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ACTA TECHNICA CORVINIENSIS

- Bulletin of Engineering

INDEXES & DATABASES

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In a very short period the **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering** 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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Abstract: The purpose of this article is to review 3D body scanning systems currently available in the market. 3D human scanning is a process of capturing and subsequent digitization of the full body or the body parts into their three-dimensional graphical representation. As 3D human body scanning techniques are becoming ubiquitous, we give an overview of the different technologies of 3D body data digitization such as techniques based on photogrammetry, depth sensors, and laser scanning as well as few more promising techniques. Also, the underlying principles that allow these systems to work are determined and explained. In order to provide directions for further integration of digitized 3D human bodies, specifications of 3D body scanning systems are compared, and a variety of commercial scanners available in the market are presented in the paper.
Keywords: 3D human body scanning, 3D body scanning techniques, 3D body scanning systems, 3D body data digitization, 3D scanners commercial products

Abstract: This work presents a different approach to inverse kinematics analysis of a PUMA robot. PUMA robot is an industrial robot arm with open chain mechanism that is used in different purposes. PUMA robot has a complicated inverse kinematics expression that needs to be solved. In this paper, the inverse kinematics problem is solved by using MSC ADAMS instead of knowing inverse kinematics expressions and calculating these expressions. PUMA robot multi-body dynamics model is built by MSC ADAMS and joint angles are derived for a circle-shaped trajectory. Used trajectory and derived joint angles are given in the form of the graphics.
Keywords: robot, robot arm, puma robot, multi-body dynamics, inverse kinematics

Abstract: This paper investigates the application of mass customization in supply chain management. Throughout research of the current literature and findings authors have discovered interesting keymarks that are related to obstacles and advantages while organization is trying to transform from mass production to mass customization. Significant aforementioned findings are gleaned, expounded nad compared with a current study in the field. Results are far from panaceas but its a next step to cope with obstacles and develop advantages of MC in supply chain management.
Keywords: SCM, mass customization, logistic, risk, processes, literature review

Abstract: Article compares cutting conditions and forces generated during milling of advanced biomaterials based on titanium. Since these are hard materials used in the manufacturing of expensive dental implants, the purpose of the article is also to identify and compare the dynamic machinability of said materials. This allows the outputs of this article to serve as an aid in the planning of production processed and calculating of production costs. A constant need for a development of new kinds of medical implants placed into human body, serving as substitutes for dysfunctional or damaged body parts, requires new materials for their production, which must meet difficult and often contradictory requirements. Such materials include for example commercially pure titanium and its alloys, which are used for their excellent biocompatibility and suitable mechanical properties.

Keywords: biomaterial, titanium, dynamic machinability

Abstract: Treatment of wastewater (WW) from wood industry is of great importance due to high concentration and toxicity of phenol and its derivatives. High concentration of phenol in WW of wood industry originates from pentachlorophenol (PCP), which is used for wood conservation. According to the Regulations on Hazardous Substances in Water [1] allowed phenol concentration in waters of the III and IV class is 300 mg/l. Conventional methods for removal of phenol from WW are either environmentally or economically unacceptable. The use of ferrate (VI) as a multifunctional chemical reagent has significant advantages over conventional methods. The subject of this paper is treatment of samples of WW from wood industry - from thermal dryer and steam chamber, by electrochemically synthesized ferrate (VI). The initial concentration of phenol in the sample from thermal dryer was 27 mg/l and in the sample from steam chamber 30 mg/l. This wastewater also has a high content of natural organic matter (COD of the sample from the thermal dryer was 3233.1 mgO_2/l and COD of the sample from the steam chamber was 4692.1 mgO_2/l). The efficiency of phenol removal by ferrate (VI) was 74.85% and 72.67% for samples from thermal dryer and steam chamber, respectively.

Keywords: ferrate (VI), phenol, wood industry, wastewater treatment, COD

Abstract: This paper presents the selection of optimal materials for the production of basic constituent elements of electric iron: housing, heater and warming plate using material properties chart (map) quantitative method and Cambridge Engineering Selection software (CES). This work is a continuation and expansion of research [1]. The results were compared with results from the paper [1] in which selection of mentioned constituent elements of electric iron materials was done using two quantitative methods: the method of properties influence (digital-logic method) andthe method of minimum deviation of actual properties compared to required (algebraic approach).

Keywords: quantitative methods, material selection, material properties chart (map), CES software

Abstract: This model explains the heat flow in a confined space with transparent walls (glass or plastic). A software is used to analyze the behavior of transparent walls coated with "LLumar" film. This film has many advantages, but in this paper, we will focus on energy savings. Energy savings give quick return on investment and are considered a smart investment. Energy-saving LLumar film can increase performance of almost every window system, significantly reducing energy consumption and requirements. Professional energy audits have shown that buildings with LLumar film can achieve annual energy savings of up to 15%, blocks 99% of harmful UV rays and improves comfort by reducing heat and glare. Regardless of whether it is residential, commercial or glass house space as described in this paper, LLumar the world's leading brand of architectural film for decades improves the well-known buildings around the world with proven results. LLumar films will greatly increase energy efficiency, appearance and functionality of glass partitions. The results are lower overhead expenses, increased comfort, improved privacy and better protection from accidents. Heat balance in glass house space is shown in the following pages.

Keywords: thermal resistance, glass wall, glass house, demand for heat

Abstract: Reverse engineering and spatial digitization became more popular recently. The popularity grows with the devices which are capable to scan the human figures, cars, parts of the buildings or even bigger objects in a single process. In general, scanning devices sometimes present disproportionate costs as the usual additional software often tops the half of the hardware price. Text of this paper is focused on the alternative device which can use very affordable software applications to generate the same results as the most expensive scanning equipment. Particular parts of this article briefly describe the principles of non-contact three dimensional scanning using the Kinect device, the process of data processing in alternative software applications and possibilities of their further utilization.

Keywords: Kinect, virtual reality, 3D data

Abstract: Customer Experience Management (CEM) is gaining in attention from organizations that want to provide value to their customers. In particular, mass customizers as well as companies that innovate following an open innovation approach will benefit more from customer experience management than those who don't apply it. However, the road to implementing CEM is very strenuous and requires dedication and resources in terms of financial means and workforce. SMEs lack such resources and have trouble in deciding how and where to start. This is why this design science research project for a scientifically based self-assessment for SMEs was conducted. Development and testing took place with a select number of SMEs The assessment tool is named CX (Customer Experience)-Liner and serves as a compass for SME to determine their course in CEM.

Keywords: Customer Experience Management, Design Science Research, Small and Medium Enterprises, Open Innovation

Abstract: Supply chain efficiencies depend upon the efficiency of logistics including warehousing activities. The efficiency of the warehouse depends on the layout, infrastructure and the operation of the warehouse. Warehouse design element aims to maximize the utility of space, equipment, and efficiency of operations. Types of storage are determined by the nature of goods to be stored. Depending on the cargo whether raw materials, components, semi finished goods or finished goods, the types of storage can vary from bulk stock, block stock, racking, pallet racking, shelf racking, etc. The paper shows a design conception for an existing warehouse. The conception can be applied to define an optimal storage structure based on a given warehouse floor area and available forecasts relating to types and volume of loading units (LU) to be stored. The study shows 6 possible alternatives for storage structure. Longitudinal and transversal twin racking arrangements with narrow and wide aisles were taken into consideration. Structure alternatives were compared based on storage capacity, specific storage capacity and utilization of floor area. The optimal storage structure was defined.

Keywords: warehouse, design conception, optimal storage, alternatives, racking arrangements

Abstract: In recent years air-conditioning systems are most widely used for human comfort. The conventionally used refrigerants in the air-conditioning systems cause ozone layer depletion and also these refrigerants have higher global warming potential. This leads to research in the area of alternative cooling methods and among the alternative cooling methods adsorption cooling systems are getting attention. The adsorption cooling system is the heat driven refrigeration system and hence solar energy can be used as the heat source in this system. In adsorption system, careful selection of the adsorbent-adsorbate pair is important. Hence, in this work water was used as refrigerant to cope with the current environmental issues. In summer the demand of the cooling system is high and hence in this work solar energy was used to drive the adsorption system. We have developed and tested an adsorption system successfully. From this work, we conclude that the development in the adsorbent technology provides solution to the shortcomings in adsorption systems and also helps to reduce global warming potential.

Keywords: Cooling, Solar, Adsorption system, development, evaluation

Abstract: A quality management often use the capability indices for measure its output merit. It is based on Six Sigma methodology in focus to higher quality performance. The higher sigma level, the better is process performing. On the other hand, there are some differences between needs for manufacturing process and needs for measuring process. The question of whether the measuring process gives the results of measurements in accordance with the specifications is serious questions regarding the quality assurance of measuring processes. In this paper are presented capability indices of the first, second and third generation and comparison between them, based on measurement data, focusing on their sensitivity. There is addressed the issue of the capability of a measuring process with using the capability indices and making the proposal for the use of the capability indices with confidence probability of 95 % in contrast to strait Six Sigma approach.

Keywords: uncertainty, confidence probability, capability index

Abstract: Today, Internet has established a new model for providing information and services to all users throughout the world. Thus, the decision to use web technologies such as HTML, XML, Java and Flash is obvious. The purpose of this study is to investigate the potential benefits of using computer tools in engineering education. Animations, visual cueing, and their combination in a multimedia environment are designed to support learners' acquisition and retention of scientific concepts and processes. The software used in the development of the animations is Macromedia Flash, a tool that allows very small vectorial graphics files to be created, thus facilitating their electronic transmission to any user connected to the network. The research was conducted on 75 students of the first year at the Faculty of Civil Construction Management of the Union "Nikola Tesla" University, Belgrade, Serbia. The course was followed by a 3-year study to assess the acceptance of the computer tools and multimedia animations for learning mathematics. This research clearly showed that students were highly interested in this way of teaching and learning.

Keywords: computer tools, Macromedia Flash, animation, Engineering education

Abstract: This work investigated the density, porosity, some mechanical properties and microstructure of PPS-AlMMC and compared the properties of the composites and those of the aluminum 6063 (Al60603) alloy. Periwinkle shells were milled to particle sizes of 75µm and 150µm and used to produce PPS-AlMMC at 1,5,10 and 15wt% filler loadings using two-step casting technique. The density, porosity, mechanical properties and microstructure of the composite materials were compared with those of the Al6063 alloy. The addition of PPS to aluminum alloy reduced the density of the composite. It was observed that the filler distributes uniformly in the matrix due to the two-step casting technique. The porosities of the composites were within acceptable level of 0-5% except for the composite with 15wt% PPS of 150µm particle size. Improved strength, ductility, hardness and modulus were obtained when the filler was used to reinforce the alloy. However, using a filler of higher particle size resulted to higher porosity, reduced tensile strength, ductility and toughness.

Keywords: Composites, periwinkle shell, two-step casting, mechanical properties

Abstract: Many studies confirm the positive aspects of the "open innovation" approach for university- industry collaborations. Often are such positive aspects connected with different, in studies proposed, step-by-step procedures of open innovation implementation, within the university- industry cooperation. Such procedures take into consideration cultural aspects of the parties, core capabilities, employees and staff, structures of organizations, issues regarding managing intellectual property, and at the end, creation of knowledge base, all in order to run university-industry cooperation successful. In this paper we show that a lot of collaborations develop themselves successful, not by following strictly methods proposed by literature, but by acting according to common sense code. We show, based on best-practice example of cooperation between the EPLAN Software & Services Company and Rheinische Fachhochschule Köln gGmbH, that some collaborations are open innovative in

Abstract: The aim of this paper is to determine functionality of the fountain solutions prepared with various amounts of IPA. For the purpose of this research, two sets of the fountain solutions, FS1 and FS2, were prepared and characterized by measuring pH value, electrical conductivity and surface tension. In addition, the Pruefbau MZ II Multipurpose Printability Testing System was used to determine amount of the fountain solution needed to cover nonprinting areas on the printing plate and disable adsorption of the printing ink. To detect chemical wear of the printing plate by the fountain solution, potentio-dynamic polarization measurements were performed. Results showed that solutions FS1 have higher pH value and higher electrical conductivity than solutions FS2.In both sets it is visible trend of increasing pH value and decreasing electrical conductivity by addition of IPA. The surface tension is lowest by FS1 in which 4 % vol of IPA is added, even more the whole FS1 set has lower surface tension than the lowest surface tension measured in set FS2 (measured in sample with 12.5 % vol of IPA). The contact angle values were in good correlation to the surface tension values (calculated Spearman's correlation coefficient was 1 for FS1 and 0.9 for FS2). In simulated printing process, better spreading of the solution on the printing plate surface was achieved using FS2, where for almost all solution samples even 5 µl were enough to reach optimal area coverage. The electrochemical measurements showed that there is no corrosion for all investigated fountain solution samples. From a research one could conclude that investigated samples do not cause corrosion of the aluminum based lithographic printing plates. The addition of the IPA causes reduction of the surface tension that leads to lower contact angle measured when applying fountain solution onto the nonprinting areas of the lithographic printing plate. The simulation of the printing process using the Pruefbau MZ II Multipurpose Printability Testing System could be used as a tool in defining amount of fountain solution needed to disable adsorption of the printing ink, but the process should be fine-tuned.
Keywords: lithography, fountain solution, printability testing, surface tension, contact angle

Abstract: Safe handling and manipulation of transformer oil in the electrical energy distribution and other sectors are to be realized in a manner and procedure that will not pose a risk of water, soil or air pollution for the protection of environment, life and health of people. Implementation of the necessary preventive and corrective measures for environmental protection, fire protection, safety and health at work is, among other things, mandatory, including the respect for and the realization of legal provisions, standards and regulations for the purpose of safe and optimal treatment and management of transformer oil, and prevention or reduction of negative impact on the environment and human health. The study presents the sources of transformer oil, testing and determining the trend of transformer oil's important features in the exploitation, with particular emphasis on potential negative impact on the environment, safety and health, therefore the results, recommendations and conclusions are given.
Keywords: transformer oil, electric power distribution, potential risk, environmental protection, safety and health of people, fire protection

Abstract: The recovery is one of the main components of the process of reproduction which determines the full life cycle of machines. The efficiency of product manufacturing depends largely on this process and it is therefore necessary to choose an appropriate details recovery technology. The subject of this study is cast iron cylinder head of a diesel engine with about 240,000 kilometers run. Results indicated a decrease of the tensile strength in the areas of combustion chambers as compared to the sections away from them. After recovery by welding with an iron-nickel electrode, the decrease in strength in the field of combustion was noticeable - 20-30%. During operation there was evidence of cracks and corrosion in depth, which further impeded the recovery process. Finally, the formation of numerous pores on the bottom of the weld pool in the area of the combustion chamber was found.
Keywords: cylinder head, welding, corrosion, destruction

Abstract: Logistics is a common word nowadays, since it is an essential component in supply chains and also in the competition of the economic operators. The goal of logistics is to provide things in adequate quality and quantity at a given destination, in an appropriate time, from an appropriate origin, with an appropriate method and equipment, and with an appropriate minimal cost. The quality and availability of the offered services by the logistics sector are of capital importance for the economical growth and for increasing employment potentials. The growing market globalization, increasing global competition, and more complex products results in application of new technologies, methods and business processes. Fast changing market environment and fluctuating customer demands require efficient operation of logistical processes. In this study the logistical tendencies and challenges are introduced with reasons and driving forces. The essence of Industry 4.0 conception is also introduced.

Keywords: market environment, customer demands, logistical processes, Industry 4.0 conception

Abstract: This paper shows a DIY ("do-it-yourself") type project. "Do-it-yourself" (DIY) is the method of building, modifying, or repairing something without the aid of experts or professionals. Academic research describes DIY as behaviors where individuals engage raw and semi-raw materials and component parts to produce, transform, or reconstruct material possessions. By promoting projects of this kind, students can understand that unconventional energy is available for everyone, at a minimal cost and with good results comparing to systems that are on the market. Students can also make a general impression that using unconventional energy represents the next stop towards the future in all the branches of the industry and protecting the environment. This paper presents the processes of designing and development of a heating system that uses solar energy. The heating system consists of two parts. The first part consists of a photovoltaic solar panel made from 36 photovoltaic cells capable of developing 65 W and 3.6 A. The second part is made of recycled materials (aluminum cans), forming radiant tubes.

Keywords: heating systems, solar energy, photovoltaic solar panel, radiant tubes

Abstract: The contribution deals with the possibilities of metal cleaning focused on environmentally friendly cleaning as laser cleaning technology of materials. The aim of this contribution is to present the new abilities of cleaning of product and tool surfaces in very short time with minimizing of waste in the future. There are mentioned and compared various material cleaning methods from classic ones to progressive ones and their influence on the environment. Laser cleaning is one of the newest progressive methods of the material cleaning. The results of this technology were recently tested and shown in the Department of Process and Environmental Engineering, Faculty of Mechanical Engineering, Technical University of Kosice together with the firm Trumpf Slovakia s.r.o. The laser cleaning technology can be used in the various fields of industry, in the production sphere, in the renovation sphere of products and materials. This technology minimizes the harmful impact on the working environment and environment as a whole area.

Keywords: environment, laser technology, cleaning, material

Abstract: In palm oil processing industry, biomass residues can be converted from being potential environmental pollutants to useful fuel for steam and electricity generation which are largely needed for industrial use. Steam boiler is an integral and important component of steam turbine used for electricity generation. Its design is however complex, time consuming and prone to errors if done manually. In this study, we report the application of computer based approach to design palm kernel shell combusting furnace for generating a desired amount of electricity. Using backward calculation approach, standard design equations were used to size furnace and its components. The equations were coded and solved using C-Sharp programming language. The results showed that to generate 5 kW of electricity from palm kernel shell; 5.5 kW turbines, 3.6 m super heater, 3.2 m riser, furnace of 1.432 m height and 0.45 m^3 volume were required having considered power loss due to friction and others. While these results are in good agreement with those

calculated manually, human errors are virtually eliminated. In addition, calculations and drafting time were reduced from 5 hrs 47 mins when done manually to about 4 mins when the developed code was used. This code can be used to size boiler for any desired power output.

Keywords: Steam boiler, palm kernel shell, design, computer aided, power output

Abstract: The research conducted over the past several decades indicates that buildings are the highest energy consumers (about 40% of total global consumption), so their environmental impact has come into focus in the previous years. In addition to standard energy efficiency measures, such as façade reconstruction or door and window replacement, increased emphasis has been placed on the construction of green roofs as a potential energy efficiency measure, wherever it is feasible, but primarily in urban environments. In the late 20th century, the fundamental principles of green architecture were established, pertaining not only to green roofs, but also to extensive and intensive greenery on large buildings, as well as green façades. In recent years, much attention has been given to roof gardens, which initiated the construction of numerous green roofs of extraordinary design. Roofs are much more than mere 'functional components' that protect the structure of a building. They give character to both individual buildings and entire city quarters. Roofs attract urban designers looking for socially responsible concepts, which are opposed to the loss of natural living space and offer solutions to the problems such as precipitation management or the urban heat island effect of densely populated cities. This paper discusses extensive, intensive, and semi-intensive green roofs.

Keywords: green roofs, extensive greenery, intensive greenery

Abstract: Amaranthus hypochondraicus is an uncommon amaranth in West Africa highly characterized with his multifunctional values which ranges from its good edible leaves, ornamental purpose and to its highly nutritious and medicinal seeds. This study was aimed at predicting yields obtained from an experimental farm using irrigation water as a single factor at four different levels. The levels of factor imposed include: applying 60%, 70%, 80% and 90% of the water needed to bring soil moisture content to field capacity. The site used in the study was designed to provide for maximum water control as much as possible. The plot framing was used to demarcate the study site into sixteen different plots of 1 m^2 each with four replicates designed with Latin Square Experimental Design. A total crop yield of 33.6 kg was obtained for all the plots. Plots treated with 90% water needed to bring soil moisture to field capacity recorded yield of 11.6 kg (representing 34.52% of total yield), plots with 80% water treatment yielded 9.3 kg (27.68%), plots with 70% water treatment recorded 7.2 kg (21.43%) and those treated with 60% water yielded 5.5 kg (16.37%). The results showed that higher yield is obtainable at higher water application. Using Design Expert to analyze the yields from the field, the predicted yields which correlate with the actual yields from the field was obtained. Significant differences existed between the yields obtained. The predicted and actual yield models gave ranges of R-square values with the highest value of 0.86 obtained plots treated with 90% water needed to bring soil moisture to field capacity. R-square values of 0.64, 0.61 and 0.47 were obtained for plots treated with 80%, 70% and 60% water needed to bring soil moisture to field capacity. The study shows that Amaranthus hypochodraicus is better predicted with minimum water stress of the field capacity.

Keywords: Amaranthus hypochondriacus, yield, field capacity and water stress

Abstract: Contemporary trends within the field of the environmental management indicate that there has been an obvious shift from the traditional "top-down" approach when defining the environmental protection policy, to the concept of environmental management towards a more open system of governance at all levels, where decisions are made on the distribution and use of environmental resources. If properly implemented, this approach recognizes the needs and obligations of those who most influence the use of environmental resources, without losing the possibility of involvement of the wider community in the management process. Increased interest in environmental quality, as well as obligations arising from the EU accession process (particularly derived from the Chapter 27: Environment) impose trend of responsible environmental management. At the other hand, global trends such as the establishment of environmental management system based on ISO

standards have the similar goals. The aim of this paperwork is to represent a comprehensive review of contemporary trends and practices in the field of environmental management, with particular regard to risk based approach. With no less importance, this paper seeks to demonstrate the application of risk-based environmental management practices in organizations already proven in the field of corporate social responsibility.

Keywords: environment, risk, management, methodology

The **ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering, Tome X [2017], Fascicule 1 [January–March/2017]** includes scientific papers presented in the sections of:

» **The 10th International Conference for Young Researchers and PhD Students – ERIN 2016**, organized by **University of Zilina, Faculty of Mechanical Engineering**, in **Liptovský Ján, SLOVAKIA, May 10–12, 2016**. The current identification numbers of the papers are the **# 4**, **# 8** and **# 12**, according to the present contents list.

» **The VIth International Conference Industrial Engineering and Environmental Protection 2016 – IIZS 2016**, organized by **University of Novi Sad, Technical Faculty "Mihajlo Pupin" Zrenjanin**, in **Zrenjanin, SERBIA, October 13–14, 2016**. The current identification numbers of the selected papers are the **# 5–7**, **# 13**, **# 17**, **# 20**, **#23** and **# 25**, according to the present contents list.

» **The 7th International Conference on Mass Customization and Personalization in Central Europe – MCP–CE 2016 – Mass Customization and Open Innovation**, organized in **Novi Sad, SERBIA, September 21–23, 2016**. The current identification numbers of the papers are the **# 1**, **# 3**, **# 9** and **# 15**, according to the present contents list.

» **The 8th International Symposium on Graphic Engineering and Design – GRID 2016**, organized by **University of Novi Sad, Faculty of TechnicalSciences, Department of Graphic Engineering and Design**, in **Novi Sad, SERBIA, 3–4 November, 2016**. The current identification number of the paper isthe **# 16**, according to the present contents list.

Also, the **ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering, Tome X [2017], Fascicule 1 [January–March/2017]**, includes original papers submitted to the Editorial Board, directly by authors or by the regional collaborators of the Journal.

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REVIEW OF 3D BODY SCANNING SYSTEMS

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Abstract: The purpose of this article is to review 3D body scanning systems currently available in the market. 3D human scanning is a process of capturing and subsequent digitization of the full body or the body parts into their three-dimensional graphical representation. As 3D human body scanning techniques are becoming ubiquitous, we give an overview of the different technologies of 3D body data digitization such as techniques based on photogrammetry, depth sensors, and laser scanning as well as few more promising techniques. Also, the underlying principles that allow these systems to work are determined and explained. In order to provide directions for further integration of digitized 3D human bodies, specifications of 3D body scanning systems are compared, and a variety of commercial scanners available in the market are presented in the paper.
Keywords: 3D human body scanning, 3D body scanning techniques, 3D body scanning systems, 3D body data digitization, 3D scanners commercial products

INTRODUCTION

Lately there has been an increased demand for realistic 3D models of human beings. Even today there are many indications that it will create a revolution in all aspects of our everyday lives. For example, the way people interact (i.e. virtual environments), clothing and styling industry, medical field etc. In this light it is obvious why the demand for 3D scanners of all price ranges has risen. The main topic of this paper will be to give an overview of the techniques widely used.

There are many different devices that can be considered 3D scanners. Any device that measures the physical world using lasers, lights or x-rays and generates dense point clouds or polygon meshes can be considered a 3D scanner. Some common terminology in usage for them includes 3D digitizers, laser scanners, white light scanners, industrial CT, LIDAR, and others. All these devices capture the geometry of physical objects with hundreds of thousands or millions of measurements.

All the different approaches to 3D scanning are stated in Figure1. Some technologies are ideal for short-range scanning (<1m, very high detail level), while others are better for mid (~m)- or long-range scanning (aerial photography). We will focus on those ranged techniques appropriate for scanning of humans i.e. those that commercially available and widespread. These can be divided into three different groups:

- Laser scanning,
- Projection of light patterns,
- Stereo-vision and image processing.

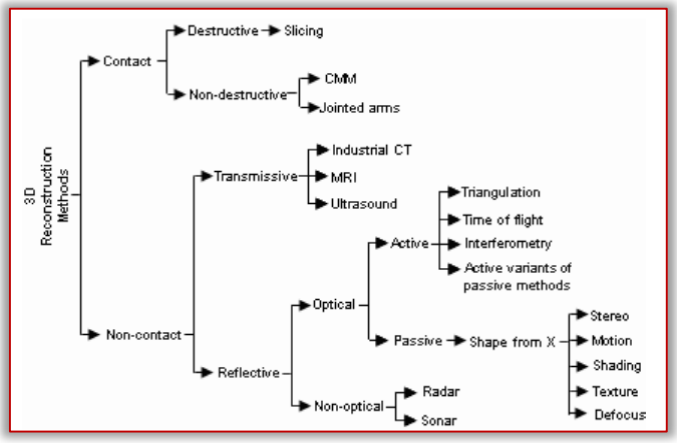

Figure 1. Classification of 3D reconstruction methods

As far as reflective ranged measurements are concerned, first distinction is between active and passive methods. With active techniques the light sources are specially controlled, as part of the strategy

to arrive at the 3D information. Active lighting incorporates some form of temporal or spatial modulation of the illumination. This can be a laser light technology or a visible light pattern projective technology. With passive techniques, on the other hand, light is not controlled or controlled only with respect to image quality. Typically, passive techniques work with whichever reasonable, ambient light available, as is often the case in stereo-vision and image processing methods.

As this is an overview of relevant 3D acquisition methods, it is not intended to be in-depth nor exhaustive. The techniques that will be presented are are widely studied and used for decades.

The organization of the paper is as follows. Section 2 gives a brief description of the 3D scanning methods belonging to the three aforementioned groups. Section 3 discussed and compares their characteristics. Section 4 lists some of the commectialy available products.. Section 5 concludes the paper.

OVERVIEW OF 3D SCANNING TECHNIQUES

Active range sensors acquire distance measurements from a well-known reference coordinate system to points of the object to be reconstructed [1']. They are very common when highly detailed models are required and have been used widely in the industry for decades. In the past ten years there have been an inrush of low-priced products based on scanning techniques to be described in the following section.

Laser Triangulation 3D Scanners

These scanners use either a laser line or single laser point to scan across an object. A sensor picks up the laser light that is reflected off the object, and using trigonometric triangulation, the system calculates the distance from the object to the scanner(Figure2).

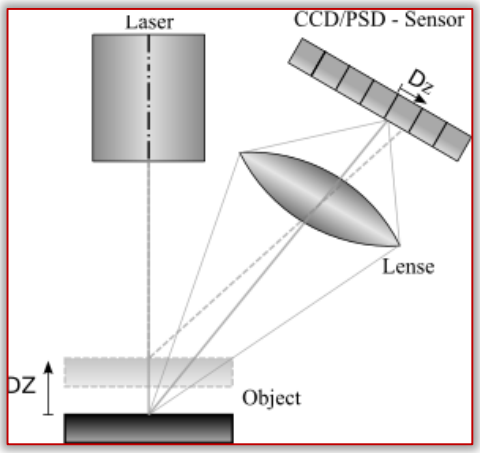

Figure 2. Laser triangulation principle, image source: Wikipedia

The distance between the laser source and the sensor is known very precisely, as well as the angle between the laser and the sensor. As the laser light reflects off the scanned object, the system can discern what angle it is returning to the sensor at, and therefore the distance from the laser source to the object's surface. Process requires precise mechanical apparatus (e.g., by steering rotating mirrors that reflect the laser light into controlled directions), as well as very precise laser beam. One would also not want the system to take a long time for scanning. Hence, one ends up with the conflicting requirements of guiding the laser spot precisely and fast. These challenging requirements have an adverse effect on the price. Moreover, total time needed to take one image per projected laser spot can be up to seconds or even minutes of overall acquisition time. There are faster, special methods, using super-fast imagers, but again at an additional cost.

In order to remedy this, substantial research has gone into replacing the laser spot by more complicated patterns. For instance, the laser ray can without much difficulty be extended to a plane, e.g., by putting a cylindrical lens in front of the laser. Rather than forming a single laser spot on the surface, the intersection of the plane with the surface will form a curve (Figure 3). Variant of the scanner with several (usually up to four) scanning pillars have been common, without the need to rotate the subject.

Structured Light 3D Scanners

Structured light scanners also use trigonometric triangulation, but instead of looking at laser light, these systems project a series of linear patterns onto an object (Figure 4). Then, by examining the edges of each line in the pattern, they calculate the distance from the scanner to the object's surface. Essentially, instead of the camera seeing a laser line, it sees the edge of the projected pattern, and calculates the distance similarly.

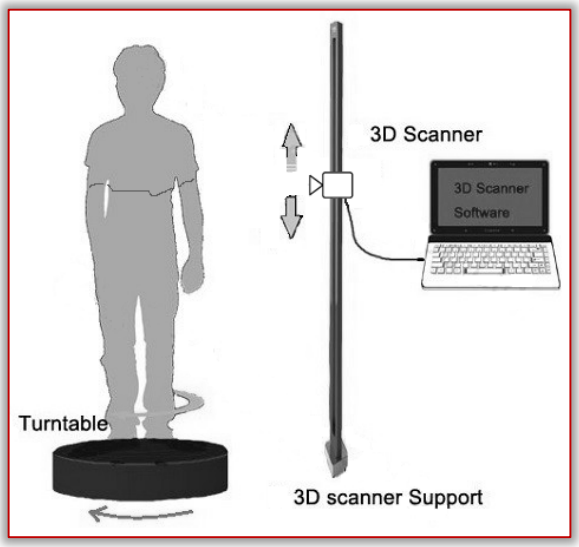

Figure 3. Laser triangulation system

Two common methods of stripe pattern generation have been established: Laser interference and projection.

The former method allows for the exact and easy generation of very fine patterns with unlimited depth of field. Disadvantages are high cost of implementation and difficulties to provide the ideal beam geometry. The projection method uses incoherent light and basically works like a video projector. A typical measuring assembly consists of one stripe projector and at least one camera.

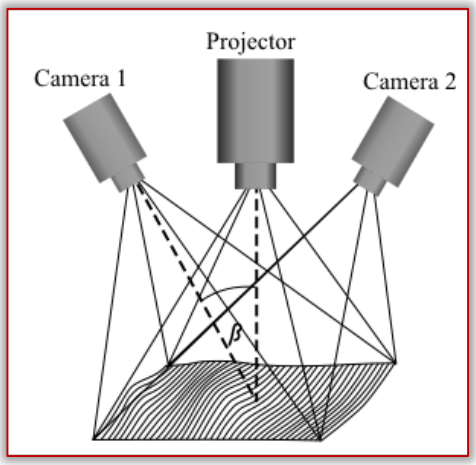

Figure 4. Structured light system, image source: Wikipedia

There are several depth cues contained in the observed stripe patterns. The displacement of any single stripe can directly be converted into 3D coordinates. For this purpose, the individual stripe has to be identified, which can for example be accomplished by tracing or counting stripes (pattern recognition method). Another common method projects alternating stripe patterns, resulting in binary Gray code sequences identifying the number of each individual stripe hitting the object. An important depth cue also results from the varying stripe widths along the object surface. Stripe width is a function of the steepness of a surface part, i.e. the first derivative of the elevation.

In order to get texture extraction, successive projections of coded and phase-shifted patterns are required to extract a single depth frame, which leads to a lower frame rate. Low frame rate means the subject must remain relatively still during the projection sequence to avoid blurring, however technology is maturing fast so this might not be the case in the near future. The reflected pattern is sensitive to optical interference from the environment; therefore, structured-light tends to be better suited for indoor applications.

Invisible (or imperceptible) structured light uses structured light without interfering with other computer vision tasks for which the projected pattern will be confusing. Example methods include the use of infrared light or of extremely high framerates alternating between two exact opposite patterns. However, in those cases it is usually not possible to extract texture information.

Time-of-flight (ToF) scanners

Laser pulse-based scanners, also known as time-of-flight scanners, are based on a very simple concept: the speed of light is known very precisely, so if we know how long a laser takes to reach an object and reflect back to a sensor, we know how far away that object is (Figure 5). These systems use circuitry that is accurate to picoseconds to measure the time it takes for millions of laser pulses to return to the sensor, and calculate a distance. By rotating the laser and sensor (usually via a mirror), the scanner can scan up to a full 360 degrees around itself.

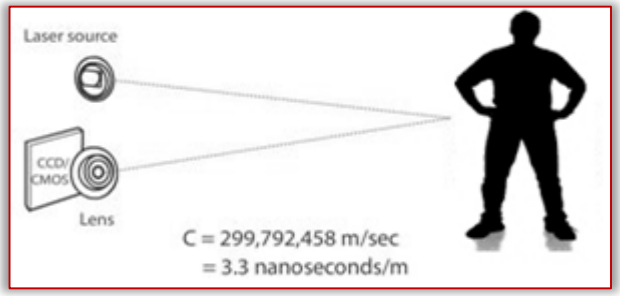

Figure 5. Time-of-flight scanning system

Laser phase-shift systems are another type of time-of-flight 3D scanner technology, and conceptually work similarly to pulse-based systems. In addition to pulsing the laser, these systems also modulate the power of the laser beam, and the scanner compares the phase of the laser being sent out and then returned to the sensor. For reasons that are beyond this paper's scope, phase shift measurement is more precise.

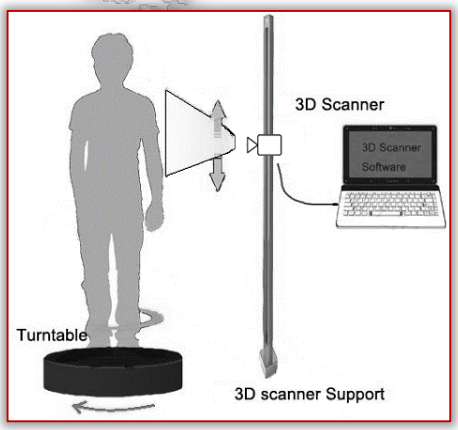

Figure 6. Typical scanning setup for either wide-angle ToF or structured-light camera systems

Figure 6 shows a typical scanning setup where the infrared light wide-angle ToF system is used.

Multi-view photogrametry systems

Most ubiquitous method in passive image-based 3D re-construction systems use the stereoscopic principles as present in human vision. Here, 3D measurements are not performed, but 3D information is generated and extracted from a sequence of images, acquired from different viewpoints (Figure 7).

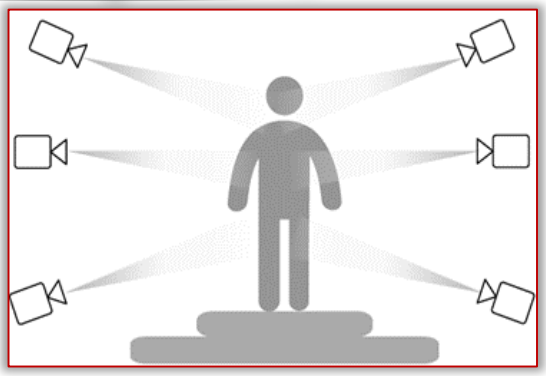

Figure 7. Multi-view geometry setup

Multi-view geometry is considered an evolution of stereo-based methods, where only two images were used: first, correspondences between points in both images were established (matching) and then their position in 3D space was determined by triangulation.

Prior to acquiring images, several things can be done to improve reconstruction quality:

- Proper coverage of the subjects from all angles to prevent occlusions, including uniform lightning.
- Cameras should be calibrated prior to acquisition of images to obtain their intrinsic parameters used in triangulation.
- A 3D reference frame defining scale, position and orientation in the form of control points (coded targets), lengths of photo-identifiable objects, and/or angles between photo-identifiable objects.

A major challenge in stereo vision photogrammetry is solving the correspondence problem [2'][3'] (Figure 8): given a point in one image, how to find the same point in the other cameras? Until the correspondence can be established, disparity, and therefore depth, cannot be accurately determined. Solving the correspondence problem involves complex, computationally intensive algorithms for feature extraction and matching [4''']. This area is well studied and there are many mature algorithms [2'][5'] and commercially available software solutions such as Point Cloud Library[6'], Photoscan [7'], Australis [8'] etc. An exhaustive list can be seen here [9'].

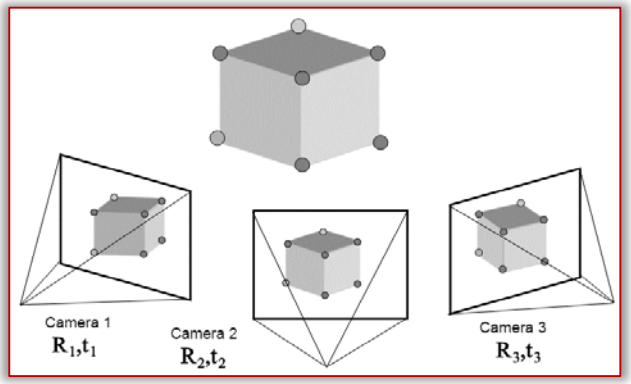

Figure 8. Multi-view point correspondence problem, image source: Noah Snavely, Cornell University

After the matching phase, triangulation process generates 3D point cloud. Usually, a refining is needed so a bundle adjustment process is performed [10']. It is an optimization procedure that refines an initial camera and structure parameter estimations for finding the values that most accurately predict the locations of the observed points in the set of available images. After that special interpolation algorithms create dense point cloud followed by polygonal mesh creation that can be exported for printing or other usage.

3D SCANNING TECHNIQUES COMPARISON

Time-of-Flight (ToF) laser systems have an advantage in precision when measuring distant objects, however for small distances the error is usually of the order millimeters because of the difficulty in measuring round-trip time precisely. Triangulation systems have limited range but relatively high accuracy of the order of micrometers. but require a good baseline. A disadvantage of ToF systems is that surface texture is not captured and that errors will be substantially larger for dark surfaces, which reflect little of the incoming signal. Missing texture can be resolved by adding a camera, as close as possible to the ToF scanning head. But of course, even then the texture is not taken from exactly the same vantage point. The output is typically delivered as a massive, unordered point cloud, which may cause problems for further processing.

In contrast to stereo vision or triangulation systems, ToF systems are very compact: the illumination is placed just next to the lens, whereas the other systems need a certain minimum baseline. In contrast to laser scanning systems, no mechanical moving parts are needed.

It is a direct process to extract the distance information out of the output signals of the ToF sensor. As a result, this task uses only a small amount of processing power, again in contrast to stereo vision, where complex correlation algorithms are implemented. After the distance data has been extracted, object detection, for example, is also a straightforward process to carry out because the algorithms are not disturbed by patterns on the object.

Time-of-flight cameras are able to measure the distances within a complete scene with a single shot. As the cameras reach up to 160 frames per second, they are ideally suited to be used in real-time applications. High resolution ToF scans, which collect millions of points, can take more than few seconds which can result in distortion from motion [11'].

The advantage of structured-light 3D scanners is speed and precision. Some existing systems are capable of scanning moving objects in real-time. In triangulation based systems, the range and depth variation are limited compared to other methods, but they have a great precision. A major advantage of structured-light is

that it can achieve relatively high spatial (X-Y) resolution by using off-the-shelf DLP projectors and HD color cameras.

In image based methods feature extraction and matching also require sufficient intensity and color variation in the image for robust correlation. This requirement renders stereo vision less effective if the subject lacks these variations i.e. when the local appearance is uniform within the neighborhood of each candidate point to be matched. Clothing can have a lack of significant local variation in their appearance or present a repeated pattern. This can, however, be remedied to some extent by placing artificial fiducial markers on the subject. ToF sensing does not have this limitation because it does not depend on color or texture to measure the distance. Secondly, occlusions in the scene make the correspondence between images ambiguous or even impossible, e.g. articulation of the body which leads to self-occlusions.

In stereo vision, the depth resolution error is a quadratic function of the distance while other two methods are much better in this respect. The main advantage of stereo vision is a very low cost of implementation as off-the-shelf cameras can be used.

The main benefit of 3D laser scanning is that it provides higher resolution and detail than photogrammetry. Therefore, facial details and even details on clothing are potentially captured more intricately with a 3D scanner, making the resulting 3D printed figurine more detailed and realistic as well. Scanning can be accomplished in a scanning booth, most often found in retail locations, or by using a 3D scanner in virtually any type of indoor or outdoor setting. A number of 3D laser scanners are available as portable handheld devices, offering quick and easy set up and flexibility in the location of the scan session. Structured light scanners can offer greater speed and accuracy than laser scanners when setup with large fields of view, approaching that of photogrammetry, but usually require several scanners to be synced together in order to capture the required angles without any “shadowing” due to “line of sight” and binocular vision restrictions. These multi-sensor systems, while very effective once set up, can be difficult and sensitive to calibrate.

The downside of using laser scanners for body form applications is that they take a second or more to capture data on any part of a subject during a scan. While that might not seem like much, the living body will move ever so imperceptibly during that second. Even if the movement is only a millimeter, the result will be a double layer of scan data in the same area of the geometry, which will cause problems when creating a mesh. Labour-intensive and often complex adjustment of the scan data is required after scanning in order to prepare the file for the 3D printer. Scanning sessions themselves can take several minutes and often must be repeated in order to properly capture the complete geometry or form[14'].

Many of the modern scanners use these techniques in combination. For example, there are cases of scanners which provide laser scanning precision with photogrammetric texture extraction component. Also as the state of these technologies is in constant movement it is impossible to make definite conclusion.

Wide range of available commercial 3D scanners can be seen in [12']. Table 1 shows the empirical comparison of scanningtechniques, in terms of speed and precision, of the same price category. In Table 1, 5 stars represent the best empirical value.

Table 1. Rough comparison of 3D scanning techniques

Scanner type:	Speed (5 stars)	Precision(5 stars)
Multi-view	*****	**
Triangulation	***	*****
ToF	**	****

After creation of the point cloud, by some of the described techniques, discarding of erroneous points (i.e. outliers) and noise removal by various statistical methods can be performed. Some of these outliers can be filtered by performing a statistical analysis on each point's neighborhood, and trimming those which do not meet a certain criterion. The sparse outlier removal implementation in the publicly available Point Cloud Library is based on the computation of the distribution of point to neighbors distances in the input data-set. For each point, the mean distance from it to all its neighbors is computed. By assuming that the resulted distribution is Gaussian with a mean and a standard deviation, all points whose mean distances are outside an interval defined by the global distances mean and standard deviation can be considered as outliers and trimmed from the data-set.

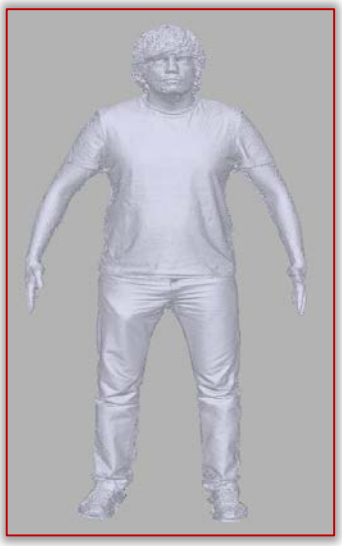

Figure 9. Typical 3D mesh model

Then a dense point cloud is generated using appropriate interpolation algorithm followed by filtering of the points from the result to adjust it and eliminate bad points. After that, creating polygon mesh model can be done for the model to be used in other 3D modeling software. An example of a generated mesh model without added texture is shown below (Fig. 9).

OVERVIEW OF COMMERCIAL PRODUCTS

There are numerous commercial scanners on the market today, with the number and variety constantly increasing. Hand-held 3D scanners are gaining popularity due to the ease of use and portability. Their pricesrange from 100 euros up to 20000 euros.

Some commercial solutions and the techniques they use:

- Microsoft Kinect 1 uses a pattern of projected infrared points to generate a dense 3D image.
- Microsoft Kinect for Xbox One uses a wide-angle time-of-flight camera.
- Intel RealSense camera (Fig. 10) projects a series of infrared patterns to obtain the 3D structure.

Low cost models like Intel RealSense 3D cameras are quickly finding their way in people's everyday lives. They are becoming a part of notebooks, phones and handheld devices, replacing the old 2D cameras, or as an add-on accesory These devices are mainly used for the scanning of parts of human body (facial expressions, hand gestures, etc.) for entertainment purposes as their resolution and texture detail tends to be low.

Figure 10. Intel RealSense 3D cameras and their place on the smartphones

Figure 11. iSense for iPads by 3DSYSTEMS

High-end, metrology-grade, portable scanners like those by Artec 3D (Eva and Space Spider) and Nikon (ModelMaker MMCx on Fig. 12) offer less than 0.5mm resolution, depending on the scanning distance. They are rarely used in full body scanning as the process can take minutes and the obtained level of details is excessive for non-special purposes.

Figure 12. Nikon ModelMaker MMCx 3D laser scanner

Structured light scanners also havewide price spectrum. In the price range of 3000euros structured-light scanners products have superiority. An example is shown on Fig. 13. Submilimeter resolution and high mesh density for scans that last only several secons has made them videly used. For full body scanning, either a turntable has to be used or a set-up of several scanners.

Figure 13. David SLS-3-STEREO structured light scanner

An emerging technology is the real time 3D scanning capability. It has applications in animation and medical imaging to capture real facial expressions and body shape changes in real time. Documenting and quantifying anatomical dense surface movement, pose, and expression. 3D camcoders have been on market for some time, and are becoming more affordable. In case of real time 3D laser scanner they are still not present on the market

CONCLUSIONS

Active sensors provide directly the range data containing the 3D coordinates necessary for the mesh generation phase. Active range scanning technology has

been applied to automatically acquire highly accurate geometric data of people. However, generally range based scanners can only capture a single static pose of a person. Passive sensors provide images that need a mathematical model to derive the 3D coordinates. After the measurements, the data must be structured and a consistent polygonal surface generated to build a realistic representation of the modeled objects or scenes. A photo-realistic visualization can afterward be generated by texturing the 3D models with image information.

Nowadays, when choosing appropriate scanner suiting ones' needs, a wide range of products currently available is rapidly increasing. The old classification of laser scanners being the most expensive is no longer true. Same goes for structured-light scanners. Both methods have products of full body millimeter precision scanners for 2000$ or less [12']. Also small and portable scanners are finding their way to the market, being pushed by large companies with aggressive pricing of several hundred dollars. If one needs a high quality texture model currently the choice boils down to multi-view photogrammetry scanners. However, structured-light scanners might not be too far behind.

The race is on among manufacturers of digital image and geometry capture technology to develop a solution that is affordable, off the shelf, quick and easy to set up, high resolution and fast, in order to accommodate movement. To this end, photogrammetry solution providers are trying to incorporate multi-camera systems and software into one simple, packaged solution. At the same time, makers of 3D laser scanners are trying to develop faster and more automatic geometry capture solutions to accommodate for movement and shorter scanning sessions. There are also major steps being taken by mainstream electronics companies and suppliers to incorporate 3D content capture into mobile phones or tablets, and this is where we are already seeing a big change in the ability of average consumers to generate usable 3D content.

As the need for 3D models of humans will certainly rise in the near future, the market of 3D scanners is becoming a lucrative business and the competition is developing new and innovative solutions at a staggering rate. It is certainly a field where a potential buyer must be up-to-date on a monthly basis.

Note

This paper is based on the paper presented at The 7th International Conference on Mass Customization and Personalization in Central Europe – MCP–CE 2016 – Mass Customization and Open Innovation, organized in Novi Sad, SERBIA, September 21-23, 2016, referred here as [15].

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INVERSE KINEMATICS ANALYSIS OF A PUMA ROBOT BY USING MSC ADAMS

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Abstract: This work presents a different approach to inverse kinematics analysis of a PUMA robot. PUMA robot is an industrial robot arm with open chain mechanism that is used in different purposes. PUMA robot has a complicated inverse kinematics expressions that needs to be solved. In this paper, the inverse kinematics problem is solved by using MSC ADAMS instead of knowing inverse kinematics expressions and calculating this expressions. PUMA robot multi-body dynamics model is built by MSC ADAMS and joint angles are derived for a circle-shaped trajectory. Used trajectory and derived joint angles are given in the form of the graphics.
Keywords: robot, robot arm, puma robot, multi-body dynamics, inverse kinematics

INTRODUCTION

PUMA (Programmable Universal Machine for Assembly) robot is an industrial robot arm with open chain mechanism that is used in different purposes like welding, surgery, laser tracking systems, etc [1-3].Inverse kinematics is to obtain the joint angles for a desired trajectory or position of the end point the robot [4]. PUMA robot has a complicated inverse kinematics expression that needs to be solved. There are several numerical and experimental studies in literature about solving inverse kinematics of PUMA robot by using different algorithms or software's [5-7].

In this paper, the inverse kinematics problem is solved by using MSC ADAMS instead of knowing inverse kinematics expressions. PUMA robot multi-body dynamics model is built and joint angles are derived using MSC ADAMS. Inverse kinematics analysis is the first step of trajectory tracking control studies. PID control and adaptive fuzzy logic control are some of the control methods of trajectory tracking [8-9].

MODELING AND INVERSE KINEMATICS ANALYSIS

In this section modeling and inverse kinematics analysis of the PUMA robot is described. Model of the PUMA robot is built by MSC ADAMS that is multi-body modeling software to build and simulate mechanical systems dynamic analysis.

PUMA robot has six degrees of freedom with a spherical wrist. In this paper only first 3DOF is studied without wrist that shown in Figure 1. Modeled PUMA robot joint angles and component dimensions of the robot is shown in Table 1.

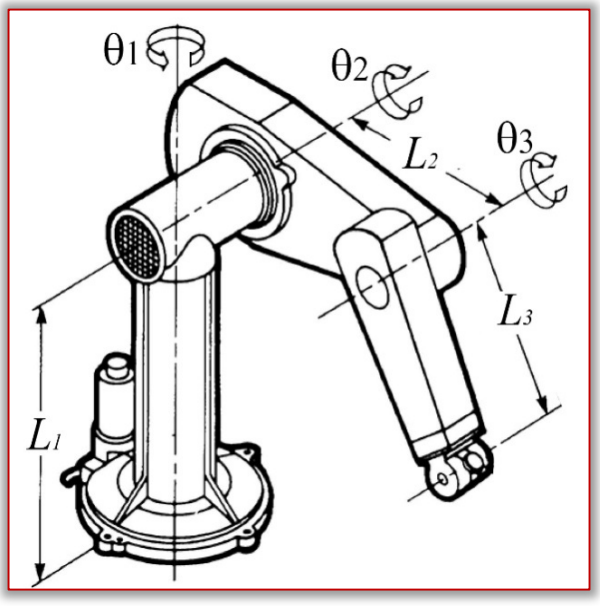

Figure 1. PUMA Robot dimensions and joint angles.

Table 1. Joint angles and component dimensions

θ_1	Waist angle	0 deg
θ_2	Shoulder angle	0 deg
θ_3	Elbow angle	-45 deg
L_1	Trunk length	0.180m
L_2	Upper arm length	0.120m
L_3	Forearm length	0.125 m

Inverse kinematics (IK) is to obtain the joint angles for a given trajectory or position to end point the forearm. PUMA robot has a complicated inverse kinematics expression that needs to be solved.

The inverse kinematics problem is solved by using MSC ADAMS and simulated by using MATLAB co-simulation instead of knowing inverse kinematics expressions and calculating this expressions.

A circle-shaped trajectory is given to end of the forearm with using MSC ADAMS capability of giving motion to the points and joint angles are derived for the trajectory. X and Y coordinates of circle generated and used as an input by MATLAB shown in Figure 2 and Figure 3. Circle-shaped trajectory is shown in Figure 4 created with X and Y coordinates.

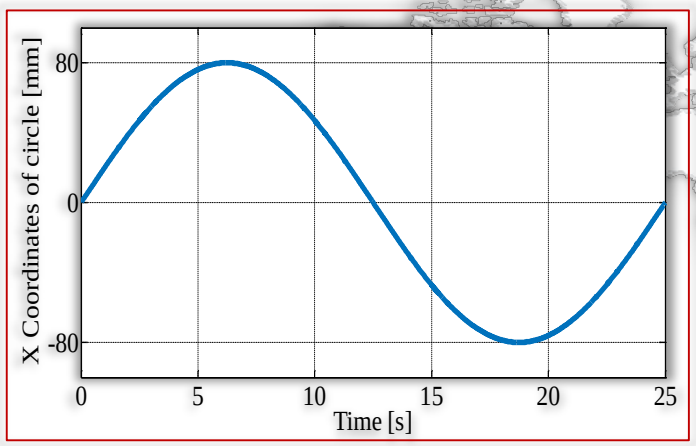

Figure 2. X Coordinates of the circle-shaped trajectory

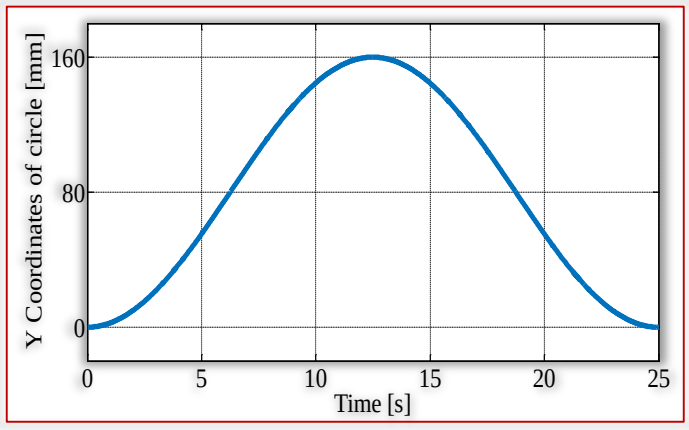

Figure 3. Y Coordinates of the circle-shaped trajectory

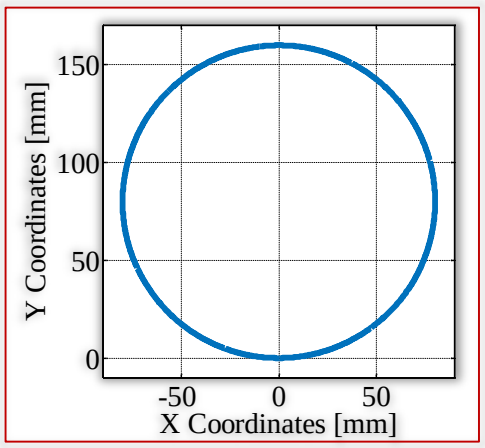

Figure 4. Circle-shaped trajectory created with X and Y coordinates

RESULTS AND DISCUSSION

Inverse kinematics problem of PUMA robot is solved by using MSC ADAMS and MATLAB co-simulation capabilities and joint angles are derived for the circle-shaped trajectory. As a result of inverse kinematics analysis Derived waist angle θ_1 is shown in Figure 5, derived shoulder angle θ_2 is shown in Figure 6 and derived elbow angle θ_3 is shown in Figure 7.

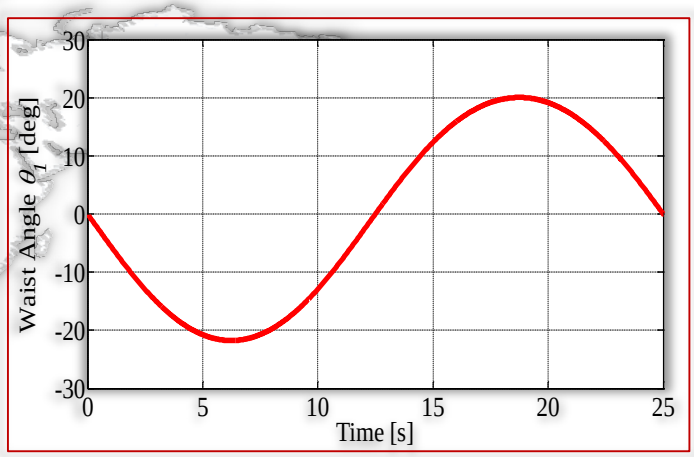

Figure 5. Waist angle

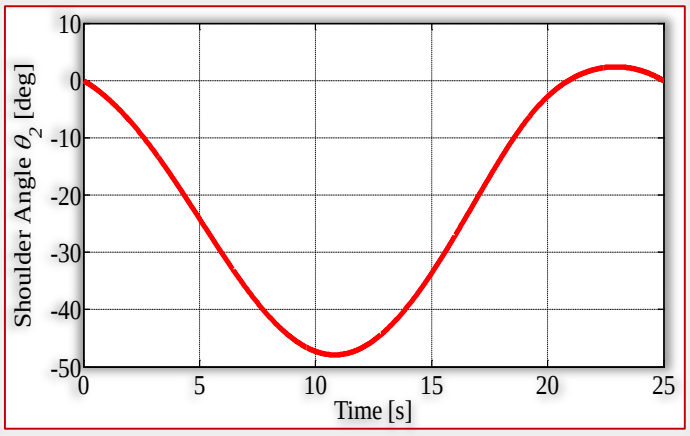

Figure 6. Shoulder angle

Moreover, simulation of inverse kinematics analysis gives visual animations as a result. Snapshots from the animation of analysis are given in Figure 8.

From these results, it can be said that using MSC ADAMS is a successful and effective method for solving inverse kinematics of a PUMA robot and dynamics of other mechanical systems.

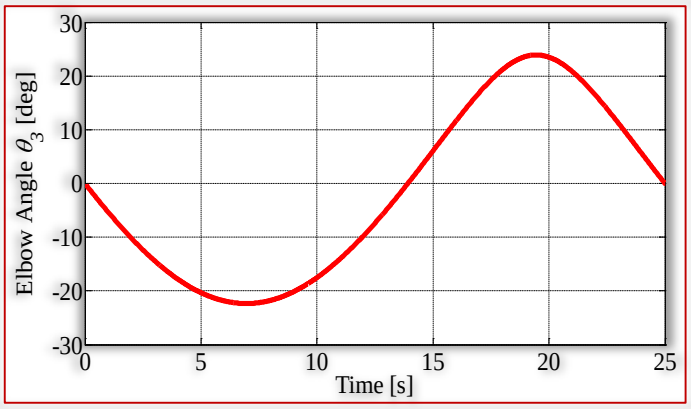

Figure 7. Elbow angle

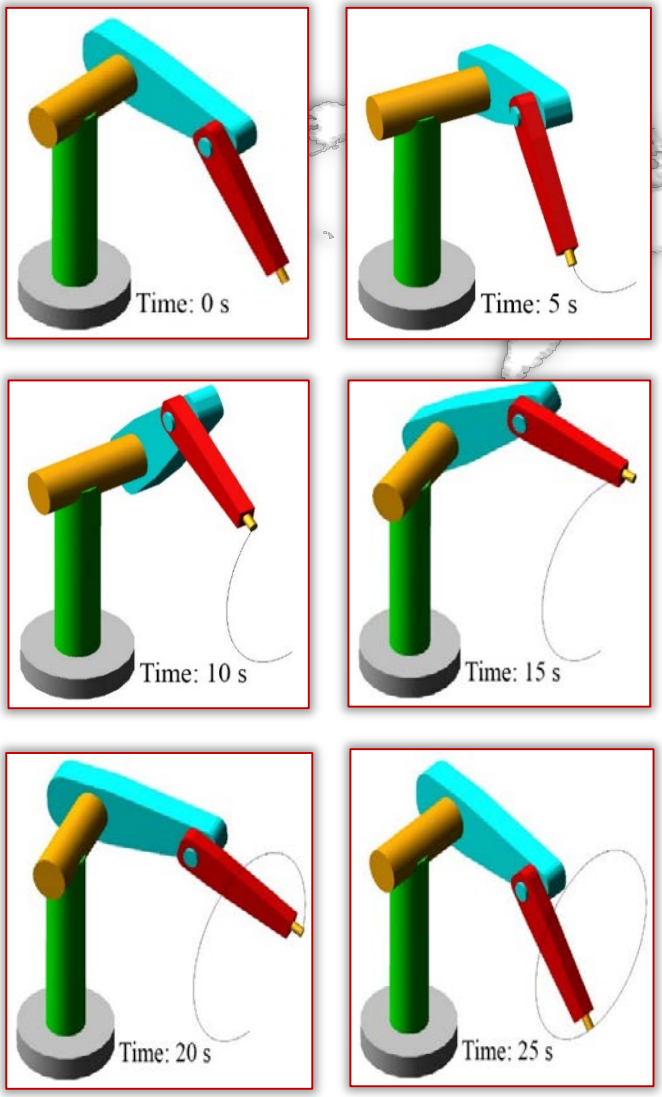

Figure 8. Snapshots from the simulation

CONCLUSION

This paper presents a different approach to inverse kinematics analysis of a PUMA robot that is an industrial robot arm with open chain mechanism. Inverse kinematics problem of PUMA robot is solved by using MSC ADAMS and joint angles are derived for the circle-shaped trajectory.

Thus, these types' robots and mechanical systems can be modeled and analyzed without mathematical model by using engineering software. As a result of the paper, proposed analysis method verified by simulations and derived joint angle results are given in the form of the graphics.

The main contribution of the paper to the literature is that different type inverse kinematics analysis approach is implemented. Furthermore, this paper can be a reference to the trajectory control studies of the robots for the future works.

Note

This paper is based on the paper presented at The VIth International Conference Industrial Engineering and Environmental Protection 2016 – IIZS 2016, organized by University of Novi Sad, Technical Faculty "Mihajlo Pupin" Zrenjanin, in Zrenjanin, SERBIA, October 13–14, 2016, referred here as [10].

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TRANSFORMATION FROM MASS PRODUCTION TO MASS CUSTOMIZATION IN SCM: OBSTACLES AND ADVANTAGES

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Abstract: This paper investigates the application of mass customization in supply chain management. Throughout research of the current literature and findings authors have discovered interesting keymarks that are related to obstacles and advantages while organization is trying to transform from mass production to mass customization. Significant aforementioned findings are gleaned, expounded nad compared with a current study in the field. Results are far from panaceas but its a next step to cope with obstacles and develop advantages of MC in supply chain management.
Keywords: SCM, mass customization, logistic, risk, processes, literature review

INTRODUCTION

In supply chain management customer is the most significant component and mass customization (hereon reffered to as MC) is mostly related to customers due to its capability to deliver highly customized services and products in the high vicinity of customer's desires. Facing the buyers' market, many industries are now shifting from mass production to continuous improvement and to mass customization [1]. The traditional mass production company is bureaucratic and hierarchical. Under close supervision, workers repeat narrowly defined, repetitious tasks. Result: low-cost, standard goods and services [2].

In order to shift to mass customization from mass production paradigm authors proposes that it is not capable of doing so if beforehand in organization haven't existed some type of quality practice or manufacturing strategy such as lean manufacturing. Firms must first focus on their processes and tasks to be standardized and easy to deal with. Later it can be easier to cope with the obstacles one at the time. After standardization step comes flexibility, which is driving wheel for agility. Agility is very important in organization while trying to implement mass customization philosophy because it corresponds to quality rate and response time to customer demands.

In MC paradigm it is crucial to provide individually designed products and services to customers through process agility, flexibility and integration.

Supply chain involves main processes starting from supplying material and ending with product delivery. The processes in supply chain are divided into two categories depending on whether they are executed in response to a customer order or in anticipation of customer orders. While Pull processes are initiated by customer order, Push processes are initiated and performed in anticipation of customer order [3]. Push processes can be reffered to as mass production or even in MC while predicting customer desires. Push process is used in MC while trying to forecast customer demands in order to facilitate costs while using a postponement strategy. Postponement is very important and it cannot be left out if organization wants to grab the economies of scale in MC. This cannot be accomplished without product modularity.

Modularity serves the purpose of enabling parts of a product to be combined using, for example assembly-to- order approach (ATO) to provide high variety or assembly of a same or different product. This also can be a good thing in supply chain, because it later can be used to delay point of differentiation which shortens delivery time to customer. Core modules are usually made at a fabrication stage which later in supply chain

can be modified in distribution centres, warehouses and even depots. Perfect example for this is personal computer industries.

In any case, MC is seen as a systemic idea involving all aspects of product sale, development, production, and delivery, full-circle from the customer option up to receiving the finished product [4].

The justification for the development of MC systems is based on three main ideas. First, new flexible manufacturing and information technologies enable production systems to deliver higher variety at lower cost. Second, there is an increasing demand for product variety and customization. Finally, the shortening of product life cycles and expanding industrial competition has led to the breakdown of many mass industries, increasing the need for production strategies focused on individual customers [2].

SUPPLY CHAIN MANAGEMENT IN MC

Supply chain management practices are important MC enablers. For example, Huang et. al.[5] found that both internal and external learning from supply chains contribute to MC capability development and that their effects are mediated by effective process implementation.

In mature markets, firms face stiff competittion and demanding customers. The implementation of mass production, which is based on a forecast driven strategy, leads to overstocking, extra marketing expenses and low profitability [6], which corresponds to higher lead time, and lower customer satisfaction.

Hence, many manufacturers adopt mass customization but few of them realize that "it is supply chains that compete not companies" [7]. Surely company has a great impact on creating a customer trusted brand but it cannot be done without proper supply chain. Hence, transforming firm from producer to customizer is also affecting on firm, partners, distribution centers and warehouses, even depots. Many have failed cause of the inability to free themself from mass production paradigm [8].

Some may say [9] that obstacles to transform from mass production to mass customization are: demand uncertanty, flexibility of equipment, order fullfillment process, information system and supply chain. Hence, many have realized that supply chain also plays a critical role while transforming from mass production to MC.

In order to transform organization from mass producer to mass customizer it needs to be capable of accepting two main characteristics to achieve mass customization level of expertise. And even so, some have failed to sustain in MC environment, like, for example Toyota. Toyota's pioneer effort to transform to mass customizer run into trouble and has had to retreat, at least temporarily, from its goal of becoming mass customizer [10]. The first stage is that organization accept, implement and sustain lean approach in manufacturing system which origins can be traced in TPS (Toyota Production System)[11]. The main goal should be eliminating waste. The second stage should be transforming lean environment into more agile environment. On contrary to lean approach agile is considered more market flexible. This means that organization must be capable of rapidly changing its processes and tasks in order to quickly respond to customer demands. This must accompany lean approach since lean has difficulties in the late stages of SCM such as stocking/sales. The fact that throughput time of a product is 12 hours or less, inventory level can still be as high as two months of sales nevertheless everything seems to be working as "lean" as it possible get. While leanness may be an element of agility in certain circumstances, itself cannot enable organization to meet precise customer demands [12].

Hence, lean paradigm should be considered when company is focused on eliminating waste therefore lowering costs, and on the other hand agility should be considered when company is focused on increasing customer satisfaction.

In order to achieve quick delivery of customizated products marketing and operations must work together[13]. This doesn't mean only company itself but the whole supply chain while trying to accomplish quick delivery. Both functional areas of business must transform to more agile approach in order to produce customer services and go beyond customer satisfaction.

Feitzinger [14] also highlights that positioning of inventory, location, number structure of manufacturing and distribution facilites should be designed to provide two capabilites. First, it must be capable to supply basic products to facilites performing customization in cost-effective manner and second, it must have the flexibility to respond individual orders and deliver goods quickly.

Determining the optimum number and location of factories could be done through process integration. By integration it is meant collaborative working between buyers and suppliers, join product development, common systems and shared information [12].

One can conclude that by integration factories could mitigate risk in such challenging environment. It can be done by utilizing postponement. This enables firm first to produce generic module based on aggregate customer demands which later can be customized based on the specific cusomter demands in supply chain. Since forming the co-operation between factories, they are now focusing on their core compentences while outsourcing all other activities, which means that companies no longer compete as themselves but as a supply chain.

It requires balancing factors such as transportation time, stock outs, obsolescence, market value, response time, etc. It can be split into centralized and decentralized networks. First, usually with lower costs but second provides better customer service. Therefore, it is not easy to decide between each other. As said before marketing and operations really need to boost up their efforts to make appropriate decisions in order to grab the market niche.

DISCUSSION

Beforehand said it is obvious that work force, suppliers, partners and customers have a great impact on mass customization paradigm. Workers can help a manufacturer to come up with new ideas with process and product features, customers can provide knowledge about unfulfilled demands, product features and functions while suppliers can provide knowledge about market trends, which help a manufacturer to come up with new product and process ideas and thereby help to define a solution space.

Therefore, MC's success depends on knowledge from customers, suppliers, and internal sources. Notice that internal sources is closely related to continues improvement characteristics or lean, while suppliers and customers could be used to transform to more agile organizational environment whilst maintaining some degree of standardization in processes.

The involvement of suppliers in design and production allows a manufacturer to pass the customer's voice to it's suppliers and hence increases the entire supply chain's flexibility in response to the customer changing needs [15]. Others [16] disagree with the claim since knowledge sourced from suppliers cannot provide manufacturer with the information how to customize and configure product with current solution space. Authors of this research agree that involvement of suppliers in design of a product plays a significant role since it affects flexibilty and therefore shortening product lead time and service delivery. Ahlstrom & Westbrook [17] came up with significant findings through a survey of 40 companies[1]. Positive outcomes experienced from product customization were: increased customer satisfaction and increased market share, while negative outcomes were: material and manufacturing costs. One of the reason that this occured is that processes in that companies haven't evolved into full customized company. It would be interesting to do the research related to the same topic in the present era since the information technology have evolved exponentially in the last ten years. Interesting fact is that beside those positive and negative outcomes questionnaire was also conducted related to difficulties in implementing mass customization where at the top was supply chain management. This indicate that there are opportunities for customization in late stages of logistic chain – distribution. This mode of customization is so called "adaptive customization" [18]. The point of customization or so called "decoupling point" is the point where the forecasting ends and satisfying customer demands starts. An example where the point of customer involvement starts can practicly be seen in figure 1.

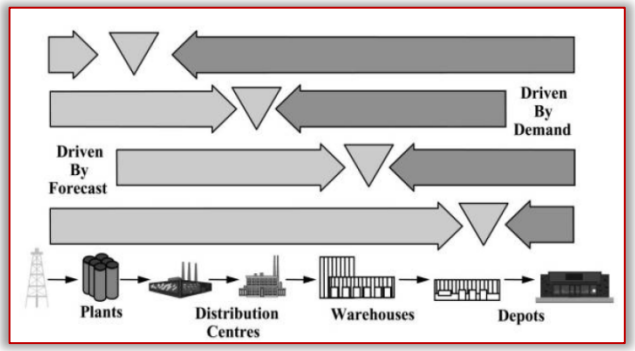

Figure 1. Material flow decoupling points and strategic inventory [19]

By [12] it is considered that challenge to supply chain management is to succesfully engineer the decoupling point. The more accurate it will easily be for a firm to achieve volume-oriented economies of scale through product standardization.

It can be seen that agility in supply chain can play significant role if the market winner is service level, while lean supply is better suited if market winner is cost [20]. Lean tools can be used effectively to eliminate waste while looking at "long run", but it cannot be used effectively in turbulent and flexibile market demands where agility requires resolving customer demands in short and uncertain planning horizons with highly customized product variants [21]. Hence, coining a new term called leagile philosophy.

Famous example usually used while explaining a good practice in mass customization environment using a postponement strategy is obviously PC industry. In the era since the 2000's market winner was lead time [22].

To become market winner and succesfully develop short lead times, organizations must develop agility first. To accomplish that it must be initiated by building on leanness. Another thing worth mentioning is that agility requires control of all processes in the supply chain which is really hard if not impossible to achieve. Therefore, organization must go through stages of lean philosophy so it can easily overcome the difficulties in later agile market. While transforming it must be focused on process enhancement [23].

Another approach which should be taken into account is separating demands into basic and urgent. This can help organization to better focus while parsing leanness from agility. Leanness and agility correspond

[1] Results were taken from companies that were using assembly of core modules (AC) and material processing (MP) mostly.

to basic and urgent demands, respectively. It can be a good metric required for management system and manufacturing practice. However, one must remember that lean approach is better in steady environment while agile approach is better in uncertain environment. Naylor [21] even points out that leanness and agility are mutually exclusive and cannot be applied in the same time in supply chain. Therefore, processes need to be agile in order to respond to unceratin and changing demands placed upon it, while accomplishing minimal waste due to excessive expenses and unneeded operations processes which resemble lean philosophy. Hence, one can induce that while agile presumes leanness, leanness might not presume agility. Since 2000's and later on authors propose that market winner still is lead time, especially with the development of social media and newly formed infrastructure of society so called Internet of things (IoT).

CONCLUSION

Our findings show that the knowledge sourced from supply chains improves firms capability to cope with the obstacles while transforming from mass producer to mass customizer. The keymarks include knowledge sourced from indoor i.e. workforce, outdoor i.e. suppliers and consumers. With co-operation and process integration firms capability rise and so does the partnership between suppliers. It can also serve a purpose of mitigating risks in supply chain environment and lowering risk of unsatisfied customer service.

Succesful transformation from producer to customizer is easier said than done, but with accurate information of customer preferences through supply chain can be used to mitigate risk in agile environment. Achieving it organization must nourish suppliers and accept it even as partners since they are both co-dependent in new era with little brand loyalty. By integration and co-operation between firm and suppliers, firm has a better chances to aline it's processes to customer demands and accomplishing higher service level and lead time, while maintaining quality and low costs. In the same time fulfilling higher profit margins and avoiding stockout penalties. Since we are entering the era of so called Industry 4.0 stockout penalties directly represent turning point in customer loyalty.

A particular important research direction should be measuring outcomes of co-operation between suppliers while trying to mitigate risk in order to achieve mass customization of product/service.

Note

This paper is based on the paper presented at The 7th International Conference on Mass Customization and Personalization in Central Europe – MCP–CE 2016 – Mass Customization and Open Innovation, organized in Novi Sad, SERBIA, September 21-23, 2016, referred here as [24].

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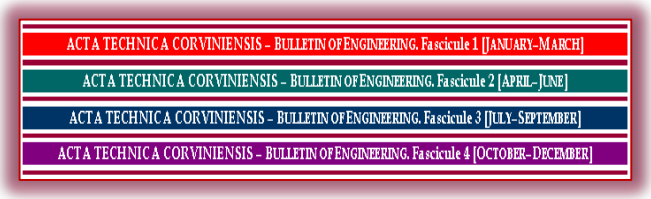
*We are very pleased to inform that our international and interdisciplinary journal **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering** completed its nine years of publication successfully **[issues of years 2008 –2016, Tome I–IX]**.*

In a very short period it has acquired global presence and scholars from all over the world have taken it with great enthusiasm.

*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 fields of science and technology. 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.*

*Now, when will celebrate the tenth years anniversary of **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**, we are extremely grateful and heartily acknowledge the kind of support and encouragement from all contributors and all collaborators!*

*On behalf of the Editorial Board and Scientific Committees of **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**, we would like to thank the many people who helped make this journal successful. We thank all authors who submitted their work to **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering.***



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MACHINING OF NEW BIOMATERIALS FOR IMPLANTS

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Abstract: Article compares cutting conditions and forces generated during milling of advanced biomaterials based on titanium. Since these are hard materials used in the manufacturing of expensive dental implants, the purpose of the article is also to identify and compare the dynamic machinability of said materials. This allows the outputs of this article to serve as an aid in the planning of production processed and calculating of production costs.
Keywords: biomaterial, titanium, dynamic machinability

INTRODUCTION

A constant need for a development of new kinds of medical implants placed into human body, serving as substitutes for dysfunctional or damaged body parts, requires new materials for their production, which must meet difficult and often contradictory requirements. Such materials include for example commercially pure titanium and its alloys, which are used for their excellent biocompatibility and suitable mechanical properties.

In the implant manufacturing are frequently used conventional machining technologies. Since titanium is classified as material with worse machinability, there is need for solutions of complications appearing during conventional machining. The main factors that contribute to poor machinability of titanium are low thermal conductivity a high friction coefficient in contact with other materials, causing thermal degradation of tools. High tensile strength and low modulus of elasticity also contribute to increased mechanical stress in cutting edge of the tool. Reducing of production costs and times while increasing production quality is a fundamental objective of the production process.

Given the geometric and dimensional accuracy and the surface quality of the products made of hard materials, it is necessary to handle problems with machining materials is used for this applications and determine such technological conditions, under which machining will be efficient.

Article is focusing on comparison of machinability of new titanium materials, used in dental implantology, for milling. Mentioned materials are commercially pure titanium TiGr5, commercially pure titanium with volume nanostructure (nTi) and alloy TiNbTa. As reference, material was chosen commonly used commercially pure titanium TiGr2.

Partial goals of article were the force rates in relation with cutting conditions and to determine structural formulas for face milling

STUDIED MATERIALS AND HARD-MILLING CONDITIONS

Unalloyed Commercially Pure (CP) Titanium is available in four different grades, 1, 2, 3 and 4, which are used based on the corrosion resistance, ductility and strength requirements of the specific application. Grade 1 has the highest formability, while Grade 4 has the highest strength and moderate formability. TiGr2 is stronger than Grade 1 and equally corrosion-resistant against most applications. Biocompatibility of Grade 2 Titanium is excellent, especially when direct contact with tissue or bone is required. Mechanical Properties of TiGr2 are Rp0,2 = 275 – 450 MPa, Rm = min. 345 MPa, A5 = 20% and HV10 = 146. [1]

TiGr5 is an alloyed titanium product containing 6% Aluminum and 4% Vanadium, a medium strength product. This titanium grade is predominantly used in airframe and turbine engine parts; and for use in surgical implants. Mechanical properties of TiGr5 are Rp0,2 = min. 828 MPa, Rm = min. 895 MPa, A5 = 10% and HV10 = 314. [2]

Nanostructured titanium (nTi) belongs to the so-called bulk nanostructured metallic materials. For these are considered materials with gran size between 1 – 100 nm. [3]

Production of Nanostructured titanium consists of forming commercially pure titanium (cpTi) by SPD technology – high plastic deformation at which chemical properties remain unchanged, but the mechanical properties are improved significantly in relation to the strength. Mechanical properties of nTi are Rp0,2 = 1200 MPa, Rm = 1240 MPa, A5 = 12% and HV10 = 336. [4]

Milling of hard materials with face mills and milling heads usually does not bring greater difficulties. On the other hand, milling with slab mill is only possible on some materials (high alloyed chrome steels etc.). In hard material milling are preferably used milling tools made of sintered carbides, tougher types particularly. [5]

Rapid durability decrease in very narrow range of cutting speeds is characteristic for milling of hard materials. Therefore cannot be applied higher cutting speeds in milling operations to increase productivity and it is necessary to apply economically acceptable cutting conditions. [5]

EXPERIMENT CONDITIONS

For the purpose of experiment we used vertical CNC 3-axis machining center HURCO WMX 30t (Fig. 1), where we performed measurements of cutting force components during face milling of selected types of titanium biocompatible materials. During machining were not used processing media so influence of third factor is eliminated. Focus was on the interaction of machined material and selected tool, which was monolithic ø4mm end mill, with four cutting edges, made of sintered carbide and coated with TiAlN.

Figure 1. Machining center HURCO WMX 30t

Figure 2. Tool selected for experiment - monolithic ø4mm end mill, TiAlN coating

Tested material samples

Samples made of TiGr2, TiGr5 and nTi were tested in form of cylinders with diameter of 5mm and length of 15 mm. Due to unavailability of TiNbTa rod blanks, samples with diameter of 4mm and length of 15mm were made

Measuring apparatus

For experimental measurement of cutting force components and torque was used piezoelectric dynamometer KISTLER type 9273.

Apparatus consists of:

- 3 – component charge amplifier KISTLER type 5006
- Analogue/Digital converter PCL 818 – HG
- DASY LAB 3,5 software
- PC

EXPERIMENTAL RESULTS

Example of behavior of measured tangential component of cutting force Fc during milling of selected titanium materials (TiGr2) at v_c= 30 m.min^{-1}, f_z = 0,04 mm, a_p = 0,3 mm is shown in Fig. 3.

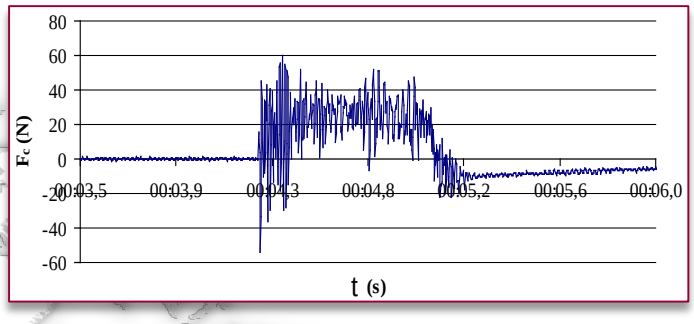


Figure 3. Behavior of measured tangential component of cutting force Fc during milling

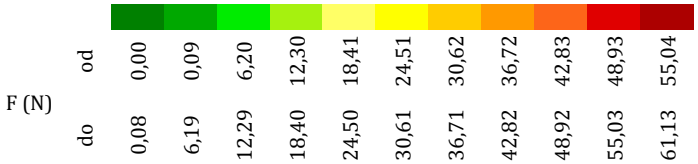
Structural formulas of cutting force components for individual materials are shown in Tables 1 and 2.

Table 1. Structural formulas of Fc and Ff determined by measuring

	F_c	F_f
TiGr2	$F_c = 12{,}64.v_c^{1{,}28}.f^{0{,}9}.a_p^{0{,}49}$	$F_f = 6{,}97.v_c^{1{,}4}.f^{0{,}62}.a_p^{1{,}46}$
R^2	0,89	0,88
nTi	$F_c = 1005{,}63.v_c^{0{,}18}.f^{0{,}88}.a_p^{1{,}07}$	$F_f = 1958{,}75.v_c^{-0{,}28}.f^{0{,}76}.a_p^{1{,}24}$
R^2	0,96	0,92
TiGr5	$F_c = 795{,}32.v_c^{0{,}17}.f^{0{,}94}.a_p^{0{,}84}$	$F_f = 74{,}74.v_c^{0{,}64}.f^{0{,}88}.a_p^{0{,}91}$
R^2	0,94	0,92
TiNbTa	$F_c = 127{,}33.v_c^{0{,}82}.f^{1{,}03}.a_p^{0{,}95}$	$F_f = 175{,}30.v_c^{0{,}28}.f^{0{,}57}.a_p^{1{,}36}$
R^2	0,91	0,9

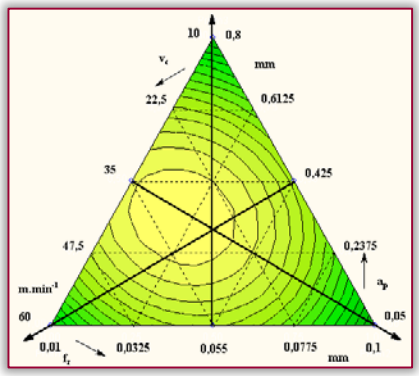
Table 2. Structural formulas of Fp and F determined by measuring

	F_p	F
TiGr2	$F_p = 1{,}05.v_c^{1{,}95}.f^{1{,}1}.a_p^{0{,}94}$	$F = 14{,}85.v_c^{1{,}34}.f^{0{,}84}.a_p^{0{,}77}$
R^2	0,9	0,87
nTi	$F_p = 178{,}25.v_c^{0{,}28}.f^{0{,}77}.a_p^{1{,}46}$	$F = 1498{,}75.v_c^{0{,}09}.f^{0{,}85}.a_p^{1{,}1}$
R^2	0,93	0,97
TiGr5	$F_p = 2114{,}31.v_c^{-0{,}11}.f^{1{,}14}.a_p^{1{,}41}$	$F = 738{,}09.v_c^{0{,}28}.f^{0{,}94}.a_p^{0{,}93}$
R^2	0,92	0,97
TiNbTa	$F_p = 8{,}47.v_c^{1{,}27}.f^{0{,}93}.a_p^{1{,}8}$	$F = 191{,}39.v_c^{0{,}63}.f^{0{,}88}.a_p^{1{,}04}$
R^2	0,87	0,95

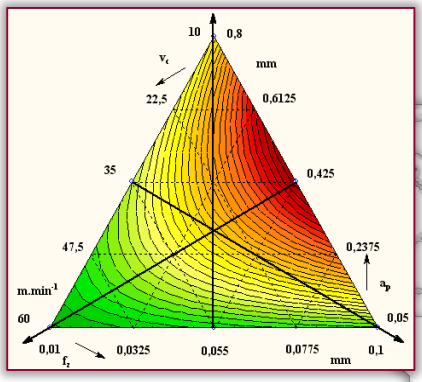


Legend for ternary graphs of cutting force components

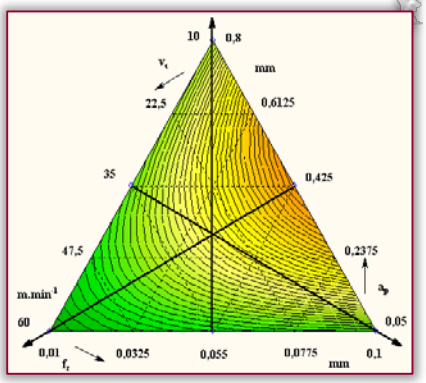
Behavior of the resultant cutting force F during machining of tested materials is shown in ternary graphs in Fig. 4.



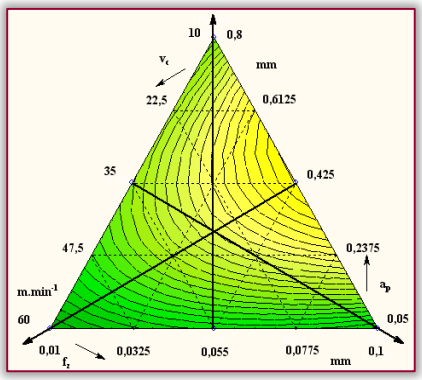
a) TiGr2



b) nTi



c) TiGr5



d) TiNbTa

Figure 4. Resultant ternary graphs for tangential cutting force component F

Dynamic machinability

Dynamic machinability is determined by the ratio of cutting forces measured during machining of reference material Fe and tested material F. According to this criterion, better machinable material is the material that causes lower cutting force at the same cutting conditions. (VASILKO, K. 2007, s. 437)

Dynamic machinability can be described by the following formula:

$$K_d = \frac{F_e}{F} \qquad (1)$$

where: Fe – cutting force during reference material machining, F – cutting force during tested material machining

As reference material for evaluation of dynamic machinability was selected commercially pure titanium TiGr2. Based on data from previous experiments we determined coefficients of dynamic machinability during milling. During number of runs the K_{df} values ranged from 0,8277-2,42 (nTi), 0,9717-2,18 (TiGr5) and 1,05-2,69 (TiNbTa). Average K_{df} values are compared in Fig. 5.

DISCUSSION AND CONCLUSION

Due to the longer-term application and greater experience in machining was as a reference material selected commercially pure titanium TiGr2, with which it was posiible to compare behavior of other tested materials during machining process.

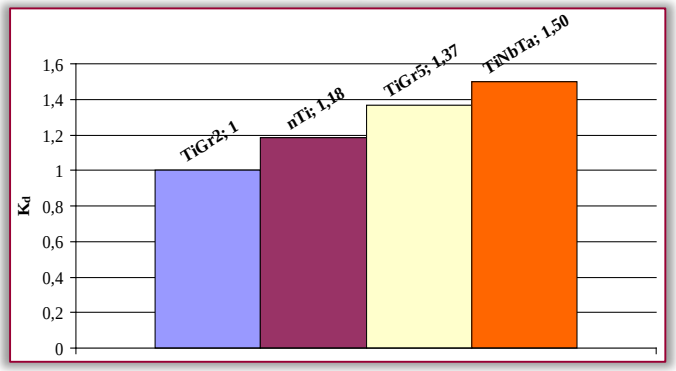


Figure 5. Graphic comparison of the dynamic machinability

The graphic comparison of the dynamic machinability shows, that all tested materials achieved better dynamic machinability than reference material. Thus, said materials are more suitable for production and given purpose. When milling, the best machinability achieved alloy TiNbTA, whose coefficient of dynamic machinability is 1,5, representing a 50% better performance than reference material TiGr2. The worst (but still better than reference material) dynamic machinability of 1,18 achieved material nTi. The cause of better machinability of new materials are significantly different mechanical properties due to present volume structures and alloys.

Acknowledgments
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Note
This paper is based on the paper presented at The 10th International Conference for Young Researchers and PhD Students – ERIN 2016, organized by University of Zilina, Faculty of Mechanical Engineering, in Liptovský Ján, SLOVAKIA, May 10 – 12, 2016, referred here as [7].

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APPLICATION OF ELECTROCHEMICALLY SYNTHESIZED FERRATE (VI) IN THE TREATMENT OF PHENOL CONTAMINATED WASTEWATER FROM WOOD INDUSTRY

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Abstract: Treatment of wastewater (WW) from wood industry is of great importance due to high concentration and toxicity of phenol and its derivatives. High concentration of phenol in WW of wood industry originates from pentachlorophenol (PCP), which is used for wood conservation. According to the Regulations on Hazardous Substances in Water [1] allowed phenol concentration in waters of the III and IV class is 300 mg/l. Conventional methods for removal of phenol from WW are either environmentally or economically unacceptable. The use of ferrate (VI) as a multifunctional chemical reagent has significant advantages over conventional methods. The subject of this paper is treatment of samples of WW from wood industry - from thermal dryer and steam chamber, by electrochemically synthesized ferrate (VI). The initial concentration of phenol in the sample from thermal dryer was 27 mg/l and in the sample from steam chamber 30 mg/l. This wastewater also has a high content of natural organic matter (COD of the sample from the thermal dryer was 3233.1 mgO_2/l and COD of the sample from the steam chamber was 4692.1 mgO_2/l). The efficiency of phenol removal by ferrate (VI) was 74.85% and 72.67% for samples from thermal dryer and steam chamber, respectively.
Keywords: ferrate (VI), phenol, wood industry, wastewater treatment, COD

INTRODUCTION

A large amount of attention has recently been focused on the removal of phenol and its derivatives from wastewater (WW) due to their toxicity and high concentration in wastewater. Phenol is a common pollutant in industrial discharges and is also believed to be an intermediate product in the oxidation process of higher molecular weight aromatic hydrocarbons. Their high concentration in the WW of wood industry originates from pentachlorophenol (PCP), which is used for wood conservation [2].

The contamination of water system by phenols and their compounds is a major problem because of the toxicity of phenol even at low concentrations. Toxic phenol concentrations are in the range of 10 - 24 mg/l for humans and from 9 - 25 mg/l for aquatic life. Lethal concentration of phenol is around 150mg/100ml [3]. Phenol and phenolic compounds are designated as priority pollutants by the Environmental Protection Agency in the US, and take 11th place in the list of 126 undesirable chemicals [4].

Phenol and phenolic compounds are classified as teratogenic and carcinogenic compounds [5]. Phenolic compounds are well known for high salinity, acidity, chemical oxygen demand (COD) and low biodegradability [6]. In addition, they have low volatilities and easily form azeotropes and eutectics [7]. All these properties make them difficult to treat.

Phenol has acute and chronic effects on human health [4]. Inhalation and dermal exposure to phenol is highly irritating to skin, eyes, and mucous. The other acute health effects are headache, dizziness, fatigue, fainting, weakness, nausea, vomiting and lack of appetite at high levels. Effects from chronic exposure (longer than 365 days) include irritation of the gastrointestinal tract. Phenol also can change blood pressure and can cause liver and kidney damage. Nervous system is affected negatively for long time exposures. Animal studies have not shown tumors resulting from oral exposure to

phenol, while dermal studies have reported that phenol applied to the skin may be a tumor promoter and/or a weak skin carcinogen in mice.

Due to its toxicity to aquatic life and humans, regulations for phenol concentration in WW are very strict. Maximum allowable discharge concentration of phenol varies from country to country, but generally it is about 10 mg/l [8]. According to the Ordinance on Hazardous Substances in Water [1] the maximum content of phenol in the waters of categories I and II is 1 mg/l, while in the waters of categories III and IV the limit is 300 mg/l.

Conventional methods for removing phenolics from wood industry WW include biological degradation, solvent extraction, adsorption and chemical oxidation [6, 9–11].

Biological treatment is economical and environmentally friendly method but at high concentrations of phenol, application of this method is not possible because of the inactivation of microorganisms. Other disadvantages are necessity of large land area and long time for microbial degradation, which makes this process less flexible in design and operation [12].

In the solvent extraction method the residual phenol concentration in wastewater barely meets the strict US Environmental Protection Agency (EPA) requirements (less than 1 mg/L in the wastewater) [13]. What is more, the separation of solute from the solvent is expensive and the loss of solvent requires additional treatment.

The adsorption process is proven to be efficient for the removal of organic contaminants and it is usually used only to treat dilute wastewater [14]. The most popular adsorbent is activated carbon due to its excellent adsorption abilities for phenolic compounds [15]. Drawback of this method is high initial cost; the regeneration of saturated carbons is also costly and results in loss of adsorbents. In addition, this treatment requires complexing agents to improve properties of activated carbon [15].

One of the possible methods of phenol removal from aqueous environments is chemical oxidation by ferrate (VI), an environmentally friendly oxidant, coagulant and disinfectant (Jiang, 2007). Ferrate(VI) is an adequate alternative to conventional methods because of its suitable physical and chemical properties such as high oxidation potential (2.2 V in acidic conditions and 0.7 V in alkaline conditions), forming of oxygen from water oxidation and high capacity for coagulation of iron(III)hydroxide as a product of ferrate(VI) reduction [16]. Ferrate (VI) can be produced by chemical or electrochemical synthesis. Ferrate (VI) produced by electrochemical synthesis has many advantages compared to chemically synthesized ferrate (VI) [17], such as simplicity and cost-effectiveness of the treatment (the use of one chemical, one system for dosing an mixing and less sludge production), exceptional purity of obtained ferrate (VI), as well as avoiding the formation of toxic by-products which originate from the application of chlorine and its compounds. Chlorine-based oxidants are not favorable option due to reaction of phenol with dissolved organic compounds and formation of toxic chlorine organic compounds such as 2-chlorphenol [18]. One more advantage of electrochemically produced ferrate (VI) is that it has no instability problem and needs no transportation, and because of ecological advantages it can be implemented in wastewater treatment practice, *in situ*.

The aim of this paper is to examine the possibility of phenol removal from wood industry WW by electrochemically synthesized ferrate (VI).

MATERIAL AND METHODS

Two wastewater samples from the wood processing plant were used in the experimental work: a sample from the thermal dryer and a sample from the steam chamber. The initial concentration of phenol in the sample from the thermal dryer was 27 mg/l and in a sample from the steam chamber 30 mg/l. This wastewater is also characterized by a high content of natural organic matter. Chemical oxygen demand (COD) of the sample from the thermal dryer was 3233.1 mg O_2/l and of the sample from the steam chamber 4692.1 mg O2/l. pH value of the sample from the thermal dryer was 4 and pH value of the sample from the steam chamber was 5.

The process of the treatment was performed using Jar test with a four-unit stirrer (Velp JLT4).

In the first step of the treatment both samples were treated with 30 mg/l $KAI(SO_4)_2$ of p.a. quality purchased at Sigma-Aldrich, St. Louis, Missouri, USA in order to remove suspended solids with a prior setting of pH value to 7.

Figure 1. Device for electrochemical synthesis of ferrate (VI)

In the second step of the treatment the samples were treated with the solution of electrochemically synthesized ferrate (VI) concentration of 8 g/l in molar ratio phenol: ferrate (VI) = 1 : 5. The process of

electrochemical synthesis of the alkaline solution of ferrate(VI) was based on transpassive anodic dissolution of iron alloys in a 10 M NaOH solution, in accordance with previous studies [17,19] and it was carried out in a laboratory facility for electrochemical synthesis of ferrate (VI), Fig. 1.

The change in the concentration of phenol and COD value of the samples were determined using standard methods at MOL Institute, Stara Pazova.

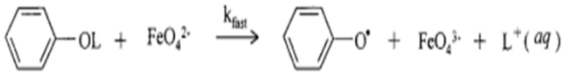
RESULTS AND DISCUSSION

Results of phenol removal by ferrate (VI) from the samples of wastewater from the thermal dryer and steam chamber are shown in Table 1.

Table 1. Reduction of the phenol concentration in the samples of wastewater from the thermal dryer and steam chamber before and after the treatment

	Phenol concentration in the untreated sample, mg/l	Phenol concentration in the treated sample, mg/l	Removal efficiency, %
Thermal dryer	27	6,79	74,9
Steam chamber	30	8,20	72,7

The results of the treatment shows high removal efficiency of phenol by ferrate (VI), 74.9% and 72.7%, for wastewater from thermal dryer and steam chamber, respectively, Table 1. Phenol is removed from aqueous solution by flocculation and coagulation with ferrous hydroxide, reactions 1–3, which is obtained as a product of ferrate (VI) reduction and has a very developed absorption area [20]. Since ferrous hydroxide has an extremely low solubility in these conditions, presence of residual Fe is not expected.



(1)

(2)

(3)

Possibility of phenol removal using ferrate (VI) was additionally confirmed by determining the value of COD in the samples treated by ferrate (VI), Table 2.

Table 2. Percentage of COD removal during oxidation reaction of phenol by ferrate (VI)

	COD of untreated sample, mgO_2/l	COD of treated sample, mgO_2/l	Reduction efficiency of COD, %
Thermal dryer	3233.1	2384	26.3
Steam chamber	4692.1	2594	44.7

The samples from thermal dryer, Figure 2, and steam chamber, Figure 3, were also characterized by high initial COD values, 3233.1 and 4692.1 mgO_2/l, for thermal dryer WW and steam chamber WW, respectively.

(a) (b) (c)

Figure 2. Sample of WW from the thermal dryer (a) before the treatment; (b) after the first step of the treatment by $KAl(SO_4)_2$; (c) after the second step of the treatment by ferrate (VI)

After the addition of ferrate (VI) into the solution, showed a COD reduction of 26.3 % for thermal dryer and 44.7 % for steam chamber. Using higher doses of ferrate (VI) could reach a more efficient reduction of COD values which requires further optimization of the treatment process of WW from wood industry by ferrate (VI).

Figure 3. Sample of WW from the steam chamber before the treatment and after the second step of the treatment by ferrate (VI)

CONCLUSIONS

The aim of this study was to examine the possibilities of phenol removal from WW from wood industry in the reaction of oxidation by freshly electrochemically synthesized ferrate (VI).

The paper shows the possibility of efficient removal of phenol by ferrate (VI) from the samples of wastewater from wood processing industry characterized by a high content of phenols and high COD value. Due to the catalytic effect of ferrous hydroxide, resulting product from the reaction of ferrate (VI) reduction, high efficiency of phenol removal from the wastewater is achieved: 74.9 % removal efficiency for the sample from thermal dryer and 72.7% removal efficiency for the sample from steam chamber. Since the treated water had a high COD value for more effective treatment it is necessary to increase the added amount of ferrate (VI).

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QUANTITATIVE METHODS FOR MATERIAL SELECTION – MATERIAL PROPERTIES CHART

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Abstract: This paper presents the selection of optimal materials for the production of basic constituent elements of electric iron: housing, heater and warming plate using material properties chart (map) quantitative method and Cambridge Engineering Selection software (CES). This work is a continuation and expansion of research. The results were compared with results from the paper [1] in which selection of mentioned constituent elements of electric iron materials was done using two quantitative methods: the method of properties influence (digital-logic method) and the method of minimum deviation of actual properties compared to required (algebraic approach).
Keywords: quantitative methods, material selection, material properties chart (map), CES software

INTRODUCTION

In the modern world there is more and more attention focused on the procedures for selecting the material from which a certain part will be made. Therefore, there is the obligation of engineers to properly decide which material, from a range of possible, is optimal for use, Fig.1. [2].

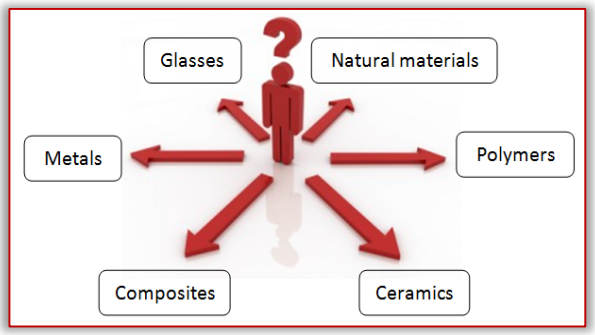

Figure 1. Selection of the appropriate material-downloaded and modified from [6]

In addition to materials for producing a particular product requires skills, knowledge and experience of the people, as well as methods of constructing and more or less complex methods of production [2]. The number, variety and quantities of materials are increasing-from massive amounts of a small number of species to the current very large amount of a combination of many types. Today it is estimated that there are more than 70 000 types of technical materials [3], among whom more than 40 000 alloys based on metals [4]. The basic purpose of the quantitative methods application is as much of objectivity in the selection of materials [5].

The paper [1] describes the procedure of selection of optimal materials for the production of electric iron constituent elements: housing, heater and warming plate using quantitative methods for the materials selection: the method of properties influence (digital-logic method) and the method of minimum deviation of actual properties compared to required (algebraic approach). This paper and the results obtained were used as a basis for comparison with the results of the selection of optimal materials of the same constituent elements of electric iron obtained in this study using material properties chart (map) quantitative method and software Cambridge Engineering Selection (CES).

METHODS FOR MATERIAL SELECTION

Material properties chart (map)

In comparing the materials it is not often enough to take one property as a criterion of evaluation, but it is necessary to consider a combination of properties. Thus, for example, for parts which have to be lightweight and be rigid at the same time the density and modulus of elasticity should be evaluated, or for structures to secure from sudden expansion of cracks

and fracture it is important at the same time high yield strength, but also high ductility and toughness. On the basis of this approach so-called "Properties chart" has been developed [2] where the diagram represents the framework regions of a number of properties of different material groups (Fig. 2). Assume that there are limitations in the process of design in terms of elastic modulus (e.g. E>10 GPa) and the density of the material (e.g. ρ <3000 kg/m^3), as shown in Fig. 2. Thereby, the materials should be selected in the window labeled "Search Region".

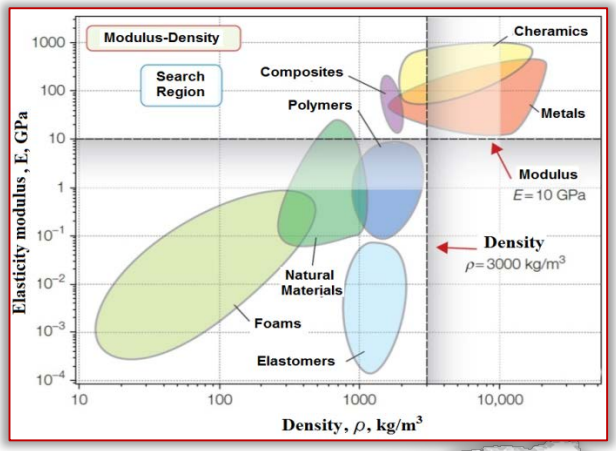

Figure 2. Material properties chart (modulus of elasticity-density) [2]

The closed line limits data for a group of materials, indicating a possible range of values regardless of the type of material. If the abscissa and ordinate are in logarithmic division, then the highest and lowest properties values can be displayed. In this way, it is easier to compare a group of materials, i.e. Framework material pre-selection. Diagrams feature gives the correlation between certain material properties.

Material selection of electric iron constitutive elements

The main criteria to be met by materials for electric iron constituent elements are shown in the Table 1[1]:

Table 1. Criteria for material of housing, heater and warming plate

Housing	Heater	Warming plate
Low density	High specific thermal resistance	Good thermal conductivity
Low thermal conductivity	Low electrical resistance (excellent electrical conductivity)	Density
Low electrical conductivity	High temperature Providing	Corrosion resistance
Shaping	Oxidation resistance	Abrasion resistance
Fracture toughness	Spontaneous combustion resistance	Solubility
Hardness	Machinability	Machinability
Price	Price	Recyclability
		Price

Electric iron housing

Seven material properties were considered [1]: density, thermal conductivity, electrical conductivity, solubility, fracture toughness, hardness and price. Using CES Selector software, limitations for electric iron housing materials that can be considered are set. Lighter material with a density of 1100-1300 kg/m^3 with the maximum price of 3 €/kg is selected. Based on these properties, it is important that the fracture toughness is at least 4 MPa·m$^{1/2}$, the value of thermal conductivity is a maximum of 0.3 W/m^{0}C and that potential material is a good electrical insulator. Of course, the material must be machinability, so, it can be easily shaped by methods of injection molding, extrusion and the like, so that the required machinability is a minimum of 4. Based on the above, the CES software offers as a result of 5 different materials: acrylonitrile butadiene styrene (ABS), polyamide, polycarbonate, polyethylene terephthalate (PET) and polyvinyl chloride (PVC). If we take into account the hardness of the material, which is very important in this case, and limit the search to a minimum of 25 HV, we obtain the optimal material for the production of electric iron housing: polyamide, Fig. 3.

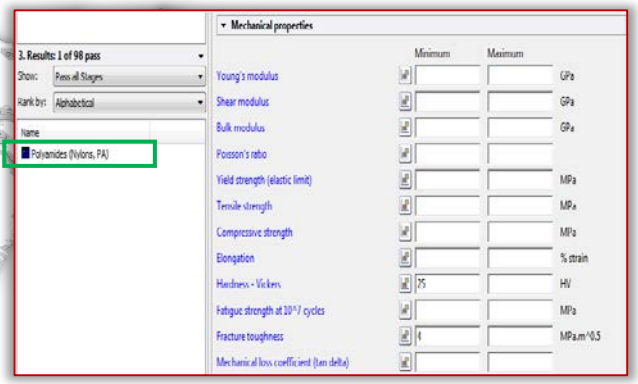

Figure 3. Optimal material for production of electric iron housing

Based on the given limits, the same result using the material property chart (map) is gotten (Fig. 4), where we can see that the optimal material, polyamide, is in the area shown in yellow.

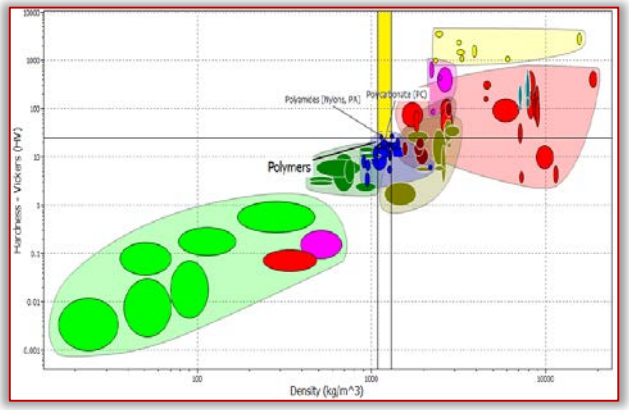

Figure 4. Material properties map (chart) for electric iron housing material

Electric iron heater

Six material properties were considered [1]: electrical resistance, thermal conductivity, electrical conductivity, the maximum heating temperature, machinability and price. The material that may be submitted by high-temperature heating during operation (800-900^{0}C) is selected while at the same time there are no its physical and chemical properties changes. Electrical resistance is also important, which should not exceed the value of 130 μohm·cm. Of course, the material must be a good electrical conductor and extremely machinable (drawing, bending) in order to achieve the desired shape of the heater. Based on the previously, CES software offers as a result a large number of different materials, even the 192. One of the main properties that the material for iron electric heater must meet is thermal conductivity. Its value is limited by interval of 9-10 W/m^{0}C. The price of material is indispensable. In this case, the maximum price should not be higher than 22 €/kg. If the last criteria is considered, the optimal material for the electric iron heaters is, in this case, Ni-Cr-Fe alloy (Nichrome), Fig. 5.

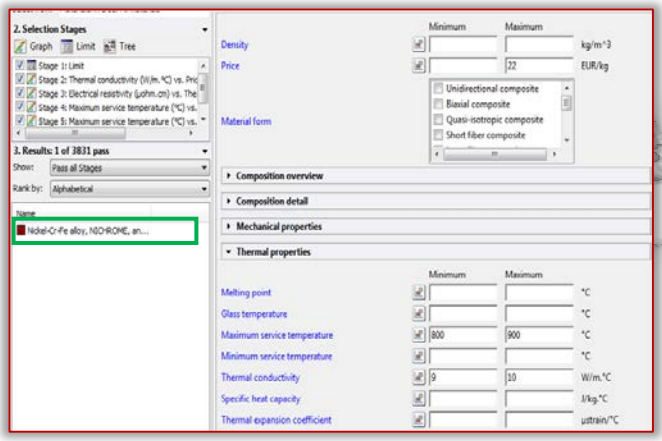

Figure 5. Optimal material for production of electric iron heater

Based on the given limits, the same result using the material property chart (map) is gotten (Fig. 6), where we can see that the optimal material, Ni-Cr-Fe alloy, is in the area shown in yellow.

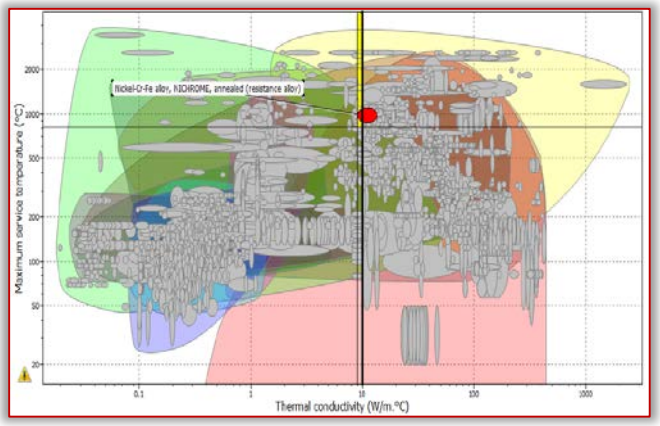

Figure 6. Material properties map (chart) for electric iron heater material

Electric iron warming plate

Five material properties were considered [1]: thermal conductivity, the maximum heating temperature, density, hardness and price. The material that needs to meet a minimum hardness of 50 HV is selected. One of the most important properties is the thermal conductivity, which the lower limit is set to 15 W/m^{0}C and the maximum temperature that the warming plate material can achieve during working life which value must be at least 150^{0}C. Based on the previously, CES software offers as a result of 3 different materials: Al alloy, Mg alloy and Silicon. An important property for the warming plate material is the mass of the material, i.e. its density, which is, in this case, limited by the value of up to 3000 kg/m^3. The price of material is indispensable. In this case, the maximum price should not be higher than 2 €/kg. If the last criteria is considered, the optimal material for the electric iron warming plate is, in this case, Al alloy, Fig. 7.

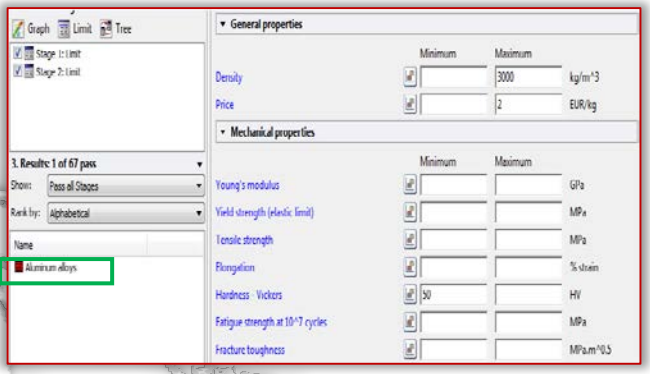

Figure 7. Optimal material for production of electric iron warming plate

Based on the given limits, the same result using the material property chart (map) is gotten (Fig. 8), where we can see that the optimal material, Al alloy, is in the area shown in yellow.

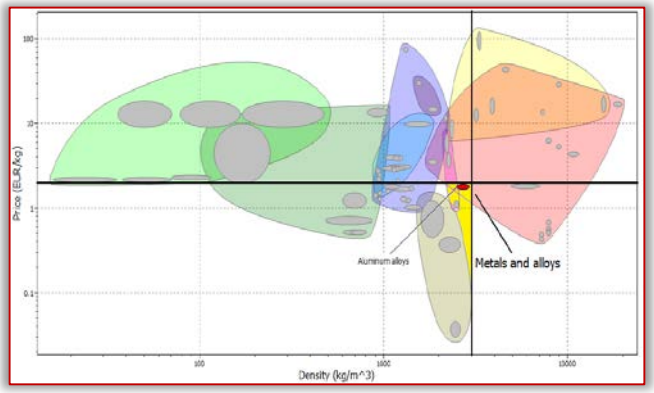

Figure 8. Material properties map (chart) for electric iron warming plate material

RESULTS AND DISCUSSION

Table 2 presents comparative results of the electric iron constitutive elements optimal materials obtained on the basis of two quantitative methods in paper [1] and results based on material properties chart (map)

quantitative method processed in the previous section of this paper.

Table 2. Comparative results of the electric iron constitutive elements materials

Electric iron constitutive elements	Method of properties influence (digital-logic method) [1]	Method of minimum deviation of actual properties compared to required (algebraic approach) [1]	Material properties chart (map)
	Material		
Housing	Polyamide	Polyamide	Polyamide
Heater	Ni-Cr-Fe (Nichrome)	Ni-Cr (Nimonic 81)	Ni-Cr-Fe (Nichrome)
Warming plate	Al alloy	Polytetra-fluor-ethylene (Teflon)	Al alloy

CONCLUSION

The material selection process is present in every part of the design process and directly affects the lifetime of the product [7]. Based on personal experience, developed methods for the appropriate materials selection and based on software support, it is possible to make a proper decision on the material to be used. This paper presents the optimal materials selection of the constituent elements of electric iron: housing, heater and warming plate using material properties chart (map) quantitative method. Based on the mentioned method, optimum materials for the housing, the heater and the warming plate of electric iron are, respectively, polyamide, Ni-Cr-Fe alloy (Nichrome 81) and Al alloy. The results were compared with the results of the optimum material from the paper [1] obtained using two quantitative methods: the method of properties influence (digital-logic method) and the method of minimum deviation of actual properties compared to required (algebraic approach). Based on these results, using the method of properties influence (digital-logic method) and material properties chart (map) quantitative method, we can ascertain that the obtained materials for the electric iron constituent elements are exactly the same, while in method of minimum deviation of actual properties compared to required (algebraic approach) Polytetrafluorethylene is approved as well as the optimal warming plate material. Of course, each of these quantitative methods has its own characteristics and, hence, the recommendation in the choice of materials is to use at least two of the methods. Further research can be extended by using some of the remaining quantitative methods for the materials selection.

Note

This paper is based on the paper presented at The VIth International Conference Industrial Engineering and Environmental Protection 2016 – IIZS 2016, organized by University of Novi Sad, Technical Faculty "Mihajlo Pupin" Zrenjanin, in Zrenjanin, SERBIA, October 13–14, 2016, referred here as [8].

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EXPECTED RESULTS FOR HEAT DEMANDS IN GLASS HOUSE SPACE, IF THE TRANSPARENT WALLS ARE COATED WITH A PROTECTIVE FILM

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Abstract: This model explains the heat flow in a confined space with transparent walls (glass or plastic). A software is used to analyze the behavior of transparent walls coated with "LLumar" film. This film has many advantages, but in this paper, we will focus on energy savings. Energy savings give quick return on investment and are considered a smart investment. Energy-saving LLumar film can increase performance of almost every window system, significantly reducing energy consumption and requirements. Professional energy audits have shown that buildings with LLumar film can achieve annual energy savings of up to 15%, blocks 99% of harmful UV rays and improves comfort by reducing heat and glare. Regardless of whether it is residential, commercial or glass house space as described in this paper, LLumar the world's leading brand of architectural film for decades improves the well-known buildings around the world with proven results. LLumar films will greatly increase energy efficiency, appearance and functionality of glass partitions. The results are lower overhead expenses, increased comfort, improved privacy and better protection from accidents. Heat balance in glass house space is shown in the following pages.
Keywords: thermal resistance, glass wall, glass house, demand for heat

INTRODUCTION

Foil LLumar is a modern product for changing the characteristics of the transparent wall. Composing various elements in the structure of the foil, the manufacturer offers solutions to several problems that occur anywhere where glass partitions are used. For example, in construction, the effect of increasing the aesthetic value of the glass and protection against external views and provide a foil widely used as modern architectural material.

The main benefit of using LLumar foil is energetic efficiency. Dual layer wall foil - glass has brand new thermal characteristics compared to the mono slice transparent wall. With the addition of the foil, it controls the quality and quantity of energy flow through the transparent wall. With this, the glass gets new energy role, and the closed space new microclimate features.

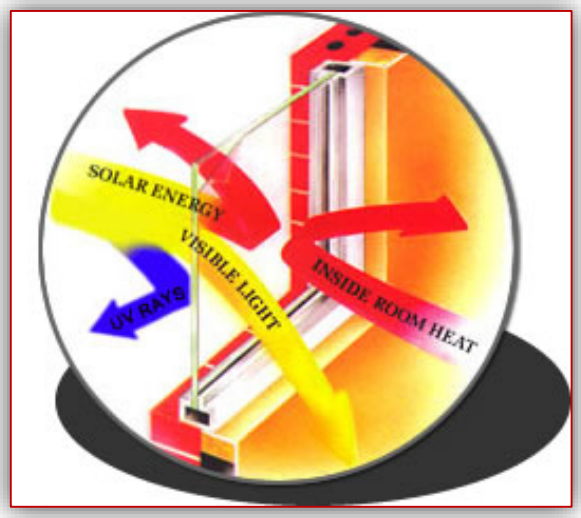

Figure 1. Foil LLumar for the transparent wall [6]

DESCRIPTION OF THE COMPUTER PROGRAM

The computer program to calculate the heat flow through transparent walls requires prior preparation, [3]. It consists of shaping the input data file, the day time, air temperature, air relative humidity, moisture contained in the air density of the air, air speed, intensity of solar radiation. The state of indoor air selects the user program. The used data is related to the city of Bitola (Macedonia) and placed in the file "LOTUS".

Once you take the input values into account the program goes on to calculate the following: coefficients of heat transfer, temperatures of transparent walls and heat flows. The calculation is repeated for every hour of the day and the output values are registered.

Table 1. Hourly data for external and internal conditions, temperature of: transparent wall on the inside and outside and heat needs for February, [1], [3], [4].

Hour	t_{vn} °C	φ_{vn} %	vn m/s	Fsz W/m²	t_{vv} °C	t_{zv} °C	t_{zn} °C	Q W
1	-1	85	2.3	0	16	7	1	20786
2	-1	85	2.3	0	16	7	1	20786
3	-1	85	2.3	0	16	7	1	20786
4	-1	85	2.5	0	16	7	1	20885
5	-1	85	2.5	0	16	7	1	20885
6	-1	85	2.3	0	16	7	1	20786
7	-1	85	2.3	8	19	9	3	22384
8	-1	85	2.3	185	23	11	1	25126
9	0	85	2.5	385	23	16	5	16005
10	1	83	2.5	449	23	16	3	15733
11	2	80	3.0	509	23	17	3	15339
12	3	75	3.0	528	23	18	4	13288
13	3	70	3.5	543	23	20	6	11225
14	4	70	4.0	524	23	18	5	13733
15	4	70	3.5	486	23	19	6	12476
16	4	70	3.5	430	23	18	6	13946
17	3	70	3.0	192	23	14	4	22036
18	3	75	2.5	0	19	10	4	21282
19	2	77	2.5	0	16	9	6	16035
20	1	80	2.5	0	16	9	6	16027
21	1	80	2.5	0	16	9	6	16027
22	0	80	2.5	0	16	6	1	20920
23	0	85	2.5	0	16	6	1	20844
24	0	85	2.5	0	16	6	1	20844
Total								438183

The hourly data is taken over a period from 1967 to 1976. This data exists for every month and every hour, and in Table 1 the average values for this period are being considered. These values exist for the whole period of growth (from September until May) of the culture (in this case a tomato) in a greenhouse. February is just taken as an example so we can give a presentation which is shown in Table 1, [1], [3], [4].

With these values you can calculated the amount of heat you need for a year, Table 2. These examples relate to a specific transparent wall.

Table 2. Heat needs for one heating season for structures with an area of 208 m² and a volume of 613 m³ dual hard plastic wall with air layer 15 mm, [2], [3]

Month	Q Wh/month
9	-9241140
10	2111937
11	5008170
12	7923290
1	14110022
2	12269124
3	11449974
4	8616300
5	5473081
6	2383110
Total	60103868

An example of calculations for heat need at different transparent walls is given in Table 3.

When we assume that the same structures are protected by a glass partition that has a thermal resistance of 0.01 m²K/W and we glue LLumar foil on it, it changes the transparency of the plastic wall. Different films have different transparency, and therefore the heat needs are different. We have no further calculations for walls made out of different materials, other than plastic.

Table 3. Thermal resistance and annual heat needs for different kinds of transparent walls for structures with an area of 208 m² and a volume of 613 m³, [3], [5], [6]

Material for transparent walls	R m2K/W	Q MWh/year
Single plastic wall thickness 1 mm	0.01	127
Dual plastic walls with air space between walls:		
– 5 mm	0.08	100
– 12 mm	0.15	81
Dual hard plastic walls with air space between walls:		
– 6 mm	0.09	98
– 12 mm	0.11	92
– 15 mm	0.24	60

In Table 4 the heat needs for February with transparency of 10-90% are presented, while in the Table 5 the annual heat needs for the heating season with varying transparency are presented.

Table 4. Heat needs in February
for a different transparency walls, [2], [3].

Transparency %	Q W
10	1300583
20	1274131
30	1247680
40	1221229
50	1194777
60	1168326
70	1141875
80	1115423
90	1088972

Table 5. Annual heat needs for different transparency walls, [2], [3].

Transparency %	Q W
10	6734351
20	6453539
30	6172726
40	5891914
50	5611101
60	5330289
70	5049476
80	4768663
90	4487851

CONCLUSIONS

LLumar foils, which already have commercial level achieved: venting the sunshine of 10-90%, reflecting the sun's rays by 10-50% and absorption of sunlight by 30-60%. Composition of the foil is determined by the required barrier properties that are specified by designers. The foil is used for setting new glass areas and for already completed projects as a corrector of the condition. The foil is mounted by gluing (pressed or water) on the outside or inside of the transparent wall according to function, to reject or retain the sun's rays, thereby, to reduce or retain heat inside the building.

NOMENCLATURE

F_{sz} W/m² - intensity of solar radiation
R m²K/W - thermal resistance
Q W - demand for heat
t_{vn} °C - external air temperature
t_{vv} °C - internal air temperature
t_{zv} °C - temperature inside of the transparent wall
t_{zn} °C - temperature outside of the transparent wall
v_n m/s - speed of wind
φ_{vn} % - relative humidity of the external air

Note

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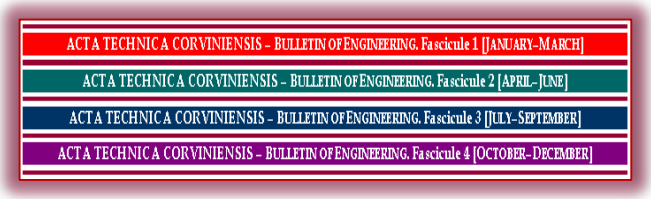
*Now, when will celebrate the tenth years anniversary of **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**, we are extremely grateful and heartily acknowledge the kind of support and encouragement from all contributors and all collaborators!*

*On behalf of the Editorial Board and Scientific Committees of **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**, we would like to thank the many people who helped make this journal successful. We thank all authors who submitted their work to **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering.***



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ALTERNATIVE METHODS OF THREE DIMENSIONAL DATA OBTAINING FOR VIRTUAL AND AUGMENTED REALITY

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Abstract: Reverse engineering and spatial digitization became more popular recently. The popularity grows with the devices which are capable to scan the human figures, cars, parts of the buildings or even bigger objects in a single process. In general, scanning devices sometimes present disproportionate costs as the usual additional software often tops the half of the hardware price. Text of this paper is focused on the alternative device which can use very affordable software applications to generate the same results as the most expensive scanning equipment. Particular parts of this article briefly describe the principles of non-contact three dimensional scanning using the Kinect device, the process of data processing in alternative software applications and possibilities of their further utilization.
Keywords: Kinect, virtual reality, 3D data

INTRODUCTION

In area of Reverse Engineering there is lot of publications. Advantages of the methods related to the reverse creation of virtual models are unquestionable. Thanks to this modern method it is possible to create virtual models of existing products really fast. Although no discussion runs about the difficulties connected to the processing of obtained data. Every device prefers certain data format, what can be noticed also in the area of software provided for data processing. Only few suitable supportive software applications can be found, while at the same time every platform proclaim unreal, almost limitless backward compatibility. Certain solution for the future could be probably found in the creation of unified procedures for collection and also for processing of the spatial coordinates with respect to the exploited digitization method and their utilization. The usual basic steps of digitization process using 3D scanners and their low cost alternative is shown on Fig. 1. The diagram shows possible workflow steps, however individual parts can be skipped depending on used equipment or on specific surface shape of digitized component. By using the most modern facilities individual steps are abbreviated only to scanning process and export to desired software. There is no need of scene preparation or additional data collection.

SELECTED NON - CONTACT SCANNING DEVICES

In the industrial practice there are several devices used for digitization of larger objects such as cars and building interiors. We focus a little also to the contact 3D scanners, although for their slowness and difficulties we omit them, as while scanning the production machines the worker must assure the fact that he wouldn't impede the normal run of the operation. For these reasons, the most effective way is to use a non-contact laser 3D scanner such as FARO LS 880.

≡ FARO LS 880

Select equipment is preferentially dedicated to the digitization of the interiors and exteriors of the buildings as for the data collection it utilizes very powerful laser beam. The principle of scanning itself lies in emission of laser beam in the direction against the scanned object. This beam is then received back in the scanning device for processing. The scanner evaluates particular obtained points and comparing the time period between emission and receiving it calculates the relevant distance [2]. These measurements are realized thousand times in a second.

The accuracy of the scanning device on distance of eighty meters lowers from one millimetre to three. While scanning larger spaces, the scanner must be moved in order to provide the possibility to catch the scene from as many views as possible. Therefore in preparation stage we place few reference balls all over the workshop. We use them for joining the partial clouds of points. Use of this device is suitable especially for large production halls however for our conditions by reconstruction of a small manufacturing cell it is inconvenient since the sensor responds on items in radius larger than 0.7 meters and because of the size of used tripod the blind zone is significantly larger in tight spaces.

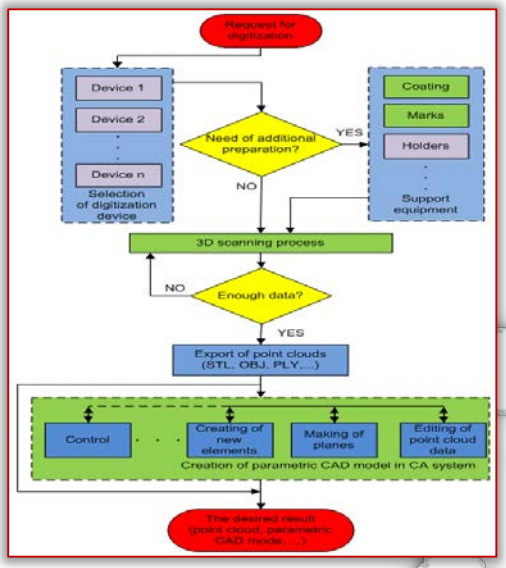

Figure 1: Diagram of basic steps of digization process

≡ ZS SCANNER 700

ZScanner 700 will serve for this comparison as a connection member between FARO LS and Kinect as it has common features with both of them. It is a commercial 3D laser non-contact scanner with higher precision (up to 50 microns), but at the same time it is a manual device such as Kinect. Unfortunately it does not have own power source so it is limited by the reach of power cable. Another disadvantage concerning the price is its operational distance - the optimal distance is around twenty centimetres from the pair of captioning cameras, what is not suitable for digitization of the halls or unsafe large environments. The device works on the base of triangulation where red laser light is projected to the digitized surface and then captioned in real time by the pair of the cameras. Used laser is rather weak, thus the scanned surfaces need to be prepared by matte spray which also is time consuming and some parts may not be painted for operational reasons. [3]. Also the surface of scanned bodies needs to be treated with certain amount of reflex marks that assure the right location of the device (at least three point marks need to be recorded at all times) as the case greatly multiple preconditioning phase and the scanning process from minutes to days, due to the need for later removal of paint and marks. On the other hand this allows the detail scanning of machine parts.

≡ KINECT

Alternative device Kinect was primarily designed as non-contact game controller for gaming device Xbox 360, but thanks to its parameters and mostly thanks to its depth sensor and USB communication bridge it became popular in many areas, such as 3D digitization (capturing device), robotics (obstacles recognition), movie industry (motion capture) and virtual reality (non-contact controller). Kinect captures the spatial and colour data simultaneously with possible frequency up to 30 frames per second, while it is able to capture the point cloud with density around 300 000 points in each frame, and, in contrast to the ZScanner through the protective glass in a laboratory [4, 5]. Thanks to this speed and relatively short continuance time of the sensor at one spot it can collect enough data for computer to create the compact web of points of scanned object. Infrared (IR) emitter consists of coherent radiation source and generator of random integrated points in the direction of light trajectory. Receiver is configured to catch the radiation from the illuminated area and on the base of changes in achieved pattern the processing unit creates the map of curvature of digitized body. Thanks to the built-in RGB camera, to the particular groups of captured points the system can also add the information about the colour. Yet because of data limits caused by used USB 2 interface Kinect recalculates the data captured in 1280x1024 pixels resolutions realizing internal processing to the smaller resolution of 640x480 [6, 7]. Data can be taken also in the mode with high resolution but data flow must have lowered to the 15 frames per second or less, what would be not suitable from the viewpoint of manual scanning device.

From the viewpoint of spatial digitization the Kinect device is suitable for obtaining the bodies in interiors (exteriors only at night). Disadvantage can be also found in the fact that the working range of the device for assuring the accuracy of 1 millimetre is at distance of around one and half meter. Helpful seems to be the upgrade of the device in the form of so-called glasses, which we developed at the Faculty of Manufacturing Technologies, what can improve the range of the sensor capturing. At the same time we have to mention that there are some Kinect-like devices already on the market, such as PrimeSense PSDK, ASUS Xtion Pro, ASUS and WaviXtion.

USAGE OF RAW 3D SCAN SCAN DATA

Despite the excellent hardware properties Kinect has a huge weakness associated with a control software. There is lot of various applications, but they usually

make only the captioning of basic views or very limited space areas. Possible cause can be found in the fact that main propagators of these alternative 3D digitizing systems are the small groups of enthusiasts, who can barely challenge the international companies. Despite this fact, first attempts can be observed such as SCENET from FARO Company. The issue that one of the leaders in the field of spatial digitization takes concern of is that simple alternative device supports and highlights the ideological correctness of its use [8]. There are excellent applications such as ReconstructME and KinFu, having the basics of data processing built on the very Point Cloud Library (PCL) project, which is focused to the creation of procedures for processing of 2D/3D images and point clouds. Exception from this course is presented only by KinectFusion from Microsoft Corp [9, 10, 11]. For our purpose we use Scanet software that served for captioning and processing of the data from Kinect.

Skanect in newer version 1.5.0 besides the collecting of spatial data and textures records also the location of the device with every frame. By gaining more data the software core can achieve higher accuracy while joining and positioning particular records what is very important for further processing. Another improvement is that not all data have to be processed in real time using the graphical chip (as it used to be). Only the optimal views are generated that allows us to scan the space with real-time overview. Rest of the data is stored at HDD for later processing [12]. This improvement allows us to digitize faster much larger areas as the optimization of the position of other point clouds and following allocation of the textures from the record can run with use of weaker hardware elements and time savings in offline mode. In next step the collected data need to be processed for further use. The best format seems to be PLY, but in digitization of large bodies we have to take into account the data severity as this PLY format in comparison to other formats. 13, 14]. Spatial information after corrections are useless in some applications, as lot of them requires the time consuming remodeling and substitution of some parts of scans with CAD models. At the Faculty of Manufacturing Technologies we use these data beside the standard ways also in direct form [15]. Our created and simplified model is after the definition of some parameters (floor recognition) suitable for simple visual presentation. We use three basic views as shown on Fig. 2 - perspective view, ground plan and 3D overview. This provides us with the walk through the digitized environment from the viewpoint of first person. Thanks to the photorealistic imaging the user easily accepts the projected environment as a part of reality, while the visual feeling is supported by scene created on the background [16, 17].

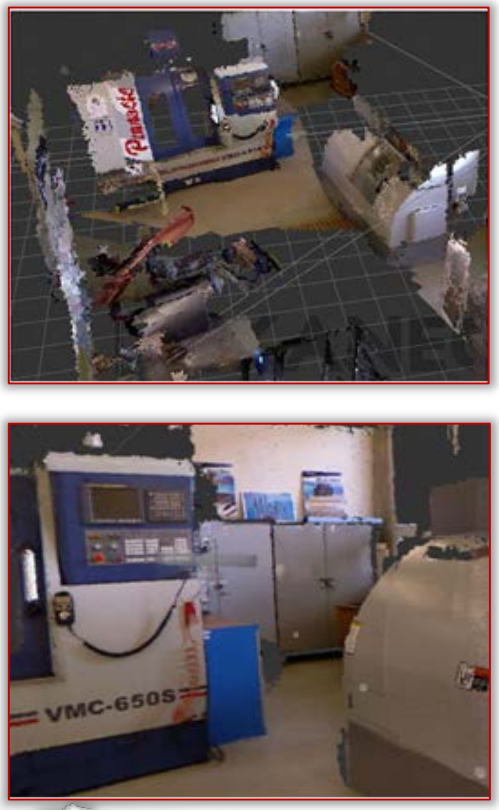

Figure 2: Diagram of basic steps of digization process

As shown on Fig.2, captured data (points, polygon mesh) of complements obtained by Kinect have the color information. By usage of Faro LS 880 additional investment is needed into the camera with adequate facilities. Despite its price Kinect offers full digitizing alternative suitable for 3D digitization of smaller spaces. Due to the specific conditions the only drawback was the time needed to manually capture the whole scene (capture of scene on Fig.2 took two minutes, detailed model up to two hours) but with plenty of detail, since its optimum operating distance is forty centimeters. Digitizing time could be significantly reduced (less than ten minutes) if the surfaces where captured on longer distance but with greater error (at five meters up to four centimeters) which would by sufficient for a visualization of the workplace.

SUMMARY

This article pointed to possible utilization of price-accessible device Kinect together with basic software applications in the area of demanding spatial digitization of interiors of industrial operations. It proved that simple alternative concept can partially challenge the known professional devices while coming up with little purchase price. Thanks to its mobility we can use the device for easy and fast scanning of hardly accessible places without special preparation of sensing surfaces, but with increasing uncertainty when operating at a larger distance as one and a half meter. Considerations are found even among the producers of superior scanning systems who recently started to

support this product by their own software solutions. Commonly used scanning devices have wider view angle and working range, but their price forces the potential customers to realize 3D digitization with use of outsourcing methods, practically selling their own know-how to the competition. In the end it is suitable to remind that spatial information do not have to go through the difficult process of transformation as the raw often presents the sufficient base for presentations and educational purposes.

Acknowledgment

Note

This paper is based on the paper presented at the 10th International Conference for Young Researchers and Phd Students – ERIN 2016, organized by University of Zilina, Faculty of Mechanical Engineering, in Liptovský Ján, Slovakia, May 10 – 12, 2016, referred here as [15].

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CX-LINER: DESIGN AND DEVELOPMENT OF A DIAGNOSTIC TOOL FOR CUSTOMER EXPERIENCE MANAGEMENT IN SMES

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Abstract: Customer Experience Management (CEM) is gaining in attention from organizations that want to provide value to their customers. In particular, mass customizers as well as companies that innovate following an open innovation approach will benefit more from customer experience management than those who don't apply it. However, the road to implementing CEM is very strenuous and requires dedication and resources in terms of financial means and workforce. SMEs lack such resources and have trouble in deciding how and where to start. This is why this design science research project for a scientifically based self-assessment for SMEs was conducted. Development and testing took place with a select number of SMEs The assessment tool is named CX (Customer Experience)-Liner and serves as a compass for SME to determine their course in CEM.
Keywords: Customer Experience Management, Design Science Research, Small and Medium Enterprises, Open Innovation

INTRODUCTION

Customer focus, customer orientation and a perfect customer experience are virtues that many companies desire or aspire. Customers are no longer regarded as rational deciders with mere interest in functional and financial product properties and benefits. A satisfied customer is not a guarantee for loyalty, extra turnover or a larger market share. To increase loyalty and customer advocacy, companies have to consider delivering a positive customer experience. As observed on a case of the demise of a retailer: "At heart, the message is relatively simple: if you sell undifferentiated products, you compete solely on price; but if you provide experiences that consumers want, you offer a differentiated service for which a premium can be charged. The difficulty, of course, is how to create and manage these unique experiences. How to create relevant 'customer experiences' [9]?" We therefore observe an increasing attention from business organizations for Customer Experience Management (CEM) in the past decade. CEM perceives customers as both rational and emotional beings that are looking for positive experiences [15]. Companies will profit if this is done in a proper way. Companies are therefore eligible to adopt ways, methods and best practices in CEM.

Literature on the practice of CEM is however limited to conceptual approaches by practitioners in practice-oriented literature, e.g. Berry et al. [1], Meyer and Schwager [8], Shaw and Ivens [16], Smith and Wheeler [17]. These publications tend to focus on the practical managerial aspects of customer experience management for large, mostly global operating firms, operating in the B2C. Such aspects entail systems and staffing that require large investments and a plethora in resources – both qualities that small and medium-sized enterprises (SMEs) usually do not possess. Practical research intended to guide SMEs in developing effective CM seems to lack, particularly in the B2B. SMEs that also wish to create awareness for and focus on CEM are left in oblivion and confusion on how and where to start with CEM and how to make it work in their case.

As part of the practice oriented research of the Windesheim University of Applied Sciences in Zwolle, the Netherlands, this lack of a practical guide for SMEs inspired us to design and develop a practical diagnosing tool for Dutch SMEs, the CX-liner. In this paper we report on this research, for which we first will describe its design, followed by a review of the literature on CEM

from which design propositions were derived and to finish with the result: the CX-Liner that was validated.

RESEARCH DESIGN

The main research question that directed this study was: 'How can a SME establish its position and status on customer experience management and possible directions for improvement, taking the most relevant and important aspects of customer experience into account?' The supporting sub questions fort his main question, aside from the fundamental question what customer experience really is, were:

- Which factors or aspects have influence on customer experience?
- Which ones are important and relevant in creating good experiences?
- Which of these factors and aspects can be controlled by the SME?
- How can these factors be integrated in a management approach?

Three customer experience experts and practitioners were interviewed to obtain answers to all these questions and to develop design propositions [12]. In addition to these expert interviews an extensive literature study was conducted in both academic and management literature. Because both literature and expert's opinions are focussed on large, B2C companies [6], additional interviews were conducted with potential users of the research results. For this latter step six entrepreneurs participated in the research to get insights on their view on customer experience management and the requirements they have for a possible tool that will guide them in the establishment of their position and directions for improvement. Based on these interviews, literature study and user requirements a self assessment tool, coined CX-Liner, was designed, using the principles of Design Science Research [18]. As an essential part of this research methodology, the design was tested in practice [21], although it took some time to accomplish this.

RESULTS FROM LITERATURE STUDY, EXPERT AND USER INTERVIEWS

Literature review

Both academic and management literature were consulted to find out what customer experience (CX) and customer experience management (CEM) entail. A large amount of articles as well as books were systematically researched, for example academic articles like Gentile et al. [5], Frow and Payne [4], Berry et al. [1], Carú and Cova [2] and Verhoef et al. [19]. Management books that were consulted came from several internationally renowned practitioners, who base their writings on academic research, e.g. Shaw and Ivens [16], Smith and Wheeler [17], Manning and Bodine [7], Schmitt [14] and Pine and Gilmore [11]. We observe that these are only a few of the large amount of literature that was used. Journée and Weber [6] conducted a similar systematic research, for a more detailed list on literature see this publication. Journée and Weber also provide a model for CEM and describe many aspects of CEM extensively, based on their literature study. We therefore refrain from repeating this literature review in this paper and refer to Journée and Weber for these results. We suffice with a summary of the most imported aspects and factors that have to be taken into account when commencing the CEM journey by a company, regardless of its size, business sector and nationality:

- Customer Experience Management aims at creating great experiences for customers, for which the company does not only focus on functional product and service quality, but try to trigger emotional quality as well [5].
- Although experience always occurs, whether intended or not, it can be managed. Management entails a systematic approach, usually following the Plan-Do-Check-Act cycle from a multidisciplinary perspective, i.e. taking into account the welfare of employees, customers and other stakeholders by controlling aspects like systems, technology, processes strategy and soft aspects, like corporate culture, humanistic treatment, and such [6].
- CEM provides a company with a distinctive approach from its competitors (that do not have any interest in CEM) which leads to competitive advantages, like more profit, loyal customers and employee empowerment [19].
- Customer experience takes place in customers' minds and is therefore personal. Yet, it can happen as a result of both direct and indirect contacts with a company or a brand [8]. It is therefore important to not only focus on the interactions a customer has with a company, but on the customer journey as a whole [13].
- To positively influence the customer experience a company can use so called experience providers (communications, visual and verbal identity and signage, product presence, co-branding, spatial environments, websites and other electronic (social) media, and – finally – people or employees) [14].
- Within a company CEM requires cooperation between all disciplines and a leadership style which is consistent wit hits CEM-aspirations [7, 17].

We observe that CEM requires a systematic approach, structure and strategic thinking by the company. For an effective result in this approach and thinking, management has to have a good knowledge of the context the company operates in, which entails customer insight (what do the customers want and experience), employee empowerment and competitive insights. Systematic approaches for the implementation

of CEM are provided by several authors, e.g. Schmitt 2003, Smith and Wheeler 2002, but seem to be intended for large companies. But these approaches can also be used as a basis to develop an approach, which is suitable for SMEs. Since we have based the CX-Liner for a large part on the Smith and Wheeler approach, we will briefly describe Smith and Wheeler's model here. According to Smith and Wheeler there are two ways to structure CX, i.e. 'experiencing the brand' and 'branding the experience'. The first way entails the translation of the brand into a brand promise. This promise refers to the value the company wants to provide to its customers while simultaneously emphasising its position. This will result in the 'branded customer experience' which is what customers are intended to experience. Conditional tot his effect is that interactions between company and customers are consistent with this brand promise. Smith and Wheeler have depicted their approach in a model, see figure 1.

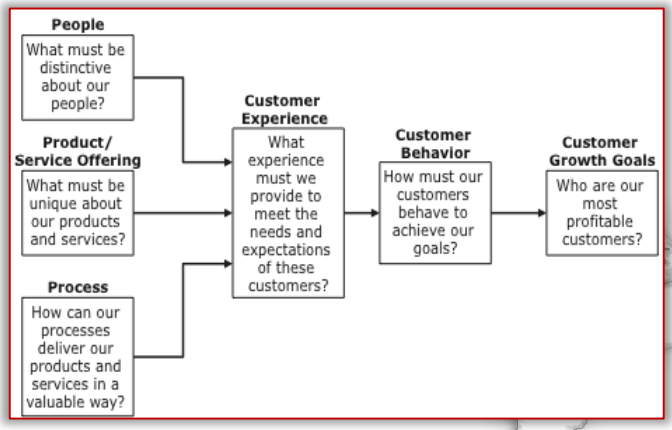

Figure 1. Branded customer experience management model (adopted from Smith and Wheeler 2002:20)

To implement this concept Smith and Wheeler have developed a checklist with questions that accompany the process model in figure 1 and a cycle – which reminds us of the Deming's PDCA-cycle – that supports a company in the development of customer-centered strategy. This cycle consists of four stages:

1. *Define* customer value, by obtaining insights on the customers you want to target, what they appreciate, and how they are influenced in terms of buying and loyalty behaviour. Based on these insights the company can define a differentiated brand promise for each group.
2. *Design* 'the branded customer experience' by mapping customer interactions, adapting employees' behaviour on these interactions, ensuring that the brand promise is fulfilled. This could result in organisational change and development for the company.
3. *Equip* employees for the realization of the brand promise, which entails that leadership has to support employee behaviour through coaching, training and education, but also by providing means for giving insights in customer feedback, i.e. measuring the realization of customer experience.
4. *Sustain* performance, by systematic analysis of customer, employee and market feedback. All systems and process measurements within the company should support the CEM efforts.

Experts' opinion

As observed in the research design, three experts, one academic and two consultants on executive level, were interviewed on their stance on CEM for the SME. The goal of these interviews was to complement literature review for the development of design rules [12].

Although these three experts mainly served larger companies with the implementation of CEM, their opinion was appreciated because of their experience and knowledge on CX-principles and practicalities. These expert interviews confirmed literature that showed that CEM is a concern for the whole organization. CEM and CX are therefore trans-functional. Every discipline within the organisation should take an outside-in stand, that is (re-)viewing their roles and behaviour from a customer's perspective. When being engaged for consulting or advice by a client company, before looking at systemic measurement results, like CSAT, NPS, and other indicators, they first try to get an impression of a company's position on CEM intuitively. "I act like a customer. I am not interested (yet) in the financial or market achievements of the company. I try to get a feeling of how the company feels." To get this result they usually look at social media communication and interaction, get in touch with an arbitrary employee to experience how the interaction flows. This way they get an impression of the client company and the trans-functional integration of the CX-strategy before the first formal contact. When the first formal contact follows, they observe employees and managers, their interactions, their behaviour, to get a feeling whether CX is "part of their DNA, their genes". Only after doing this they proceed with more traditional diagnostics, like interviewing, process and system auditing, and documental research. Thus, this qualitative experience of the CEM efforts from a company precedes the more formal and traditional diagnostics. In these formal diagnostics, managers are interviewed on the company's brand aspirations and promises. A step that usually follows is that the customer journey is mapped. It is very common and important to involve customers in this step, because they are the ones that can truly tell what they experience. Most companies lack these qualitative customer insights, regardless of their previous efforts in customer journey mapping. Only after this has been done, quantitative indicators like volumes and lead times, are integrated in the customer

journey map in order to evaluate effects and consequences of failures and good practices.

Experts indicate nine categories of aspects that are essential for CEM implementation within organisations. These nine categories are briefly described and identified through *italics.* All organisations that want to excel in CX and CEM should be intrinsically motivated to search for (1) *distinction;* they must have the aspiration to differentiate their strategy in order to create superior experiences. To accomplish this they should clearly define (2) *common values,* also known as core values or brand identity. When these values have been defined the organisation has to get insights on how to please its (potential) customers. One should look for those triggers that make the customer experience more pleasure with one's organisation than other organisations through an experience study. Subsequently, one has to think about how to root CX in the organisation's genes, in its DNA. It is therefore important that (3) *top management takes lead and act as an apostle* in the initiatives. Otherwise, failure will be inevitable. On deciding in immersing in customers' experiential world, an organisation should be (4) *aware of an over-estimation* of its extant achievements. If this reality check exposes different results than expected, the organisation could be devastated, resulting in a negative alteration of its view on customers. Regardless of the results from such an experience study, they have to be shared with employees, in order to ensure rooting in the genes. As a matter of fact, (5) *employees* also have to be *involved actively* in experience studies and other activities on CEM-implementation (bottom-up). (6) *Support and facilitation* are key to the success. That requires (7) *customer knowledge and involvement*. To sustain the implemented CEM is troublesome and not without difficulties. A way to cope with this is to make customer experience and programmes an (8) *integral part of a company's core values*. And, in order to verify the effects, the organisation has to develop (9) *metrics* and embed them in the organisation.

User interviews

In addition to the previously mentioned parts of this design research, five potential users of the tool were interviewed to collect their stance on CEM and possible user requirements they have for the future tool. These interviews confirm and acknowledge that most entrepreneurs are confused by what literature and consultants state on CEM and CX. They have trouble with jargon and in establishing what of the actions that are recommended are applicable for SMEs. They also lack the resources (time and money) to engage experienced and competent consultants to guide and assist them in the journey of CEM implementation.

In these interviews we have therefore been able to discuss the requirements for use of the tool-in-design with the entrepreneurs. We have charted all these requirements and categorized them into use requirements, functional requirements and conditions for use. The list is very comprehensive but also of such a size that we limit our elaboration on the most important ones. We refer to a local publication for the SME for the complete list [20].

One important requirement is that the SME is capable of understanding language and pragmatics of the tool. This requirement revealed that SMEs are also looking for a way of self-assessment in their CEM efforts. To engage with an external party that also fixes shortcomings or implements improvements which result from the assessment, will give the transaction a commercial bias, and is therefore subjective in the eye of the entrpreneur. Tool use in itself should be intuitive, easy. In order to facilitate a self-assessment, the time and costs needed with the assessment have to be low. Otherwise it can become an obstacle in using the tool. Results have to be presented in a simple graphic way instead of in bulky reports, but have to indicate directions for improvement in a clear way. And – somewhat contradictory to the self-assessment requirement – results preferably have to be benchmarked for the sector the company operates in. This indicates that the tool has to submitted to a central platform – online or physical – in order to integrate the input in sector results. It also means that the assessment survey has to be generic and not company-specific – a certain level of abstraction is inevitable. Three keywords depict these requirements: clear, consistent and adequate.

THE DESIGN: THE CX-LINER

Foundations of the design

The creative step in this research was the translation of the theoretical and practice insights, elaborated on in section 3, into design propositions that will lead to the intended design: a self-assessment tool for the SME to establish its position on CEM and to provide directions on improvement for CEM. The propositions are depicted as the most central and important elements that a sound CEM implementation should consist of. This implementation is based on two foundations: one for the process of CEM staging, and the other one for the (organisational) aspects that have to be considered. The process foundation has been briefly described in section 3.1, which is the Smith and Wheeler –model for a CEM strategy. This model consists of the stages: (1) *define* customer value; (2) *design* the 'branded customer experience'; (3) *equip* employees to fulfil the brand promise; and (4) *sustain* performance

This process foundation can be coupled to or mixed with our second foundation which is based on the McKinsey's 7S-model [10]. This choice is based on the theoretical and practice finding that CEM is trans-

functional and involves all levels, systems, leadership style and culture of an organisation. These aspects are comprehensively covered in the 7S's from the model: strategy, systems, structure, skills, style, staff and shared values. We will refrain from elaborating on the 7S-model, since we expect it to be fairly known with scholars.

The coupling with the Smith-Wheeler model is motivated as follows. The Smith-Wheeler (process) model as a whole is coupled with a first "S", the company's strategy, and is reflected in the design as a whole: the tool is a diagnostic for a company's CEM strategy. The remaining six elements of the 7S can subsequently be coupled to the four stages in the Smith-Wheeler model.

Shared values and Style with Define

An organisation can only be successful with CEM when CEM strategy is acknowledged and supported by top management (Style). And to root in the genes of the organisation CEM has to become part of an organisation's culture (Shared values). Smith and Wheeler's Define-stage entail the creation of a foundation for CEM by mobilising both management and employees in order to acquire an outside-in attitude.

Style, Structure and Staff with Design

Once the foundation has been established, the CEM strategy can be *design*ed by connecting the brand promise with organisational behaviour. This has to be achieved by management's role (Style) in establishing structures (Structure) for organisational change and employee behaviour (Staff).

Staff and Skills with Equip. Subsequently the SME should start fulfilling the brand promise by *equip*ping employees (Staff) with the necessary competences (Skills) to evoke the intended customer experience.

Skills, Systems and Shared values with Sustain. To *sustain* the efforts in creating distinctive customer experience in the long term, it is important to train, educate and develop employees do they can keep meeting changes in customer demands (Skills). Systems like employee appraisal, improvement methods, management metrics are also needed for this longer term approach (Systems). This has to be embedded in such a way that the whole organisation takes part in the CEM strategy and that CEM becomes an important part of organisational values (Shared values).

We visualize this coupling of the two foundations in figure 2, which will serve as a means for a graphic representation of a company's position on CEM later on.

42 propositions in the self-assessment

The two foundations, Smith and Wheeler's process model and McKinsey's 7S-model for CEM elements, serve as a basis for the self-assessment. The idea is that there is an ideal order of process stages and steps in which the several elements of a strategy can be implemented. For each step one can assess whether this step has been addressed and carried out by means of a proposition that represents the ideal situation.

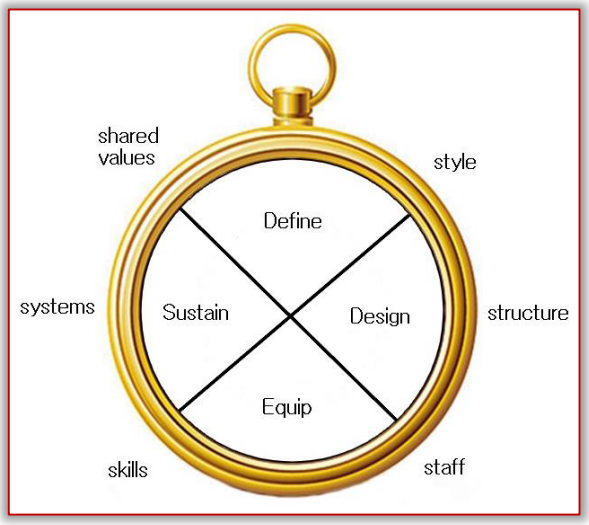

Figure 2. "Brand Customer Experience" integrated with 7S-model

For each stage of Smith and Wheeler's process model we have defined three propositions. However, these propositions are stated in an order, which reflects the incremental progress of implementation. This means that if the strategy implementation has been carried out in a right order, the choice for a certain proposition entails that one also has to fulfil the previously stated propositions. We, thus, obtain a total of 12 propositions, that all have to be met in the given order to be acknowledged as a mature CEM strategist. These 12 propositions also cover the first S of strategy, as explained earlier.

For each remaining S we have also defined five propositions, again in such an order that they best reflect the sound approach and order for these elements in CEM implementation. For these 6 S's we come to a total of 30 propositions. Along with the 12 process or strategy propositions we get a grand total of 42 propositions that entail order and comprehensiveness of the CEM approach and implementation.

The propositions are in Dutch and stated in such a style that they reflect the ideal situation regarding the stage of implementation or the aspect for ideal CEM within the company. A company that wants to diagnose itself merely has to agree or disagree with the proposition, as a whole or partially. It can be used by any SME, regardless of the industry it operates in. The propositions have been developed to state CEM aspects for SME's. The proposition are not incorporated in this paper, but can be supplied upon request.

Maturity levels and directions for improvement in CEM

The company scores each proposition on a scale of 1 ("I do not have any clue, unaware") to 5 ("We fully comply to this condition") to reflect its current position in CEM. The scale reflects a maturity scale from beginner (level 1) to expert (level 5): the more one agrees with a proposition, the higher the score for that aspect of CEM will be, and – therefore – the more mature the company is on that proposed aspect. The resulting score is not obtained by adding the individual scores per proposition, but totalled per quadrant of the diagram in figure 2. Each quadrant consists of specific propositions: three for each stage in the Define-Design-Equip-Sustain process model and five for each S coupled to that quadrant – some quadrants consist of two S's and some of three – varying the total of propositions per quadrant from 13 tot 18. The results can be graphically depicted in the diagram of figure 2.

Each proposition has an embedded set of actions that have to be executed in order to comply with the proposition. And, in addition, the order in which these propositions have been integrated in each quadrant and the quadrants are dimensioned is of such nature, that it also reflects a progress in maturity. For instance, it would be very unlikely for someone to score high on proposition number 8 in the first quadrant, when he has a (very) low score one or more previous propositions, e.g. propositions numbers 3 and 5. Thus, although he might get a good total in that quadrant, scoring his company as 'advanced', it reflects the omission of certain steps or actions, in this case embedded in propositions 3 and 5. Similarly, the quadrant order also reflects the ideal order of implementation. It would, example given, also be very unlikely for a company to score as 'expert' in the 'Equip' stage, while it scores as a 'beginner' in the 'Define' and/or 'Design' stage. Both outcomes, however, give direction to the improvement program the company has to follow in order to score as 'expert' on all aspects. In addition, it gives priority rules in case of non-compliance with more propositions.

How to use it: an example

Figure 3 shows the fictitious case of a company that has applied the CX-Liner. In this example the respective quadrant totals (blue dots) are: Define 27, Design 42, Equip 41 and Sustain 32. The lower score on Define, compared to the higher scores on Design and Equip indicate that there is something missing in this stage for a sound CEM-implementation and that the company has to make improvements in defining its brand promise. The score of 32 in Sustain also show that more work has to be done in sustaining its efforts. The exact aspects that have to be improved can be found by looking up the propositions with the lowest scores in this quadrant.

The S-values (yellow dots) on the other hand are Shared values 14, Style 8, Structure 11, Staff 18, Skills 16 and Systems 13. This result is indicative for a company that has put a lot of effort in its employees through selection training and organizational culture, but has somewhat neglected the importance of leadership (style) and change management (structure). In combination with the stage scores, this company has to have (top) management take a responsibility in defining what the organisational and brand values are and what customers to serve. It then has to make employee programs consistent with this strategy.

Ergo, the diagnosis shows what the company has been doing well on CEM but has not been doing it in the correct order and has left out some important organizational aspects like leadership and brand promises, but that can still be recovered, when given the proper attention.

VALIDATION OF THE CX-LINER

As for any design, the DSR methodology requires the testing of the design as a means to validate the research.

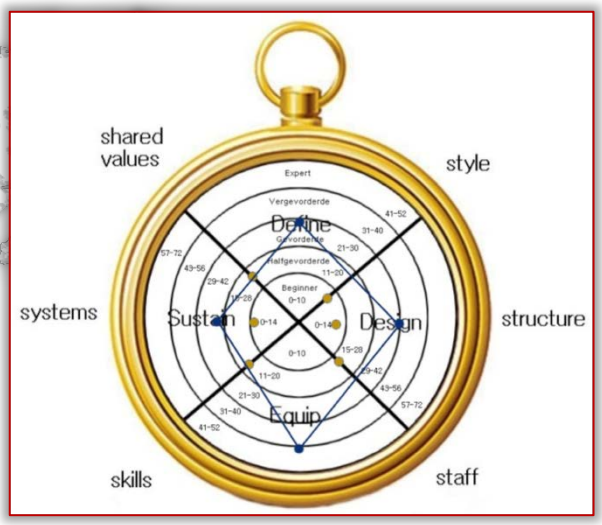

Figure 3. Application of the CX-liner, an example

In our research testing did not immediately take place. And to be completely honest, we even was launched the design before it was even tested. We did this because we strongly believe that the CX-liner is a useful and powerful diagnostic tool that many SME will appreciate. And in addition, at the moment of the completion the design, we were running out of time, leaving us no room to set up a test program. Nevertheless, testing is regarded as an obligation in DSR [18]. But fortunately, DSR testing doesn't need a large amount of respondents as in randomized controlled trials required in the medical field, but can be based on a pragmatic number of cases [3].

Three SME companies have tested the CX-liner, of which one was a B2B company. All test participants

were service providers. Testing took place by going through the process of self-assessment, receiving and interpreting the resulting diagram and directions for improvement, evaluating the CX-liner and reflecting on the whole process. The evaluations were conducted through surveys and personal interviews with the applicants of the CX-liner. It can be observed that all applicants evaluated the CX-liner in a positive way. They thought it is useful to diagnose oneself en that it provides good insight for the improvement. However, there is also room for improvement of the tool. To start with, respondents stipulated that a benchmark for the business sector would be useful. They argue that it is probably not a matter of getting the highest score on CEM as a whole, but to distinguish oneself in a positive sense from others in the same business. We support the idea that each business has its own peculiarities and that it could imply that partial perfection can also be regarded as distinctive. But, on the other hand, insight in business sector benchmarks could also lead to procrastination where improvement is needed from customers' perception. Another suggestion was to do an additional survey among the company's customers, so that over-estimation by the respondent can be avoided: self-reporting can lead to bending the truth, although the company is fooling itself. Finally, two participants found that the propositions are sufficient for the assessment, since each proposition has the improvement action embedded. It their view the graphic representation is a cosmetic feature that can be left out.

CONCLUSION

The research objective was to design and validate an assessment tool for Dutch SMEs to establish their status on CEM strategy implementation and to provide directions for improvement in the journey of reaching great customer experiences. The design process was based on literature review and synthesis, expert interviews and user interviews. The process resulted in the CX-liner that is based on two ideal foundations: the Smith-Wheeler process model for CEM strategy implementation and McKinsey's 7S-model identifying the management aspects for CEM. The CX-liner is a self-assessment tool, which is carried out by diagnosing one's own situation through 42 propositions that represent the ideal implementation actions for CEM. The more propositions the company agrees with, the better it is diagnosed as an expert on CEM strategy. Propositions that do not meet any or full compliance indicate the directions for improvement. The order in which the propositions are presented is a means to prioritize improvement actions. Testing has proved the CX-liner to be useful and insightful from user perspective, but has also resulted in some insights for improvement of the tool. These improvements will be considered in an update and redesign of the initial tool.

Note

This paper is based on the paper presented at The 7th International Conference on Mass Customization and Personalization in Central Europe – MCP–CE 2016 – Mass Customization and Open Innovation, organized in Novi Sad, SERBIA, September 21-23, 2016, referred here as [22].

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WAREHOUSE DESIGN – DETERMINATION OF THE OPTIMAL STORAGE STRUCTURE

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Abstract: The paper shows a design conception for an existing warehouse. The conception can be applied to define an optimal storage structure based on a given warehouse floor area and available forecasts relating to types and volume of loading units (LU) to be stored. The study shows 6 possible alternatives for storage structure. Longitudinal and transversal twin racking arrangements with narrow and wide aisles were taken into consideration. Structure alternatives were compared based on storage capacity, specific storage capacity and utilization of floor area. The optimal storage structure was defined.
Keywords: warehouse, design conception, optimal storage, alternatives, racking arrangements

INTRODUCTION

Supply chain efficiencies depend upon the efficiency of logistics including warehousing activities. The efficiency of the warehouse depends on the layout, infrastructure and the operation of the warehouse. Warehouse design element aims to maximize the utility of space, equipment, and efficiency of operations.

Layout design [1] is completed taking into account the types and volumes of goods, required warehouse operations, and available warehouse infrastructure. The design aims to maximize space utilization, minimize material handling equipment movement and manpower movement.

Types of storage are determined by the nature of goods to be stored. Depending on the cargo whether raw materials, components, semi finished goods or finished goods, the types of storage can vary from bulk stock, block stock, racking, pallet racking, shelf racking, etc.

Most common storage type is the racking system. The racking design [1] takes into account the storage type, storage unit, volume, and weight coupled with the available floor space and roof height to design system that maximizes the storage capacity. Put away and picking process and transactional volumes are also taken into consideration.

METHOD, AIM AND CONSTRAINTS OF WAREHOUSE DESIGN

Our task was to form the optimal storage structure in an existing warehouse building. The product structure and the volume of goods to be stored were given. The aim of warehouse planning was the formation of possible storage structure alternatives for a given warehouse floor area and choose the optimal structure based on the following aspects:

- maximal storage capacity,
- maximal specific storage capacity,
- maximal utilization of floor area and space.

Constraints during the design were the followings: floor area, roof height, column arrangement, size and location of area used for order picking or loading in and loading out (Figure 1).

Areas b_{11}, b_{21} used for order picking, b_{31} is used for loading in and loading out activities. Areas b_{12}, b_{22}, b_{32}, b_{13}, b_{23} and b_{33} can be used for storage.

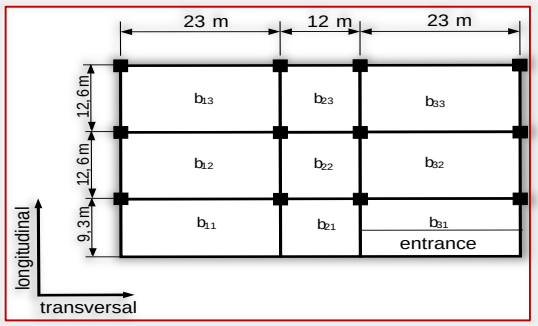

Figure 1. Layout of an existing warehouse building

FORMATION OF STORAGE STRUCTURES

At first we have to analyze the goods to be stored (type, volume, loading unit, turnover, etc.).

Storage structure, location of storage zones, applied storage techniques (racking, material handling tools and equipment), high of the building and the width of aisles are very important to take into consideration during the formation of storage alternatives.

The applicable storage structures can be the followings:

- racking storage:
  - adjustable pallet racking,
  - deep store drive-in pallet racking,
  - gravity pallet racking,
  - sliding pallet racking,
- without racking, storage on floor area in blocks.

It can be defined that the adjustable pallet racking is the adequate storage structure to be formed based on forecasts relating to the product types and volumes.

We examined two main types of this racking system in which the racking lines are in longitudinal and in transversal direction (Figure 1) [3]. It is worth to examine narrow- and wide aisle structures which requires different loading in-, loading out and order picking strategies and materials handling equipments.

The aim of the analysis is the elaboration of possible storage structures, determination of an optimal structure according to maximal storage capacity, maximal specific storage capacity, maximal utilization of floor area and space [4, 6].

Additional alternatives were examined according to the transversal and longitudinal location of loading units (LU) in the racking.

The following alternatives were examined based on the above mentioned aspects:

1. Longitudinal twin racking
Longitudinal racking system with narrow aisles (1.1.)
Loading units are in longitudinal direction on the racking (**1.1.1.**)
Loading units are in transversal direction on the racking (**1.1.2.**)
Longitudinal racking system with wide aisles (1.2.)
2. Transversal racking system
Transversal racking system with narrow aisles (2.1.)
Loading units are in longitudinal direction on the racking (**2.1.1.**)
Loading units are in transversal direction on the racking (**2.1.2.**)
Transversal racking system with wide aisles (**2.2.**)

Figure 2. Formation of storage alternatives

LONGITUDINAL TWIN RACKING SYSTEM

In the racking system the racking lines and aisles are in longitudinal direction, parallel to the longitudinal side of the building (Fig. 3-5). This structure provides a good utilization of floor area.

Both narrow and wide aisles were examined.

Longitudinal racking system with narrow aisles (1.1.):

Formation of the structure is depicted on Fig. 3-4.

- Loading units are in longitudinal direction on the racking (**1.1.1.** - Fig. 3.): In this case the width of twin racks is 1800 mm, width of narrow aisles is 1400 mm.

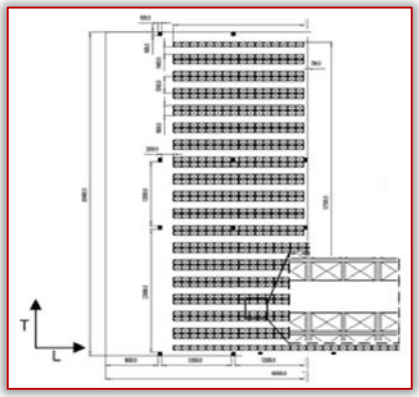

Figure 3. Narrow longitudinal aisle (LU in longitudinal)

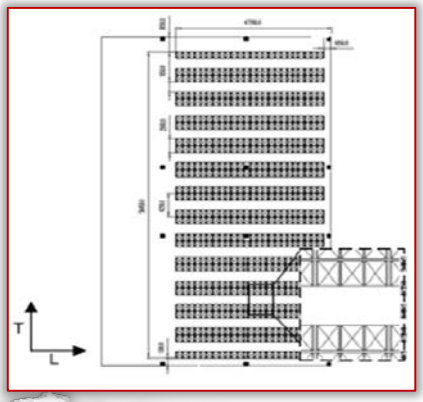

Figure 4. Narrow longitudinal aisle (LU in transversal)

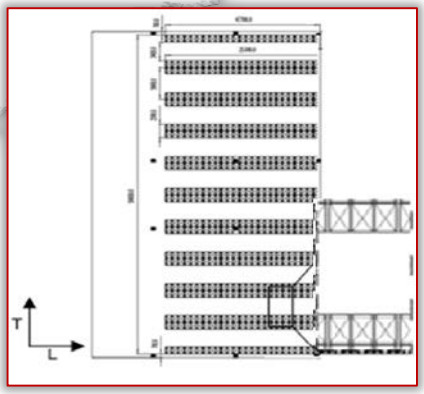

Figure 5. Wide longitudinal aisle (LU in transversal)

During the design we had to take into consideration the fix column arrangement of the building. We tried to define the racking lines that the columns will be in the racking line not in the aisles.

- Loading units are in transversal direction on the racking (**1.1.2.** - Fig. 4.): In this case the width of twin racks is 2500 mm, width of narrow aisles is 1850 mm.

Longitudinal racking system with wide aisles (1.2.):

We analyzed also the wide aisle structure (Fig. 5.). We suggest the application of conventional high lifting forklifts. The suggested width of the aisle is 3400 mm to provide the two-directional traffic of forklifts.

Transversal aisles were also formed to intensify the activity of forklifts, efficiency of loading in, loading out and order picking activities.

TRANSVERSAL TWIN RACKING SYSTEM

Racking system consists of racking lines in transversal direction, orthogonal to the longitudinal side of the building (Fig. 6-8.).

This structure results a larger number of racking lines and aisles, which provides an easier handling of a large number of product types and an easier traffic of forklifts.

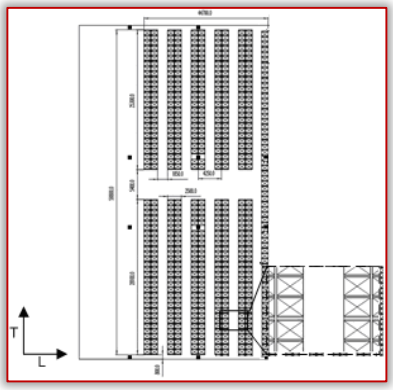

Figure 6. Narrow transversal aisle (LU in longitudinal)

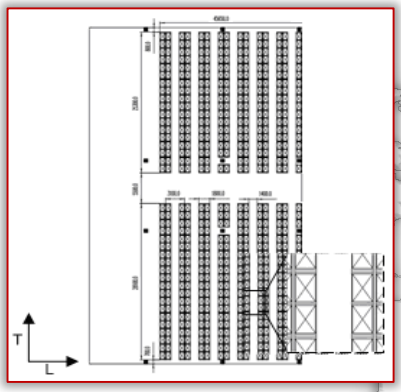

Figure 7. Narrow transversal aisle (LU in transversal)

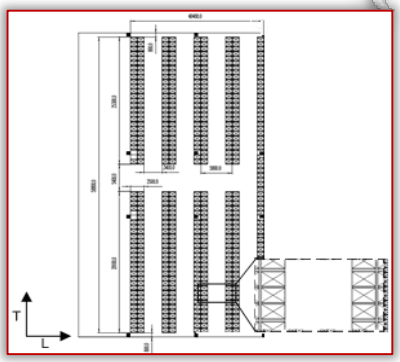

Figure 8. Wide transversal aisle (LU in longitudinal)

Transversal racking system with narrow aisles (2.1.):

Both transversal and longitudinal locations of loading units in the racking were examined (Fig. 6-7). We suggest the formation of a wide longitudinal aisle for supporting of activities completed in the transversal aisles.

- Loading units are in longitudinal direction on the racking (**2.1.1.** - Fig. 6.): In this case the width of twin racking is 2500 mm, width of narrow aisles is 1850 mm. Width of longitudinal aisle is 5400 mm.
- Loading units are in transversal direction on the racking (**2.1.2. -** Fig. 7.): Width of twin racking is 1800 mm, width of narrow aisles is 1400 mm. Width of longitudinal aisle is 5500 mm.

Transversal racking system with wide aisles (**2.2. -** Fig. 8.)**:**

We suggest the application of conventional high lifting forklifts. The width of aisles is 3400 mm to provide two-directional traffic of forklifts. The width of longitudinal service aisles is 5400 mm.

COMPARISON OF STRUCTURE ALTERNATIVES

Comparison of different structure alternatives was based on the following aspects: maximal storage capacity, maximal specific storage capacity, maximal utilization of floor area and space [5, 6].

Storage capacity of storage structures

Storage capacity of structures can be calculated by the following equation (dimension is Loading Unit):

$$n_i = r \cdot n_T \cdot n_L, \qquad (1)$$

where: r: number of layers of loading units (LU) in vertical direction on racking, n_T: number of LU stored in transversal direction on floor area, n_L: number of LU stored in longitudinal direction on floor area.

The number of layers of loading units in vertical direction on racking is 8 layers in all cases of structures (r=8).

The loss of storage capacity caused by fix location of building columns should be taken into consideration during the calculation of storage capacities.

The results (Table 1) of the calculations for the different storage structure are the followings:

Table 1. Storage capacity of different alternatives

Alternatives	Storage capacity (n_i) [pieces]
1.1.1.	4576
1.1.2.	5160
1.2.	3968
2.1.1.	5016
2.1.2.	4544
2.2.	4032

It can be summarized that a higher storage capacity can be provided by the application of longitudinal racking compared to transversal arrangement.

The optimal arrangement of narrow aisle structures is the longitudinal racking system in which the LUs are in transversal direction.

In case of wide aisle arrangement also the longitudinal racking system seems to be more advantageous.

It is not enough to compare only the storage capacities of narrow and wide aisle structures. If we want to compare these we have to take into consideration of construction cost, operation cost, service cost, service strategies and productivity of handling equipments of the alternatives simultaneously. This analysis requires further research work.

Specific storage capacity of storage structures

Longitudinal and transversal arrangement can be also compared based on the total number of LUs stored on the total storage floor area.

Specific storage capacity can be defined by the following equation:

$$\rho_i = \frac{n_i}{A_{ti}}, \quad (2)$$

where: ρ_i: specific storage capacity (ρ_i) [pieces/m²], n_i: maximal number of LUs stored in case of the i^{th} alternative [pieces], A_{ti}: total storage area in case of the i^{th} alternative [m²].

This total racking area is not includes the area of aisles. The result of calculations is summarized in Table 2.

Table 2. Specific storage capacity of different alternatives

Alternatives	Total storage area (A_{ti}) [m²]	Specific storage capacity (ρ_i) [pieces/m²]
1.1.1.	1392	3.29
1.1.2.	1392	3.7
1.2.	1392	2.85
2.1.1.	1328	3.78
2.1.2.	1330	3.42
2.2.	1350	2.99

Specific storage capacity of the two most advantageous narrow aisle structures is near the same and the specific storage capacity of the two wide aisle arrangements is also near the same. Specific storage capacity of narrow aisle structures is higher compared to wide aisle arrangements. The optimal structures are the longitudinal racking with narrow aisles (LUs in transversal direction) system and the transversal narrow aisle (LUs in longitudinal direction) arrangement. If we taking the storage capacity into consideration the longitudinal racking system with narrow aisle (LUs in transversal direction) is the ideal formation.

Utilization of floor area of different alternatives

Alternatives can be compared based on factor of utilization of floor area (φ_i) and utilization of internal space. Utilization of floor area [%] can be calculated:

$$\varphi_i = \frac{A_{ti}}{A_{ri}} \cdot 100\%, \quad (3)$$

where: φ_i: factor of floor area utilization of i^{th} alternative [%]; A_{ti}: total storage area in case of the i^{th} alternative [m²]; A_{ri}: total racking area used for storage in case of the i^{th} alternative [m²].

Result of calculations can be summarized in Table 3.

Table 3. Total storage area with racking area and utilization of floor area

Alternatives	Total storage area (A_{ti}) [m²]	Racking area (A_{ri}) [m²]	Utiliza-tion of floor area (φ_i) [%]
1.1.1.	1392	768	55,17%
1.1.2.	1392	770	55,32%
1.2.	1392	592	42,53%
2.1.1.	1328	734	55,27%
2.1.2.	1330	729	54,81%
2.2.	1350	601	44,52%

We can summarize that floor area utilization of narrow aisle arrangements are near the same and floor area utilization of wide aisle structures are also near the same. But if we taking the storage capacity into consideration the longitudinal racking system with narrow aisle (LUs in transversal direction) provides the optimal solution.

CONCLUSION

The paper shows the warehouse design conception of an existing warehouse, which conception is suitable to define an optimal storage structure for case of a given warehouse floor area.

We examined two main types of a twin racking system in which the racking lines are in longitudinal and in transversal direction. It is worth to examine narrow- and wide aisle structures which requires different loading in and loading out strategies and materials handling equipments. Additional alternatives were also examined according to the transversal and longitudinal location of loading units (LU) in the racking.

The aim of the analysis was the elaboration of possible storage structures, determination of an optimal structure according to maximal storage capacity, maximal specific storage capacity, maximal utilization of floor area and space.

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DEVELOPMENT AND EVALUATION OF SOLAR BASED ADSORPTION COOLING SYSTEM

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Abstract: In recent years air-conditioning systems are most widely used for human comfort. The conventionally used refrigerants in the air-conditioning systems cause ozone layer depletion and also these refrigerants have higher global warming potential. This leads to research in the area of alternative cooling methods and among the alternative cooling methods adsorption cooling systems are getting attention. The adsorption cooling system is the heat driven refrigeration system and hence solar energy can be used as the heat source in this system. In adsorption system, careful selection of the adsorbent-adsorbate pair is important. Hence, in this work water was used as refrigerant to cope with the current environmental issues. In summer the demand of the cooling system is high and hence in this work solar energy was used to drive the adsorption system. We have developed and tested an adsorption system successfully. From this work, we conclude that the development in the adsorbent technology provides solution to the shortcomings in adsorption systems and also helps to reduce global warming potential.
Keywords: Cooling, Solar, Adsorption system, development, evaluation

INTRODUCTION

The conventional air conditioning systems works on the principle of vapour compression refrigeration cycle. The conventional air conditioning consists of an evaporator, a compressor, a condenser and an expansion valve. In conventional air-conditioning system, electrical energy is supplied to run the compressor. The function of the compressor is to transfer heat from room to the surroundings. The temperature and pressure of the refrigerant is increased by the compressor due to compression of the refrigerant. The refrigerant rejects heats to the surrounding through condenser and changes it phase so that it can be used for cooling. However, the pressure of the refrigerant is high and hence the refrigerant is allowed to expand in the expansion device. The temperature of the refrigerant is reduced due to expansion and the low temperature refrigerant enters the evaporator. The refrigerant absorbs the heat from the evaporator and hence the cooling effect is produced. In recent years, air conditioners have become almost essential in homes and offices as it provides thermal comfort and indoor air quality. The air conditioners consume significant amount of electrical energy and the production of the electrical energy from the conventional sources release greenhouse gases. The use of CFCs, HCFCs and HFCs based refrigerants in the air conditioning systems cause ozone layer depletion and contribute to global warming. Hence, researchers are carrying out studies to find suitable alternative methods of cooling. Among the different alternative cooling systems, adsorption cooling system is getting popular as it a heat driven system and we can use waste heat or solar energy.

ADSORPTION COOLING SYSTEMS

Adsorption is the adhesion of fluid molecules on the walls of a solid material and it creates a film on the adsorbent surface. The adsorbed molecules lose energy when adsorbed by adsorption bed resulting in an exothermic reaction.

Few researchers developed a refrigeration cycle using activated carbon granules as an adsorbent and CO2 as an adsorbate. Their demonstrated that it is possible to produce a low temperature using an activated carbon bed for adsorption/desorption of carbon dioxide [1]. Few researchers recommended activated carbon /R-

134a adsorption refrigeration working pair as compared to activated carbon powder with R-507A, R-407c, R-507A, R-407c and R-134a. This is because of its higher maximum adsorption capacity than the other and also for long life performance adsorption refrigeration system [2].

Skander et al simulated the specific cooling effect and COP for the driving heat source temperatures between 30 ºC to 90 ºC with different cooling load temperatures. They found that the maximum COPs ofACF-CO2and Maxsorb-CO2 systems are 0.083 and 0.15 respectively. Few researchers used CO2as the refrigerant and suggested that the two-stage adsorption refrigeration can work at lower regeneration temperatures. They reported that the COP of the two-stage cycle is higher than that of the single-stage cycle for these low regeneration temperatures [4]. Skander et al analyzed the dynamic behavior of a 4-bed adsorption chillers using R1234ze, as the refrigerant and highly porous activated carbon of type Maxsorb III as the adsorbent. Their simulated results show that the system is can produce 2 kW of cooling power with the heat source temperature of 85 °C. Few researchers suggested that the performance of CaCl2–ammonia adsorption system can be improved by distributing activated carbon uniformly in the mass of CaCl2. This process increases mass transfer and uplift the cooling power density [6].

Abdual Hadi et al studied the effect of the process variables on the performance of a two bed adsorption chillier with the capacity of 1.5 tons with the adsorption pair, activated carbon-methanol. They reported that the two beds adsorption system gives continue cooling effect. Also it is reported that the active carbon hollow fibers possess higher ratio of geometric area to volume as compared to classic active carbon [8]. Few researchers produced activated carbon from carbonized olive stones in the temperature range from 700 to 800 degree C and can be activated by ZnCl2 and KOH [9]. Astina and Bun Kisa carried out experiments on activated carbon and propane adsorption refrigeration system to produce continuous cooling. From the experimental results, they reported that the adsorption refrigeration system provides cooling capacity, cycle time and COP around 50 kJ, 210 min and 0.15 respectively.

MATERIALS AND METHODS

The pyranometer with data logger was used in this work to measure the solar radiation flux and is shown in the Figure 1. It consists of thermopile sensor with black coating which absorbs the solar radiations and converts the thermal energy into electrical energy. It senses the solar radiations at instant and converts the heat production due to radiation into micro volts displayed in form of W/m2 in data logger. A sunshine recorder was used for measuring the duration of the sunshine. The sunshine recorder is used for measuring number of hours of sunshine in a day. It was placed from 9.00 AM to 3.30 PM in the month of April 2016, at Nagarjuna College of engineering which has latitude of 12.970 N. It doesn't record the number hours of day light but only measure the hours of radiation. It consists of three seasonal cards such as summer, equinox and winter cards and is shown in the Figure 2.

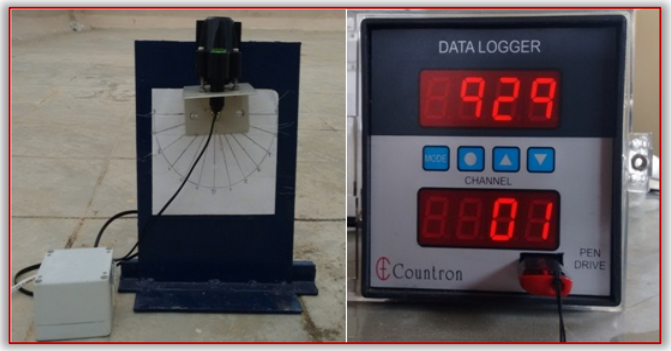

Figure 1. Pyranometer with data logger

Figure 2. Sunshine Recorder

A 10 KVA solar PV system was used in this work. A solar inverter was used to convert the variable Direct Current (DC) output from the PV panels to alternating current (AC) and then supplied to OFF-grid for the utilization and to supply power to the evaporative cooling system. Figure 3 shows the solar PV system and the solar inverter.

Figure 3. Solar PV panels with inverter

The selection of the adsorbent-adsorbate pair is essential for the successful operation of adsorption system. In adsorption system, the refrigerant is chosen based on its evaporating temperature and pressure, environmental impact, heat capacity and ability to be adsorbed on solid beds. However, the refrigerants with high heat capacity per unit volume and low environmental impact are selected. Water has higher latent heat and is non-toxic and hence it was chosen as the refrigerant. Silica gel synthetically prepared from sodium silicate contains a nano-porous silica micro-structure. It is produced from naturally occurring mineral and is purified and processed into either granular or beaded form. It adsorbs water due to its higher specific surface area. The moisture in the silica gel can be removed by adsorption rather than by absorption into the bulk of the gel. The silica gel can be regenerated at low heat source and hence it was used in this work. Hence, the adsorption pair used in this work is silica gel and water.

The adsorption system consists of desorption chamber, condenser, adsorption chamber and evaporator and is shown in the Figure 4. The adsorption system depends upon the affinity of the adsorbent bed to attract the refrigerant vapour from the evaporator and this process creates a low pressure in the evaporator. When the adsorbent bed is close to the saturation point, heat is applied to adsorbent bed. The addition of heat evaporates the refrigerant and the refrigerant vapour goes to the condenser where it is condensed in the condenser before returning to the evaporator. When this cycle is completed, the adsorbent bed is cooled by the cool water until the adsorption conditions are established. After this process, the valve between the evaporator and the adsorbed is reopened.

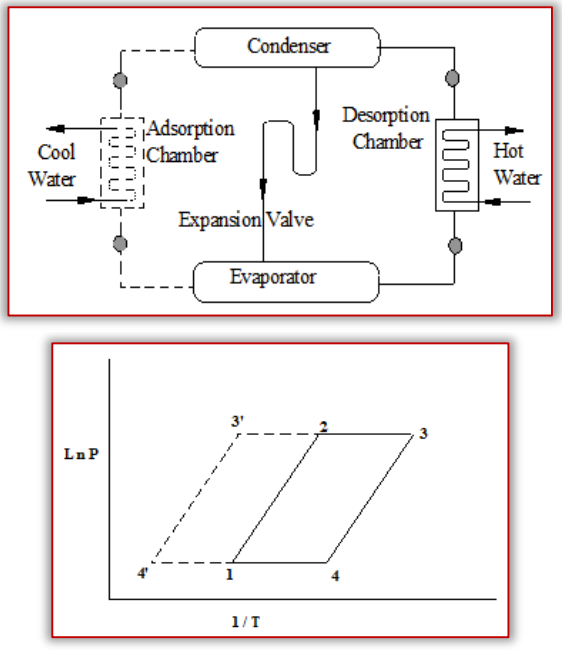

Figure 4. Adsorption Cooling System

Adsorption refrigeration system uses solid adsorbent to produce cooling effect as the bed adsorb and desorb a refrigerant to produce cooling. The adsorbent bed desorbs refrigerant when heated and adsorb refrigerant vapor when cooled. A basic adsorption cycle consists of four thermodynamic processes which is shown in the vapour pressure diagram, Figure 4.

1. Heating and Pressurization (1-2)

At starting of the process, the adsorbent is cold and saturated with the refrigerant and this state is represented as point 1. When heat is applied, the adsorbent is heated which results in desorbing a certain amount of the refrigerant from the adsorbent. This process causes increase in pressure from evaporator pressure to condenser pressure, without changing the refrigerant uptake and this process continues until the minimum desorption temperature is reached. This process is called as preheating. The end of this process is represented as state point 2. This process is similar to compression in vapour compression refrigeration system.

2. Heating, Desorption and Condensation (2-3)

The adsorber continues receiving heat and the desorption process starts from the point 2 and the refrigerant is condense data constant pressure in the condenser. The desorption process continues till the adsorbent temperature reaches the maximum desorption temperature. Also the refrigerant uptake reaches the cycle minimum uptake and the point 3 shows the end of this process. This process is similar to condensation in vapour compression refrigeration system.

3. Cooling and Depressurization (3-4)

After this process, the adsorbent adsorb refrigerant vapour due to pre-cooling. This reduces the system pressure from condenser pressure to the evaporator pressure. When the system is pre-cooled further, a portion of the previously desorbed and condensed refrigerant is adsorbed. The remaining liquid refrigerant in the evaporator supplies the latent heat of vaporization required for this process. This results in decreasing the refrigerant temperature from state point 3 to state point 4. This process is similar to expansion in vapour compression refrigeration system.

4. Adsorption and Evaporation / Cooling (4-1)

The cooling effect is produced during this process and adsorber continues releasing heat when it connected to the evaporator. The adsorbent temperature decreases slowly which causes the adsorption of vapour. The heat required for the evaporation is supplied by the heat source at low temperature. The adsorption process produces the cooling effect and point 4 shows the starting of the process and the process continues due to by further cooling in the adsorber–desorber heat exchanger. This process continues until the entire

refrigerant is evaporated. This process is similar to evaporation in vapour compression refrigeration cycle. In figure 4, the line 3' to 4' represents the saturation line.

The cycle 1-2-3'-4' represents the refrigeration cycle and the cycle 1-2-3-4 represents the adsorption cycle and also represents the conditions of adsorbent. The simple adsorption system does not produce continuous cooling. In adsorption system, the adsorption bed is charged with refrigerant at low temperature and pressure. The adsorption bed is heated when adsorption slows down which causes vapour is released from the bed.

RESULTS AND DISCUSSION

Analysis of solar radiation and power production

The study of solar radiation was carried out from 9.10 AM to 3.10 PM using the sunshine recorder, pyranometer and compared with the power produced by the 8 PV panels each of 230Wcapacity. The card burnt length shows the hours of the sunshine at respective time on the card and solar radiation flux (W/m2) recorded with the pyranometer is plotted against time and compared with the sunshine recorded card, correspondingly the power generated from the PV Panels are noted from the solar inverter.

Figure 5 shows the results of the reading recorded by the sunshine recorder and the solar radiation flux on the Equinox card. The card is placed at 9:10 AM and the sunshine is observed from 9:15 AM to 3:10 PM. There was cloud formation during the daytime and hence there is a slight variation in the solar radiation flux. The radiation flux was high during afternoon and was appeared to be constant. The average solar radiation flux was 926.34W/m2 and power generation from 9:00 to 3:30 was about 3.8 kW.

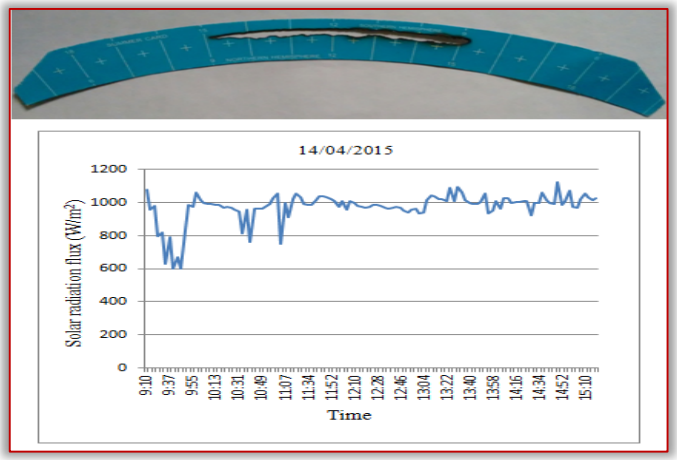

Figure 5. Sun shine hours
and solar radiation of Equinox card

A silica gel and water based adsorption system was developed and tested successfully. Figure 6 shows the adsorption refrigeration system which was powered by solar PV panel.

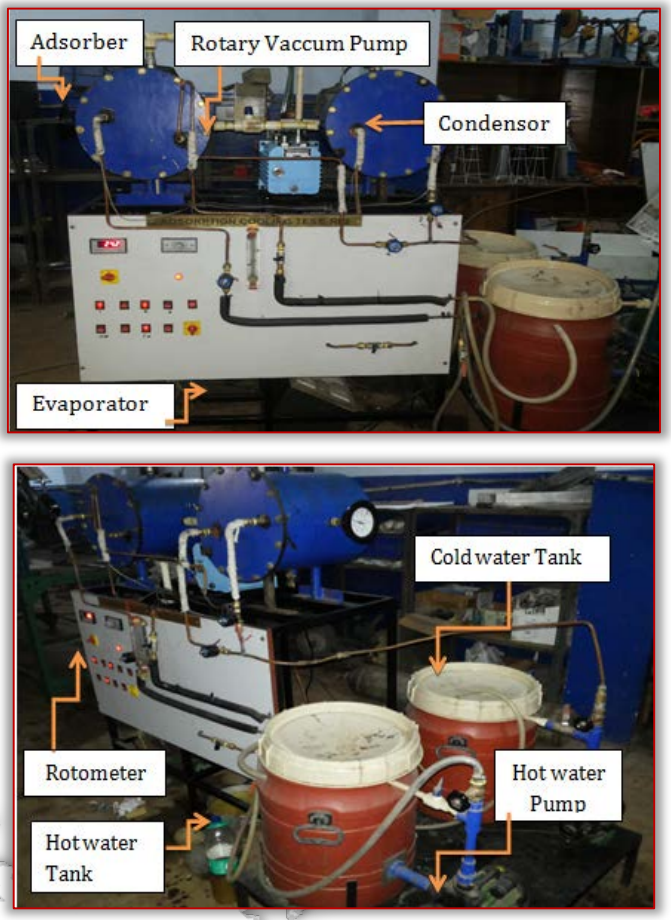

Figure 6. Adsorption Refrigeration System

The adsorption operating condition is as follows. The evaporator and adsorber pressures were maintained at 655 and 650 mm of Hg respectively. The temperature of the hot fluid supplied to the system is 75˚C. The reduction in temperature due to adsorption process with the time is shown in the Figure 7. Adsorber cooling water inlet temperature of about 34 degree C, was evaporating temperature of 14 degree C and adsorption/desorption phase time was 15 minutes.

Effect of cooling load on evaporator pressure

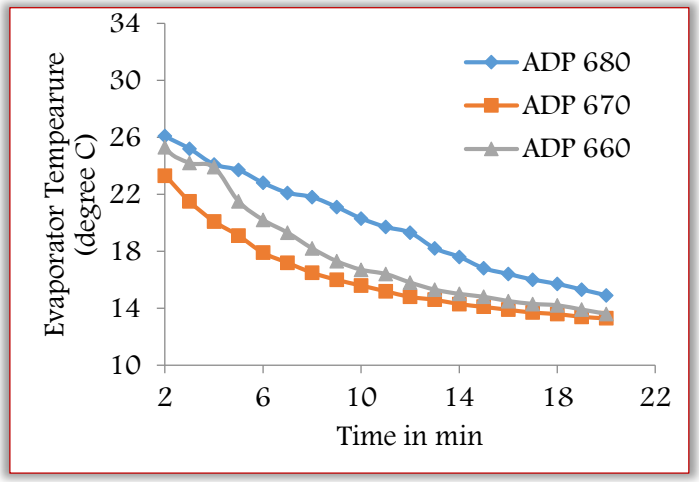

Figure 7. Variation in Evaporator Temperature
with respect to time with 500 ml water

The effect of adsorption pressure on the evaporator temperature with respect to time and at cooling load of 500 ml is shown in the Figure 7. From the figure, it is observed that the adsorption pressure significantly affects the evaporator temperature. The adsorption pressure of 670 mm of Hg gives lowest evaporator temperature as compared to other pressures. The adsorption pressure of 680 mm of Hg gives higher evaporator temperature. Hence, the optimized adsorption pressure required for this adsorption system is 670 mm of Hg.

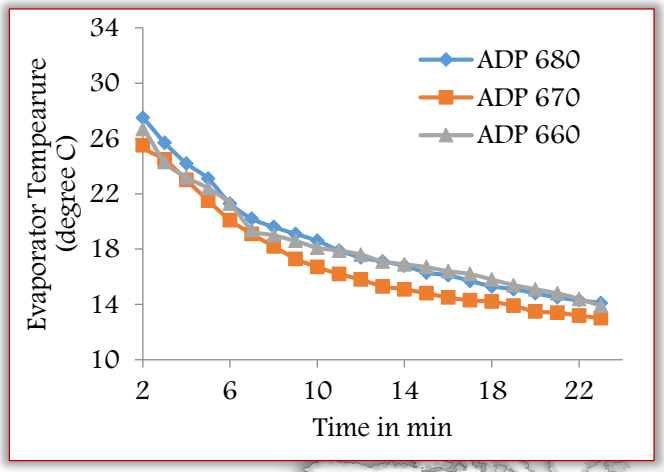

Figure 8. Variation in Evaporator Temperature with respect to time with 750 ml water

Figure 8 shows the effect of adsorption pressure on the evaporator temperature with respect to time and at cooling load of 750 ml. From the figure, it is observed that the adsorption pressure of 670 mm of Hg gives lowest evaporator pressure. However, the variation in evaporator pressure is minimum for the adsorption pressure of 660 and 680 mm of Hg. Also, this pressure gives higher evaporator pressure as compared to the adsorption pressure of 670 mm of Hg.

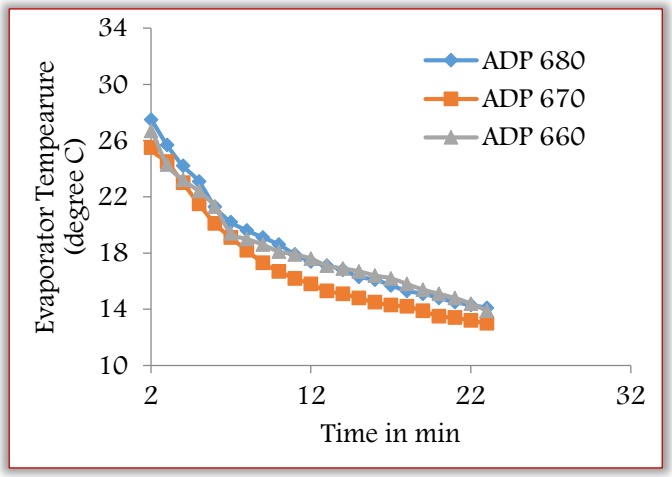

Figure 9. Variation in Evaporator Temperature with respect to time 1000 ml of water

Figure 9 shows the effect of adsorption pressure on the evaporator temperature with respect to time and at cooling load of 1000 ml. From the figure, it is observed that the adsorption pressure of 670 mm of Hg gives lowest evaporator pressure as compared to other pressure values such as 660 and 680 mm of Hg. Initially the variation in evaporator pressure is significant, however this difference is small after a particular time interval. From the above discussion we observe that the adsorption pressure of 670 mm of Hg is better for the designed solar powered adsorption system.

CONCLUSION

A solar based adsorption system was developed and tested successfully. The system was able to produce a cooling effect and the lowest temperature obtained was 13.5 degree C. Since the demand of the cooling system is high during summer, the solar based adsorption system will provide an alternative to the conventional energy sources. The adsorption pressure of 670 mm of Hg gives the lowest evaporator temperature as compared to other pressure values such as 660 and 680 mm of Hg.

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CAPABILITY INDICES FOR MEASUREMENT PROCESS

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Abstract: A quality management often use the capability indices for measure its output merit. It is based on Six Sigma methodology in focus to higher quality performance. The higher sigma level, the better is process performing. On the other hand, there are some differences between needs for manufacturing process and needs for measuring process. The question of whether the measuring process gives the results of measurements in accordance with the specifications are serious questions regarding the quality assurance of measuring processes. In this paper are presented capability indices of the first, second and third generation and comparison between them, based on measurement data, focusing on their sensitivity. There is addressed the issue of the capability of a measuring process with using the capability indices and making the proposal for the use of the capability indices with confidence probability of 95 % in contrast to strait Six Sigma approach.
Keywords: uncertainty, confidence probability, capability index

INTRODUCTION

Capability indices compares the desired (prescribed) the accuracy of the process to the actual process variability. The C_p index was first time mentioned by J. M. Juran and his associates in 1974 and later in 1986 his work was followed up by V. E. Kane, who introduced the C_{pk} index. These two are also called capability indices of first generation and are most commonly used in practice. To estimate the performance of the measurement process we can adopt these indices, although there are primarily designed for measuring capability of the manufacturing process. In addition to the symbol C_p, there are also other indications of this index. For example, Finley mentioned CPI (capacity potential index) or Montgomery PCR (process capability ratio) [2].

CALCULATION PRINCIPLE

The C_p index to measure the capability of the manufacturing process will be calculated as follows:

$$C_p = \frac{USL - LSL}{6 \cdot \sigma} \quad (1)$$

where the (USL) is the upper specification limit, (LSL) is the lower specification limit and (σ)
is the process standard deviation.

By using the capability indices is the performance of a process monitored in long-term. This monitoring is done on the critical parameters of product specifications, but does not apply to processes that are evaluated by characters of attribute. The difference between Long-term process capability from the preliminary is, that the values are recorded over a longer period of time and thus takes into account all the weighty parameters for process variance [4].

For proper calculation of an index is necessary to have appropriate data collected and in sufficient amount of the data. It is recommended to collect the data at regular time intervals, at least 25 sub-groups consisting of 2 to 25 values in the section, which can deliver a sufficient amount of data to be able to express all the common sources of variation affecting the process.

When we using capability indices for evaluating a measurement process the ratioof the prescribed (required) and the actually accuracy rate of the process is monitored. This can be achieved through the maximum permissible error or the expanded uncertainty, making the requirements for the measurement process. For example, if the tolerance interval T for a product that we measure is set, the measurement process should produce results with expanded uncertainty 3 to 10 times smaller than half of the tolerance interval, depending on how stringent are the requirements for the accuracy. Generally, when we have fixed these requirements, as an upper tolerance

limit USL and lower tolerance limit LSL, that defines the value of T as the difference between USL and LSL.
The requirement for expanded uncertainty U is set up directly, accordingly the needs for the measurement, or it can be determined using the formula:

$$U = \frac{T}{2 \cdot p} \quad (2)$$

where(p) is the number between 3 to 10.
The measured values with the expanded uncertainty U should be smaller than USL and greater than LSL by that value. Therefore, should be tendency to choose this p higher number, which leads to smaller U. On the other hand, this increases demands on measurement and therefore is necessary some compromises to make.
In the equation (1) was used in the denominator six sigma which represents a 99.7% confidence probability that values quality characteristic can be found in the tolerance range. Since with measurement process is normally uncertainty with confidence probability of 95% involved, it should be appropriate use the value of four sigmas, which captures the same confidence probability, in the denominator.
The formula for execution the C_p to indicate the measurement process capability will be as follows:

$$C_p = \frac{2 \cdot U}{4 \cdot \sigma} = \frac{U}{2 \cdot \sigma} \quad (3)$$

where(U) is the requirement for expanded uncertainty and (σ)is the process standard deviation.
C_p index structure is based on the assumption that the requirement for expanded uncertainty is properly determined and the process is centred. The systematic error is zero and the arithmetic mean is close to identical with the nominal value of the check standard.
Index can get only positive values. If the value of C_p is less than 1, the process in definitely not capable. When the index value is greater than 1, we can say that the process is capable to perform the tasks for which it is intended. But in practice we should be looking for values 1,33 and above because there always will be some fluctuations and measurement process is never in perfect state of statistically control.
The drawback is its inability to say whether the measurements are within the required tolerance range. It's just the extent of potential capability, because it does not place the actual margin of tolerance with respect to the required tolerance margin [3].
As was noted above, the C_p index provided that the process is centred and neglects its bias from check standard.
For this purpose, has been introduced C_{pk} index, as an indicator of the actual process capability. C_{pk} index responds to deflect the process mean from the centre of the tolerance range. From the actual nominal value of the check standard.
C_{pk} index values will be obtained as minimum from the equation:

$$C_{pk} = \min\left(\frac{(X_{CS}+U)-\bar{\bar{X}}}{2 \cdot \sigma}, \frac{\bar{\bar{X}}-(X_{CS}-U)}{2 \cdot \sigma}\right) \quad (4)$$

where(U) is the requirement for expanded uncertainty, (σ)is the process standard deviation, $(\bar{\bar{X}})$ is the arithmetic average of the data set and (X_{CS}) is the nominal value of the check standard.
If we define $X_{CS} - \bar{\bar{X}} = \Delta$, then the equation will be:

$$C_{pk} = \frac{U-|\Delta|}{2 \cdot \sigma} \quad (5)$$

In case that, the uncertainty of the check standard(U_{CS}) isn't small enough compared to requirement for expanded uncertainty, it must be taken into account in calculation.
Then:

$$C_{pk} = \min\left(\frac{(X_{CS}+U)-\bar{\bar{X}}-U_{CS}}{2 \cdot \sigma}, \frac{\bar{\bar{X}}-(X_{CS}-U)-U_{CS}}{2 \cdot \sigma}\right) \quad (6)$$

or

$$C_{pk} = \frac{U-|\Delta|-U_{CS}}{2 \cdot \sigma} \quad (7)$$

C_{pk} index like C_p should have values greater than 1,33. Index values in excess of 1 but below 1,33 may be accepted, but must be increased attention to monitoring the process.
Using this index, we can find out how the measurement process centred. About the measurement process centralization tells us following relations [4]:

- $C_p = C_{pk}$, the process is centered in the middle of the tolerance range,
- $C_p > C_{pk}$, the process is not ideally centered,
- $C_{pk} = 0$, the process is centered on the upper or lower specification limits,
- $C_{pk} < 0$, the process is centered outside the tolerance range.

SECOND AND THIRD GENERATION

The second generation of capability indices can be considered index C_{pm} and C^*_{pm}, which are based on the concept of Taguchi's approach to the evaluation of quality and his loss function. They quantify process capability in terms of quality indicator X variability around the target value (nominal value of check standard).
C_{pm} index in measurement process will be defined as follows:

$$C_{pm} = \frac{U}{2 \cdot \sqrt{\sigma^2 + (\bar{\bar{X}} - X_{CS})^2}} \quad (8)$$

The third generation of capability indices was introduced in late 90s, when people pointing on the shortcomings of previous generations. They criticized in particular the sensitivity of these indices to the use of assumptions (normality, independence of observations, process stability). [2]
The result is the C_{pmk} index, which is more sensitive to variability around the target values than the C_{pk} and C_{pm}, and is actually a combination of these indices.
C_{pmk} index is defined as follows:

$$C_{pmk} = \min\left(\frac{(X_{CS}+U)-\overline{\overline{X}}}{2\cdot\sqrt{\sigma^2+(\overline{\overline{X}}-X_{CS})^2}}, \frac{\overline{\overline{X}}-(X_{CS}-U)}{2\cdot\sqrt{\sigma^2+(\overline{\overline{X}}-X_{CS})^2}}\right) \quad (9)$$

or we can use the simpler variant

$$C_{pmk} = \frac{U-|\Delta|}{2\cdot\sqrt{\sigma^2+(\overline{\overline{X}}-X_{CS})^2}} \quad (10)$$

COMPARISON

In the next section we apply each of the indexes on data provide from the measuring the pH level of the filtrate in whitening process of the celluloses. The device that was used to measure level of pH was from company ABB type TB82PH. The measured values were taken once per week in a period of one year, when the sample was taken from the filtrate and compared the measured pH value with a pH of same sample measured in the laboratory. For calculation was used deviation between the value from the measuring instrument and the value from laboratory. The difference is requested as small as possible so we put the nominal value of the check standard equal zero.

Uncertainty of the instrument used in the laboratory was 0,02 according to the calibration certificate, which is a value small enough to the requirements at the expanded uncertainty, which is 0,5, so it could be neglected.

The following table shows the characteristics of the data selection used in the calculations.

Table 1: The process sample parameters

n	σ	σ^2	$\overline{\overline{X}}$	X_{CS}	Δ
52	0,1896	0,0359	-0,0713	0	0,0713

From the specified parameters we can calculate the value of each index:

$$C_p = \frac{0,5}{2\cdot 0,1896} \cong 1,32$$

$$C_{pk} = \frac{0,5-|0,0713|}{2\cdot 0,1896} \cong 1,13$$

$$C_{pm} = \frac{0,5}{2\cdot\sqrt{0,1896^2+(-0,0713-0)^2}} \cong 1,23$$

$$C_{pmk} = \frac{0,5-|0,0713|}{2\cdot\sqrt{0,1896^2+(-0,0713-0)^2}} \cong 1,06$$

The C_p value suggests that the measurement process should have enough capability, this would be true only if the process was centred perfectly. C_{pk} already capture the bias to the left of the nominal value of the check standard, but its value can still be considered capable. Surprisingly C_{pm} has a higher value than C_{pk}, this is due to its lower sensitivity to bias, especially with relatively high variance of data to the requirement. Even if the values of all indices are marginal, we can consider the measurement process as capable. Only C_{pmk} reacts strongly enough to indicate significant weaknesses of process capability.

On the histogram from the data set we can see the process is displacement to the left.

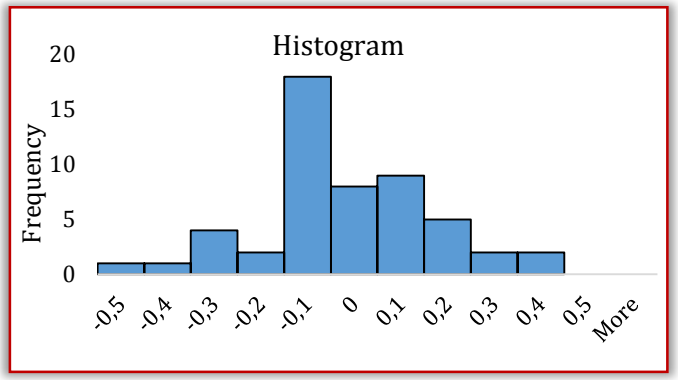

Figure 1: Histogram from process sample

Afterwards was calibration of the pH-meter performed and the probe was replaced. Then, was made 17 measurements and comparisons with laboratory results in two days in different times.

The selection characteristics are shown in the Table 2.

Table 2: The new process sample parameters

n	σ	σ^2	$\overline{\overline{X}}$	X_{CS}	Δ
17	0,1640	0,0269	0,0059	0	-0,0059

After substituting into the formula, we get:

$$C_p = \frac{0,5}{2\cdot 0,1640} \cong 1,52$$

$$C_{pk} = \frac{0,5-|-0,0059|}{2\cdot 0,1640} \cong 1,51$$

$$C_{pm} = \frac{0,5}{2\cdot\sqrt{0,1640^2+(0,0059-0)^2}} \cong 1,52$$

$$C_{pmk} = \frac{0,5-|-0,0059|}{2\cdot\sqrt{0,1640^2+(0,0059-0)^2}} \cong 1,51$$

After adjustments were made, we can see that the values of all tested indices are similar and achieve positive results. At this time the pH measurement process meets its capability requirements.

A similarity value is due to greater centralization process, which can be seen on the histogram new data sheet.

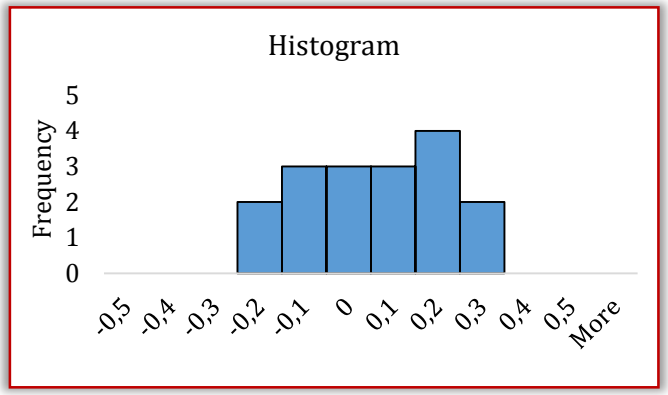

Figure 2: Histogram from new process sample

CONCLUSIONS

The paper is presenting capability indices based on the 95% probability confidence, since the expanded uncertainty is determined with same 95% probability.

As well, the proposed indices taking into account the value of the check standard as target value and the loss function according to Taguchi.

We tested the pH-meter measuring process, where we were able lack of the capability revealed only using the C_{pmk} index. The data indicates that the studied process is in order with respect to the requirement after adjusting the measuring device.

It is also important to say that if our calculations were made using six sigma instead four sigma, the measurement process would be classified as incapable, and that would be a mistake.

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Note

This paper is based on the paper presented at The 10th International Conference for Young Researchers and PhD Students – ERIN 2016, organized by University of Zilina, Faculty of Mechanical Engineering, in Liptovský Ján, SLOVAKIA, May 10–12, 2016, referred here as [5].

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COMPUTER TOOLS IN ENGINEERING EDUCATION – EXAMPLE ON MACROMEDIA FLASH

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Abstract: The purpose of this study is to investigate the potential benefits of using computer tools in engineering education. Animations, visual cueing, and their combination in a multimedia environment are designed to support learners' acquisition and retention of scientific concepts and processes. The software used in the development of the animations is Macromedia Flash, a tool that allows very small vectorial graphics files to be created, thus facilitating their electronic transmission to any user connected to the network. The research was conducted on 75 students of the first year at the Faculty of Civil Construction Management of the Union "Nikola Tesla" University, Belgrade, Serbia. The course was followed by a 3-year study to assess the acceptance of the computer tools and multimedia animations for learning mathematics. This research clearly showed that students were highly interested in this way of teaching and learning.
Keywords: computer tools, Macromedia Flash, animation, Engineering education

INTRODUCTION

Today, Internet has established a new model for providing information and services to all users throughout the world [30]. Thus, the decision to use web technologies such as HTML, XML, Java and Flash is obvious [27]. FLASH is a very powerful graphics and animation development system that was introduced by Macromedia (now a subsidiary of Adobe Systems) in 1997. Over the past decade, it has become the de-facto standard for animation, gaming and multimedia applications on the World Wide Web. Many companies have web page that include animations created with Macromedia Flash, due mainly to the two most important characteristics of this application: creation of vectorial graphics and interaction of it user with the animations. We should add that Flash allows the user to interact with the animation being displayed, thus the user can control the visualization of the film, take decisions, write, press buttons, move, drag, etc.

The contribution made by Flash is clear: animation + interactivity, and we should remember that interactivity is the greatest advantage that multimedia contributes to teaching [11]. It is only necessary to select the content correctly and insert them properly in the program. In most cases, Flash animations have become teaching aids [4] that are now common in many courses and universities and this represents a notable advance in teaching innovation achieved in recent years.

In the literature, there is of course no shortage of studies about the effects and the benefits of computer tools and animations in classroom instruction. Author [26] studied such effects long before the modern animations tools were introduced. Authors [11], [27], [3] and [19] discussed the use of interactive graphical tools in applications such as engineering education, computer science education and ecology. Authors [12] presented a study of the psychology of student interaction with animations. Authors [24] described some important concepts in the interactive learning process, such as the design principles of an interactive learning environment, the technology needed for gauging human performance, etc. Authors [13][14] published an extensive study of the cognitive and psychological aspects of multimedia learning. Authors [21] pointed out that multimedia applications have

slowly transformed the typical university communication network to an education delivery system. Author [25] argued in a short article for the first time that the Macromedia Flash development system can be a serious instructional authoring tool (this is the view shared by the present author).

Authors [10][9][16][17][18] and recently [6] demonstrated some specific Flash examples for mathematics teaching.

MATERIAL AND METHODS

Overview of the experiment

One purpose of the current study was to investigate whether animations were more effective than static graphics to promote learning. Animations have the potential to facilitate knowledge construction with this type of learning content [7][22][29]. Therefore, we hypothesized that animations enhance retention of both concepts and processes. The study also investigated the potential cognitive benefits of adding visual cues to visualizations to enhance science learning in a multimedia environment. Based on the literature reviewed in previous section, we hypothesized that visual cueing is effective to enhance learning. In addition to learning, cognitive load and motivation were also investigated. By providing learner control over animations, the transitory nature of animations could be overcome. Therefore, we expected that when comparing animations to static graphics, animations would reduce extraneous load and consequently foster germane load. We also expected visual cueing to reduce extraneous load in multimedia learning environment, which is in line with [15] and [28]. Only a few studies have investigated learners' motivation in multimedia learning, e.g., motivation in an agent-based environment [20], and in an online animation-based environment [23]. As motivation impacts learning [5][8], this study explored the potential effects of animations and visual cueing on learners' intrinsic motivation in the multimedia environment.

Participants and questions of the Research

The research was conducted on 75 students (tree generations as per 25 of the first year students) at the Faculty of Civil Construction Management of the UNION University, Belgrade, Serbia. The course was followed by a 3-year study (2010, 2011. and 2012.) to assess the acceptance of the computer tools and multimedia - Flash animations for learning mathematics. In addition to the statistics collected about the test scores, the students who were tutored with the new techniques were also asked directly two questions after the conclusion of the study:

(1) 'Do you agree that the Flash animations contributed significantly to *lecturing* mathematics: I disagree, I agree, I totally agree?' and

(2) 'Do you agree that the Flash animations contributed significantly to *learning* mathematics: I disagree, I agree, I totally agree?'

Computer-based learning environment of mathematics. Example

Lectures of the mathematics courses included exactly the same information i.e. axioms, theorems, examples and tasks like on the traditional class of math, but the main information source was software created in Macromedia Flash 10.0, which is proven to be very successful and illustrative for creating multimedia applications in mathematics lectures [2]. Our multimedia lecturing material was created in accordance with methodical approach, i.e. cognitive theory of multimedia learning [13][14], as well as with principles of multimedia teaching and design based on researches in the field of teaching mathematics [1]. This material includes large number of dynamic and graphic presentations of definitions, theorems, characteristics, examples and tests from the area of mathematical geometry and analyses based on step-by-step method with accent on visualisation. Important quality of making one's own multimedia lectures is possibility of creating combination of traditional lecture and multimedia support.

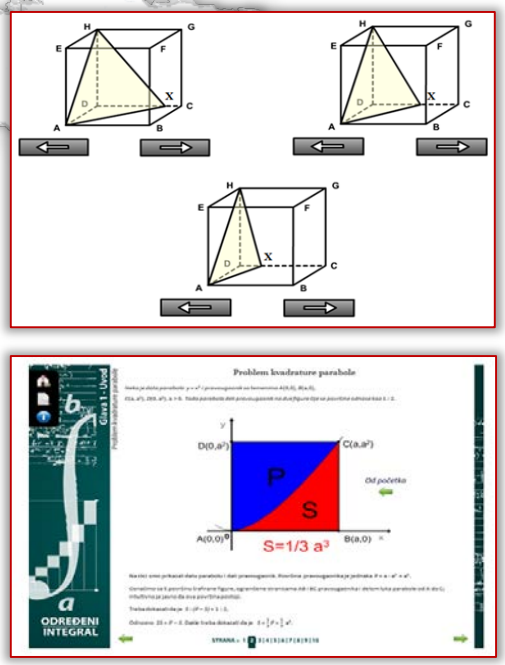

Figure 1. Examples of animations for teaching Geometry (a) and Analyses (b) created with Macromedia Flash.

RESULTS

In summary, multimedia learning helps to promote a better understanding of how to foster meaningful learning through the integration of words and pictures (printed or spoken text andillustrations, graphs, maps, animation or video).

Students' opinion

The students tested and worked with all the animations and subsequently responded to a series of surveys

giving us, the teachers, their opinions, advice, comments and recommendations on the use of animations in the classroom.

The purpose of our first question is to go to the core of the issue concerning the use of animations in the classroom. We proposed to the students that the traditional explanations of theory given by the teacher should be replaced by animations, (Fig. 2). The students were not positively impressed by the idea of receiving a class of theory without the teacher, as, despite their interactivity, animations still do not have the same level of interactivity as a teacher. However, students mentioned that animations may be a great help for the teacher in the classroom.

In a second question, when we asked whether they prefer classical or multimedia way of individual learning mathematics, the students were answered multimedia - Flash animation, explaining it with the following reasons:

- ✓ **Step-by-step**: The most frequent answer to the survey is directly related with the control students have over animations. Most of the animations have controls that allow the user to stop, resume, go to the beginning, go to the end, go one step forward or one step back. These devices allow the students to control the visualization and adapt the animation to their learning rate. Flash allows the user to control the animations, and although, in most cases, this is one of its most important properties, it may be counterproductive if the user progresses through the animation at a higher speed than the speed of the visualization itself [4].
- ✓ **Amusing**: The students find animations amusing and they consider this a positive characteristic. As many of them pointed out, they are learning unconsciously, without being aware that they are visualizing three-dimensional concepts with quite a high level of complexity. This affective characteristic of learning is highly motivating as it attracts and holds the users attention – an essential aspect without which teachers will never be able to use with advantage any kind of educational resource [12]. This is why affective characteristics may play a very important role in the teaching–learning process.
- ✓ **Availability**: Another of the strong points of animations is that, as they are located in a web server, they can be consulted at any time. Furthermore, the students consider that having material they can access as many times as they want constitutes an enormous advantage.
- ✓ **Explanation**: The three characteristics mentioned above would be of no use if the teaching animations created do contain clear explanations with a well-defined structure that address the most important concepts of each lesson in a didactic way.

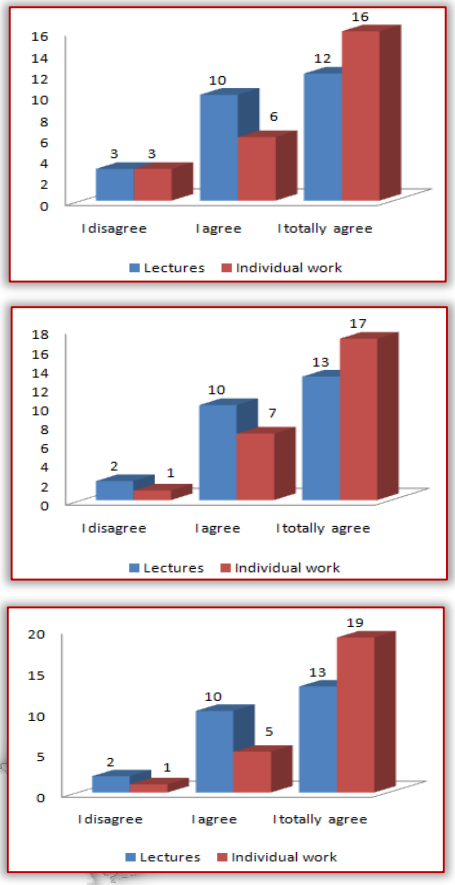

Figure 2. Students' answers to the question: Should Flash animations be used in lecturing and individual learning mathematics?((a) – generation 2010, (b) – generation 2011, (c) - generation 2012)

CONCLUSIONS

Flash technology has revolutionized Internet. The generation of animations of a very small size, together with their interaction capacity and ease of use, has led to the spread of this technology among most creators of web pages, and many sites include animations or colorful presentations in their initial pages, thanks to Flash.

This technology opens a field with many applications for university teaching, since the theory content of the subjects can be converted to a greater or lesser extent into multimedia content, which students may consult and control at any time. But animations are not a solution to teaching problems since, if they are not correctly designed, they may be counterproductive for the learning process.

In the specific case of engineering education, the use of these animations is more enriching as, in many cases, it accelerates the development of the students' spatial perception – a basic objective in the training of any engineer. From experiments carried out with students who used animations created with Flash, a series of practical findings were obtained on how to create

educational animations for educational teaching – learning process:

- ✓ Split up the content to be animated by Flash into basic learning units.
- ✓ Provide the animations with as much interactivity as possible.
- ✓ Hold the user's attention without recourse to unnecessary distractions.
- ✓ Allow the student to control the animation at all times.

The creation of these animations, together with their use in theory classes as a supplement to the work of the teacher, is guaranteed success among the students, as our experience shows. There was clearly a very significant improvement in the student's test scores as a result of introducing animations in traditional classroom instruction and great number of the students who believe that animations of mathematical concepts did contribute significantly to their understanding of mathematics.

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*We are very pleased to inform that our international and interdisciplinary journal **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering** completed its nine years of publication successfully **[issues of years 2008 –2016, Tome I–IX]**.*

In a very short period it has acquired global presence and scholars from all over the world have taken it with great enthusiasm.

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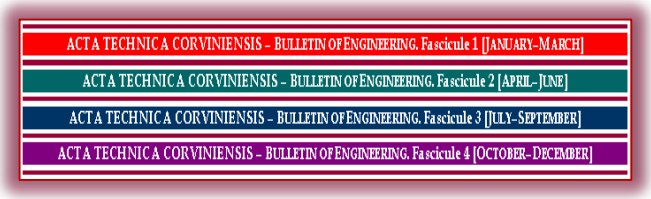
*Now, when will celebrate the tenth years anniversary of **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**, we are extremely grateful and heartily acknowledge the kind of support and encouragement from all contributors and all collaborators!*

*On behalf of the Editorial Board and Scientific Committees of **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**, we would like to thank the many people who helped make this journal successful. We thank all authors who submitted their work to **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering.***



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ASSESSMENT OF THE DENSITY AND MECHANICAL PROPERTIES OF PARTICULATE PERIWINKLE SHELL-ALUMINIUM 6063 METAL MATRIX COMPOSITE (PPS-ALMMC) PRODUCED BY TWO-STEP CASTING

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Abstract: This work investigated the density, porosity, some mechanical properties and microstructure of PPS-AlMMC and compared the properties of the composites and those of the aluminium 6063 (Al60603) alloy. Periwinkle shells were milled to particle sizes of 75µm and 150µm and used to produce PPS-AlMMC at 1,5,10 and 15wt% filler loadings using two-step casting technique. The density, porosity, mechanical properties and microstructure of the composite materials were compared with those of the Al6063 alloy. The addition of PPS to aluminium alloy reduced the density of the composite. It was observed that the filler distributes uniformly in the matrix due to the two-step casting technique. The porosities of the composites were within acceptable level of 0-5% except for the composite with 15wt% PPS of 150µm particle size. Improved strength, ductility, hardness and modulus were obtained when the filler was used to reinforce the alloy. However, using a filler of higher particle size resulted to higher porosity, reduced tensile strength, ductility and toughness.
Keywords: Composites, periwinkle shell, two-step casting, mechanical properties

INTRODUCTION

Researchers have shown interests in the development of aluminum metal matrix composite (Al-MMCs) because of their potential applications in industries such as aerospace, automotive, thermal management, electrical and electronic as well as sports. Al-MMCs are engineered materials made by incorporating non-metallic reinforcement(s) into aluminium or its alloy so as to tailor the properties such as strength, hardness, stiffness, electrical and thermal conductivity as well as other properties of the material. Al-MMCs offer high strength to weight ratio and high stiffness to weight ratio [1]. In the composite, the good properties of the metal such as light weight, high ductility, electrical and thermal conductivities are combined with the properties of the reinforcement such as low coefficient of thermal expansion, high stiffness, and strength and abrasion resistance to produce material with desired properties. The reinforcement could be in the form of continuous and discontinuous fibres, whiskers or particulate [2]. The applications of Al-MMCs are limited by high cost and hence the search for cheap agricultural materials as reinforcements to enhance their applications [3]. Particulate Al-MMCs (PAl-MMCs) are less expensive compared to continuous fibre reinforced Al-MMCs (CFRAL-MMCs) and are usually produced by either the solid state (powder metallurgy processing) or liquid state (stir casting, infiltration and *in-situ*) processes [2]. The particulate ceramics materials used to reinforce aluminium are usually carbides, oxides and borides such as SiC, Al_2O_3, TiB, TiC, etc. [4]. The properties of the material are affected by factors such as the type of reinforcement, the method of production, the volume or mass fraction of reinforcement, the particle size of the reinforcement, the shape and distribution of the reinforcement in the matrix. For example, the impact strength and hardness of particulate Al-SiC MMC have been reported to increase

with increasing weight fraction of reinforcement and at 25wt% of the reinforcement; there was over 100% increase in strength and about 90% improvement in the hardness of the composite over those of the pure aluminium [5]. The method of stirring also affected the dispersion of the reinforcement in the matrix [5]. Also, the density, strength and hardness of Al6061-SiC and Al7075-Al_2O_3 were compared at 2, 4 and 6wt% addition of reinforcements and it was reported that the experimental densities of the composites were similar to those of the theoretical densities, but however, the addition of Al_2O_3 into the Al matrix resulted to improved strength, hardness and density slightly higher than the improvement obtained with SiC addition; the addition of harder reinforcements also improved the wear resistance of the composites over that of the unreinforced Al alloy [6].Low density, low coefficient of thermal expansion, good mechanical strength and hardness, as well as good thermal and electrical conductivities are some of the properties that make Al-MMCs functional electronic packaging and thermal management materials especially for weight sensitive applications over conventional copper tungsten (CuW) and copper molybdenum alloys [1,7]. Some works have recently been reported on the utilization of agricultural wastes as filler for Al-MMCs. Agricultural wastes are cheap compared to carbide, oxide and boride fillers. They constitute environmental problems, hence, the need to find useful applications for them. Rice husk ash (2-3µm) has been used to reinforce Al6061 aluminium alloy and it was reported that the reinforcement distributes uniformly in the matrix and enhanced the tensile strength and hardness with increase in mass fraction of the reinforcement up 8% over the unreinforced alloy [3]. Particulate coconut shell was used to reinforce recycled aluminium cans to improve the tensile strength and wear resistance [8]. The use of rice husk ash (RHA) as the reinforcement for aluminium (AlSi10Mg)-RHA composite was investigated; it was reported that there is filler distribution in the matrix, tensile strength, compressive strength and hardness increased with the increase in weight fraction of the reinforcement and the properties are better at lower particle sizes [9].Further, the properties of Al-7%Si-Rice Husk Ash and Al-7%Si-Bagasse Ash composites were compared and rice husk ash offered better reinforcing properties than bagasse ash [10]. Also, Fly ash has also been used to produce fly ash reinforced aluminium alloy (Al6061) composites [11].

Periwinkle (*Turritellacommunis*) is a type of edible sea snail which is dark, oval in shape with hard shell. Periwinkles are abundant on rocky shores in hinterlands in the South-South of Nigeria which include Cross-River, Rivers, Akwa-Ibom and Bayelsa. They are sold in various markets across the country. After consumption, the shells are discarded and add to solid wastes in the metropolis. Some researchers have investigated the use of periwinkle shell as reinforcement for cashew nut shell liquid [12-13], polyester [14-15] and phenolic resin [16-17]. In all these, particulate periwinkle shell was reported to improve the tensile strength, compressive strength, wear resistance and also lowers the density. Higher mechanical properties were achieved with lower particle sizes.

In this work, we evaluated the effect of particle size and weight fraction of particulate periwinkle shell filler on the density and mechanical properties of PPS-AlMMC.

MATERIALS AND METHODS:

Materials

The major materials required for this work are aluminium 6063 alloy (Al6063) and periwinkle shells. The alloy with chemical composition shown in *table 1*was purchased from the Nigerian Aluminium Extrusion Limited (NIGALEX), Lagos, Nigeria. Periwinkle shells were sourced from the local market at Otueke, Bayelsa State, Nigeria. The other materials are the consumables for density and metallographic assessments.

Table 1: Composition of the aluminium ingot

Element	Al	Si	Fe	Cu	Mn	Mg	Zn	Cr
Average content	98.18	0.5953	0.4635	0.0117	0.0244	0.3459	<0.002	0.0107
Element	**Ni**	**Ti**	**Sr**	**Zr**	**V**	**Ca**	**Be**	
Average content	0.0347	0.0566	<0.000	0.0772	0.0114	>0.070	<0.000	

Materials Preparation

» **Production of PPS**

Periwinkle shells were, washed, boiled in water at 100^{o}C for 40 minutes, allowed to cool, thoroughly washed to remove sand particles and dirt and thereafter dried under the sun for two days and heated in an oven at 110^{o}C for thirty minute to remove all moisture. The shells were crushed with hammer mill, pulverized with a ball mill and sieved to 75µm and 150µm particle sizes at the Mineral Processing Laboratory, Federal University of Technology Akure (FUTA), Nigeria.

» **Stir Casting**

The facilities at the Foundry Workshop of the FUTA were used for the production of the composite materials. Two-step casting as described by [18]was used to produce the composite materials.The quantity of Al6063 and PPS required to produce composites having 1, 5, 10 and 15 weight percent of the PPS were

calculated. The aluminium ingot was charged into a gas-fired crucible furnace and heated to 730°C ± 30°C which is above the liquidus temperature of the alloy and the liquid was allowed to cool in a furnace to a semi-solid state of temperature about 600°C. The calculated PPS was added at this temperature and the semi-solid mixture was stirred manually with a spindle for five minutes. The composite slurry was re-heated to 730°C and stirred vigorously for five minutes and the molten composite was cast in metallic die. Unreinforced Al6063 was also cast as the control specimen. The compositions of the various composite specimens cast are shown in *table 2.*

Table 2: Charge compositions of the composite materials

Specimen	Particle size of PPS (μm)	Weight percent of PPS (wt%)	Weight percent of Al6063 matrix (wt%)
1	Nil (control)	00	100
2	75	1	99
3	75	5	95
4	75	10	90
5	75	15	85
6	150	1	99
7	150	5	95
8	150	10	90
9	150	15	85

Characterizations:

» **Chemical Analysis of PPS**

X-ray Fluoresce Spectrometer was used to determine the elemental composition of the PPS. The system detects elements between sodium (Na, Z=11) and uranium (U, Z =92). PPS is found to containly majorly calcium as shown in *table 3.*

Table 3: Elemental composition of PPS

Element	Ca	Fe	Si	Mo	Al
Content	70.3350	0.5066	0.0724	0.2372	0.1938
Element	P	S	Sn	Sb	Others Elements
Content	0.2746	0.3987	0.4561	0.4511	27.0745

» **Determination of Density of PPS**

Since PPS does not dissolve in kerosene, the density of PPS was determined using pycnometer, kerosene and digital weighing balance. Empty pyconometer was weighed and the weight recorded as M_0. The empty pycnometer was filled with kerosene and weighed (M_1) and the mass of kerosene that fills it, M_{k1}, calculated from equation (1)

$$M_{k1} = M_1 - M_0 \quad (1)$$

The volume of kerosene that fills it was calculated from equation (2), where p_k is the density of kerosene calculated from the ratio of mass to volume.

$$V_{k1} = \frac{m_w}{p_k}, \quad (2)$$

The pycnometerwas emptied and dried. A quantity of 75μm PPS was added to the empty pycnometer and the weight of the pycnometer together with the PPS measured as M_2. The weight of the PPS, M_{pps}, added is calculated from equation (3).

$$M_{pps} = M_2 - M_0 \quad (3)$$

Kerosene was added and the weight of the whole content, M_c, taken to determine the weight of kerosene added as M_{k2};

$$M_{k2} = M_c - M_2 \quad (4)$$

The volume of kerosene (V_{k2}) added is determined from equation (5)

$$V_{k2} = \frac{M_{k2}}{p_k} \quad (5)$$

The volume of the PPS (V_{pps}) put in the pycnometer was calculated from equation (6)

$$V_{pps} = V_{k1} - V_{k2} \quad (6)$$

$$\text{Density of PPS} = \frac{M_{pps}}{V_{pps}} \quad (7)$$

» **Determination of Density and Porosity of Composite Materials**

The basic method of calculating density is by dividing mass by volume. In this work, experimental density of each specimen was determined by Archimedes' principle. The theoretical densities of the composites were calculated from the rule of mixture as shown in equation (8). The weight percentages of PPS in the composites were converted to volume fractions using the density of PPS calculated in equation(7)and the density of the alloy to convert mass of alloy to volume so as to accurately calculate the theoretical density. The difference between the theoretical and experimental density of each composite specimen was used to estimate porosity using equation (9) [19].

$$p(\text{PPS-AlMMC}) = p(\text{Al6063}) \times V_f(\text{Al6063}) + p(\text{PPS}) \times V_f(\text{PPS}) \quad (8)$$

where: p(PPS-AlMMC) = Theoretical density of composites, p(Al6063) = Density of Al6063 alloy, V_f(Al6063) = Volume fraction of Al6063 alloy, p(PPS) = Density of PPS and V_f(PPS = Volume fraction of PPS.

$$\text{Porosity} = \frac{\text{Theoretical density} - \text{Experiemntal density}}{\text{Theoretical density}} \quad (9)$$

» **Tensile Testing**

Uniaxial tensile test was performed on each specimen at room temperature using Instron Universal Testing Machine at a cross-headspped of 10mm/s. The tensile specimens were machined and tested in accordance with ASTM E8M-91 [20] with the guage length of 40mm and guage diameter of 5 mm.

For each specimen, three repeated tests were carried out to guarantee reliability. The tensile properties reported are tensile strength, modulus of elasticity, percentage elongation and energy at break.

» **Hardness Testing**

The hardness of the aluminium alloy and composites was determined with Vicker Hardness Tester (*LECO AT 700 Microhardness Tester).* The dimension of each specimen for hardness testing is 25x20mm and each specimen was grinded and polished to obtain a flat

smooth surface. During the testing, a load of 980.7mN for 10s on the specimen through square based pyramid indenter and the hardness readings taken in a standard manner. The readings were taken in three different points at the surface of the hardness specimen and the average computed as the hardness of the specimen.

» **Metallography**

Software driven optical metallurgical microscope was used to study the microstructure of the alloy as well as the composites. Prior to viewing of specimens with optical microscope, emery papers of grit sizes ranging from 500µm-1500µm were used polish the surfaces of the specimens.

Thereafter, fine polishing was performed using a suspension of polycrystalline diamond of particle sizes ranging from10µm – 0.5µm with ethanol solvent. Each specimen was etched with $1HNO_3$: 1HCl solution [18] prior to viewing with the optical microscope for microstructural study.

RESULTS AND DISCUSSION

» **Density and Porosity**

The particle density of PPS determined was 2.3g/cm^3 while the density of the Al6063 alloy was 2.68g/cm^3. The densities and porosities of the composites are shown in *tables 4 and 5.*

Table 4: Densities and percentage porosities of PPS-AlMMC with 75µm particulate PPS

Specimen	Theoretical density (g/cm^3)	Experimental density (g/cm^3)	Porosity (%)
2	2.676	2.61	2.5
3	2.657	2.56	3.7
4	2.638	2.52	4.5
5	2.615	2.50	4.4

Table 5: Densities and percentage porosities of PPS-AlMMC with 150µm particulate PPS

Specimen	Theoretical density (g/cm^3)	Experimental density (g/cm^3)	Porosity (%)
6	2.676	2.55	4.8
7	2.657	2.53	4.8
8	2.638	2.51	4.9
9	2.615	2.41	7.8

From the results shown in *tables 3 and 4,* the composites have lower densities than the alloy. The density decreases gradually as the weight fractions of the filler increase. The decrease in density is more significant in composites with 150µm PPS filler compared to those with 75µm PPS filler.

The decreased density with addition of the particulate periwinkle filler is a result of the lower density of the filler compared to the matrix. This is a positive development because it will further maximize the utilization of PPS-AlMMC where lighter weight is desired and properties such as specific strength and stiffness will be higher in the composite compared to the aluminium alloy.

Porosity or void in the composite material accounts for the difference between the theoretical and experimental densities of the composite materials. It is observed that porosity increases with increase in filler content and higher in composites with PPS filler of higher particle size. Porosity is as a result of trapped air or poor wettability of the reinforcement. High porosity results to low strength and other mechanical properties. Generally, the porosities of the composite materials are within acceptable range for the entire specimen due to the two-step casting method adopted as earlier reported [18]; except in specimen 9 due to poor wettability of PPS with larger particle size at higher weight fraction in the matrix. More research will be carried out in order areas so as to further improve matrix-filler wettability in the composite.

» **Microstructure**

The optical micrographs of the Al60603 alloy and those of the composites are shown in *figures 1-9*.

It is observed that PPS disperses in Al6063 alloy. There is homogeneity of the microstructure. Also, the coarse grains of the alloy were refined to finer grains by the introduction of PPS.

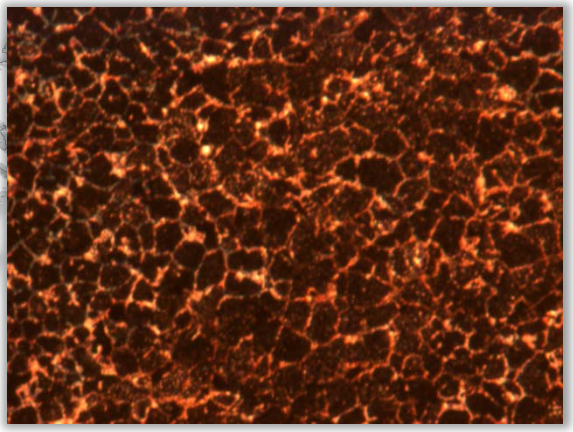

Figure 1: Optical micrograph of specimen 1 (x50)

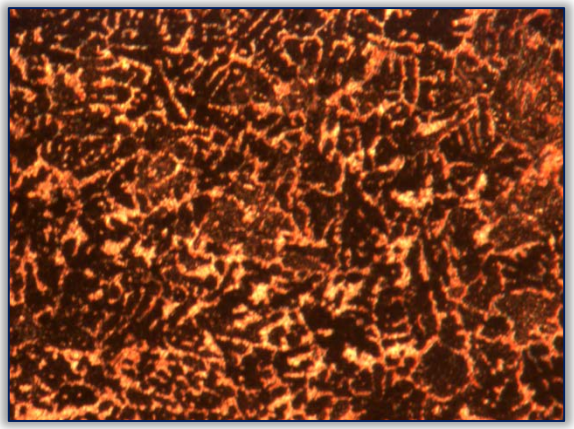

Figure 2: Optical micrograph of specimen 2 (x50)

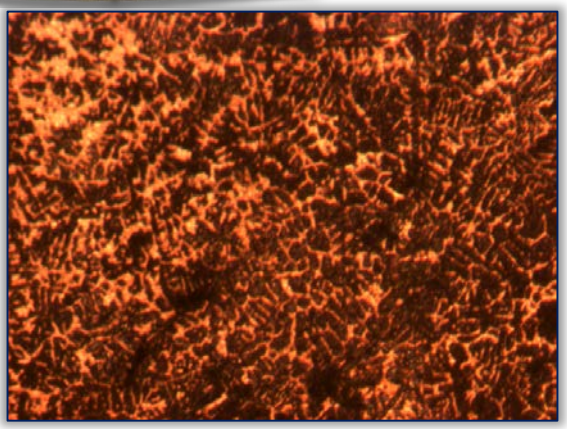

Figure 3: Optical micrograph of specimen 3 (x50)

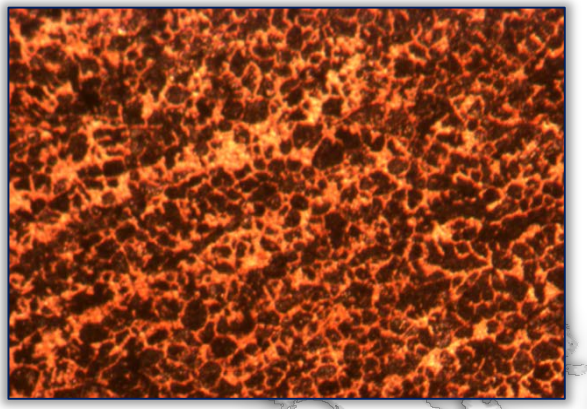

Figure 4: Optical micrograph of specimen 4 (x50)

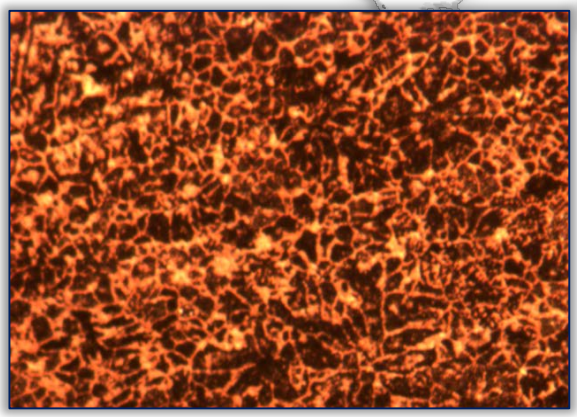

Figure 5: Optical micrograph of specimen 5 (x50)

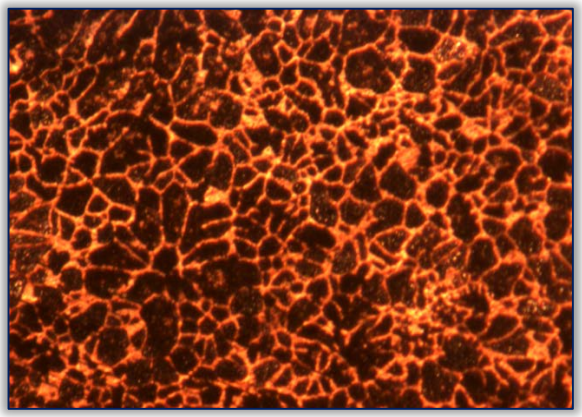

Figure 6: Optical micrograph of specimen 6 (x50)

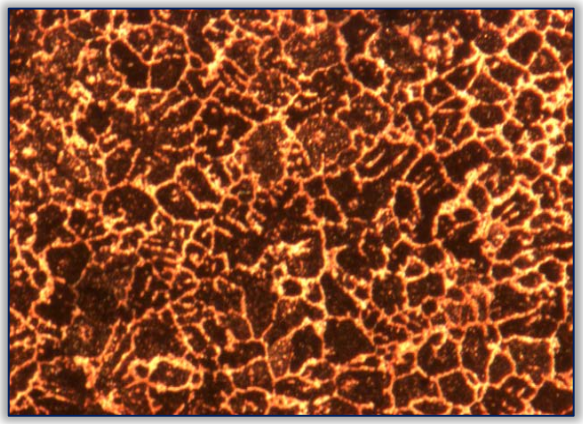

Figure 7: Optical micrograph of specimen 7 (x50)

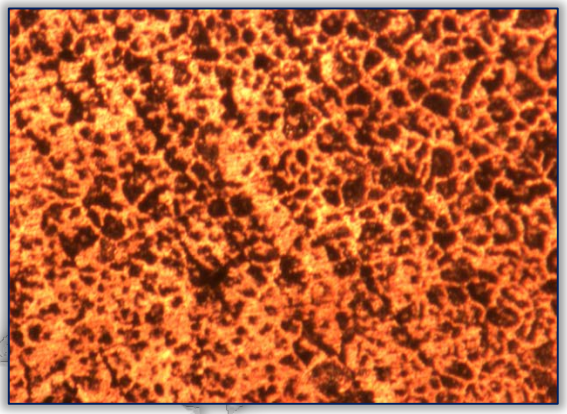

Figure 8: Optical micrograph of specimen 8 (x50)

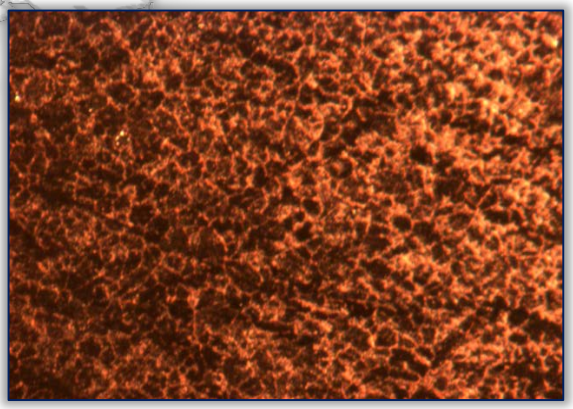

Figure 9: Optical micrograph of specimen 9 (x50)

» **Tensile Properties**

The tensile strength, elastic modulus, percentage elongation of the alloy and PPS-AlMMC are shown in figures 10-14. The composites possess higher elastic moduli than the alloy. At low particle size, there is improvement in strength up to 10wt% of PPS in the alloy while the strength depreciated above 5wt% PPS in the alloy when th particle size is 150µm. The introduction of PPS in Al6063 alloy is observed to improve strength, modulus and ductility at 75µm particle size of the filler.

The PPS has strengthening capacity and increases the capacity of the composite to carry load. Also, due to its ability to refine the grains, improved ductility depicted

by the higher percentage elongation, strength and toughness are observed in the composites over those of the alloy in line with Hall Petch Equation. However, at higher particle size of the filler, due to low surface area and poor wettability, the porosity of the composite increases, which give rise to lower strength at high percentage of the filler in the matrix.

» **Hardness**

The hardness of Al6063 alloy and PPS-AlMMC are shown in *figure 14.* In the composite with 75µm PPS filler, there is a decrease in hardness at 1wt% filler addition followed by continuous increase in hardness at 5, 10 and 15 wt% filler.

However, at 150µm PPS particle size, maximum hardness was achieved at 1wt filler loading followed by 5wt 5 filler content and thereafter the hardness becomes lower compared to the alloy.

PPS has the potential to improve the hardness at low wt% with higher particle size filler while with lower particle size filler, improved hardness is achieved at higher wt% filler loading.

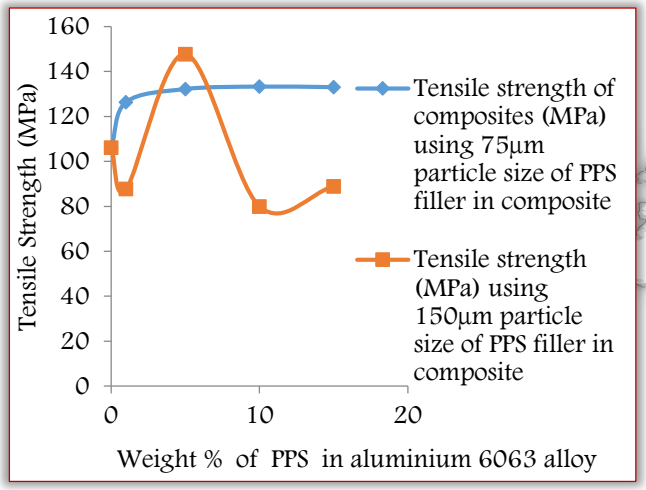

Figure 10: Tensile strengths of Al60603 alloy and PPS-AlMMCs

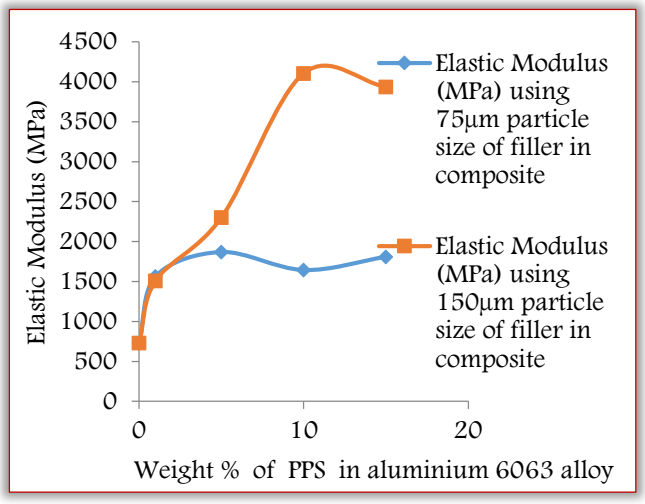

Figure 11: Elastic moduli of Al60603 alloy and PPS-AlMMCs

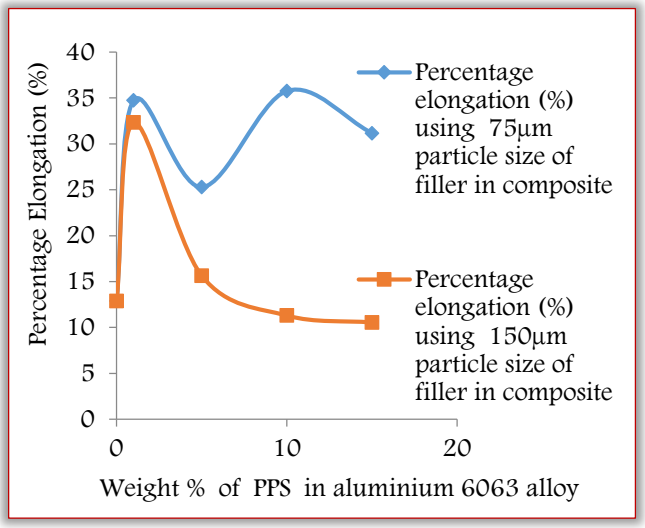

Figure 12: Percentage elongations of Al60603 alloy and PPS-AlMMCs

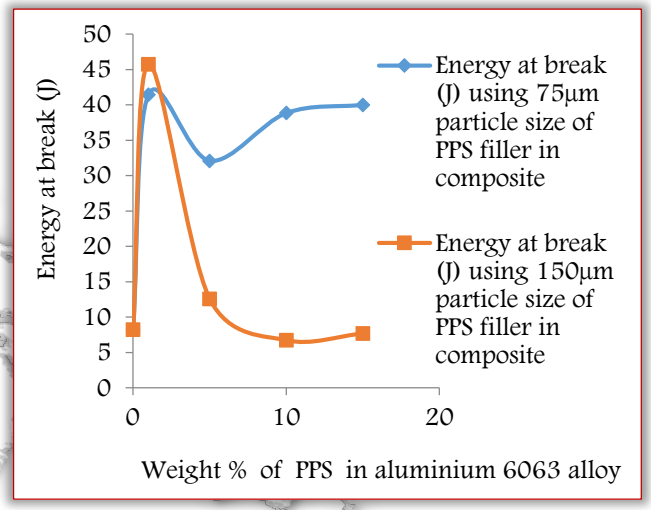

Figure 13: Energies at break of Al60603 alloy and PPS-AlMMCs

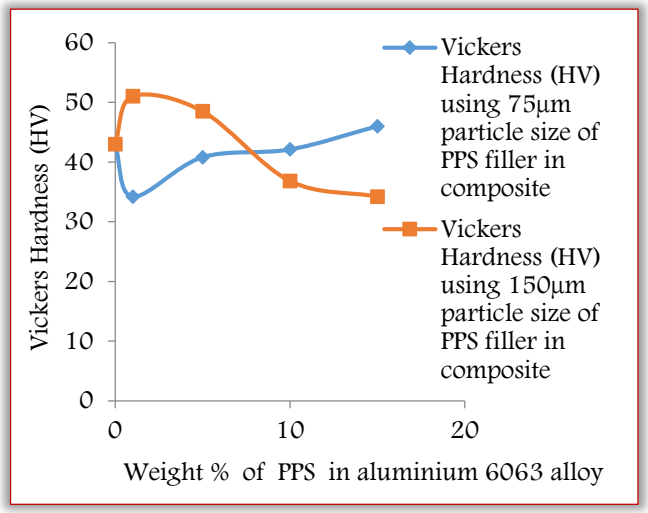

Figure 14: Vickers hardness of Al60603 and PPS-AlMMC composites

CONCLUSIONS

From the results, the following can be concluded:

- PPS-AlMMC has lower density than Al6063 alloy. The porosity of the composite is low due to filler matrix compatibility and two-step casting process. At higher particle size and filler content, the compatibility of the matrix and filler reduces and porosity increase resulting to lower strength and hardness.
- PPS distributes uniformly on Al6063 alloy and refines the grains from coarse grains to fine grains.
- Due to the ability of PPS to refine the grains of Al6063 alloy, the addition of PPS in the alloy improves the strength, elastic modulus, ductility and hardness of the composites. The composites are cheaper than aluminuim matrix reinforced with carbide, oxide and boride fillers. The composites can be used in areas where lighter weight and higher strength are required within the aerospace, automotive and electronic industries such as cylinder liners in engines, aluminuim calipers and power electronic modules.

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COMMON SENSE APPROACH AS A BASIS FOR SUCCESSFUL UNIVERSITY-INDUSTRY COOPERATION

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Abstract: Many studies confirm the positive aspects of the "open innovation" approach for university- industry collaborations. Often are such positive aspects connected with different, in studies proposed, step-by-step procedures of open innovation implementation, within the university- industry cooperation. Such procedures take into consideration cultural aspects of the parties, core capabilities, employees and staff, structures of organizations, issues regarding managing intellectual property, and at the end, creation of knowledge base, all in order to run university-industry cooperation successful. In this paper we show that a lot of collaborations develop themselves successful, not by following strictly methods proposed by literature, but by acting according to common sense code. We show, based on best-practice example of cooperation between the EPLAN Software & Services Company and Rheinische Fachhochschule Köln gGmbH, that some collaborations are open innovative in their practice, even if they do not follow the open innovation idea and that open innovation as an idea is not the primary reason for successful cooperation.
Keywords: Open Innovation, University-Industry Cooperation, Common Sense Code

INTRODUCTION

In different studies, is the open innovation idea priced to be a business success factor [1]. Many companies, as well as higher institution organizations, pursues a business to guarantee their good economic performance, they have to produce innovative products, or to offer innovative and novel knowledge, meet customer, students' and own needs, and respond rapidly to market burdens.

The idea of open innovation supports the notion that companies and educational institutions do not necessarily have all the competencies to perform every operation in-house, so that they search for partners, to share their "problem" and on the same way as before, to come to the wishfully results [2]. Along these lines, partnerships between two or more partners, should help in solving the set of difficulties, which may not be solved by the partners alone. Additionally, recent studies of open innovation have pointed to the rising significance of external sources of innovation, so that in the latest years, many enterprises have established partnerships, with so-called centers of knowledge like institutions of higher education [3]. It is also to be pointed out that most of the studies about open innovation mention the R&D activities in connection with the "open innovation" idea, but only few of them so-called formal and unformal collaborative projects. Objective of this paper is to indicate whether open innovation is a way for successful holistic designing of one university-industry cooperation, or such one successful cooperation can be based on ordinary personal experiences and heuristic methods that enable drawing intuitive insights or tacit knowledge from our experience by shaping the cooperation.

PRINCIPLES OF OPEN INNOVATION APPROACH

As stated by [12, p.40] "Innovation has been defined in a different manner". One commonly accepted definition of innovation is well-defined by [13, p.5], along with the innovation is "the adoption of an idea or behavior, whether a system, policy, program, device, process, product or service, that is new to the adopting organization".

Accordingly, innovation is "something new or improved, which is done by the enterprise to significantly add value…" [14, p.4]. Organizational innovation is widely described as the company's

capability to realize a variety of coordinated actions, in order to distribute new products or services to the market in a way that outclasses the market opponents.
In a narrower sense, innovation result only from ideas when these are implemented into new products, services or procedures, which really find successful use and penetrate the market (i.e. diffusion). In the innovation-related terminology, terms such as "open" and "closed" models are often used. The concept of closed innovation is a model where companies generate their individual innovative ideas and do their distinct R&D to update invention into innovation. The concept of the open in contrast to the closed innovation model, is described as the action of using "purposive inflows and outflows of knowledge to accelerate internal innovation…" [17, p.1]. The crucial differences between the two abovementioned models are visibly illustrated in Figure 1.

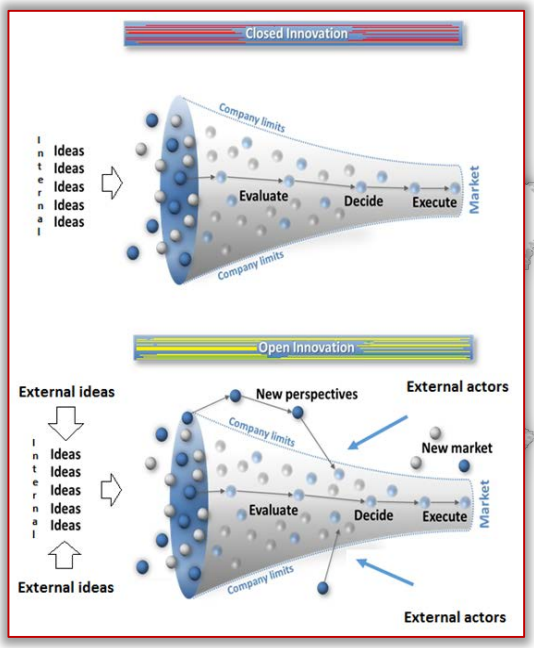

Figure 1 – Closed and Open Innovation Model, adopted by [18]

External actors in Figure 1 could be universities, companies, institutions or individuals. In the open innovation model, all actors can bring their own ideas and practical support into the joint project, in order to realize services or products, appropriate for the market. This means that R&D activities are not delimited by firm's boundaries. Furthermore, some of the features of the open innovation model, are that appreciated R&D activities may be exposed and established externally, the focus lies on building a better business model. On the other side, the issues of the intellectual property are not merely an internal matter, but it is arranged with external partners. The open innovation strategy that companies implement may vary, in relation to their size and determinations, as well as the type of openness of the innovation progress. According to [19], there are four types of openness and their associated benefits. According to [20], these types of openness can be shaped as a two-dimensional frame, consisting of the evaluation of the studies on open innovation. The two-dimensional framework encompasses the comparison between the so-called inbound (acquiring and sourcing) and outbound (selling and revealing) innovations versus pecuniary and non-pecuniary methods. Its intention is to evaluate the motives, by which some enterprises gain, and others may lose, with the application of the open innovation notion. The framework is presented in following figure.

Open Innovation Type	Description	Mechanisms
Outside-in (Inbound) ➢Pecuniary inbound [Acquiring] ➢Non-pecuniary inbound [Sourcing]	Involves opening up the company's own innovation processes to many kinds of external inputs and contributions	• In-licencing intellectual property • Scouting • Crowdsourcing • Intermediaries • Competitions and tournaments • Communities
Inside-out (Outbound) ➢Pecuniary outbound [Selling] ➢Non-pecuniary outbound [Revealing]	Involves allowing unused and under-utilized ideas and assets to go outside the organization for others to use in their businesses and business models	• Out-licencing intellectual property and technology • Donating intellectual property and technology • Spin-offs • Corporate venture capital • Corporate incubators
Coupled ➢Bi-directional ➢Interactive collaboration in form of joint production	Involves combining purposive inflows and outflows of knowledge to collaboratively develop and/or commercialize an innovative	• Strategic alliances • Joint ventures • Consortia • Networks • Ecosystems • Innovation platforms

Figure 2. Two-dimensional frame of open innovation in accordance with [20]

According to the authors, specific frames are in accordance with [12, p.42], defined as follows:

(1) Revealing: this type of openness relates to outbound, non-pecuniary innovation indicates how much the firms expose about their inside resources without direct monetary recompenses, taking into consideration, the not direct benefits for the firms.
(2) Selling: this type of openness relates to outbound, pecuniary innovation indicates, how the companies buy and sell their developments, and know-how by selling or licensing the assets developed in other organizations.
(3) Sourcing: this type of openness relates to inbound, non-pecuniary innovation indicates, how the companies can use external bases of innovation. The underlying principle is, that the more external sources of innovation are acquired, the more open is the companies' research policy.
(4) Acquiring: this type of openness relates to inbound, pecuniary innovation indicates, the achievement of participations for the innovation progress by the way of the market, that is, how companies license and gain know-how from third parties. Firms licensing or gaining know-how from third parties should have research ability and experience to review knowledges.

Connected to the grouping of the number of players involved in the process of innovation, there are, the so-called spots of concentration, where open innovation is positioned [21]. These spots can, according to the literature, be: internal R&D, internal cross-functional collaboration, mass collaboration and R&D alliances. The spots of concentration of the open innovation process are related to the locus of the innovation process and the number of the actors n>2.

UNIVERSITY-INDUSTRY ALLIANCES AND OPEN INNOVATION

In the case of universities and companies, both of them try to gain benefits out of cooperation. Scrutinizing both parties, it can be stated that enterprises have incomplete access to all essential competencies, services, apparatus, assets, etc.. On the other side, universities try to gain financial support for their work, to commercialize their academic research results and with it, their status within the academic society.

Therefore, there is an obvious benefit from the collaboration for both sides. There are studies proposing that organizations "embed the innovation process in their daily business and long-term strategy, in order to create new products and solutions because the innovation is also a key factor for organizations." [4, p.1].

In order to correctly use peripheral resources, according to the authors, the innovation process and partnership in the segment of the new product development becomes more open innovative. In [5, p.3078] it is mentioned that, "Looking further on the operational issues, universities may face some thoughtful complications related to alliance with industrial companies. The risk for universities doing fundamental research, if join to the project with industrial partner, can be the pressure they are exposed to, to concentrate themselves too much on applied research and with it to ignore the elementary research and fundamental education, because the project funding comes mostly from industrial companies.

Often, daily business requires much efforts so that supplementary working time is needed to do both, daily job and project job, so that the educational daily requirements cannot be met without extra work or extra working force." As stated in [6], restrictions to academic honesty, i.e. in the form of delays in publication or problems associated with "in secret" issues, may appear.

A further problem may well relate to the dependence on financial support. By accepting financial support, universities may commit themselves to enterprises which support them, and therefore lose their bargaining power. It can lead to divergences in proprietorship and use of academic properties [7]. Moreover universities have expectations, which have to be fulfilled. One of the main issues is the result of the partnership. That is, often, the results achieved may end up being fairly insignificant equaling with the efforts invested in co-operative open research, and guaranteed knowledge transfer my not happen [8],[9]. Further obstacles relate to organizational cultural issues, like unmotivated stuff, or different perceptions of time horizons, which may hinder such open innovative ideas [10], [11].

Despite the obstacles, collaborations are usual, often practiced by companies, universities and other partners. Some collaborations follow the open innovation idea, others are based on further principles, such as the so-called common sense code principle.

COMMON SENSE APPROACH TO UNIVERSITY-INDUSTRY COOPERATION

Some cooperation opportunities develop themselves gradually and become after a while a fruitful business idea. This gradual development can be based on no specific model, but on the common sense approach. This means that instead of implementing strict procedures, the cooperation is developed by mutual tendency to follow best-principles and practices of doing business and realization of the target objectives. Thanks to the collaboration between the Rheinische Fachhochschule Köln (RFH), University of Applied Sciences in Cologne/Germany and EPLAN Software and Services GmbH & Co.KG, a third party certification program carried out at RFH has been developed.

The main focus of the cooperation has been the so-called informal declaration of intend. In this informal meeting minutes, the targets and expected results have been defined. Those have been reached by the RFH, in expected time of 6 months and in expected quality. It was a natural step for the definition of the further collaboration steps. Gradually, further steps and collaboration targets have been defined. Those have been reached to the full satisfaction of both partners. In order to reach the targets, some open innovative methods and approaches, as well as further business approaches (differed by open innovation idea) have been implemented, without to highlight their affiliation to some business model or to explicitly relay on some suggestions of specific academic writings.

Moreover, according to common sense, the necessity to "open" some information has been jointly accepted, as well as the necessity for definition of joint research in addition to development of interfaces. Decisions, how far and under which circumstances, sharing of internal information and knowledge have to be carried out, was mostly result of meetings. Important subjects have been protocolled but not defined very strictly, without losing the sight of the target objectives and middle or long term goals. By this way external cross-functional

collaboration have been developed and kept functional for 8 years. The concept developed between both organizations is related to the, in-between, international model of certification of the E-CAD users of the software developed by EPLAN company. Certification itself, is carried out solely at RFH. In the following section one of the joint developed certification models is presented.

STUDENT CERIFICATION MODEL DEVELOPED BY RFH & EPLAN

As a result of this collaboration, three different certification programs have been developed: EPLAN Certified Engineer for industrial customers, EPLAN Certified Technician, as so-called Eplan Education model for attenders of technical colleges and vocational schools and EPLAN Certified Student, also as Eplan Education model, for visitors of universities and universities of applied sciences.

Figure 3. Eplan Education Micro-Side [22]

As stated in [5, p.3081] "in consideration of the continuously growing number of the applicants of the CAD/CAE software EPLAN Electric P8 in the industry and educational market, RFH in collaboration with the EPLAN Company has created new international certification models for scholars and students called EPLAN Certified Student (ECS) and EPLAN Certified Technician (ECT). ECS is certification which considers universities and universities of applied sciences, and ECT certification considers vocational schools, master schools and technical colleges. In order to be efficiently prepared on the examination, as a part of the project, scholars and students can use EPLAN Education P8 software for free. It can be downloaded in news version via EPLAN Education micro side and be freely used by students, pupils and trainees for the duration of their training in order to intensify and build upon preceding lessons". The web site to the cooperation, related to the named certification program, is presented in figure 3.

The result of the collaboration is permanently in use, and is becoming still developed. Scholars, as one of the beneficiaries have many advantages out of the certification program.

On the one side, they earn up-to date knowledge, because the content of the certification procedure is becoming permanently updated according to the E-CAD software development and according to the updated methods of the application of the software.

On the other side, the owner of the certificate, owned after theoretical and practical exam, attain in usual case appreciation from the future employer, because employers do not must to invest in employees training any more. This especially, because knowledge necessary to pass the exam corresponds the standard industrial training which is quite cost-intensive. It means, that employers of the certificate owners, can count on financial savings if employing the person which is holder of ECS or ECT certificate.

Figure 4. ECS certificate issued by RFH

Other certification programs jointly developed, offer similar benefits for all stakeholders involved in the project.

CONCLUSION

Analyzing the principles of open innovation model it can be stated that the open innovation model is one of the relevant business success models, also for university-industry cooperation. Many alliances between different intuitions follow the principles of this model, some of them rely on the gradually development of the joint idea and possible R&D activities, without strictly following the categories and contents of the open innovation approach. One such case, the cooperation between university and industrial partner described in this paper, have been presented. The main results indicate that much of the steps in one successful cooperation can be rather common sense based and triggered by circumstances, rather than formally defined. Less formalism, with certain amount of reasonable human and business understanding, can be a success factor for long-term university-industry partnerships.

Note

This paper is based on the paper presented at The 7th International Conference on Mass Customization and Personalization in Central Europe – MCP–CE 2016 – Mass Customization and Open Innovation, organized in Novi Sad, SERBIA, September 21-23, 2016, referred here as [23].

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DETERMINATION OF FOUNTAIN SOLUTION'S FUNCTIONALITY

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Abstract: The aim of this paper is to determine functionality of the fountain solutions prepared with various amounts of IPA. For the purpose of this research, two sets of the fountain solutions, FS1 and FS2,were prepared and characterized by measuring pH value, electrical conductivity and surface tension. In addition, the Pruefbau MZ II Multipurpose Printability Testing System was used to determine amount of the fountain solution needed to cover nonprinting areas on the printing plate and disable adsorption of the printing ink. To detect chemical wear of the printing plate by the fountain solution, potentiodynamic polarization measurements were performed. Results showed that solutions FS1 have higher pH value and higher electrical conductivity than solutions FS2.In both sets it is visible trend of increasing pH value and decreasing electrical conductivity by addition of IPA. The surface tension is lowest by FS1 in which 4 %vol of IPA is added, even more the whole FS1 set has lower surface tension than the lowest surface tension measured in set FS2 (measured in sample with 12.5 %vol of IPA). The contact angle values were in good correlation to the surface tension values (calculated Spearman's correlation coefficient was 1 for FS1 and 0.9 for FS2). In simulated printing process, better spreading of the solution on the printing plate surface was achieved using FS2, where for almost all solution samples even 5 µl were enough to reach optimal area coverage. The electrochemical measurements showed that there is no corrosion for all investigated fountain solution samples. From *a* research one could conclude that investigated samples do not cause corrosion of the aluminum based lithographic printing plates. The addition of the IPA causes reduction of the surface tension that leads to lower contact angle measured when applying fountain solution onto the nonprinting areas of the lithographic printing plate. The simulation of the printing process using the Pruefbau MZ II Multipurpose Printability Testing System could be used as a tool in defining amount of fountain solution needed to disable adsorption of the printing ink, but the process should be fine tuned.
Keywords: lithography, fountain solution, printability testing, surface tension, contact angle

INTRODUCTION

Lithography is a printing technique in which selective adsorption of printing ink on the printing plate is achieved by opposite surface properties of printing and nonprinting areas. It is a two liquids technique where beside printing ink fountain solution must be used to enable nonprinting areas to repel the printing ink [10]. Fountain solution is composed of water and some additives including buffer and surface-active substances.

The buffer solution must keep the fountain solution in defined pH value (4.5 – 5.5) as lower or higher pH value would significantly influence printing process and/or stability of the printing plate. Surface-active substances are added in order to decrease surface tension of the solution and enable coverage of the nonprinting areas on a printing plate with lower amount of the solution. Most commonly used surface active substance in lithography is propan-2-ol (isopropyl alcohol, IPA), but due to its bad influence on ecology and human health [6], in recent years fountain solutions with lower IPA amount or even without IPA (alcohol free fountain solution) have been developed [2].

Furthermore, with the increase of the environmental behavior, some governments have issued guidelines to reduce amounts of alcohol in fountain solutions [7].

MATERIAL AND METHODS

For the purpose of this research two sets of commercial fountain solutions were prepared. First set (FS1) was prepared using concentrate, which is used for

composition of the low alcohol or alcohol free (without use of IPA) fountain solution and the second set (FS2) is made of concentrate in which lower amounts of the IPA should be added (to 12 % vol). Each set consists of five samples by changing the amount of the IPA. The FS1 was made by adding 4 % vol of the concentrate (as proposed by the producer) in the distilled water and then adding 0, 1, 2, 3 and 4 % vol of IPA. The FS2 was made by adding 2.5 % vol of concentrate (proposed amount of the producer is 2 – 3 % vol) in the distilled water and adding 2.5, 5, 7.5), 10 and 12.5 % vol of IPA.

Characterization of the fountain solutions was performed by measuring pH value, electrical conductivity and by calculating surface tension. Surface tensions of prepared fountain solution samples were calculated using stalagmometric method (drop weight method). This method is one of the most commonly used to determine surface tension of a liquid. The method is based on the Tate's law (1) [5]:

$$mg = 2\pi r\sigma \quad (1)$$

where m is mass of the liquid droplet, g is gravitational acceleration, r is radius of the nozzle and σ is surface tension of the liquid.

Alternatively, as the surface tension is proportional to the weight of the drop, the surface tension of the unknown liquid could be compared to a reference liquid of known surface tension (2).

$$\sigma_s = \sigma_r \frac{m_s}{m_r} \quad (2)$$

where σ_s is surface tension of an unknown liquid, σ_r is surface tension of referent liquid, m_s is mass of droplet of the unknown liquid, m_r is mass of droplet of the referent liquid.

The surface tension for the purpose of this paper was calculated using equation (3), which is derived from the (2) introducing number of droplets in the same volume of liquid.

$$\sigma_s = \sigma_r \frac{n_r \rho_s}{n_s \rho_r} \quad (3)$$

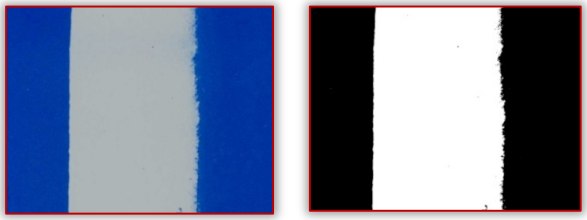
where σ_s is surface tension of an unknown liquid, σ_r is surface tension of referent liquid,n_s is number of droplets of the unknown liquid, n_r is number of droplets of the referent liquid, ρ_s is density of the unknown liquid, ρ_r is density of the referent liquid.

The density of the liquids was calculated using pycnometer and as a referent liquid water was used.

The pH value was measured by pH meter "WTW" GmbH pH 340/SET – 1 and conductivity was measured using "WTW" GmbH LF 330/SET. To determine interaction between fountain solution samples and printing plate contact angle (CA) on the nonprinting areas of a conventional aluminum based printing plate. The printing plate was exposed by a metal-halide lamp for 60 pulses (the exposure unit calculates amount of energy on the plate surface) and developed in fresh sodium based alkaline developer for ten seconds.

The contact angles were measured using Dataphysics' OCA 30 unit. This unit highly automated to disable influence of the operator on the results. It is equipped with an automated dispense unit to use drops of defined volume, automated movement of sample table, video system to enable measurement of the contact angle at precisely defined time after initial solid-liquid contact. These features enable better control of the measurements as they have significant influence on CA results [1]. Measurements were conducted using the Sessile drop method, at 24°C with drop volume of 1 µl. CA computations were made using Laplace-Young fitting method. In addition to the contact angle computation, to detect interaction between printing plate's nonprinting areas and fountain solution, printing simulation was performed. The Pruefbau MZ II Multipurpose Printability Testing System, equipped with the offset attachment (to enable offset printing simulation) was used for the printing simulation. This laboratory unit enables printing in precisely defined conditions regarding amount of fountain solution and printing ink, printing speed and printing pressure. For the purpose of this experiment, the printing speed was 1 ms^{-1}, printing pressure was 150 Ncm^{-2} and the amount of the fountain solution was 4, 5 and 6 µl.The printed plate samples were developed and dried at room temperature (24°C) just before the start of the printing process simulation.

The plate samples were then scanned using Epson Perfection V750 Pro and analyzed using ImageJ image analysis software [3]. The ImageJ is an open source software and is constantly been developed to meet needs of the users. The images were converted into a black & white and then area not covered by printing ink was calculated (Figure 1).



a) b)

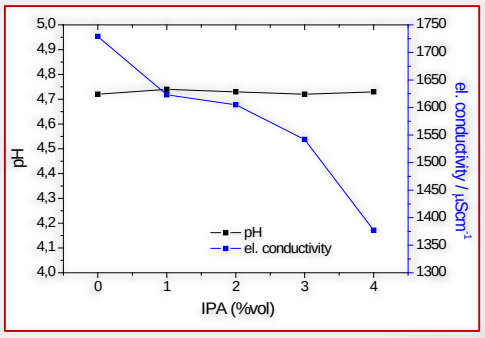
Figure 1: Images of printing plate samples:
a) original image, b) converted image

To detect possible chemical wear of the printing plate in the fountain solution a potentiodynamic polarization was performed. The potentiodynamic polarization was conducted using Ametec VersaSTAT3 Potentionstat and Galvanostat. The measurements were conducted in a standard three-electrode electrochemical cell. The electrochemical cell consists of saturated calomel electrode (SCE), graphite counter electrode and working electrode (plate samples). The prepared fountain solution samples were used as the electrolyte was. The potentiodynamic polarization was performed in potential range of ±250mV from the open circuit

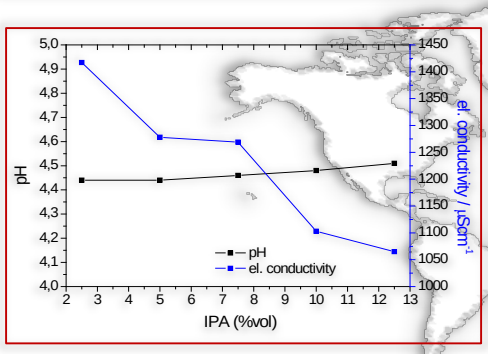
potential measured one hour after plate sample was immersed in the electrolyte. The measurement were conducted at temperature of 24°C.

RESULTS AND DISCUSSION

In Figure 2 one could see the results of the pH value and electrical conductivity of prepared fountain solution samples. Both sample sets have similar results, the pH value is stable, i.e. does not significantly change by addition of IPA. Nevertheless, pH value increases with the increase of the IPA amount added as could be seen in Figure 2b, where amounts of the IPA are higher. This is probably due to a slight dissociation of the IPA in water.



a)

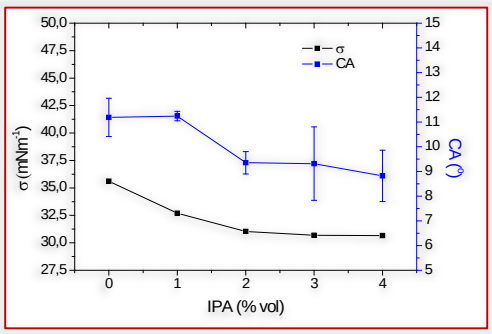


b)

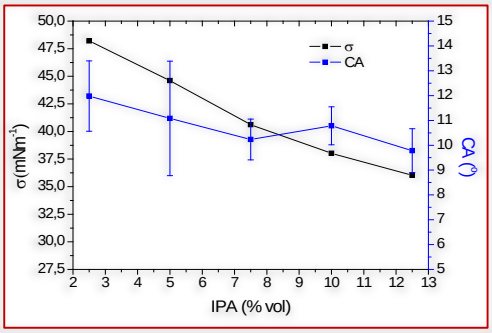
Figure 2: pH value and electrical conductivity of solutions: a) FS1, b) FS2

On the other hand, IPA amount significantly influence electrical conductivity, causing it to decrease. At both samples the electrical conductivity decreases for nearly 400 µScm^{-1}, but as FS1 (Figure 2a) has a higher initial value, the decrease is about 5% lower. The decrease of the electrical conductivity is probably caused by low dissociation of the IPA in water and therefore decreasing the fraction of the ions in the solution.

The influence of the IPA amount in a solution on its surface tension and interaction with the printing plate surface is presented in Figure 3. It could be seen that decrease of the surface tension with the amount of the IPA added is more present in the FS2 in comparison to the FS1. Furthermore, adding more than3 %vol in FS1 is not efficient as sample with 4 % vol has almost the same surface tension as previous sample (Figure 3a). On the other hand, the trend of the surface tension value of FS2 samples show that further addition of IPA would probably decrease surface tension of solution even more (Figure 3b).



a)



b)

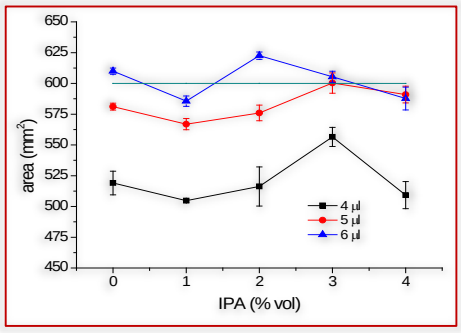
Figure 3: Surface tension and CA of solutions: a) FS1, b) FS2

The FS1 solutions were made of commercial concentrate that could be used even without adding IPA, so it has in its composition some surfactants with lower hazardous influence than IPA (according to the technical data sheet glycol derivates are present in concentration of 15-25% [8]). The FS2 solutions were made of concentrate in which no glycol derivates are present, according to the safety data sheet [9].

The increase of the IPA amount in a fountain solution causes decrease of the contact angle when applying the solution onto nonprinting areas of the lithographic printing plate. The CA is lower when using FS1 in comparison to the one measured using FS2. The surface tension and the CA correlate, as could be seen when calculating the Spearman's correlation coefficient. The calculated results were r_s = 1 for FS1 and r_s = 0.9 for FS2.

In Figure 4 one could see the results of the calculated area covered by the fountain solution before inking. The green line at 600 mm^2 is denotes optimal wetting of the printing plate's nonprinting areas. It could be seen (Figure 4) that 4 µl of the solution is not enough for preventing inking of the area for both solution sets. Increasing volume of the fountain solution applied the area not covered by printing ink increases. Using solutions from set FS1 it could see increase of the area without inking when using 4 and 5 µl, with exception of solution with 4 % vol of IPA (Figure 4a). Use of 6 µl causes more area without ink than optimal, meaning too much of solution was applied on the printing plate's surface causing spreading of the fountain solution out of the zone where fountain roller passed over printing plate's surface. Although results of the contact angle

and surface tension of investigated solutions imply lower functionality of FS2 set, results of the area not covered with ink show that even 5 µl is enough to reach optimal area of the printing plate covered by fountain solution (Figure 4b).



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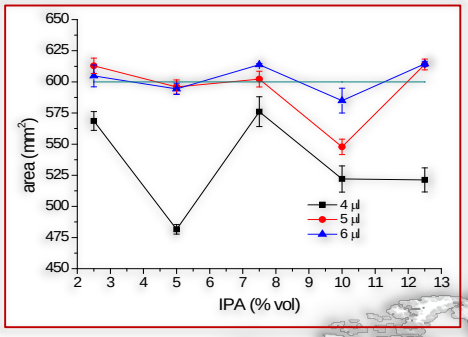

b)

Figure 4: Area of the nonprinting areas covered with the fountain solution: a) FS1, b) FS2

The electrochemical measurements showed that in all solutions in the investigated potential spectra (±250 mV) from open circuit potential current is lower than 1 mA. If the current is lower than 1 µA, the corrosion of the material is very slow and it is not significant to the exploitation of printing plate [4].

CONCLUSIONS

This research was conducted to determine functionality of the two fountain solutions, one proposed to use IPA and the other to be used with low amount or even without addition of IPA. Furthermore, printing process simulation by a printability tester was introduced as a tool in defining fountain solution functionality.

From this research it could be concluded that investigated samples do not cause greater corrosion of the aluminum based lithographic printing plates, i.e. it does not influence. The addition of the IPA causes reduction of the surface tension that leads to lower contact angle measured when applying fountain solution onto the nonprinting areas of the lithographic printing plate. The simulation of the printing process using Pruefbau MZ II Multipurpose Printability Testing System could be used as a tool in defining amount of fountain solution needed to reject printing ink, but the process should be fine tuned.

Acknowledgments

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Note

This paper is based on the paper presented at The 8th International Symposium on Graphic Engineering and Design – GRID 2016, organized by University of Novi Sad, Faculty of Technical Sciences, Department of Graphic Engineering and Design, in Novi Sad, SERBIA, 3-4 November, 2016, referred here as [11].

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TRANSFORMER OIL AND POTENTIAL RISKS FOR ENVIRONMENT

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Abstract: Safe handling and manipulation of transformer oil in the electrical energy distribution and other sectors are to be realised in a manner and procedure that will not pose a risk of water, soil or air pollution for the protection of environment, life and health of people. Implementation of the necessary preventive and corrective measures for environmental protection, fire protection, safety and health at work is, among other things, mandatory, including the respect for and the realisation of legal provisions, standards and regulations for the purpose of safe and optimal treatment and management of transformer oil, and prevention or reduction of negative impact on the environment and human health. The study presents the sources of transformer oil, testing and determining the trend of transformer oil's important features in the exploitation, with particular emphasis on potential negative impact on the environment, safety and health, therefore the results, recommendations and conclusions are given.
Keywords: transformer oil, electric power distribution, potential risk, environmental protection, safety and health of people, fire protection

INTRODUCTION

Transformer or insulating oil is often used in the operation of oil transformers, which also includes transport, storage, filling, handling of oil in the operation of various devices and managing used oil. There is a potential risk of environmental pollution and/or danger to human health and life in every operation stage, especially in emergency situations in case of spillage, evaporation and/or formation of flammable products. In order to prevent or mitigate undesirable consequences of such phenomena, timely inspections, implementation of all the measures needed and appropriate rehabilitation are required. The study analysed essential characteristics of oil and transformers in the power transformer stations belonging to the MH "ERS" ZEDP "Elektro-Bijeljina" joint-stock company Bijeljina and the potential risks to the environment. Business activities of the above mentioned company are: distribution, supply and production of electricity [1].

MATERIAL AND METHOD

Ξ Transformer oil

The oil in a transformer, as shown in Figure 1, is insulation, cooling; it assists in extinguishing sparks, dissolves gases formed during the degradation of oil, and dissolves gases and moisture from the cellulose insulation and atmosphere. Transformer oil may be of mineral or synthetic plant origin. [2]

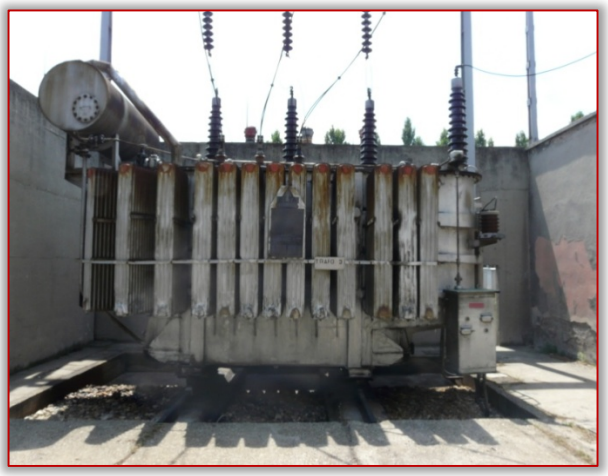

Figure 1: Transformer connected to electrical grid in an insulated bulkhead [2]

Transformer oil is transported in rail tank cars or tanker trucks, barrels or metal containers, with mandatory inspection in order to prevent uncontrolled spillage and contamination. Supply of transformer oil depends on the need for replacement, topping up,

sampling and other ordinary and extraordinary situations.

The transport containers must be clearly marked with a tag containing the name of oil and the manufacturer, designation according to the standard, batch number, and date of delivery. Storage areas must comply with the regulations that apply to the corresponding petroleum products, i.e. must be well ventilated and cool with ambient temperature not higher than 50°C, and without potential sources of fire. The barrels are stored in either closed or covered area, not exposed to contamination and corrosion, and are laid on wooden pallets [3], as shown in Figure 2.

Figure 2: Stacking of barrels on wooden pallets

Ξ Classification and generation of waste transformer oil

Waste transformer oil is classified as hazardous waste [4]. Waste transformer oil and other types of hazardous and non-hazardous waste are generated in the processes of maintenance, overhaul, replacement of electrical equipment and other activities of electricity distribution companies. Waste transformer oil is generated in the following situations:

- After the analysis of transformer oil sample; if the results show unsatisfactory quality, the replacement with new oil follows;
- If damage to the power transformer caused discharge of transformer oil into the environment;
- If damage to the power transformer caused discharge of transformer oil in the transformer oil pit collector.

Metal barrels containing waste insulating/transformer oil is marked with stickers (displaying hazardous properties of the substance), and identification card.

Ξ Test method and trend determination of dielectric strength of transformer oil in exploitation for the aim of analysis of environmental impacts, potential risks and safety

Dielectric strength of transformer oil is tested according to the standards JUS N.A5.014, SRPS N.A5.014, SRPS EN 60156. Testing the dielectric strength of insulating oil is, in principle, the same for all types of oil (for transformers, switches and capacitors), whether they are new or used ones.

Since the dielectric strength is extremely sensitive to the slightest contamination of the sample, careful sampling is essential. Insulating oil samples for testing dielectric strength are to be taken only by persons qualified and experienced in the handling of insulating transformer oil or persons working under their direct supervision.

The oil sample is taken at the spot, which is considered to be less pure, for example, at the lowest point of the transformer [5], as shown in Figure 3.

Figure 3: Discharge of oil
at the lowest point of transformer

The control sample is taken in dry weather, but if taken in wet weather conditions, special protective measures (e.g. protection from rain, wiping, drying, and waterproof covers for sample transport, etc.) are to be taken [6].

During sample preparation, the sample container needs to be shaken gently and overturned several times in order to provide, to the fullest extent possible, the homogeneous distribution of impurities contained in the oil and avoid creation of air bubbles. Immediately thereafter, the sample is poured into a test cell, slowly, to avoid the formation of air bubbles. The oil temperature at the time of the test should be equal to the ambient temperature; the best is around 20 °C. This temperature must be recorded. [5]

Samples of the new oil delivered in tankers or barrels and used oils are tested in the existing state, without prior processing.

Testing is conducted as the electrodes are connected to alternating voltage frequency of 50 Hz, which, starting from zero, is evenly increasing by 2 kV/s until it reaches a value causing the overshoot. The test will be repeated six times with the same filling of the cell.

Dielectric strength is the arithmetic mean value of the six results obtained, if no value deviates by more than

25% from the arithmetic mean value. If there is a deviation, the entire procedure is to be repeated.[5] Record on testing is to include overshoot voltage, expressed in kV, obtained in the course of all tests carried out and the mean value of all results. The type of electrodes used, the frequency of the test voltage and oil temperature are to be also entered into the records. [5]

RESULTS AND DISCUSSION

During the exploitation (operation) of a transformer, the transformer/ insulating oil is often used, thus there is a potential risk of environmental pollution and/or danger to human health and life, especially in emergency situations. It is highly significant not only for the users of the transformers in associated substations and other high-voltage installations, but also for the relevant professional engineering institutions, to know the prescribed transformer oil's features values and their monitoring, what the potential risks to the environment and humans' safety are and what the life cycle of the individual elements of the plant is. This is particularly important for the power transformers, which are the most expensive, the most sensitive and the most risky part of the plant.

The transformer lifetime depends on the lifetime of its insulation, which consists of transformer oil and solid compounds [1]. In this respect, the importance of testing and trend determination of dielectric strength of transformer oil at substations and other power installations is recognized.

When it comes to defining the time limits for the purpose of this analysis, the adopted time limit is 5 years.

Significant facts and results are observed on the basis of the analysis of various factors, small or great influence on the dielectric strength of oil in the transformers installed in power transformer stations belonging to the "Elektro-Bijeljina" joint-stock company Bijeljina within the above mentioned time period.

The average value of dielectric strength of oil in the transformers installed in various associated substations (TS) and other power transformer stations of voltage level 35/10 kV, has ranged from 138.5 to 261.6 kV/cm [1].

In general, the strength of oil indicates a downward trend, as shown in Figure 4.

Age of the transformers installed in the power transformer stations belonging to the Company, voltage level 35/10 kV, in the reporting period ranged from 8 to 50 years [1] and is on the rise, as shown in Figure 5, which is not a positive trend from the standpoint of environmental protection, labour safety, technical, economic and other aspects.

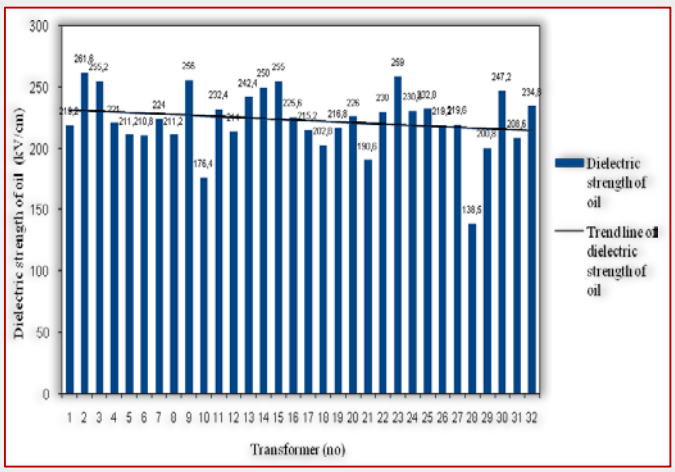

Figure 4: Dielectric strength of oil in transformers installed in power transformer stations belonging to the "Elektro-Bijeljina" joint-stock company Bijeljina

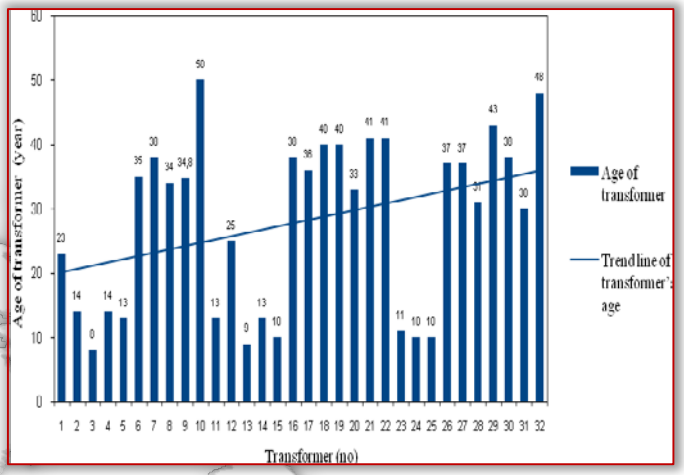

Figure 5: Age of transformers installed in power transformer stations belonging to the "Elektro-Bijeljina" joint-stock company Bijeljina

In the reporting period, the trajectory of transformer age was inversely proportional to the value of dielectric strength of oil, as shown in Figure 6.

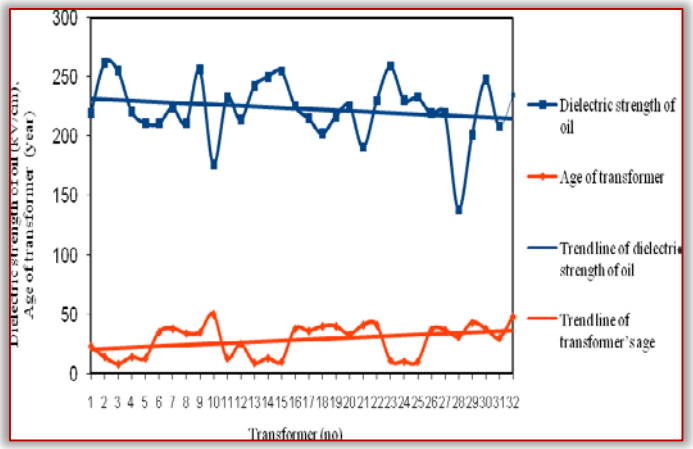

Figure 6: Dielectric strength of oil and age of transformers in power transformer stations belonging to the "Elektro-Bijeljina" joint-stock company Bijeljina

With the increasing trend in transformer's age, the decreasing trend in the value of dielectric strength of oil is recorded at the same time.

The lifespan of the power transformer is difficult to assess. This causes a great deal of attention, both here and on the global scale, because a large number of transformers, particularly in developing countries, are at the end of life. Most power transformers in the world have been in operation for over 30 years [7]. The average age of transformers in power transformer station of 35/10 kV voltage level in the "Elektro-Bijeljina" joint-stock company Bijeljina is 28 years [1].

Available methods do not provide a fully accurate data for determining the status or the end of transformer's operating life. Therefore, a team consisting of experienced engineers, technicians and other experts is obliged to carry out a series of additional analyses, tests, inspections and audits regarding the above mentioned. The most common transformer related problems are about transformer oil leaks, the malfunctions of cooling systems and various elements, which in certain situation, particularly in emergency situations, may pose a risk to the environment.

In accordance with previously analyzed data, it is evident that dielectric strength of transformer oils in operation has a decreasing trend, as opposed to the age structure of the transformers in researched systems, which has significantly deteriorated. Unless appropriate measures and activities are taken, the continuation of the decreasing trend in dielectric strength of oil in the transformers installed in the power transformer stations of the above mentioned and other similar power distribution systems in the region, is forecasted. Such forecast requires a quicker response by the relevant experts in order to cease these trends, or at least partially reversed them. When reviewing aforementioned problems, be sure to take into account the requirement that the minimum value of dielectric strength of transformer oil is 120 kV / cm [6] in the transformers installed in associated substations of 35/10 kV voltage level, which represents the required threshold of used insulating oil, according to the standards [5]. Those findings, based on the results of conducted research and forecasted future trends of mentioned factors, need to be taken extremely seriously, with special emphasis on increasing risk of accidents and possible negative effects on the environment, safety and health of people.

Some power plants - substations are missing transformer oil pit collector, which would prevent oil spills from the transformer into the environment in case of malfunctions, system elements failures and emergencies.

Experts from the field of engineering, protection etc, as well as the competent authorities, must have open communication based on an integrated basis, and the possibility of efficient cooperation between themselves, with responsible persons and the public [8], that all are the indispensable system links.

CONCLUSION

The negative impact of transformer oil on the environment is multiple. The most common risk is the risk of waterways and soil contamination. Particularly dangerous is the presence of oil in the water flow of so-called sanitary protection zone used to supply the settlements with top quality water.

Main conclusions resulting from the analysis in this study are that the dielectric strength of transformer oils in operation has a trend of constant decrease and that the age structure of the transformers installed in the substations and other power transformer stations in researched or other similar power systems in developing countries has significantly deteriorated. It is necessary to act urgently and to rapidly procure and install new transformers and transformer oils in the power systems or generally overhaul the existing transformers with transformer oil regeneration in the most power transformer stations, or to carry out the activities as a combination of the aforementioned. This is very important, especially when taking into account the fact that the transformer operation safety directly depends on the dielectric strength of transformer oil, likewise potentially negative impact of transformer oil on the environment in case of system failure or small/large spillage/ discharge of oil into either water or soil, especially in case of emergencies. The need for consistent preventive actions is imposed as imperative in the integration with the implementation of technical measures and activities from the fields of environmental protection, fire protection, safety and health at work, as well as other forms of protection. The aforementioned activities are to eliminate or reduce to a minimum any potential contingency situations and the above listed negative trends in the power transformer stations, which could lead to accidents, the negative impact of transformer oil on the environment, as well as substantial risk to both the environment and the life and health of people.

Some substations of 35/10 kV voltage level are missing transformer oil pit collector, which would prevent oil spills from the transformer into the environment in case of emergencies or accidents, thus it is necessary to construct, as soon as possible, a transformer oil pit collector, which is a preventive measure and recommendation, in accordance with general and specific environmental objectives, investment plans and priority activities.

The local authorities are to be requested to establish the centers for waste oil collection at preferred and safe locations in their area of responsibility. Waste

collection centers should have an easy access and enabled quick evacuation in case of spillage and/or other emergencies. This will eliminate the additional costs for preparatory works and other activities, and provide easier access and manipulations with minimum risk to the environment and human health.

Based on the conducted research presented in this paper (study) and data synthesis from the domain of subject matter, it can be concluded that the results, recommendations and conclusions, in addition to the researched system, may be applied to most power distribution systems, particularly in transition economies of European Union.

Note

This paper is based on the paper presented at The 7th International Conference on Mass Customization and Personalization in Central Europe – MCP–CE 2016 – Mass Customization and Open Innovation, organized in Novi Sad, SERBIA, September 21-23, 2016, referred here as [9].

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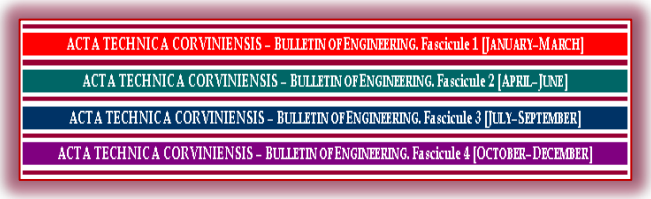
*We are very pleased to inform that our international and interdisciplinary journal **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering** completed its nine years of publication successfully **[issues of years 2008 –2016, Tome I–IX]**.*

In a very short period it has acquired global presence and scholars from all over the world have taken it with great enthusiasm.

*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 fields of science and technology. 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.*

*Now, when will celebrate the tenth years anniversary of **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**, we are extremely grateful and heartily acknowledge the kind of support and encouragement from all contributors and all collaborators!*

*On behalf of the Editorial Board and Scientific Committees of **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**, we would like to thank the many people who helped make this journal successful. We thank all authors who submitted their work to **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering.***



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[1.]I.H. IVANOV

DESTRUCTION OF A CAST IRON CYLINDER HEAD IN OPERATION AND AFTER WELDING RECOVERY

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Abstract: The subject of this study is cast iron cylinder head of a diesel engine with about 240,000 kilometers run. Results indicated a decrease of the tensile strength in the areas of combustion chambers as compared to the sections away from them. After recovery by welding with an iron-nickel electrodes, the decrease in strength in the field of combustion was noticeable - 20-30%. During operation there was evidence of cracks and corrosion in depth, which further impeded the recovery process. Finally, the formation of numerous pores on the bottom of the weld pool in the area of the combustion chamber was found.
Keywords: cylinder head, welding, corrosion, destruction

INTRODUCTION

The recovery is one of the main components of the process of reproduction which determines the full life cycle of machines. The efficiency of product manufacturing depends largely on this process and it is therefore necessary to choose an appropriate details recovery technology.

Cast iron is widely used as a construction material, featuring a good casting properties and low coefficient of linear expansion, high durability and workability.

The widespread use of cast iron parts in the automotive, agricultural and lifting transport equipment and damaging them during the operation process creates the need for their recovery, in order to reduce the cost of replacement of the parts with new ones. The recovery through welding and hard-facing of worn and damaged cast iron parts, due to the construction and physical-chemical properties of iron, is still difficult.

Rapid cooling of the molten metal in the surfacing zone, as well as combustion of silicon contributes to the bleaching of the cast iron, which hampers its processing with cutting tools.

Consequently, the low plasticity of the cast iron in uneven heating and cooling may form cracks in the welding seam itself and in area around the seam. The low melting temperature and the rapid transfer of cast iron from solid to liquid state and back hinders the complete exit of the gases from the seam, resulting in pore formation.

There are many methods and technologies for the recovery of cast iron parts of the automotive transport equipment, which give sufficient reliability for the operation of the renovated details [2,5,8]. The possibilities for modifying the surface allow to increase wear resistance by introducing alloying elements in the deposited zone. Yet much difficulty represents the restoration of cast iron cylinder heads due to the need to obtain hermetic compound with sufficiently high strength and at the same time workability by cutting.

This study presents the results of the tests on samples of cast iron cylinder head of a car Opel Omega 2.3 TD with around 240,000 *km* run.

METHODOLOGY OF THE EXPERIMENT

Samples taken from the combustion chamber (Figure 1) and from the place with the least heat load (a side wall of the first cylinder) were tested. The thickness of the walls, where the samples were taken from, was identical, in order to avoid the influence of the scale factor on the structure and casting properties.

Hard facing and welding of samples were carried out with electrodes ENiFe produced by Elektrodi JSC, Ihtiman. The electrodes have the following chemical composition: C - 1%, Ni - 53%, Fe – 46%. Before hard facing and welding of the samples, the electrodes were heated to 150o C for 1 hour to remove hydration water.

Metallographic and fracture graphic studies were implemented using microscope Neophot 32. Microhardness was measured using the method of Vickers on a PMT-3 setting with a 50-gram load.

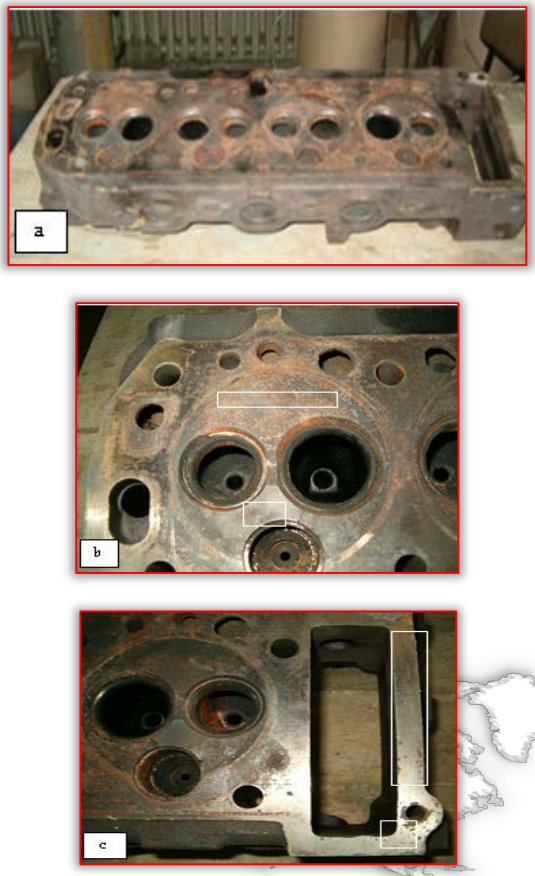

Figure 1. Cast iron cylinder head of a car Opel Omega 2.3 TD with the place of the samples

Samples for the tensile test had rectangular cross section with dimensions 6.8 x 7.1 mm. The welded samples were prepared for welding in X shape. During welding they were clamped to avoid distortions. The final dimensions were received by grinding. The tensile test was conducted on a universal testing machine until samples' destruction. Hardness was measured by Brinell's method under standard test conditions.

RESULTS AND DISCUSSION

During details repair determining the chemical composition of the details is not always economically feasible. That is why determining the cast iron type was performed by examining its microstructure and mechanical characteristics. Microstructural base material of the cylinder head was cast iron with lamellar graphite Fig. 2 with Brinell hardness 195-200 HB.

The tensile strength of the samples taken from the combustion chamber was Rm = 185 ÷ 200 MPa and those on the outside wall - Rm = 220 MPa. The metal ferrite-pearlite matrix had predominantly pearlite structural component. Modification of the structure was observed in the combustion chamber due to the beginnings of graphitization of carbon from the cementite. It was a consequence of the increased diffusion capacity of the carbon at high temperatures, the combustion chamber material was subjected Fig. 3.

Figure 2. Microstructure of the base material of the cylinder head

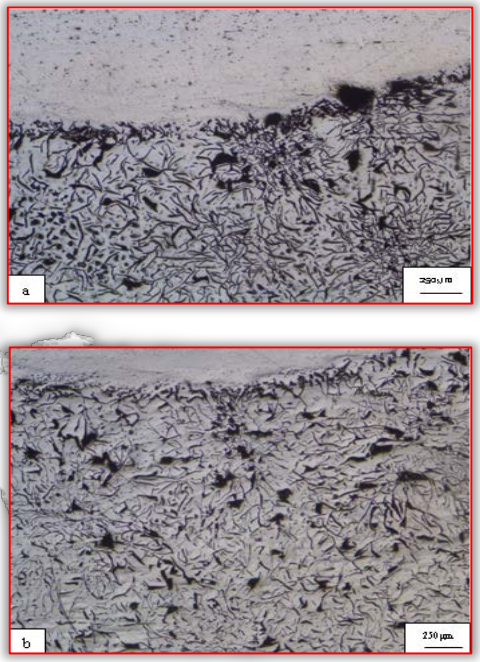

Figure 3. Microstructure after welding of cylinder head in the combustion chamber – a) and the base material – b)

As it is known, graphite inclusions in the cast iron reduce tensile strength and ductility. In this case, the increase in their number and their effect as stress concentrators, lead to reduced tensile strength of the cast iron after the impact of high temperatures and aggressive environments. The presence of defects (corrosion of the material in depth and cracks) further decreased the strength - Fig. 4 and Fig. 5. The reasons for the occurrence of corrosion of the combustion chamber material were the high temperatures of the combustion gases and the oxidizing environment in the combustion process.

Corrosion processes occurred at grain boundaries and at the most intensive border between the graphite and metal matrix. Due to the cyclicality of engine operation and the continuous change of the gas phase temperature - from 360 to 2200 ° C, the material was subjected to prolonged heat fatigue [3,4,7]. It caused the appearance of microcracks and their development

in depth until the connection of the fuel space with the water space in the cylinder head. From the continuous observations of details with similar defectiveness it was found their predominant generation and development in two main areas: first, at places where the combustion process was most intensive (pre-chamber - inlet valve); and second, at places with sharp edges, smallest section and relatively low cooling (between the valve seats)[1,3,9].

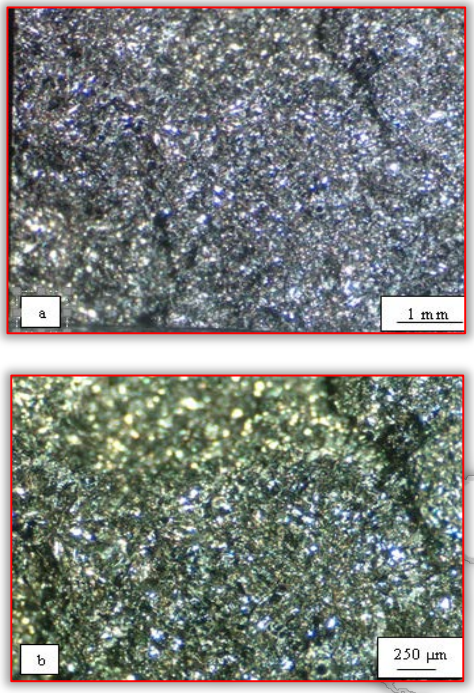

Figure 4. Fracture surface of cylinder head in the combustion chamber after tensile testing

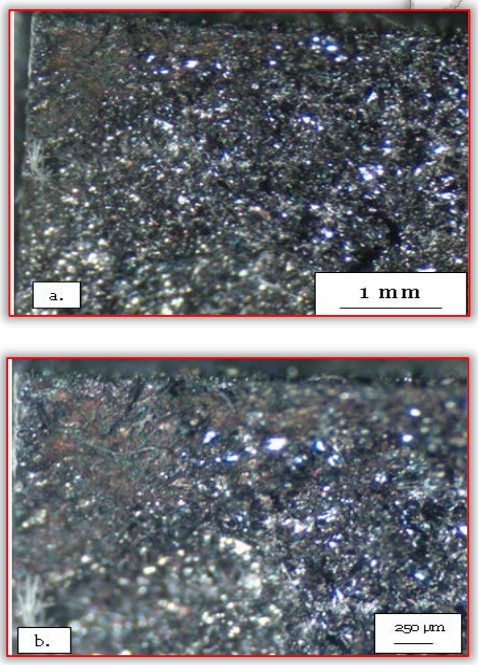

Figure 5. Fracture surface and corrosion of cylinder head in the combustion chamber after tensile testing

During operation the main cause of damage to the details was the stress of tension arising from the non-free change of the workpiece size in the presence of a temperature gradient between its parts. As a result of the heat significant local extensions of the detail took place, and this happened at a time when the volume of the cold detail remained constant due to the low thermal conductivity of cast iron. This lead to the formation of internal stresses. Their accumulation lead to the formation of cracks during detail operation. Some major differences between the samples were identified during the analysis of tensile testing fractures. Microcracks had been created during operation in the cast iron that was subjected to prolonged thermal and oxidative stress. With time the microcracks had developed into macrocracks with growth direction from the surface of the material into its depth Fig. 4a and b. The reasons for the cracks' occurrence and growth were the above-mentioned corrosive processes, thermal fatigue, low silicate fatigue, as well as the high pressures which, under extreme conditions, reaches 0.8-0.9 MPa.

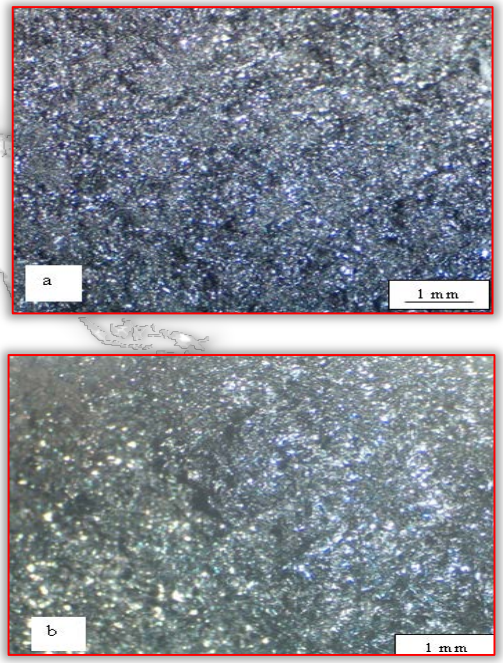

Figure 6. Fracture surface of cylinder head from the wall a) and the combustion chamber b) after tensile testing

Probably the spread of the cracks affects the vibrations in the engine. The material on the cleft surface was highly oxidized and the characteristic yellow-brown colour is observed in fig. 5 a) and b). The destruction of the material during the tensile testing continued along these microcracks. The fractures of the samples of the material, which was not subjected to thermal and oxidative stress, lack cracks and oxidation in depth - Fig. 6a.

After the welding of the samples, the differences in the tensile strength increased. In all specimens the destruction in tensile testing occurred in the heat affected zone. The decreased strength of the welded samples may be explained by the presence of many

defects and the occurrence of brittle phases in the transition zone and the heat affected zone. Furthermore, the presence of oxides in depth creates prerequisites for cavities of the welded joint as depicted on Fig. 7 c.

Comparing the stresses at which the destruction of the welded samples of the wall and the combustion chamber occurred, a difference of 20-30% was observed. This was mainly due to increased porosity on the bottom of the weld pool compared with the samples from the wall.

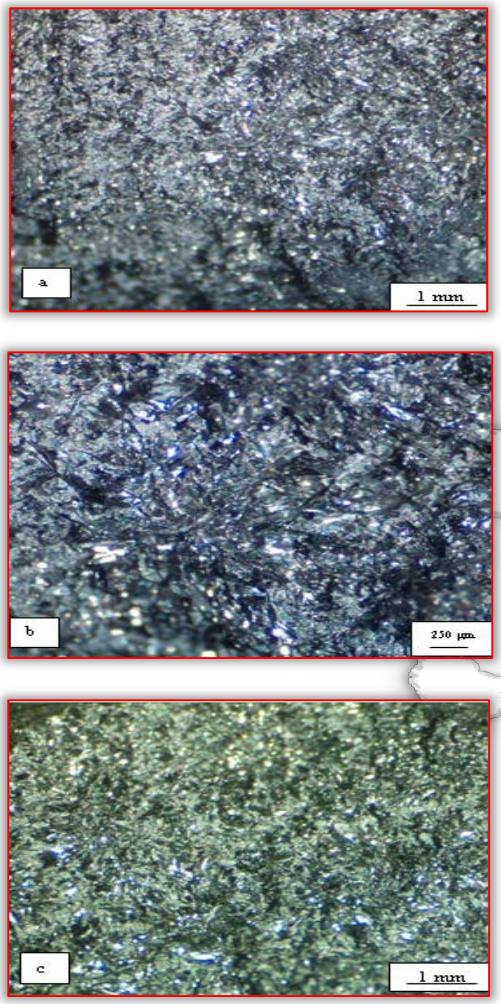

Figure 7. Fracture surface of cylinder head from the combustion chamber after tensile testing

CONCLUSION

As a result of the combustion process, irreversible changes occur in the structure and strength of the material of the cast iron subjected to thermal and oxidative deterioration. These changes have a negative influence on subsequent recovery by welding, strength and density of the welded joint cannot be ensured. For these reasons, it is difficult to ensure long-term operation recovered by welding with an iron-nickel electrodes, cast iron cylinder heads.

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INDUSTRY 4.0 CONCEPTION

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Abstract: The growing market globalization, increasing global competition, and more complex products results in application of new technologies, methods and business processes. Fast changing market environment and fluctuating customer demands require efficient operation of logistical processes. In this study the logistical tendencies and challenges are introduced with reasons and driving forces. The essence of Industry 4.0 conception is also introduced.
Keywords: market environment, customer demands, logistical processes, Industry 4.0 conception

INTRODUCTION

Logistics is a common word nowadays, since it is an essential component in supply chains and also in the competition of the economic operators.

There are several existing definitions for logistics. Logistics is the planning, organizing and coordinating of the flow of materials, information, energy, money and values inside a logistic system. Beyond the realization of these processes logistics is also an interdisciplinary discipline that synthesizes and utilizes the state-of-art knowledge and methods of several disciplines connected to logistics in order to realize a given logistical task.

Therefore, the goal of logistics is to provide things in adequate quality and quantity at a given destination, in an appropriate time, from an appropriate origin, with an appropriate method and equipment, and with an appropriate minimal cost.

The quality and availability of the offered services by the logistics sector are of capital importance for the economical growth and for increasing employment potentials.

Globalization, enhanced competition in the global market, more complex products with shorter lifecycle and fluctuating customer demands gave rise to new technologies, business processes and the application of global supply chains. Therefore, the logistic sector is currently meeting and will meet in the future new practical challenges, and the fast respond to them is the key of success for the economic operators.

INTRODUCTION OF THE EUROPEAN LOGISTICS SECTOR: INFLUENCING FACTORS AND CHALLENGES

The logistical performance of the European Union is nearly 1,000 billion Euro (Fig. 1.). The logistic sector is in constant growth. The Western-European countries are the leading countries, while Hungary is dropped behind with its 4.9 billion Euro (which is 0.5 % of the total European performance). The Hungarian logistical sector gives 6 % of the GDP of Hungary, while in case of Western-European countries it reaches up to 10-13 %. Therefore – as emerges from the statistics – it can be concluded that an efficient logistical sector in a country strongly promotes a successful economy.

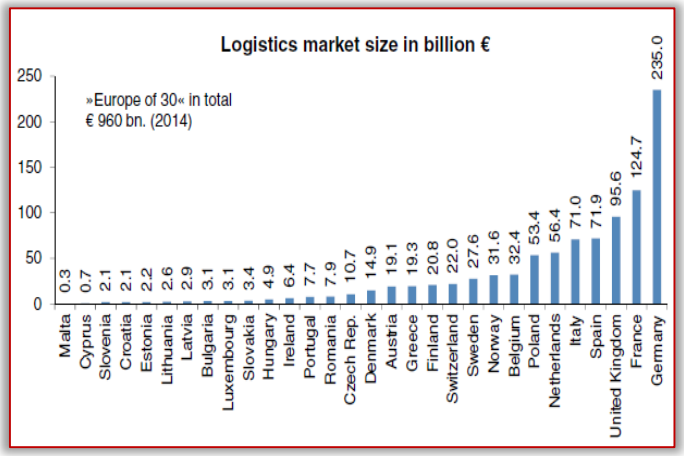

Figure 1. Top 30 countries of Europe in terms of the performance of their logistic sector
Source: Fraunhofer Institute [1]

Furthermore it is clear that the logistic sector of Hungary has to meet high standards because our geographical location and our economical-cultural role as a joint of East and West Europe would provide significant opportunities in this sector.
According to a study of Fraunhofer Institute from 2015 mostly 10 driving forces listed in Table 1 influence the logistic sector of Europe [1].

Table 1. 10 main driving forces that influence the logistic sector

DRIVING FORCES	
1. Globalization	Drivers which can be hardly influenced
2. Demographic development	
3. Sustainability	
4. State intervention	
5. Rising risk	
6. Professionalization – efficiency	Drivers which can be adopted for successful business options
7. Focusing on core competencies – effectiveness	
8. Service oriented	
9. Innovative technologies	
10. Faster ticking clocks	

According to an international survey executed by Jones Lang LaSalle from [2] companies working in the logistic sector defined their main challenges for the next five years with the 13 points:
Reduction of supply chain costs, changing customer demands, increasing volume of e-commerce, improvement of relations between supply chains, reduction of stock level, sensitivity and flexibility of supply chains, sustainability, application of new technologies, intermodality, cooperation in transport activities, reverse logistics, new transport corridors, increasing of global purchase.

INDUSTRY 4.0 CONCEPTION

The tendencies of the 21st century – such as the s life-cycles of products are shorter while consumers demand more complex, unique products in larger quantities – poses many challenges to the production.
There are many sings that show that the current practices in the utilization of resources is not sustainable, which will limit the production.
The industrial sector is going through a paradigm shift, which will change the production drastically. The traditional centrally controlled and monitored processes will be replaced by decentralized control, which is built on the self-regulating ability of products and workpieces that communicate with each other.
The essence of Industry 4.0 conception is the introduction of network-linked intelligent systems, which realize self-regulating production: people, machines, equipments and products will communicate to one another.
This paradigm shift includes the conception of Industry 4.0, which is widely used in Europe, especially in Germany. The name of the conception forecasts the upcoming 4th industrial revolution**,** because according to the theory of the conception the 1st industrial revolution introduced automation, the 2nd mass production, the 3rd is the utilization of robots. Industry 4.0 will bring intelligent production robots.
The goal of the conception is to make flexible, custom production economical, and to use resources efficiently. It requires each equipment that takes part in the production to communicate with one another. The organization of information flow is executed by a central production control system.
Products control their own production, since to communicate with unique product codes with the machines and equipments, which means virtual and actual reality merges together during the production. The scheduling of the production will be also controlled by the communicating products. Factories will be self-regulating and optimize their own operation.

THE 5 MAIN COMPONENTS OF NETWORKED PRODUCTION

The 5 main elements of the networked production can be defined by the following [4]:

Digital workpieces

The dimensions, quality requirements and the order of technological processing is given for the digital workpieces.

Intelligent machine

Intelligent machines communicate simultaneously with the production control system and the workpiece under processing, so that the machine coordinates, control and optimize itself.

Vertical network connection

When processing the unique specifications given by the customer for the product to be manufactured the production control system forwards the digital workpiece created by automated rules to the equipments. The products control their own manufacturing process, since they communicate with the equipments, devices and the other workpieces about the conditions of the production.

Horizontal network connection

The communication is realized not only within one factory, but also in the whole supply chain; between the suppliers, manufacturers and service providers. The main purpose is to enhance the efficiency of production and to utilize the resources in a more economical way.

Smart workpiece

The product to be manufactured senses the production environment with internal sensors and controls and monitors its own production process in order to meet the production standards, since it is able to communicate with the equipments as well as the components already incorporated and to be incorporated.

The production technology of Industry 4.0 is not a technology from the far-away future. In July 2015 the Changing Precision Technology (Dongguan, China) became the first factory where only robots work. Each labour process is executed by machines: the production is done my computer operated robots, the transport is implemented by self-driven vehicles, even the storage process is completely automatic. Furthermore, although not fully, but many companies apply some of the innovative technologies listed in section 2.3.

THE FRAMEWORK OF INDUSTRY 4.0 CONCEPTION, RELEVANT TECHNOLOGIES

The importance of production arranged in global network is that the manufacturing process can flexibly adapt to the unique costumer demands, to the activity of the other parties of the supply chain and to the rapidly changing economic environment.

The term Industry 4.0 is getting global recognition and the survey of PWC [5] from 2016 defines three main areas, where it affects the corporate world:

- integration and digitalization of horizontal and vertical value chains,
- digitalization of products and services,
- the formation of digital business model and costumer relations.

The connected new technologies are shown in Fig. 2.

Figure 2. The main technologies of Industry 4.0 [6]

The cyber-physical production systems (CPPS) [4]

Cyber-physical production systems are online networks of equipments that connect IT technology and mechanic or electronic accessories, which are able to communicate on a network.

Intelligent machines are sharing information continuously about the current stock levels, problems, errors or the changes in demands/orders. The processes and deadlines are controlled in order to increase efficiency and to optimize lead times.

Sensors and controlling accessories allows the machines to keep contact with the factories, networks and people. Intelligent production robots are organic parts of the system, they communicate with the production control system and the workpiece to be processed, so that they are able to optimize the whole manufacturing process and realize system-wide optimization of resources.

Machine-to-machine Communication (M2M)

Machine-to-machine (M2M) communication is essential in cyber-physical systems, since it allows that the devices connected to the network initiate and actuate communication without human intervention or help. For example robots working on a production line can provide each other the necessary components, or stop the whole line in case of errors.

Artificial intelligence (AI)

Artificial Intelligence (AI) is the ability of machines to learn and think logically. With the help of AI machines can perform more complex task, which were unknown by them before not only by programs written by people, but also independently, 'consciously'.

Horizontal and vertical system integration

Products communicate with the production machines and the other workpieces as well to operate their own manufacturing. Furthermore, communication is realized not only within one factory, but also in a whole chain, between each party, such as suppliers, producers and service providers.

Internet of Things (IoT)

Machine to machine communication requires the existence of an information channel, which is called the Internet of Things (IoT). This term is applied for different, identified objects and their internet-like network. Actually IoT is a network connection and data exchange of objects, equipments, vehicles, buildings or other incorporated electronic devices. With the aid of IoT the objects not only percept their environment but also allowed to regulate it, so that the devices can be used more efficiently and economically.

Big data

Systems operating as an intelligent network requires huge, almost unmanageable amount of information. This gigantic data set is called 'big data'. The collection, storage, transport, maintenance and analysis of this data also requires lots of work.

Cloud services, cyber security

The essence of the operation of cloud-based services is to store data of softwares on a distant device, so called 'cloud' instead of local data storage. These stored information can be accessed by any given place and device with internet connection. This raises questions about the examination of access permission, safety of the distantly stored data, or in other words 'cyber security'.

Virtual reality, simulation

Actual and virtual reality merge together throughout the production. Virtuality plays an important role in

this conception both in design and production. The simulation of processes is essential during product design, production planning, and in case of material flow and stocking processes, or in modeling unexpected events and their effects.

According to experts there is 20-30% growth potential in intelligent production networks, and the companies that refuse to follow the development and modernization will fall behind in the global competition. In the near future companies will become digital corporations, which will allow them to realize custom production with maximum efficiency according to the costumers' demands. The prior condition for this is to allow every equipment, device, workpiece to communicate with each other. Although in the near future human resource will still remain the key and essential factor in production.

CONCLUSION

Globalization, changing economic environment and customers' demands and the ever increasing competition in the market emerged the need for new manufacturing technologies and business processes. These changes constantly confront the practice of logistic with new challenges. This study describes the global logistic tendencies and changes of the main production and logistic processes, as well as the driving forces and reasons behind them.

The industrial sector is going through a paradigm shift, which will change the production drastically. The traditional centrally controlled and monitored processes will be replaced by decentralized control, which is built on the self-regulating ability of products and workpieces that communicate with each other. The essence of Industry 4.0 conception is the introduction of network-linked intelligent systems, which realize self-regulating production: people, machines, equipments and products will communicate to one another.

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SOLAR AIR HEATING COLLECTORS IN TWO MODULAR SOLAR PANELS BUILD INTO A „DO-IT-YOURSELF" TYPE PROJECT USING PHOTOVOLTAIC CELLS AND RECYCLED ALUMINUM CANS

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Abstract: This paper shows a DIY ("do-it-yourself") type project. "Do-it-yourself" (DIY) is the method of building, modifying, or repairing something without the aid of experts or professionals. Academic research describes DIY as behaviors where individuals engage raw and semi-raw materials and component parts to produce, transform, or reconstruct material possessions. By promoting projects of this kind, students can understand that unconventional energy is available for everyone, at a minimal cost and with good results comparing to systems that are on the market. Students can also make a general impression that using unconventional energy represents the next stop towards the future in all the branches of the industry and protecting the environment. This paper presents the processes of designing and development of a heating system that uses solar energy. The heating system consists of two parts. The first part consists of a photovoltaic solar panel made from 36 photovoltaic cells capable of developing 65 W and 3.6 A. The second part is made of recycled materials (aluminum cans), forming radiant tubes.
Keywords: heating systems, solar energy, photovoltaic solar panel, radiant tubes

INTRODUCTION

These days, people have been talking a lot about renewable energy. The world is growing too dependent on non-renewable energy, such as fossil fuel, natural gas, oil and coal. There needs to be another idea to be green and environmentally friendly. These renewable energy sources can be used for hundreds of years without hurting the environment. There has been much research going on in science labs and farms across the country, so these sources are always evolving into better and better things. The sources are almost limitless, but there are some common ones. The most widely used heating installations in current technologies are based on burning fossil fuel but we should take in consideration that health policies nowadays are directed towards lowering the use of this kind of fuel. Nowadays, to ensure the proper conditions we need to live in, every home must be built with a heating system, with enough efficiency to ensure the optimal use of heat and water. An example of a heating system of this kind transforms the solar energy, which is unlimited into heat. The uses of heating systems based on renewable energy represent the cheapest solution to produce heat. [1-4, 7-9, 12, 15]

If effective support policies are put in place in a wide number of countries during this decade, solar energy in its various forms – solar heat, solar photovoltaic, solar thermal electricity, solar fuels – can make considerable contributions to solving some of the most urgent problems the world now faces: climate change, energy security, and universal access to modern energy services.

The largest solar contribution to our energy needs is currently through solar heat technologies. The potential for solar water heating is considerable. Solar energy can provide a significant contribution to space heating needs, both directly and through heat pumps. Direct solar cooling offers additional options but may face

tough competition from standard cooling systems run by solar electricity. Solar energy offers a clean, climate-friendly, very abundant and inexhaustible energy resource to mankind, relatively well-spread over the globe. Its availability is greater in warm and sunny countries.

Taking into consideration the time that needs to be taken to develop new technologies and at the same time the replacement of old and outdated current equipment's, it is necessary to speed up the development of technologies that can sustain the production of cheap and clean energy. [1-4, 7-9, 15] At the same time, the line of thought and the lifestyle in the society that we live in, needs to be stimulated and rejuvenated for a change to really happen.

Today, renewable energy accounts for over 20% of total global electricity generation, with solar ranking fourth after hydro, bioenergy and wind. The majority of solar energy technologies on the market today are based on the 'photovoltaic effect', whereby an electric current is produced in a material when exposed to light. [7-9, 15] Solar energy could account for 8–15% of global electricity in 2050, depending on factors such as market demand, energy policy, manufacturing costs and technological advances. [7-9, 12, 15]

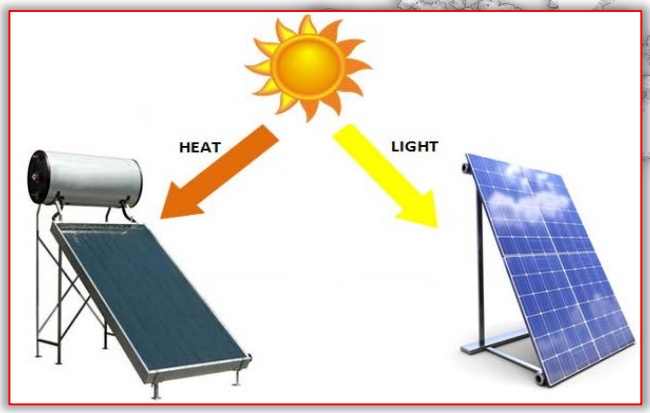

Figure 1. Solar heat and solar photovoltaic

The main concern is that on short and medium notice, renewable energy sources cannot be a complete alternative. However due to the huge possibilities that these new technologies can bring, we are experiencing heavy funding in these area of research. Renewable technologies are advantageous because of many reasons [1-4, 7-9, 15]:

- they do not polluted,
- they require minimal cost of productions, and
- the solar energy is inexhaustible, and so on.

The solar energy is without doubt the most widely used renewable energy source. Every day the sun provides our planet 20.000 times the energy that the population of Earth needs, and in just three days, the Earth receives from the sun the equivalent of all the fossil fuels that our planet disposes of. Solar-based electricity can also take part in preserving our planet's climate changes that area alarming lately. Photovoltaic solar panel transforms energy coming from the sun into electrical energy. These panels do not have to be watched and require a minimal maintenance. Current photovoltaic modules show a minimal degradation after 20 years. [1-4, 7-9, 15]

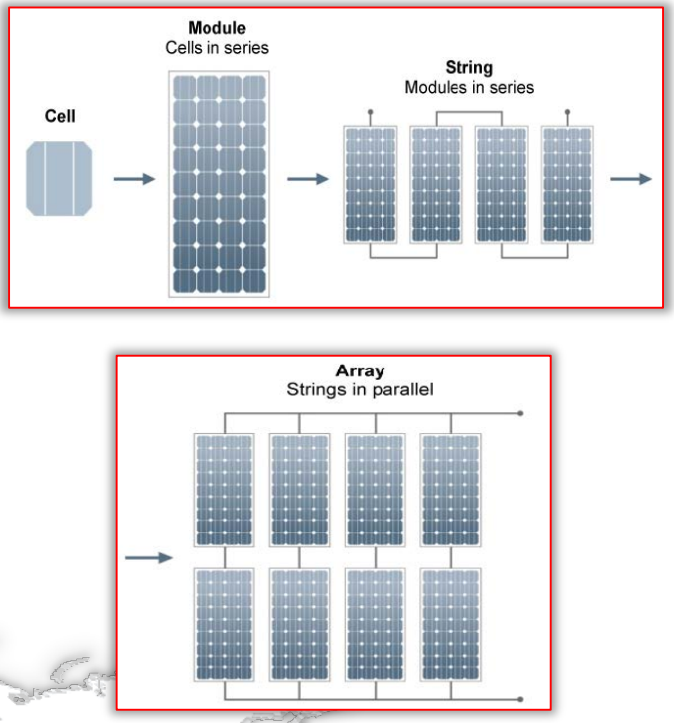

Figure 2. Current photovoltaic modules built into solar panels

Photovoltaic solar modules, commonly referred to as "solar panels," are the main collection devices in a renewable solar energy system and are the components that actually convert the Sun's rays into a daily source of clean and sustainable power. Simply put, photovoltaic solar panels create electricity by converting radiant sunlight into usable electrical power via a phenomena coined the "photovoltaic effect." They work by using individual solar cells (PV cells) that contain a photovoltaic material that converts energy from the Sun into a flow of electrons. [7-9, 14-15] Now, modern renewable energy systems have come around and are economically viable for both commercial and residential applications. Solar panels are not all you need, modern systems require supporting components including high tech batteries, charge controllers and junction boxes. [1-4, 7-9, 15]

METHODS / DESCRIPTION OF WORK

The paper shows the design and the production of a heating system using solar energy. The system is composed from two modules. The plant uses in whole energy collected from the sun, namely: radiant panel absorbs energy emitted by solar rays and converts it into heat. For directing heat formed in the aluminum tubes used was photovoltaic panel, which transforms the solar energy into electrical current. For the evacuation of air has been used fan supplied in the same way. [4-6, 16, 17]

Figure 3. The first module – the photovoltaic panel [4-6]

The first solar module consists of a handmade photovoltaic panel made from 36 solar cells that produces 65W and 3.6 A. [4-6]

The second solar module consists of recycled aluminum soda cans, cut from the top and connected at their top forming radiant tubes. The tubes are being placed in a wooden box containing two rooms: one of evacuation and one of admission. These two rooms are being connected through the tubes. The airflow is provided from two air fans placed in the two special rooms inside the wooden box. [4-6]

In figure 4 the few steps to follow showing you how to make a solar panel out of soda cans are presented. It is advisable to perform a thorough assessment of your home insulation in order to improve heating efficiency and minimize all possible losses. [4-6, 13, 16-18] This is very important because after minimizing heat loss in your home, you can actually install smaller solar system and get the same result as with the twice-bigger heating system.

First, we build the housing for solar collector, which is typically, is made of wood. Solar absorber is made out of beer and soda aluminum cans, painted in matte-black paint resistant to high temperature. The upper part (cover) of cans is specifically designed to provide more efficiency in heat exchange between the cans and the passing air. [4-6, 13, 16-18]

Figure 4. The second module – the panel from recycled aluminum soda cans [4,5]

Glue the cans together to form a column the same length the wood frame has. We used heat resistant metal adhesive to fix them. Then paint the columns a deep shade of true black, using a thermally conductive paint. It is important to have this dark shade because this is what converts the solar energy into heat, which can be harnessed in the form of flowing hot air. [4-6, 13, 16-18]

MATERIALS AND EQUIPMENT USED FOR MAKING THE INSTALLATION

For the photovoltaic module the following were used 36 photovoltaic solar cells, Plexiglas, glass (0.77 x 0.67 m), led used for verifying that the panel works and flux markers. [4-6, 13, 16-20] For the radiant panel were used 110 recycled aluminum soda cans, wooden boards, easily expandable poliuretanic foam, and cellulosic isolating material. In both cases, special equipment used for montage (boring mill, milling drill, jig saw, cutter) are used. [4-6]

The systems above presented are simple small passive solar heaters made from recycled aluminum drinks cans and a simply photovoltaic cells, and are used to heat a

garage. If the building to be heated is well insulated, a solar heater such as this can lift the temperature by a significant number of degrees. A larger heater or a number of similar heaters can be used to heat larger spaces, or to heat smaller spaces to a higher temperature. [4-6, 13, 16-20]

"Do-it-yourself" solar air heating collectors are one of the better solar projects. They are easy to build, cheap to build, and offer a very quick payback on the cost of the materials to build them. They also offer a huge saving over equivalent commercially made collectors. [4-6, 13, 16-20]

Figure 5. Modular panels

Two of the more popular designs are the pop can collector and screen absorber collector. The pop can collector uses columns of ordinary aluminum soda pop cans with the ends cut out. The sun shines on the black painted pop cans heating them, and air flowing through the inside of the can columns picks up the heat and delivers it to the room. [4-6, 13, 16-20] The screen collector uses two or three layers of ordinary black window insect screen as the absorber. The sun shines on the screen and heats it, and the air flowing through the screen picks up the heat and delivers it to the room.

We have seen that soda cans can be repurposed in many ways in our homes, especially by transforming them into decorative items. This time, soda cans find themselves a practical role in our homes by becoming a solar panel. Of course, it takes some ingenuity, patience and basic knowledge of thermodynamics to turn those beverage empties into a powerful and efficient passive solar energy cell. Passive means that it does not generate electricity directly, but rather passively assists a standard generator or serves as heating. More specifically, the heat energy from the sun then transfers through the very conductive aluminum into the air inside. [4-6, 13, 16-20]

This solution fits as a glove to those homes built in isolated areas, while it is also an efficient means of saving money in urban areas as well.

ECOLOGICAL ASPECTS

Aluminum cans (soda or beer) are easy to recycle and there are huge environmental benefits for doing this - yet many cans still go to landfill. If we recycle more cans we can reduce the amount of raw materials needed to produce new products. All the soda cans came from a local recycling depot.

Many of the drink products we buy are packaged in cans made from aluminum and this material can be recycled after we have finished with them to make either new cans or other products.

Figure 6. Blank aluminum cans

Aluminum cans are very easy to recycle. Aluminum can be melted down and made into new products repeatedly because it never breaks down or loses quality. Most recycled aluminum is used to make new cans. From the time a can arrives in a recycling facility, it takes just 60 days to melt it down, turn it into a new can, fill it with a new beverage and place it back on store shelves. Recycled cans are also used to make other kind of products.

Due to the lightweight and smaller price tag, it does not move as much as the other, more expensive metals does. In fact, when compared with copper, lead, nickel, tin and

zinc, it is the least expensive metal. This is generally because it is also the most prevalent.

CONCLUSIONS AND FUTURE IMPROVEMENTS

Over the last few years, DIYers have mostly settled on a few types of solar air heaters to make. This type was inspired by the commercial solar air heater, which uses recycled aluminum soda/beer cans stacked end-to-end to create long tubes for the air to flow through. The cans are painted black and act as the absorber. Many DIYers make this type, probably due to the abundant supply of cans and the „coolness" of the approach. Just as with the can solar air heater, the air flows inside the downspout taking heat from the inner surface as it makes contact with it. This paper shows an experimental heating system that uses solar energy. With further research, we can add many improvements to the installation.

At the current level of development, the first step in upgrading the photovoltaic module is to assemble a storage battery that can accumulate the energy, so that it can function overnight. The second step is to assemble an invertor that inverts the continuous electricity into alternative electricity. That way household device can be powered from the photovoltaic module.

It is really easy and simple to build cheap pop can DIY solar panels for supplemental home heating, by re-using scrap parts and empty pop cans. Pop can DIY solar panels are actually thermal panels that heat and recirculate the air inside the room. Water, or any kind of liquid is not used here, which makes these panels resilient to extremely low temperatures and winter freezing accidents.

The construction of a solar water heater and a solar air heater can be DIYers projects. Basically air or water is conducted through pipes or conduits to a panel where the heat exchange takes place. A growing fad in the construction of homemade air-heating solar panels is to build the collector with empty aluminum soda or beer cans. The tops and bottoms of the cans are punched or drilled out and the cans are glued together to form a continuous airtight pipes. The box that holds everything is well insulated (sides and bottom) every interior surface exposed to sunlight is spray painted a dark, sunlight absorbing color – preferably using a high quality, high temp, UV protected paint.

Solar absorbent / collector is crafted using empty beer and soda aluminum cans, painted in matte-black paint resistant to high temperature. The upper part (cover) of cans is specifically designed to provide more efficiency in heat exchange between the cans and the passing air.

DIY solar air heating collectors are one of the better solar projects. They are easy to build, cheap to build, and offer a very quick payback on the cost of the materials to build them. They also offer a huge saving over equivalent commercially made collectors.

The radiative solar energy reaching the earth during each month is approximately equivalent to the entire world supply of fossil fuels. Thus, from a purely thermodynamic point of view, the global potential of solar energy is many times larger than the current energy use. However, many technical and economic problems must be solved before large-scale use of solar energy can occur. The future of solar power deployment depends on how we deal with these constraints, which include scientific and technological problems, marketing and financial limitations, and political and legislative actions including equitable taxations of renewable energy sources.

However, even with all the research and development in the solar industry, one thing is for certain, solar panels are the best way for homeowners to create electricity simply and efficiently. Regardless of the myriad of technological advances, solar panels will remain the primary component of home solar energy production systems for the near future. There will always be various different types of photovoltaic cells being developed in an effort to improve efficiency and production costs, but the modern solar panels are amazing.

Note

This paper is based on the paper presented at The VIth International Conference Industrial Engineering and Environmental Protection 2016 – IIZS 2016, organized by University of Novi Sad, Technical Faculty "Mihajlo Pupin" Zrenjanin, in Zrenjanin, SERBIA, October 13–14, 2016, referred here as [21].

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NEW POSSIBILITIES IN CLEANING OF MATERIALS AND ENVIRONMENT

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Abstract: The contribution deals with the possibilities of metal cleaning focused on environmentally friendly cleaning as laser cleaning technology of materials. The aim of this contribution is to present the new abilities of cleaning of product and tool surfaces in very short time with minimizing of waste in the future. There are mentioned and compared various material cleaning methods from classic ones to progressive ones and their influence on the environment. Laser cleaning is one of the newest progressive methods of the material cleaning. The results of this technology were recently tested and shown in the Department of Process and Environmental Engineering, Faculty of Mechanical Engineering, Technical University of Kosice together with the firm Trumpf Slovakia s.r.o. The laser cleaning technology can be used in the various fields of industry, in the production sphere, in the renovation sphere of products and materials. This technology minimizes the harmful impact on the working environment and environment as a whole area.
Keywords: environment, laser technology, cleaning, material

INTRODUCTION

Degreasing of metal materials in the mechanical industry is an important technology force leaning materials to further processing as a finishing surface treatment or as a pretreatment before surface operation of workpieces, or is used in the maintenance of machinery parts and tools. By degreasing of metal surfaces not only removes lubricant from surfaces, butal so cleans mechanical particles from dust, abrasive parts and others. With the continuously deteriorating of environment, it is necessary to use such degreasing technologies of materials that have minimal negative impacts on the environment. Also the environment protection is encompassed by standards and decrees of REACH. [1]

The cleaning technology of materials must be quick, clear and short one. We can divide the cleaning technologies from various points of view as decreasing of materials, rust removal and surface pre-treatment of materials and also according to various methods of cleaning as [2]:

- ☐ mechanical cleaning technologies,
- ☐ chemical cleaning technologies,
- ☐ progressive cleaning technologies.

The cleaning of metal materials by mechanical technologies belongs to the oldest method of the material cleaning as brushing, blasting technologies. The cleaning process takes a relatively long time and is usually dusty and noisy, with waste as used sand, metal balls. Chemical cleaning technologies requires the using of various degreasers, chemicals, which are very dangerous for the environment in terms of storage of new and pure chemicals, their utilisation, storage of the waste chemicals and their neutralisation or recycling and joined with chemical vapours and with the necessity of rinsed water operations.

PROGRESSIVE CLEANING TECHNOLOGIES

Progressive cleaning technologies as ultrasonic cleaning technology, water jet and abrasive water jet technologies, dry ice cleaning technology, laser cleaning are based on the utilisation of the physical parameters. They enable to work more quickly, save the time, effectively and can clean accessible parts of machines and tools, reduce waste, which are very important requirements of producers. Ultrasonic cleaning technology transforms the high frequency energy on acoustic mechanics oscillations. Absorbent materials and degreasing parts due to the absorption causes the

change of the ultrasonic energy on the thermal energy. By effect of the temperature changes occurs between degreasing substances and dirt to the partial separation and thus the scouring medium gets between subject degreaser and the dirt. In US cleaning process we need chemicals, rinse water and also the waste occurs, which creates ballast from the environmentally point. In the Figure 1 is shown the principle of the ultrasonic cleaning of materials. This technology enables to clean also the shape complicated product with cavities, shown in the Figure 2, which is one of the advantages of this type of cleaning. [3].

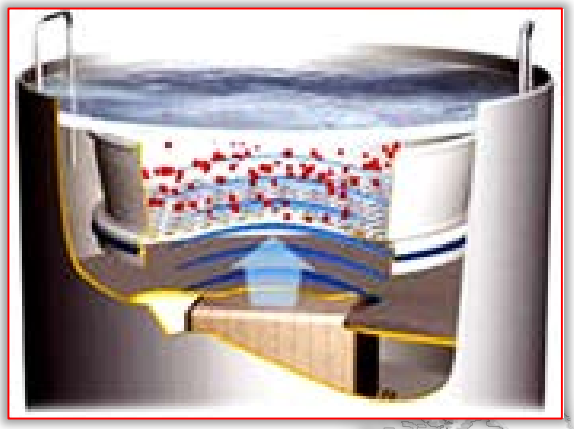

Figure 1. Principle of the US cleaning technology [3]

Figure 2. Example of US cleaning of product before and after cleaning

Dry ice blast cleaning technology utilizes a unique combination of forces to powerfully lift surface contaminants without causing of damage or creating harmful secondary waste similar to sand, bead and soda blasting. Dry ice blast cleaning prepares and cleans material surfaces by using a medium accelerated in a pressurized air stream. In the Figure 3 is shown the principle of dry ice blast cleaning [5].

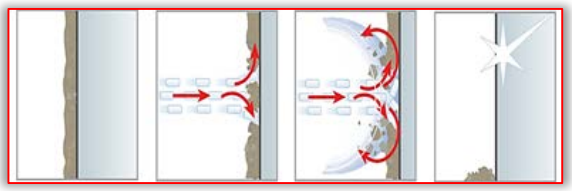

Figure 3. Principle of dry ice blast cleaning [4]

Dry ice blast cleaning offers comprehensive cleaning benefits over traditional methods, and can save up to 80% over current cleaning costs, Figure 4[6]. In the Figure 5 is shown the necessary equipment of dry ice cleaning. Except of degreasing, it can be used at the plastic cleaning from the extrusion screws at the plastic production, Figure 6.

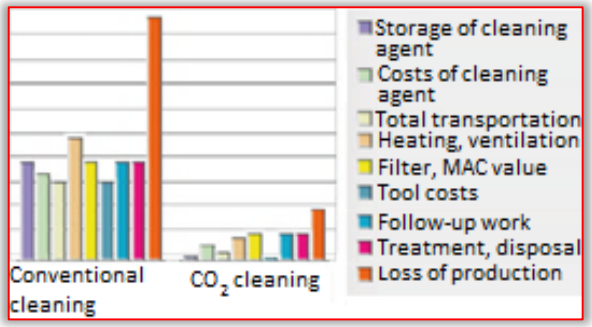

Figure 4. Incidental costs [5]

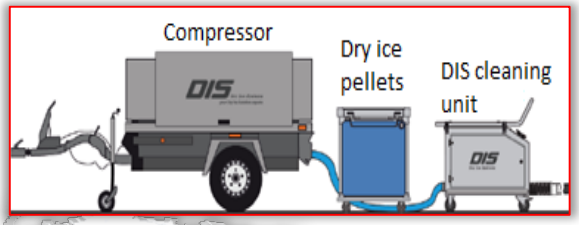

Figure 5. Equipment of dry ice cleaning [4]

Figure 6. Extrusion screws before and after cleaning operation [7]

In the Table 1 is shown the comparison of blasting technologies according to environmental requirements. Upon contact, traditional blasting materials become contaminated when used to clean hazardous substances and objects. These blasting materials are also then classified as toxic waste and require appropriate safe disposal.

Table 1. Comparison of blasting technologies according to environmental requirements [8]

Cleaning method	No secondary waste	Non-conductive	Non-toxic	Non-abrasive
Dry Ice Blasting	•	•	•	•
Sand Blasting		•	•	
Soda Blasting*		•	•	
Water Blasting*			•	•
Hand Tools	•		•	
Solvent/ Chemicals				•

LASER CLEANING TECHNOLOGY

Laser cleaning technology offers a highly selective, reliable, precise and safe cleaning method of removing layers of corrosion, pollution, unwanted paint, lubricants, other surface coatings and are environmentally friendly, using no water or chemicals and producing no effluent. Primarily laser cleaning technology is used for industrial cleaning in the automobile, aerospace, bakery, food, electronics, restoration industries and surface treatment, renovation and paint removal applications. It also removes contaminants, production residue and coatings without damaging the substrate. Metallic and reflective surfaces are ideal although other substrates can be addressed. Laser cleaning systems offer an extremely high level of control and precision. The innovative laser cleaning systems combine power and versatility, with the lowest operating cost of all industrial cleaning methods. [17], [18].

The cleaning surface reflects laser energy and is minimally affected; however, any contaminants on the surface absorb the laser energy and are quickly vaporized. The fumes or particulates are removed by an in-built filter of laser machines. When a laser beam irradiates on the material surface, it may be considered that energy flows in only one direction in a semi-infinite body. The depth the laser energy penetrated into the material surface is constrained by the duration of the laser irradiation. Increasing irradiation time will allow the laser energy to penetrate deeper so as to raise the material substrate temperature. In the Figure 7 is shown the dependence Optical absorption depths for several materials over a range of wavelengths [9].

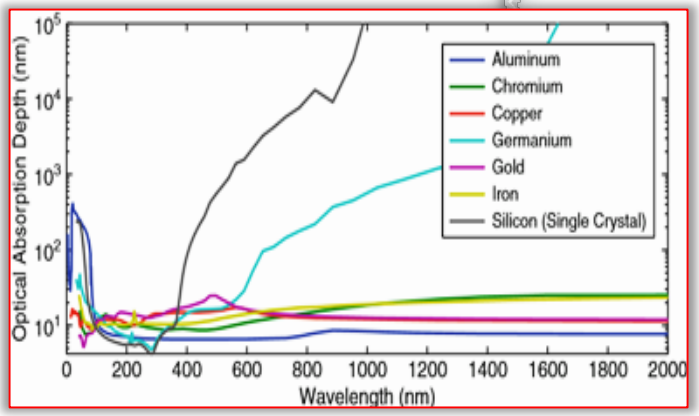

Figure 7. Optical absorption depths for several materials over a range of wavelengths [9]

The different effects of laser power flux and irradiation duration on the temperature elevation in the material can influence on the quality of laser cleaning.. For the purpose of laser cleaning, higher surface temperatures are desirable for the removal of machining debris. However, the elevation of temperature may damage the tested/ cleaned material structure, which should be prevented. Therefore, high power flux and short irradiation laser pulses are likely to be optimum for laser cleaning purposes. [10]. In the Figure 8 is shown the focus position of laser beam, which is a one way how we can prevent the damage of material structure and surface during the cleaning operation. [11].

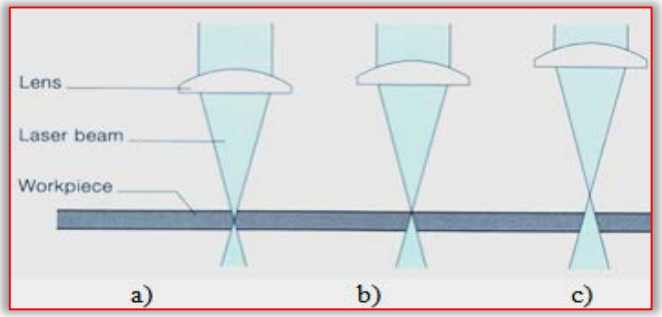

Figure 8. Focus position of laser beam: a) in the workpiece, b) on the surface, c) above the part [11]

MATERIALS AND METHODS

The realization of the experimental testing of laser cleaning was made in Technical University in Kosice together with the cooperation of the firm Trumpf Slovakia s.r.o., Figure 9. Used materials for the experiments were following:

a. Material: Steel sheet KOSMALT 190, dimension of table: 100x50 mm, thickness: 2 mm, mechanical properties were according to standard STN 038737
b. Synthetic lubrications [12],[13],[14]:

1. Berutox M21 EPK 420, temperature range: -5 °C to + 200 ~ + 220°C, viscosity of the basic oil: 490 mm2.s-1, at the temperature t = 40°C,
2. Berutox M 21 KN, temperature range: -5 °C to + 200 ~ + 220 °C, viscosity of the basic oil: 490 mm2.s-1, at the temperature t = 40 °C,
3. Beruplex LI-EP 2, temperature range: -30 °C to + 150 °C.

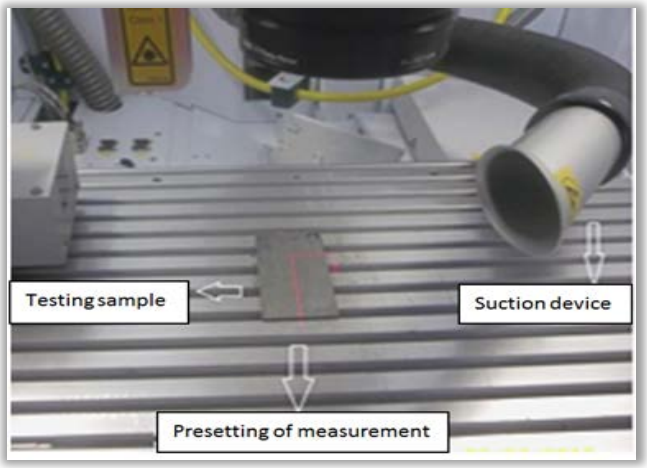

Figure 9. Laser cleaning – position of the sample

There was used 5 tested pieces for each material and lubricant combination for the experiment.

After degreasing with technical white gasoline, the tested samples were weighed on laboratory scales MS, METTLER TOLEDO. The three types of lubricants were

applied on the samples by a paintbrush and were weighed again. In the Figure 10 is shown prepared tested pieces greased with three types of lubricants. The decreasing of tested samples by laser cleaning were experimentally provided on the laser compact machine TruMarkStation 5000, with the least power, to not do an effect on the surface layer of the metal by hardening.

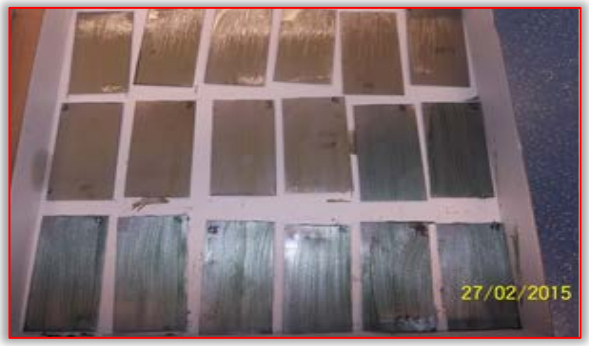

Figure 10. Tested materials

There was used the "c" type of focus position of laser beam as it is shown in the Figure 8. The condition of the laser parameters are shown in the Table 2.

Table 2. Testing parameters of laser beam at the degreasing of testing sample

beam source	TruMark 6130
optics	F 163
wavelength λ	1604 μm
speed of the laser beam v	1000 mm/s
frequency	50 kHz
defocus	1,5 mm

In the Table 3 is shown the chemical parameters of the steel KOSMALT 190. [15], [16]

Table 3. Chemical elements of steel KOSMALT 190

Chemical element	C	Mn	$Si_{max.}$	$P_{max.}$	$S_{max.}$	Al	$Cu_{max.}$	$Ti_{max.}$
content[%]	max. 0,04	max. 0,19	0,01	0,015	0,012	0,02 – 0,06	0,060	-

RESULTS

After laser cleaning operations, the tested samples were weighted again and were found the weight loss of tested samples. The weighted values of the tested samples are shown in the Table 4.

Table 4. Examples of the values of the tested samples c leaned by laser beam

	Weight of tested sample			
Sample	Degreased sample by white gasoline	Sample + lubrication	Degreased sample by laser	Used lubricant
1	53,189	53,607	53,505	Berutox M 21 EPK 420
2	52,029	53,074	52,77	Berutox M 21 KN
3	53,972	55,518	54,593	Beruplex LI-EP2

After preparing of tested samples with three types of lubricant, Figure 11, the laser beam passed only one time through the surface samples during the laser cleaning. During the experiments we changed the setup of the laser focus on the position +2,+1,0, -1, -2 regarding to basic position (according Figure 8).

These results are shown from the Figure 12 to Figure 14.

a) b) c)

Figure 11. Tested samples No. 14, 7, 29 before degreasing by laser cleaning: a)No-14 Beruplex, b) No-7 Berutox M21 EPK/420,c) No29 Berutox M21 KN

In the Figure 13 and Figure 14 are shown the laser paths with the cleared areas and areas with the rest of lubricant. From the practice of laser testing is known, that the synthetic lubricants remove very hardly. The experiment confirmed this assumption.

The details of tested samples were examined in the microscope Olympus at mag. 50x, mag. 100x.

a) b) c)

Figure 12. Tested samples No. 14, 7, 29 after laser cleaning: a)No-14 Beruplex, b) B No-7 Berutox M21 EPK/420, c) C No29 Berutox M21 KN

In the Figure 15 and Figure 16 are shown the path of laser cleaning on the sample that can be observed as a macrostructure of tested material with the remains of lubricants in the form of drops.

In the Figure 17 are shown the examples of the microstructures of tested samples with using of two lubricants, where can be seen the laser points (as the path) and residual of lubricants drops.

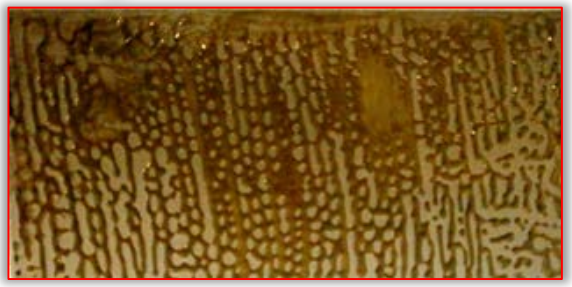

Figure 13. Sample after laser cleaning Lubricant Berutox M 21 EPK 420, mag.5 x

Figure 14. The sample after laser cleaning Berutox M 21 KN, mag.50x

Figure 15. The sample after laser cleaning lubricant Berutox M 21 KN , mag.50x

Figure 16. Detail of degreasing of lubricant Berutox M 21 KN, mag.50x

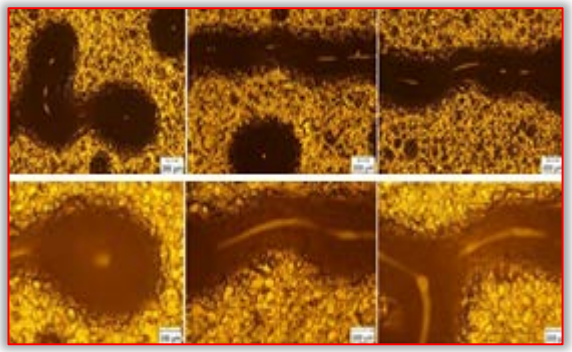

Figure 17. Samples after laser cleaning: lubricant Berutox M 21 EPK 420, mag.100x, Berutox M 21 KN, mag. 100x

The results of the comparison of the chosen tested samples weighted on the laboratory scales and cleaned by laser beam, are shown in the Figure 18.

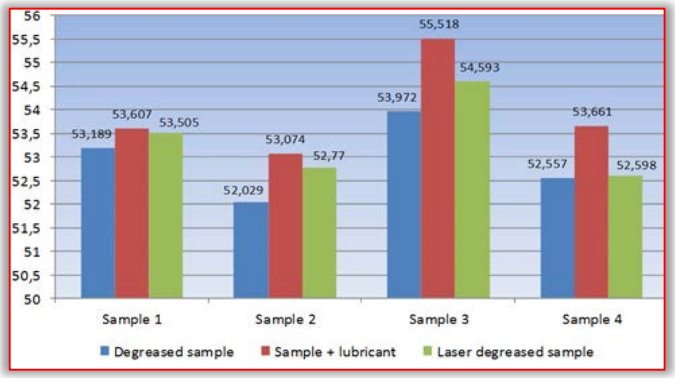

Figure 18. Degreasing of testedsample by laser beam, 1 – Berutox M 21 EPK 420, 2 – Berutox M 1 KN, 3 – Beruplex LI-EP 2, 4 – Berutox M 21 KN

CONCLUSION

Due to the ongoing problem of environmental protection of living and workplace environment, we try to find ways how to minimize production waste and reduce the number of technological operations on the products.

The engineering industry as a whole is greatly utilize the lubrication of materials for the rust protection, for technological operations and od the other hand we must degrease the workpieces before surface finishing operations . Also during the life-service of machines occurs the necessity to do the maintenance or to remove the dust from functional parts. That is why we try and look after new progressive technologies, which enable to minimize the number of technological operations, save the amount of chemicals. This is the new way how to minimize the impact on the environment. One of these ways was to try degreasing of the testing samples by laser technology and as it can being in ultrasonic machines with the using of chemicals and rinsing water.

In cooperation with TRUMF Slovakia, s.r.o., we tested and verified the possibility of cleaning of the samples with a laser beam (with the compact machine TruMark 5000) for the first time.

From the experiments, it is shown that during the laser cleaning tests of the samples, it is necessary to define the exact conditions of cleaning, how to set parameters of laser beam, to define the material properties as reflexivity, mechanical properties to reach the best results.

The samples were greased by the synthetic lubricants BERUTOX M 21 KN and the lubricant Berutox M 21 EPK 420, where the worst results were reached with the samples, which were greased by the lubricant Berutox M 21 EPK 420. Organic lubricants, as sunflower oils or fat burn during the cleaning operations that is why we did not used them.

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DEVELOPMENT OF COMPUTER PROGRAM FOR DESIGN OF A SCALABLE COMBUSTION FURNACE USING PALM KERNEL SHELL AS HEAT SOURCE

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Abstract: Steam boiler is an integral and important component of steam turbine used for electricity generation. Its design is however complex, time consuming and prone to errors if done manually. In this study, we report the application of computer based approach to design palm kernel shell combusting furnace for generating a desired amount of electricity. Using backward calculation approach, standard design equations were used to size furnace and its components. The equations were coded and solved using C-Sharp programming language. The results showed that to generate 5 kW of electricity from palm kernel shell; 5.5 kW turbines, 3.6 m super heater, 3.2 m riser, furnace of 1.432 m height and 0.45 m^3 volume were required having considered power loss due to friction and others. While these results are in good agreement with those calculated manually, human errors are virtually eliminated. In addition, calculations and drafting time were reduced from 5 hrs 47 mins when done manually to about 4 mins when the developed code was used. This code can be used to size boiler for any desired power output.
Keywords: Steam boiler, palm kernel shell, design, computer aided, power output

INTRODUCTION

In palm oil processing industry, biomass residues can be converted from being potential environmental pollutants to useful fuel for steam and electricity generation which are largely needed for industrial use [22]. Nigeria, being the fifth largest producer of palm oil, accounts for about 1.5 % (93 0,000 metric tonnes) of the global output. However, a huge quantity of oil palm residues which could otherwise be used for energy generation is being wasted [11]. Muhammad et al. [14] reported that about 30 tonnes of fresh fruit bunches /hr produce from a few palm oil mills can be used to generate up to 20 - 35 MW of electricity. This can significantly reduce greenhouse gases and increase employment for local population [21].

There are several technologies that enable oil palm mill to generate enough energy for its consumption and sometimes for export. Among them are fixed (1 kW- 50 MW), fluidized (5 MW- 100 MW) and dust technology (10 MW- 500 MW). Efficiencies of these technologies are dependent on fuel properties and the mixing quality between flue gas and combustion air [20]. Another researcher [17] recorded high combustion efficiency and low emission performance in a fluidized bed combustion of palm kernel shell using optimized particle size, although the start up and running cost of operation associated with this technique make it difficult to be operated by small scale business. Remarkable improvement has also been recorded on design of large scale grate furnaces (fixed bed), yet additional work need to be done in small scale businesses in term of poor mixing especially when co-firing different fuel and high moisture fuel content for improve combustion and reduction of ash deposition on components of grate furnace [15]. The unique features of grate furnace are the tolerance of fuel type; positive movement of fuel down grates reduces blockages and well controlled air distribution lead to high combustion efficiency [23]. In addition, the use of additive mixed with solid wastes can significantly reduce alkaline metals deposition on the surface of riser tubes [13]. These will increase combustion process and decrease ash deposition.

Boiler design is a complex and time consuming procedure. It is also prone to errors if done manually. Previously, emphasis was laid on primitive and probabilistic design processes which resulted in high cost of production. Dimensions of boiler for power generation often depend on fuel and vaporization efficiency; the mass balance, heat balance and heat transfer which has to be specified through empirical results and experiences. In this paper, we report the application of computer based approach to design palm kernel shell combusting furnace for generating a desired amount of electricity using backward calculation approach.

MATERIALS AND METHOD

Palm Kernel Shell (PKS) were collected from a local palm oil processing mill in Ogbomoso, Southwestern Nigeria. The shells were crushed into smaller pieces by using a granulator (SG-16 Series) and further reduced with a blender. They were subsequently sieved to 5.0 mm particle size according to [17]. The proximate and ultimate analyses of the PKS were done following [2]. Higher Heating Value (HHV) of the mixtures was determined using GallenKamp Bomb Calorimeter according to [3].

Development of Grate Furnace and its Components

The furnace under consideration was based on principle of water tube natural circulation. The main components of this furnace are steam drum, downcomer, riser tubes which represents the complete fluid flow loop.

Water flows to the steam drum through downcomer riser loop. The riser tubes were situated inside furnace where heat of flue gases vaporizes the water into steam and back to the steam drum through steam header collection (Figure 1). Because steam water mixture inside riser tubes is less dense than the saturated water at inlet tube, fluid flows upwards in the riser tubes and back to the drum. The density difference between water at the inlet tube and steam-water mixture produces enough force to overcome friction and gravitational resistance to flow, therefore maintain a steam flow system [4].

The steam drum is partitioned into two zones. The lower section allows water intake to the drum while the upper section produces steam which flows from the top of the drum into the superheater tube. The superheated steam is expected to turn turbine to generate electricity. The design analysis follows backward calculation approach of sizing the power plant component to generate steam for 5 kW of electricity (Generator – Turbine – Superheater – Riser tubes – Furnace dimensions). The design approach to each component is described in the following sections.

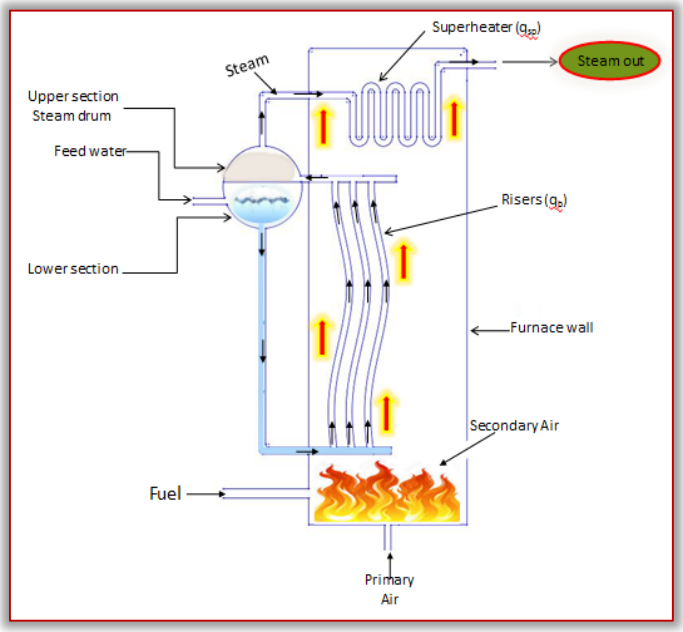

Figure 1: Schematic diagram describing water to steam circulation loop

Turbine: is a rotary engine that converts the energy of the steam, water or gas into mechanical energy. The mechanical energy is then transferred through a driven shaft to power electric generator.

The power input from turbine P_{turb} can be related to the power output of generator P_{out} by Eq. (1).

$$P_{turb} = P_{out} + P_{loss} \quad (1)$$

The generator efficiency η_{gen} is calculated from Eq. (2).

$$\eta_{gen} = \frac{P_{out}}{P_{out}+P_{loss}} \quad (2)$$

where,

$$P_{loss} = P_{mechanical} + P_{I^2R\,loss}$$

The mass flow rate of steam m_s from superheater entering turbine was estimated using energy equation for adiabatic expansion which relates the power output to steam energy declining by passing through the turbine [5].

$$m_s = \frac{P_{turb}}{C_{pm}\,\eta(T_{in}-T_{out})} \quad (3)$$

For steam: c_p = 1.8723 kJ/kgK and c_v = 1.4108 kJ/kgK. But, $\gamma = \frac{C_p}{C_v}$, therefore:

$$T_{out} = T_{in}\left(\frac{P_{out}}{P_{in}}\right)^{\frac{\gamma-1}{\gamma}} \quad (4)$$

where, T_{in} is the inlet steam temperature, T_{out} is the outlet steam temperature, γ is the index number C_p is the specific heat capacity of steam at constant pressure and C_v is the specific heat capacity of steam at constant volume C_{pm} is the mean specific heat capacity of steam. For 5 kW power rating, T_{in}, P_{in} and P_{out} are chosen as 400°C, 0.1 MPa and 0.45 MPa, respectively. These were the state properties of steam turbines obtained from V-FLO Pump and System, Beijing, China (www.v-flo.com).

Coulson and Richardson [6] defined the mean specific heat capacity C_{pm} over the temperature range T_1 to T_2 by Eq. (5).

$$C_{pm} = \frac{\int_{T_1}^{T_2} C_p dT}{\int_{T_1}^{T_2} C_p dT} \quad (5)$$

The specific heat capacity (C_p), as a function of temperature, is given by Eq. (6)

$$C_p = a + bT + cT^2 + dT^3 \quad (6)$$

Superheater: Is heat exchanger that transfers heat energy from a heating medium to a heated medium. The heating medium is usually flue gas while the heated medium is steam. An energy balance equation of super heater is:

$$q_{sp} = m_s C_{pm}(T_{sp} - T_s) \quad (7)$$

where, $q_{sp}$is the heat duty required by the superheater, T_{sp} and T_s is the temperature of superheated and saturated steam from superheater and boiler respectively.

The energy balance equation of the riser tube is given by Eq. (8):

$$q_b = m_s c_p(T_s - T_d) + x_s m_s L \quad (8)$$

Assuming the water from down comer is saturated T_d = 100 C, and T_s = 100 C; steam is in equilibrium with water in the riser. $T_s = T_d$ =100 C, Therefore

$$q_b = x_s m_s L \quad (9)$$

where, q_b is the heat duty required by the riser tube, L is the specific latent heat of vaporization

x_s is the dryness fraction of steam/water mixture

$$q_f = m_{fuel} \times LHV \quad (10)$$

where, m_{fuel} is the mass of the fuel, q_f is the heat liberated by the fuel

$$m_{air} = \text{Air} - \text{fuel ratio} \times m_{fuel} \quad (11)$$

Furnace volume: Chungen et al., [7] documented typical value of volumetric heat release rate (q_v) for biomass as 0.176 MW/m³. Similarly, [19] reported furnace strain level largely depends on different fuels and if the electric power of the plant is known, strain levels for volume can be chosen.

The furnace volume V, grate area A and furnace height h can be obtained from Eq. (12), Eq. (13) and Eq. (14), respectively.

$$V = \frac{q_f}{q_v} \quad (12)$$

$$A = \frac{\pi d^2}{4} \quad (13)$$

$$h = \frac{V}{A} \quad (14)$$

Sizing of riser and superheater:

The heat duty required in the riser is given by:

$$q_b = UA\Delta T_{LM} \quad (15)$$

And the overall heat transfer (U) based on the outside area (A) of the riser tube can be estimated as;

$$\frac{1}{U} = \frac{1}{h_g} + \frac{t_r}{k_w} + \frac{1}{h_b}\left[\frac{d_o}{d_i}\right] \quad (16)$$

where: h_g is the heat transfer coefficient of flue gas, t_r is the wall thickness of riser tube, k_w is the thermal conductivities of stainless steel (304), d_o and d_i are internal and external pipe diameter, h_b is the heat transfer coefficient of water boiling.

The analysis of heat transfer associated with flow past the exterior surface of a solid is a complicated situation due to boundary layer separation [10]. Nusset number can also be used to calculate heat transfer coefficient of flue gas (h_g).

Specific heat capacity, dynamic viscosity and thermal conductivity of flue gas

Verbanck [24] determined specific heat capacity of flue gas (C_{pg}) as the summation of the product of the mass fraction of each component of flue gas m_k (kg/kg) by its respective specific heat at the relevant temperatures c_k (kJ /kg°C) as:

$$C_{pg} = \sum m_k c_k \quad (17)$$

$$c_k = A + BT + CT^2 \quad (18)$$

Hassan and Ibrahim [9] stated that heat losses through casings must be accounted for if accurate computation of flame temperature is to be made. This was done by setting up heat balance equation for flue gas as follows:

$$Q_{combustion} - Q_{loses} = \sum C_{pg} \times m_g \times (T - T_{air}) \quad (19)$$

where; $Q_{combustion} = m_{fuel} \times LHV$ (20)

According to [9],

$$Q_{loses} = 5\% \times Q_{combustion} \quad (21)$$

The dynamic viscosity μ_g of flue gas is obtained from Eq. (22) by [24]:

$$\mu_g = \sum \frac{\mu_k m_k}{\sqrt{M_k}} \div \sum \frac{m_k}{\sqrt{M_k}} \quad (22)$$

Thermal conductivity of the flue gas(k_g) was determined from Eq. (23) according to [8]

$$\frac{k_g}{\mu_g C_v} = 1.32 + \frac{1.77R_g}{C_v} \quad (23)$$

$$C_v = C_{pg} - R_g \quad (24)$$

From Eq. (23) and Eq. (24), we have;

$$k_g = \mu_g(C_{pg} - R_g)\left[1.32 + \frac{1.77R_g}{C_{pg} - R_g}\right] \quad (25)$$

where, R_g is the characteristic gas constant of flue gas,

R_{CO_2} =188, $R_{O_2} = 260, R_{H_2O} = 462$,

$R_{N_2} = 297, R_{SO_2} = 130$

C_v is the specific heat capacity of flue gas at constant volume

Prandtl and Reynolds numbers of the flue gas

The Prandtl number P_r and Reynolds number Re_D of flue gas are given by Eq. (26) and Eq. (27), respectively.

$$P_r = \frac{\mu_g C_{pg}}{k_g} \quad (26)$$

$$Re_D = \frac{m_g d_b}{\mu_g A_{cr}} \quad (27)$$

where, A_{cr} is the crossectional area of flow of flue gas, D is the diameter of riser tube

For an external cross flow to a cylindrical pipe, the Reynolds number range 40-4000 and $P_r \geq 0.7$, the average corresponding Nusselt Number according to [10] is given by:

$$\overline{NU_D} = 0.683 Re_D^{0.466} P_r^{1/3} \quad (28)$$

$$\overline{NU_D} = \frac{h_g D}{k_g} \quad (29)$$

The empirical equation proposed by [12] for the calculation of heat transfer coefficient of water boiling h_b is as follow

$$h_b = 2.8P^{0.176} q^{0.7} \quad (30)$$

valid at $0.2bar \leq P \leq 98bar$

where, $q =$ heat flux $\frac{W}{m^2} = \frac{q_b}{A_s}$, P is the saturated pressure, A_s is the surface area of riser

Evaluation of logarithmic mean temperature (ΔT_{LM})

Heat obtained by the riser is the heat given out by the flue gas

$$q_b = m_g C_{pg}(T_{gin} - T_{gout}) \quad (31)$$

For a cross flow heat exchanger, [19] gives the Logarithmic Mean Temperature Difference as follow

$$L_{MTD} = \frac{(T_{gin} - T_{so}) - (T_{gout} - T_{sin})}{\left[\frac{T_{gin} - T_{so}}{T_{gout} - T_{sin}}\right]} \quad (32)$$

where; T_{gin} is the temperature of flue gas in,

T_{gout} is the temperature of flue gas out,

T_{so} is the temperature of saturated steam out

From the equation (15) the total heat transfer surface area A_s is given by;

$$A_s = \pi d L \quad (33)$$

Where; d_o = outside diameter of tube (m) and L = length of tube (m).

Software development: Based on equations (1-33) an algorithm was written and then translated to computer code using C# programming language and .Net framework. The flow chart upon which the algorithm was based is shown in Figure 2.

The code receives input parameters in order to size components for 5 kW of electricity and gives dimensions of furnace, riser and superheater tube as outputs. In addition, 2D drafting of combusting furnace was done in AutoCAD and was dynamically loaded into the Visual Studio workspace of the application.

It should be noted that .Net frame work was selected because of its ease of deployment, interoperability, and automatic management of resources and cross platform support. Here is the algorithm for the software development:

(a) Enter the electrical output power in kW and efficiency of synchronous generator in (%) from design requirement;

(b) The properties of the PKS based on its ultimate analysis (i.e. carbon, hydrogen, oxygen nitrogen and sulphur) were supplied;

(c) The mass fraction of the flue gas component and the mean specific heat of the flue gas component available were stored in the software database; Submit to compute for turbine parameters;

(d) Click on further calculations on furnace, heat transfer coefficient of flue gas and heat transferred on super heater and riser tube; submit to compute furnace parameters, convection coefficient and length of superheater and riser tube; and when all conditions required for sizing furnace components have been adequately satisfied with respect to the calculation to the four steps above, the design parameters are then used to draft the 2D of the furnace. This is done through drafting modules wherein the geometries has been mathematically represented within the developed software.

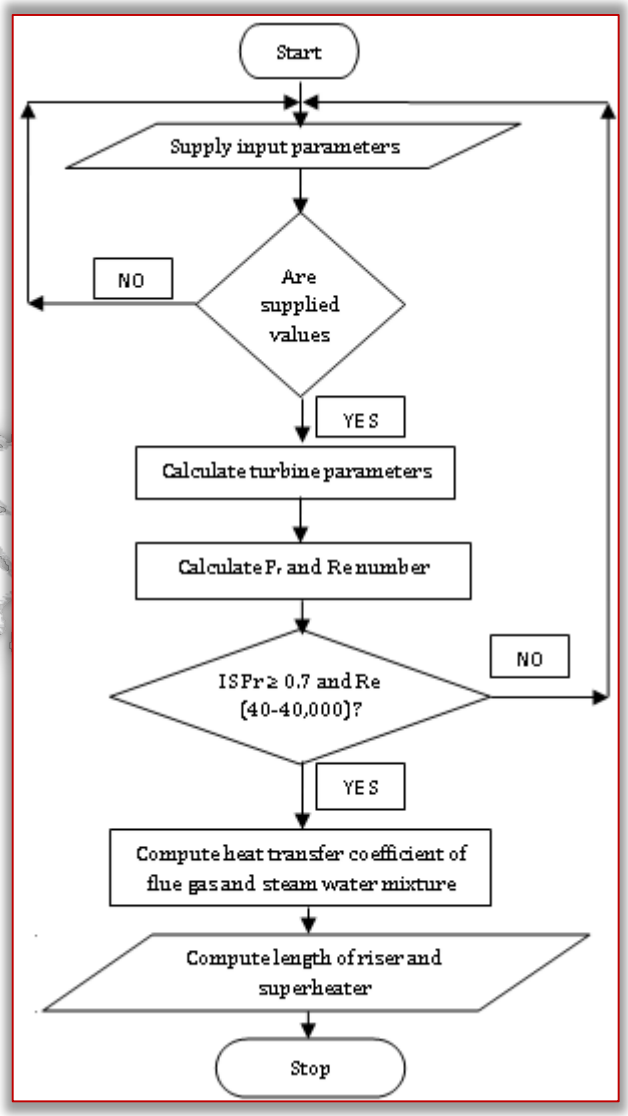

Figure 2: Flowchart showing sizing of PKS combusting furnace

Fabrication and assembly of steam boiler: The components of the boiler developed are superheater, riser, water tank, drum, and furnace chamber. Figure 3 depict the exploded view of PKS combustion unit. The fabrication process, material selection and cost analysis for each component' are reported elsewhere.

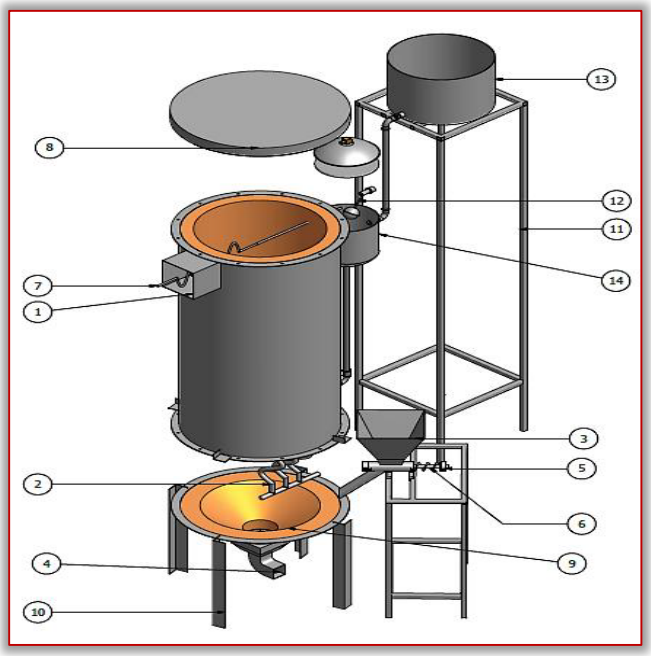

Figure 3: Exploded view of PKS Combusting Furnace

Item	Qty	Part list
1	1	Superheater port
2	3	Riser
3	1	Hopper
4	1	Primary air inlet
5	2	Ball bearings
6	1	Auger
7	1	Superheater
8	1	Furnace cover
9	1	Bricks
10	1	Furnace stand
11	1	Water tank stand
12	1	Water level valve
13	1	Water tank
14	1	Drum

RESULTS AND DISCUSSIONS

Proximate and ultimate analysis

The proximate analysis of the sample of PKS collected from a local oil palm mill in Iresapa Ogbomoso Southwestern, Nigeria (Table 1) showed moisture content, volatile matter, fixed carbon, and ash of 2.70 %, 44.20 %, 52.79 % and 0.31 %, respectively. These results are largely different from those of [16]. It can be seen that this biomass contain low moisture and ash content which resulted to substantial higher heating value of the shell while compared to [16].

Similarly, the ultimate analysis (Table 2) shows that percentage weight of oxygen and hydrogen content in this study are higher while carbon, sulphur and nitrogen content are lower compared to those of [16]. This might be due to the variations in the species, location, soil type, climatic condition of the palm kernel shell sourced.

Table 1: Proximate Analysis
(% by weight on dry basis) *[16]

Property	This study	[16]*
Moisture	2.70	5.40
Volatile matter	44.20	71.10
Fixed Carbon	52.79	18.80
Ash	0.31	4.70

Table 2: Ultimate Analysis
(% by weight on dry basis) *[16]

Roperty	This study	[16]*
Carbon	45.12	48.06
Hydrogen	10.67	6.38
Nitrogen	0.27	1.27
Oxygen	40.11	34.10
Sulphur	0.62	0.09
LHV (MJ/kg)	15.17	

Component dimensions based on the developed software

The graphical user interface for sizing turbine parameters is shown in Figure 4. The input parameters, which are the output power, efficiency of generator and location of PKS used, are provided.

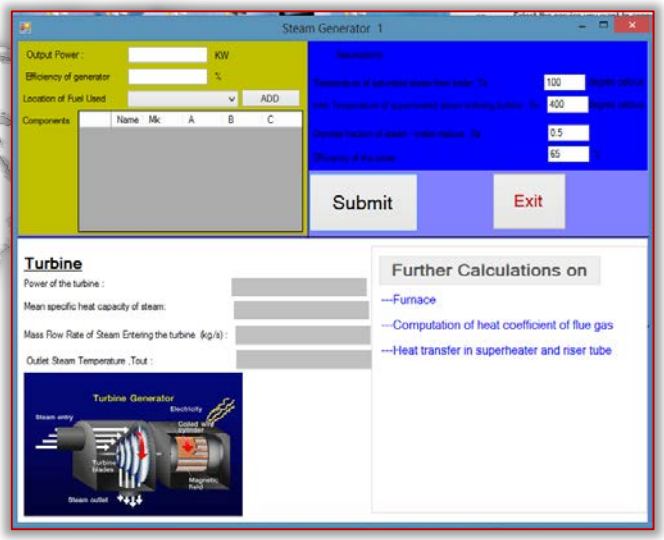

Figure 4: Template for the Turbine Parameters

To obtain furnace parameters, length of riser and superheater tube, 'further calculation' bottom is clicked. For example, to size turbine components for 5 kW of electricity generation, the efficiency of a synchronous generator (90 %) is provided and Ogbomoso is selected as the location of PKS used. By clicking the 'submit' button, we obtained 5.56 kW of turbine, 0.0275 kg/s of steam entering turbine, 276.09 °C of outlet steam temperature and 0.03571 kJ/mol°C of mean specific capacity of the steam (Figure 5). These values are required to generate 5 kW of electricity. By clicking 'further calculations on furnace' heat transfer coefficient of flue gas and heat transferred on super heater and riser tube, and the furnace can be appropriately sized.

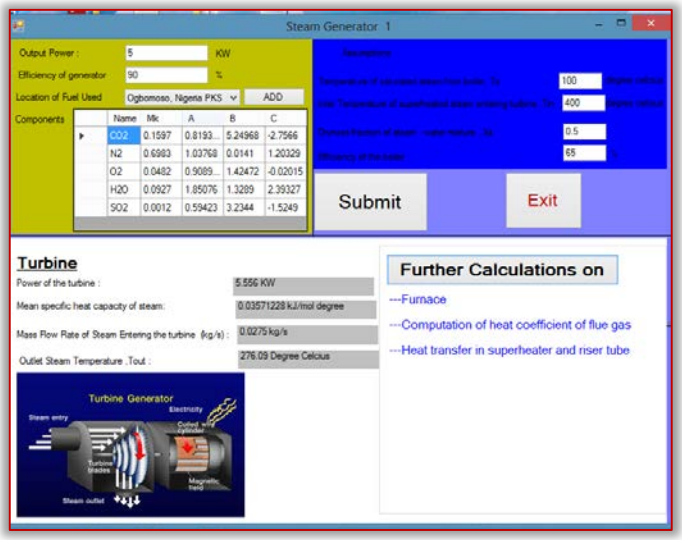

Figure 5: Output Screen for the Turbine Parameters

For 5 kW; 17.36 kg/hr of fuel, 0.405 m^3 volume, 1.432 m height and 0.0376 m^3 volumetric air flow rate are needed (Figure 6).

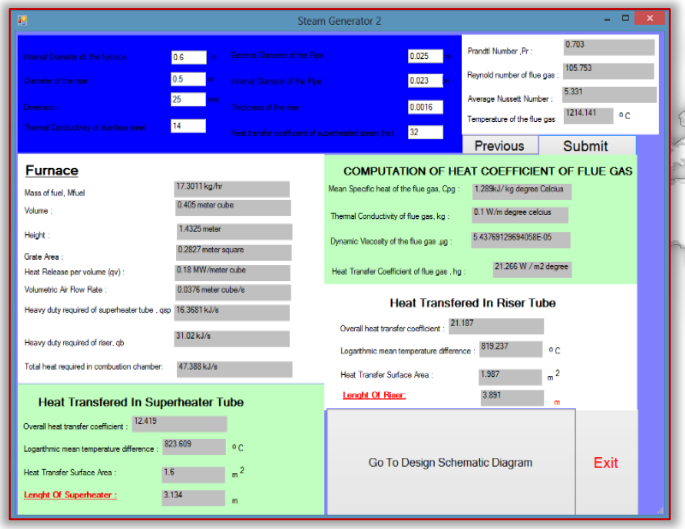

Figure 6: Output Screen for the Furnace parameters and Length of riser and superheater tube

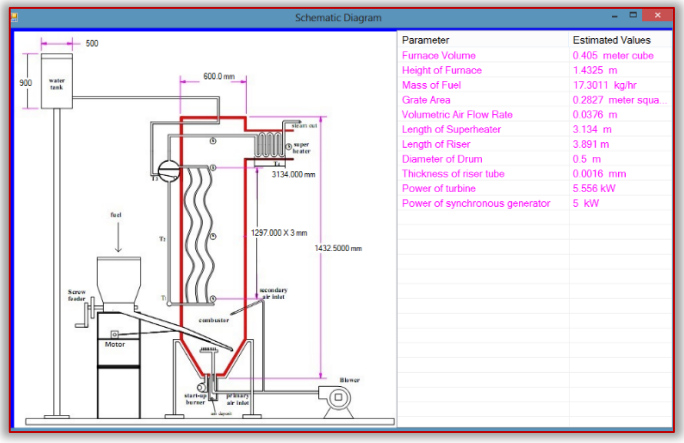

Figure 7: Output Screen Schematic Drawings and Estimated Values of (5 kW) PKS Combustor

The equivalent designed PKS combusting furnace is shown in Figure 7. The software can be used to size furnace for generating specified power.

To validate the accuracy of the developed software, we compared the results obtained manually with those obtained via the software. The results are found to be very similar (Table 3).

Table 3: Comparison of manually calculated and software generated values on PKS furnace design

Parameters	Manually calculated values	Computer generated parameters
Power of the turbine	5.560 kW	5.556 kW
Mass flow rate of steam entering turbine	0.028 kg/s	0.028 kg/s
Outlet steam temperature	276.10 C	276.05 C
Specific heat capacity of steam	0.0362 kJ/mol°C	0.0357 kJ/mol°C
Mass of fuel	17.3 kg/hr.	17.301 kg/hr.
Volume of furnace	0.414 m^3	0.405 m^3
Grate Area	0.283 m^2	0.287 m^2
Height of furnace	1.4325 m	1.4325 m
Volumetric air flow rate	0.035 m^3/s	0.035 m^3/s
Diameter of drum	0.500 m	0.500 m
Thickness of riser tube	1.6 m	1.6 m
Heat duty of riser tube	31.01 kJ/s	31.02 kJ/s
Heat duty required of superheater	16.461 kJ/s	16.368 kJ/s
Total heat required in furnace	47.349 kJ/s	47.388 kJ/s
Length of riser tube	3.782 m	3.891 m
Length of superheater	3.135 m	3.135 m

Table 4: Data Sheet for Power Plant Components for 10 and 25 kW

Parameters	Rated Power	
Parameters and Estimated values	10 kW	25 kW
Power of the turbine (kW)	11.11	27.77
Mass flow rate of steam entering turbine (kg/s)	0.05	0.035
Specific heat capacity of steam (kJ/mol°C)	0.035	0.137
Mass of fuel (kg/hr)	34.60	86.53
Volume of furnace (m^3)	0.81	2.026
Grate Area (m^2)	0.28	0.282
Height of furnace (m)	2.86	7.167
Volumetric air flow rate (m^3/s)	0.075	0.188
Thickness of riser tube (m)	0.002	0.002
Heat duty of riser tube (m)	62.04	155.21
Heat duty required of supreheater (kJ/s)	32.77	81.90
Total heat required in furnace (kJ/s)	94.77	237.13
Length of riser tube (m)	3.89	3.89
Length of superheater (m)	5.25	10.85

In terms of time saving, manual calculations and drafting of furnace components details took about 5 hrs 47 minutes while the same process was completed in 4 mins when the software was used. The software can be used to size furnace and its component for any desired output. Data sheet power plant component for 10 and 25 kW were shown in Table 4.

CONCLUSION

The developed software using C-sharp programming language automatically sizes the furnace and its components with two dimensional working drawings. The software outputs were compared to the manual computations, and the results were found similar.

For a fuel feed rate of 17.3 kg/hr and volumetric air flow rate of 0.00376 m^3/s; the temperature of flue gas, mean specific heat capacity of steam and outlet steam temperature required for 5 kW power rating were 1214 C, 0.0357 kJ/mol C, and 276.05 C respectively.

Manual calculations and drafting of furnace components details took about 5 hrs 47 mins while the same process was completed in 4 minutes when the software was used. In addition, inaccuracies due to human errors are virtually eliminated. However, cost analysis, fabrication process of the developed boiler and material selection were not reported, in addition the developed software is only suitable for sizing furnace and its components using oil palm wastes as a source of fuel.

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GREEN ROOFS

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Abstract: Roofs are much more than mere 'functional components' that protect the structure of a building. They give character to both individual buildings and entire city quarters. Roofs attract urban designers looking for socially responsible concepts, which are opposed to the loss of natural living space and offer solutions to the problems such as precipitation management or the urban heat island effect of densely populated cities. This paper discusses extensive, intensive, and semi-intensive green roofs.
Keywords: green roofs, extensive greenery, intensive greenery

INTRODUCTION

Building design changes constantly, but the function of buildings always remains the same: protection, comfort, and warmth during winters and coolness during summers.

The research conducted over the past several decades indicates that buildings are the highest energy consumers (about 40% of total global consumption), so their environmental impact has come into focus in the previous years. In addition to standard energy efficiency measures, such as façade reconstruction or door and window replacement, increased emphasis has been placed on the construction of green roofs as a potential energy efficiency measure, wherever it is feasible, but primarily in urban environments.

Green roofs provide additional green surfaces in urban areas with limited open space, but they also raise the value of buildings. The appeal of these roofs is best corroborated by the fact that they can also be conceptualized as public gardens, or business or recreational spaces, which offer numerous possibilities for use [1, 2].

Green roofs are commonly built on flat rooftops. Flat-roofed buildings are one of the symbols of modern architecture. The most important representatives of this architectural trend are Le Corbusier, Walter Gropius, Bauhaus School representatives, Frank Loyd Wright, and others. Le Corbusier defined the roof garden as a key living space for future urban population.

Austrian architect Friedrich Stowasser was one of the first architects to stress the significance of green roofs as a means of non-aggressive resistance against negative evolution. He saw nature as heightened reality, a source of universal harmony, and he believed that it should be protected from its worst enemy – humans. He wanted the time spent in his buildings to imitate the time spent in nature. He also considered trees to be a constituent part of human constructions. Hence, his buildings typically include trees and shrubbery on rooftops.

In the late 20th century, the fundamental principles of green architecture were established, pertaining not only to green roofs, but also to extensive and intensive greenery on large buildings, as well as green façades.

In recent years, much attention has been given to roof gardens, which initiated the construction of numerous green roofs of extraordinary design.

Today, green roofs are constituent elements of bioclimatic architecture [3, 4].

ADVANTAGES & DISADVANTAGES OF GREEN ROOFS

Green roofs can serve as balconies, because their inclination should be minimal, only enough to allow water to drain. A 0.5% inclination is sufficient. On the other hand, the inclination should not exceed 40° due to erosion and in order to preserve the compactness of the green mass. There are construction technologies that

enable construction at higher inclinations, but they are also costly. Depending on the building statics, the weight of the green roof should also be considered. There are roofs with the soil layer as thick as 50 cm but there are also those very thin soil layers.

Green roofs have certain advantages over regular roofs:

- they reduce energy consumption in buildings because they act as thermal insulation, thus reducing building heating and cooling expenses by ca. 20%;
- they protect the roof from UV radiation and mechanical damage, which extends the roof's life;
- water is retained and it slowly evaporates, thus preventing high-volume drainage into the storm sewer, which in turn eliminates the need for additional sewerage infrastructure;
- they reduce dust levels in the surrounding area;
- they regulate air humidity;
- they provide new habitats for plants and animals;
- they absorb sound, thus reducing traffic noise levels;
- they raise the market value of the building;
- they create additional space for walking or resting;
- they enhance their surrounding visually and aesthetically.

However, these roofs also have some disadvantages:

- their cost is usually higher than that of regular roof systems;
- they require frequent maintenance, which also incurs additional costs;
- building structure has to bear additional load [1, 5].

GREEN ROOF TYPES

The most widely used green roof construction joins the reinforced concrete panel as the load bearing construction to the applied insulation system, depending on the desired effects and the thickness of greenery in the top soil layer and planted greenery [6 - 9] .

Table 1. Provides the features of extensive and intensive roofs

Parameter	Extensive	Intensive
Vegetation	Sedum, grass, medicinal and culinary herbs	Grass, ornamental shrubs, trees
Height	< 15cm	25–100cm
Irrigation	Mostly without	Always required
Weight	50–150kg/m²	250–1000 kg/m²
Walking space	None/Limited	Yes
Water tank	4-12mm	18-39mm
Load bearing capacity	Mostly sufficient	Requires very strong roofing construction
Maintenance	Very rarely	The same as regular gardens
Inclination	Up to 45º	Flat or terraced

Depending on their thickness, green roofs can be:

- extensive,
- intensive,
- semi-intensive.

Figure 1 shows buildings with green roofs.

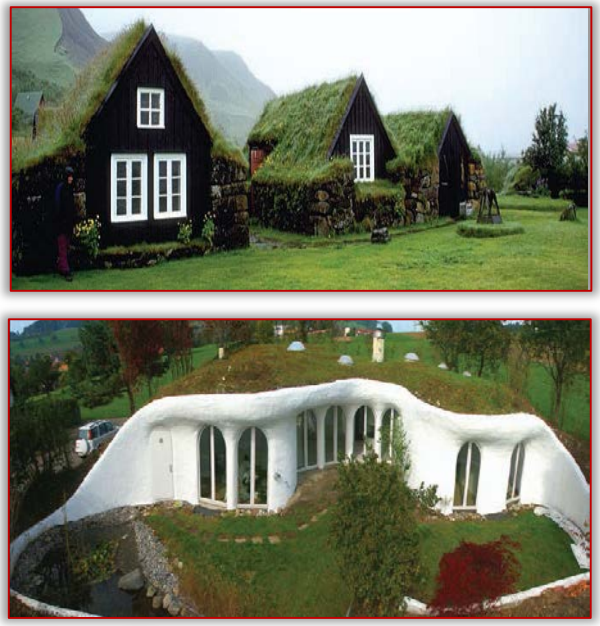

Figure 1. Green roofs: 1) Green roofs of the Skogar museum, Iceland; 2) Earth house in Switzerland

EXTENSIVE GREEN ROOFS

Extensive green roofs are impassable roofs. They should be planted with grass that is extremely resilient to drought and with ground cover plants no more than 30 cm in height, i.e. extensive greenery, which requires only 5-15 cm thick soil layer. The structural load of such roofs is 50 to 200 kg/m².

Extensive covers are suitable for inclined roofs and for converting old roofs into green without any changes in the construction, which is not adjusted to bear larger loads. Extensive roofs are not intended for recreation, heavy weights, or trees.

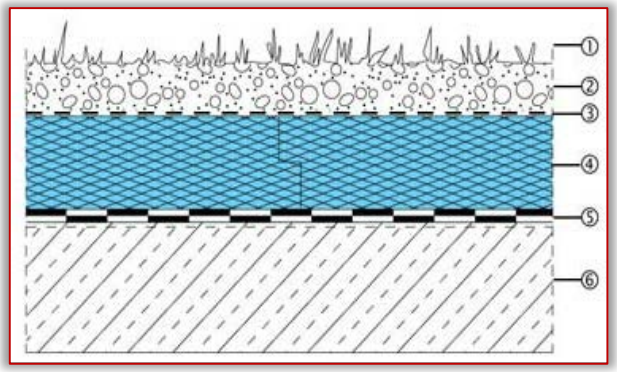

Figure 3. Single-layer extensive green roof: 1) extensive lawn – vegetation; 2) drainage vegetation layer 80-100 mm thick; 3) fabric (e.g. polypropylene) 110-140 g/m²; 4) insulation material; 5) bituminous waterproofing sheet; 6) concrete ceiling

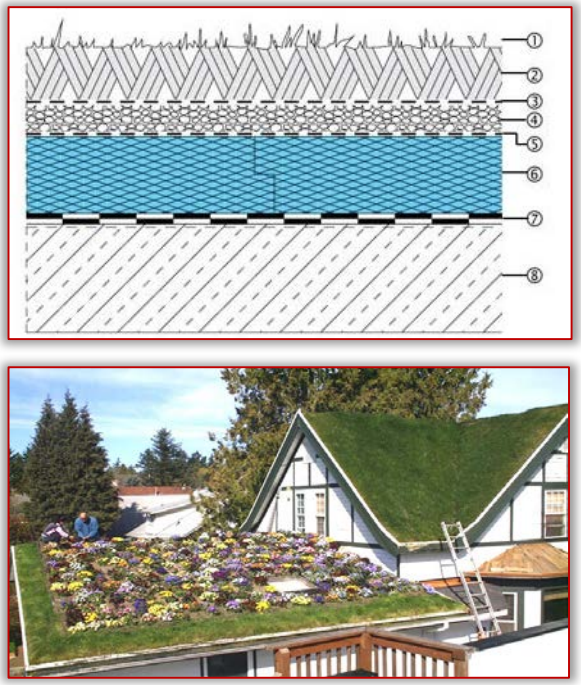

Figure 2. Extensive roof with drainage system: 1) extensive lawn – vegetation; 2) soil layer 80-100 mm thick; 3) separation/filtration layer; 4) drainage layer; 5) fabric (e.g. polypropylene) 110-140 g/m^2; 6) insulation material; 7) bituminous waterproofing sheet; 8) concrete ceiling

INTENSIVE GREEN ROOFS

Roof gardens – intensive roofs – are multifunctional green roofs, which retain large amounts of water. It is suitable for lawns, perennial plants with deeper substrate, shrubs, and trees.

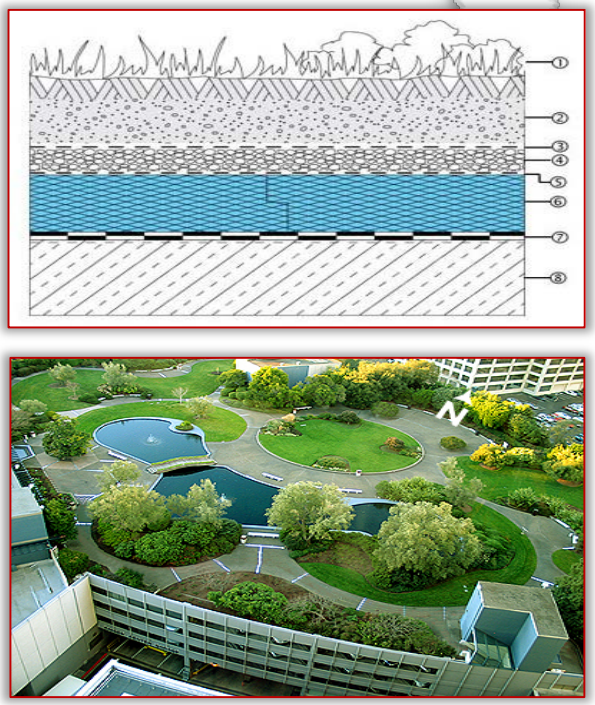

Figure 4. Intensive green roof: 1) vegetation; 2) drainage soil layer 200 mm thick; 3) separation/filtration layer; 4) drainage layer; 5) fabric (e.g. polypropylene) 110-140 g/m^2; 6) insulation material; 7) bituminous waterproofing sheet; 8) concrete ceiling

Such roofs allow the integration of pathways, terraces, access roads, playgrounds, swimming pools, etc. There are essentially no limits to the design provided that the building structure allows it. Intensive green roofs are passable and are covered in large shrubbery, trees, and other taller plants ranging from 0.50 m to 4.0 m. Medium and tall shrubbery and shorter trees, i.e. intensive greenery, require ca. 1.20 m thick soil layer for normal growth, while their load on the structure is 300-500 kg/m^2.

Intensive green roofs have a relatively flat surface with 1-1.5% or up to 3% inclination. Intensive roofs require considerably more care and maintenance, for instance, more frequent fertilization and larger amounts of minerals for large plants to grow. Depending on the choice of plants, sometimes water tanks are required, as well as irrigation, fertilization, and maintenance systems, just like with regular gardens.

SEMI-INTENSIVE GREEN ROOFS

Semi-intensive green roofs share the properties of extensive and intensive roofs. Parts of these roofs are passable and are used for rest or recreation. They are designed as extensive roofs with low maintenance requirements, while being accessible and open for public use, which is a property of intensive roofs. They include plants 0.25-0.50 m tall, with the soil ca. 0.20 m thick, which adds about another 250 kg/m^2 load on the building structure. The plants that are usually used for these roofs are also very low-maintenance, e.g. grasses or medium-height sedums.

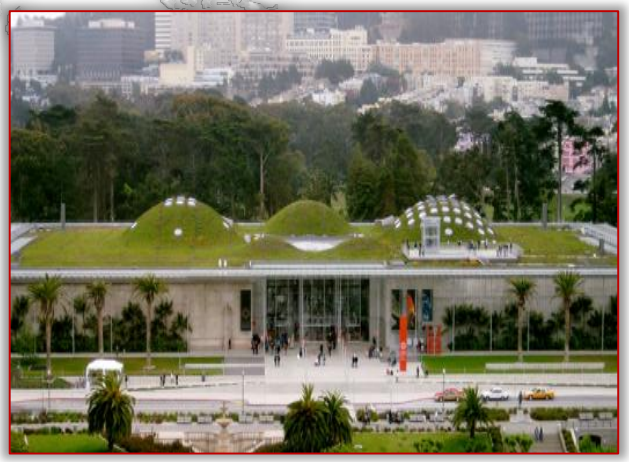

Figure 5. Semi-intensive green roof

CONCLUSIONS

Green roofs can be found in many countries, having recently grown quite popular in urban areas, where particular and more resilient plants are used, with a special drainage technique. Flat, usually concrete, roofs are a common issue in cities, as they often leak and create problems for the upper floor occupants. Through conversion into green roofs, they become useful and aesthetically pleasing. Green roofs protect the roof structure from extreme temperature shocks, provide space for walking or resting, reduce water drainage

issues, reduce heat radiation and reflection with their green layers, aesthetically enhance the surrounding area, completely eliminate the negative effects of dust, and reduce the negative impact of traffic noise. They also protect the roof insulation and roofing from UV radiation and balance out daily temperature fluctuations, thus extending the life of the roof system.

Note

This paper is based on the paper presented at The VIth International Conference Industrial Engineering and Environmental Protection 2016 – IIZS 2016, organized by University of Novi Sad, Technical Faculty "Mihajlo Pupin" Zrenjanin, in Zrenjanin, SERBIA, October 13–14, 2016, referred here as [10].

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PREDICTING AMARANTH YIELD (Amaranthus Hypochondriacus) CULTIVATED ON A NON-COHESIVE SOIL

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Abstract: Amaranth hypochondraicus is an uncommon amaranth in West Africa highly characterized with his multifunctional values which ranges from its good edible leaves, ornamental purpose and to its highly nutritious and medicinal seeds. This study was aimed at predicting yields obtained from an experimental farm using irrigation water as a single factor at four different levels. The levels of factor imposed include: applying 60%, 70%, 80% and 90% of the water needed to bring soil moisture content to field capacity. The site used in the study was designed to provide for maximum water control as much as possible. The plot framing was used to demarcate the study site into sixteen different plots of 1 m^2 each with four replicates designed with Latin Square Experimental Design. A total crop yield of 33.6 kg was obtained for all the plots. Plots treated with 90% water needed to bring soil moisture to field capacity recorded yield of 11.6 kg (representing 34.52% of total yield), plots with 80% water treatment yielded 9.3 kg (27.68%), plots with 70% water treatment recorded 7.2 kg (21.43%) and those treated with 60% water yielded 5.5 kg (16.37%). The results showed that higher yield is obtainable at higher water application. Using Design Expert to analyze the yields from the field, the predicted yields which correlate with the actual yields from the field was obtained. Significant differences existed between the yields obtained. The predicted and actual yield models gave ranges of R-square values with the highest value of 0.86 obtained plots treated with 90% water needed to bring soil moisture to field capacity. R-square values of 0.64, 0.61 and 0.47 were obtained for plots treated with 80%, 70% and 60% water needed to bring soil moisture to field capacity. The study shows that Amaranthus hypochodraicus is better predicted with minimum water stress of the field capacity.
Keywords: Amaranthus hypochondriacus, yield, field capacity and water stress

INTRODUCTION

The challenge for agricultural practices to increase food production to obtain food security still persists after 45 years of the Green Revolution (Hobbs, 2007 and Prabhu, 2012). The first Millennium Development goal is to reduce hunger and poverty by 2015 (Dixon et al.,2006). The demand for food is increasing, not only because of the growing population, but also to provide more nutritious food with high protein quality and nutraceutical compounds. Amaranth (Amaranthus hypochondriacus) (Prince of Wales) is a crop naturally resistant to water deficit and is a good source of protein; the seeds have high amounts of protein containing essential amino acid such as lysine, methionine and squalene, an important precursor for all steroids (He et al., 2002, Barba et al; 2009, Garcia-Gonzalez, et al; 2009, Achigan-Dako, et al; 2014). Since the beginning of the 1980s, amaranth has been rediscovered and several reports have tried to promote it as a basic crop (Kauffman, 1992). In addition to nutritional characteristics, amaranth plants have agronomic features identifying it as an alternative crop where cereals and vegetables cannot be grown (dry soils, high altitudes and high temperatures) (Omamiet al., 2006). In general, the selection of promising genotype in a breeding program is based on various criteria, with the most important being final crop yield quality (Kozaket al., 2008).Dietary intake of vegetables is low in Africa compared to the world's average. This situation is worsened by low water availability for vegetable production especially in the dry season. Amaranth can be grown in the different agro-ecologies of Nigeria is a dual purpose crop with edible leaves and seeds rich in essential nutrients, minerals and proteins

(Olufolajiet al., 2010). There is dearth of knowledge about water requirements of amaranth especially as it relates to varietal water use efficiencies (Liu and Stutzel 2004; Quereshi et al; 2012). Amaranth varieties differ in morphology, physiological structures, root system and days to maturity. These differences could be responsible for the ability of one variety to use irrigation water more optimally than the other (Olufolaji and Tayo 1989). This study was therefore conducted to predict the optimum yield that can be obtained under different water stress situations.

METHODOLOGY

The Study Site and Land Preparation

This study site (Fig 1)is located at University of Ilorin main campus, Ilorin, Kwara State, Nigeria. The institution is situated at Ilorin South Local Government Area, Ilorin, Nigeria which lies on the latitude 8^0 30^1 N and longitude 4^0 35^1 E at an elevation of about 340 m above the sea level (Ejieji and Adeniran, 2009). Ilorin, the capital city of Kwara State is in Southern Guinea Savannah Ecological Zone of Nigreria with an annual rainfall of about 1300 mm. Plot framing was done immediately after the field has been irrigated to field capacity and the sample for the determination of field capacity has been taking from the field. Framing was done to minimize inter-seepage of irrigation water from one plot to the other thereby minimizes experimental error due to treatment (irrigation water).. The plank frame is 25mm x 100 mm (i.e. 1" x 4") plank. The frame is then fully forced to the ground.

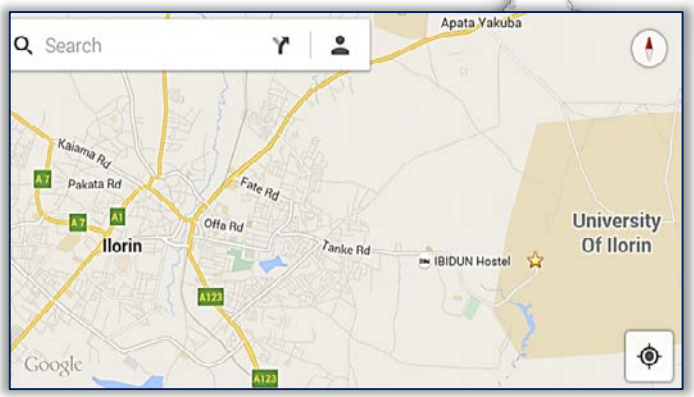

Figure 1: Ilorin Metropolis indicating University of Ilorin, Kwara State, Nigeria. *Source: Google search GPS*

Experimental Design

The experimental field was designed using Latin Square Design (LSD) with four (4) blocks of four replicates applying the principle of rational mechanism. Moreover, the principle of local control is adequately accommodated.

Sieve Analysis for Determination of Soil Cohesiveness

The sieve analysis (Table 1) conducted shows that the field soil is non-cohesive since the proportion of the clay content is negligible.

Table 1: Soil sieve analysis

Sieve Size	weight retain (g)	% retained	% passing
2	330	14.52	85.48
1.7	260	11.44	74.03
1.4	257	11.31	62.72
0.3	710	31.25	31.47
0.15	400	17.61	13.86
0.075	280	12.32	1.54
< 0.075	35	1.54	0.00

Determination of Moisture Content at Field Capacity

The field was irrigated till the soil was saturated and then allowed to drain for about 72 hours. At this point, the field was assumed to be at field capacity (Michael, 2008). A graduated sampler of 4.4 cm diameter and about 55 cm long was carefully driven through the soil to take sample randomly in the experimental field to a depth of 40 cm (covering the effective root depth zone of amaranth which is about 30-40 cm). The sample was cut into five (5) layers which represent 8 cm profile each. Each profile mass was determined and recorded separately as m_1(wet mass). The samples were placed in the oven at temperature of 105 ^{0}C for 24 hours. The oven dried mass were determined and simultaneously as m_2. The moisture content at field capacity was determined as:

$$mc_{fP} = \frac{m_2 - m_1}{m_1} \times 100\ (\%) \quad (1)$$

$$\rho_b = \frac{m_d}{V_s} \quad (2)$$

where $m_d = m_2$ and $V_s = \frac{\pi\phi^2}{4}$

$$\rho_b = 4\left(\frac{m_3 - m_1}{\pi d^2 h}\right) \quad (3)$$

where ρ_b = bulk density of soil (g/cm^3), h = height of sampler, m_1= mass of wet sample, m_2 = mass of dry oven dry sample, where ρ_b = bulk density of soil (g/cm^3), ϕ = diameter of sampler, V_s = volume of sampler

Available Water(AW)

$$AW = \frac{D\rho_b}{\rho_w}\left(\frac{FC - WP}{100}\right), cm \quad (4)$$

For this study, the moisture content at field capacity (FC) = M_{cf}

$$AW = \frac{D\rho_b}{\rho_w}\left(\frac{M_{cf} - WP}{100}\right), cm \quad (5)$$

where: ρ_w = density of water, D = soil profile depth

$$WP = \frac{FC}{F} = \frac{M_{cf}}{F} \quad (6)$$

where:

WP is moisture content at wilting point and F is a factor ranging from $2.0 - 2.4$

The factor F depends on the percentage of silt content in the soil. Since the soil is made up of 85.48 % mainly sand (70.08%) and silt (15.4%) which gave ratio 1:4.5 silt to clay, F of 2.1 was adopted. For this research, WP was calculated to be 12.04%.

Analytical Modeling of Irrigation Management

From Figure 2,

$$AW = D\frac{\rho_b}{\rho_w}\left(\frac{FC-PWP}{100}\right), cm \quad (7)$$

$$d = D\frac{\rho_b}{\rho_w}\left(\frac{FC-m_c}{100}\right) = X\%TAW \quad (8)$$

$$FC = D\frac{\rho_b}{\rho_w}\theta_v, cm \quad (9)$$

where θ_v is the volumetric FC (%).

Table 4 gives the soil data from the experimental farm taking into consideration the equations 3.7 and 3.9 at D = 35 cm (an approximate of root depth zone of amaranth).

Table 4: Soil moisture data

Soil moisture	Value
ρ_b	1.355g/cm^3
FC (25.3%)	11.999 cm
PWP (12.04%)	5.710 cm
TAW	6.289 cm

Net volume of water required for irrigation per plot, V_n

$$V_n = I_d \times A \quad (10)$$

where A = area of the plot, For this study, A =1 m^2

Actual volume of water required for irrigation per plot

$$V_{actual} = (I_d + Losses - Gain)A \quad (11)$$

$$Losses = ET \quad (12)$$

$$Gain = ER + S \quad (13)$$

where: ER = effective rainfall. This can be obtained from the installed raingauge. S = carry over soil moisture in the root zone which is an equivalent of the instantaneous moisture depth in the root zone. ET = evapotranspiration

Mathematically,

$$S = Dm_c\frac{\rho_b}{\rho_w} \quad (14)$$

Water losses have been reduced to ET only because the soil has been significantly drain therefore subsequent drainage is negligible.

Equation 11 could be rewritten as given in eqn 15

$$V_{actual} = (I_d + ET - ER - S)A \quad (15)$$

where: V_{actual} is the actual volume of irrigation water required per plot.

Models for the Average Evapotranspiration and Irrigation Interval

Average evapotranspiration (ET) was obtained by subjecting the soil at field capacity to normal atmospheric conditions and thereby determine the soil moisture content to the assigned root zone by taking sample randomly in at least four points of the experimental field. This experiment was done for at least 7 days by randomizing the portion of the field from which the sample was taken. Average daily changes in moisture content were obtained as analyzed in Table 5. The daily results for the moisture content as it changes with evapotranspiration is given in Table 6 while Table 7 shows the computed daily moisture fluctuation in the experimental field.

Average daily ET

The model for the average daily ET is given in eqn (16)

$$ET = D\frac{\rho_b}{\rho_w}\sum_1^N\frac{\Delta m_c}{N},\ N \neq 0\ (cm) \quad (16)$$

Average daily change in moisture content

The model for the average daily change in moisture content (S) is given in equation (17)

$$S = D\frac{\rho_b}{\rho_w}\sum_1^N\frac{m_c}{N},\ N \neq 0\ (cm) \quad (17)$$

Table 5: Daily change in moisture content

Day	Moisture content, m_c (%)	Δm_c (%)
1	m_{c1}	FC - m_{c1}
2	m_{c2}	m_{c1} - m_{c2}
3	m_{c3}	m_{c2} - m_{c3}
4	m_{c4}	m_{c3} - m_{c4}
5	m_{c5}	m_{c4} - m_{c5}
6	m_{c6}	m_{c5} - m_{c6}
7	m_{c7}	m_{c6} - m_{c7}

Table 6: Moisture content as it changes with evapotranspiration

Day 1	Day 2	Day 3	Day 4
19.52941	26.19757	21.42623	15.51843
24.17009	18.6328	13.88376	15.01813
19.9103	15.6724	21.61145	15.71328
19.92371	18.57409	24.80854	18.08946
24.75423	20.43652	20.39208	25.69545
19.40966	21.08277	18.53065	15.0448
24.56603	19.1812	15.72103	15.14658
30.49977	17.82752	15.44887	16.76808
26.19686	19.72206	21.56738	20.65447
22.64384	22.06304	20.21851	24.88199
23.16039	19.939	19.36085	18.25307

Day 5	Day 6	Day 7
18.94045	19.77863	15.21053
17.89559	16.83545	13.89855
16.97857	18.41935	12.3536
17.79751	16.59328	18.02191
22.61252	14.85455	20.08153
16.69656	16.61056	14.88135
18.24947	17.35238	16.89479
14.77242	17.79825	15.52352
13.18516	16.76271	15.1047
19.70063	16.29061	17.26649
17.68289	17.12958	15.9237

Table 7: Computed Moisture Content Fluctuation in the Soil

Day	Moisture content, m_c (%)	Δm_c (%)
1	23.16039	2.13961
2	19.939	3.22139
3	19.36085	0.57815
4	18.25307	1.10778
5	17.68289	0.57018
6	17.12958	0.55331
7	15.9237	1.20588
Average	18.7785	1.339471

ET = 0.635 cm/day

Irrigation Interval

The empirical model computed for irrigation interval is given in equation (18)

$$I_v = \frac{d}{\left(\frac{\sum_1^N \Delta m_c}{KN}\right)} \quad \text{(days)} \qquad (18)$$

where: K is a crop factor, N = no of days, Δm_c is the daily change in soil moisture, d is depth of water required to bring the soil to field capacity and I_v is the irrigation interval.

Since the average moisture content next day after irrigation is 18.78% (8.906 cm), while the field capacity is 25.30% (11.999 cm), then water needed to bring the soil to FC is the difference between FC and S which is equivalent to 6.52% (3.093 cm). At 60% SMD (i.e. 60% of 3.093 cm) it gives 1.8558 cm. For this research, actual S the difference between I_d and 1.8558 (i.e. 3.093 – 1.856) which is equivalent to 1.237 cm.Since d is 3.77 cm and the average moisture loss per day ET is 1.339% (0.635 cm), therefore, for this study, irrigation interval was divided into two (2) phases: vegetative phase 2-7 WAP and the maturity phase 7-9 WAP. Table 8 give the summary of the determination of irrigation interval for each phase while Table 9 summarize the net actual volume of irrigation water required per plot in the absence of rainfall.

Table 8: Determination of Irrigation Interval

Phase	K	ET (cm/day)	d (cm)	I_v (day)
Vegetative phase (2-7 WAP)	0.7	0.635	3.77	8
Maturity phase (7-9 WAP)	1.0	0.635	3.77	5

Table 9: Net and Actual volume of irrigation water required per plot

Level	I_d of d	I_d (cm)	ET	S	V_n (litres)	V_{actual} (litres)
1	I_d = 60% of d	2.26	0.635	1.237	22.6	16.6
2	I_d = 70% of d	2.64	0.635	1.237	26.4	20.4
3	I_d = 80% of d	3.02	0.635	1.237	30.2	24.2
4	I_d = 90% of d	3.39	0.635	1.237	33.9	28.0

For this study, irrigation interval of 4 days (vegetative phase) and 2-3 days (maturity phase) was adopted using half of the actual volume of water required for irrigation for every plot.

Development of growth equation

The yields obtained from the conduct of the field experiment in relation to their various treatments could be used to model the growth equation of the amaranth through their graphical relationship. It is certain that the yield would do best at certain soil moisture which is in fraction of field capacity or water required to bring the soil to field capacity. The linear relationship between the yield and the treatment is in form of equation (19)

$$Y = f(A,B,C,D,E) = kX \qquad (19)$$

where: Y = yield (treatment effect);A, B, C, D are treatments (water application in percentage of field capacity or of water required to bring soil to filed capacity).

The growth model (in terms of yield) was developed using: regression analysis and design expert.

Regression Analysis and Modeling

Regression model is of form of eqn 20

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k + \varepsilon \qquad (20)$$

where: y is the response variable (yield, kg) that you wish to predict β_0, β_1, $\cdots\beta_k$ are parameters with unknown values; x_1, x_2, $\cdots$ x_k are independent variables (water application,%)

The random error εwas assumed to have a normal distribution probability distribution with mean equal to zero and variance equal to σ^2 and that they are mutually independent.For this study, Regression Calculator was adopted for the experiment analysis and modeling. This was so because it iseasy-to-use statistical software for regression analysis. It does not require any programming or some sort of command.It also provides advanced modelling tools such as variable selection and transformation.

Design Expert and Optimization

Design expert was used to optimize the yields obtained from the study. It is an automatic system that uses combined, mixture, response surface and factorial design. For this study, Factorial Design of Experiments (DOE) was adopted because it accommodates to a large extent all engineering experimental design provided that the factor for the design does not exceed twelve. Factorial design expert was used to analyze individual yield per plant and obtain predicted optimized yields.

Validation of Results

Validation of results was done by adopting polynomial function model (mathematical and graphical) by comparing the actual measurement with the optimized predicted measurements for all levels of factor (60%, 70%, 80% and 90% of the field capacity respectively). Graphical analysis of the optimized predicted measurements and actual measurements were determined for every level of factor.R^2 for every level of factor were obtained and compared with measured values.

RESULTS AND DISCUSSION

Results of the Amaranth Yield at Different Levels of Water Application

Figure 2 summarized the yield of Amaranthus hypochondraicus of each plots using random treatment effect of water application in percentage of the field capacity. The water applications in percentage of field capacity are indicated by the symbols as described by

the key. Table 10 shows yield per plant from the experimental farm. It shows that the yields at: 60% of the field capacity ranges from 1.2 kg – 1.5 kg, 70% of the field capacity ranges from 1.7 kg to 1.9 kg, 80% of the field capacity ranges from 2.1 kg – 2.5 kg while 90% of the field capacity ranges from 2.5 kg to 3.3 kg.

The study shows that as the moisture content increases the R-square value increases, that is, the R-square value increases as crop water stress reduces. This show that the yield of the study crop, Amaranthus hypochondraicus is better predicted as moisture content approaches that at field capacity. The R-squares values show that Amaranthus hypochondraicus is highly sensitive to water stress.

Design Expert Optimization

Using design expert optimization, the response in yields per plant in relative to each standard order, block and run is summarized in Table11. An average of ten yields were selected randomly from the field and classified into ten classes namely Yield 1, Yield 2, Yield 3, …, Yield 10. The selected measurements were analyzed as shown in the results in Tables 11 and 12.

ResultsValidation

The predicted results as evaluated by design expert optimization were compared with the actual results from field. It was found that the various observations with their relative levels of factor were so close in magnitude (Tables 11 and 12).

When the predicted and actual results were graphically analyzed through polynomial function model the R-square obtained showed that there is significant difference between the efficiency of various levels of water application in relation to the yield obtained.

Figs 2 to 5 shows that at the water stress of 60, 70, 80 and 90%of the field capacity, R-square was found to be 0.4688 (46.88%), 0.6077 (60.77%), 0.6409 (64.09%) and 0.8628 (86.28%) respectively. This infered that higher yield is achievable at higher moisture contents.

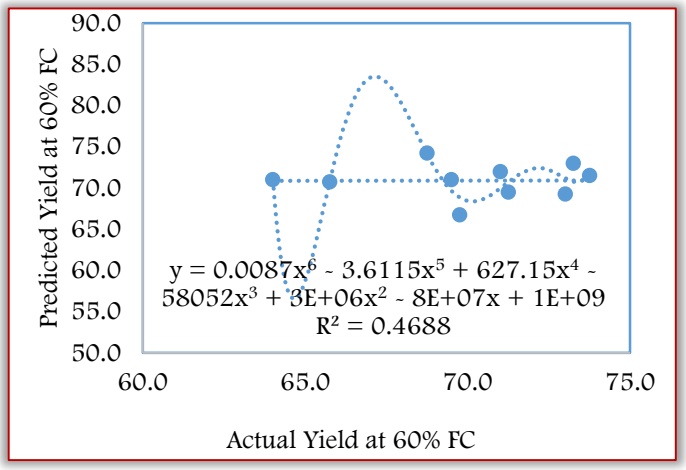

Figure 2. Predicted Yield vs Actual Yield (at 60% moisture content of the field capacity

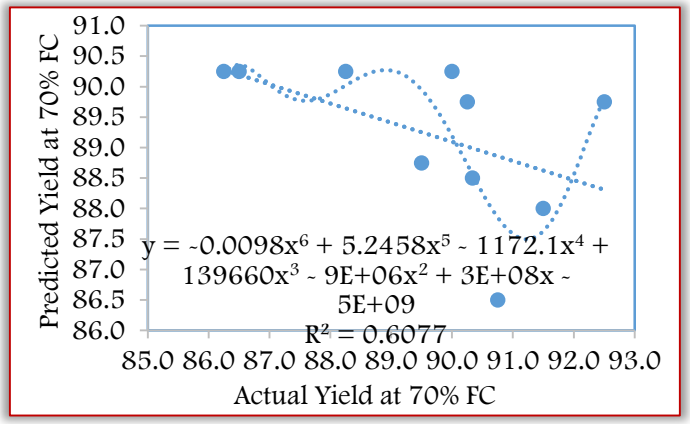

Figure 3. Predicted Yield vs Actual Yield (at 70% moisture content of the field capacity)

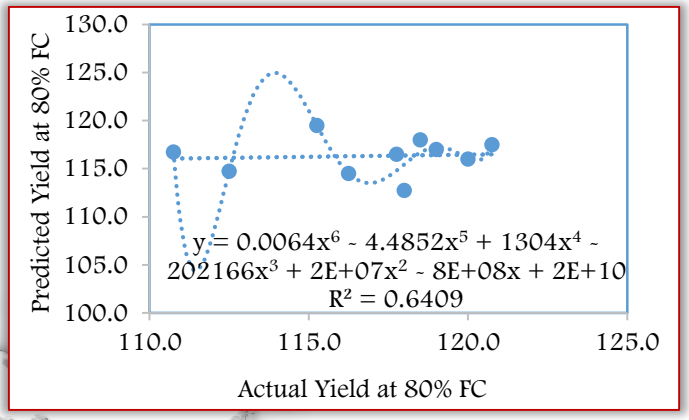

Figure 4. Predicted Yield vs Actual Yield (at 80% moisture content of the field capacity)

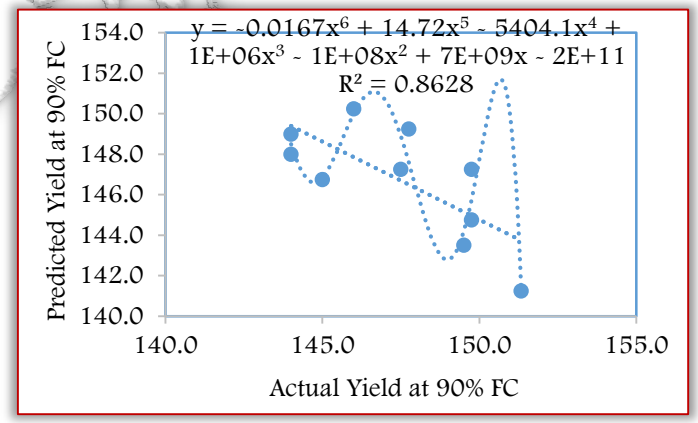

Figure 5: Predicted Yield vs Actual Yield (at 90% moisture content of the field capacity)

Table 11: Predicted Measurement at Various Degree of the field capacity

Response	Predicted (g)			
	60% FC	70% FC	80% FC	90% FC
Yield 1	73.0	88.0	119.5	143.5
Yield 2	70.8	89.8	117.5	149.3
Yield 3	71.5	90.3	117.0	150.3
Yield 4	69.3	89.8	116.0	149.0
Yield 5	69.5	86.5	118.0	146.8
Yield 6	71.0	90.3	116.8	144.8
Yield 7	74.3	90.3	114.8	148.0
Yield 8	66.8	88.8	114.5	147.3
Yield 9	72.0	90.3	116.5	147.3
Yield 10	71.0	88.5	112.8	141.3
Average	70.9	89.2	116.3	146.7

Table 12: Actual Measurement at Various Degree of the field capacity

Response	Actual (g)			
	60% FC	70% FC	80% FC	90% FC
Yield 1	73.3	91.5	115.3	149.5
Yield 2	65.8	90.3	120.8	147.8
Yield 3	73.8	86.5	119.0	146.0
Yield 4	73.0	92.5	120.0	144.0
Yield 5	71.3	90.8	118.5	145.0
Yield 6	69.5	86.3	110.8	149.8
Yield 7	68.8	88.3	112.5	144.0
Yield 8	69.8	89.5	116.3	149.8
Yield 9	71.0	90.0	117.8	147.5
Yield 10	64.0	90.3	118.0	151.3
Average	70.0	89.6	116.9	147.5

CONCLUSION

This study shows that the accuracy of predicting the yield of Amaranthus hypochondraicus increased as the moisture content increases, the highest is obtained when there is no water stress, that at 100% of the field capacity. Optimization of measurements from the experimental farm indicates maximum yields at the maximum field capacity which goes in agreement with the actual measurement after validation.The field water regulation of the amaranth for maximum yield is best done at possible maximum field capacity. It is therefore recommended that the moisture content be maintained at the field capacity in other to obtain maximum yield for every amaranth planted on a non-cohesive soil.

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ENVIRONMENTAL MANAGEMENT SYSTEMS: CONTEMPORARY TRENDS AND PRACTICES

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Abstract: Increased interest in environmental quality, as well as obligations arising from the EU accession process (particularly derived from the Chapter 27: Environment) impose trend of responsible environmental management. At the other hand, global trends such as the establishment of environmental management system based on ISO standards have the similar goals. The aim of this paperwork is to represent a comprehensive review of contemporary trends and practices in the field of environmental management, with particular regard to risk based approach. With no less importance, this paper seeks to demonstrate the application of risk-based environmental management practices in organizations already proven in the field of corporate social responsibility.
Keywords: environment, risk, management, methodology

INTRODUCTION

Contemporary trends within the field of the environmental management indicate that there has been an obvious shift from the traditional "*top-down*" approach when defining the environmental protection policy, to the concept of environmental management towards a more open system of governance at all levels, where decisions are made on the distribution and use of environmental resources. If properly implemented, this approach recognizes the needs and obligations of those who most influence the use of environmental resources, without losing the possibility of involvement of the wider community in the management process. The basis for undertaking a series of activities starts from the harmonization of legislation, institutional organization in the field of environmental protection, funds raising etc. to concrete plans on taking preventive measures.

Compared to all environmental factors, it is possible to group existing approaches in environmental management, in next order:

1. the first group consists of pollution control mechanisms for each environmental factor individually, meaning independently of one another (i.e. Command and Control Regulations, which, for example, relates solely to the protection of water resources without considering the protection of soil, etc.). This approach is quite characteristic for the seventies of the twentieth century,
2. a second group consists of mechanisms that have a touch of integration, or perceived impacts of pollution globally, i.e. in respect of all environmental factors, but does not consider the activities and processes of society. This approach is characteristic for the eighties of the twentieth century,
3. the third group includes mechanisms which in addition to environmental factors considers factors of society, in terms of prevention, but only at the level of operators that generate pollution (consideration of material and energy flows). This approach is characteristic for the nineties of the twentieth century,
4. the fourth group consists of industrial ecology mechanisms where besides pollution prevention efficiency of utilization of environmental resources is also considered, as the performance reduction regarding emitted pollution, eco-efficiency and dematerialization of production. This approach is characteristic for the first decade of the twenty century,

5. fifth group consists of mechanisms that have a touch of sustainability, where in addition to industrial ecology, there is a look at the social component, inter and intra-generation justice, and a tendency towards an equitable distribution of profits as a result of the exploitation of environmental resources. This approach is characteristic for the second decade of the twenty-first century [1][2].

MATERIAL AND METHODS

As discussed in [3] a modern environmental management system (EMS) requires the identification of environmental aspects, root causes of their occurrence and calculus of their impacts.

An illustrative flowchart of EMS procedures at the level of an organization is presented at Figure 1.

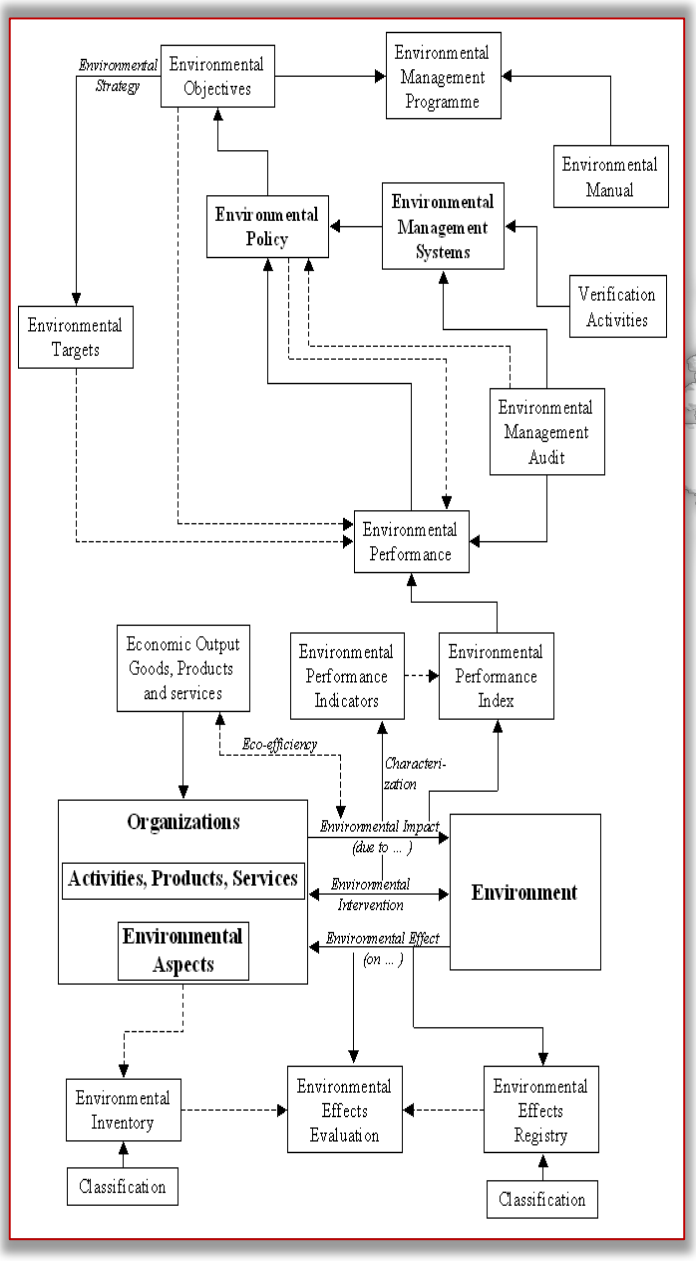

Figure 1. An illustrative Environmental Management System (EMS) flowchart [3]

Planning the environmental protection management systems within an organization includes the identification of environmental aspects and selection of the most significant of them.

The selection of the environmental aspects in certified organization that implements and operates an EMS depends on the available technology, experience, defined budget, defined mission and vision and, of course, the adopted environmental objectives mentioned within adopted environmental protection policy.

The selection and prioritization of the abovementioned environmental aspects in certified organization should be based on the application of the proven methodologies, such as risk - based approach to the environmental management issues, seeking rather the preventive activities that restorative ones [5].

RESULTS AND DISCUSSION

Process of identification and characterization of environmental aspects represents a set of procedures defined within the guidance documents [6]. Although there are tools for ranking and environmental aspects prioritization, still challenge is an unbiased choice of significant aspects (with significant impacts) meaning allocation of limited resources (financial, human, technical...) in order to increase environmental performance.

As a contemporary trend, perhaps still not sufficiently recognized, risk - based approach to environmental management could be very useful approach to the issue of aspects ranking and prioritization. Within this approach, the significance of the environmental aspects (and its impacts) is defined based on the total score of the mathematical product between the degree of impact significance and the likelihood of occurrence, according to the previously defined criteria.

While the environmental impacts assessment consists of:

- environmental basis,
- potential impacts prediction,
- mitigation measures, and
- monitoring,

risk - based approach to environmental management meaning consideration of:

- hazard identification (in sense of likelihood),
- exposure assessment (in sense of importance), and
- risk characterization.

As an effective tool for visualization and comprehensive review of scored aspects, environmental risk matrix could be used, as shown in figure 2.

Nevertheless, it is always should beard in mind that risk - based approach to environmental management is related to environmental policy issue, objectives and environmental management plan dedicated to planed activities.

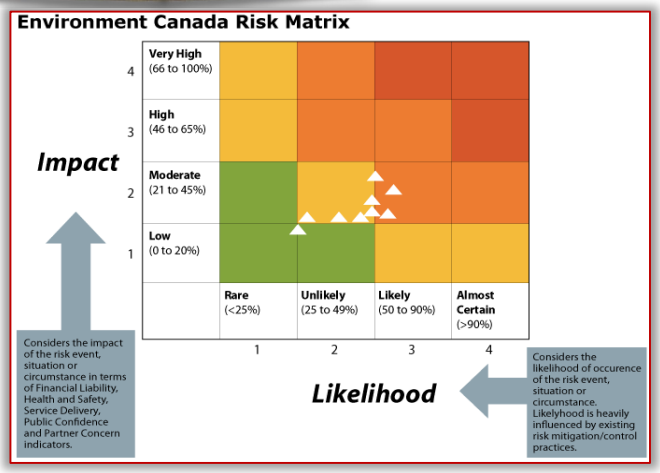

Figure 2. Environmental risk (harm) matrix, Canadian experience [8]

CONCLUSION

The basis for the preservation of environmental quality is existence of an effective environmental management system implemented at the all relevant activities and processes within organization. An objective selection of the most important environmental aspects means that the limited resources of organization are going to be allocated in the most positive manner (meaning greatest effects). With no less importance is a fact that effective environmental management systems actively contributes both to the environmental protection and corporate social responsibility of an organization.

Acknowledgments

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Note

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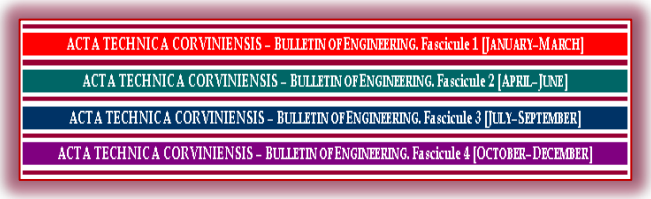

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The title is centered on the page and is CAPITALIZED AND SET IN BOLDFACE (font size 14 pt). It should adequately describe the content of the paper. An abbreviated title of less than 60 characters (including spaces) should also be suggested. Maximum length of title: 20 words.

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State the paper's purpose, methods or procedures presentation, new results, and conclusions are presented. A nonmathematical abstract, not exceeding 200 words, is required for all papers. It should be an abbreviated, accurate presentation of the contents of the paper. It should contain sufficient information to enable readers to decide whether they should obtain and read the entire paper. Do not cite references in the abstract.

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The manuscript must be typed single spacing. Use extra line spacing between equations, illustrations, figures and tables. The body of the text should be prepared using Georgia or Times New Roman. The font size used for preparation of the manuscript must be 11 or 12 points. The first paragraph following a heading should not be indented. The following paragraphs must be indented 10 mm. Note that there is no line spacing between paragraphs unless a subheading is used. Symbols for physical quantities in the text should be written in italics. Conclude the text with a summary or conclusion section. Spell out all initials, acronyms, or abbreviations (not units of measure) at first use. Put the initials or abbreviation in parentheses after the spelled-out version. The manuscript must be writing in the third person ("the author concludes... ").

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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.

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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.

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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.

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