (%)	Services (%)	Total
Original profession	3	33	64	100
New profession	0	23	77	100
If one could choose again	1	11	88	100

As regards the second choice of profession, the diminishing interest in agricultural crafts is very obvious. At the same time, the popularity of industrial trades is also increasing because many people were forced to leave their original career after the employing companies went bankrupt or closed down. It is especially true for the processing industry. It is interesting, that the engineering industry has kept its rank, but it should be noted that 9 out of the 16 persons who pursue the second career here work as semi-skilled workers. The construction industry is still very popular, and many people would choose jobs in construction industry if it was possible. It is very interesting if we consider that the economic crisis of 2008 affected primarily the Hungarian construction industry. It also refers to the fact that the labour market position of the given area is less important in career selection. As regards the service sector, the economic services, repairing are the most popular, because more and more people work or would work there. Transportation and warehousing are also highly ranked within the new occupations. The demand for trading and catering jobs is slightly decreasing (Table 12).

Table 12: Distribution of respondents according to the sector branch of their profession (%)

	Original occupation	New occupation	If you could choose again
Agriculture	2	0	1
Forestry	1	0	0
Processing industry	14	5	0
Construction industry	2	2	7
Machine industry	16	16	4
Chemical industry	1	0	0
Trading	21	20	19
Catering	15	11	13
Transportation, warehousing	6	18	6
Business services (repairing)	18	25	46
Health, social services	4	3	4
Total	64	77	88

Table 13: Distribution of respondents according to their current dreams about a new occupation (%)

Would choose the original occupation or something close to it	5
Would choose again the second occupation or something close to it	23
Would choose something completely different	72
Total	100

It is an outstanding value that 72% of the respondents would choose a profession which is completely different from their original choice. Thought provoking that 23% of career-leaving skilled workers are not satisfied with their second occupation either, so changing professions cannot

be regarded successful in their case. 5% of respondents would choose again their original trade or something very similar to it (Table 13).

CONCLUSION

One of the outputs of the research is the statement that the career-related decision made at the end of the primary school is not necessarily a final decision, even if it is affected by the parents or friends of the same age group. The main reason for choosing a new profession was the interest-based career correction process. The labour market possibilities, however, were only slightly considered by those leaving their occupation.

The society should give high priority to the organizational development and operation of human resources and infrastructure of training places based on changing market needs. Everybody should have access to them and to the adequate information sources. The special assistance of career or labour market advisors can have a key role in ensuring access to the training courses, orientation among crafts, professions and jobs, proper knowledge of the labour market and ourselves.

REFERENCES

[1.] Bitterova, M. – Hajós L. (2009): The school project management influence on the economy of education. Bulletin of the Szent István University, Gödöllő, pp. 258-263; ISSN 1586-4502

[2.] Cseh Papp I. (2010): Labour Market Status of Young People in Hungary. Practice and Theory in Systems of Education, Volume 5; Number 2; pp. 169-176; ISSN 1788-2583

[3.] Csernovitz A. – Szegedi E. (szerk.) (2012): Munkaerőpiac-orientált felsőoktatás. Ötletek, bevált gyakorlatok az „Új készségek és munkahelyek" nevű európai kezdeményezéshez. Budapest, Tempus Alapítvány, p. 75

[4.] Ferencz Á. – Nótári M. (2012): The management of the education and the students in the Kecskemét College. Annals-Journal of Engineering. 10/2, pp. 87-90

[5.] Ferencz,Á.-Nótári, M.-Lévai,P. (2012): Professional further training of farmer as a function of agricultural innovation. The 3rd International Conference on Society and Information Technologies. Orlando, USA. pp. 148-152.

[6.] Kutas J. (1996): Hallgatói létszám, felsőoktatás-finanszírozás. Labour Review, May

[7.] Mocanu, C. – Zamfir. A. – Lungu, E. – Militaru, E. (2012): School-to-Work Transition of Higher Education Graduates in Four Eastern European Countries. Maastricht, School of Management Working. Paper 15. http://web2.msm.nl/RePEc/msm/wpaper/MSM-WP2012-15.pdf

[8.] Pulay Gy. (1996): Employment Policy in the Era of Economic Stabilization. Labour Review, February

[9.] Polónyi I. (2010): Foglalkoztathatóság, túlképzés. Bologna. Educatio, 3

[10.] Polónyi I. (2011): Keresztúton a hazai felsőoktatás. Felsőoktatási Műhely, 1

[11.] Polónyi I. (2011): Tervvágyak, terválmok Educatio, 3

[12.] Polónyi I. (2012): Honnan jönnek a hallgatók. Educatio, 2

[13.] Polónyi I. (2012): Felsőoktatás és gazdaság? Iskolakultúra, 1

[14.] Varga J. (2010): Mennyit ér a diploma a kétezres években Magyarországon? Educatio, 3

[15.] Veroszta Zs. (2010): A foglalkoztathatósághoz kötődő hallgatói várakozások Educatio, 3

[16.] Vincze Sz. (2009): A diplomások túlképzésének megnyilvánulásai. Új Pedagógiai Szemle, 8-9

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ANALYZING THE EFFECT OF CASTING DYNAMICS ON THE MECHANICAL PROPERTIES OF ALUMINUM-SILICON ALLOY

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Abstract: Casting dynamics such as electromagnetic stirring, stirring in gaseous atmosphere, high energy ultra-sound and mechanical vibration when applied during pouring may improve the mechanical properties of Aluminum-silicon alloy. In this work, mechanical vibration was applied to the mold during solidification varying the applied frequencies. Test samples were made, 3 were vibrated vibrated and 1 was not vibrated(As-Cast) Analysis of results obtained shows that the specimen vibrated at 5 Hz has the ability to absorb energy and to resist load and shock within its elastic limit hence it is resilient. This specimen presents all the properties required for a piston alloy .The results obtained practically shows that there would be improved mechanical properties with an increment in the frequency of vibration.
Keywords: Effect; Casting dynamics; Mechanical properties; Alloy

INTRODUCTION

Scientific research has lately demonstrated that the mechanical and properties of metallic materials can be improved not only through alloying or the change of the cooling conditions but also through the application of physical and mechanical treatments during solidification [1].

The physical and mechanical treatments that have been applied so far are:

- Electromagnetic stirring
- Stirring in gaseous atmosphere
- High energy ultra-sound
- Low frequency mechanical vibrations [2]

These treatments influence the following factors of the liquid alloy:

a) The limiting stratum. Due to the application of treatments, the limiting stratum comes off the mould face and thus determines an intensification of the heat transfer from the alloy and mould. This leads to the increase of the diffusion speed and the decrease of the concentration gradient.
b) The flow of the alloys. By the application of treatment, whirls are produced that destroy the particles existing between the liquid and the solid phases, thus achieving a constant refining of the melt and an increase of the heat transfer between the liquid and the solid phases.
c) Cavitations. The application of treatments brings about the phenomenon of cavitations, i.e. gas bubbles occur that are eliminated through the surface.
d) The surface tension and the moistening angle between the heterogeneous grains and the liquid decrease, a fact which brings about leads to an increase in the number of germination centres.
e) The degree of under-cooling decreases and leads to less mechanical work done.
f) The diphase zone decreases and brings about a reduction of the mechanical work of grain formation. At the end of the solidification process, a greater number of grains is obtained, improving thus mechanical properties of the alloy.

As a conclusion, due to the application of the physical and mechanical treatment, the alloys obtained have finer grains, their chemical composition is homogenous and the amount of gases in the alloys is reduced [11][14]. All these lead to better mechanical properties.

The vibration of the liquid alloys during solidification by means of low frequency vibrations gives good results, mainly in the case of the non-ferrous alloys but also in steels [7]. Experimentation with mold vibration in order to alter the as-cast microstructure of cast components date back to 1868. In one of the earlier investigations, Chernov found that application of mechanical vibration during solidification of steel caused refinement of austenite. More recent investigations by Abu-Dheir et al shows an effect of mechanical vibrations on the morphology of silicon in Al-Si alloys, which manifests itself in significant enhancement of mechanical properties [17]. Also recent work by Dommaschk showed that a refined grain structure of Al-Si alloys could be obtained by mold vibration.

MATERIAL AND METHOD

Two different kinds of casting were carried out to determine the effect of vibration on the microstructure and mechanical properties of cast aluminum alloys.

In this work, round cast to shape and size test bars were produced using mild steel die mould and subjected to various tests in order to study the effects of vibration on the castings

Sourcing of Materials

The raw material was sourced locally from scraps of automobiles parts like cylinder head, piston etc These were melted in a stationary crucible bale out furnace at 720^{0}C where the alloying with 11% wt silicon took place.

Using a die mould, casting was done at 680^{0}C and allowed to cool under ambient temperature. Further casting was done under vibration for different Frequencies 1, 3 and 5 using a Podmares vibrating Machine. These were also allowed to cool under ambient conditions.

Preparation of the Specimen for UTS

The non vibrated cast specimen and the vibrated specimens were machined to the required shape and sizes (Figure 1) and the universal testing machine was used to subject the specimens to tensile stress shows the readings obtained.

Preparation of Specimens for Hardness Testing

This is the resistance of the specimen to either permanent or plastic deformation. The Brinnel test was carried out on the vibrated and non-vibrated specimens. This consists of indenting the surface of the specimen with a 10 mm diameter steel at a load of between 300kg – 500kg. This load was applied for a time of 30 seconds and the diameter of indentation was measured with a low power microscope after the removal of the load. The brinel's hardness number (BHN) is expressed as the load P divided by the surface area of the indentation.

This is expressed as

$$BHN = \frac{P}{\left(\pi D/2\right)\left(D - \sqrt{D^2 - d^2}\right)} = \frac{P}{\pi D t}$$

where P = applied load, kg; D = diameter of ball, mm; d = diameter of indentation, mm; t = dept of the impressions, mm; BHN = kg/mm^2

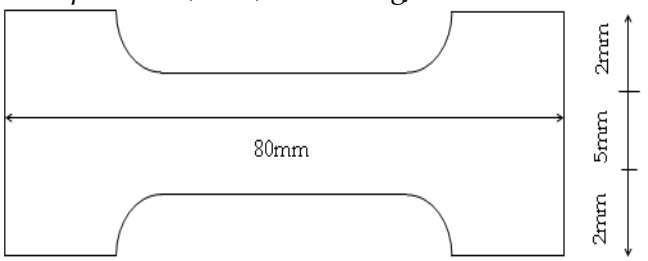

Figure 1: Cylindrical specimen for UTS

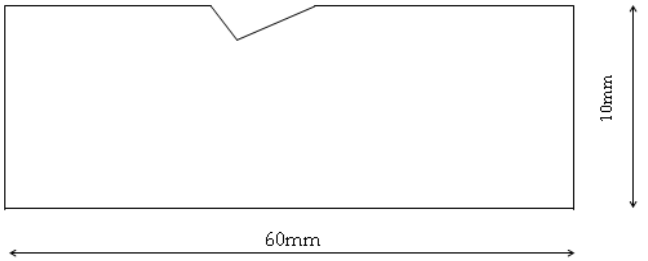

Figure 2: Cylindrical Specimen for Impact Test

Preparation for Impact Test

The specimens were machined to shape and sizes. Using the Mach Avery Testing Machine and a shipping force of 220ft.1b with a velocity of 16.5ft per sec, impact was made on the specimen and the readings were taken.

RESULTS

The Effect of Vibration on the Mechanical Properties.

In the figure 3 the histogram for extension at maximum load and tensile strain at break point are expressed. This shoes that the As-Cast specimen (Normal) has a higher value of extension at break point which means that the material is ductile, this is followed by the vibrated at 5Hz specimen, and the vibrated specimen at 3Hz while the vibrated

specimen at Amplitude 1 has the lowest value. It is also found that the strain at maximum load is the same at the break point which presented a higher value in the Normal specimen followed by the vibrated 5Hz specimen, vibrated specimen Amp1 with the lowest value. This means that the normal specimen (As-Cast) is more deformable than the other 3 when it is loaded with its elastic limit making it move malleable than the others.

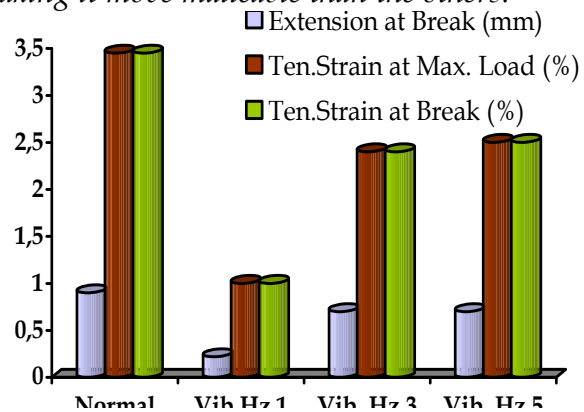

Figure 3: Comparative graph for Extension / strain relationship

In Figure 4 the graph of Load/ Stress relationship reveals that applying the same relationship reveals that applying the same maximum load and standard load at break point the tensile stress of sample vibrated at 3Hz is higher than the Normal specimen (As-Cast) while the specimen vibrated at 5Hz has the higher value.

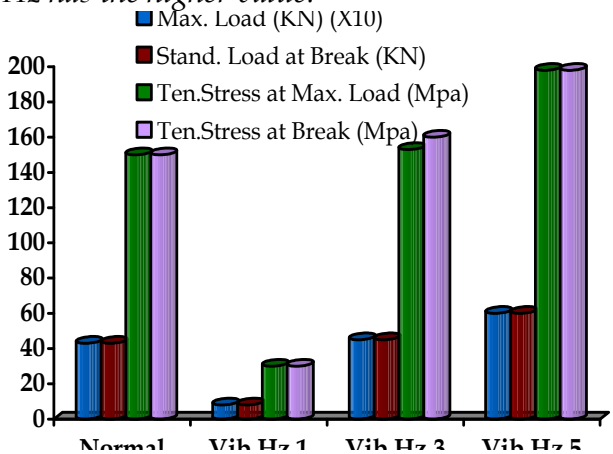

Figure 4: Comparative graph for Load/ Stress Relationship

The specimen vibrated at 1amp has negligible or no effect on the tensile stress. The implication of this is that the specimen vibrated at 5Hz has the highest capacity to withstand stress. We can therefore say that the higher the frequency of vibration during casting the stronger the material. This material is stiff which makes it good for piston alloys.

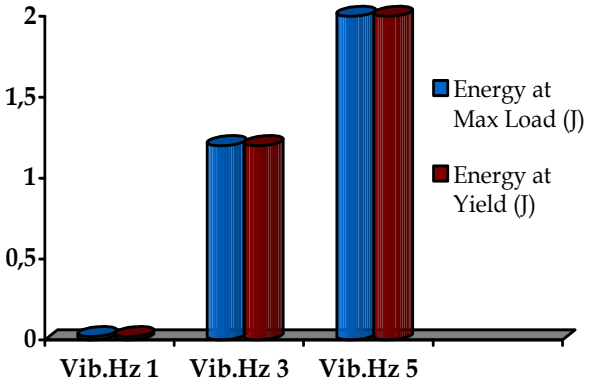

Figure 5: Comparative graph for Energy stored

The graph of Energy as shown in figure 5 reveals that the specimen vibrated at 5amp has the highest Energy at Maximium loading and energy at yield followed by specimen vibrated at 3Hz and specimen vibrated at 1Hz with the lowest value. We can deduce from this that specimen vibrated at 5Hz has the ability to absorb energy and resist load and shock, within the elastic limit hence it is resilent. This specimen presents all properties required for a piston alloy.

Table 1: Results of mechanical tests on vibrated and non-vibrated specimens

Mechanical Properties	Specimen 1 (Normal)	Specimen 2 (VIB. Hz: 1)
Max. Load (KN)	4.26	0.88
Tensile Stress at max load (Mpa)	144.88	31.91
Tensile Strain at max. load (%)	3.4	0.88
Standard Load at break (KN)	4.26	0.88
Extension at break (standard) mm	0.82	0.21
Tensile Stress at break stand (mm)	144.8	31.91
Tensile Strain at break(stand)mm	3.4	0.88
Tensile stress at yield(MPa)	0	0
Modulus(E) (Mpa)	10181.34	0
Energy at break (J)	2.2	0.04
Energy at max. load(J)	2.2	0.04
Energy at yield (J)	0	0
Extension at yield(mm)	0	0
load at yield	0	0
Tensile strain at yield mm/mm	0	0
Pressure Ratio	0	0
Energy at X 0 Intercept (J)	0.00044	0
Impact Force Kgm/s2	0.81	0.54
Hardness in HB	105	74.1

Table 1: Results of mechanical tests on vibrated and non-vibrated specimens (continuing)

Mechanical Properties	Specimen 3 (VIB. Hz: 3)	Specimen 4 (VIB. Hz: 5)
Max. Load (KN)	4.28	6.2
Tensile Stress at max load (Mpa)	157.12	193.32
Tensile Strain at max. load (%)	2.31	2.4
Standard Load at break (KN)	4.28	6.26
Extension at break (standard) mm	0.56	0.58
Tensile Stress at break stand (mm)	157.12	193.32
Tensile Strain at break(stand)mm	2.31	2.4
Tensile stress at yield(MPa)	0	
Modulus(E) (Mpa)	10986.71	11709.15
Energy at break (J)	1.19	1.9
Energy at max. load(J)	1.19	1.9
Energy at yield (J)	0	
Extension at yield(mm)	0	0
load at yield	0	0
Tensile strain at yield mm/mm	0	0
Pressure Ratio	0	0
Energy at X 0 Intercept (J)	0.00163	0.01308
Impact Force Kgm/s2	0.81	1.08
Hardness in HB	87	125

Table 2: Result from impacting test

Frequency	Vibrated applied force (Kgm/s^2)	Applied force ($lb.\ ft/s^2$)
1	0.54	4
3	0.81	6
5	1.08	8
	NON-VIBRATED	
	0.81	6

Table 3: Result from hardness test

Frequency	Vibrated HB	Non-Vibrated HB
1	74.1	
3	87	105
5	125	

DISCUSSION - Comparative Analysis of Mechanical Properties for Vibrated and Non-Vibrated Specimen

One of the aims and objectives of this research work is to induce good mechanical properties in casting of components through vibration. The summary of test results is shown in table 3 and interpreted as follows:

In figure (3) the histogram for extension at breakpoint, tensile strain at maximum load and tensile strain at break point are expressed. This shows that the As-Cast specimen (Normal) has a higher value of extension average point which means that the material is ductile, followed by the specimen vibrated at 5Hz and the specimen vibrated at 3Hz while the specimen vibrated at 1 Hz has the lowest value. It is also found that the strain at maximum load is the same at breakpoint which presented a higher value in the normal specimen followed by the vibrated specimen at 5Hz, vibrated specimen at 3Hz and vibrated specimen at lamp with the lowest value. The implication is that the normal specimen (As-Cast) is more deformable than the other 3 specimen when it is loaded within its elastic limit making it more malleable than the others.

In figure (4) the graph of load/stress relationship reveals that applying the same maximum and standard loads at breakpoint, the tensile stress of sample vibrated at 3 Hz is higher than the normal specimen (As-Cast) while the specimen vibrated at same has a higher value, the specimen vibrated at 1 Hz has negligible or no effect on tensile stress. The implication of this is that the specimen vibrated at 5 Hz has the highest capacity to withstand stress. We can therefore deduce that the higher the frequency of vibration during casting the stronger the material.

However, what we cannot confirm is that at what point would increment in the frequency of vibration have negative effect on mechanical properties. This material is stiff and that makes it suitable for piston alloy.

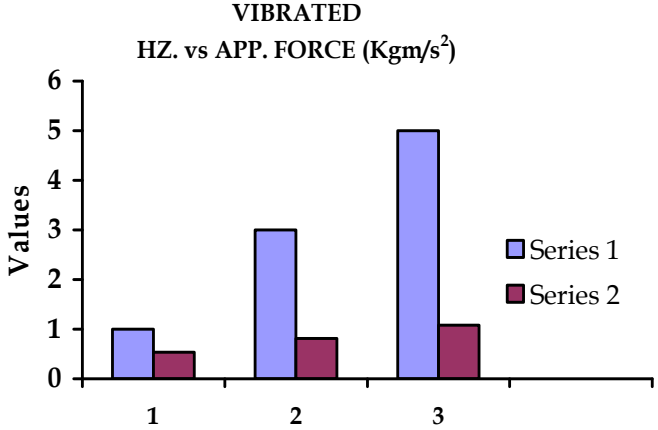

Figure 6: Comparative graph of applied force and frequency

Energy relationship between vibrated samples alone figure (5) reveals that the specimen vibrated at 5 Hz has the highest energy at maximum loading and energy at yield, thus is following by specimen vibrated at 3 Hz while the specimen vibrated at 1 Hz has the lowest.

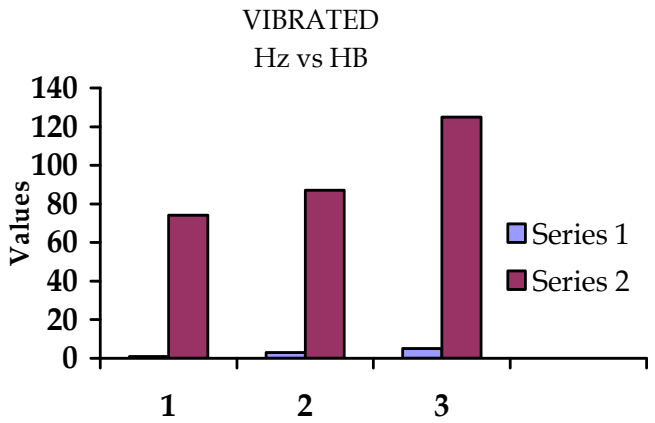

Figure 7: Comparative graph of frequency and Hardness value

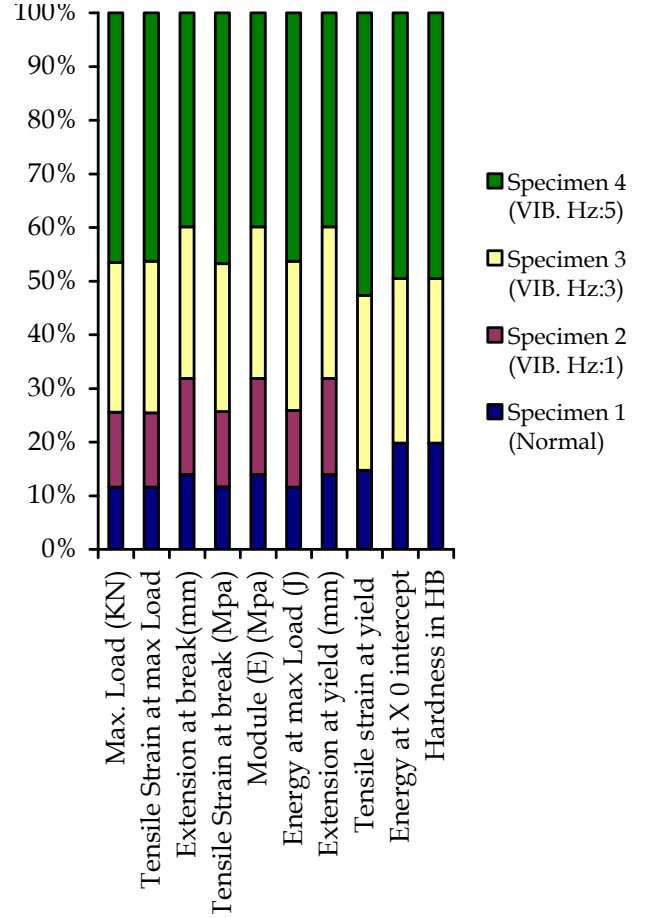

Figure 8: An overview of selected mechanical properties for all specimens

We can deduce from this that the specimen vibrated at 5 Hz has the ability to absorb energy and to resist load and shock within its elastic limit hence it is resilient.

This specimen presents all the properties required for a piston alloy, however, what happens after this level is recommended for further work.

An overview of the mechanical properties of all the vibrated components shown in Figure (8) shows practically that there would be an increment in mechanical properties with an increment in the frequency of vibration.

REFERENCES

[1.] *R.M. Pillai et al. Journal of Materials Processing Technology, vol 146 2004,338–348*

[2.] *Eskin G. I., Ultrasonics Sonochemistry Vol. 8, no. 3 , 2001pp 319-325*

[3.] *Eskin G. I., Ultrasonic Treatment of Light Alloy Melts, Gordon and Breach, Amsterdam 1998.*

[4.] *H. Xu, X. Jiana, Meeka T., Han Q., Materials Letters vol 58 2004 pp. 3669–3673*

[5.] *Jian X. et al Scripta Materialia, 2006, v 54, n 5, pp 893-896*

[6.] *H. Xu, X. Jiana, Thomas T. Meeka, Qingyou Han Materials Letters, 2005, vol.59, pp. 190-193*

[7.] *RADJAI A.,Miwa K., Metallurgical And Materials Transactions A Vol. 31a, 2000, p 755-762*

[8.] *Zong C. J. Transactions of the Nonferrous Metals Society of China , v 13, n 3, 2003, p 473-83*

[9.] *Yoon E.P. et al , Materials Science Forum, v 475-479 ,1998, pp 320-332*

[10.] *Mizutani Y. et al Materials Transactions, v 45, n 6,2004, pp 1944-1948*

[11.] *Vives, C. Metallurgical and Materials Transactions B ,vol 27B, no 3,1996, pp457-64*

[12.] *F. C. Robels Hernandez, J. H. Sokolowski, Journal of Metals, 2005, p 48-52*

[13.] *Product manual, Agree series mechanical shakers, LAB Equipments, Franklin Park IL USA*

[14.] *Campbell J., International Metals reviews, Vol 26, no. 2 ,1981, pp 71-108*

[15.] *Fisher T. P., British Foundryman vol. 66 No. 3, 1973, pp 71-84*

[16.] *Bast et al, Advanced engineering materials, 2004, vol 6, no. 7 pp 550-554*

[17.] *Abu-Dheir N et al. Solidification of aluminum alloys, TMS, 2004 pp 361-36*

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AN EFFICIENT APPROACH FOR DETERMINING INDUCTION MOTORS PARAMETERS

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Abstract: *The paper presents an efficient approach for determining the equivalent circuit parameters of squirrel cage induction motors by genetic algorithms. A T80B4AB3 type squirrel cage induction motor is analyzed. The T-shaped equivalent circuit is utilized. There are five unknowns in the equivalent circuit, namely: stator resistance and stator leakage reactance, rotor resistance and rotor leakage reactance, and magnetizing reactance. The known quantities from measurement are the input voltage, input current, power factor and slip. Genetic algorithms are used for determining the induction motor parameters. The results are compared by using one, two and three sets of measured data. The accuracy of the proposed approach is verified by determining the relative error in the parameters, obtained by genetic algorithms with regard to analytical values. It is shown that the presented approach needs only two points from the induction motor load curve. In contrast, the standard approach requires at least three points from the motor load curve to obtain relative error less than 1%.*
Keywords: *genetic algorithms, induction motors, parameters of T-shaped equivalent circuit*

INTRODUCTION

Electric drives using induction motors are one of the main fields of interest to the control systems and electrical engineering specialists. The quality and effective control of induction motors (IM) is based on their equivalent circuits [1].

The necessity of knowing the equivalent circuit parameters of IM is constantly growing due to the following reasons [2]:

- ✓ *students should get deeper, up-to-date and accurate knowledge in the physical processes occurring in IM;*
- ✓ *designed power converters should possess better quality indices in static and dynamic modes;*
- ✓ *increasingly adequate models of IM are needed for their research and improvement.*

The conventional method for estimation of IM equivalent circuit parameters is based on the no-load and blocked rotor tests which are a time-consuming task, especially if the motor is already coupled to driving equipment. This paper presents a more sophisticated approach for determining the equivalent circuit parameters of induction motors. The approach is based on only a series of measured or analytically obtained data such as stator voltage, current, power factor and slip. A genetic algorithm model for determining the parameters is synthesized that enables the simultaneous satisfaction of steady-state stator current and power factor by defining an objective function. The results obtained by the synthesized model are compared with analytical data. An analysis is performed that proves the validity and adequacy of such models in IM control systems.

SURVEY OF THE METHODS FOR EQUIVALENT CIRCUIT PARAMETERS ESTIMATION OF INDUCTION MOTORS

The methods for IM equivalent circuit parameters estimation can be classified in two main groups – experimental and computational. The classical experimental methods are a good alternative to the methods using nameplate data. They are performed by two tests – no-load test, blocked rotor test and measurement of the stator winding resistance [3].

The no-load test is used to determine the core loss resistance. The blocked rotor test enables to determine the rotor resistance, the magnetizing reactance and the sum of the stator and rotor leakage reactances. By this approach, however, it is not possible to know how the leakage reactances are shared between the rotor and stator. This deteriorates the accuracy when predicting the dynamic performance of the motor. Moreover, in order to perform these tests in practice, several difficulties are faced. First, it is difficult to block the rotor when the motor is incorporated in a drive system. Second, the no-load test is often hard to perform since IM usually rotate with load such as fan or gear. Third, IEEE Standard 112 requires performing the motor tests with a voltage unbalance not exceeding 0.5% [3]. Field conditions, however, may exceed this limit significantly. Thus when evaluating motor performance in the field a more accurate and reliable approach is needed.

The modern experimental methods include all methods using tests different from the classical no-load and blocked rotor tests. Such methods include the use of transients in the motor equivalent circuit when supplied from direct voltage and/or direct current [4]. These methods have the following advantages – they are of short duration (only a few seconds) and the motor is not separated from the driving mechanism. Their disadvantage is the necessity of converter to have additional functions in order to perform the tests and to be provided with software to analyze the motor response to these tests. These functions are comparatively easy to realize. Recently electric drives appeared that perform auto adjustment by no-load and standstill tests.

An efficient modern experimental method is proposed in [5]. It determines the equivalent circuit parameters based on the recorded time variations of voltage, current, power and speed from start-up till no-load. The method is accurate but has several disadvantages. It needs expensive equipment to record the time variations of the above electrical and mechanical quantities. The method is intrusive since all loads should be decoupled from the motor during the test. Finally, it is applicable only to large high-voltage induction machines rated 1 MW and above.

Some of the computational methods are based on the motor nameplate and catalog data. Three methods for determining the equivalent circuit parameters when taking into account the steel losses are described in [6]. The methods are based on several assumptions such as:

- *equal leakage inductances of stator and rotor windings;*
- *zero value of the referred leakage inductance of rotor winding when determining copper losses;*
- *zero value of the referred leakage inductance of stator winding when determining steel losses, etc.*

All three methods require knowing the rated supply voltage, stator current, rated power, power factor, rated speed and rated efficiency. It is also necessary to know the stator resistance which is easy to measure. The errors of the different parameters when using these methods vary from 4% to 60% [6].

When catalog data for motors is available, it is easy to develop procedures for changing one type of equivalent circuit with another, as well as to relate the obtained results with synchronous speed, rated power, rated, breakdown and starting torque. Such approach is very attractive and several converter manufacturers use it [2, 7].

The methods based on the motor nameplate and catalog data are convenient and non-intrusive. They can be applied to various equivalent circuit modifications. Due to the assumption for constant efficiency the nameplate and catalogue data methods give good results for loads above 50%. When using these methods, however, three additional problems may occur. First, the nameplate efficiency may be given according to a standard other than IEEE Std. 112. The three most frequently used standards are the National Electrical Manufacturers Association (NEMA) that uses IEEE Std. 112, the Japanese Electrotechnical Committee (JEC) and the International Electrotechnical Commission (IEC). The three standards are not in agreement which may results in different efficiencies for a given motor [8]. Second, the motor may have been rewound and the nameplate or catalog data may no

longer be valid. Third, the field voltage unbalance and harmonics content may be different from that for which the nameplate or catalog data is derived. In this way when estimating the equivalent circuit parameters a great percentage of statistical error may be introduced. Another problem is the fact that due to various reasons, most manufacturers usually do not publish detailed data about their production.

Other computational methods for equivalent circuit parameters estimation are the analytical methods using analytical expressions, developed decades ago [9]. They aim to obtain a steady-state performance of a motor for a given set of dimensions. The solutions by these methods are obtained very quickly, typically in seconds, on modern computers. The analytical methods, however, make quite a number of approximations, as IM operation involves 3D phenomena, saturation, eddy currents, etc. Some important details of geometry are also overlooked. These approximations deteriorate the accuracy of analytical methods.

The fast improvement of computer performance, combined with the development of the finite element method (FEM), lead to another important class of computational methods – the numerical methods. The numerical methods predict IM parameters using the magnetic field numerical solution [10]. A number of professional software packages using FEM are now available that provide two or three dimensional magnetic field solutions. The 3D solutions are accurate but need long preprocessing and solution times. Therefore mostly 2D models of IM are analyzed. The 2D FEM analysis of IM yields reliable results, but has several disadvantages. First, the good software packages are commercial and expensive. Second, the finite element method requires detailed information about the stator and rotor geometry, number of turns, wire diameter, reluctivity curve of steel, etc. Third, it is necessary to compute analytically the stator end turn leakage reactance, the rotor end ring reactance and resistance [11].

The last class of computational methods are the methods based on genetic algorithms, applied in the present paper.

The survey of the methods for equivalent circuit parameters estimation shows, that intrusiveness, cost and accuracy are the major considerations when selecting a method for determining IM parameters. Users prefer a cheap and low intrusive method providing a good accuracy.

MECHANISM AND MAIN OPERATORS OF GENETIC ALGORITHMS

The genetic algorithms (GA) optimization is a stochastic search method that involves a random generation of potential solutions and then systematically evaluates the solutions until stopping criteria are met. Sets of non-linear equations are solved which are represented by objective functions based on some criterion (the calculated error). Also the reciprocal value of this criterion, called fitness function, is used. The mechanism of GA consists of the following steps [12]:

- √ *Step 1: Create an initial population for mating;*
- √ *Step 2: Define the fitness (or objective) function of each member of the population;*
- √ *Step 3: Search for natural selection;*
- √ *Step 4: Select population members from the mating pool;*
- √ *Step 5: Generate offspring;*
- √ *Step 6: Mutate the members of the population;*
- √ *Step 7: Terminate the optimization or for continuing go to Step 2.*

Genetic algorithms that find good results are composed of the following three operators:

- √ *Selection – the process of choosing two parents from the population. The aim of this operator is to emphasize fitter individuals so that they can create offspring with higher fitness. Selection is a method that randomly chooses chromosomes from the population according to their evaluation function – the higher the fitness, the bigger chance an individual has to be selected. The most common types of selection are roulette wheel and tournament selection. The roulette wheel selection is easy to perform but it is unstable. For this reason in the present approach tournament selection is used. The best individual from the tournament is the one with the highest fitness and this one is the winner of the potential individuals. The tournament*

selection is very efficient and leads to an optimal solution.

- √ *Crossover – the process of taking two parent solutions and producing a child. Thus, the population is enriched with better individuals. In the present work scattered crossover is used. It is created with the help of random binary vector called a mask. It selects the genes where the vector is "1" from the first parent and the genes where the vector is "0" from the other parent. That is how the child is produced by combining the genes of the two parents.*
- √ *Mutation – it prevents the algorithm to be trapped in a local minimum. Mutation makes small random changes in the individuals from the population, and thus it provides genetic diversity in the future offsprings and allows the GA to explore wider search space [13]. Genetic algorithms have several advantages over the other optimization methods. They find the global minimum, instead of a local minimum. GA do not require the use of the derivative of the function, which is not easily obtained or may not even exist.*

DEVELOPMENT OF THE GENETIC ALGORITHM MODEL AND OBJECTIVE FUNCTION DEFINITION

In order the natural selection to be used for estimating the parameters of induction motor equivalent circuit, an objective function should be defined. This function is based on the equations of the T-shaped equivalent circuit without considering the steel losses (Figure 1).

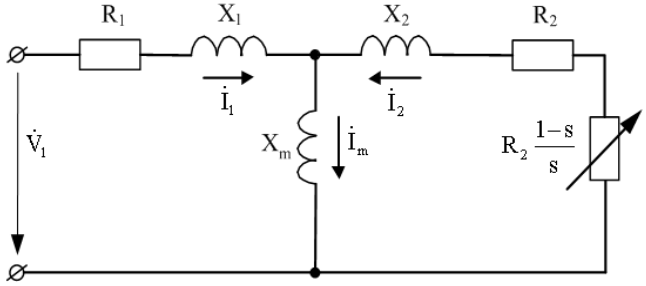

Figure 1. T-shaped equivalent circuit of the induction motor

There are five unknowns in the circuit in Figure 1, namely: stator resistance R_1 and stator leakage reactance X_1, rotor resistance R_2 and rotor leakage reactance X_2 (both referred to stator), and magnetizing reactance X_m. The known quantities from measurement are the input voltage V_1 that equals the rated voltage, the input current I_1, power factor cos φ and slip s.

Based on the T-shaped induction motor equivalent circuit in Figure 1, the stator current can be calculated:

$$\dot{I}_1 = \frac{\dot{V}_1}{Z_{eq}} = \frac{\dot{V}_1}{R_{eq} + jX_{eq}} \qquad (1)$$

where Z_{eq} is the equivalent circuit impedance.

The equivalent circuit resistance R_{eq} is equal to:

$$R_{eq} = R_1 + \frac{\frac{X_m^2 R_2}{s}}{\left(\frac{R_2}{s}\right)^2 + (X_2 + X_m)^2} \qquad (2)$$

The equivalent circuit reactance X_{eq} is computed as follows:

$$X_{eq} = X_1 + \frac{\left(\frac{R_2}{s}\right)^2 X_m + X_2 X_m (X_2 + X_m)}{\left(\frac{R_2}{s}\right)^2 + (X_2 + X_m)^2} \qquad (3)$$

Now the power factor can be calculated:

$$\cos\varphi = \cos\left(\tan^{-1}\frac{X_{eq}}{R_{eq}}\right) \qquad (4)$$

Based on formulae (1) and (4), we shall develop the objective function:

$$F_{obj} = \sum_{i=1}^{n}\left(\frac{\cos\varphi_{c,i}}{\cos\varphi_{m,i}} - 1\right)^2 + \sum_{i=1}^{n}\left(\frac{I_{1c,i}}{I_{1m,i}} - 1\right)^2 \qquad (5)$$

In (5) $I_{1c,i}$ and cos $\varphi_{c,i}$ are the values computed by (1) and (4). $I_{1m,i}$ and cos $\varphi_{m,i}$ are the measured values. The variable n varies from 1 to 3 in our case.

The analysis of (5) shows that the developed objective function reflects the error in the measured motor data and the results obtained with GA optimization. This means that the lower the error in the computed and the measured data, the smaller the values of the objective function. Thus, the fitness of the individuals rises because the objective function is reciprocal of the fitness function.

The aim of GA is to minimize the error of the objective function defined by (5). In the present work the value of F_{obj} is set to zero and in this way the global minimum of the objective function is found.

RESULTS AND DISCUSSION

The parameters of a T80B4AB3 type squirrel cage induction motor with the following nameplate data

are estimated: 0.75 kW output power, 380 V phase-to-phase voltage, 50 Hz frequency and 2 pairs of poles. The obtained GA results for the above mentioned motor are compared to the analytical data sets shown in Table 1.

Table 1. Analytical data sets used in GA

Stator current [A]	Slip	Power factor
1.86	0.06	0.62
2.39	0.10	0.74
3.07	0.15	0.78

One of the main difficulties when applying GA is how to choose an appropriate set of parameter values. Before running the algorithm, the user has to specify a number of parameters such as population size, selection rate, etc. According to the parameters setup, different results are obtained [14]. Their accuracy is measured by the relative error:

$$\varepsilon = (X_{GA} - X_{an}) / X_{an}. \quad (6)$$

In (6) X_{GA} is the value of the parameter, computed by the GA optimization, and X_a is the analytical value of the same parameter.

The population size value is very important for GA performance. If it is too small, accurate solutions may not be reached. On the other hand, if population size is too large, unnecessary computational time is spent. The standard setting for population size is 20 to 100 individuals [14]. In order to guarantee good accuracy, however, we chose population size higher than the standard (500), although it lead to slightly higher computation time. Otherwise the population would lack diversity, the algorithm would explore only a small part of the search space and not find global optimal solutions. The standard configuration of the GA parameters is given in Table 2. These settings are chosen by analogy, namely using past experience that has proved successful for similar problems [14, 15].

Table 2. Genetic algorithm parameters

Population size	500
Selection function	tournament
Tournament size	4
Elite count	2
Mutation function	adaptive feasible
Crossover function	scattered
Crossover fraction	0.8

Table 3 shows the equivalent circuit parameters estimated by the genetic algorithm as well as the relative error in the estimated parameters with regard to the analytical values. Due to the random nature of GA, each computed parameter value in Table 3 is an average of the best values from GA obtained in 10 runs.

Table 3. Equivalent circuit parameters and relative error

Parameter		R_1	R_2	X_1	X_2	X_m
Analytical value [Ω]		10,2	10,52	8,17	19,16	143,57
1 data set	GA [Ω]	63,32	11,11	44,74	104,92	56,84
	ε [%]	520,80	5,55	447,61	447,61	-60,41
2 data sets	GA [Ω]	10,44	10,48	8,21	19,25	142,85
	ε [%]	2,39	-0,36	0,44	0,49	-0,56
3 data sets	GA [Ω]	10,26	10,48	8,17	19,16	143,18
	ε [%]	0,57	-0,36	-0,01	0,01	-0,27

The results in Table 3 show that the proposed GA approach is very sensitive to the number of the used data sets. When one data set is used, there is a great discrepancy between analytical and estimated values. In this case the maximum error exceeds 500%, because one single point can not define the nonlinear IM current-slip curve accurately.

The use of two data sets greatly improves the accuracy, the maximum relative error being less than 3%. With 3 data sets the maximum ε is below 1%. Thus, it can be concluded that when more data sets are used, more accurate results are obtained.

Figure 2 shows the convergence versus the number of iterations when using 3 data sets. The total number of generations is 476 and the algorithm terminates at the value of 4.2026e-007. A zoomed picture for the 450th iteration is also shown in Figure 2.

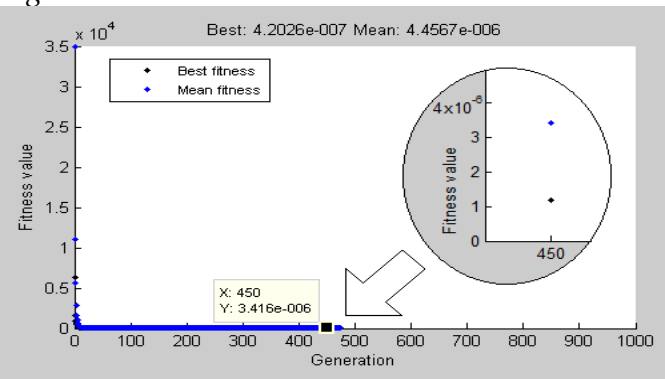

Figure 2. Convergence history with 3 data sets

Next a new improved setup for solving the GA model for estimating the IM parameters is proposed. Table 4 shows the GA parameters settings. The computed results are given in Table 5.

Table 4. Improved GA parameters

Population Size	500
Selection Function	Roulette Wheel
Elite Count	2
Mutation Function	Adaptive Feasible
Crossover Function	Intermediate
Crossover Ratio	1,0

Table 5. Results from the improved GA optimization

Parameter		R_1	R_2	X_1	X_2	X_m
Analytical value		10,2	10,52	8,17	19,16	143,57
1 data set	GA [Ω]	66,19	19,11	44,71	104,85	51,92
	ε [%]	548,88	81,63	447,21	447,25	-63,84
2 data sets	GA [Ω]	10,25	10,49	8,14	19,09	143,13
	ε [%]	0,52	-0,26	-0,32	-0,37	-0,30
3 data sets	GA [Ω]	10,19	10,49	8,15	19,11	143,28
	ε [%]	-0,06	-0,30	-0,24	-0,24	-0,21

The results from Table 5 confirm the fact that when one data set is used (i.e. one single point from the load curve), there is a great discrepancy between the analytical and estimated parameters. In this case the relative error exceeds 500% again.

When two data sets are used, however, the accuracy of the improved GA optimization is greatly increased. The maximum error is 0.52% as compared to the 2.39% from the standard approach.

Both the improved and standard GA optimization reach a relative error less than 1% when three points from the load curve are used.

Thus an adequate optimization process using GA should be designed to find the global minimum over a wider power range of the induction motor rather than using a single load point. This can be achieved by incorporating at least two (improved approach) or three (standard approach) load points in the objective function defined by (5).

CONCLUSION

An efficient genetic algorithms approach for estimating the equivalent circuit parameters of squirrel cage induction motors is proposed. It is less sensitive to the number of input data sets than the standard approach. The sensitivity and accuracy of the approach are analyzed. The results show that to obtain relative error less than 1%, the proposed approach needs only two sets of electrical input data (voltage, current, power factor) and slip of the motor. For comparison, the standard technique needs at least three points from the motor load curve to obtain error less than 1%. The proposed GA approach has several advantages over the conventional methods for estimating the equivalent circuit parameters of induction motors. It is simple, less intrusive and yields practically the same results as when using the much more time-consuming and complicated conventional methods.

REFERENCES

[1.] Pillay, P.; Sabur, S.; Haq, M.: A model for induction motor aggregation for power system studies. Electric Power Systems Research. Vol. 42, 225-228, 1997.

[2.] Leonhard, W.: Control of electrical drives. Springer Verlag, 2001.

[3.] IEEE Standard Test Procedure for Polyphase Induction Motors and Generators. IEEE Std. 112-1996. IEEE Power Engineering Society, New York.

[4.] Barrass, P.: Automatic characterization of induction motors for optimum performance. TechOPS, 2005.

[5.] Babau, R.; Boldea, I.: Parameter identification for large induction machines using direct online startup test. Workshop on Electrical Machines Parameters. Technical University of Cluj-Napoca, Romania, 47-52, May 2001.

[6.] Ozyurt, C.; Ertan, B.: Prediction of induction motor parameters from manufacturer's data. XIV-th International Symposium on Electrical Apparatus and Technologies SIELA 2005. 2-3 June 2005, Plovdiv, Volume II.

[7.] OMRON. Compact Vector Control AC Drive V1000. Quick Start Guide, 2007.

[8.] Queck, J.; Olszewski, M.: ORNL/TM-13165. January 1996. Lockheed Martin Energy Research Corp. Assessment of methods for estimating motor efficiency and load under field conditions.

[9.] Boldea, I.; Nasar, S.: The induction machine handbook. CRC Press, 2002.

[10.] Zhou, P. et al.: Finite element analysis of induction motors based on computing detailed equivalent circuit parameters. IEEE Transactions on Magnetics. Vol. 34, No. 5, September, 3499-3502, 1998.

[11.] Ertan, B. et al.: Identification of parameters of an induction motor from field solution. ICEMS 2003. Vol. 1, 1-6, Nov. 2003.

[12.] Haupt, R.; Haupt, S.: Practical genetic algorithms. Wiley & Sons, 2004.

[13.] Zebulum R.: Evolutionary Electronics. CRC Press. 2002.

[14.] Lobo, F.; Lima, C.; Michalewicz, Z.: Parameter setting in evolutionary algorithms. Springer-Verlag, Berlin Heidelberg, 2007.

[15.] Phumiphak T. et al.: Estimation of induction motor parameters based on field test coupled with genetic algorithm. Proceedings of 2002 International Conference on Power System Technology PowerCon 2002. Vol. 2, Kunming, China, 1199–1203, Oct. 2002.

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THE INFLUENCE OF DEVELOPMENT AGENCIES ON THE DEVELOPMENT OF LOCAL COMMUNITIES

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Abstract: Development of local communities dependent on the actions of development agencies, and particularly the effects of regional and local development agencies. Percent have data available that are potentially exploitable resources, can directly encourage the establishment of small and micro enterprises, and thereby facilitate and achieve sustainable development in all economic regions and local communities. Therefore it is necessary to form a regional development agency.
Keywords: Development Agencies, small and micro enterprises, local Development

INTRODUCTION

Today, the very presence of the opinion that entrepreneurship and micro, small and medium enterprises , the main and most important factor in solving many problems in ensuring a successful economy and overall economic development. Entrepreneurship and SMEs undoubtedly have great significance in terms of employment, successful business and economic development. To SME sector had a significant role in the development should have a much longer tradition than that of in our area, where the earlier period of little or no importance has been given to entrepreneurship and SMEs. Contemporary theory and practice of development and improvement of SME and their success depends on the financial and non- financial support from institutions, whether governmental or non-governmental organizations.

Republic Agency for Development of Small and Medium Enterprises in the Republic of Srpska was established in accordance with the Law on encouraging the development of small and medium-sized enterprises, and it has began work in September 2004th year. It works as a legal entity and non-profit organizations. The agency provides support to the establishment and development of small and medium sized enterprises in the Republic of Srpska and it is generator of the overall system to support the development of small and medium enterprises.

The main objectives of the Agency are to increase the participation of SMEs in the economy of the Republic of Srpska, changes in the business structure by increasing the share of manufacturing activities and services in the gross domestic product, increased technological development, competitiveness and open new markets for small and medium businesses, increasing the number of businesses and new workers in these enterprises and regional cooperation with neighboring countries in order to exchange experiences and achievement of regional comparative advantages for entrepreneurship.

The Agency has the task of drafting documents on the development of Small and Medium Enterprises of the Republic of Srpska operationally implemented incentive policy, promote employment, vocational training, re-training and re-training of workers, establish and encourage communication return small and medium-sized enterprises, entrepreneurs and their associations with the Government and other institutions in the RS and BiH. Agency should encourage the initiation and development of local development agencies and local centers for business development, assist and coordinate the development of a network of local development agencies and encourage inter-municipal projects, promote entrepreneurship and support business innovator, organize, collect and process legal and other information of interest small and medium-

sized enterprises, the establishment of a single informations system statistical data and information relevant to the small and medium enterprises, to participate in international projects and their implementation, to support initiatives of the private sector and the winder experiences of best practices at all levels.

From the standpoint of supporting entrepreneurship and SMEs, most of the work is, and should remain at the entity level and lower levels, ie. at the level of economic regions and local communities, which have long lead various activities to support SMEs. Shortcomings in the existing legal framework for SMEs are not being adequate infrastructure to support the business, as well as difficult and complicated access to credit. This lead to large obstacle to the development of entrepreneurship and SMEs in RS compared to most other countries in the region.

THE WORLD PRACTICE AND EXPERIENCE OF FOSTERING SMEs AND ENTRENEURSHIP

At the end of the last century, the pursuit of the creation of a large number of SMEs, entrepreneurship has become a significant factor in economic and social development around the world. When it is revealed as a very important state role at the national, regional and local level support the development of entrepreneurship.

Start of establishing institutional networks to provide institutional support to the SME sector, the dates from the eighties, when he noticed the importance of SMEs in the economic reconstruction of the UK. Schematic representation of the possible support network for SMEs is shown in Figure 1 [1].

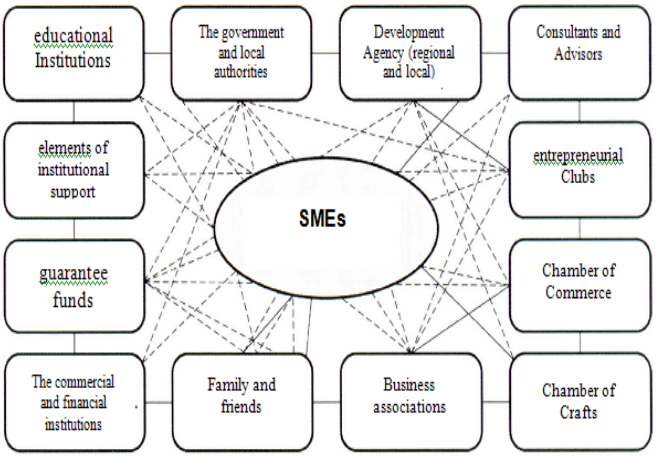

Figure 1. Support Network for SMEs [2]

By organizing the first common policy framework to support SMEs in the EU in 1986. he began to create the Action Programme for SMEs. Measures of the Action Program initiated a number of activities in the elimination of administrative, financial and legal constraints for the operation of SMEs and to encourage cooperation and partnerships for SMEs. Forms of assistance for SMEs: Help for Beginners Business Assistance to existing businesses in the growth and development, particularly in special situations (new products, new markets, innovation, exports, technology transfer, networking and co-operation contract, the placement of financial instruments), and support for existing businesses that found themselves in difficulty[1].

In essence, the structure and form of assistance to small and medium-sized enterprises are varied and depend on many circumstances in the respective country, but it is important to learn the practice of some countries and the need to adjust the observed environment, during the establishment and operation. Also from state to state aid has a variety of programs and performers. Basically these are national, regional and local governments, nonprofit organizations, and commercial providers. Typically, entrepreneurs are not satisfied with the action of institutions for support and assistance. Comments relating to the bureaucracy of the institution, offering abstract knowledge unadjusted needs of entrepreneurs, because they tend to view problems in lack of funding.

SITUATION IN THE REPUBLIC OF SRPSKA FROM THE ASPECT OF SUPPORT TO DEVELOPMENT ENTREPRENEURSHIP & SMEs

In this way the great historical transformation of the former socialist self-management of the economy to a market economy, the state should play a major role. The crucial question that arises for BiH as a whole is a question of the ability to find a balance between the power of decision-makers in government structures and their functions versus the population as a whole, ie. question of striking a balance between the category of authority and responsibility categories.

In this context, if the state promotes regional economic development, the region continues to face the process of their efforts in the promotion and implementation of the development process. At the

same time creating and accountability region to foster not only their local area, but also to create the conditions for future integration process of individual regions of a single economic space, with the aim of improving the quality of life both within individual regions, and the entire area Bosnia. To support the development of small and medium-sized enterprises in the Republic of Srpska gained in importance 2002nd the adoption of the Program of small business development for the period in 2002 - 2005th years, after which he adopted the Law on Promotion of Small and Medium Enterprises SMEs.

The adoption of the Act created the conditions for the legislative, institutional and financial support to this area During the 2004th pursuant to the Act have been established: the Department for SMEs and manufacturing trades in the then Ministry of Economy, Energy and Development and the Republic Agency for Development of Small and Medium Enterprises. At the same time the local establishment local agencies for the development of SMEs so that by 2009 was formed of 18 local agencies, and a number of municipalities have expressed interest in establishing them. Support the development of SMEs at the local level and also provide for the development of municipal departments that together with these institutions form a network to support the development of SMEs. Institutional support to the SME sector is one of the strategic priorities in the overall system of support the SME sector. Looking at the institutional support for the development of the SME sector, we distinguish between two support levels: national and local, The Law on encouraging the development of SMEs, in Article 14 defined by the holders of the Strategy of development of SMEs, some of which are at the level of the most important Ministry of Industry, Energy and Mining and the Republic Agency for SME Development. It is important to note that the Government of the Republic of Srpska late marta 2009. was appointed by the Council for the Development of SMEs and Entrepreneurship of the Republic of Srpska with the principle of focusing on small businesses.

As the process of local economic development taking place within the local government level, and the process of European integration the local level is increasingly more active role in creating a favorable business environment, strengthening institutional support and infrastructure for the management of development processes is gaining in importance.

One of the main activities of local development agencies is that their work considered strategy implemented to encourage the development of SMEs at the national level. However, in practice, it often happens that the local development agency primarily tasked to coordinate and facilitate the process of local economic development overall. The very role of local development agencies stems from the needs of a unit of local government who is the founder of the agency. On the one hand, there are agencies that are highly specialized for specific types of support the SME sector, the agency aimed at the overall development of the municipality and are the main implementers of the overall local development strategies. According to the analysis infrastructure for the management of development processes in the Republic of Srpska there are 18 local development agencies or 28.57% of the total number of local authorities [2].

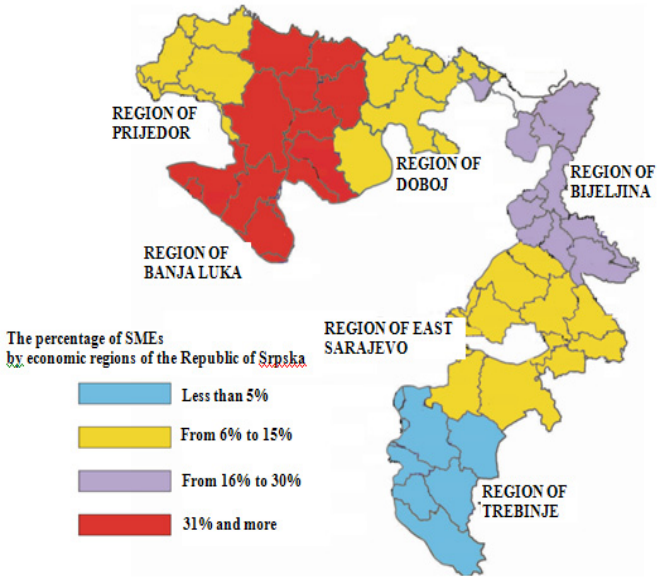

Figure 2. Territorial representation of SMEs by economic regions [2]

Less government units have been formed separate organizational units outside the institutions of local government, but in the very institutions established departments for development, particularly in small and underdeveloped local government exists only report that performs the

role of managing the process of local economic development. Local governments that have this kind of planning institutions to processes of local economic development is 31 or 49.18% of the total number of local government units in the Republic of Srpska [2].

A certain number of units of local government has not developed any form of organization infrastructure for management of development processes, and 15 local government units or 23.84% of the total number of local government units in the Republic of Srpska [2]. Figure 2 shows the territorial representation of SMEs by economic regions.

EMPIRICAL STUDIES INCENTIVES SMEs & ENTREPRENEURSHIP FROM REPUBLIC AGENCY FOR DEVELOPMENT OF SMEs

The research process was carried out in the territory of the Republic of Srpska, which is divided into six economic regions, namely: Banja Luka, Bijeljina, Doboj, Prijedor, East Sarajevo and Trebinje. The research involves the extent to which the Republic Agency SMEs in the Republic of Srpska supports and services to small and medium enterprises and entrepreneurs in different economic regions. The results were relevant municipal services, entrepreneurs, owners of micro, small and medium enterprises in the municipalities in which the research was conducted, and the emphasis was placed on three economic regions: Bijeljina, Trebinje and East Sarajevo.

Selection is based on the fact that these three regions territorially linked, geographically located in the eastern part of the Republic of Srpska, percentage of small and micro enterprises in the total number of SMEs in the RS is lower than in the other three regions, as can be seen from Figure 2, a very small number of local development agencies, which presents relevant business unit in terms of a given study.

RESULTS AND DISCUSSION

The research, conducted in the Republic of Srpska, ie. in its three economic regions: Region Bijeljina Region East Sarajevo and Trebinje region, I came up with an answer to the question: To what extent is represented stimulation of your work by the Republic Agency for SME Development of the Republic of Srpska? The results of the responses given by the surveyed participants in the study are shown in Figure 3.

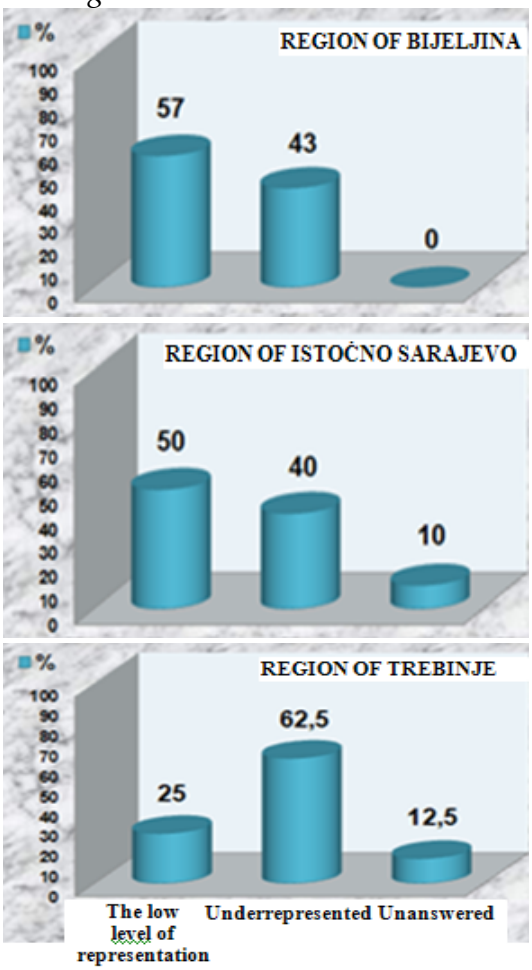

Figure 3. The level of representation of the stimulus SMEs Republic Agency for Development of SMEs [1]

CONCLUSION

Developed countries have identified the importance of regional development agencies and their effective use in terms of improving the living standards, raising the level of environmental protection, as well as increased employment. Regional development requires the use of regional resources and resources as the other Republican Agency is not able to stay up all measures and to manage resources in all regions solely because of the lack of information in terms of potential. RDAs should have strategies and plans for initiating and encouraging SMEs and entrepreneurs in a given region, which will be coordinated with the national level will be realized.

Each region has its own characteristics, in terms of resources and infrastructure, and directing them to be in the direction of achieving the best effect, which is reflected in their efficient use. In the Republic of Srpska gradually creates a favorable

environment for the development of SMEs and entrepreneurship, primarily to strengthen financial support and infrastructure.

Local communities and municipalities, should direct their activities towards the improvement of infrastructure, to harmonize their rules and regulations with institutions of the region and the state work together to provide the best possible environment for start-up and survival of SMEs.

Local government is the holder of shaping the development strategy of the region and the community the municipality and its entrepreneurial advocate. Deliberately encourage the local community to own the development of infrastructure and entrepreneurial potential and attract investments automatic is a concept of regional development. Each of the six economic regions of the Republic of Srpska has its potential for development, including infrastructure, resources used, and potentially exploitable resources, each in its own way in terms of the given potential.

REFERENCES

[1] *Medaković, V., Research of conditions for development of small and micro enterprises and development of entrepreneurial infrastructure model, Doctoral thesis, Faculty of Mechanical Engineering, East Sarajevo, 2012.*

[2] *The Government of the Republic of Srpska: Annual report for the area of small and medium-sized enterprises and craft - entrepreneur activities in the Republic of Srpska 2009th year, 2010.*

[3] *Jojić, R., Božić, R., Preduzetništvo za novi vek, East Sarajevo - Pristina, 1998.*

[4] *Jojić, R.: Management, Institute for Economics and Development, East Sarajevo, 2002*

[5] *Ökmen, M., Özer, B., Bal, V., An Evaluation Of Regional Development Agencies' Roles In Regard To Social Sustainability: A Discussion Of Turkish Development Agencies' Experience, 3rd International Symposium on Sustainable Development, Sarajevo 2012.*

[6] *Petkovic, D, Hadžić, A., Regional development agencies and their role in qualitative macro-economical B&H development, 3rd Scientific Conference with International participation "KVALITET 2003" Zenica, 2003.*

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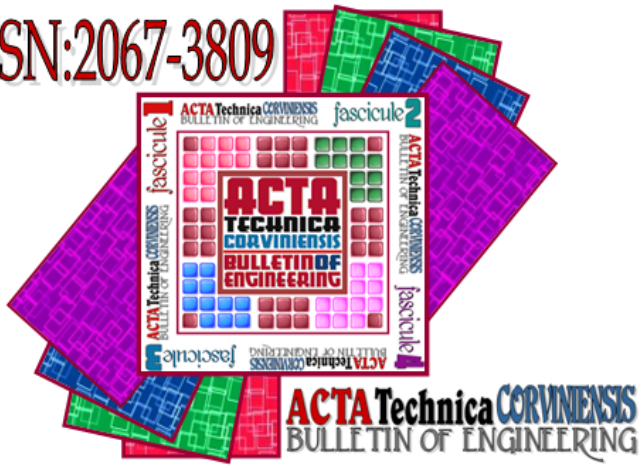

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EFFECT OF HEAT TREATMENT ON HARDNESS AND WEAR RESISTANCE OF A FAILED AUTOMOBILE BRAKE DISC

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Abstract: *In an attempt to improve the wear resistance of a failed automobile brake disc, different type of heat treatment operation was carried out on the samples of the disc. The samples were heated to 840°C 860°C and 880°C in a muffle furnace, and quenched in water, palm oil and air, separately. Water and oil quenched samples were later tempered at 200°C. The chemical composition of the failed brake disc was obtained by an optical emission spectrometer (OES), while the hardness value was measured using Brinell hardness testing machine. The highest Brinell hardness value of 331 BHN was obtained from the water-quenched sample heated to 880°C. The hardness values of the oil-quenched samples surpass that of air-quenched samples. The tempered samples displayed lower hardness values compared with the hardened samples, although the sample heat treated at 880°C, water-quenched and tempered still possesses high hardness value. The reduction in hardness of most of the samples after tempering suggests possible increase in ductility and toughness. As a result of the heat treatment and subsequent quenching, the retained austenite in the samples transforms to martensite, while the ferrite, flakes of graphite, and cementite were restructured. This shows that the brake disc could be hardened and tempered to obtain optimum hardness with improved ductility and toughness. This will result in better wear resistance, increase service life, and thus reduce brake failure and other related transportation hazard.*

Keywords: *Failed brake disc, Cast iron, Microstructure, Hardness Value, Quenching media*

INTRODUCTION

Failure of engineering materials is an undesirable phenomenon that may result from improper design, material selection, processing or misuse among others [1, 2]. A component or part of a system fails when it ceases to perform its designed functions. It could either be in form of fracture or wear of parts, plastic deformation or general corrosion or degradation. Brake system is an important integral part of vehicle that is very hazardous when it fails in service. The failure could lead to accident that can result in economic losses, vehicle damage, human injuries and even death. Brake disc is a wheel assembly designed to slow down the rotation of the wheel by friction caused by pushing brake pads against the disc drum with a set of calipers. Brake disc is usually made of cast iron but could be made of composites such as reinforced carbon-carbon or ceramic matrix composites [3, 4]. Cast iron is an alloy consists mainly of iron and carbon with Si and other alloying elements. The wear resistance and strength of cast iron can be improved by hardening and tempering [5]. Hardening treatment involves heating an alloy or metal samples to a sufficiently high temperature, holding at that temperature prior to rapid cooling or quenching in water, oil or salt baths [5]. This process will result into high hardness value, better wear resistance and improved strength. However, in order to relieve the internal stresses, and improved ductility and toughness, it is critical to temper the hardened samples. The investigated brake disc sample was observed to have become thinner compared with the un-used sample, prior to fracture. This indicates that the brake may have failed due to excessive wear. Hence, there is need to improve the wear resistance of the automobile brake disc in order to increase their service life. In this present study, hardening and tempering heat treatment have been used as methods of improving the wear resistance of the failed brake disc specimens. Different heating

and quenching regimes using water, oil and air are employed, and the wear behaviour of the quenched and tempered specimens are explained in terms of changes in hardness after the heat treatments and microstructure of the specimens.

EXPERIMENTAL PROCEDURES

The chemical composition of the failed brake disc sample used for this investigation was obtained using an optical emission spectrometer and the result is presented in Table 1.

Test Specimen Preparation

Fifteen (15) test pieces were prepared for hardness tests and microstructural analyses after heat treatment operations were done on the as-received sample. The test pieces were ground with SiC paper of different grit sizes prior to polishing to 1 µm diamond suspension finish. After polishing, the test pieces were cleaned ultrasonically in acetone, then alcohol, and immediately dried.

Heat Treatment Operation

The test pieces were heated to 840°C, 860°C and 880°C in a muffle furnace, and then quickly taken out of the furnace, and then quenched in water, palm oil and air, separately. The water- and oil-quenched samples were tempered at 200°C to remove the internal stresses and restore ductility. Surface morphologies of the as-received, quenched and tempered samples were examined with optical microscopy, and the hardness tests were also carried out using brinell hardness tester.

Hardness Test

Brinell hardness tester under a static load of 3000kg (29.43KN) with a ball indenter of 10mm diameter was used for the determination of the hardness of the test specimens. Each of the test specimens was flatten after the different heating and quenching regimes, and then mounted on the anvil. The specimens were brought in contact with the ball indenter at a dwell time of 10 to 15 seconds. The hardness of the specimen was determined from the diameter of the resulting impression, which was measured with the aid of a calibrated microscope according to BS240 and ASTME 10-84 standard.

Microstructural examination

The microstructure of the test specimens before and after heat treatment was observed with an optical microscopy. Prior to examination, both the as-received and the heat treated specimens were prepared for metallographic examination.

RESULTS AND DISCUSSION

Table 1 shows the chemical composition of the failed brake disc. Carbon is about 3.39 wt%, while silicon is about 2.74 wt% indicating that the sample is a greycast iron [5]. Apart from the brittle nature of grey cast irons, they are also susceptible to failure due to external forces, internal pressure, errors or flaws due to fabrication, and corrosion damage [6, 7]. Most of the carbon in grey cast iron is present in the form of continuous network of flake graphite platelets, which are dispersed throughout the metal matrix. This metal matrix controls the mechanical properties of grey cast irons, and also contributes to their relative weakness and lack of ductility [8]. Strength and ductility of grey cast irons could be increased through hardening and tempering operation at appropriate austenitizing temperatures [5]. This will improve the service-life of the grey cast iron components in automobile and other equipment.

Table 1. Chemical composition of the brake disc (wt.%).

Element	Composition (wt.%)	Element	Composition (wt.%)
C	3.39	Cu	0.027
Si	2.74	W	0.001
S	0.004	Ti	0.170
P	0.011	Sn	0.006
Mn	0.24	Co	0.002
Ni	0.012	Al	0.013
Cr	0.035	Nb	0.001
Mo	0.007	Mg	0.038
V	0.004	Fe	93.30

The hardness of the quenched and tempered specimens (Figures 1 and 2) were higher compared with the as-received specimen, with hardness value of 159 HBN. The hardness values increased with increased heating temperature with highest hardness of 331 HBR at 880°C obtained from the water-quenched specimen. This was followed by oil-quenched (220 HBR) and then air cooled (197 HBR) specimens heat treated at 880°C. The hardness value of the water-quenched sample also corresponds to the microstructural changes of austenite in the as-received to martensite. The hardness values of the tempered samples decreased compared with the un-tempered samples, indicating possible increase in ductility and

toughness. The presence of silicon in the cast iron reduces the solubility of carbon in austenite. Increase in austenitizing temperature increased the amount of carbon in solution [9], and subsequently give rise to higher hardness value as exhibited in water–quenched specimens at 880°C.

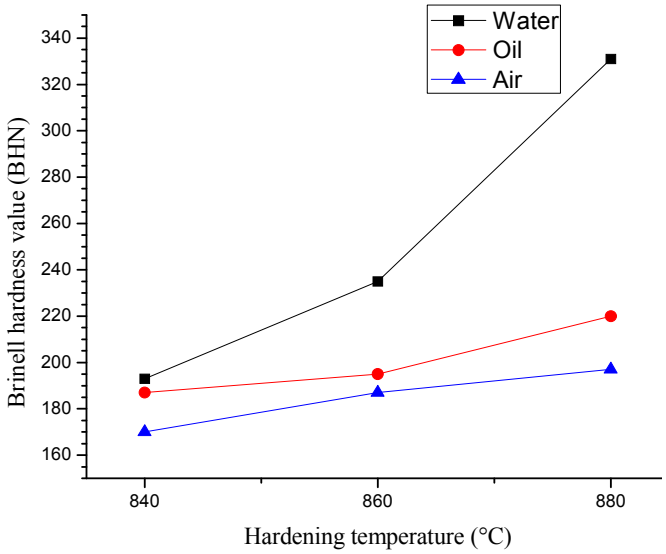

Figure 1: The hardness values of the samples quenched in different media (water, oil and air).

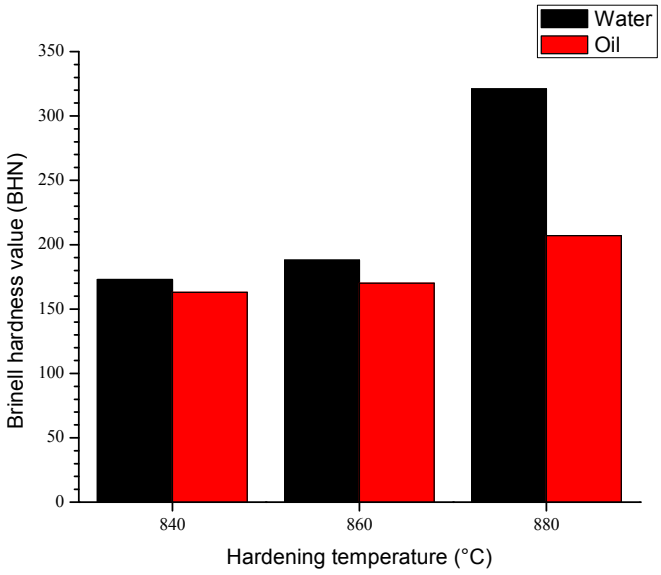

Figure 2: The hardness values (HBN) of the tempered specimens after quenching in water and oil.

MICROSTRUCTURE

Figure 3a is the optical micrograph of the as-received failed brake disc, which shows the presence of austenite, ferrite, cementite and flakes of graphite. The microstructure of the water quenched specimen (Figure 3b) revealed the presence of finely-dispersed ferrite with dendritic tempered martensite phase in a matrix of eutectic carbides, which gave rise to the high hardness value of water-quenched specimens. However, similar microstructure was observed in oil quenched (Figure 3c) specimens with the ferrite not finely dispersed compared to the water-queched specimen, but were mainly found along the grain boundaries. The amount of tempered martensite phase in a matrix of eutectic carbides was less in both the oil quenched and air cooled specimens (Figure 3d) when compared with the water quenched specimens. During tempering, there was growth of small carbide embedded in a ferritic matrix along with the transformation of retained austenite into martensite. The microstructure of tempered martensite consisted of extremely small and uniformly dispersed cementite particles embedded within a continuous matrix which may be nearly as hard and strong as martensite, but with substantially enhanced ductility and toughness [1, 10].

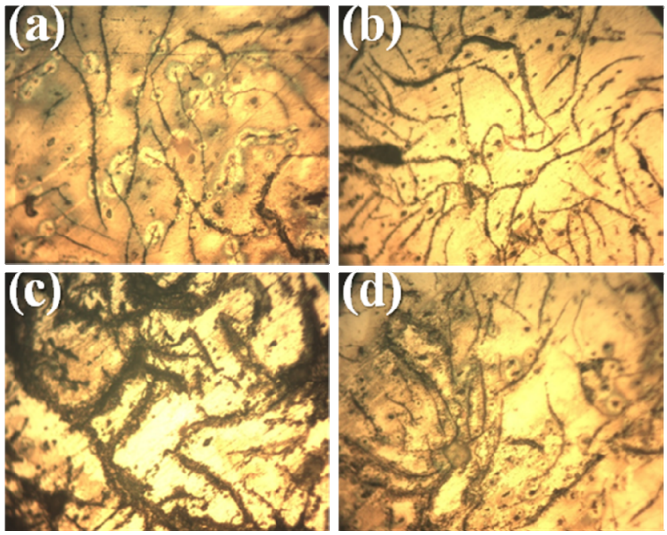

Figure 3: Optical micrographs showing microstructure before and after heat treatment at 880°C and quenching in: (a) As-received; (b) Water-quenched; (c) Oil quenched; (d) Air-quenched

Figures 4a and 4b are micrographs of water and oil quenched and tempered specimens, which show part of austenite matrix formed transformed into martensite and tempered martensite with the presence of cementite which influenced the hardness of heat–treated specimens. In the course of the heat treatment, the austentizing temperature, cooling rate and quenching media usually contribute to the precipitation of small carbide and formation of more uniform refined martensite of the heat–treated alloys. In addition, the presence of higher silicon content in cast –iron

gave rise to greater degree of decomposition of the cementite and coarse flakes of graphite produced [1, 5]. The effect of rapid cooling of water–quenched (tempered) specimens ensured the formation of tempered martensite, indicating significant improvement in toughness and ductility without sacrificing the high hardness value. Thus, from the results, it is proposed that heat treatment should be carried out at 880°C with appropriate quenching and tempering, to improve the wear resistance and toughness of the brake disc.

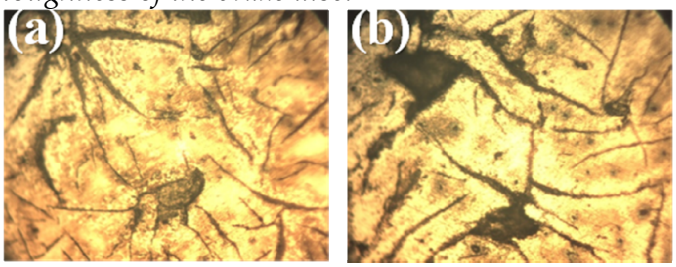

Figure 4: Optical micrographs showing microstructure after hardeningt at 880°C and tempered in: (a) Water-tempered; (b) Oil quenched

CONCLUSION

The hardness values of the failed brake disc specimens have been increased through the use of a quenching medium such as water, oil and air from 159 HBR in the as-received condition to a value in the range of 163-331 HBR depending on the quenching medium used. However, the hardness values of the quenched specimens decreased after tempering indicating improved toughness and ductility. The high hardness value of tempered water quenched specimen at 880°C is believed to indicate improved wear resistance. The tempered specimens also displayed improved microstructure than the quenched samples. Hence, water quenching and tempering of heat treated brake disc sample will improve its service performance, and thus safeguide the life of road users.

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REFERENCES

[1.] *William, D.C. Material Science and Engineering an Introduction, 6th Ed. Sanat Printers, Kundli, Haryana, 2006.*

[2.] *Vijendra, S (Physical Metallurgy for Degree, 1st Ed., Standard Publisher Distributors, Delhi, 1999.*

[3.] *Kalpakjian, S and Schmid, S.R. Manufacturing Process for Engineering Materials, 4th Ed., Pearson Education Inc. Hong Kong, 2003.*

[4.] *Barbarossa, F., and Bono, G.S. The Car Care Book, 2nd Ed., Delmar Publisher Inc, 1988.*

[5.] *Rajan, T.V: Sharma, C.P.; and Sharma, A. Heat Treatment -Principles and Techniques. Prentice-Hall of India Private Limited, New Delhi, India, 1988.*

[6.] *Morris, Jr., R.E., Principal Causes and Remedies of Water Main Breaks, Journal of the American Water Works Association, vol. 59, no. 7, p. 782, 1967.*

[7.] *Rajani, B., Zhan, C. and Kuraoka, S., Pipe-soil interaction analysis of jointed water mains, Canadian Geotechnical Journal, Vol. 33, No. 3., 1996.*

[8.] *Degarmo, E. Paul; Black, J T.; Kohser, Ronald A. Materials and Processes in Manufacturing (9th Ed.), Wiley Interscience, U.S.A, 2003. ISBN 0-471-65653-4*

[9.] *Elliot, R. Cast Iron Technology, Butterworth, U.K, 1988.*

[10.] *John, V.B. Introduction to engineering materials, Macmillan Education, United Kingdom, 1992.*

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WIRELESS SENSOR NETWORKS IN AIRCRAFT DESIGN AND STRUCTURAL HEALTH MONITORING

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Abstract: *Aircraft industry faces many challenges to reduce both operational and maintenance cost. One of the possible ways for reducing these costs is the introduction of wireless sensor networks (WSNs). WSNs are already finding a variety of applications for both safety-critical and non-safety critical distributed systems. This paper deals with the application of WSNs for aircraft structural health monitoring. Special attention has been given to the WSNs design issues using available components on the market.*
Keywords: *Wireless sensor networks, aircraft structural health monitoring, micro-electro-mechanical systems, condition-based maintenance, sensor node*

INTRODUCTION

The weight of an aircraft directly impacts the operational cost. At present, a pound saving in aircraft weight translates to $100 savings per year per aircraft. Many innovations have in aircraft industry towards weight reduction. The percentage of composite, hybrid materials and advanced aluminum alloys in airframe have increased substantially over the years realizing significant weight benefits. However, full potential of composites, hybrids and advanced aluminum alloys, as substantial reduction in material allowable, are yet to be realized due to still prevailing conservative design philosophy. It is essential to increase the confidence in assessing fatigue, crack/delamination identification/growth and damage tolerance characteristics of these advanced materials. This will help in reducing conservatism built in current aircraft structural design leading to realization of slender aircraft airframe structures.

Over the last decade Wireless Sensor Networks (WSNs) have been successfully applied in many engineering fields such as: structural health monitoring (SHM), industrial applications, environmental monitoring, traffic controls, health applications, etc. This paper deals with application of WSNs for aircraft structural health monitoring.

STRUCTURAL HEALTH MONITORING

Generally speaking, the aim of structural health monitoring (SHM) is to monitor structures using embedded or attached non-destructive evaluation sensors and to utilize the data in order to assess the state of the structure. Often structures equipped with various types of sensors are compared to human nervous system as shown on the Figure 1. In the other words, Structural Health Monitoring is the imitation of the human nervous system. Having detecting the damage by the sensors embedded in the structure, the central processor, as a human brain, can build a diagnosis and decide what kind of actions have to be done.

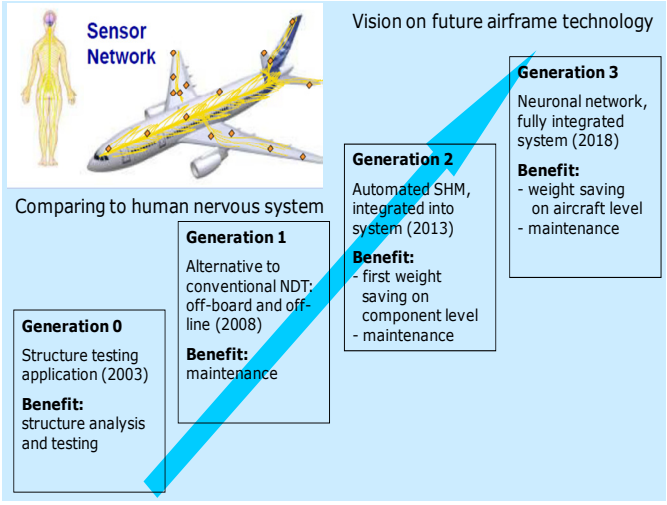

Figure 1. SHM application in Airbus

The Figure 1 presents a stepwise approach towards SHM application in Airbus. As we can see, the automated SHM will be integrated into system in 2013. The company expects to establish a fully integrated system in 2018.

SHM is a new and improved way to make a non-destructive evaluation with a minimum of manual intervention. It includes all monitoring aspects which are related to damages, loads and conditions, which have a direct influence on the structure. Knowing the integrity of in-service structures on a continuous real-time basis is a very important objective for manufacturers, end-users and maintenance teams. Structural health monitoring allows an optimal use of the structure, a minimized downtime, and the avoidance of catastrophic failures. Therefore, structural health monitoring drastically changes the work organization of maintenance services: by aiming to replace scheduled and periodic maintenance inspection with condition-based maintenance and by drastically minimizing the human involvement, and thus improving safety and reliability.

Traditionally, the sensors deployed on the structure are connected through coaxial wires. WSNs consistently reduce the installation and maintenance costs. Furthermore, the compact size and low cost of a single wireless sensor node enables the deployment of a large number of units on the monitored structure, especially in those locations difficult to be reached by wires, increasing the screening resolution of the system.

In the commercial and military aircraft there are a number of safety-critical and non-safety critical systems. These systems are based on wired connections and, therefore, they are complex and difficult to route. The Airbus A380, for instance, has over 300 miles of cables consisting of approximately 98.000 wires and 40.000 connectors. Replacement of the current wire harness-based sensors with a wireless sensor network (WSN) can help to achieve the goal of increasing the number of sensors, as well as, the system redundancy.

WIRELESS SENSOR NETWORKS TECHNOLOGY

Wireless network refers to any type of computer network which is not connected by cables. Wireless sensor networks (WSNs) consist of spatially distributed autonomous sensors designed to monitor physical parameters or environmental conditions, such as temperature, strain, pressure, vibration, sound, motion, pollutions, etc. Consequently, the sensors cooperatively pass their data through the network to a main location. The base station may communicate with the user or task manager node via Internet or Satellite. A wireless sensor, also known as a mote (reMOTE), smart dust, smart sensor or sensor node within the network performs the function of sensing, data processing and wireless data transmission. It is powered by an individual power source which often consists of a battery with a limited energy budget.

The development of WSNs largely depends on the availability of low-cost and low-power hardware and software platforms for sensor networks. With the micro-electro-mechanical system (MEMS) technology, the size and cost of a sensor node have been significantly reduced.

The nodes communicate wirelessly and often self-organize after being deployed in ad hoc fashion. Systems of 1000s or even 10.000 nodes are anticipated.

A sensor node typically consists of five main components (Figure 2). One or more sensors gather data from the environment and report the data to the microprocessor. A microprocessor is a central part of a wireless sensor node. It processes all the data that receives from memory, sensor, or transceiver. A transceiver communicates with the environment. It is used radio frequency (RF) as a transmission medium to send data wirelessly. The transceiver can take data from a microprocessor to send it over the air and vice versa. A memory is the main resource for storing programmes and intermediate data coming from the sensors or the transceiver. The size of the memory depends on the application of the sensor. The battery supplies all parts with energy. To assure a sufficiently long network lifetime, energy efficiency in all parts of the network is crucial. Although most sensors have a traditional battery, there is an early stage research regarding production of sensors without batteries, using similar technologies applied to passive radio frequency identification (RFID) chips without batteries. The sensor nodes are usually

scattered in a sensor field. Each of them has the capabilities to collect data and route data back to the base station.

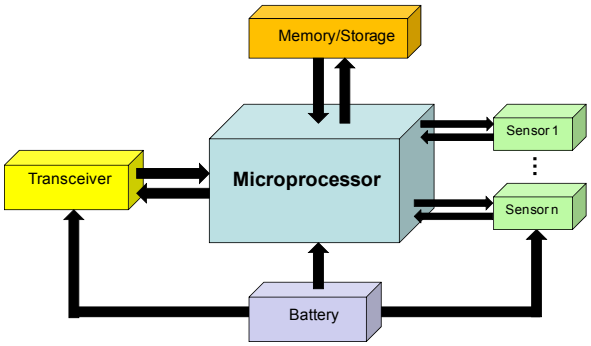

Figure 2. Hardware components of a sensor node

WIRELESS SENSOR NETWORKS DESIGN ISSUES USING AVAILABLE COMPONENTS ON THE MARKET

A well known USA company MicroStrain has deployed wireless sensors and wireless sensor gateways for a number of applications. Sensors that measure strain, acceleration, displacement, pressure, temperature, inertial loads, and torques have been combined in time synchronized networks to provide a rich amount of information for improved condition based maintenance. Sensors can be quickly deployed in discrete locations of the aircraft structure. With highly synchronized data sampling, and extended range communication, MicroStrains's WSN's are able to collect and aggregate data in a single database, and push it to the cloud for remote access.

The main features of the Lossless Extended Range Synchronized (LXRS) wireless sensor systems are as follows:

- *Losless wireless communications protocols provide 100 % packet success rate*
- *Extended Range radio link to 2 kilometers*
- *Scalable wireless sensor networks support continues, burst, and hybrid sampling modes*
- *Time Synchronized to +/-32 microseconds.*

The LXRS Wireless Sensing System works by leveraging advanced bi-directional radio communications protocols. When data are received without errors by the wireless sensor data aggregator (WSDA) base station, the WSDA sends an acknowledgement that these packets were received. Data that are not acknowledged remain within each LXRS sensor node's non-volatile memory for re-transmission according to the network scheduler. It has to be noted that data are time-stamped by each node at the time of analog-to-digital (A/D) conversion. Therefore, even when re-transmitted, all data are accurately time stamped.

Wireless accelerometer node

Wireless Accelerometer Node (The G-Link -LXRS) presented in Figure 3 features on-board triaxial ±2 g or ± 10 g MEMS (Micro-Electro-Mechanical Systems) accelerometers and an internal temperature sensor. G-Link -LXRS can be employed to measure vibration or acceleration, or as a tilt sensor or inclinometer. The G-Link -LXRS is compatible with any WSDA - Base, WSDA - 1000 or SensorCloud. At the heart of MicroStrain's LXRS Lossless Data Wireless Sensor Networks are WSDA (Wireless Sensor Data Aggregator) gateways, which use exclusive beaconing protocols to synchronize precision timekeepers within each sensor node in the network.

Figure 3. Wireless Accelerometer Node

The WSDA - 1000 Wireless Sensor Data Aggregator

The Wireless Sensor Data Aggregator (WSDA - 1000) presented in the Figure 4 is a single-board computer with Ethernet connectivity designed to operate as an integral part of MicroStrain LXRS Wireless Sensor Networks. The WSDA - 1000 is capable of collecting lossless data from a wide range of MicroStrain wireless sensor nodes operating in LDC or Synchronized sampling mode.

Figure 4. WSDA (Wireless Sensor Data Aggregator) – 1000

The general features and benefits of the WSDA - 1000 Wireless Sensor Data Aggregator are the following:

- *Programmable communication range from 70 m to 2.000 m*
- *Time Synchronized to +/-32 microseconds.*
- *2 GB non-volatile embedded flash for local storage*
- *Command, control, and monitoring of a remote wireless sensor network from user PC*
- *Full industrial temperature range supported (-40º C to 85º C)*

CONCLUSION

The aircraft industry will greatly benefit from the use of WSNs. These benefits through weight savings, reduction in subsystems design complexity and improved condition based maintenance will directly benefit the airlines in terms of additional revenues, as well as, lower operational and maintenance costs. Nevertheless, using wireless technology gives the potential to lead to more efficient future aircraft designs and quicker time-to-market.

Wireless Sensor Networks, based on some components available on the market, can be applied for aircraft structural health monitoring. The user has to choose the type of sensors which wants to apply. Sensors can be quickly deployed in discrete locations of the aircraft structure. As mentioned, the MicroStrains's sensing systems are ideal for both small scale applications requiring a few sensor nodes and large scale applications requiring hundreds of sensor nodes. Wireless sensor nodes are able to collect and aggregate data in a single database, and push it to the cloud for remote access.

REFERENCES

[1.] *Rama K.Y., Rohit K.K. (2011). Application of wireless sensor networks to aircraft control and health management systems, J Control Theory Appl, 9 (1), p. 28–33*

[2.] *Stankunas J., Rudinskas D., Lasauskas E. (2011). Experimental Research of Wireless Sensor Network Application in Aviation, Electronics and electrical Engineering, ISSN 1392 – 1215 2011. No. 5(111), p. 41-44*

[3.] *Vujic, D., (2011). Recent trends in structural health monitoring of aircraft, OTEH 2011 Conference Proceedings, ISBN 978-86-81123-50-8, p. 53-158.*

[4.] *Vujic, D., Stojic, R., Filipovic, Z., (2012). Wireless sensor networks technology in aircraft structural health monitoring, OTEH 2012Conference Proceedings, ISBN 978-86-81123-58-4, p. 139-145.*

[5.] *Vujic, D., (2011). Structural health management of complex engineering structures, HEAVY MACHINERY – HM 2011 Conference Proceedings, ISBN 978-86-82631-58-3, p. 37-42.*

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DATA PROTECTION IN MICROCOMPUTER SYSTEMS AND NETWORKS

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Abstract: The possibilities and ways for data protection in microcomputer systems and their networks are considered and described in the paper. The overview of the most important threats and attacks on security of microcomputer systems and networks is given first. Then, the possibilities and ways for protection of those systems and data are described. Finally, the paper provides a detailed description of one actual practically implemented system of cryptographic protection of data on personal computers which represents the combination of hardware and software protection.
Keywords: microcomputer system, data protection, security of data and systems, attacks and threats on security, hardware protection, software protection, cryptography

INTRODUCTION

Safety or security od the microcomputer systems, information systems, software, generally speaking user data is one of the most important and the most present problems in computer technology and computer industry. The most important issue is how to secure the data from unauthorized use. Computers, dominantly microcomputer systems are used in almost all spheres of human life, from private to the business. Since existing computer systems, there are people who want to violate their security what at the end leads to damage and loss of user data. The first step in computer and network security is to formulate a realistic assessment of threats to the system. It should have a clear picture of the dangers in order to prepare defense [1].

Safety or security can be defined as the degree of protection from some danger, damage, loss, etc. In security and protection of microcomputer systems and network several principles are now established as the basic postulates:

- Security is a process, not a product, service or procedure but contains them with a lot of elements and measures which is carried out continuously.
- There is no absolute security or absolutely protected systems.
- With the different methods of protection it should have in mind the human factor with all the weaknesses [2].

ATTACKS AND THREATS ON SECURITY OF MICROCOMPUTER SYSTEMS & NETWORKS

Classification of attacks & threats to security

There are several threats to computer and information systems. According to the classification by NIST (National Institute of Standards and Technology) threats to computer and information systems can by divided into [3]: errors and failures, fraud and theft, sabotage by employees, loss of physical and infrastructural support, hackers, malicious software (malware) and threats to user privacy.

Types of attacks & threats to security

In order to adequately assess the security needs of an organization and pick an efficient way to select security products, policies, procedures and solutions, each manager in a company who is in charge of security, must have systematic way of defining requirements about security and one categorized approach, which ensures that these requirements are met. One approach is to consider the following aspects of information security and data [4]:

- Security attack - Any action that endangers the security of information.
- Security mechanism - The mechanism that detects an attack and that the system recovers from the attack.
- Security service - A service that enhances the security of the system for processing and transmitting data. Security service includes the use of one or more security mechanisms [4].

In fact, attacks may be defined as actions that are aimed at endangering the security of information and computer systems and networks. There are several kinds of attacks that can be classified into following four categories: interruption (an attack on availability), interception (an attack on confidentiality), modification (an attack on integrity) and fabrication (an attack on authenticity) [4].

Threats can be classified into passive and active. Passive does not directly affect the behavior of the system, while active can affect the behavior and functioning of the system. Passive attacks refer to eavesdropping and surveillance, tracking information, but without modification. Active attacks made changes to the content or information flow. Passive would be the disclosure of message content and traffic analysis. Active include masking, spoofing, replay - repeat network traffic, modification of message content and denial of service.

The most important attacks and threats are: Denial of service (DoS attack), Buffer overflow attack, Malicious programs (Malware) – Viruses, Worms, Trojan Horse, Spyware, Adware, Backdoor, Rootkit, Bootkit, Spoofing, Phishing, Sniffing and so on.

METHODS OF DATA PROTECTION IN MICROCOMPUTER SYSTEMS & NETWORKS

There are several approaches and division for methods of protection. According to some authors, there are four groups of protection methods that include: cryptographic methods, programming methods, organizational methods and physical methods [4]. Many authors consider this division outdated and use schemas based on ten domain of security defined by the organization (ISC)² (International Information Systems Security CertificationConsortium).

Among the most important methods of protection systems are included: cryptography, backup, antivirus solutions, antibootkit and antispyware, firewall, digital signature techniques, methods of protection against DoS attacks, the security services in the TCP/IP model (IPSec protocol, SSL/TLS protocol), IDS, IPS, SIEM systems, using the hardware key or dongle and so on.

DESCRIPTION OF PRACTICAL IMPLEMENTATION OF DATA PROTECTION SYSTEM ON PERSONAL COMPUTERS

Practical implementation of system for data protection on personal computers (PC) that is described here involves a program that performs encryption of user data. The program was developed in the Java programming language. This solution enables protection of any data (any document) from the computer using variety of cryptographic methods. It also uses hardware protection of the program from unauthorized use.

The hardware protection is implemented using USB memory device (stick) or USB flash drive. USB flash stick is very inexpensive, and allows storage of large quantity of data. The USB memory is used as a hardware key for the program. Therefore, the solution combines hardware and software protection. Program is intended for using on standard PC computers under Windows operating system. But, with some modifications it could be used on other operating systems. Its main advantages are simplicity, ease of use, low price and immediate protection level of user data, especially for applications that do not require a very high level of security. For conventional applications and less demanding users this solution represents simple, cheap and effective way of protection.

Using this solution any important file (document) on a PC can be encrypted. Thus obtained encrypted file is stored on PC and it can be sent over a network without concerning for its safety. It is impossible for someone else to unauthorized uses that file or any king of data encrypted with this program. Only after decryption process this data can be used.

The functioning of the program and its using is reflected in the following. When starting the program first appears welcome message which indicates that the program is running. After that, it is necessary to put USB flash stick into the USB port of a PC computer. For security reasons, it has no notes or indications for this step, but the user knows that it is a step that needs to be done. When the USB flash drive is in the USB port starting security checks defined in program. These checks include comparing XML files, one that is on the USB flash drive and another on a hidden location

on the computer. This file on computer is on secret location on HDD in order to prevent its locating and modification. Next check is existence of a hidden file (text file - .txt) on USB stick that is digitally signed, and elements of digital signature are at different locations on the USB flash stick and the computer. Very important is the way in which the program is connected to the USB flash stick and PC on which it is used. It is checking of serial number of USB flash stick and serial number of PC motherboard. In this way it is restricted using of program only with certain USB flash stick and on certain PC to protect program against unauthorized use. If any of these checks is not passed the program will not work and cannot be used. If all is well, if all checks passed, the next think is to input username and password. Passwords are stored using a hash function, using the SHA-1, with SALT supplement. Three wrong entries will result in deleting the XML file that is located in a hidden location on PC and thus all the checks will not be met and the program will no longer be operational. Implementation of the program on a PC can be accomplished in several ways. The first way is jar format on a computer. By clicking on it the program will run. Another way is to run executable file (.exe). Third, perhaps the most convenient way for the user is installation, which is identical to the standard installation program under Windows operating system. Clicking on the Install icon will open a box, and follow installation procedure.

After installation of the program its icon appears on the desktop as well as supporting documents in the Start menu. Clicking on the program icon it runs and begins with defined checks as previously described. If everything is correct, all the checks are met, it will open a login form as in Figure 1.

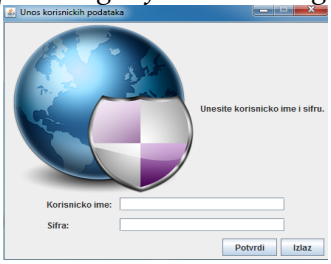

Figure 1. Login form

After entering correct user data (username and password) opens the main box as in Figure 2. Three incorrect inputs of user data result with overwriting one of XML file and program can't be used until program owner reinstall the program. Below is given code that is part of login method (loginMetoda) in class Login form, and after that the main box opens when entered the correct user data.

```
public Boolean login Metoda (String userTekst, String password) {
Boolean is Autorizovano = false;
String salted Password = SALT + password;
String hashed Password = generate Hash (salted Password);
String stored Password Hash = DB.get(userTekst);
If (hashedPassword.equals(storedPasswordHash)){
  isAutorizovano = true;
 }else{
  isAutorizovano = false;
 }
 return isAutorizovano;
}
```

The main dialog frame contains six buttons that allow selection of various methods for protection data. Follows a description of all methods.

Document protection

Document protection allows protection of any document from computer. It is used symmetric cryptography where the same key is used for encryption and decryption of data. The procedure includes selecting a file (document) for encrypt/decrypt from PC.

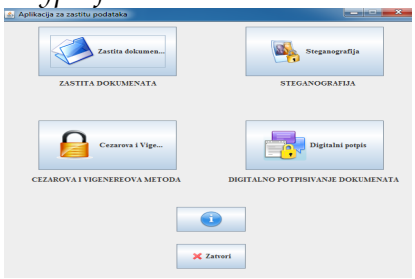

Figure 2. The main frame of the program

After selecting the file automatically is generated a key that is added to the document and then is necessary to enter desired name and extension under which document is stored on PC. In this way the document is protected and can be sent over a network or other form of distribution. If someone wishes to perform decryption the procedure is similar. It is necessary to select desired document from PC and then enter name and original extension of document, and key (the same that is used for encryption). In this way is performed decryption of document. The key is created

randomly in the range of numbers that cover the type Int. Any other key except the one with which is executed an encryption will result in a failed decryption. Figure 3 shows the framework for working with this part of the program.

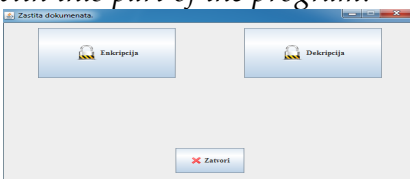

Figure 3. Document protection

Steganography

Great expansion of social networking and image sharing across the Internet, is led to idea of integration this type of protection. Idea is to hide a some text in an image. On a very simple way enters the text, loads an image in which want to hide the text, save it on PC, and procedure is done. Here it is used the principle of LSB (Least Significant Bit) where the least significant bit is substituted with bit of secret message.

Caesar Cipher and Vigenère Cipher

These two methods are widely used in the world of cryptography. They are integrated into the program for simplicity and fast encryption of short messages. Caesar cipher is one of the oldest methods where the letter of the text for encryption is changed with the appropriate letter. Vigenère cipher use series of Caesar ciphers based on key letters.

Digital signature

Digital signature is widely used in computer security. It is used for authentication of information. Its main purpose is the protection of author of the message, document or some other file from the possibility that someone else sends, published or otherwise. It ensures the authenticity, integrity, and secured recognition. Due to the increasing number of messages that are sent through the Internet, and often contain documents that are very important to the user, it is integrated into a program. Selecting this option in programs main box the user is in ability to generate and verifies digital signature of some document.

CONCLUSION

Safety or security of the computer, dominant microcomputer systems and information systems is one of the important issue of computer sciences. From this aspect, it is always necessary to carefully evaluate the relationship between investments in security and achieved effects. Here are analyzed the most important attacks and threats to the safety. Also are described best-known principles and methods of system protection, various aspects of protection and the most important methods of protection such as cryptography, firewall, digital signature techniques and security services in the TCP/IP model.

Presented practical example of protection implemented on PCs combines hardware and software protection. Software part of protection is realized in Java programming language. It combines different methods and performs cryptographic protection of desired documents from PC. As hardware part of protection is a standard USB flash stick. It contains information for specific user who is working with program. Without this USB flash stick the program cannot be used. Practically implemented system of protection is relatively simple and inexpensive, and allows obtaining medium level of protection. It uses a standard USB flash stick that is inexpensive and whose price is dropping. However, large capacity of USB flash stick allows to store large amount of data, related to a specific user, specific computer, computer network or any other. Described solution is flexible and can be easily customized for using on other operating systems with other methods of encryption.

REFERENCES

[1] *C. Easttom: „Computer security fundamentals“, Second edition, Pearson, 2012.*
[2] *http://de.napravisajt.com/web-server-administracija/sigurnosti-linux-mreza-i-servera.html*
[3] *„Sigurnosna politika“, CARNet CERT, Dokument CCERT-PUBDOC-2009-05-265 http://www.cert.hr/sites/default/files/CCERT-PUBDOC-2009-05-265.pdf*
[4] *http://mikroknjiga.rs/Knjige/SRSM/01_SRSM.pdf*

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RFID AS A MODERN BRAND PROTECTION TECHNOLOGY

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Abstract: *In this paper we will present the newest achievements using RFID (Radio Frequency Identification) technology in relation to brand protection in today's industry. At the beginning, our presentation of the paper will go to the explanation of RFID technology as a modern industrial concept and later moved on the details about brand protection in manufacturing. Today, machine builders around the world put great emphasis and at the same time devote attention on the quality of their products such as machine uptime, productivity so flexibility is important selling detail. RFID solutions can make big contributions and provide valuable scale compared to reverse-engineered copies from low-quality competitors which produce cheap spare parts or simply parts.*
Keywords: *RFID, brand protection, machine builders, part builders*

INTRODUCTION

To start, RFID stands for Radio Frequency Identification. RFID is a suite of technologies that includes "tags" which get applied to items that need to be tracked, "readers" or "interrogators" that scan the tags nearby for their data, and a series of integration technologies that link the readers back to central databases and systems that track the data being scanned [1].

An RFID tag is based on a chip or integrated circuit (IC) usually composed of silicon. A tag insert or inlay is the IC attached to an antenna, which is usually printed or etched on a substrate material. The tag itself is the inlay plus its encapsulated protective packaging. The packaging can be flexible or stiff, as the application warrants.

An RFID system typically consists of a radio-enabled device that communicates with or "interrogates" a tag or label, which is embedded with a single chip processor and an antenna. The "interrogator" or RFID reader may be a fixed antenna or it may be portable, like a bar code scanner. The tag itself is an extension of the bar code labels you see everywhere today, but with more intelligence. The advantage of these more intelligent systems is that, unlike barcode tracking systems, an RFID system can read the information on a tag without requiring line of sight or a particular orientation. This means that RFID systems can be largely automated, reducing the need for manual scanning.

In the back end of the system, a host computer stores all collected data within a database. Since RFID tags can also carry data, tags can serve as data transfer agents, synchronizing disparate information systems. Tags may carry a product's history or genealogy, and may interact and communicate with manufacturing production systems for increased automation and process error proofing. The tags can either be Read Only (RO) or Read/Write (R/W) capable. There are two types of RFID tag: active and passive [1].

Active*: Battery powered, Read-write and read only versions available, Longer read ranges (10 to 130 feet), Higher tag costs ($10 to $1000 per tag), 2D location systems possible. Example: toll booths or railroad car tracking. Active Tags will broadcast all the time or sit waiting for a request from a reader to blast its signal, Figure 1.*

Passive*: Powered by reader, Read-write and read only versions available, Shorter read ranges, Lower tag costs (Less than $1 per tag), Item ID. Example: item management. A properly calibrated reader being place within range of the tag and collecting the data within the signal activates passive tags, Figure 1.*

Figure 1. RFID working units in practice using

RFID AND BRAND PROTECTION

Worldwide brand theft is costing companies more than $400 billion annually in revenues and is growing at an alarming rate of up to 15% a year. The World Health Organization (WHO) estimates that 10% of the global drug market is made up of fake products in fake packages. Not only does counterfeiting lead to revenue loss and brand defamation, it undermines security, placing consumers directly in harm's way.

RFID tags or chips allow brand owners, packagers and retailers to "talk" to their products from the beginning to the end of the supply chain. Tags can contain a range of information about a product, including manufacturing and packaging facility locations, packaging line runs, date codes, product ingredients, packaging supplier data and logos. Tags can be sandwiched between layers of plastic or paperboard used for packaging and paper or film used for labels. RFID readers are then placed all along the supply chain, following a product and its package ensuring its authenticity and safety [2].

However, one of RFID's major stumbling blocks has been high cost. Typically, RFID chips can run up to $1.00 of more per tag. But as chips get thinner and smaller, it is estimated that RFID costs will dip down to the 10 to 20 cents per chip range. RFID experts say that cost will lessen as RFID manufacturers develop cheaper tags while increasing production volumes.

Parts availability is a key factor to guaranteeing profitability for every machine suppliers and machine users. In this case, it is easy to offer customers a complete catalog of original parts via fast and reliable distribution way using tags. The idea is not to do it more frequently and frequently but to do it faster, more reliably, and to automatically generate data that can be used to generate a report to the customer, and can be stored in a database that will be used to follow the machine and spare parts performances.

Because these kinds of machines are frequently reverse engineered and copied using rapid prototyping technology or other modern production way, every part has to be checked to determine if it is an original and suitable for the aimed machines or not. This is done by reading an RFID tag (active or pasive) embedded or incorporated in the mentioned parts or spare parts, thus guaranteeing that only original, high quality parts are used. Not only does this minimize end customer complaints due to varying product quality, but it also has the added advantage of routing 100% of the spare parts business though the machine builder. On this way spare parts business provides continuing sales, ensures the quality of the parts, and protects the high professional image of both the machine builder and parts manufacturer [2].

Protect quality and brand protection ensure that non-approved or pirated spare parts cannot be used and purchased. Maintenance cycles can be strongly determined and replacement parts business can be controlled on easy way by customers.

Each tagged part will carry key information about its ownership and maintenance needs i.e. history. This will help speed up machine repairs – reducing delays– and will improve the overall safety of the machines.

In this paper we will consider production used in automotive industry and healthcare equipment. For example, carmakers are taking similar steps to improve the safety of their products. Key safety components such as brakes, air backs and seats or the rest parts of the car, can be tagged so that the car manufacturer can trace faulty goods back to the supplier and then demand repairs or replacements. In future it will be possible to link RFID tags containing a unique identification number, such as the Electronic Product Code (EPC), to very important information, e.g. date of manufacture, materials used for that and origin of components.

Mention RFID and packagers may automatically think in terms of chips/tags, unwieldy readers and high cost. But a chipless RFID technology has been developed and licensed by a company called Inkode. The Inkode system involves embedding tiny metal

fibers–called Taggents [TM]–into plastic and paper or any other materials that radio frequency waves can penetrate. These microscopic particles are energized by low power and respond when "excited" by radio frequency waves [3].

Other example, even sophisticated healthcare equipment as medical devices or implants can be tagged with RFID to ensure it is functioning properly and to track maintenance and inspection information. When medical devices have to be followed-up, it is often difficult for clinical engineers to identify which devices of the huge numbers in circulation are faulty. That's because companies frequently produce goods that look nearly identical but have minor changes in features. In addition, it's very difficult to track the make and model number of medical devices that have already been used in surgery, such as artificial hips, knee joints and dental implants. One company is developing ways to RFID-tag the implants' packaging so that product information, such as expiration dates, can be tracked accurately and patients can know that their implants are safe so customer safety will increase considerably.

In this paper, as a result of our evaluation we will show that applying RFID technology, also, saves more than 50% of data entry time process. Other benefits of this technology are that gray market activity will be decreased on minimum scale so profit of companies will go up [3].

The brand label shows the value of your product. The unique number stored on the label's RFID chip identifies the product beyond doubt as yours or a counterfeit. It proves the product's authenticity not only to you but also to your customer. A combination of holograms with the RFID label and a separate authenticity card is even more convincing and enables the customer to check the product online at home.

Iveco, a commercial truck and bus manufacturer owned by the Fiat Group, plans to expand the RFID system it uses to process the receipt, picking and shipping of replacement parts, as well as guarantee their authenticity. The application, which has been in operation at Iveco's distribution centre in Turin, Italy, for approximately one year, will be installed at a DC in Madrid during the few next weeks.

Machine builders everywhere put great emphasis on the quality of their products; machine up - time, productivity, and flexibility are important selling points. RFID solutions can make essential contributions and provide valuable USPs compared to reverse-engineered copies from low quality competitors.

RFID also automates inventory counts, providing a complete, accurate snapshot of asset status in a mere fraction of the time it would take to conduct a physical manual inventory. To track assets with RFID, tags are attached to all assets - from servers, racks, and laptops to office chairs, carts, and kegs. To take inventory, an employee can simply roam the facility with a handheld RFID reader or a mobile RFID reader on a cart - there's no need to properly identify the asset, locate a bar code, and scan each asset one by one. Without the intensive labor, companies can afford to replace the annual audit with weekly or even more frequent inventory counts. And RFID's automation eliminates the costly errors associated with manual inventory, including missed or mis-categorized assets. The result is an up-to-date accurate picture of asset status as frequently as needed to best manage the business (www.motorola.com).

Airbus is introducing Radio Frequency Identification (RFID) technology to its supply of aircraft spare parts. This follows the successful introduction of the technology to its aircraft tools supply chain four years ago. RFID technology allows the storage and modification of data on a microchip and the exchange of data with PC or EDP systems. Together with its industrial partner, eConnective AG, and co-developer of the technology, Fraunhofer Institute, Magdeburg, Germany, Airbus has launched a test phase with the help of a European Airbus operator. This will allow the RFID transponder chip to be used for the first time on civil aircraft spares.

Airbus pioneered the use of the RFID technology in aircraft tool management in 1999. As a result, all Airbus tools with manufacturer serial numbers are now equipped with the microchip for radio frequency identification, offering electronic support for loan and repair management of tools. The microchips are installed on the tools as well as the tool boxes and contain data about the history of the

tool as well as shipping, routing and customs information. It is anticipated that the availability of this ground-breaking technology on aircraft spares parts will significantly help to simplify inventory and repair management of the equipped repairable and rotable spare parts [4].

One of the major benefits of this new technology for the airlines is a simplified component repair management, where the repair and flight history of the component will be available electronically. The microchip assures the availability and accuracy of vital information and documentation and also allows a comprehensive tracking system.

The airlines will further benefit by time saved on trouble shooting, parts inspection, repairs administration and on the whole logistics cycle. This increase in efficiency will contribute to the airlines' bottom line through reduced spares investment needs, higher spares availability rates and simplified administration.

A leading aircraft manufacturer with the most modern and comprehensive product line on the market, Airbus is a global company with design and manufacturing facilities in France, Germany, the UK and Spain as well as subsidiaries in the U.S., China and Japan. Headquartered in Toulouse, France, Airbus is an EADS joint Company with BAE SYSTEMS.

A new car immobilizer system uses three RFID readers to make it tougher for thieves to drive off with your automobile. RFID security systems installed in new vehicles by car manufacturers have succeeded in reducing car thefts, according to statistics gathered by immobilizer manufacturers, These RFID security systems work by fitting a car's ignition key with a passive RFID transponder containing a unique ID code, Figure 2.

Figure 2. RFID for automobile

Whenever the key is inserted into the ignition switch, it activates an RFID reader connected to a control module in the engine's central computer (which controls such things as the car's ignition and fuel systems) and is wired to an antenna built into the vehicle's steering column. The RFID reader generates a random number, which is transmitted to the key. The key's transponder combines the random number with its own unique serial number, encrypts the new number and transmits it back to the car's RFID reader. If the numbers don't match, the car won't start [2].

CONCLUSION

Machine builders around the world put great emphasis and at the same time devote attention on the quality of their products such as machine uptime, productivity so flexibility is important selling detail. RFID solutions can make big contributions and provide valuable scale compared to reverse-engineered copies from low-quality competitors which produce cheap spare parts or simply parts.

RFID also automates inventory counts, providing a complete, accurate snapshot of asset status in a mere fraction of the time it would take to conduct a physical manual inventory. To track assets with RFID, tags are attached to all assets - from servers, racks, and laptops to office chairs, carts, and kegs.

REFERENCES

[1] *Finkenzeller, K, (2010). RFID Handbook: Fundamentals and Applications in Contactless Smart Cards, Radio Frequency Identification and Near-Field Communication. John Wiley & Sons.*

[2] *RFID Pakistan, RFID, from http://www.rfid-pakistan.com, accessed on 2013-04-11.*

[3] *RFID Journal, E journal, form http://www.rfidjournal.com/, accessed on 2013-03-10.*

[4] *RFID Europe, E Journal, from http://www.rfidineurope.eu/, accessed on 2013-03-10.*

[5] *SMARTRAC, Medical and healthcare, from http://www.smartrac-group.com, accessed on 2013-03-03.*

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WIND ENERGY POTENTIALS OF VLASINA REGION

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Abstract: Obtaining of all acceptable locations is one of the main tasks for siting of wind turbines. The main goal of this paper was to estimate wind potentials in Vlasina region, mainly on Streš er and Besna Kobila mountains. Finally, 231 locations are accepted, which covers the most of the area of the south of Vlasina lake, until the borders with FYR Macedonia and Bulgaria, respectively. The estimations were obtained using the WAsP simulation software. Final results are compared by means of the quality and quantity of the wind data and capacity factor. Finally, the economical analysis of the acceptabillity of the installing of wind turbines was done. This paper is concerned by the National Program of Energy Efficiency, project number: TR33036, funded by the Government of Republic of Serbia.
Keywords: wind power assesment, complex terrain, CFD, WAsP, WindSim

INTRODUCTION

Energy, especially electrical, is of vital importance in the world today. Many assesments of the fuel resources, mostly fossil, clearly marks the fact that this resources, especially for oil, are close to the end. The need for energy constantly rises, so introduction of new resources is inevitable. All these facts points to the necessity of transition to the sustainable development, especially to the usage of renewable energy sources. Wind energy clearly takes its place, considering its large potentials, purity and availability. The present constrains are mostly of financial nature.

The most important task is the siting of wind turbines (obtaining the best possible locations for installing of the turbines, considering the possibility for energy production and minimization of losses). For that purpose, the wind atlas method is developed, which became easy for use with the fast development of computers. Position of wind turbine is in strong correlation with energy production. According to the previous research [4], linear models can't estimate correctly the wind energy potentials in the terrain where the ruggedness index (index that represents the terrain slope value) exceeds 0.3. In such a case, using full CFD models, followed by experimental validation is necessary.

MATHEMATICAL MODEL

CFD models are more precise, but they need much more computational time, in the order of two or even three degrees of magnitude. Considering the need to obtain the results as soon as possible, the best micro models were extracted from the larger macro models (well known nesting technique) using the fast linear software [4]. Then the best wind turbine locations were obtained by using CFD software.

In this paper combination of a linear (WAsP [1]) and full nonlinear model (WindSim, a module in PHOENICS code [2]) is used.

Linear model

Linear model is expressed by:

- continuity equation:

$$\frac{\partial}{\partial x_i}(\rho U_i) = 0$$

- logaritmic vertical wind profile:

$$U_z = \frac{U_*}{\kappa}\left(\ln\frac{z}{z_0} - \psi\right)$$

- Weibull distribution equations:

$$f(U)=\frac{k}{A}\left(\frac{U}{A}\right)^{k-1}\exp\left[-\left(\frac{U}{A}\right)^{k}\right]$$

$$F(U)=\exp\left[-\left(\frac{U}{A}\right)^{k}\right]$$

Representative of the linear software packages is WAsP [1], [4]. It calculates the speed-up effects of the hills, taking into consideration the effect of redistribution of energy in the flow from the component in the flow direction into the vertical component.

Nonlinear model

Nonlinear model solves the full set of governing equations of steady fluid flow. The governing equations have the following form:

- *continuity equation:*

$$\frac{\partial}{\partial x_i}(\rho U_i)=0$$

- *momentum equations:*

$$U_j\frac{\partial U_i}{\partial x_j}-\frac{\partial}{\partial x_j}\nu_{eff}\left(\frac{\partial U_i}{\partial x_j}+\frac{\partial U_j}{\partial x_i}\right)=-\frac{1}{\rho}\frac{\partial P}{\partial x_i}$$

- *turbulence model equations:*

$$U_j\frac{\partial k}{\partial x_j}-\frac{\partial}{\partial x_j}\left[\left(\nu+\frac{\nu_T}{\sigma_k}\right)\frac{\partial k}{\partial x_j}\right]=P_k-\varepsilon$$

$$U_j\frac{\partial \varepsilon}{\partial x_j}-\frac{\partial}{\partial x_j}\left[\left(\nu+\frac{\nu_T}{\sigma_\varepsilon}\right)\frac{\partial \varepsilon}{\partial x_j}\right]=\frac{\varepsilon}{k}\left(C_{\varepsilon 1}P_k-C_{\varepsilon 2}\varepsilon\right)$$

where

$$P_k=\nu_T\left(\frac{\partial U_i}{\partial x_j}+\frac{\partial U_j}{\partial x_i}\right)\frac{\partial U_i}{\partial x_j}$$

$$\nu_{eff}=\nu+\nu_T;\ \nu_T=C_\mu k^2/\varepsilon$$

The modified set of model coefficients is:

$C_\mu=0.0324$, $C_{\varepsilon 1}=1.44$, $C_{\varepsilon 2}=1.92$, $\sigma_k=1.0$, $\sigma_\varepsilon=1.85$

The full set of these nonlinear partial differential equations is solved by WindSim [2] software package.

Test case

The differences in wind energy estimations while using these linear or full CFD software are considerable. Many investigations were done on this subject, dealing with different aspects of the software operation. Test model of Seličevica mountain [4] was choosed by its adequate orography, as can be seen in Figure 1. It was shown that the WAsP predictions are about 30% larger than WindSim ones [3], due to neglecting of the second-order terms in the momentum equation.

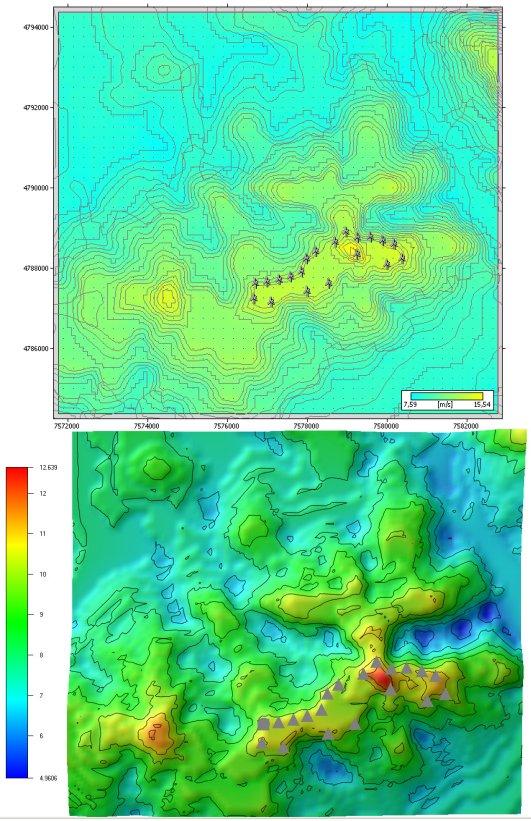

Figure 1. Mean wind speed fields simulated in WAsP (left) and WindSim (right)

For obtaining of the results the nesting technique is used. Simulations were done for the Enercon E48 wind turbine. It is very appropriate to use WAsP as the initial software on mezzo level estimations, and WindSim for more precise micro level estimations, as the computational time for WAsP is about 20 times less than for WindSim. This comined methodology had given very good results for a numer of sites.

VLASINA REGION WIND POTENTIALS

Scope of this paper is the Vlasina region, which is situated eastern of the South Morava river and southern of Suva Planina mountain, up to the borders with Bulgaria and Macedonia, respectively. The most promising locations are mountains Strešer and Besna Kobila, which dominates the Southeast of Serbia. This region, with the highest altitude of 1922m above sea level and relatively gentle slopes is very promising for wind energy. Another advantage is the existence of several hydro power plants, which allows combining wind and hydro energy, which gives possibility of energy storage.

Chosen wind turbine type is Enercon E-82, with unit power of 2MW. Considered mezzo model was

choosen by former simulation on the bigger model, from which, using the nesting technique, named mezzo model is obtained.

For the turbine siting the method of wake loss minimization and maximal annual energy production was used. Also, the recommendations about distance between wind turbines for the siting were as follows: in the wind direction minimally 7D (D – rotor diameter) and in the normal direction 4D.

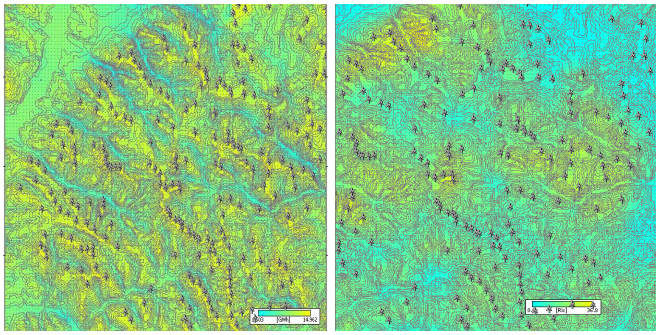

Figure 2. Annual energy production (left) and ruggedness index (right) fields

On the basis of the data about the terrain slopes and roughnesses, obtained from the digital map, and the data about the wind speed and direction represented with the long term wind rose on the site of the main meteorological station Vranje, the simulations were performed in both software packages: WAsP and WindSim. The result shown are the fields of possible energy production and terrain slopes.

Finally, 231 possible location were obtained through the simulations. The summary data are presented in the following table.

Table 1. Summary data for the Vlasina wind farm

Parameter	Total	Average	Minimum	Maximum
Gross AEP [GWh]	2979.609	13.011	8.290	15.168
Net AEP [GWh]	2966.845	12.956	8.242	15.147
Wake loss [%]	0.43	-	-	-

Expected capacity factor (expected ratio of possible energy production to the nominal production) is about 30.1%, which marks this location as highly desirable.

ECONOMICAL ANALYSIS

Economical analysis is one of the most important parts of every project. Renewable energy, including wind energy, is not an exeption. Having in mind current prices of wind turbines, state of the global and local financial markets, and the fact that the local infrastructure is not very developped, preliminary financial analysis was done. The initial assumptions are: the farm will operate for 25 years; initial investment is 924 million EUR; subventions will be 10%; annual discout rate will be 10%; annual inflation will be 7%; increase of the electricity price will be 12% per annum. Expected electricity price is 0.104EUR. The estimated financial indicators are shown in the following table.

Table 2. Financial indicators

FINANCIAL INDICATORS			
Rate of income (year 01)	ROI	240.06	[%]
Simple payback time	SPB	0.41	[year]
Net present value	NPV	57773754	[EUR]
Internal rentability rate	IRR	0.00	[%]
Dynamic payback time	DPB	0.01	[year]
Benefit/cost ratio	B/C	4611.03	[-]
Lifelong cost savings	LCS	6364823	[EUR/ year]

Using above mentioned financial indicators, it was calculated that annual income of the wind farm in Vlasina region could be about 202 million EUR. It shows that the project payback time is up to 5 years, which gives hope that such a project could be realized.

CONCLUSION

Wind energy is one of the fastest growing renewable energy resources. Most of the EU members are using it widely. Yet, the available usable locations are not limitless. This gives opportunity to the less developed countries to use the available funds, considering the plan of 20% of energy in Europe to be obtained from renewable sources.

Vlasina region is scarcely populated area, and as such is in great need of investment. Wind resources are very desirable, as well as the existence of Vlasina Lake, which can be used for

energy storage.
Dissadvantage is that this area is highly used by migrating birds, so the environmental impact should be carefully estimated.

LITERATURE

[1.] *Schaffner B., Wind Modeling in Mountains: Intercomparison and Validation of Models, study for METEOTEST, Bern, Switzerland and VECTOR AS, Tonsberg, N.*
[2.] *Stevanović, M.Ž. (2008). Numerički aspekti turbulentnog prenošenja impulsa i toplote. Univerzitet u Nišu, Mašinski fakultet, Niš.*
[3.] *Živković, M.P. (2006). Procena energije vetra na terenima kompleksne orografije – uporedna analiza metodologija. Univerzitet u Nišu, Mašinski fakultet, Niš*

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QUESTION THAT IS ASKED FOR DECADES: WHO WILL MOVE OUR CARS IN THE FUTURE?

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Abstract: *For decades, discussions on road traffic have been followed by forecasts on limited reserves of mineral oil and other fossil fuels, by increased demands regarding the vehicle's economy and by more and more severe legislations regarding reduction of CO_2 emission and noxious components in exhaust gases. The question of which power units will drive the automobiles of the future or which will replace the internal combustion piston engine in the next 10 to 15 years, has not lost its actuality even after 130 years of engine development. Energy supply has the key role in answering this question. Forecasts that the known reserves of mineral oil will be spent in the next 30 to 40 years and that the four-stroke piston engine will be replaced by better power units have been repeated for several decades.*

Keywords: *car, road traffic, exhaust gases, energy supply*

HISTORY - A VIEW AT THE PAST

For many decades the question has been set on which power units will drive the automobiles of future, that is who will replace the piston internal combustion engine (IC engine) in the next 10 to 15 years? This question has not lost its actuality even today and the generation of engineers and scientists currently engaged in these problems has an impression that development had never been as dynamic and diverse as nowadays.

The French writer, André Malraux, had said: "If you want to read the future, then you should scroll through the past!"

For almost 140 years, the piston IC engine has been without the competition as a power unit, not only for motor vehicles - automobiles, but in many other areas of human activities. During historical development, many other power units (Figure 1) have been investigated, none of which, with a sum of its features, had succeeded to establish itself in any field of application of the IC engines [1].

For several decades, discussions on road traffic have been followed by forecasts on limited reserves of mineral oil and other fossil fuels, by increased demands regarding the vehicle's economy and by more and more severe legal regulations regarding reduction of noxious exhaust emission and carbon dioxide (CO_2) emission.

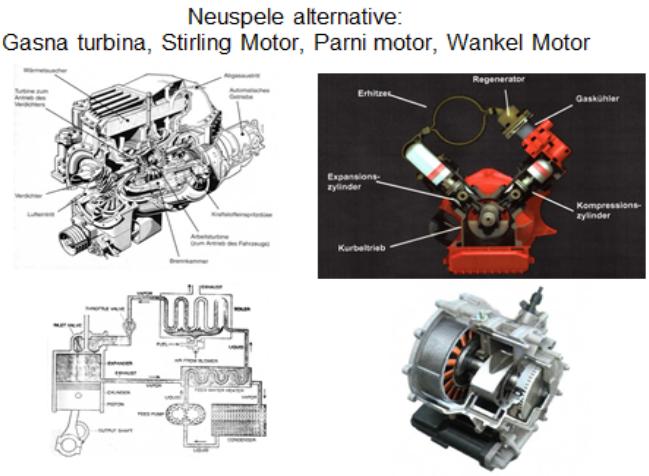

Figure 1: Unsuccessful alternatives

THE STATE OF THE ART

From year to year, the modern vehicles are safer, more reliable and their negative impact on environment is getting smaller. In spite of this, emission and fuel consumption must be further reduced so their impact on human environment would be as small as possible

It is very interesting that, despite huge efforts to replace the conventional piston engine with some other, better power unit, and despite the forecasts that it could not fulfil more and more severe legislation set in front of the automobile, it has shown a very great development potential that has enabled it to fulfil all demands set before it so far.

Pretty picture of the achieved engine progress is painted by Porsche 911 vehicle which has been evolutionary and continually developing for 45 years. At the first test of exhaust emission performed in 1966, a former Porsche 911 vehicle with the engine displacement of V_H = 2.0 dm³ and the power output of 130 HP (96 kW), has had fuel consumption of 15.4 l per 100 km. The modern Porsche 911 vehicle has engine displacement of 3.6 dm³ and the power output of 295 kW (400 HP) and the fuel consumption (at the same test) amounts to 8,2 l per 100 km, that is, it is 47% lower than its predecessor.

Of course, the toxic components from the exhaust emission in modern engines are incomparably lower than in their predecessors. The same amount of legally limited components (CO, HC, NO_x) emitted by a single automobile half a century ago is being emitted by 300 to 500 modern automobiles.

ECOLOGICAL DEMANDS SET BEFORE THE MOTOR VEHICLE

After the distance travelled for almost 140 years, IC engine, in its further development, must take more into account the social framework in which it is placed. The central place thereby belongs to:

- *increasing anthropogenic emissions, in context with discussions on climate change,*
- *demographic changes in the world, with increasing number of population on Earth, who desire appropriate living conditions and with moving the age limits,*
- *increasing urbanization and*
- *limited reserves of fossil fuels that follow this development.*

These social frameworks, as well as forecasts that both passenger and freight traffic will further grow in the next 20 years, explain the reason for more severe legislation set before the automobile and its power unit.

Firstly, there is reduction of energy consumption and closely related reduction of CO_2 emissions. Member countries of the European Union have adopted the so-called "20-20-20" program in 2007 or the program with the goal to reduce, between 2007 and 2020, energy consumption by 20%, to reduce CO_2 emission by 20% and to cover 20% of energy needs with so-called green energy, i.e. energy from the renewable sources.

Satisfaction of the legislation on reducing CO_2 emissions is one of the greatest challenges in development of new propulsion systems for vehicles. The European Union and Japan lead today in regard to the legislations on the reduction of CO_2 emissions; China prepares stricter regulations, followed by the USA and the other countries (Figure 2).

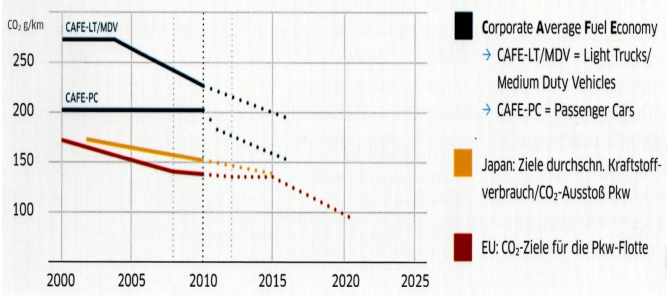

Figure 2: CO_2 emission reduction goals

According to current plan, the new passenger cars in the European Union will be allowed to emit, on average, just 95 gCO_2/km (equivalent to ≈ 3.8 l/100km) from 2020 and this value should be reduced to 70 gCO_2/km (≈ 2.8 l/100 km) from 2025. Currently, average value of CO_2 emission from passenger vehicles in Germany amounts to 148 gCO_2/km (equivalent to ≈5.9 l/100 km).

*Of course, it is required that the automotive industry will continue to meet the ever harsher legislation on reduction of toxic components in the exhaust gases: carbon monoxide (CO), unburned hydrocarbons (HC), nitrogen oxides (NO_x) and particulate matter (PM). In the European Union, the strongest legal regulations for now, known as Euro 6, are predicted for the year 2014, while in the United States, with legal regulation LEV 2 (**L**ow **E**mission **V**ehicles), the California Air Resources Board (CARB) has introduced the world's sharpest legal rules defined as SULEV (**S**uper **U**ltra **L**ow **E**mission **V**ehicles) CO = 1,0 g/mi, NMHC = 0,01 g/mi, NO_x = 0,02 g/mi, PM = 0,01 g/mi.*

*In order to classify the vehicle as PZEV (**P**artial **Z**ero **E**mission **V**ehicle), the limit value recommended for SULEV vehicles must be guaranteed for 15 years of the vehicle operation and for the path of 120,000 miles (192.000 km) travelled. Evaporative emission of the stationary vehicle must be zero and the vehicle emissions at operating vehicle are controlled by OBD II (**O**n **B**oard **D**iagnostic II) system.*

At the end of their "life" (End of Live Vehicles, ELV), passenger vehicles must meet the legal requirements on recycling, which in the European Union say that, from 2015, only 5% of vehicle weight may go to landfills, while 95% of vehicle weight must be used, either as material or energy.

TOPICS IN MODERN DEVELOPMENT OF IC ENGINES

IC engine is the most important engine of our mobile society. Its power output, reli-ability and fuel economy has not yet been achieved by any other alternative drive system – nor its current environmental friendliness.

To respond to the demands that are set upon it, the IC engine is still continuously and evolutionary developing. Its future depends, above all, on the further increase of efficiency in all areas of work. Former studies show that there is still considerable potential for further reductions in fuel consumption and CO_2 emissions that is estimated as at least 15% for both gasoline and Diesel engines in the short-term.

Downsizing

Under pressure from legislation, the main priority in the development of the engine is to reduce the fuel consumption. One of the attractive ways that is being increasingly used is the so-called "downsizing" or reducing the engine displacement, and thus the number of cylinders, while maintaining the desired power with the help of engine boosting. The fact that it is more important what cylinders do and not how many of them there are in the engine is slowly being accepted by the professional world.

"Downsizing" process, i.e. a supercharged engine with a relatively small displacement, had allowed the mass use of diesel engines in passenger vehicles 20 years ago and completely had thrown out the naturally aspirated diesel engines from applications, even in the field of commercial vehicles. While this process in diesel engines have long been the standard, manufacturers of vehicles with gasoline engines introduce in their programs more engines with reduced displacement and boosting (Fig.3), (Table 1) in order to meet CO_2 emission value of 130 gCO_2/km (equivalent to ≈ 5.2 l/100 km) required by the European Commission.

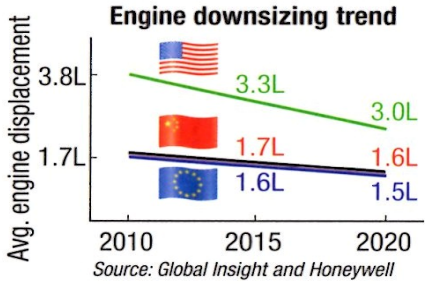

Figure 3: Trend of „downsized" gasoline engines in the world market

For the current generation of "downsized" turbocharged engines, the displacement is reduced by about 75% compared with the displacement of the naturally aspirated engine having the same power.

Table 1. The producers of turbocharged „downsized" engines

Producer	Displacement V_H [dm^3]	Number of cylinders	Power [kW]	CO_2 [g/km]
Ford	1.0	3	100	
Kia		3		85
Fiat	0.875	2		
Nissan	1.2	3		95
Renault	0.9	3	66	
VW	0.8	2	35	

While complex charging systems with two (mostly turbo) compressors and direct injection at diesel engines have become almost standard, they begin to be more and more applied in gasoline engines, more often combined with variable valve timing scheme.

Working process

Success of internal combustion engines decisively depends on the combustion process, which takes place in the cylinder. Efforts to reduce the losses during charge exchange have led to the development of valve drives with variable valve timing.

Direct fuel injection with pressures of over 2000 bars has become a standard for diesel engines, while direct fuel injection with pressures of over 100 bars is more and more applied in gasoline engines as well. Gasoline engines with two injection systems increasingly appear on the market (Figure 4).

The first system allows the injection of the main fuel quantity in the initial stage of realization of the mixture. It is used to achieve homogeneous, lean mixture of fuel and air. The second, smaller

amount of fuel is injected just before the combustion of the mixture, in order to facilitate its safe ignition.

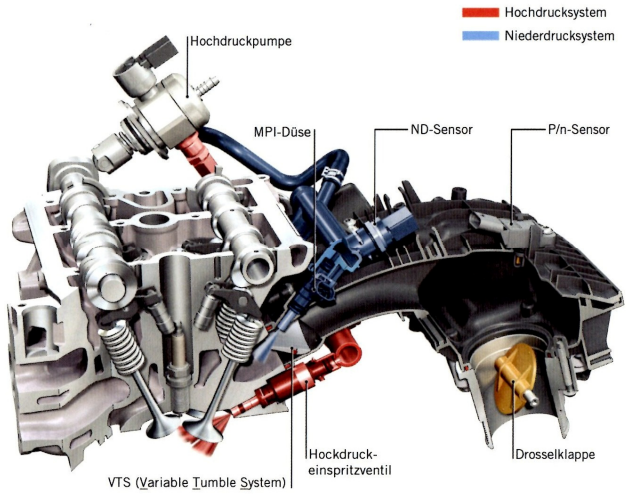

Figure 4: Engine with two injection systems (Audi)

In a recent dispute between the automotive industry and an inventor, it has been found that modern diesel engines operate on the principle, which has been described by so-called thermodynamic cycle with isothermal expansion (Figure 5).

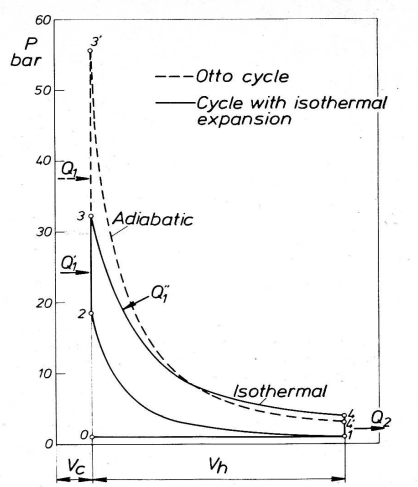

Figure 5: Otto cycle and cycle with isothermal expansion [4,5]

This thermodynamic cycle had been patented back in 1975 [4]. The goal was to achieve high efficiency with the low emissions of nitrogen oxides (NO_x) and unburned hydrocarbon (CH). In order to achieve this, it is necessary that the amount of heat supplied is divided into two parts. The first, main amount of energy (fuel energy, Q_1') is introduced in the first phase of the cycle, at constant volume, with wich the maximum combustion temperatures, responsible for the creation of NO_x, is reduced while the second, smaller quantity of energy (Q_1") is introduced during the expansion, which provides relatively high temperature, important for further oxidation of unburned hydrocarbons during the expansion stroke and in the exhaust system. It was found that all modern Gasoline and Diesel engines with multiple injection operate in accordance with this thermodynamic cycle.

Reducing mechanical losses

Many of the measures to improve IC engines have already been applied after years of effort, so that it becomes increasingly difficult to devise the ways for their further optimization. Especially for Diesel engines, options for the further improvement of the combustion process are almost exhausted, so it's harder to develop engines using conventional methods and all possible potentials where further optimization is still possible are searched for on the engine as a whole. Beside the efforts in improving the combustion process and reducing the engine losses during charge exchange, a great potential is still seen in reduction of mechanical losses and friction (Figure 6) [6].

In addition to new technological procedures in the processing of cylinder liners, piston group and bearings, this area also includes the reduction of piston mechanism weight, which significantly reduces the inertial forces at higher engine speeds, and thus also reduces the mechanical losses.

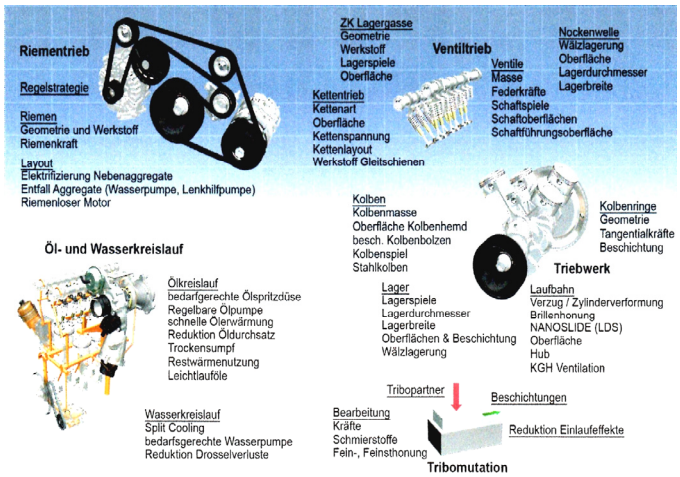

Figure 6: Measures for reduction of engine mechanical losses

In addition to optimization of the engine, further development of all the important components that affect not only the combustion process, such as the injection system, but the entire operation of the engine, particularly systems for lubrication and

cooling, is required. Significant potential for reduction of mechanical losses is also in variable drive of auxiliary units on the vehicle: oil pump and water pump, which are involved in the work according to engine needs. Neglecting these potentials will not allow further necessary development of IC engines.

Modular design of engine

Of course, all these necessary measures to improve the engine, in addition to large investments in research and development, have resulted in the increase of production costs, including the price of the engine.

At the end of 1960-ies, before the introduction of legislation on reduction of exhaust emissions and fuel consumption, the production cost of one full 8-cylinder engine with the exhaust system in the U.S. was around 160 to 180 US $. The production cost of modern engines that meet all legal requirements, are several times higher.

Despite the steady increase in production costs, continuous efforts are being made to reduce, as far as possible, this costs. Similarly, as many years ago, when the principle of "common platform" has been introduced in the construction of vehicle in order to reduce production costs, the modular design principle is also observed in the construction of the engine which represents a common base to build a family of engines with different displacements and numbers of cylinders by one producer.

Modules - joint groups and sets - are divided into groups of the base engine (piston mechanism, cylinder head, valve mechanism) and sets that are built on the engine (elements for filtering of the exhaust emission, intake system with integrated cooler for cooling the air for turbocharging).

Even in the engine concept phase, it is taken into account to modularize the engine to the greatest extent. In addition to reducing the production cost of the engine, modular construction offers possibility to produce the engines in different places and for different markets and applications. With no major losses in time, the engines can be built according to the different requirements that are set in the world in the standardized production plants, with always optimal technical solutions.

HYBRID DRIVE

In the last ten years, the vehicle power plants with two units: IC engine and electric motor have been recognized as the only alternative to a purely engine power unit that is produced in series

Micro hybrid

The initial step in this direction, the so-called "micro hybrid" or start-stop automatics (start-stop generator) has become an integral part of modern engines. In the city driving, fuel savings with this system amount to about 3% to 5%.

Mild hybrid

*A "Mild Hybrid", in addition to the start-stop generators, uses power of the electric motor at start-up and acceleration of the vehicle. The energy needed for the electric motor is taken from a relatively small battery. Driving the vehicle for a long distance with electric motor is not possible for this system, because the battery is too small. Very often, braking energy recuperation is frequently used in this system during deceleration. Fuel savings during city driving and during new European driving cycle (NEUDC, **N**ew **E**uropean **U**rban **D**riving **C**ycle) are about 15% to 20%.*

Full hybride vehicle

Unlike "mild hybrid" vehicles, "full hybrid vehicles" have a battery of sufficient size, so the electric motor can drive the vehicle on a relatively long distance. Electric motor power is between 20 kW and 60 kW. Fuel savings or CO_2 emission reduction in the new European test are between 20% and 50%.

The key features of full hybrid vehicles are: pure electric driving ability at a certain distance, the exclusion of both engines operation at idle speed and braking energy recuperation.

Range extender. Plug in hybrid

High production costs and the price of full hybrid vehicles and their relatively small radius with pure electric drive, and the fact that most of the vehicle distances during the day do not exceed 30 to 60 km, led to hybrid vehicles solution with so-called "range extender" or "plug-in" systems.

Electric battery and electric motor power are dimensioned at these vehicles in a way that enables pure electric driving for about 50 to 60 km, for example, going to work and returning home, where the battery is charged during the night to ride the

next day. If the vehicle has to take more distance or the energy consumption is increased (lights, wipers, heating, air-condition), then the additional IC engine is engaged in operation, which is so dimensioned that allows unobstructed started drive ("range extender").

"Range extender" - IC engine, as modular part of a hybrid concept, provides compensation of known deficits of purely electric drive. To support the electric motor, one relatively small and light IC engine (V_H = 0.3 to 0.8 dm^3) with low production costs is used (Figure 7).

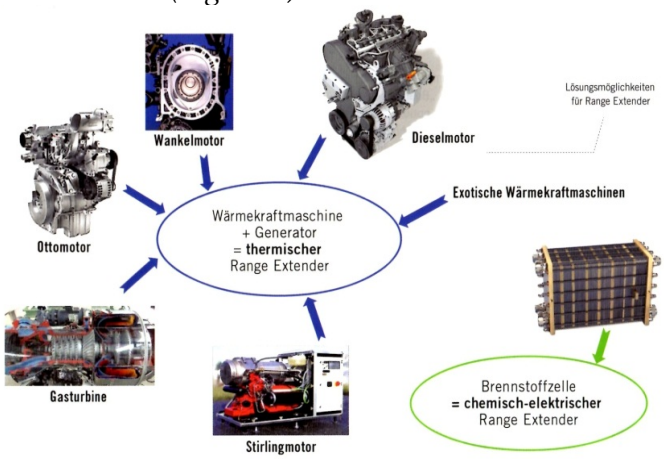

Figure 7: Investigated power units as „range extender"

Almost all alternative power units that were once offered to drive motor vehicles now are being investigated as possible variants for the position of the "range extender" engine (Wankel engine, two-stroke engine, gas turbine, etc.).

Despite all the efforts to promote the hybrid vehicles at the market as a serious alternative to a pure engine drive, their share in the total vehicle fleet is still very small: At the beginning of 2012, the number of new hybrid vehicles in traffic in Germany totalled 12.622. The share of hybrid vehicles in Germany in total number of passenger vehicles is now about 0.80%.

ELECTRIC VEHICLES

In its efforts to reduce CO_2 emissions, the current policy in many countries is very focused on electric drive motor vehicles. After the nuclear disasters in the USA (Three Mile Island), Ukraine (Chernobyl) and Japan (Fukushima), electro-mobility provides opportunities to reduce CO_2 emissions only if the electric energy is derived from the so-called renewable energy sources (water, wind, solar energy). Since more than half of electric energy today is generated using fossil fuels (coal, oil, natural gas), the switch to electric vehicle drive does not reduce CO_2 emissions, but, on the contrary, induces its global increase.

Electric automobiles are not the discovery of today's techniques. The first electric cars were already built between 1835 and 1839 [9]. At the beginning of the 20th century, more vehicles were powered by electric motors than with IC engines. Advantages and disadvantages of electric vehicles at that time were similar to those that now follow the development of these automobiles.

Forecasts of some countries regarding the introduction of electric vehicles in the traffic sounded very seriously a few years ago. Federal Republic of Germany had a goal that 1 million vehicles in the traffic should be with pure electric drive until 2020. In 2030, that number should be increased to six million electric vehicles. China has planned that, by 2015, half a million electric vehicles should be found in traffic, and by 2020, this number should be increased by ten times - to five million vehicles [10].

The main drawbacks of electric vehicles are found, same as 150 years ago, with the battery or accumulator of electric energy or with its capacity, weight and production cost.

The capacity of the today's best batteries, Lithium-ion batteries, amounts to 0.5 kWh/l, which is 20 times less than that of gasoline and diesel fuel (9-10 kWh / l). Low capacity means great battery weight for any longer distances, which vehicle shall travel. Today, they amount to a maximum of 120 to 150 km at a flat, dry road, on a sunny, not too hot day. Turning on the lights, wipers, heating or air conditioning of the vehicle, reduces the potential radius of the vehicle by half.

Second major handicap of electric vehicles is the high production cost of battery that has been moving between 600 and 800 €/kWh for years, which is 20 to 25 times greater than for IC engines. The goal of battery price reduction is set between 200 and 300 €/kWh, which is expected to happen in about 10 years.

Electric vehicles producers are trying to reduce production costs for both electric and hybrid vehicles with using electric modules, which can be

integrated into existing vehicle platforms. Thus, the modular building system is one of more important paths of development for electric automobiles.

Listed shortcomings of electric drive, along with a lack of necessary infrastructure and standards for supply stations, cables, sockets and still great amount of time of several hours for charging the battery, have led to slow correction of ambitious plans on the share of electric vehicles in traffic.

In early 2012, there were only 4541 electric vehicles in traffic in Federal Republic of Germany or 0.01% of the total number of vehicles in traffic. In China, until this year, 7.000 electric vehicles were sold, representing 0.02% of the vehicles in traffic.

Most experts agree that, in the next 15 to 20 years, electric vehicles will not make a greater breakthrough in the market, but they will be used only for small, local fleets. According to Professor Lenz (Technical University of Vienna), electric vehicle will not at all contribute to improving the state of human environment, while, for vehicle buyers, it means a considerable increase of the price of vehicle that is significantly inferior in terms of all properties compared to IC engine drive [7].

Fuel cells

At the beginning of the 1990s, especially under the influence of development in Daimler Company, the electric vehicle drive with so-called "fuel cell" as a source of electrical energy, which was supposed to be the solution to drive the vehicle in the near future, had been euphorically presented. In the Fuel Cell electrical energy, that serves for movement of vehicle, is produced by joining the fuel (hydrogen H_2) and oxygen from the air (O_2). The other product of this chemical reaction is water (H_2O), which has no harmful effect on the human environment.

Company	Honda	Daimler	GM	Ford	Chrysler	Renault	Toyota	Nissan
Start of production	2003	2004	2004	2004	2007	2010	2015	2018
Prediction from year	(2000)	(2000)	(1998)	(2001)	(1997)	(1999)	(2004)	(2010)

Figure 8: Predictions on introduction of fuel cells in serial production

Almost all vehicle producers have invested heavily in research and development of fuel cells. Predictions about the introduction of fuel cells in mass production were very optimistic (Figure 8).

Most producers claimed that they will start the serial production in 2003 or 2004 [8, 9, 10]. To date, however, the basic weaknesses of the system have not been solved. High production cost (100 to 150 times higher than that of IC engines of the same power), lack of fuel (hydrogen has proved to be the only possible solution) and a complete lack of the necessary infrastructure for the production, distribution and storage of hydrogen have meant that the chances for application of fuel cells in road traffic are considered much smaller than the chances for battery-powered electric vehicles.

VIEW AT THE FUTURE

Accepting the advice from Andre Marlowe that "If you want to read the future, then you should scroll through the past", the past development shows that, so far, no alternative power unit has managed to threaten the primacy of IC engines. Today's parameters also show that the IC engine remains unchallenged power unit for motor vehicles.

Experts around the world mutually agree that the piston IC engine will maintain its dominant status for several decades as the main power unit for vehicles.

FUELS

They also agreed that fuels based on mineral oil and other fossil sources will not be able to meet the growing global demands for energy alone, so the answer to the question which sources of energy will be available will also carry the answer to the question of which power units will drive the future vehicles. Apparently, in the future, several fuels with similar characteristics, originating from the different sources will simultaneously exist at the market.

Conventional fuels derived from crude oil globally remain, according to today's forecasts, as the main source of energy in the next 30 years (Figure 9) - the prognosis that has been repeated for over 50 years.

Maximum exploitation of oil wells is expected in the next 15 to 20 years, after which there should be the reduction of oil supply, although the demands for energy continue to grow steadily. This fact

means that the time of cheap oil is over. With the increase in prices of oil or fuel, many alternative fuels which could not, because of their high cost, be promoted at the market until now, become economically interesting.

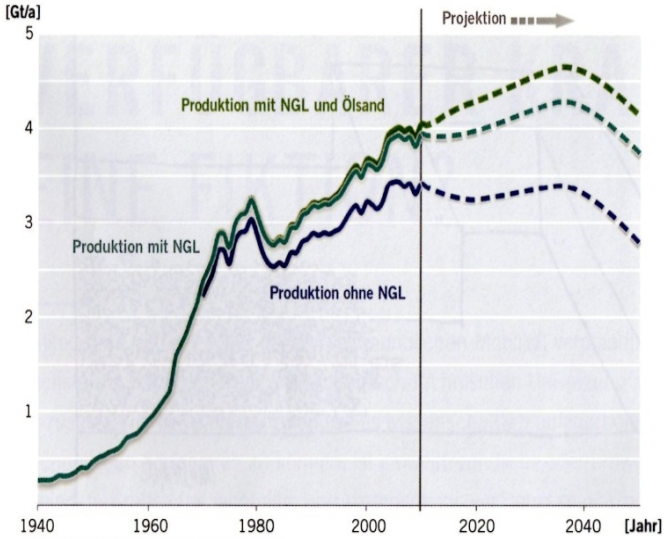

Figure 9: Trends in exploitation of mineral oil and natural gas resources

Relying on the European Directive on fuel quality (2003/30/EG) and direction on the use of renewable energy sources (2009/28/EG), the European Commission, in its ambitious plan to support the use of renewable energy sources in traffic, follows a specific goal that, by year 2020, at least 10% of conventional fuels in the European Union is replaced by fuels from regenerative sources [14, 15].

In the first place, there are fuels from bio-mass as fuels from renewable sources. The goal of the efforts to introduce these fuels is to enable the traffic neutral in terms of CO_2 emissions. Since the gaining of the first generation of biofuels is potentially in competition with food production and is therefore subject to harsh criticism, experts are working intensively on the next generation of biofuels, where fruit of the plant will not be used to produce fuels, but only as plant waste material. Obtaining the biofuels from algae seems especially attractive looks and it has been intensively investigated.

Beside fuels from biomass, synthetic fuels, which are likely to have greater importance in the future than it is considered now, gain more and more importance. These include:

- *ETBE - Ethyl-tertiary-butyl-ester,*
- *Synthetic fuel obtained from natural gas (GTL, **G**as **t**o **L**iquid) and*
- *Synthetic fuel obtained from coal (CTL, **C**oal **t**o **L**iquid).*

Efforts to obtain synthetic or gaseous fuels from CO_2 emission, emitted by power plants and large industrial plants, by using excess electricity from regenerative sources or to conduct the "recycling" of CO_2, seem to be attractive.

CONCLUSIONS - MOTOR VEHICLE DRIVES IN THE NEXT 15 TO 20 YEARS

Since the liquid fuels from fossil and biogenic sources will be the main energy sources for road transport in the coming decades, the IC engine will keep its dominant position as a power unit for motor vehicles during that time. Of course, it will continue to be optimized in all phases of the operating cycles and in every detail of its construction.

The potential for further reduction of fuel consumption and CO_2 emissions is still large (Figure 10).

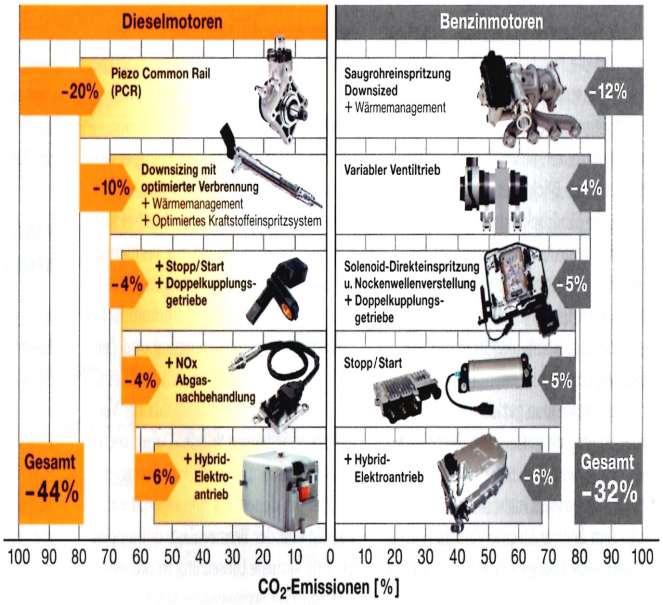

Figure 10: Measures for further reduction of CO_2 emission and fuel consumption

The start of power unit electrification, a hybrid drive, will probably remain a definitive solution for the foreseeable future.

Shorter and shorter intervals available for product development and introduction of innovations in engine construction, along with the growing demands regarding the conservation of natural reserves of the planet, have led to the fact that

collaboration between a producer and several partners from automobile industry has become an important factor in achieving success. Thereby, the cooperation with the so-called subcontractor industry or the suppliers has the most important role. Over 70% of the value of an automobile is created today in the suppliers. This picture will not be changed in the future.

Today, about 70 million of road vehicles are made annually in the world. In the meantime, China has become the largest producer, with annual production of over 16 million vehicles. In the next 5 years, the number of vehicles is projected to increase for more than 30%.

More than 99% of the produced vehicles will be driven by further developed IC engines. This provides the engineers in the automotive industry with safe, interesting and intensive work in the coming time.

At the end, let's repeat the conclusions, which have been repeated for decades:

1. *Four-stroke piston engine stays as main power unit for motor vehicles in the next 10 to 15 years.*
2. *World oil reserves are secured for the next 30 to 40 years.*

REFERENCES

[1.] *Gruden, D.: "On future of power units for motor vehicles" (in Serbian), MVM2010, Kragujevac, 2010*

[2.] *"Zusammenwirken der Antriebskomponenten", MTZ, 73(2012) 7/8*

[3.] *"Motoren mit kleinem Hubraum", MTZ, 73 (2012) 5*

[4.] *Gruden, D.: "Patentschrift 25 36 775", Deutsches Patentamt, 18.8.1975; US Patent and Trademark office, 1978*

[5.] *Gruden,D.: "Combustion and Exhaust Emission of an Engine Using the Porsche-Stratified-Charge-Chamber-System", SAE Paper 750888*

[6.] *Schommers, J.: "Reibleistungsoptimierung – Basis für die Zukunftsfähigkeit der Verbrennungsmotoren", Daimler, Stuttgart, 2012*

[7.] *33. Internationales Wiener Motorensymposium, Wien, 2012*

[8.] *Andert,J. et all: "Range Extender von KSPG, ein neuer Wegbreiter der Elektro-mobilität" MTZ 73 (2012) 5*

[9.] *Hohl, G.:"150 Jahre Elektromobilität", ÖVK, Wien, 2012*

[10.] *"Chinas E-Mobilitätsstrategie geht nicht auf", VDI-Nachrichten, 20.04.2012*

[11.] *"Automotive Engineer", January 2000*

[12.] *Schilke, N.A.: "US Fuel Cell Technology", President SAE International 2001*

[13.] *Hertel, P.: "Membranen für Brennstoffzellen", ATZ 107 (2005) 6*

[14.] *"Alternative Kraftstoffe", MTZ 73 (2012) 6*

[15.] *"Alternative fuels for transport", IFP – Energie nouvelles, Lyon, 2012*

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FIGURES AND TABLES

Figures (diagrams and photographs) should be numbered consecutively using Arabic numbers. They should be placed in the text soon after the point where they are referenced. Figures should be centered in a column and should have a figure caption placed underneath. Captions should be centered in the column, in the format "Figure 1" and are in upper and lower case letters.

When referring to a figure in the body of the text, the abbreviation "Figure" is used Illustrations must be submitted in digital format, with a good resolution. Table captions appear centered above the table in upper and lower case letters. When referring to a table in the text, "Table" with the proper number is used. Captions should be centered in the column, in the format "Table 1" and are in upper and lower case letters. Tables are numbered consecutively and independently of any figures. All figures and tables must be incorporated into the text.

EQUATIONS & MATHEMATICAL EXPRESSIONS

Place equations on separate lines, centered, and numbered in parentheses at the right margin. Equation numbers should appear in parentheses and be numbered consecutively. All equation numbers must appear on the right-hand side of the equation and should be referred to within the text.

CONCLUSION

A conclusion section must be included and should indicate clearly the advantages, limitations and possible applications of the paper. Discuss about future work.

ACKNOWLEDGEMENTS

An acknowledgement section may be presented after the conclusion, if desired. Individuals or units other than authors who were of direct help in the work could be acknowledged by a brief statement following the text. The acknowledgment should give essential credits, but its length should be kept to a minimum; word count should be <100 words.

REFERENCES

References should be listed together at the end of the paper in alphabetical order by author's surname. List of references indent 10 mm from the second line of each references. Personal communications and unpublished data are not acceptable references.

Journal Papers: *Surname 1, Initials; Surname 2, Initials and Surname 3, Initials: Title, Journal Name, volume (number), pages, year.*

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