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ACTA TECHNICA CORVINIENSIS – BULLETIN of ENGINEERING

Tome IX [2016]
Fascicule 3
[July – September]

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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AIMS, MISSION & SCOPE

General Aims

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ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering is an international and interdisciplinary journal which reports on scientific and technical contributions. Every year, in four online issues (fascicules 1 – 4), **ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering [e-ISSN: 2067-3809]** publishes a series of reviews covering the most exciting and developing areas of engineering. Each issue contains papers reviewed by international researchers who are experts in their fields. The result is a journal that gives the scientists and engineers the opportunity to keep informed of all the current developments in their own, and related, areas of research, ensuring the new ideas across an increasingly the interdisciplinary field. Topical reviews in materials science and engineering, each including:

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

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

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

ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering encourages the submission of comments on papers published particularly in our journal. The journal publishes articles focused on topics of current interest within the scope of the journal and coordinated by invited guest editors. Interested authors are invited to contact one of the Editors for further details.

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You are invited to contribute review or research papers as well as opinion in the fields of science and technology including engineering. We accept contributions (full papers) in the fields of applied sciences and technology including all branches of engineering and management. Submission of a paper implies that the work described has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis) that it is not under consideration for publication elsewhere. It is not accepted to submit materials which in any way violate copyrights of third persons or law rights. An author is fully responsible ethically and legally for breaking given conditions or misleading the Editor or the Publisher.

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- ✓ Analytical Chemistry
- ✓ Inorganic Chemistry
- ✓ Materials Science & Metallography
- ✓ Polymer Chemistry
- ✓ Spectroscopy
- ✓ Thermo-chemistry

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- ✓ Development Economics
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- ✓ Industrial Organization
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- ✓ Monetary Economics
- ✓ Resource Economics
- ✓ Transport Economics
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- ✓ Hydrology
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- ✓ Soil science

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

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We are very pleased to inform that our journal **ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering** is going to complete its eight years of publication successfully. In a very short period it has acquired global presence and scholars from all over the world have taken it with great enthusiasm. We are extremely grateful and heartily acknowledge the kind of support and encouragement from you.

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Abstract: Paper presents a case study focused on design of the cooling system of injection mould for thermoplastic processing, demonstrated on a model example from engineering industry. At first, the whole mathematical approach how to compute suitable cooling system was described in paper. Subsequently, the advantages of the conformal cooling system compared to conventional were investigated with utilization of the numerical modelling. For this purpose a free–form shaped thin–walled part from automotive industry was selected – component of the rear view mirror. In order to achieve shortest cooling time during this part moulding and its minimal warpage, the several conventional and conformal cooling systems were proposed and were evaluated based on results of the numerical modelling. Finally, the best cooling solution was integrated into shape cavity of the 2+2 family mould
Keywords: design of injection mould, conformal cooling, plastic part warpage, numerical modelling

Abstract: The concept of Total Logistics Management (TLM) is a response to the challenges of contemporary economy, proposing the idea of an enterprise oriented towards flow. Flow has a broad definition here. It concerns materials, information as well as finances. Effective and efficient flow as referring to any category should be the objective of any organization. It must be noted that one of the basic element of TLM is the product itself as well as designing it in such a way to make it logistically efficient. A logistically efficient product is a product that would support the flow while being attractive to a customer. When considering optimization of logistic costs and processes the features and properties of a product are usually not considered as they are believed to be limiting conditions. The changes are made in the way specific processes are executed, while product properties remain unchanged.
Keywords: mass customization, logistic, efficiency, product

Abstract: Meat industry wastewater represents a serious problem regarding environmental degradation and human health protection. Even though this type of wastewater is biodegradable and therefore relatively easily purified, in Serbia, it is often discharged into the sewer and surface receiving water, without the prior treatment. The aim of the study was to create the Inventory of the meat industry and abattoir facilities in the territory of Vojvodina region, Serbia, in order to get an insight into number of entities that discharge polluted water into environment. Most of the discharged wastewater ends up in septic tanks, public sewerage system, or is removed as solid waste and stored on the landfills and open dumps. To ensure environmental sustainability, the polluted effluent should be managed in a way that minimizes its adverse effects on the environment. The first step towards achieving this goal is to determine the number of facilities, as the potential polluters. During the study 59 subjects were registered, and 52 of them took a part in the survey. The results indicate poor quality or complete absence of wastewater treatment and quality control.
Keywords: wastewater, meat industry, abattoir, water treatment, environment

Abstract: The use of ultra–filtered lactic acid whey retentate was investigated for making of sour cream. The utilization of lactic acid whey is limited due to its' special properties, so the logical utilization way is to use it in fermented products. First, we concentrated lactic acid whey collected from cottage cheese making by ultrafiltration (UF), then UF Whey Retentate (UFWR) was added (by 2, 5 and 10%) into fat standardized cream for sour cream making. We investigated the texture and sensory properties of the sour cream samples compared with the industrial products. Generally, we can state that the use of small portion of UF whey retentate did not result noticeable changes and did not reduce the sensory value of sour creams. Higher UF whey retentate addition improved some texture properties of experimental samples, but the summarized evaluation of UFWR addition was not unequivocal. Control samples showed better results. Based on my results, the sample what contained 5% UF whey retentate had good texture and acceptable sensory properties. Furthermore, more than 5% UF lactic acid whey retentate (coming from our own ultrafiltration process) resulted remarkably worse sensory properties than the other samples. Further investigation is needed to find the optimal composition and sensory properties of UFWR. Furthermore, we have to perform technological investigation to reach higher concentration factor using pre–treatment of whey and to avoid the precipitation of whey proteins during high temperature pasteurization of cream, cream mixed with UFWR or diafiltered whey retentate. We guess that the use of one stage diafiltration would already decrease the unfavourable sensory properties of lactic acid whey retentate.
Keywords: lactic acid, ultrafiltration (UF), UF Whey Retentate (UFWR), sour cream

Abstract: This study investigated the effects of spin casting method on mechanical behavior of aluminum composite (Al6063/SiC). The composites were cold rolled to 10% deformation before solution heat treating at 520^{0}C for 1hour after which it was rapidly cooled in water. Experimental and theoretical density was used to evaluate the porosity of the composite. After cold rolling with 10% deformation and solution heat treating, it was discovered that silicon carbide were well dispersed in aluminum matrix better when compared with the as–cast of both spin and sand casting. The tensile strength and yield strength for spin casting were better when also compared with sand casting.
Keywords: aluminum, silicon carbide, composite, solution heat treating, spin casting

Abstract: Valves are devices of great importance in the operation of hydro systems, in particular, when is necessary to control the flow. The objective of this paper is to determine, through SolidWorks Flow Simulation module, the minor loss through a globe valve at different partially open settings. The Flow simulation allows an analysis of current lines and the hydrodynamic parameters of flow. Therefore we can determine the hydraulic energy losses and can appreciate the value of the main flow parameters.
Keywords: computational fluid dynamics, flow simulation, numerical analysis, hydraulic loss

Abstract: A forestry nursery in Tokoroa, New Zealand grows approximately 3 million Radiata pine seedlings per annum of which about 65% (2 million) are of suitable quality for forestry plantations. The high rejection rate of 35% was attributed to poorly trained, seasonal workers and unsophisticated equipment. It was estimated that about 22% of seedling rejection (approximately 220,000 per year) was due to poorly dibbled holes that caused bends in the stems. The bends occurred when planters pinched the stems of the seedlings in an attempt to make them vertical. A research and development project was undertaken to develop a mechatronic dibbling machine that could produce vertical holes of specified depth. The machine also had to produce 120,000 holes per day and be flexible with regard to spacing and size. The completed mechatronic dibbling machine was tested at the Tokoroa nursery and produced 98% of the holes at the required angle and 100% of useable depth. Harvesting, the following season, showed that the unwanted stem bends had been eliminated with a subsequent reduction in rejects. Furthermore, it was found that worker productivity increased by approximately 10% as they did not have to spend time setting seedlings vertically.
Keywords: forestry, dibbling, mechatronic, cuttings, seedlings, machinery

Abstract: In a continuously developing world, where many activities are high consumers of natural resources, including water, it has become absolutely necessary to apply methods of wastewater treatment. The purpose of wastewater treatment is to improve water quality, in order to be discharged into the environment, without being harmful for different environmental factors. In this paper are presented the equipment used in the mechanical stage of a wastewater treatment plant, and also the status of wastewater treatment plants in Romania.
Keywords: wastewater, mechanical water treatment, treatment plant

Abstract: The paper presents the results of experiment made using a pendulum for road restraint systems with damping elements, according to STAS 1948. Deformable parapets are created to protect the vehicles and other participants at traffic from danger and serious injury. The results of the experiment are very important for the knowledge of the type of parapets that are used on the roads.
Keywords: shock, test, parapets

Abstract: In this paper, a non–linear finite element analysis (FEA) has been done to analyze the internal stresses and strains under static load up to failure for the concrete slab and steel beam sections for simple and continuous composite beams with external prestressing. The concrete slab is partially connected with steel I–beam section by headed stud (shear connectors). ANSYS computer program (version 15) has been used to analyze the three–dimensional model. The nonlinear material and geometrical analysis based on Incremental –Iteration load method, is adopted. The reliability of the model was demonstrated by comparison with experimental results of simple prestressed composite beam carried out by another author. The results wash obtained by FEA solutions have shown good agreement with experimental results. The analysis for continuous prestressed composite beam covers: load deflection behavior, strain and stress in concrete slab and steel beam, force in shear connector, slipping between concrete and steel, and failure modes.
Keywords: Composite steel–concrete beams, finite element analysis (FEA), external prestressing, shear connection, slipping, uplift

Abstract Friction products are safety–critical items, which must be carefully designed and selected to ensure several performance criteria. The design or formulation selected is a compromise between several conflicting priorities and the trade–offs can be tailored according to the wide range of different customer requirements that exist in the market. Brake blocks, also called "shoes", are made of cast iron, respecting the principle of having a different hardness (and resulting wear) from the other elements of the friction pair, i.e. the wheel (made of steel). For making brake shoes are used frequently gray cast iron with lamellar graphite and nodular cast iron, which have a good thermal conductivity (necessary for the proper discharge of heat due to friction), good mechanical properties, good wear resistance. Our research approaches the issue of quality assurance of the brake shoes, from the viewpoint of the quality of materials, which feature can cause duration and safety in exploitation. In this work the investigated subjects are the gray cast iron brake shoes, with lamellar graphite and with a high content of phosphorus (0.8–1.1%), according to requirements for the brake shoes related materials. In order to achieve the chemical composition behavior upon the phosphorous gray cast iron shoe's hardness 100 charges were analyzed.
Keywords: phosphorous gray cast iron, brake blocks (shoes), hardness, Matlab area

Abstract: In this paper an analytical solution is presented to determine the deflection, slip and stresses in bimetallic beam with flexible shear connection. The thermal load is derived from uniform temperature change. The Euler–Bernoulli hypothesis is assumed to hold for each layer separately and a linear constitutive equation between the horizontal slip and the inter–laminar shear force is considered. An example illustrates the application of the developed analytical method.
Keywords: bimetallic beam, interlayer slip, shear connection, thermal load

Abstract: The design and test evaluation of a multi stage cantilever beam type sustained load testing rig was undertaken in this research. The aim was to make available to local researchers a cost effective, technically efficient, and easily operated testing facility for stress corrosion cracking studies. The design criteria and materials selection were based on design theory and operational principles, local availability of raw materials and components, material properties, materials and fabrication costs, ease of utilization and maintenance, specimen and testing specifications, and basis for data generation. The testing procedure involved the use of circumferential notch specimens subjected to sustained loads noting the time to failure; with 10 % load shedding used for successive loading of specimens to failure. Macroscopic crack evolution of aluminium samples tested with 5 wt% NaCl solution as specific environment showed promise of the rig for reliable SCC studies. The rig was also observed to be safe for use and the precautions prescribed adequate to guarantee accurate data generation and maintenance of the rig. The cost for the design of the test rig was about 50,000 Naira ($250.00) which is cheaper in comparison to conventional SCC testing equipment operating on similar principles which are designed abroad.
Keywords: Stress corrosion cracking; sustained load fracture; circumferential notch specimens; fracture mechanics; cantilever beam

Abstract: The characteristic of color perception is a functional process established at the level of the adapted cones to light, fact observed on night lighting when only rods are excited, and the eye is unable to distinguish colors. The purpose of this paper is to analyze the behavior of the human eye, in simulated laboratory conditions, by exposing them to different types of colored stimuli. Different types of wavelengths, time and frequency of exposure are taken into consideration, attempting to replicate thus the traffic conditions. For it will use a device self created specifically for these types of experimental simulations. It will track and analyze the reactions of subjects where the eye is protected and unprotected and various psychological conditions (most will track eye fatigue).
Keywords: Driver, Visual Function, Optometric Evaluation, Chromatic Vision, Simulation

Abstract: In recent years, adsorption cooling systems are getting attention due to ozone layer depletion issues and global warming potentials related to the conventionally used refrigerants. The adsorption cooling system is the heat driven refrigeration system and hence waste heat energy of the industries or automobiles or solar energy can be used as the heat source in the adsorption system. In adsorption system, the environmental friendly refrigerants such as water, can be used and hence it can cope with the current environmental issues. In adsorption system, different combination of adsorbent–adsorbate pairs is used for successful operation and hence a careful selection of the adsorbent–adsorbate pair is important. With the availability of solar energy and increase in the demand of the air conditioning in the summer, solar adsorption cooling is considered as the best alternative solution to overcome the problems associated with the conventional air conditioning systems. The development in the adsorbent technology provides solution to the shortcomings in solar adsorption systems and helps to achieve higher adsorption capacity per unit mass of adsorbent. In recent years, significant number of simulation work has been carriedout to predict the adsorption system dynamic performance under various operating conditions and accommodate design changes efficiently. This paper discusses the basics of adsorption system and also provides a review of different types of adsorption systems.
Keywords: Cooling system, Adsorption system, engine exhaust powered, solar powered

Abstract: Determination of dielectric properties can provide the electrical or magnetic characteristics of the materials, which useful in many research and development fields improving design, processing, quality and control of product. Many different measurement methods have been developed, but most of them are limited in used frequency and properties of the examined material. At University of Szeged measuring equipment was developed. Measuring method we used is based on reflection method. There are four diodes detecting electrical signs. From these electrical parameters dielectric properties can be determined.
Keywords: dielectric parameters, reflection method, standing wave ratio

Abstract: Automated test and measurements systems provides autonomic computation of data that gives high accuracy, efficiency, resolution and precision in the measurement task. This paper presents the development of an automated test and measurement system to determine cut–off frequency of low pass filter. The software coding was carried out in the LabVIEW programming environment and appropriate hardware were setup to conduct test on series of low pass filter to validate the developed system. The test result shows high degree of accuracy which was validated via manual approach to confirm the effectiveness of the developed system.
Keywords: low pass filter, cut–off frequency, measurement, automation

Abstract: Adaptronics science as scientific and multi–interintegrator strategy is used as a vanguard of opening new possibilities for the design, construction and implementation of innovative products and adaptronics systems. Testing soil and arable land can be improved by adapting existing solutions in different areas. An example is the smart device, drone type that can be used in the testing and monitoring of soil and arable land. Precision agriculture is the key area where drones already proving its economic efficiency. If until now, unmanned aerial vehicles were most often used in military and intelligence area, 2015 was an important year in agribusiness supported by the use of such devices: the price is now accessible and the law clarified some aspects of their detention in civilian purposes. An important aspect is the concept of organic agriculture used to improve quality of life.
Keywords: adaptronic and cyberadaptronic systems, organic agriculture, drones, agribusiness

Abstract: The enormous amount of construction activity in Khartoum city associated with its rapid economic development has produced a large amount of construction and demolition waste over the past three decades. The majority of these wastes has not been well processed, which led to severe damage to the environment. The scenario in Khartoum city showed that there is a clearly need for better construction and demolition of waste management in their construction industry. Thus, this paper aims to determine the critical success factors (CSFs) amongst 18 factors which obtained from the previous studies. A questionnaire survey was conducted in Khartoum city; Sudan in order to conclusively these CSFs can serve as valuable references for stakeholders to develop effective construction and demolition wastes strategies. This also adds to the knowledge on how to reduce adverse environmental impacts caused by construction activities in rapidly developing economics.
Keywords: CSF, waste management, construction, projects, Khartoum city, Sudan

Abstract: In Horizon 2020 Program University of Szeged, Faculty of Engineering and Szeged Transport Ltd. as partners involved in the ELIPTIC (Electrification of Public Transport in Cities) [5] project. (Figure 1; 17) Their aim is to learn about more travel behaviour, environmental–friendly passengers point of view and public transport quality in Szeged, the development of electric–powered modes. Participants are more than 30 partners, from different countries include transport operators, authorities, research centres, universities and other organizations. The problems, so that the tasks are similar, but they differ from each other significantly as well due to the local circumstances. After the test, scheduled for the trolleybus–network wireless and more electric–powered modes of development.
Keywords: public transport, environmental protection, Szeged, traveling behaviour

Abstract: The agricultural industry is very complex and need a lot of attention and qualified employments. Agriculture is a seasonal, highly mechanized activity. The only activity that takes place throughout the year is farming. For other types of activities, the use of automated systems is not always profitable. Harvesting using manpower requires employing a large number of people for a limited time, which may lead to social problems in addition to high labor costs. The big problems of employments are that there is activity only seasonal and are hands work. The same think is in grove–olive, where necessary many workers with experience to collect olives

with their hands. In this case take a lot of time to collect the entire olive grove. For increase production of olives is necessary to collect the olives mechanics with robots. The use of such robots is also justified by people's need to adjust to their environment, adjustment to a certain purpose meaning the increase process of the interaction productivity, by decreasing the necessary effort and increasing the quantity and quality of the environment output.
Keywords: agricultural industry, olives, production, collects, seasonal

Abstract: The assessment of the eco–friendly level of machinery and equipment is currently commonplace. Eco–friendly levels of each product are defined in the pre–production stages of the product's lifecycle. Pair comparison method is one of the several ways of assessing the environmental quality of the product. The assessment is based on four factors – technological, economic, environmental and social. The efforts to preserve natural sources and eliminate adverse effects on the environment are already incorporated in the process of equipment design and penetrate to the manufacture, distribution, use and disposal of particular equipment. The article provides specific examples of assessments carried out on the impact drills with different technical parameters made by one manufacturer. For the purposes of the assessment we used Bosch impact drills with different technical parameters.
Keywords: Environmental quality, product, impact drill, paired comparison

Abstract: Current technology in machine and equipment industry frequently employs components made from hyper–elastic materials such as rubber, various polymeric foams etc. When pressed against another body, such materials illustrate different behavior by comparison to the contacts of linear elastic materials. It is therefore of interest to investigate the mechanical behavior of such materials in contact. The present paper advances a finite element model of the circular contact between a spherical punch made from a hyper–elastic material and a rigid half–space. The numerically obtained results are then compared to previously advance experimental results.
Keywords: rubber, hyper–elastic behavior, simulation, circular contact

Abstract: Pakistan, being a least developed and economically sluggish country, cannot widely support and implement the community projects for its nation. Community development projects in Pakistan mostly rely on foreign aids. The agenda behind this support to the least developed countries is to facilitate them in achieving the Millennium Development Goals. The Charter of United Nations also encourages the promotion of social progress and better standards of life by the employment of external machinery.In Pakistan, the community development professionals design projects in a closed room without doing the practical need assessment with the people, in the field and serve projects in a plate for the community. The aim of this paper is to analyze the factor which affects the sustainability of the community projects. The study has found that the projects which were designed without the consultation, involvement and participation of the community people could not be sustainable. Based on the outcome of the study, I conclude that for the sustainability of community projects it is necessary that community should identify their problems in facilitation of the social researcher by using different tools and should also propose solution to these problems. On the basis of this collected data community projects should be initiated.
Keywords: Community; Community based projects; Sustainability; MGDs

Abstract: This paper contains theoretical studies with Finite Element Analyses for a complex coupling consisting of a towbar (for Audi Q5), a transverse frame to grip on vehicle chassis and the necessary elements for fitting (flanges, screw–nut system, welding). It was proceeded first with the conception and design of all components but also the assembly and fastening system. For the execution and analyze of the model, it was started by shaping it, meshing it with shell and solid type of elements and analysis of the state of tension and deformation under load; it will simulate and determine experimentally the behavior of the towing assembly in compression conditions (braking). The sample contains fastening elements by welding. Finally, it was done a comparison of theoretical and experimental results; further work will follow on some optimization of the components from the studied assembly.
Keywords: towbar, displacement, load, stress

Abstract: The communal solid waste refuse dump of the „A·S·A Hódmezővásárhely Köztisztasági Ltd." Is located on the outskirts of Hódmezővásárhely on the area No. 01957/1. The refuse dump is situated south of Hodmezovasarhely, west of no. 4414 road, about 5–6 kilometres from the centre. In terms of public service obligation the communal solid waste of Hódmezővásárhely and six other settlements is taken to the refuse dump (Csanytelek, Mindszent, Mártély, Földeák, Békéssámson, Makó, Nagyér), its area of responsibility is 200.000 people. It is operating in accordance with the Waste Management Law of 2000 No. XLIII and the related legislation and the public service contracts signed with the municipalities. The refuse dump and its facilities are built on the basis of an impact assessment of 1994. The refuse dump of Hódmezővásárhely is situated on 20 ha of land and the top height of the landfill is 30m. The refuse dump can store 3,9 million m3 of refuse and will provide environment friendly storage for the refuse of Hódmezővásárhely and its environs for 50 years. The refuse dump is provided with technical protection, leachate collection system and landfill gas drainage system constructed on the base of Austrian standards. Its cultivation is done by heapmaking technology. Based on the permission of ATIKÖFE the waste that may be delivered to the refuse dump are the following: household waste, not hazardous industrial waste, sewage sludges, debris and soil.
Keywords: landfill gas, alternative energy, environmental conditions, EWC codes, waste composition

Abstract: Currently, many countries in the world face the serious consequences of global warming, such as: floods, landslides, excessive heat during summer, drought and many others. The material consequences of climate changes on the economy, on human life and on the environment are very serious. Human activity overloads the atmosphere with carbon dioxide and other emissions that cause global warming, capture heat, slowly increase the planet's temperature and have a significant and harmful impact on our heath, on the environment and on the climate. The increase of providing renewable energy would allow replacing energy sources that have high carbon emissions and would lead to the reduction of global warming. The paper presents aspects regarding the importance of using renewable energy, as alternatives to using conventional energy sources (coal, petrol, wood, etc.).
Keywords: renewable energy, global warming, greenhouse gas, biomass

Abstract: Energy demand of the world is increasing day by day as the population increases. Plant origin agri–wastes have an important energy potential, and are environmental friendly with low emission values. Solid biofuels from agri–wastes in the form of briquettes can be a good alternative renewable energy resource to fossil fuels. In this study, biomass waste from oat cultivation were dried till 10–14 % moisture content and chopped till 10 mm particle size and converted to briquettes by a hydraulic press under 240 MPa pressure. Some parameters for briquettes like density, breaking resistance[shatter index), shaking resistance[tumbler index), moisture resistance of briquettes, water intake resistance, ash content, calorific values and chimney gas emission values were determined.
Keywords: biomass, agricultural residue, energy, oat

Abstract: Solid biomass combustion is characterized by two main issues: fuel high moisture weight (that generates some ignition failures) and the high rate of carbon monoxide from flue–gasses (that diminishes the efficiency of the burner an increases the pollution). Hydrogen injection (with a higher combustion velocity) disables the disadvantages mentioned above, allowing the design and operation of more efficient and less pollutant biomass boilers. The paper enhances the theoretical and experimental issues related to the hydrogen use during solid biomass combustion. The research is fully original, according to our knowledge there are no similar paper in the literature.
Keywords: combustion, solid biomass, efficiency, pollution

Abstract: This work was carried out to investigate the effects of chemical treatment on the mechanical and water absorption properties of wood sawdust reinforced cementitious composites. Araba (*seiba pentandra*) wood, a specie of softwood sawdust was selected and treated with KOH solution at an elevated temperature of 50 ^{o}C for 4 hours followed by washing with distilled water and sun drying for 5 days. The dried sawdust was further pulverized and sieve to obtained particle size of 150 µ and oven dried at 65 ^{o}C for 1 hour. The composites were developed by mixing the particulate wood dusts with oil palm fiber and the cementitious matrix in predetermined proportions. Mechanical and physical properties tests were carried out on the cured samples to determine properties such as compressive, flexural and water absorption properties respectively. From the analysis, it was found that both chemically treated and untreated fiber and filler serves as good reinforcement materials where chemically treated samples gave the best results in compressive properties while untreated samples gave the best results in bending and water absorption properties.

Keywords: sawdust; oil palm fiber, cementitious, particulate, chemical treatment, composites

The ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering, Tome IX/2016, Fascicule 3 [July – September] includes scientific papers presented in the sections of:

- **ISB–INMA TEH' 2015 International Symposium (Agricultural and Mechanical Engineering)**, organized by „Politehnica" University of Bucharest – Faculty of Biotechnical Systems Engineering, National Institute of Research–Development for Machines and Installations Designed to Agriculture and Food Industry – INMA Bucharest, EurAgEng – European Society of Agricultural Engineers and Romanian Society of Agricultural Engineers – SIMAR, in Bucharest, ROMANIA, between 29 – 31 October, 2015. The current identification numbers of the papers are # 7–8 and # 27–29, according to the present contents list.
- **International Conference on Science and Technique based on Applied and Fundamental Research – ICoSTAF 2016**, organized by University of Szeged, Faculty of Engineering, in Szeged, HUNGARY, 2 June 2016. The current identification numbers of the papers are # 4, 16, 20 and 26, according to the present contents list.
- **The 1st International Conference "Experimental Mechanics in Engineering" – EMECH 2016**, organized by Romanian Academy of Technical Sciences, Transilvania University of Brasov and Romanian Society of Theoretical and Applied Mechanics, in Brasov, ROMANIA, between 8 – 9 June 2016. The current identification numbers of the papers are # 6, 9, 14, 18, 23 and 25, according to the present contents list.

Also, the ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering, Tome IX/2016, Fascicule 3 [July – September], includes original papers submitted to the Editorial Board, directly by authors or by the regional collaborators of the Journal.

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1. Miroslav KOŠÍK, 2. Jozef BÍLIK, 3. Roland ŠUBA

DESIGN OF INJECTION MOULD WITH CONFORMAL COOLING USING NUMERICAL MODELLING

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Abstract: Paper presents a case study focused on design of the cooling system of injection mould for thermoplastic processing, demonstrated on a model example from engineering industry. At first, the whole mathematical approach how to compute suitable cooling system was described in paper. Subsequently, the advantages of the conformal cooling system compared to conventional were investigated with utilization of the numerical modelling. For this purpose a free-form shaped thin-walled part from automotive industry was selected - component of the rear view mirror. In order to achieve shortest cooling time during this part moulding and its minimal warpage, the several conventional and conformal cooling systems were proposed and were evaluated based on results of the numerical modelling. Finally, the best cooling solution was integrated into shape cavity of the 2+2 family mould
Keywords: design of injection mould, conformal cooling, plastic part warpage, numerical modelling

INTRODUCTION

Injection moulding of the thermoplastics is dynamically process where temperature fields are changing very fast and periodically. In order to stabilize such temperature variation, tempering/cooling system is integrated in every injection mould. The function of the tempering system is to retain a constant mould temperature so the optimal moulding conditions were attained for the proper mould cavity filling, minimal warpages of the produced parts and minimal production times. The phase of the cavity filling requires the higher mould temperatures so the molten plastic can smoothly fill up whole cavity without underfills. On the opposite side, the low mould temperatures are required in order to cool down produced parts in minimal production times. Moreover, the third aspect must be taken to account: uniform cooling of the whole part, because its warping is caused mainly by temperature differences inside the mould during cooling. To meet these requirements, all the heat which is supplied into mould during filling phase must be removed by cooling system uniformly and as soon as possible, however, only to the sufficient mould temperature for next cavity filling. In general, the effectiveness of the used cooling system is given by cooling channels geometry, their size and shape, distance from mould cavity, temperature and volumetric flow of the coolant and mould material. The whole procedure how to design cooling system is described in this case study. In first, thermokinematics of the injection moulding process and principles for the cooling system creation are described. Next, the design of the appropriate cooling system is demonstrated on a part from automotive industry. Since the free-form shaped part was used, several variants of the conventional and conformal cooling systems were investigated by numerical modelling. Finally, the best solution was applied to injection mould.

THERMOKINETICS OF MOULDING PROCESS

In order to design optimal cooling system of the injection mould there is a need to know all the thermal processes occurring during moulding cycle.

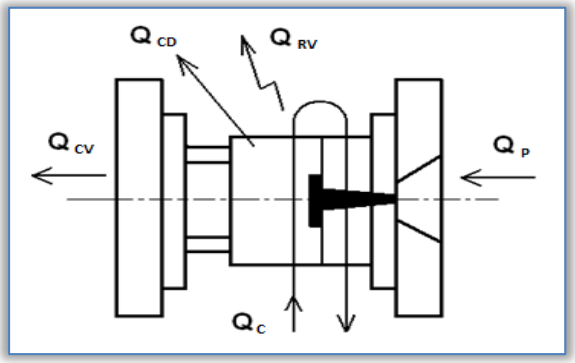

Figure 1. Thermal balance of injection mould

These can be derived from the basic condition of the heat transfer in moulding process:

$$Q_P = Q_C + Q_L \quad [J]$$

where: Q_P - heat supplied by molten plastic [J], Q_C - heat removed by coolant [J], Q_L - heat loss to ambient environment [J], according to Figure 1.

In the case of the heat loss, all kinds of the heat transfer are observed as following:

Q_{CD} - heat conduction to clamping plates of injection machine [J], Q_{CV} - heat convection to environment [J], Q_{RD} - heat transfer by radiation to ambient environment [J],

The source of the heat supplied to mould is molten plastic. In the specific case, it can be also heat generated in injected melt due very high shear rates during cavity filling. The overall heat brought to the mould is determined as:

$$Q_P = m \cdot c_T \cdot (T_M - T_E) = C_T \cdot (T_M - T_E) \quad [J]$$

or:

$$Q_P = m \cdot \Delta H \ [J]$$

where:

m- weight of moulded part including runners [kg],

c_T- specific heat capacity of melt [J/K·kg],

C_T - heat capacity of melt [J/K],

T_M - temperature of melt [K],

T_E - temperature of ejected part [K],

ΔH- enthalpy difference of plastic during melt injection and part ejecting [J/kg]

According to heat supplied to the mould, the required cooling time can be computed. Cooling time is defined as a time needed for the part to be cooled down to recommended ejection temperature, starting at the end of filling phase. The following relations are valid.

Cooling time for thin-walled part:

$$t_{THIN} = \frac{s^2}{\pi^2 \cdot a} \cdot \ln\left(\frac{8}{\pi^2} \cdot \frac{T_M - T_{IM}}{T_E - T_{IM}}\right) \ [s]$$

where: s - maximal thickness of part wall [m],

a - thermal conductivity of plastic [m²/s],

T_{IM} - initial mould temperature [K] [1].

- Cooling time for thick-walled part, if L >> s:

$$t_{THICK} = \frac{s^2}{23{,}14 \cdot a} \cdot \ln\left(0{,}692 \cdot \frac{T_M - T_{IM}}{T_E - T_{IM}}\right),$$

or if L ≈ s:

$$t_{THICK} = \frac{1}{\left(\frac{23{,}14}{s^2} + \frac{\pi^2}{L}\right) \cdot a} \cdot \ln\left(0{,}561 \cdot \frac{T_M - T_{IM}}{T_E - T_{IM}}\right) [s]$$

where: L - length of part [m] [1].

Subsequently, the needed cooling capacity can by computed. Cooling capacity is defined as a quantity of heat removed from mould for time unit according to following relation:

$$\dot{Q}_{CL} = Q_P / t_{THIN} = Q_P / t_{THICK} \quad [J/s]$$

or:

$$\dot{Q}_{CL} = h_{MM} \cdot S_C \cdot (T_{CW} - T_C) \ [J/s]$$

where: $h_{MM} = \frac{\lambda_C}{D} \cdot Pr^{0,42} \cdot (Re^{0,42} - 180)$ [W/m²·K]

$$Pr = \frac{\eta \cdot c_C}{\lambda_C} \ [-], \ Re = (v \cdot \rho \cdot D) / \eta \ [-],$$

and individual variables are:

h_{MM} - heat transfer coefficient between mould / cooling channel wall and coolant [W/m²·K],

S_C- size of cooling channel surface [m²],

T_{CW}- temperature at cooling channel surface [K],

T_C-temperature of coolant [K],

λ_C - thermal conductivity of coolant [W/m·K],

D- cooling channel diameter [m],

Pr- Prandtl number [-],

Re- Reynolds number [-],

η - dynamic viscosity of coolant [Pa·s],

c_C - specific heat capacity of coolant [J/kg·K],

v - velocity of coolant flow [m/s⁻¹],

ρ - coolant density [kg/m³]

or in specific case, the thermal loss can be considered in cooling capacity calculation:

$$\dot{Q}_{CL} = \frac{Q_P}{t_{CY}} - \frac{(Q_{CV} + Q_{CD} + Q_{RD})}{t_{CY}} \ [J/s]$$

where the loss by heat convection is:

$$Q_{CV} = h_{CP} \cdot S_{CP} \cdot t_{CY} \cdot (T_{MT} - T_{IP})$$

$$\dot{Q}_{CV} = h_{CP} \cdot S_{CP} \cdot (T_{MT} - T_{IP})$$

with: h_{CP} - heat transfer coefficient between mould clamping plates, $h_{CP} = \lambda_P / l$. If thermo-insulating plate is used:

$$h_{CP} = \frac{1}{\frac{1}{\lambda_P} + \frac{l_{IP}}{\lambda_{IP}}} \ [W/m^2 \cdot K],$$

λ_P - thermal conductivity of clamping plates material [W/m¹·K],

λ_{IP} - thermal conductivity of clamping plates material [W/m¹·K],

l - distance of mould cavity from clamping plates [m],

l_{IP} - thickness of insulating plate [m],

S_{CP} - contact surface between mould clamping plates [m²],

T_{MT} - mould temperature [K],

T_{IP} - clamping plate temperature [K],

t_{CY} - time of one moulding cycle [s],

the loss by heat conduction is:

$$Q_{CD} = h_{MA} \cdot t_{CY} \cdot t_O \cdot (S_A + 2 \cdot S_P) \cdot (T_{MT} - T_A)$$

$$\dot{Q}_{CD} = h_{MA} \cdot (S_A + 2 \cdot S_P) \cdot (T_{MT} - T_A)$$

with:

t_O- mould opening time [s],

h_{MA} - heat transfer coefficient between mould and ambient flowing air [approximately 6 - 10 W/m²·K],
S_A- external mould surface in contact with ambient air [m²],
S_P - external mould surface in contact with ambient air [m²],
T_A - ambient air temperature [K],
and the loss by heat radiation is:

$$Q_{RD} = \sigma \cdot C_0 \cdot t_{CY} \cdot S_A \cdot (T_{MT}^4 - T_A^4)$$

$$\dot{Q}_{RD} = \sigma \cdot C_0 \cdot S_A \cdot (T_{MT}^4 - T_A^4)$$

with: σ - emissivity of mould material [-],
C_0 - Stefan-Boltzmann constant

$$C_0 = 5{,}67 \cdot 10^{-8} \text{ [W/m}^2\text{·K}^4\text{]}.$$

Required cooling capacity can be also determined in relation to individual cooling circuit:

$$\dot{Q}_{CCi} = \dot{Q}_{CL} / i \quad \text{[J/s]}$$

where i - number cooling circuits.
Generally, the amount of removed heat is dependent mainly on the volume of coolant overflowed through mould and its temperature drop at inlet and outlet. The necessary volumetric flow of the coolant (volume of the coolant which must flow through the one cooling circuit for time unit) can be determined as:

$$\dot{V}_i = \frac{\dot{Q}_{CCi}}{c_C \cdot \square \cdot (T_{C2} - T_{C1})} \text{ [m}^3\text{/s]}$$

where:
T_{C1} - temperature of coolant at the inlet,
T_{C2} - temperature of coolant at the outlet.
The recommended maximal temperature difference at the coolant inlet and outlet is 3 °K. Effectiveness of the heat removal is more significant in case of the higher Reynolds number, thus in case of the turbulent coolant flow. Consequently, the parameters of the cooling channels can be determined as [2]:
- Maximal diameter of the cooling channel:

$$D_{MAX} = \frac{4 \cdot \rho \cdot \dot{V}}{\pi \cdot \eta \cdot Re} = \frac{4 \cdot \dot{V}}{\pi \cdot \nu \cdot Re} \text{ [m]}$$

where:
ν - kinematic viscosity of coolant[m²/s]
- Minimal diameter of the cooling channel:

$$D_{MIN} = \sqrt[5]{\frac{\rho \cdot L_C \cdot \dot{V}}{10 \cdot \pi \cdot \Delta p}} \text{ [m]}$$

where:
L_C - estimated cooling channel length [m]
Δp- difference of coolant pressure at the coolant inlet and outlet [Pa]
The recommended maximal pressure drop is 0,1 MPA. The signature of the individual variables is the same in whole computation procedure. However, the design of the optimal cooling channel dimensions is dependent on other influences and should consider designer experience. The recommended distance between mould cavity and cooling channel H is in range of 2D < H < 5D of the cooling channel diameter. Exact value is influenced by coolant pressure and mould material strength, as well as in the case of spacing between channels W, which should be set in the range of H < W < 2H [2].

COOLING SYSTEM DESIGN

However, according to requirements of the engineering industry, more and more shape-complicated parts are produced nowadays. Computation of the appropriate cooling system for such a free-form shaped parts by analytical approach can be very difficult and inaccurate, therefore, numerical modelling is widely used for its investigation [3, 4]. In addition, the more complicated the part geometry is, the more complicated cooling system is usually required. In order to achieve uniform and adequate cooling of these parts, the cooling channels must copy the pattern of the part geometry, but this cannot be attained by straight, conventional drilled channels. Therefore, engineers are forced to use advanced cooling technologies increasingly. There are many non-conventional cooling methods, for example as Spot Cooling, Tool-Vac Cooling, cooling by Ranque - Hilsch vortex tubes, and others. In this case study, effectiveness of the conformal cooling was studied in comparison to conventional drilled. Conformal cooling channel is a cooling passageway which follows the shape or profile of the mould cavity to perform rapid uniform cooling process for injection moulding, as it is demonstrated in studies [5, 6, 7, 8]. Its principle is shown in Figure 2.

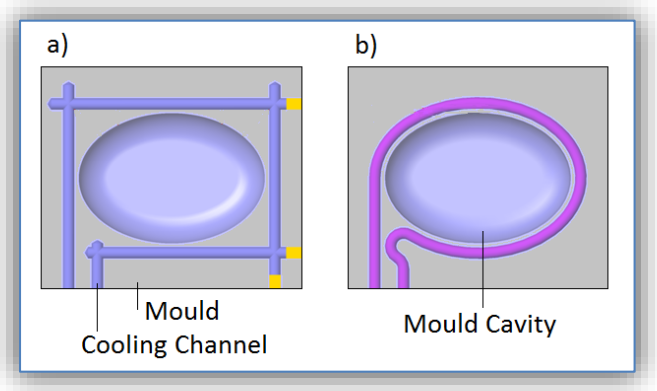

Figure 2. Comparison of the: a) conventional, and b) conformal cooling channels

For investigation, a free-form shaped thin-walled part from automotive industry was selected - cover of the rear view mirror. Cover is lacquered to high gloss and its surfaces must be smoothly aligned to surfaces of the adjacent mirror covers. Therefore, the high dimensional accuracy must be achieved during moulding.

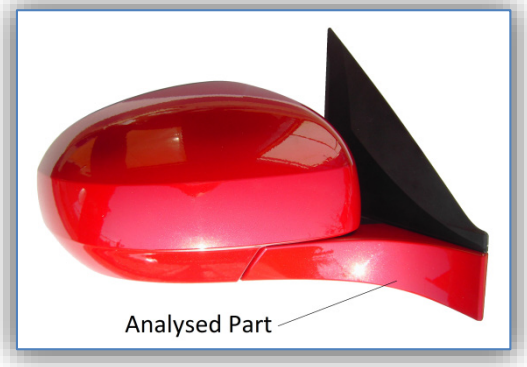

Figure 3. The rear-view mirror and analysed part

Analysed cover as a component of the complete mirror set is shown in Figure 3. Detail of the cover showed from both sides, created as CAD model, is in Figure 4.

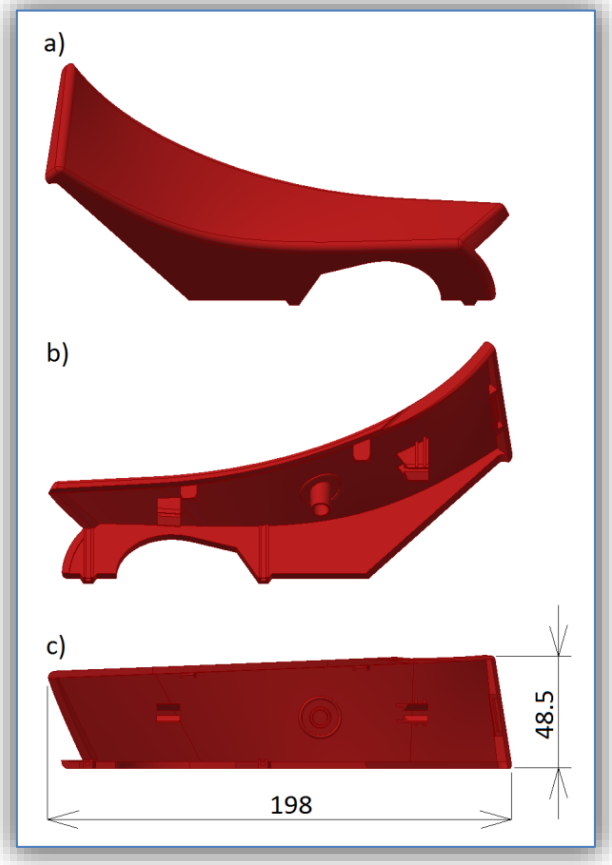

Figure 4. CAD model of the cover from:
a) front side, b) back side, c) dimensioned view

Cover is made from ABS Novodur P2H-AT with wall thickness in range of the 1 - 3 mm. Injection shot volume is around 44580 mm^3 and part weight is 0,03 kg.

Cover includes the fixing and guiding features, which require using of the cores and lifters in mould, limiting the space for channels drilling and thus the coolant cannot be applied to important places of the heat concentration. Cover is product of the mass-production and designed as left and right. Any shortening of the production time can have significant influence on production cost saving and final product price. Therefore, creating of the conformal cooling in this case would have positive effect.

In the first step, the heat conduction in mould during cover moulding was studied in order to determine where cooling channels should be localized. Hence, the fast computation model of the mould with runner and without cooling system was prepared in Moldex3D/Solid and preliminary analysis of the cavity filling/ packing was carried, mainly in order to identify the distribution of the temperature fields in mould. Also an effort to optimization of the injection parameters. In Figure 5, the areas of the heat concentration inside the solidifying cover, which require more intensive cooling, is showed as a result of the preliminary analysis. Typically, these are the areas of the thicker walls, corners and region of the runner gate, which solidifies last. They are characterized by molten core at the end of the packing phase.

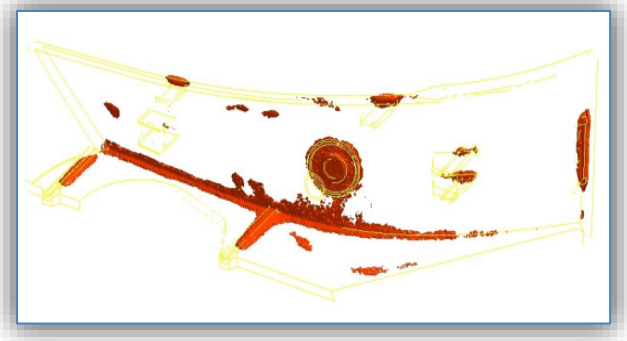

Figure 5. The areas of the potential heat concentration inside the cover

Consequently, the several types of the conventional and conformal cooling channels were designed. In following Figures 6 and 7, some models of these designs are illustrated.

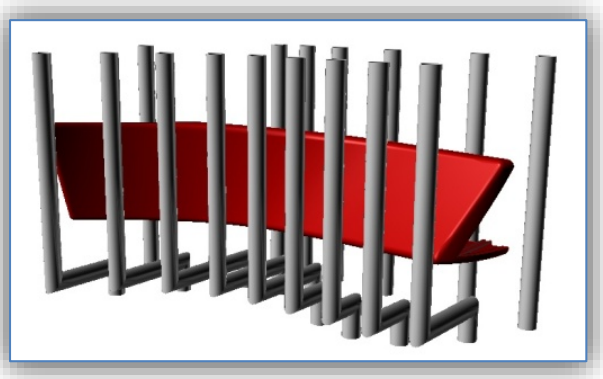

Figure 6. Design of the conventional cooling channels

For all of these designs, full computation model of the complete injection mould was generated from solid meshes of the mould cavities, runner systems, cooling systems and mould bases. In order to

achieve maximal accuracy of the analysis results, the mould cavities were meshed by BLM hybrid meshes from tetrahedrons elements for cavity cores and two refined layers of the hexahedron elements for cavity surfaces. The example of such full computation model is shown in Figure 8.

Figure 7. Several designs of the conformal cooling channels

In the next step, the detailed analyses of the cavity filling, packing, cooling phase and part warpage were performed in Moldex3D/Solid solver for all cooling system designs.

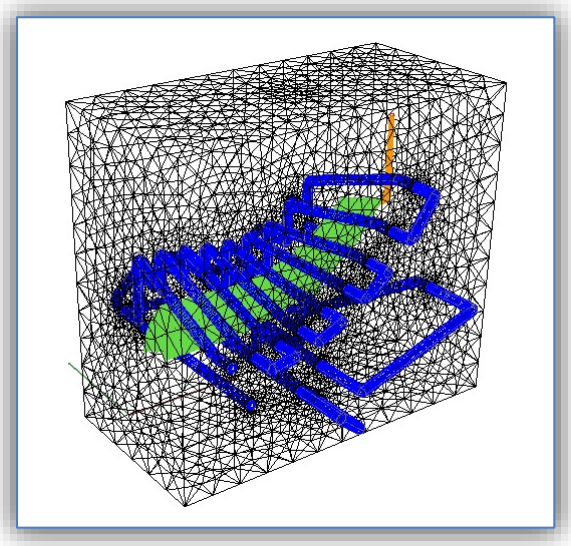

Figure 8. Full computation model of the injection mould with conformal cooling.

RESULTS

The freeze temperature of used plastic was approximately 115°C and recommended temperature for part ejection from mould was 85°C. For all of the cooling designs, estimated cooling time of the 20 sec. was preliminary determined at first and temperatures fields inside the moulds and parts were simulated in this time step. The results of these analyses are shown in Figures 9 - 12 in cross-sections of the moulds with the best conventional and conformal cooling solution.

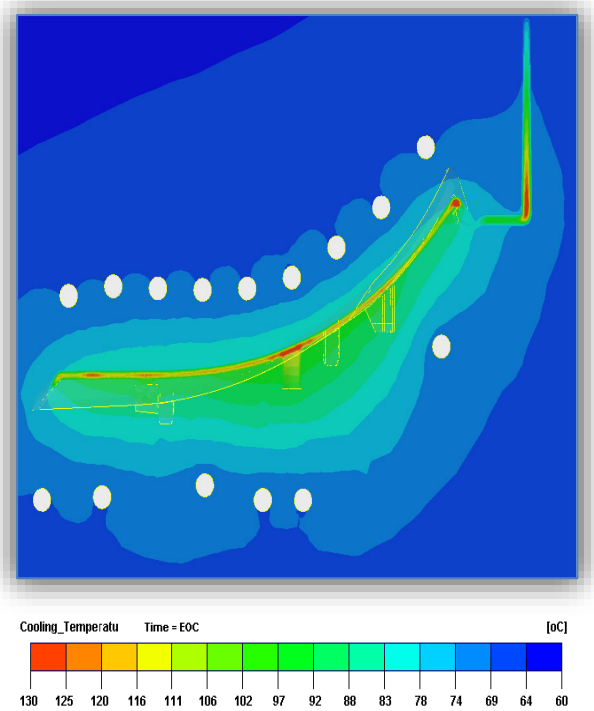

Figure 9. Temperature fields in conventional channels cooled mould after 20 sec. of cooling time (perpendicular cross-section)

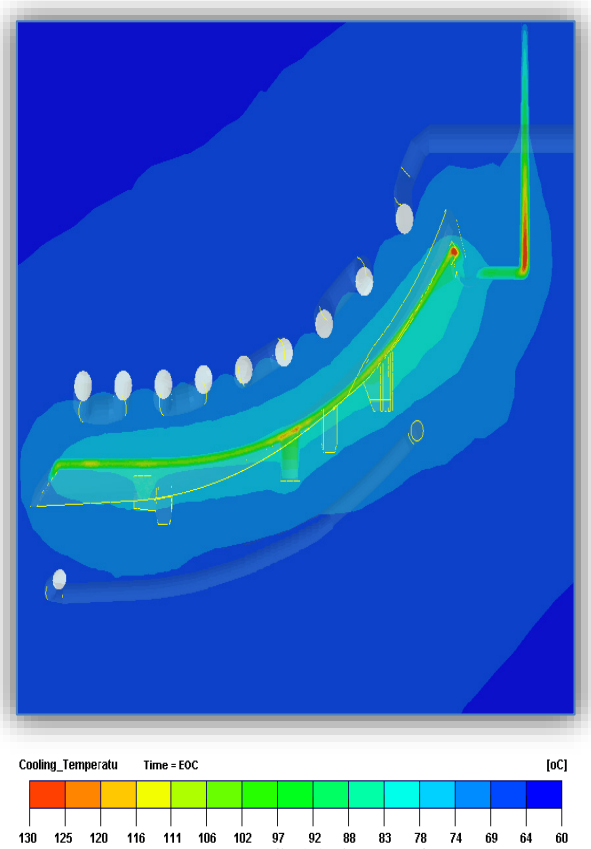

Figure 10. Temperature fields in conformal channels cooled mould after 20 sec. of cooling time (perpendicular cross-section)

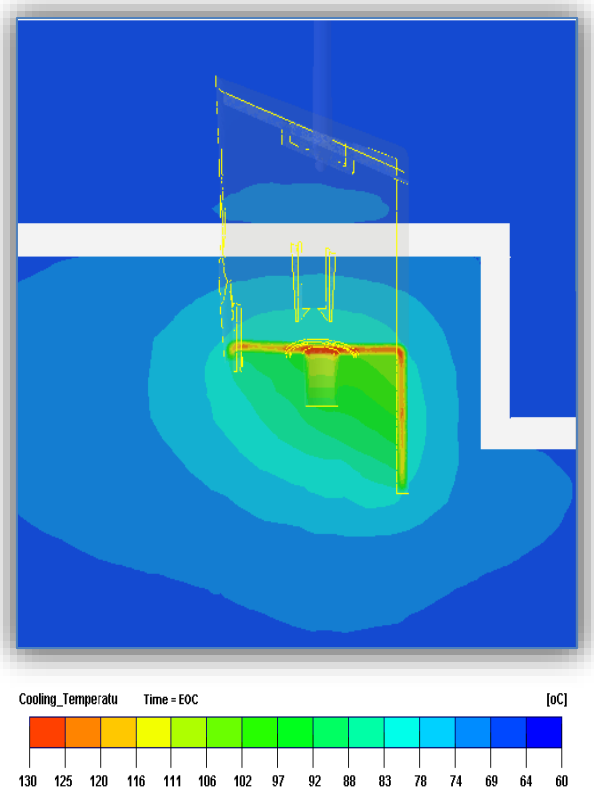

Figure 11. Temperature fields in conventional channels cooled mould after 20 sec. of cooling time (longitudinal cross-section)

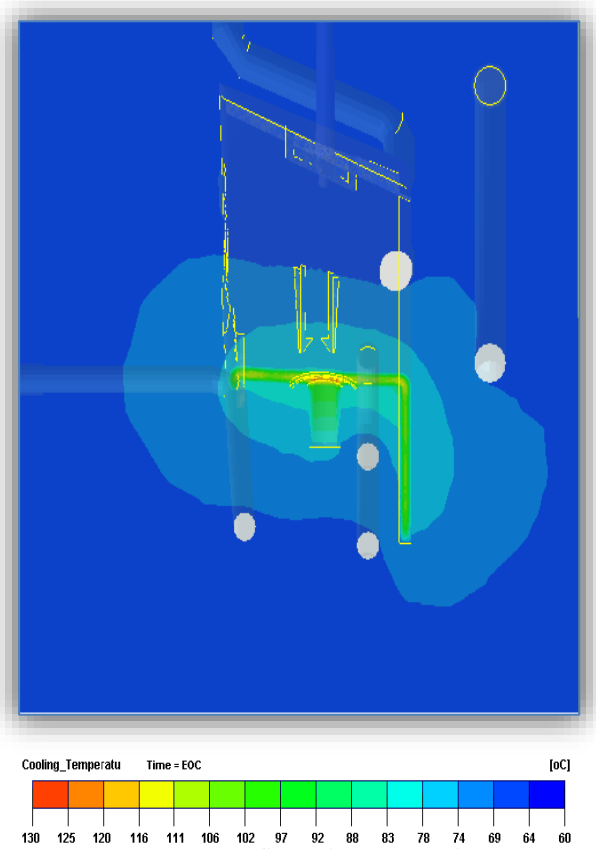

Figure 12. Temperature fields in conventional channels cooled mould after 20 sec. of cooling time (longitudinal cross-section)

According to results, the most of the conventional cooled part achieved temperatures higher than 115°C at the end of 20 seconds cooling time, thus the most of plastic was in molten state in this time. Although conformal cooled part contained molten core also, this were only minimal and acceptable for part ejection due to most of this part was cooled down to temperature about 85°C, thus to sufficient temperature for part ejection. The estimated cooling time for the conformal cooled cover of 20 seconds was identical as computed required cooling time of 23 seconds, according to mathematical relation for cooling time of the thin-walled parts. As following analyses showed, the necessary cooling time in case of the conventional cooling cover was 34 second. The obtained time saving was 41 %. If mass-production of the 50 000 cycle (for one mould life cycle) is considered, time saving of 194.4 hours would be obtained.

In the next step, the results of the warp analyses were evaluated. During cooling, the cover had tendency to bend and flexure to itself. The warping behaviour of the solidifying cover is shown in Figure 13.

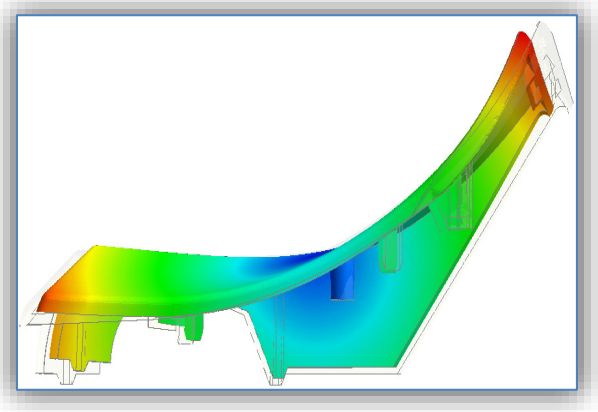

Figure 13. Warp behaviour of conventional cooled cover in scale 2

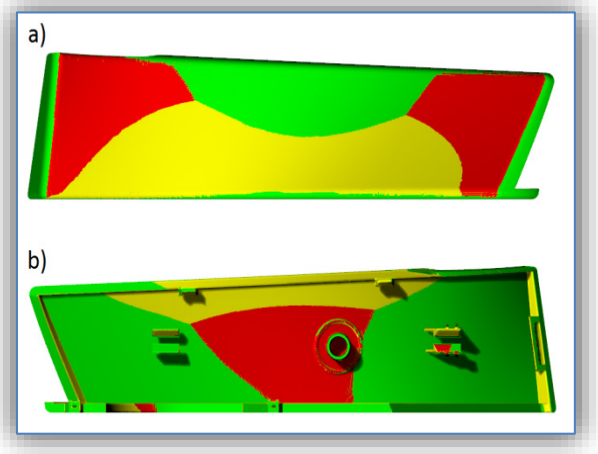

Figure 14. The comparison of the non-deformed (green), conventional cooled (red) and conformal cooled (yellow) cover

The maximal total displacements were observed on the opposite outer corners. In the case of the conventional cooling, the maximal displacement achieved almost 3 mm. On the other side, it was only 1.4 mm in the case of the conformal. However, the warp behaviour of the covers cooled by both cooling systems was partially different mainly due to conformal channels located in area around the mould inserts, where conventional channels cannot be introduced. The comparison of the non-deformed, deformed conventional and deformed conformal cooled cover is shown in Figure 14. In case of the fixing and guiding features, the attained total displacement were in lower range of less than 1 mm between both cooling variants.

Since the conformal channels offered more effective cooling than conventional ones, these were integrated to design of the family 2+2 injection mould for two right and two left cover. Its final design including cooling channels is shown in Figure 15.

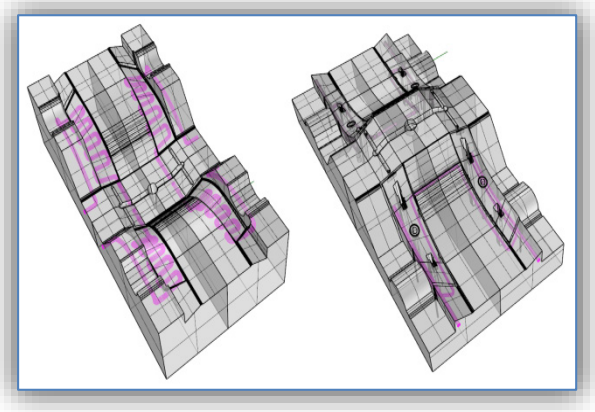

Figure 15. Final design of the injection mould with conformal cooling (A and B blocks)

In an effort to achieved the maximal effectiveness of the cooling, the channels with elliptical cross-section profile was used in areas between mould inserts due to elliptical profile is characterized by the higher perimeter in relation to internal area than it is in a circular, so the heat transfer from mould to coolant can be increased by this way. Cross-section of the mould in area with elliptical channels is shown in Figure 16.

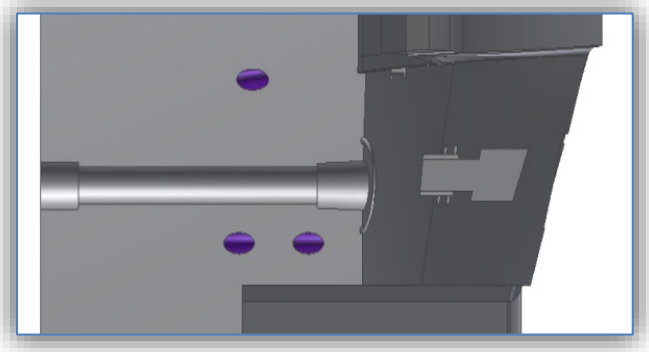

Figure 16. Cooling channels with elliptical cross-section in area of the mould inserts

Generally, the same minimal distance of 8 mm between mould cavity and channel axis was preserved for all channels so the same conditions were retained for correct cooling systems investigation.

Table 1. Moulding Parameters

Parameter	Value	Unit
Melt Temperature	240	°C
Mould Temperature	60	°C
Filling Time	1.6	s
Packing Time	6	s
Coolant Temperature	60	°C
Max Injection/Packing Pressure	12	MPa

Finally, the injection moulding parameters according to Table 1 were determined for cover production.

CONCLUSIONS

In this case study, a cooling effectiveness of the several variants of the conformal cooling system design were investigated in comparison to conventional using a part form automotive industry. As results of the numerical modelling shown, there can be achieved more intense heat removal and more balanced temperature fields inside mould during cooling, which can have the positive effect on cooling time decreasing and reduction of the product warpages. The effectiveness of the conformal cooling channel is given mainly by the possibility of the geometrical freedom for its design. If the application of the conformal cooling channels should be approved, the using of the adequate production technology for mould manufacturing must be considered. However, although the benefits of the conformal cooling system were proven by the numerical analyses, the final confirmation of the obtained results requires another experiment based on the real injection moulding and product warpages measuring.

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MASS CUSTOMIZATION AS ONE OF THE KEY ELEMENTS OF LOGISTIC EFFICIENCY OF A PRODUCT

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Abstract: The concept of Total Logistics Management (TLM) is a response to the challenges of contemporary economy, proposing the idea of an enterprise oriented towards flow. Flow has a broad definition here. It concerns materials, information as well as finances. Effective and efficient flow as referring to any category should be the objective of any organization. It must be noted that one of the basic element of TLM is the product itself as well as designing it in such a way to make it logistically efficient. A logistically efficient product is a product that would support the flow while being attractive to a customer. When considering optimization of logistic costs and processes the features and properties of a product are usually not considered as they are believed to be limiting conditions. The changes are made in the way specific processes are executed, while product properties remain unchanged.
Keywords: mass customization, logistic, efficiency, product

INTRODUCTION

When considering optimization of logistic costs and processes the features and properties of a product are usually not considered as they are believed to be limiting conditions. The changes are made in the way specific processes are executed, while product properties remain unchanged. There is a point, however, when further attempts at optimization may not bring the expected results. A question then arises how a product itself influences the execution of logistic processes in an enterprise and if the changes in a product's design can introduce specific added value for the enterprise without decreasing the value and quality of a product in the eyes of clients.

Including logistic aspect in designing a product may be a significant challenge for an enterprise and means radical change in perceiving the role of logistics in a production enterprise. Expanding production management by system and process approach to quality management should be also expanded by including logistic issues. Logistic management then becomes one of key elements that should be taken into consideration as soon as designing a product starts. This should not mean that logistics is superior to all other areas of an enterprise's activities, but that it should be included in strategic areas of management, which is one of essential assumptions of the concept of total logistics management [10].

The concept of Total Logistics Management (TLM) is a response to the challenges of contemporary economy, proposing the idea of an enterprise oriented towards flow. Flow has a broad definition here. It concerns materials, information as well as finances. Effective and efficient flow as referring to any category should be the objective of any organization. It must be noted that one of the basic element of TLM is the product itself as well as designing it in such a way to make it logistically efficient. A logistically efficient product is a product that would support the flow while being attractive to a customer.

ESSENCE OF LOGISTICALLY-EFFICIENT PRODUCT

A logistically-efficient product is defined as a material object of market exchange which possesses a set of features and properties that enable it, within the internal dimension of an organization, to move through supply, production and distribution areas, and, in the external dimension of an organization, enable logistic management to effectively and efficiently integrate handling orders, managing supplies, storing, packaging and transport with external subjects as a part of supply chain [2]. It should also be noted that a logistically-efficient product enables both the producer and customer to gain benefit. As the interests of both sides are often contradictory, an attempt to combine the benefits will result in creating an 'imperfect' product, but

one that will facilitate executing logistic processes and one satisfying to a client [4].
Logistic efficiency may be analyzed in reference to a variety of products which is why it is difficult to unambiguously define the features and properties that will facilitate its flow in logistic channel. However, it is possible to point to general conditions that a product has to fulfil in the context of particular logistic functions.
When handling orders, the role of a product is connected mainly to the information field – the possibility of synthetic description and parametrization of the product's features. From the point of view of logistic handling a situation when a product exists in only one variation without a possibility of altering as requested by a client is beneficial. It decreases the risk of making a mistake while receiving an order and shortens the time of handling it (information necessary to be given by a client is limited to the number of pieces of an item). If a product is available in different variations (e.g. colors) it is beneficial if the variations are standard (color is chosen from a sampler, parts to be selected are standard) which enables to precisely define the variations.
When analyzing logistic efficiency of a product from the perspective of supply management, the structure of a product needs to be addressed. The supply of each of the elements comprising a product (raw materials, semi-finished products, and product parts) requires to be handled separately in management process, which is why the more complex the product the more work needs to be put into forecasting, controlling and supplementing the supplies. On the other hand, from the point of view of managing supply of the whole stock, standardization of parts is important. It is much more beneficial, in the context of logistics, if parts of items are normalized and can be used interchangeably.
Another aspect concerns technological process. Executing production goes beyond the tasks of supply management according to Pfohl; it has been assumed that that the specifics of the production influence decisions regarding materials management. Firstly, material intensity of a product determines the amount of stored supplies, which, in turn, translates into the amount of frozen capital. From the point of view of logistics as well as accounting liquidity 'lean' products literally improve management [7]. Production time is also vital for logistic efficiency of a product. There is no doubt that the shorter it takes to manufacture a product the quicker the flow of materials is. Time taken to prepare production should also be considered. If the time of re-tasking machinery is too long, it is not profitable to produce a few pieces of a product. Increasing that number often results in producing goods to store them, i.e. increasing the number of ready-made goods. Thus, it can be assumed that a product with shorter production preparation time is more logistically-efficient.
In the context of storing, the following situation is beneficial:

- a product takes less storage area and storage space (a product can be pile dup – the higher the pile the better);
- a product does not require special storage conditions;
- a product will not expire;
- no adjustment activities in a warehouse are necessary (e.g. re-packaging);
- automation is possible to be applied [8] – a product has standard shape and size.

Each of the mentioned aspects influences the reduction of time, saving of storage space or lowering storage costs.
There is no doubt that a product's packaging should improve its logistic efficiency, which means that it should streamline the flow of materials. Packaging should then protect a product from decreasing in value to the maximum possible extent, facilitate storing, transport and manipulation as well as provide information necessary to identify the product. Features and properties of packaging can compensate for features and properties of a product itself that can reduce its logistic efficiency (e.g. non-standard shape).
From the perspective of transport optimization, the following features are important:

- size of a product in relation to the capabilities of the available transport infrastructure;
- features that facilitate loading and unloading;
- lack of features that hinder transport, such as susceptibility to mechanical damage or requirement for particular transport conditions [3].

These features influence rise in quality, shortening the time and reducing the costs of transport.
When considering the conditions to be fulfilled by a logistically-efficient product in order to support the execution of each logistic function, it may be concluded that standardization should be considered an important element of logistic efficiency. For standard orders, products of standard dimensions, consisting of standard parts, having standard packaging it is easier to find solutions – concerning production process, warehouse equipment, means of transport and IT aspects – that would allow both to save time and to streamline the flow. The benefits of standardization may also include improvements in the fields of supervision, control, training, service and handling.

All of these are aimed at gaining the most important benefits for an enterprise – economical ones.
The definition of a logistically efficient product also emphasizes the fact that the product should fulfill the conditions of posing no hazard for health and life, simultaneously fulfilling a user's individual needs. A question then arises: what actions need to be taken to satisfy clients with often extremely varied preferences. The answer has to be sought in the concept of mass customization, that is: offering products tailored to customers' needs on a mass scale at prices comparable with those of standard products [1].

LOGISTIC DIMENSION OF MASS CUSTOMIZATION

The combination of the advantages of mass production and the possibility of offering a personalized product is the key element of the concept of logistic efficiency of a product. Mass customization combines contradictory notions, which is why its application requires a compromise between the expectations of the producer and the client. The client is involved in the process of creating a product, but their involvement may reach different stages of production process [6]. Thus, four degrees of customization with decreasing level of product personalization can be distinguished:

- pure customization,
- tailored customization,
- standardized customization,
- pure standardization.

In pure customization the client participates in designing the product, which is why it is possible to create an item that meets their individual preferences. Tailored customization assumes the client's involvement at the production stage. It allows to modify the shape and size of standard elements according to the client's requirements. Involving the client at the assembly or distribution stage, as in standardized customization, results in adjusting the product but only to the extent allowed by a list of standard options. In pure standardization an individual client's needs are not considered [9]. If the client's involvement in the process of creating a product is defined this way, it should be noted that in many cases the clients' wishes have to converge with the needs of effective and efficient flows within the enterprise. What is more, there may be many situations when these wishes contradict the logistic objectives of an organization. Thus it has become more and more frequent economic practice to attempt to create such business model in which logistic efficiency of a product becomes the key element of competition.
From the point of view of logistic efficiency of a product, standardized customization option seems to be the best choice. This approach gives the client an opportunity to choose the most suitable parameters of a ready-made product without extra payment. Simultaneously, an enterprise can take advantage of the effect of standard elements production scale, thus gaining organizational and economic benefits.
Product customization can take on different forms depending on the range of changes to a product and product perception by a client [5]. Also in this case there are four forms of customization – here they comprise a matrix (figure 1). In the case of transparent customization, the changes to a product introduced by the producer are unnoticeable to a client. This occurs in a situation when an enterprise, based on observing clients' preferences, introduces changes to products that are bought repeatedly so as to meet the clients' expectations to the highest possible degree. Collaborative customization is based on introducing changes to a product by the producer in communication with an individual client, due to which the client can receive a product that fulfils their needs to the greatest extent. A different situation occurs in case of adaptive customization where neither the product changes nor the way it is perceived by a client does. The essence of customization here concerns the possibility of adjusting one product to different needs by the user (e.g. lighting system) or self-adjustment of a product to the user's needs (e.g. molded insoles). The last form – cosmetic customization is based on offering the client a standard product in which only the features determining its perception have been changed, e.g. packaging [9].

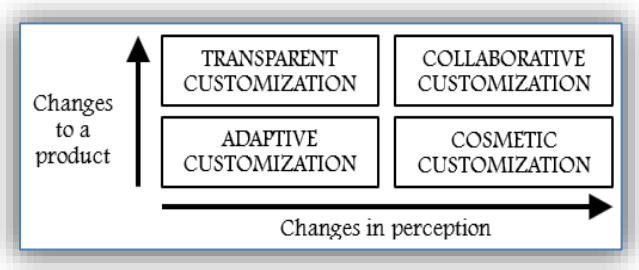

Figure 1. Forms of customization [9]

Considering the assumptions regarding logistic efficiency of a product, the most favorable forms of customization from the point of view of logistic efficiency of a product are transparent and collaborative customization. In both cases the possibility of introducing changes to a product allows to find features and properties that can be modified to the benefit of both clients and production enterprise, particularly in logistic context. Obviously, it is vital to find a common ground for the added value which will improve the competitiveness of a product from the point of view of a client and an enterprise. It seems that the notion of logistic efficiency of a product as a source

of added value for a client and a production enterprise should become the next step in research conducted by the authors.

From the point of view of logistic efficiency of a product, there is one notion that deserves attention in the concept of mass customization that is the notion of modularity. Product modularity means that a product consists of independent modules by combining which a product tailored to an individual client's needs is created. [9]. Standard modules perform the function of spare parts which results in the possibility of using the same elements in different products which, in turn, translates into the reduction of the amount of supplies and decreasing the risk of surplus or shortage of components [9].

To illustrate the issue of mass customization as an element of logistic efficiency of a product an example of furniture production can be given. A producer usually offers several lines of products (systems) differing in style, consisting of products fulfilling the same functions (wardrobes, shelves, chests of drawers). If an enterprise treats each of these lines separately, it offers its customers a wide range of products (due to this, there is greater likelihood of meeting the requirements of an individual client), however, it has to face managing a significant number of components. If the products of the same function are treated as one product it might be possible to simplify managing the range. For the purpose of customization, it is necessary to isolate modules that can be changed according to a client's requirements. In case of a chest of drawers there can be four modules: drawers front sides, elements of the body, handles and other equipment (slides, other parts of drawers). The last module is standard and will not be subject to a client's choice. The choice of the first three modules from among variations differing in color, pattern, material will allow the client to create a chest of drawers with features that they most prefer. If the company additionally designs its products in such a way that standard modules can be applied in several products (identical dimensions, distance between handle holes), it can take full advantage of mass production and the clients will gain a wide range of personalized products at the price of standard ones.

CONCLUSIONS

Contemporary logistics meets clients' expectations. Supplying the right product" in accordance with the 7R rule requires taking individual needs of customers into consideration. The concept of Total Logistics Management uses the notion of logistically efficient product able to offer benefits for both the producer and client. The application of mass customization through re-designing products in a way that is favorable for mass production and through the use of theory of modularity becomes one of the key elements of logistic efficiency of a product. Modularity allows to adjust a standard product to clients' preferences without generating additional costs and simultaneously enables to create a product that supports the realization of logistic functions in an enterprise. The presented analysis and the authors' reflections have initiated research into logistic efficiency of a product as a source of added value for a client and for a production enterprise.

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MEAT INDUSTRY WASTEWATER MANAGEMENT IN VOJVODINA REGION (SERBIA) - CURRENT SITUATION

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Abstract: Meat industry wastewater represents a serious problem regarding environmental degradation and human health protection. Even though this type of wastewater is biodegradable and therefore relatively easily purified, in Serbia, it is often discharged into the sewer and surface receiving water, without the prior treatment. The aim of the study was to create the Inventory of the meat industry and abattoir facilities in the territory of Vojvodina region, Serbia, in order to get an insight into number of entities that discharge polluted water into environment. Most of the discharged wastewater ends up in septic tanks, public sewerage system, or is removed as solid waste and stored on the landfills and open dumps. To ensure environmental sustainability, the polluted effluent should be managed in a way that minimizes its adverse effects on the environment. The first step towards achieving this goal is to determine the number of facilities, as the potential polluters. During the study 59 subjects were registered, and 52 of them took a part in the survey. The results indicate poor quality or complete absence of wastewater treatment and quality control.
Keywords: wastewater, meat industry, abattoir, water treatment, environment

INTRODUCTION

The meat industry is the type of food industry, which causes degradation of the environment to a large extent. This industry sector has a significant role in increasing water use, but only a small amount of the used water is a constituent of the final product, the remaining part is discharged as a wastewater with high biological and chemical oxygen demand, high fat content and high concentrations of dry residue, sedimentary and total suspended matter as well as nitrogen and chlorides (Urbaniak and Sakson, 1999; Arvanitoyannis and Ladas, 2008; Bohdziewicz and Sroka, 2005; Sroka et al., 2004). Wastewater will be generated whenever food is handled in any form, processed, packaged and stored (Iacovidou et al., 2012; Yushina and Hasegawa, 1994).

In meat processing industry, water is used primarily for carcass washing after hide processing from cattle, calves, and sheep or hair removal from hogs and again after evisceration, for cleaning, and sanitizing of equipment and facilities, and for cooling of mechanical equipment such as compressors and pumps. A large quantity of water is used for scalding of hogs for hair removal before evisceration (Ur Rahman et al., 2014; FAO, 2006; 2008).

During slaughtering and processing, usage of water and wastewater generation are relatively constant and low compared to the cleanup period that follows. Meat processing wastewater flow rates can be highly variable, especially on an hourly basis (FAO, 2006). Variability of the wastewater quality and quantity represents a serious problem in the situations when drawing of certain conclusions is needed. Especially when there is no permanent monitoring of wastewater quality provided.

Wastewater from meat processing can contain mineral elements and water supply systems and mechanical equipment may be significant source of metals, including copper, chromium, molybdenum, nickel, titanium, and vanadium (González-González et al., 2014; Wong and Cheung, 1995).

The main constituents of meat processing wastewater are biodegradable organic compounds, primarily fats and proteins, present in both particulate and dissolved forms. Pesticide residues may be present from treatment of animals or their feed. Therefore, the major problem of wastewater treatments for meat industries are the usual pollutants of these waters, such as organic macromolecules: proteins, polysaccharides, amino sugars, nucleic acids, humic and fulvic acids, and cell components in addition to wastewater

microbial contamination found in these waters (Mostafa and Darwish, 2014).
Significant amount of total coliform, fecal coliform, and fecal streptococcus groups of bacteria is present due to the presence of manure in meat processing wastewater. Although members of these groups of microorganisms generally are not pathogenic, they do indicate the possible presence of pathogens such as Salmonella spp. and Campylobacter jejuni (Barkocy-Gallagher et al., 2003; Sandvig and van Deurs, 2000). They also indicate the possible presence of gastrointestinal parasites and enteric viruses (EPA, 2004).
All of the mentioned possible pollutants from the meat industry processes are contaminants that cause concern in wastewater treatment (G. Coskuner and N.S. Ozdemir, 2006).
Global meat production was estimated at approximately 280 million tonnes in 2008. Experts predict that by 2050 nearly twice as much meat will be produced as today, for a projected total of more than 465 million tonnes (Kosseva, 2013). Consumption of meat and other animal products also continues to grow (Nordgren, 2012; Graca et al., 2014). From analysis of the Food and Agricultural Organisation of the United Nations (FAO) Food Balance Sheet data, it is clear that there has been a significant increase in global meat consumption over time. Aggregate meat consumption increased by almost 60% between 1990 and 2009, from 175,665 thousand tonnes to 278,863 thousand tonnes, driven in part by a growing world population (Henchion et al., 2014; Delgado, 2003). Most of this increase in production will come through industrialized animal production systems (Allievi, 2015). Although it is well known that meat industry sector is one of the main causes of insufficient effluent quality, data on meat production in Vojvodina region, Serbia, are poor due to lack of public awareness and non-compliance with national legislation. These trends will have major consequences on contamination of environment and human health as well as on the establishment of good wastewater management practice in Serbia.
Meat production makes huge amounts of waste (Cuadros et al., 2011; Virmond et al., 2011; Ur Rahman et al., 2014; Vujic et al., 2010). Processes, like rendering and hide processing operations, can be the significant sources of all kind of wastes mainly discharged on unsanitary landfills and opened dumps. Meat processing wastes consist of blood, viscera, soft tissue removed during trimming and cutting, bone tissue, urine and fences, soil from hides and hooves, and various cleaning and sanitizing compounds (Ur Rahman et al., 2014).
In Serbia, there is a lack of data regarding the total number of meat industry facilities that have wastewater treatment. Also the information about quantity and quality of wastewater generated in meat industry processes is unknown.
Vojvodina makes almost a quarter of the Serbian territory or 21,506 square kilometres. Although husbandry is in continuing decrease for years, meat production does show positive trends. Apart from smaller farmers, there are also large trading companies, who have their own food production, pig and cow production and sales.
Within the National project of the Ministry of Education, Science and Technological Development: Improvement and development of hygienic and technological procedures in production of animal originating foodstuffs with the aim of producing high-quality and safe products competitive on the global market, preparation of the meat industry inventory was the main activity in the first phase in order to develop, organize and archive the database. The inventory contains data on sources, types, amounts, method and place of discharge of polluting substances into water, as well as on amounts, type, content and the method for treatment and disposal of wastewater. Main focus was on meat industry facilities in the territory of Autonomous Province of Vojvodina (AP Vojvodina), and the research was conducted in the year 2011.
This kind of research was conducted for the first time in Serbia indicating the relevance of obtained results. In the future, knowledge gained from this Project phase could be used for strengthening the capacity of meat industry sector in the Republic of Serbia. Obtained data could be used for evaluation of potential risks for natural water resources, where untreated or partially treated wastewater is discharged.

METHODOLOGY

Researchers from the Department of Environmental Engineering, Faculty of Technical Sciences, University of Novi Sad conducted the preparation of the Inventory of the meat industry potential polluters from the territory of the AP Vojvodina. Researchers separately studied three regions within AP Vojvodina: Srem, Banat and Bačka. The first phase of the investigation consisted of identification of all legal entities from the meat industry sector in each region. These data were obtained from the Serbian Business Registers Agency (SBRA), and the overall number of potential water polluters within this sector totals up to 94 legal entities. The research group collected all the information through field observations and fulfilled the Questionnaires with meat industry employments. After this phase, it was concluded that there are

only 59 registered meat industries still operating in the territory of Vojvodina in the year 2011.
The Questionnaire was conducted in all the particular meat processing facilities and the most important data about the wastewater defined within the survey were:

- Wastewater discharge location – Information about the wastewater recipient
- Information about flow rate and methods for measuring – Estimation of flow rate or measured data
- Wastewater treatment – Information about existing wastewater treatment method
- Wastewater quality control before and after the treatment – Information about whether a treatment exists

The following phases included collection and processing of the data, requested within the Questionnaire, identification of GPS location of all potential polluters and field visits, which included identification of wastewater discharges at each polluter, if any.
For the collection of a geographic information system (GIS) data and mapping of all identified meat industry facilities the Trimble® GeoXT Handheld device from GeoExplorer series has been used. All recorded GPS locations were stored in the joint database together with the data collected through questionnaires. For this purpose ESRI's ArcInfo GIS software was applied. ArcGIS is a GIS for work with maps and geographic information. It is used for: creating and using maps; compiling geographic data; analyzing mapped information; sharing and discovering geographic information; using maps and geographic information in a range of applications; and managing geographic information in a database. The system provides an infrastructure for making maps and geographic information available throughout an organization, across a community, and openly on the Web.

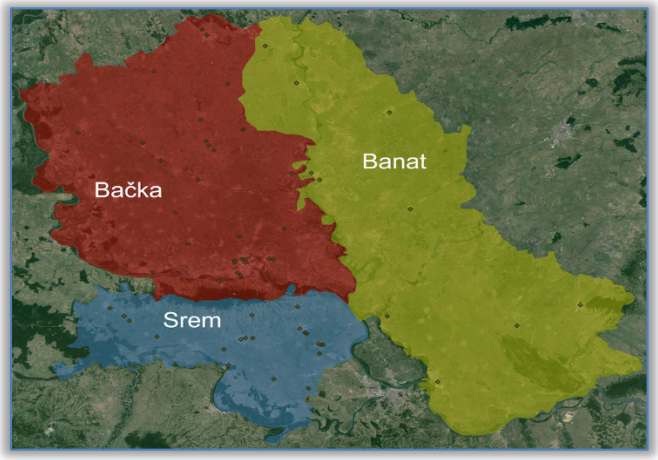


Figure 1. Locations of existing registered meat industry facilities in Vojvodina

Figure 1 presents the overview of locations of meat industry facilities in Vojvodina, prepared using ArcInfo. When observing the regions of Vojvodina separately, it can be concluded that the most extensive meat production is in the region of Srem. It is almost twice the number of meat industry facilities in Bačka, and almost six times higher than in Banat region. Most of them are located in the industrial centres of the region.

RESULTS AND DISCUSSION

During the campaign, 59 meat processing facilities have been identified. All the results used in this paper were obtained by processing the data given through a Questionnaire, which was answered by 52 subjects. Meat industry facilities are divided by the primary activity of these selected industries into: abattoirs, meat production facilities and facilities for the manufacture of meat products. Many of the selected plants combine these activities (Fig. 2). Concerning these 52 selected meat industry facilities, 3 of them are just abattoirs (5.8%), 3 of them are combined abattoirs and meat production industries (5.8%), 3 are combined abattoirs and facilities for manufacture of meat products (5.8%), 30 facilities have all three activities combined – abattoir, meat production and manufacture of meat products (57.7%), 8 are just manufacture of meat products (15.4%) and 5 facilities have combined production of meat and meat products (9.6%).
After observing all of the data from the selected meat industry facilities, it can be concluded that the number of facilities that have an abattoir is 39, from which 26 have wastewater treatment, and the other 13 have no treatment at all (Fig. 3). Concerning these 26 abattoirs that have wastewater treatment, 12 of them have quality control of wastewater before the treatment, as well as after the treatment, 1 abattoir facility have only before, and 6 only after wastewater treatment. Seven abattoirs with the wastewater treatment conduct wastewater quality control neither before nor after the treatment. It should be mentioned, that there are two abattoirs that have quality control of the wastewater, but do not have the wastewater treatment.

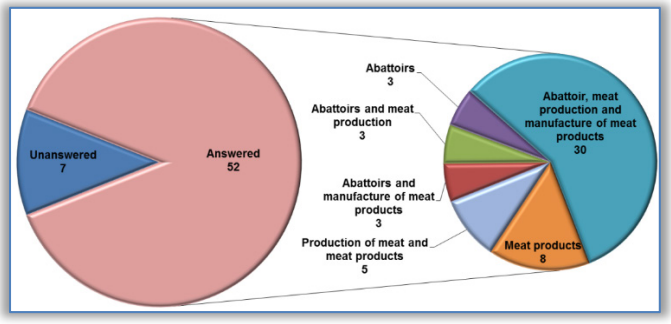


Figure 2. Division of meat industry facilities by primary activity

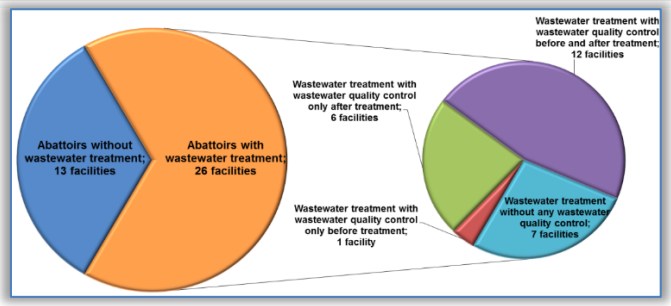


Figure 3. Wastewater treatment quality control in abattoirs

Within 52 observed meat industry facilities, 38 are dealing with the processes of the meat production from which 26 have the wastewater treatment. When observing the meat production industries that have wastewater treatment, 11 of them have quality control of wastewater before and after the treatment. One facility has a wastewater quality control only before, and 8 only after the treatment. Six meat production facilities with the wastewater treatment do not conduct wastewater quality control either before or after the treatment (Fig. 4). Also there are two meat production facilities that have quality control of the wastewater, but do not have the wastewater treatment.

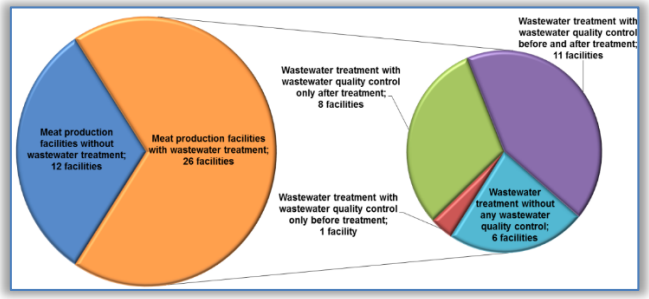


Figure 4. Wastewater treatment quality control in meat production facilities

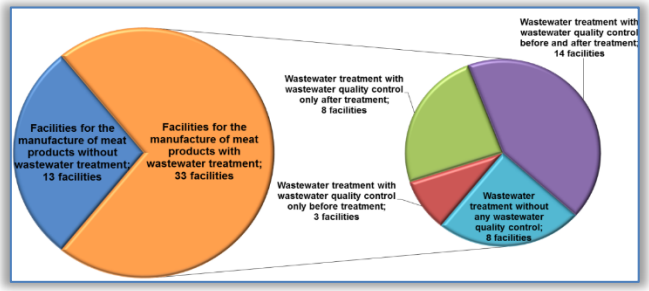
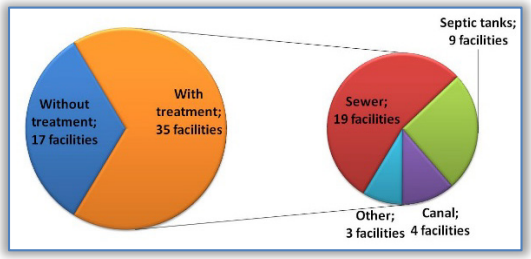


Figure 5. Wastewater treatment quality control in facilities for the manufacture of meat products

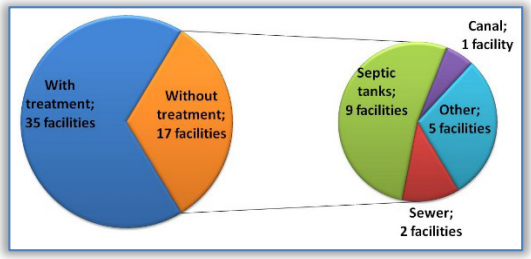
The number of facilities for the manufacture of meat products is 46, and 33 of them have wastewater treatment, while 13 do not have treatment at all. Two of those 13 meat product manufacture facilities have wastewater quality control, but they do not have solution for wastewater treatment. Thirty three meat product manufacture facilities, which do have the wastewater treatment, are divided into four groups: those that control the wastewater only before the treatment – 3 facilities, those that control the wastewater only after the treatment – 8 facilities, those that control the wastewater before and after the treatment – 14 facilities, and finally those that do not conduct wastewater quality control either before or after the treatment – 8 facilities (Fig. 5).

The data collected from all meat industry facilities showed that most of them discharge the wastewater into a public sewer (40.4%) or directly into a canal (9.6%). Also a large number of the meat industry facilities discharge the wastewater into their own septic tanks (34.6%). The main concern are the facilities that discharge the wastewater into sewers, which ends up in canals or rivers. It is important to perceive the number of facilities that have wastewater treatment before discharging it.

The research data indicate that a great number of all the meat industry facilities that discharge their wastewater into a public sewer have wastewater treatment, up to 90.5% of them (Fig. 6). Facilities that discharge their wastewater into septic tanks have wastewater treatment in only 50% of cases. The most important conclusion after collecting the data is that 80% of all facilities that discharge their wastewater directly into a canal have wastewater treatment. This means that 88.5% of wastewater from surveyed meat industry facilities that ends up in a canal or river is treated before discharge. It should be noted that this information is not sufficient without a detailed observation of the types of treatment these facilities have.



a)



b)

Figure 6. Recipients of meat industry facilities wastewater: a) with wastewater treatment and b) without wastewater treatment

The total number of meat industry facilities that have wastewater treatment is 35 (Fig. 6), which is 67.3% of the 52 industries that responded to the Questionnaire. Twenty seven meat industry facilities have the pre-treatment of the wastewater (77.14%), which is not the only form of wastewater

treatment they conduct (Fig. 7). Six meat industry facilities have only primary treatment, one has disinfection and one only secondary treatment. Fig. 7 also shows methods of wastewater treatments in these 35 surveyed meat industry facilities. As it was mentioned before, most of discharged wastewater ends up in septic tanks, public sewerage system, canals or rivers, or it is removed as solid waste and stored on the unsanitary landfills and open dumps. According to the "Regulation on emission limit values of pollutants in water and deadlines for achieving them ("Official Gazette RS" no. 67/2011 and 48/2012), for discharging of industrial wastewater into the public sewerage system, pre-treatment of wastewater is required (Mostafa and Darwish, 2014). Given the fact that the Regulation entered into force after this research, it can be concluded that most of the studied subjects previously fulfilled this requirement of the Regulation.

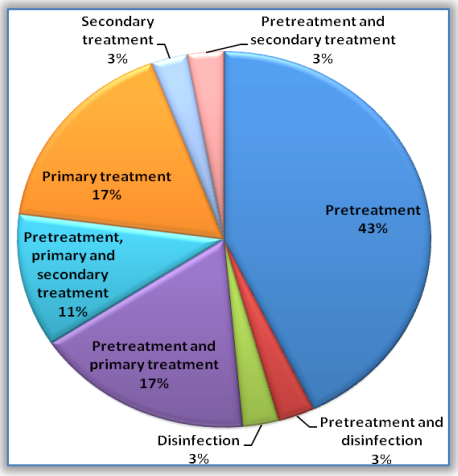


Figure 7. Methods of wastewater treatments for 35 surveyed meat industry facilities

Good water quality control practice is of great importance for wastewater management and preserving of natural water resources. During the field research and survey it was noted that most of the existing wastewater treatments are incomplete. One of the objectives in this phase of research was to get information about wastewater quality control before and after the treatment. The number of industries that have wastewater treatment (35 of them), but do not have quality control before is 16 (45.7%), and the number of those who do not control the quality of wastewater after the treatment is 11 (31.4%), which is unsatisfactory for the EU and the new regulations in the Republic of Serbia. Even though some of the industries do not have any treatment, there is a small percentage of them that monitor the quality of wastewater (11.8%).

Still, there is a big lack of data regarding the quantity of discharged wastewater. Obtained results about the flow rate are mainly based on engineering evaluation or they are gained through monitoring of water consumption.

CONCLUSIONS

This paper aimed at analysing the current practice in meat industry wastewater management in order to get the preliminary data on the real influence of this sector on environment and human health in Vojvodina region, Serbia. The lack of adequate infrastructure for wastewater treatment causes the bulk of poor quality meat industry wastewater to be discharged in water bodies, which damages health of living organisms and environment.

There were no official data about the number of abattoir and meat industry facilities from previous studies, and there were no information regarding meat industry wastewater management in Vojvodina region, which is why the results of the conducted survey are valuable and significant for future studies.

Results obtained in this study showed that almost 70% of surveyed subjects treat their wastewater, but only 11% of them include pre-treatment, primary and secondary treatment while 43% include just pre-treatment of wastewater. It can be concluded that most of the applied treatments are incomplete due to financial problems and unavailability of the satisfactory techniques.

Regarding quality control of wastewater, the situation is even worse, more than 60% of surveyed subjects do not conduct the monitoring of their effluents and discharge them into the sewer, canals or rivers, or into the collection tanks. Application of obsolete technologies and inadequate quality control practice, characterise meat industry sector of Vojvodina as dominant source of surface water pollution, which indicates its high impact to the environment and human health. This situation gives room for further work in meat industry sector in Vojvodina and creates opportunities for new developments in the field of wastewater treatment.

The results obtained during this study in combination with other sources of information suggests that there is a considerable degree of variation among facilities even within each segment of the industry in wastewater management practice and this initial version of the study can provide valuable data for further investigation in this area.

It is of great importance to continue with solving problems regarding wastewater treatment, but also to work on development and implementation of good monitoring practice in Vojvodina region, Serbia. The complexity of the problem requires approaches considering technical, organizational and governance aspects.

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EXAMINATION OF THE USE OF UF LACTIC ACID WHEY RETENTATE IN SOUR CREAM MAKING

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Abstract: The use of ultra-filtered lactic acid whey retentate was investigated for making of sour cream. The utilization of lactic acid whey is limited due to its' special properties, so the logical utilization way is to use it in fermented products. First, we concentrated lactic acid whey collected from cottage cheese making by ultrafiltration (UF), then UF Whey Retentate (UFWR) was added (by 2, 5 and 10%) into fat standardized cream for sour cream making. We investigated the texture and sensory properties of the sour cream samples compared with the industrial products. Generally, we can state that the use of small portion of UF whey retentate did not result noticeable changes and did not reduce the sensory value of sour creams. Higher UF whey retentate addition improved some texture properties of experimental samples, but the summarized evaluation of UFWR addition was not unequivocal. Control samples showed better results. Based on my results, the sample what contained 5% UF whey retentate had good texture and acceptable sensory properties. Furthermore, more than 5% UF lactic acid whey retentate (coming from our own ultrafiltration process) resulted remarkably worse sensory properties than the other samples. Further investigation is needed to find the optimal composition and sensory properties of UFWR. Furthermore, we have to perform technological investigation to reach higher concentration factor using pre-treatment of whey and to avoid the precipitation of whey proteins during high temperature pasteurization of cream, cream mixed with UFWR or diafiltered whey retentate. We guess that the use of one stage diafiltration would already decrease the unfavourable sensory properties of lactic acid whey retentate.
Keywords: lactic acid, ultrafiltration (UF), UF Whey Retentate (UFWR), sour cream

INTRODUCTION

Major part, actually 65-90% of milk, become side products (or waste) in cheese and casein production. By some estimation, 62 billion litres of whey are produced each year world-wide [1] causing significant problems for producers considering environmentally aspects. But whey contains valuable organic compounds (as proteins, lactose, fat) and minerals. Actually, the beneficial effect of whey proteins and other compounds on human health are well-known [2], [3], [4], [5], [6], [7], [8], [9]. Therefore, this extremely huge amount of whey is a big problem and there is need to reduce its polluting effect and to produce valuable products. By today, the utilization of whey has arrived to the separation and purification of different special compounds from the simple use as the feed for animals. Whey proteins and serum proteins seem to be the most valuable components of whey, but the other compound are also good raw materials (e.g. lactose) for the further utilization. The simplest utilization is to produce flavoured whey drinks as "Riska Shake" produced by Alföldi Tej Ltd., Hungary. But, usually the sensory properties, low pH and the low solid content make whey difficult to use it in other products. Consequently, the taste and smell ameliorate, and the reducing of moisture content can open up new perspectives for the lactic acid whey utilization.

Many researcher published results from the use different membrane filtration techniques for whey concentration [10], [11], [12], [13], [14], [15]. Very important results were published related to the enhancement of membrane techniques to reach higher efficiency and to the removal of lactic acid from lactic acid whey [16]. This objective can be reached with the use of vibration [17], with sonication [18], with electrical methods [19], [20], with diafiltration [21] or with optimization of the condition of the filtration [22]. As a result of the development of whey membrane filtration process, much utilization form can be used in food and

medicine industry. There are many results have published in different area (including the use of lactic acid whey) as the purification of whey proteins [23], fractionation of bioactive peptides from whey [24], the enzyme recovery from solutions [25], [26], the production of lactic acid [27], and the stabilization of different emulsions as well [28], [29]. Other applications as follows, the improve of foaming properties [30], stabilization of different whey protein drinks [32], bacterial production of hyaluronic acid [33], improving of bread properties [33], not to mention of the traditional possibilities as the production of ordinary whey powder and different whey cheeses (e.g. Ricotta). A complex, fully utilization system of acid whey was presented in [34].

Our objective was the investigation of ultra-filtered lactic acid whey retentate (UFWR) use with low concentration factor in the production of sour cream in order to reduce the amount of whey as wastewater. The low concentration factor of whey can be justified by lower expenses comparing to ultrafiltration with two or three stages diafiltration or reverse osmosis. Other aim was to explore the effect of UFWR addition (as milk substitute) on the texture and sensory properties.

MATHERIALS AND METHODS

Ultrafiltration

A simple ultrafiltration was performed in batch system without diafiltration, using VSEP-LP vibration ultrafilter (New Logic Research, Inc., Emeryville, California 94608, USA). Conditions: pressure: 8.0 bar; Temperature: 40°C; Membrane: PAN (poli-akril-nitril); Cut off value: 10 kDa (Figure 1). Ultrafiltration was performed using a simple batch system without special pre-treatment of lactic acid whey, so the concentration factor was fairly low (1.8).

Figure 1. VSEP ultrafilter

Chemical investigation

A Bentley 150 milk analyzer (Benleyinstrument Inc. Chaska, Minnesota 55318 USA), was used for the determination of whey composition, ultrafiltered retentate and permeate at 40°C. Data were expressed in m/m%. Composition of the different experimental media is presented in Table 1. We did not reach remarkably protein increment and lactose was enriched, probably due to the different complex molecule formation.

Table 1. Composition of whey, permeate and Uf retentate (m/m%; concentration factor: 1.8)

	Fat	True protein	Crude protein	Lactose	Total solids
Whey (Feed)	0.15	0.59	0.90	3.67	6.49
Permeate	0.40	0.49	0.63	3.27	5.61
Retentate	0.44	0.88	1.32	5.52	8.66

Experimental sour cream making

After the addition of different percent (2%, 5%, 10%) of UFWR into milk (without pH buffering) and after fat standardization to 16 m/m%, cream was heated to 60°C for homogenization at 150 bar pressure with Gaulin Lab 60 homogenizer (Graafdijk-Oost 23, 2973 XB, Molenaarsgraaf, Netherlands).

a)

b)

Figure 2. The homogenizer (a) and the packaging machine (b)

Then homogenized cream was pasteurized at 72°C with 1 minute holding and then it was cooled to 26°C in order the inoculation. The gentle pasteurization condition is explained by the heat sensitivity of whey proteins fortified in cream. Inoculation rate was 2 ml/3000ml cream, from a 20% culture solution using DI-PROX® M 272 freeze-dried starter (Bioprox Ltd. 92532 Levallois-Perret Cedex, France).

Then different samples were packed in cups with a semi-automatic packaging machine (Junior Handy type, Zootechnika Ltd. Gödöllő, Hungary). After packaging, the samples were fermented in a thermostat (Labor MIM, Hungary) at 26°C for reaching 4.6 pH measured with Orion 4Star instrument (Thermo Fischer Scientific Inc., Singapore). Then samples were cooled in a refrigerator and were stored until the investigations.

Texture properties

Brookfiled LFRA CT3 texture analyser (Brookfield Engineering Laboratories, Inc., Middleboro, Massachusetts, USA, 02346) was used for the determination of hardness, adhesiveness and adhesive force of sour cream samples.

Measuring conditions: simple compression test was used with 12 mm diameter plastic cylinder (penetration target: 20 mm; penetration force: 50 mN; speed: 0.5 mm/s). Measures were performed in three replicates using five parallel samples. Every sample was measured in three place of the surface.

Whey leakage ratio

Whey leakage was determined with method published in [35]. First a 40 mm diameter semi-sphere was cut into surface of curd then after one hour the weight of accumulated whey was measured. Less amount of whey (higher water binding capacity) means better texture.

Sensory evaluation

Sensory evaluation was performed by ten persons using Hungarian Standard 12253-84. A part of sensory evaluation was the comparison of experimental samples to the control samples - contained 20% fat content - made in a dairy firm.

RESULTS

Whey leakage

The measured whey leakage values (Table 1) were high, considering the classification method in [35] (<0.5ml, 0.5–1.0ml, >2.0ml). It can be explained with the experimental condition of sour cream samples making, e.g. the low pasteurizing temperature and the slow heating rate.

But the explored differences demonstrate that whey proteins can play an important role in the water bonding capacity of lactic acid gels as sour cream. Interestingly, the higher whey retentate ratio decreased the whey leakage first, more than 5% ratio resulted worse result. It is explained by the higher dilution ratio of cream with UF whey retentate, maybe because of its lower crude protein content compared to cream (1.94-2.01%). Higher ratio of UF whey retentate resulted lower protein content in the cream - UF retentate mixture than the dilution in lower ratio. The 5% UFWR ratio was the optimal in our experiments.

Table 1. Whey leakage of sour cream samples (g; n=45)

Whey ratio (%)	Repetitions			Average
	First	Second	Third	
2	5.35	5.62	5.47	5.48
5	2.09	2.83	2.38	2.38
10	4.08	4.12	4.08	4.09

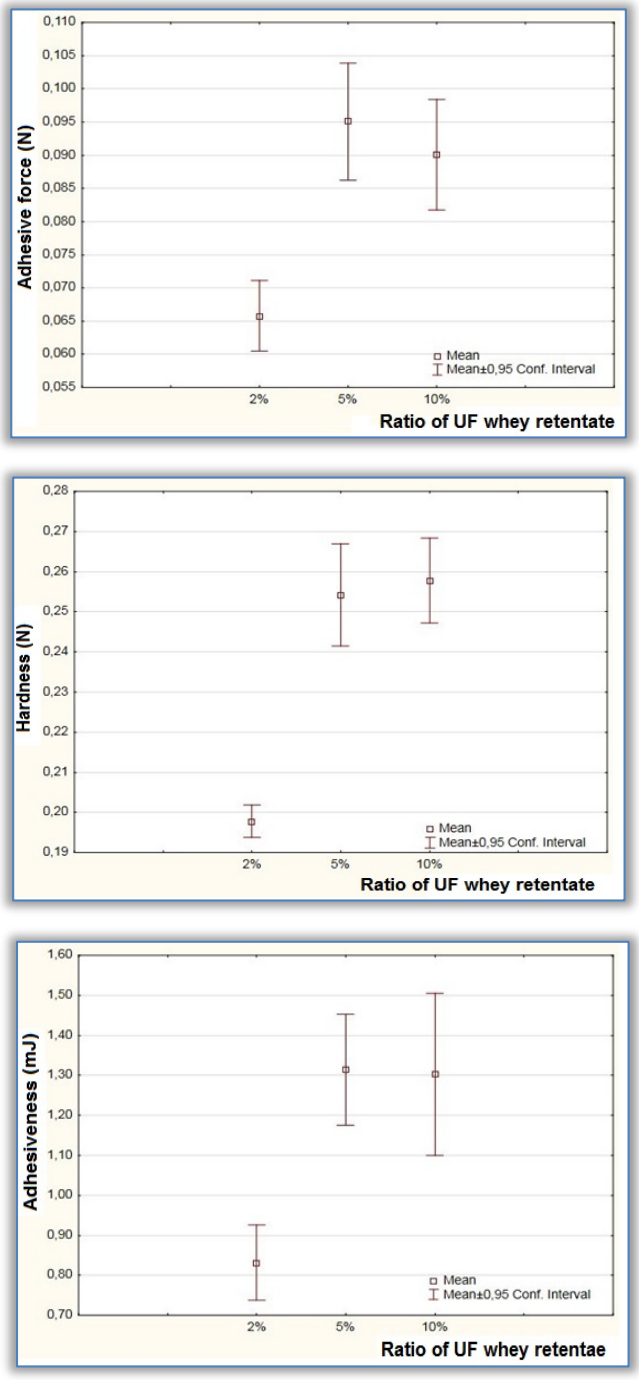

Figure 3. Texture properties of different samples made with UF whey retentate (n=45)

Texture analysis

Significant difference ($p \leq 0.05$; using Statistica 12 for MS Windows software) was explored between the samples made with 2% and 5% UF whey retentate added, and also between the samples 2% and 10% UF retentate added samples (Figure 3).
But the difference was not significant between the samples made with 5% and 10% UFWR addition. The higher values of investigated texture properties are explained by the higher amount of denatured whey proteins built into the casein protein matrix during the lactic acid clotting. The lack of the further improving in this properties can be explained by the lower relative ratio of casein in the mixture contains higher ratio of UF whey retentate. As the aggregation between denatured whey proteins and casein micelles can improve texture properties, as the lower casein content in the mixture can compensate this beneficial consequence.

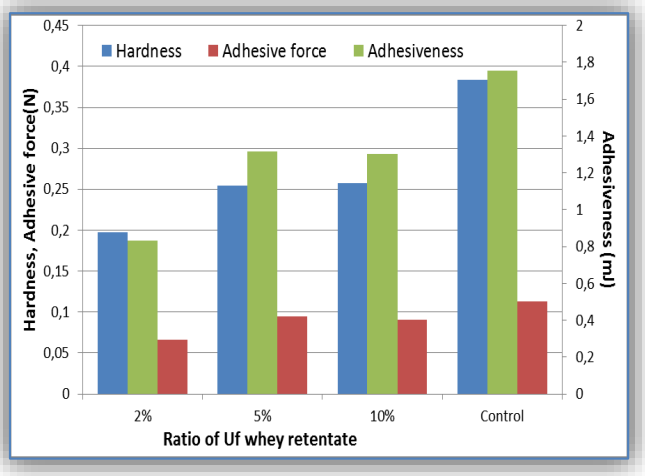

Figure 4. Comparison of texture properties of experimental and the control samples(n=10)

As the Figure 4 represents, the control sample gave slightly better results. It is explained by higher fat content (20%) and the industrial processing condition. But the results of samples made with the addition of 5% and 10% Uf whey retentate were close to the control ones.

Sensory evaluation

The sensory evaluation showed markedly different results compared to the results from texture analysis. Higher UFWR addition resulted worse judgement of experimental samples (Figure 5). Especially, samples made the highest UFWR addition had got unsavoury characteristics.
We can confirm that the special sensory property of whey, especially lactic acid whey ones limit the further direct utilization. Higher ratio of UFWR addition resulted worse scores in every repeats, except the smell. The sample made with 10% UFWR addition represented the worst score (12.5 points) so this experimental product cannot be marketed.

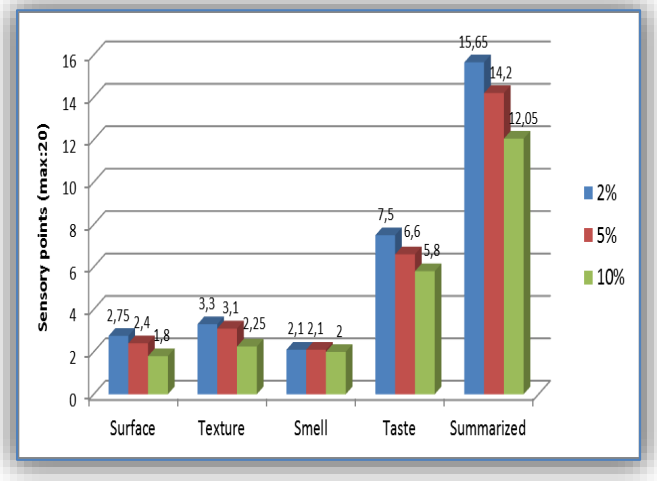

Figure 5. Sensory evaluation of samples with Uf whey retentate addition

CONCLUSIONS

The addition of UFWR into cream can be a form of the utilization of this dairy side product. We investigated the use of UFWR from a single batch ultrafiltration in order to limit the cost of the further processing costs. We did not achieve enough high protein content in retentate and as mild sensory properties of experimental samples, our mixtures did not result a real, satisfactory solution. Although, the texture properties of experimental samples were improved (5% UFWR addition resulted the best result) the sensory scores decreased with the increase of UFWR addition. Based on the sensory evaluation, the limit of the addition of Uf lactic acid whey retentate came from a single batch ultrafiltration is 5%. Further investigation is needed to find the optimal composition and sensory properties of whey UFWR using diafiltration. Furthermore, we have to perform technological investigation to reach higher concentration factor using pre-treatment of whey and to avoid the precipitation of whey proteins during the high temperature pasteurization of cream, cream mixed with UFWR or diafiltered whey retentates. We guess that the use of one stage diafiltration would already decrease the unfavourable sensory properties of lactic acid whey retentate.

Note

This paper is based on the paper presented at International Conference on Science and Technique based on Applied and Fundamental Research – ICoSTAF 2016, organized by University of Szeged, Faculty of Engineering, in Szeged, HUNGARY, 2 June 2016

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EFFECTS OF SPIN CASTING ON MICROSTRUCTURE AND MECHANICAL BEHAVIOUR OF AA6063/SiC COMPOSITE COLD ROLLED AND HEAT TREATED

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Abstract: This study investigated the effects of spin casting method on mechanical behavior of aluminum composite (Al6063/SiC). The composites were cold rolled to 10% deformation before solution heat treating at 520^{0}C for 1hour after which it was rapidly cooled in water. Experimental and theoretical density was used to evaluate the porosity of the composite. After cold rolling with 10% deformation and solution heat treating, it was discovered that silicon carbide were well dispersed in aluminum matrix better when compared with the as-cast of both spin and sand casting. The tensile strength and yield strength for spin casting were better when also compared with sand casting.
Keywords: aluminum, silicon carbide, composite, solution heat treating, spin casting

INTRODUCTION

Casting is a manufacturing process by which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify, and upon solidification, the metal assumes the shape of the mould but experience some shrinkage [1]. The solidified part is also known as a casting. Casting is the most economical of all fabrication processes. There are different casting processes which include, sand, die, spin, continuous and investment casting. Sand casting is the most common employed of all the casting processes [2].

Different casting methods have different microstructure and different Properties when cold rolled but improper casting may give rise to defects such as pin hole, porosity, shrinkage cavity and which are largely responsible for poor mechanical properties of aluminum alloys produced. Aluminium alloys have great use potential in the structural components in the aerospace and automobile industries mainly because of their low density and high specific strength [3], also aluminium alloys have a wide diversity of industrial applications because of their high specific strength, light weight and corrosion resistance. Therefore these alloys motivate considerable interest to the aviation industries [4, 5].

AMCs have found wide applications in our daily life. There are some advantages in using particles reinforced AMCs materials than unreinforced materials such as- greater strength and high specific modulus, improved stiffness, light weight, low thermal expansion coefficient, high thermal conductivity, tailored electrical properties, increased wear resistance and improved damping capabilities. Reinforcing constituents can be incorporated within the matrix in the form of particles, short fibers, continuous fibers or mono filaments. Now it is used in aerospace, thermal management areas, industrial products, automotive applications such as engine piston, brake disc [6].

The research work presented here is aimed at improving and also comparing the mechanical properties of AA 6063/SiC composites by adopting cold rolling and solution heat-treatment in combination as a secondary processing stage using spin and sand casting methods.

MATERIAL

The AA6063 was utilised for this research with chemical composition shown in Table 1.

Table 1. Chemical Composition of AA6063

Element	Si	Mg	Fe	Mn
(%)	0.48	0.86	0.46	0.9
Element	Cr	Zn	Ti	Al
(%)	0.04	0.005	0.01	98.82

METHODS

The two casting methods used were spin and sand casting

Mould Preparation

A woodworking lathe machine model MCF3020 was used to machine the wooden pattern materials obtained from hard wood that produced the pattern, sprue and risers with adequate taper. The

patterns were dimensioned 300 mm long and of different diameters; 15 mm, 20 mm, 30 mm, 35 mm. The size of the patterns was made 2% oversize than the specified dimension to compensate metal contraction during solidification. The down sprue of diameter 50 mm, was tapered to diameter 40 mm and 30 mm long was also made.

The mould is prepared with green sand being the main material used which comprises of the mixture of bentonite, recycled silica sand and water. The green sand has good permeability, good grain size, accurate moisture content and with a very good refractoriness which can withstand heat at very high temperature. Bentonite is added to the green sand to increase its bonding strength. Suitable moulding boxes is first selected, large enough to accommodate the pattern of its varying sizes and then rammed slowly but with good force. Facing sand was mixed into the drag and the content was well rammed. The drag was turned upside down on the mould board, the pattern as well as its accessories were placed on the board inside the flask in such a position that space is left for gate cutting. The excess sand will be cut off to bring it in line with the edge of the cope, a parting sand was properly applied for the easy removal of the mould from the pattern. The gating system was properly designed for smooth channeling of the molten metal into the mould cavities through the sprue, runner, in-gates and riser that were perfectly placed in position [2]. The cope was placed over the drag and top parts of the pattern assembled in position.

Melting and Charging

Charge calculation was worked out to determine the quantities of Aluminium (6063) and silicon carbide required to produce the composite. Prior to charging, the crucible furnace was checked to prevent leak of molten metal and also to guide against moisture, which can generate vapour during melting. The Aluminium (6063) ingot were charged into the crucible furnace and heated to 700^{0}C with the introduction of silicon carbide. The molten composite was then cast into prepared spin casting mould and stationary sand moulds.

Cold Rolling and Heat Treatment

The products from spin and sand casting were subjected to cold deformation using a miniature cold rolling machine. The cold rolling operation was performed using a round orifice to 10% degree. The heat treatment procedure carried out on 10% cold rolled spin and sand samples involved heating the samples to a single-phase solid solution temperature of 520^{0}C and held for 1hour at this temperature before cooling rapidly in water.

Density Measurement

The determination of the experimental densities of the various casting products were carried out measuring the weight of the test samples using a high precision electronic weighing balance with a tolerance of 0.1mg. The weights of the measured samples were divided by their respective volume. The theoretical density was evaluated by using the rule of mixtures given by:

$$\rho AA6063/SiC = \text{Vol. AA 6063} \times \rho AA6063 + \text{Vol. SiC} \times \rho SiC$$

where,

ρ AA6063 = Density of aluminium alloy, Vol. Al 6063 = Volume fraction of AA 6063, Vol. SiC = Volume fraction SiC, and ρSiC = Density of SiC,

$$\text{Experimental density} = \frac{\text{mass of the sample}}{\text{volume of the sample}} \quad (1)$$

The percentage porosity of the cast aluminium was determined by use of equation

$$\% \text{ Volume porosity} = \frac{\rho cal - \rho exp}{\rho cal} \quad (2)$$

where ρ_{cal} = Theoretical Density (g/cm^3), ρ_{exp} = Experimental Density (g/cm^3) [7, 8]

Tensile Properties Determination

Universal testing machine was used to determine the tensile strength, uniaxial tension tests were performed on the samples after cold rolled and heat treated. The testing was performed using an instron universal testing machine for spin casting sample and stationary casting sample respectively. Four repeated tests were performed for each test condition to guarantee reliability of the data generated. The tensile properties evaluated from the stress-strain curves developed from the tension test were ultimate tensile strength (σu), and yield strength (σy).

Metallographic Examination Procedure

The microstructures for each cast products were investigated. The specimens were prepared for optical examination by polishing using series of emery papers of grit sizes ranging from 600μm – 60μm, while fine polishing was performed using polycrystalline diamond suspension of particle sizes ranging from 10μm – 0.5μm with ethanol. The samples were etched using 2% natal before the microstructure examination was performed, using optical metallurgical microscope of model AX10 (ZEIZZ).

RESULTS AND DISCUSSIONS

The effect of casting methods on the deformation of AA6063/SiC products with 10% cold rolled and solution heat treated were given in fig.1. The ultimate tensile strength (UTS) for spin casting is 51.42MPa and 22.38MPa for sand casting while the yield strength (YS) for spin casting is 47.01MPa and 22.93MPa for sand casting. The reasons for the low UTS and YS in sand casting is as a result of clustering of SiC in the aluminium matrix even after cold rolled and heat treated and while for spin casting there were even distribution and

homogenization of SiC and after cold rolled and heat treated, there were more distribution of SiC which enhance the yield strength and ultimate tensile strength.

Table 2. Tensile Strength Result

Casting methods	AA6063 alloy products, 10%cold-rolled + solution heat-treated	
	Yield strength (YS) (MPa)	Ultimate tensile strength (UTS) (MPa)
Spin casting	47.01	51.42
Sand casting	22.93	22.38

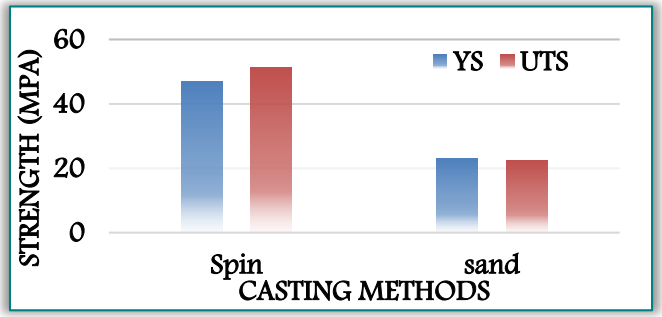

Figure1. Tensile strength of cast AA6063/SiC, 10% cold-roll with solution heat-treated

Rockwell hardness test

The results obtained from hardness test conducted using the Rockwell hardness test method and four indentations are presented in table 3.

Table 3: Hardness test (HRA)

Casting methods	Cast AA6063/SiC products, 10%cold-roll+solution heat-treated				
	1st	2nd	3rd	4th	Average
Spin casting	43.4	50.7	57.6	57.2	52.7
Sand casting	53.0	49.7	54.3	50.0	49.5

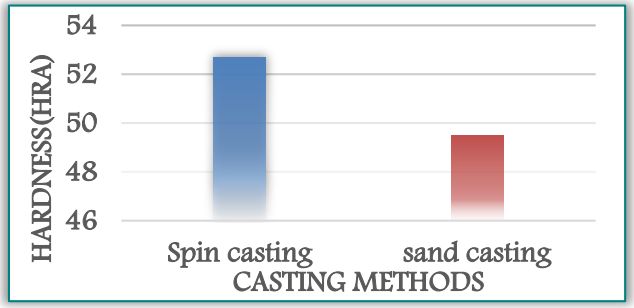

Figure 2. Hardness of cast AA6063/SiC, 10% cold-rolled and solution heat-treated

The hardness of the test samples varies with the methods used, from Figure 2 it was observed that spin casting had higher hardness than sand casting, this is as a result of crystal lattices of SiC precipitates in spin casting which show coherency with that of the aluminium phase, and these two elements (silicon and carbide) form the primary hardening phase (silicon carbide, SiC) in aluminium alloy 6063 [9]. Consequently, severe strain fields are created around these crystals which impede the motion of dislocations and thereby causing increased hardness of castings obtained in spin casting [10]. The variation found in hardness of the two cast products may also be attributed to their porosity and density.

Table 4: Percentage Porosity

Types of casting	Theoretical density (g/cm^3)	Experimental density (g/cm^3)	Porosity (%)
Spin	2.75	2.73	0.74
Sand	2.75	2.66	1.48

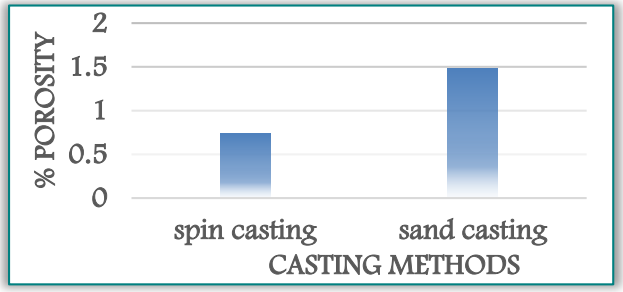

Figure 3: Percentage Porosity for cast AA6063/SiC, 10% cold rolled and solution heat treated

Percent Porosity

The percent porosity of the as-cast for spin casting and sand casting, also 10% cold rolled and solution heat treated AA6063/SiC for spin and sand casting were presented in figure 3. It was observed that as-cast sand casting has higher porosity percentage in comparison with as-cast spin casting, which can be attributed to the spin machine which compresses the alloys thereby aiding the collapse of voids, micro-cracks vacancies in the alloy making it more compacted. When the as-cast for spin and sand casting were 10% cold rolled and solution heat treated, there were reductions in percentage porosity with sand casting still having higher percentage porosity of 1.48 when compared with spin casting 0.74.It was cleared that cold rolling and solution heat- treating aids in reducing the percentage porosity, thereby improving the quality of the cast product, therefore it could be deduced that cold rolling and solution heat treating helps in collapse of voids, micro-cracks thereby making the cast products compact and denser.

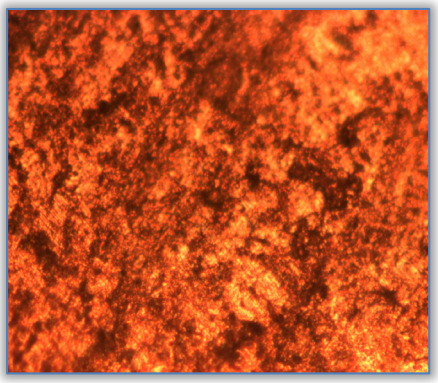

Plate (a) Micrograph of cold rolled and solution heat treated AA6063/SiC for spin casting (X200)

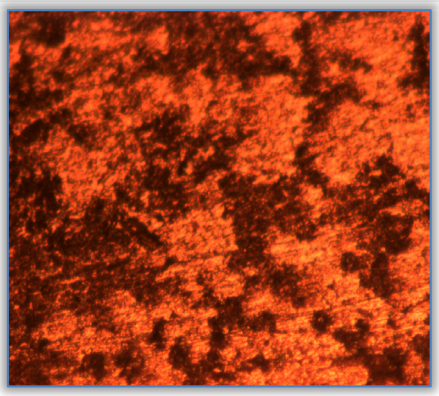

Plate (b) Micrograph of cold rolled and solution heat treated AA6063/SiC for sand casting (X200)

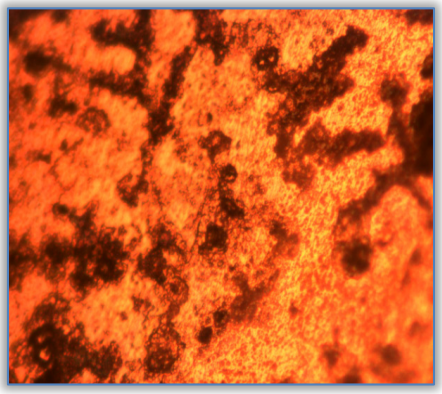

Plate (c) Micrograph of as-cast spin casting for AA6063/SiC (X200)

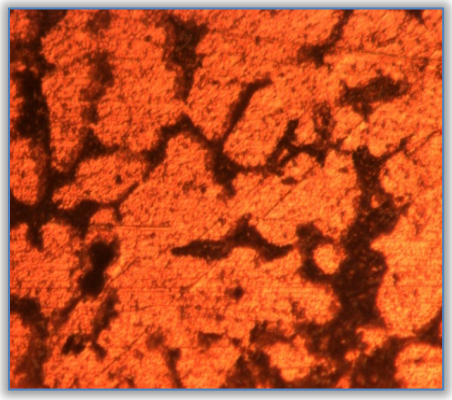

Plate (d) Micrograph of as-cast sand casting for AA6063/SiC (X200)

Microstructure

Plate (a) and (b) shows optical photomicrographs for spin and sand casting of AA6063/SiC which were 10% cold rolled and solution heat-treated conditions. SiC particulates were observed to be well dispersed in the cold rolled and solution heat-treated in spin casting when compared to sand casting which was also cold rolled and solution heat treated. This is a clear indicator that the cold rolling and solution heat-treatment processes helped in achieving a homogenization of SiC particles in aluminium matrix and reduced particle clusters in the composites produced. In plate (c) and (d) which shows the as-cast for spin and sand casting, it was observed non homogenization of SiC particles in aluminium matrix in sand casting whereas in spin casting the SiC were well dispersed aluminium matrix which may be attributed to shaking and movement of spin casting machine.

CONCLUSIONS

In this experimental study, where SiC content were made constant for spin and sand casting and thereafter cold rolled and heat treated, the following conclusions can be expressed.

(a) Clustering and non homogenization of SiC particles in aluminium matrix of as-cast sand casting was observed, while as-cast for spin casting, the SiC were dispersed.

(b) When cold rolled and heat treated, both the spin and sand casting products show appreciable dispersion of SiC in aluminium matrix in which spin casting was better.

(c) The hardness, ultimate tensile strength and yield strength in spin casting were better than sand casting.

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1. Eugen-Vlad NĂSTASE

DETERMINATION OF LOCAL LOSSES IN A GLOBE VALVE AT DIFFERENT OPENINGS

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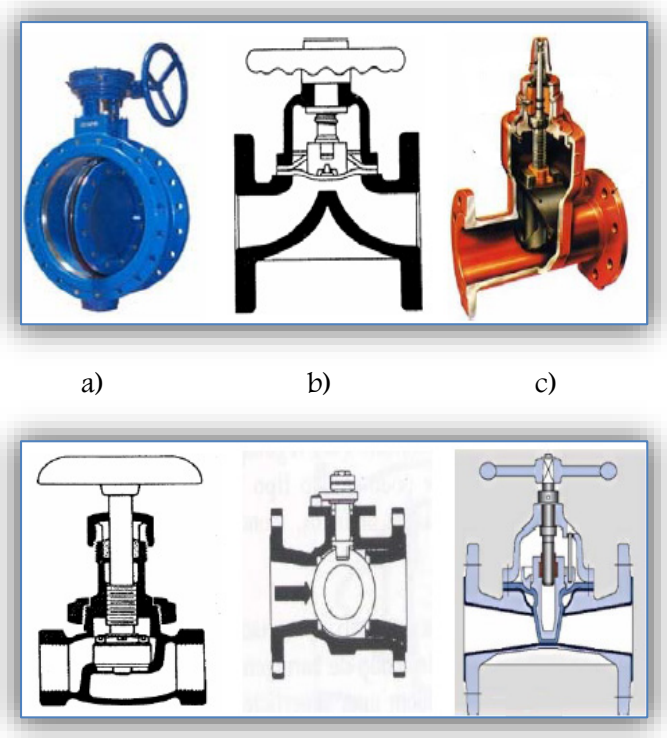
Abstract: Valves are devices of great importance in the operation of hydro systems, in particular, when is necessary to control the flow. The objective of this paper is to determine, through SolidWorks Flow Simulation module, the minor loss through a globe valve at different partially open settings. The Flow simulation allows an analysis of current lines and the hydrodynamic parameters of flow. Therefore we can determine the hydraulic energy losses and can appreciate the value of the main flow parameters.
Keywords: computational fluid dynamics, flow simulation, numerical analysis, hydraulic loss

INTRODUCTION

Valves are widely used in irrigation, energy, water distribution networks and process industries and in many other area [3]. All these are actually types of hydraulic systems. In generally a hydraulic systems are composed of a set of pipes, valves and other hydromechanical equipments necessary for adequate operational management, control and safety. Valves are devices of great importance in the operation of hydro systems, in particular, when is necessary to control the flow. The valves can be classified [3],[5], depending on the shutter movement, into two groups (see figure 1):

- valves with linear motion
- valves with angular motion

The butterfly valve, (figure 1a) is often used in water systems, under low hydraulic loads. They are valves suited for emergency shut-off, more specifically, for safety valves with overspeed closing disposal. The diaphragm valves are characterized by having a flexible membrane (diaphragm) whose periphery is fixed in the body of the valve (figure 1b). As for membrane valve (figure 1f), it works by pressing one side of the membrane through the actuator, restricting the passage of the flow. This type of valve is used, preferably, in situations of hostile operation. The spherical valves, the wedge (figure 1c) and shears are the most suitable for the task of stopping the flow. The globe valves (figure 1d) have a great use in automatic control of pressure and flow. They can present various shutter types and regulation hydraulic systems. Due to the pathway that the liquid makes inside, these valves have a large loss of hydraulic load, even in situations of total openness. The spherical valves (figure 1e) are, preferably, used at systems with high hydraulic load or for quick flow cuts under high pressure situations. These valves when fully opened induce a low loss of hydraulic load. A globe valve is a linear motion valve used to stop, start and regulate flow in a pipeline.



a) b) c)

d) e) f)

Figure 1. Different types of control valves

The fundamental principle of the globe valve operation is the perpendicular motion of the disk

away from the seat. The disk of a globe valve can be totally removed from the flowpath or it can completely close the flowpath. This ensures that the ring-shaped space between the disk and seat ring gradually close as the valve is closed. This property gives a globe valve reasonably good throttling capability. Therefore, the Globe Valve can be used for starting and stopping flow and to regulate flow.

MATHEMATICAL MODEL

In engineering practice the hydraulic loss in any piping system is traditionally split into two components: the loss due to friction along straight pipe sections and the local loss due to local pipe features, such as valves, throttles, elbow, bend, etc. Working fluid of our experiment was water. Water was allowed to pass through our target valve. The minor loss coefficient is usually calculated through the outlet and inlet total pressure difference Δp from the following formula [3] :

$$\xi = \frac{2\Delta p}{\rho v^2} \qquad (1)$$

where ρ is the water density, and v is water velocity. Since we already know the water velocity and the water density (998 kg/m³), then the goal is to determine the total pressure value at the valve's inlet and outlet. The valve studied in this paper is mounted on the stand pipe in the laboratory of the department of fluid mechanics. Nominal diameter of pipiline is two inches.

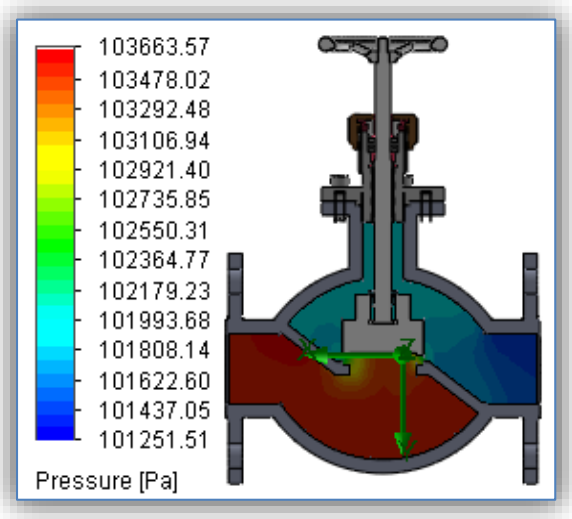
RESULTS OF SIMULATION

The flow was simulated through flow control valves for different valve closure positions. For the simulation and therefore the determination of the coefficient of local losses were considered three situations relating to the degree of openness.

Results of simulation is presented: for case 1, d = 4.33 mm (figure 2), case 2, where d = 8,66 mm (figure 3) and case 3, where d = 13mm (figure 4). In case of simulation „d" is the distance between disk and seat. The variation of valve head loss coefficient with valve closure position was obtained. This variation shows the energy dissipation induced by the valve in the flow for different valve opening positions.

From velocity vector distribution, represented in figure (2b), can be concluded that the flow trajectories converge upstream of the valve which can lead to flow separation in the same region and to rotational movement with high turbulence inside the valve. The flow through the valve results in the contraction of the liquid vein (figure 2a) immediately upstream and downstream of the closure and therefore in the flow velocity increase in these regions. This fact explains the pressure decrease from the region immediately upstream of the actuator towards downstream.

Table 1 presents the numerical results obtained from the simulation and the value of the coefficient of local losses for case 1.



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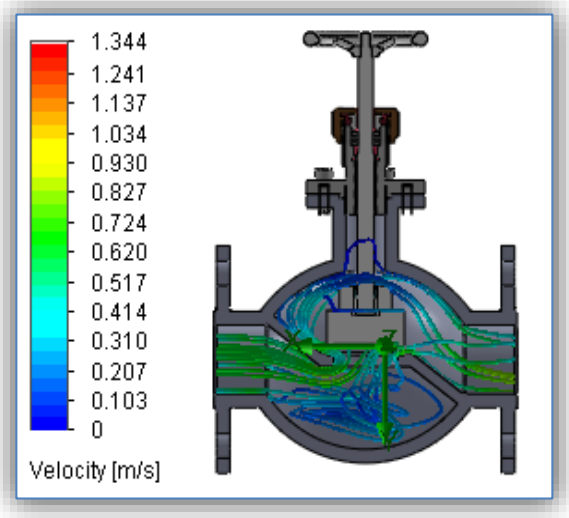


b)

Figure 2. Variation of pressure (a) and velocity profile (b) for the case 1 of simulation;

Table 1: Results for case 1 of simulation

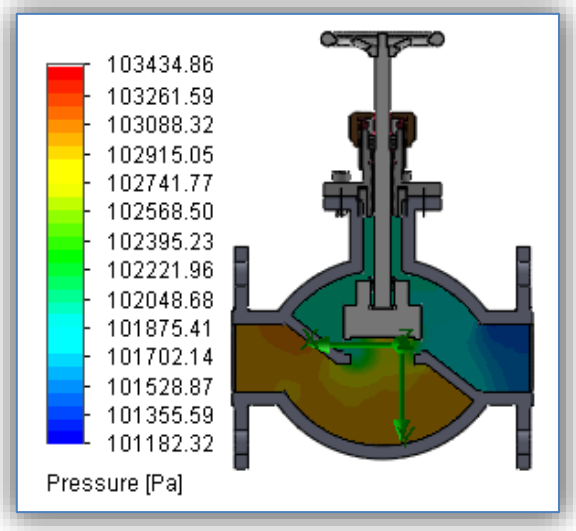
Inlet pressure [Pa]	Outlet Pressure [Pa]	Pressure drop Δp [Pa]	Velocity v [m/s]	Local loss coefficient $\xi=2\Delta p/\rho v^2$
103771,74	101718,25	2053,49	0,677	9,11

For the second case of the simulation increase the flow space. According to the graph in Figure 3a, is found in the upstream pressure drop compared to the previous case.

In the table 2 is show the results obtained and the value of the local losses coefficient for case 2 of simulation.

Table 2: Results for case 2 of simulation

Inlet pressure [Pa]	Outlet Pressure [Pa]	Pressure drop Δp [Pa]	Velocity v [m/s]	Local loss coefficient $\xi = 2\Delta p/\rho v^2$
103280,89	101793,62	1487,27	0,703	6,03



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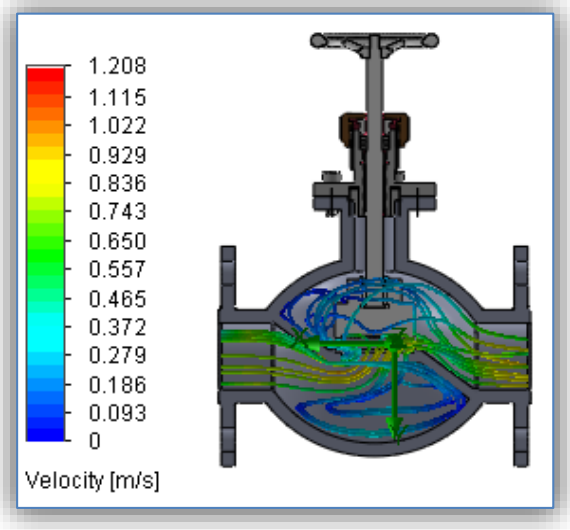


b)

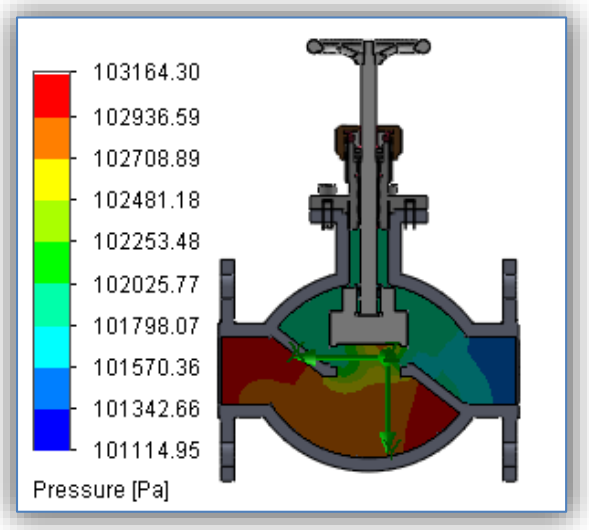
Figure 3. Variation of pressure (a) and velocity profile (b) for the case 2 of simulation;

Table 3: Results for case 3 of simulation

Inlet pressure [Pa]	Outlet Pressure [Pa]	Pressure drop Δp [Pa]	Velocity v [m/s]	Local loss coefficient $\xi = 2\Delta p/\rho v^2$
103230,84	101802,47	1428,37	0,718	5,55

Simulation for the third case, when the opening is maximum in figure 4a is seen as a pressure difference between upstream and downstream it is not so great.

Observe also the uniformity of flow velocity between upstream and downstream. Numerical results obtained from simulation and local resistance coefficient for case 3 are presented in table 3.



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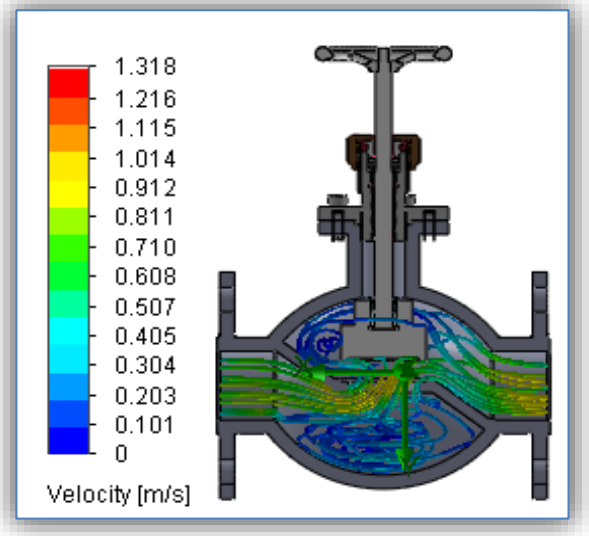

b)

Figure 4. Variation of pressure (a) and velocity profile (b) for the case 3 of simulation;

CONCLUSIONS

After simulations can be seen as the flow velocity of the fluid increases with the degree of openness. With increasing degree of openness also increases the coefficient of local losses.

Computational fluid dynamics continues to be an impressive tool in helping model real world problems.

The solid works flow simulation module, can be used to give insight into visualization of complex flows.

Three-dimensional simulation technique is used to observe the fluid field and to denote flow velocity and hydrodynamic pressure through valve at different opening settings.

The visualization of power lines using a simulation program, shows the variation of the main hydrodynamic parameters and can give us information on appearance and maintenance of the local loss.

Minor head loss across the valve is directly proportional to the square of the flow velocity through the valve.

The values obtained for the coefficient of local losses are within the limits specified by the literature.

Note

This paper is based on the paper presented at The 1st International Conference "Experimental Mechanics in Engineering" - EMECH 2016, organized by Romanian Academy of Technical Sciences, Transilvania University of Brasov and Romanian Society of Theoretical and Applied Mechanics, in Brasov, ROMANIA, 8 - 9 June 2016

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DEVELOPMENT OF MECHATRONIC DIBBLING MACHINE FOR IMPROVING THE QUALITY OF FORESTRY SEEDLINGS

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Abstract: A forestry nursery in Tokoroa, New Zealand grows approximately 3 million Radiata pine seedlings per annum of which about 65% (2 million) are of suitable quality for forestry plantations. The high rejection rate of 35% was attributed to poorly trained, seasonal workers and unsophisticated equipment. It was estimated that about 22% of seedling rejection (approximately 220,000 per year) was due to poorly dibbled holes that caused bends in the stems. The bends occurred when planters pinched the stems of the seedlings in an attempt to make them vertical. A research and development project was undertaken to develop a mechatronic dibbling machine that could produce vertical holes of specified depth. The machine also had to produce 120,000 holes per day and be flexible with regard to spacing and size. The completed mechatronic dibbling machine was tested at the Tokoroa nursery and produced 98% of the holes at the required angle and 100% of useable depth. Harvesting, the following season, showed that the unwanted stem bends had been eliminated with a subsequent reduction in rejects. Furthermore, it was found that worker productivity increased by approximately 10% as they did not have to spend time setting seedlings vertically.
Keywords: forestry, dibbling, mechatronic, cuttings, seedlings, machinery

INTRODUCTION

A forestry nursery located in Tokoroa, New Zealand supplies approximately 3 million Radiata Pine seedlings per year to the forestry industry. Once harvested, the seedlings are transported to forestry blocks for planting. The vast majority of seedlings (over 90%) are Radiata Pine as shown in Figure1, but larger seedlings such as Plug Plus and Douglas fir are also grown. In peak season, up to 120,000 Radiata Pine seedlings per day are planted.

Figure 1 – Bed of Radiata pine seedlings after 1 year growth

This spiked wheel dibbling process, though fast, produced non-circular holes due to the rotation of the spike in the soil. In the forestry nursery this is called 'tearing' and the plan shape of a spiked wheel produced hole is represented in Figure3. Consequently, when juvenile seedlings were planted in the non-circular holes they did not stand vertically as required

Each Radita Pine seedling requires a vertical hole, +/- 3 degrees from vertical, lateral spacing of 80mm (+/- 2mm), longitudinal spacing of 125mm (+/- 2mm) and hole of 10mm (+/- 0.5mm) diameter of depth of 40mm (+/- 3mm). These requirements were given by the nursery manager and are based on experience. As approximately 90% of holes are for Radiata Pine, this research focussed on improving the quality of Radiata Pine holes. Once the holes are produced, juvenile seedlings are manually planted in the holes.

The process of producing holes for planting seedlings is called dibbling. To compensate for rejects, the nursery had to plant approximately 5 million seedlings to achieve a yield of 3 million. Poor quality holes, caused by antiquated dibbling methods, was one of the major causes of inconsistent quality. Formerly, dibbling for Radiata Pine was achieved using a spiked wheel towed behind a tractor as shown in Figure 2. The spiked wheel

method could not meet the required hole specification under any conditions.

Figure 2. Radiata Pine dibbling mac hine

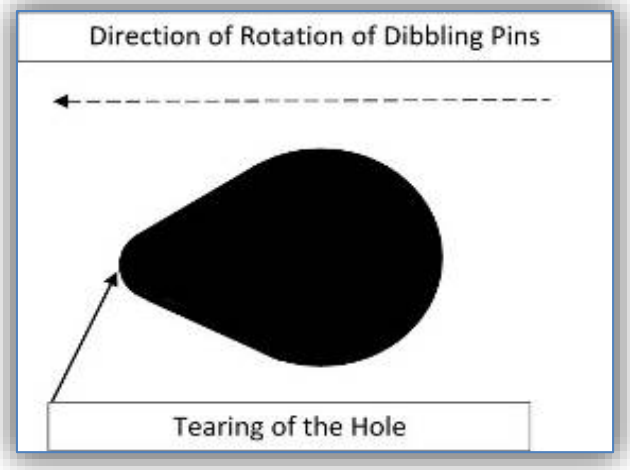

Figure 3. Non-circular holes caused by the spiked wheel dibbling machine `tearing'

To compensate for this, planters manually set each juvenile seedling visually. They then used their fingers to gather the soil around the stem to fix it in position. It was found that the manual setting caused bends in the stems, accounting for approximately 22% (220,000 per annum) of rejects. Furthermore, the Plus Plug and Douglas Fir seedlings required manual dibbling as the holes were too large to be produced by a spiked wheel. This was labour intensive and therefore costly. To overcome these problems, research was undertaken at the University of Waikato into the feasibility of a mechatronic dibbling machine.

Automated dibbling and seeding has been investigated by a number of researchers. Commonly, spiked wheels are used for dibbling holes, especially for seed planting and are often combined with an integrated seed dropping mechanism [3, 4]. Whereas this is effective for seeds, it is not viable for planting juvenile seedlings due to 'tearing' of the holes by the spike.

Investigations into plunger type dibblers and seeders as alternatives to the commonly used Coulter drill have been undertaken [1,6]. However, the emphasis of that research was on how to make a hole and drop a seed in it rather than producing holes to meet a defined specification for planting seedlings. Furthermore, these dibblers lacked the flexibility and speed required for the forestry nursery.

Lawrence et al [5], developed a dibbler using microprocessor control that offered greater opportunity for varying hole spacing too suit a range of crops. They found that using the new design, 96% of the hole spacing for potatoes and 98% for onions were within the required +/-10% specification. This flexibility and controllability highlights the advantages of using computer technology compared to purely mechanical systems. However, their system was not suitable for forestry nurseries as the holes have to be deeper and straighter for forestry seedlings and they had no method of achieving this. Consequently, it was found that no dibbling machine existed that met the requirements of the forestry nursery and therefore a new machine had to be developed.

MATERIAL AND METHOD

Firstly, a detailed investigation of dibbling and associated issues was undertaken in close collaboration with the forestry nursery managers. One requirement from the managers was that they wanted drilled holes, not punched. This was because punched holes compress the soil and inhibit root growth. Laboratory experiments were undertake to determine the best drilling speed, drill types and power for a range of soil conditions. Five seedling trays, each comprising forty eight cells were filled with nuresry soil. The soil was then compacted until it resembled the soil consistency in the nursery for a range of conditions from wet to dry. It was very difficult to quantify these conditions so they were based on the experience of the nursey manager. An electric drill was used for the testing and was modified such that its speed could be controlled over a range from approximately 100 to 3000 rev/min. This was achieved using voltage control with a switching DC power supply. The drill speed was measured with an optical tachometer. A scissor mechanism was used to keep the drill vertical during testing. It was found that for Radiata Pine, the optimal drilling speed was approximately 1000 rev/min with a 10mm auger drill. At 1000 rev/min, the drilling left soil at the edge of the hole that planters could use to set the seedling. Furthermore, the centrifugal force on the dirt ensured the drill did not clog with soil. The vertical drill speed was approximately 0.25 m/s. The drilling power consumption was found from the product of the current and voltage and at optimal speed, in dry soil

conditions was approximately 2W. The mechatronic dibbling machine had to be towed by an existing nursery tractor in a continuous process. Also, only the tractor driver was to operate the dibbler and it had to be easily reconfigured to accommodate a range of sizes and hole spacing.

In order to achieve the requirements, the machine had to produce straight vertical cylindrical holes whilst the machine was being towed behind a tractor driving at variable speed. The speed of the nursery tractor when driving with a creeper gearbox was between 0.2 to 0.4 m/s. Even in lowest gear, the speed variation of the tractor would have led to poor quality holes unless there was some sort of closed loop control that linked the dibbling to tractor speed. To achieve closed loop control, a programmable logic controller (PLC) coupled with sensors and precision pneumatics was used. A rotary encoder was mounted in a roller at the front of the dibbler. Therefore, the rotational speed of the roller was directly proportional to the horizontal speed of the tractor. The PLC then calculated the instantaneous speed requirement of a horizontal pneumatic cylinder such that it would match the tractor speed. A control signal was then sent to a Norgren pneumatic speed control valve. A horizontal, speed controlled pneumatic cylinder then moved forward at the speed of the tractor.

As the cylinder moved horizontally, a second pneumatic cylinder, with 16 rotating drill bits, descended to drill the holes. The matching of the horizontal cylinder speed with tractor speed ensured there was zero relative velocity between the vertical drilling cylinder and the planting bed. Once the holes were drilled, the vertical cylinder lifted the drills from the bed and the horizontal cylinder rapidly returned the starting position ready for another cycle. The entire cycle took approximately 1 second.

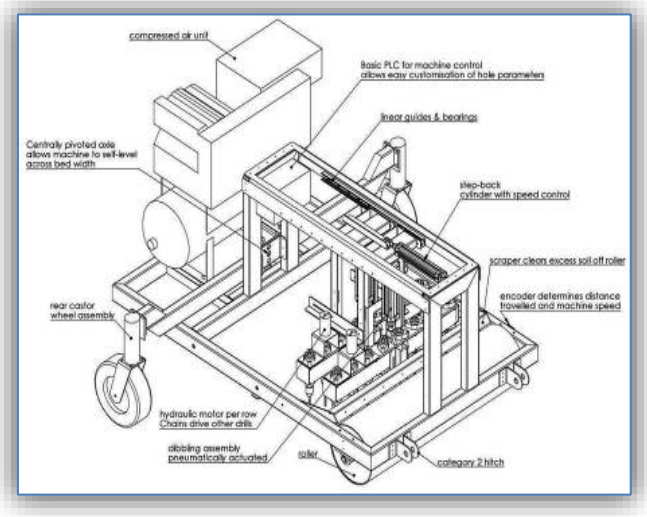

Figure 4 – Arrangement of mechatronic dibbling machine concept

It was found that to achieve the 120,000 holes per day and given the limitations of the pneumatics, that 16 drill bits were required. An arrangement drawing of the mechatronic dibbler is shown in (Figure 4).

Even though this was a research exercise, the nursery wanted to permanently replace the spiked wheel dibbler with the mechatronic dibbler prototype. Therefore, extra design criteria were added to the original mechatronic dibbler requirements as listed below:

- Must be able to operate in all weather conditions – as dibbling is done in winter, weather conditions include hard frosty ground, severe wind and rain with associated mud.
- Easy repair and maintenance.
- Easy and fast transportation from the storage building to the planting beds (up to 1.5km).
- Easy movement from one bed row to the next.
- Minimal disturbance to the bed surface, to protect the pesticide layer.

To accommodate these extra requirements the machine used components such as electronics and bearings rated to Ingress Protection (IP 67). This allowed the machine to operate in severe weather conditions and be easily cleaned by waterjet at the end of each day.

For easy maintenance and repair, only high quality, respected brand components were used. Therefore, if a component failed it could be easily sourced and replaced. Non-bought in components were manufactured directly using laser cutting which is fast and readily available in New Zealand.

Rear wheels were added that kept the machine stable when in use but also robust enough for transportation. The machine had hoist attachments so it could be easily connected to a hydraulic tractor hoist for lifting the front for movement from storage to bed and bed to bed.

A front roller provided support and was also used for sensing forward speed without disturbing the pesticide layer.

Once the concept was agreed by the nursery managers, detail design was undertaken using 3D computer aided design (CAD). This was combined with computer aided engineering (CAE) tools to undertake stress calculations using finite element analysis (FEA) to ensure machine robustness. CAE dynamic tools were also used to ensure the machine could achieve the required speed.

The final design was manufactured using Computer Aided Manufacture (CAM), assembled and commissioned by the University of Waikato's AgriEngineering Research Group.

RESULTS

The completed mechatronic dibbler was tested on site at the Tokoroa nursery and achieved the

120,000 required holes per day. The finished dibbler in operation is shown in Figure 5.

Figure 5 – Completed mechatronic dibbling machine during testing

For the mechatronic dibbling machine, a sample of 100 holes was used to determine the consistency of the depth and angle. As the vast majority of holes were for Radiata Pine, they were used in the sampling. A simple measuring system was built that comprised a rod of 10mm diameter, a protractor for measuring hole angle and a rule for measuring hole depth, see figure 6.

Figure 6 – Measuring device for hole depth and angle

The scales of the measuring system could be read to +/- 1mm and +/- 0.5 degrees. 100 holes were randomly chosen from a mechatronically dibbled bed. The rod was inserted in the holes and depth and angle ready by eye. The results from the testing are shown in (figure 7).

The basic requirement was that holes for Pine Radiata were 40mm +/- 3mm deep and +/- 3 degree angle from the vertical. Due to the lack of resolution of the measurement method, many of the 100 measurements had the same value.

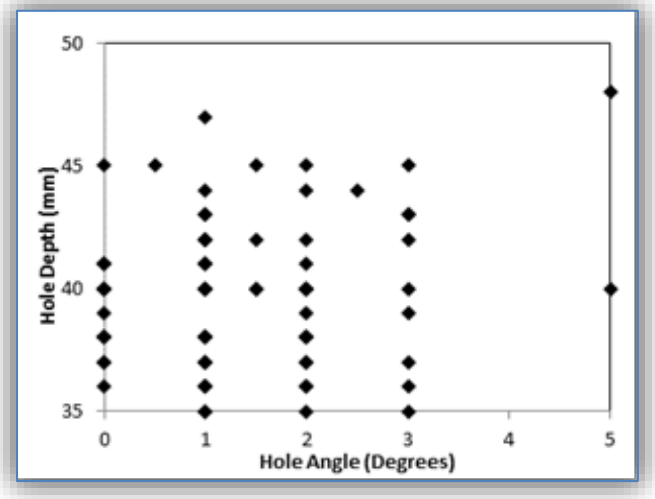

Figure 7 – Hole depth v hole angle for mechatronically dibbled Radiata pine seedlings

It can be seen that the even with the uneven planting bed, the dibbler achieved 76% of holes within the +/- 3mm tolerance. Only 2% of holes are outside the required +/- 3 degree angle. The average hole depth was 39.7 mm and angle 1.3 degrees with standard deviations of 3.3mm and 1.1 degrees respectively. With regard to the angle, this is at least an order of magnitude better than the spiked wheel dibbled holes. It was found that all the spiked wheel dibbled holes were outside the requirements. The nursery managers were confident that even the 24 holes outside the depth tolerance would produce saleable seedlings, suggesting that the +/-3mm tolerance should be increased to +/-5mm.

It was observed that the uneven surface of the planting bed caused varying hole depth and angle. This was because the machine's depth sensor is located in one place on the bed whereas there are 16 holes, each in different places.

Furthermore, it was also observed that the level of the bed was not even.

Even though the hole data provides useful information on quality, the best indicator is the position of the juvenile seedlings when placed into a mechatronically dibbled hole and spiked wheel hole respectively.

Figure 8 shows 5 juvenile seedlings in holes made by the spiked wheel dibbler. It can be seen that the 'torn' hole causes non vertical seedlings. These then have to be manually set to the vertical position. It can also be seen that the surface of the planting bed is very 'disturbed' due to the tearing effect of the spikes.

Figure 8. Juvenile seedlings in spiked wheel dibbled holes

Figure 9. Juvenile seedlings in mechatronically dibbled holes

Figure 9 shows 5 juvenile seedlings placed in holes made by the mechatronic dibbler. It can be seen that all the seedlings are vertical and of even height. The nursery managers decided that all holes produced by the mechatronic dibbler, including those outside their original specification, were suitable for planting.

It can also be observed that the bed surface is far less disturbed than the spiked wheel bed surface. This highlights the superior quality of the mechatronic dibbling process. An unexpeted advantage of the mechatronic dibbler was that planter productivity increased by approximately 10% because they did not have to spend time setting the seedlings vertical.

The mechatronic dibbler has now been operating for three seasons and has produced several million holes. The bent stem problem has been eliminated and planter productivity increased.

CONCLUSIONS

A Tokoroa forestry nursery in New Zealand was suffering approximately 220,000 per annum seedling rejects due to poorly dibbled holes. A research and development project was under taken by the University of Waikato to develop a mechatronic dibbling machine that could produce good quality holes at the required rate and also be flexible with regard to spacing and hole sizes. Furthermore, the nursery wanted the dibbling machine to be towed by a tractor operating at close to a constant speed, to ensure a continuous system.

To achieve the requirements, a computer controlled mechatronic dibbler was developed. The dibbler used an encoder on a roller to provide feedback of the tractor speed to a PLC. This then provided a closed loop signal to a horizontal pneumatic cylinder that matched the forward speed of the tractor. The holes were then drilled by a second vertical pneumatic cylinder with 16 drill bits. The relative horizontal velocity between the bed and drill bits was zero. After drilling, the cylinders rapidly returned to the start position to begin the process again.

The completed dibbling machine was tested at the Tokoroa nursery and performed as expected, producing 98% of holes at the required angle and 76% at the required depth. All the holes were considered good quality by the nursery manager suggesting that the current depth tolerances should be increased to +/- 5mm, especially when considering the uneven surface of the planting bed. The machine is now fully commissioned and dibbling holes on a daily basis at the nursery.

Acknowledgement

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BASIC EQUIPMENT FOR THE MECHANICAL TREATMENT OF WASTEWATER

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Abstract: In a continuously developing world, where many activities are high consumers of natural resources, including water, it has become absolutely necessary to apply methods of wastewater treatment. The purpose of wastewater treatment is to improve water quality, in order to be discharged into the environment, without being harmful for different environmental factors. In this paper are presented the equipment used in the mechanical stage of a wastewater treatment plant, and also the status of wastewater treatment plants in Romania.
Keywords: wastewater, mechanical water treatment, treatment plant

INTRODUCTION

In the current state of economic and social development, is becoming more difficult to achieve the satisfaction of water needs for household, industrial, energy and agricultural use, given that each of these activities entail the pollution of groundwater and surface waters. Water pollution is mostly due to industrial development, growth of urban population and discharge into rivers and lakes of sewage, more or less treated [10].

In recent years increasing attention has been directed toward the discharge, presence and potential effects of persistent pollutants in the environment. While many of these pollutants break down relatively quickly in the environment, many others are highly resistant to degradation [6].

European Council Directive 91/271/2002 is the legal basis regarding the legislation on wastewater. This Directive, transposed by G.D. 188/2002, defines water treatment as the process of "removal from wastewater of toxic substances, microorganisms, etc., aiming to protect the environment, the envoy first, and also soil and air." Hence, water treatment is a complex process of withholding and neutralizing harmful dissolved substances, in colloidal state or in suspension, present in industrial and municipal wastewater, that are not supported in the aquatic environment into which is discharged the treated water and that allow restoring the physicochemical properties of water before use [10].

Given the differences in location, economic resources, living standards of different countries, and also the characteristics of water and its pollutants, many nations adopt diverse techniques for wastewater treatment [1]. Wastewater treatment processes include:

a. Mechanical treatment (primary) - the wastewater treatment processes are of physical-mechanical type, and consists of: withholding of coarse bodies and suspension of wastewater, sedimentation (settling) of the solids in suspension, floating of impurities with lower density than that of water or which are brought by aggregating to this status, filtration and centrifugation, methods generally used in the sludge treatment and ultraviolet disinfection. European Council Directive 91/271/2002 stipulates that, following the processes of mechanical treatment, the biochemical oxygen demand of the incoming waste water is reduced by at least 20 % before discharge and the total suspended solids of the incoming waste water are reduced by at least 50 % [15].
b. Chemical treatment - the wastewater treatment processes are of physico-chemical nature. Chemical processes are applicable in wastewater holding large quantities of fine matter in suspension, colloid, or even dissolved substances that are very difficult to separate by classical mechanical methods. In this case, after the classical the chemical step, into which are placed a number of substances that favor the accumulation of large flocks colloidal substances, or which react with compounds in the water, forming compounds that are easier to separate. Also as chemical process is water

disinfection at the end of the treatment process, using chemical substances.

c. Biological treatment - the treatment processes are both physical, and biochemical. Biological processes involved in the treatment of wastewater refers to the decomposition of organic materials by bacteria and are of two types, depending on the nature of the bacteria:
   - » *aerobic processes* of decomposition of organic substances in the presence of oxygen, a process carried out by aerobic bacteria, which feed on these substances;
   - » *anaerobic processes* of decomposition of organic oxygen scavengers that organic compounds by anaerobic bacteria, in terms of lack of oxygen.

In figure 1 is presented the technological flow in the mechanical stage of a wastewater treatment plant.

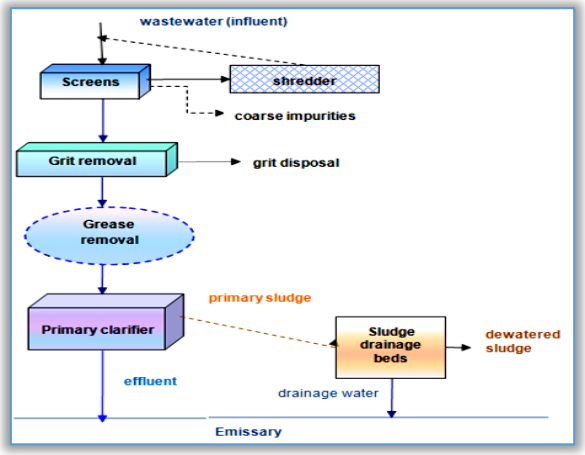

Figure 1. Diagram of a mechanical wastewater treatment plant

Some treatment plants are equipped with tertiary treatment step, which aims to remove excess compounds (e.g. nutrients - nitrogen and phosphorus) and to ensure water disinfection (e.g. by chlorination). This step may be biological, mechanical, chemical or combined, using conventional technologies (filtration) and special processes (adsorption on activated carbon, chemical precipitation, etc.).

By withholding or neutralization of toxic or recoverable substances from wastewater are obtained treated waters, in various degrees (which are either discharged into an emissary or are used as water for irrigation or in other purposes), and sludges that can be processed, stored, decomposed or recovered [4]. After going through these steps of treatment, the water must hane an acceptable quality, in accordance to the standards for treated wastewater.

MATERIAL AND METHOD

Bar screens are designed to withhold large bodies representing 3-5% of the total materials transported by the wastewater. Usually, bar screens are made from profiled bars, parallel and equally spaced, rigidly fixed on ransverse bearings, leaving between interspaces named gap. After interspace size, bar screens can be classified as rare and dense, and by the plan shape, the bar screens can be: plane, radial, curved etc. [2].

Bar screens are made of stainless steal to prevent the corrosion. The retaining of coarse suspensions can be done manually or automated. Automation is preferred if the bar screens are subjected to high flow rates of wastewater or if the wastewater contains large amounts of solid debris. With the help of mechanical rakes, the screens are constantly scrapped off to remove material deposited, which is then dumped into a container [7]. In figure 2 is presented a continuous bar screen. Usually, continuous screens are often being installed in channel sewery where the screen moves through the sewage and takes with it the coarse waste; the waste can also be removed from the sewage by a slow combined movement of the screen components. These types of screens have very scant gaps (3-8 mm) [13].

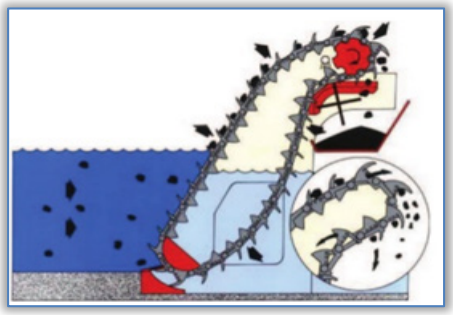

Figure 2. Continous bar screen [13]

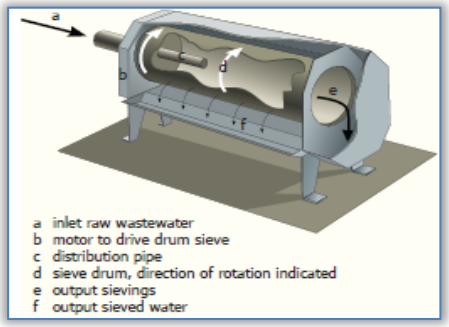

Figure 3. Drum sieve [13]

Sieves have the same role as bar screens, but they have denser holes, retaining solid particles of smaller diameter. A constructive solution is the drum sieve (figure 3) presents a drum sieve that can be used for chicken slaughterhouses to remove feathers and their organs. A drum sieve consists of a slow rotating drum that is equipped with small perforations. The drum is driven through a gear box by an electric motor [13]. The wastewater enters the drum axially and leaves radially, trapping the screenings inside the drum [7].

The sieved particles stay in the drum and through both the revolving movement of the drum and the internal screw are placed at the end of the sieve screen and then cast out [13]. Water jets periodically clear the screenings from the drum [7].
More small particles from industrial wastewater can be removed from wastewater by sieves than by bar screens [13].
Grit chambers are devices used for retaining granular mineral suspensions, characterized by lack of putrefaction and higher sedimentation rate of solid matter organic, putrescible in suspension. The role of grit chambers is to protect moving mechanical equipment against the abrasive action of sand, to reduce the possibilities of clogging of pipes, caused by deposition of sand and to reduce the frequency of cleaning of digesting tanks and clarifiers of excessive accumulation of sand.
The vortex grit removal unit (figure 4) removes large particles of gravel and sand from the wastewater. The flow of wastewater enters into each grit unit and is directed to create a circular vortexing current. This current creates an area of low velocity in the center of the chamber. The heavier grit and sand falls down to the bottom while the water and other solids stay moving in a circular flow pattern. The grit is collected on the bottom of the unit, and is discharged and sent to the landfill for disposal [12].

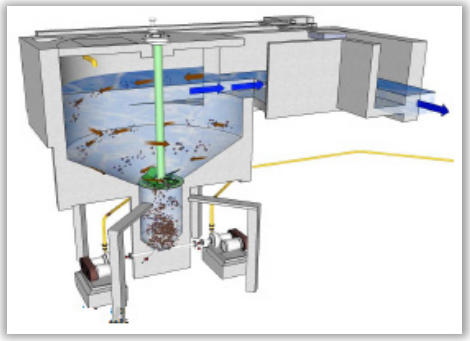

Figure 4. Vortex Grit chamber [12]

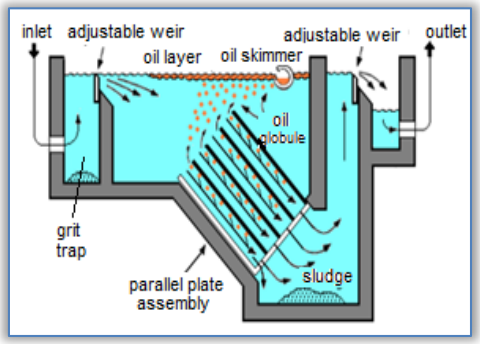

Figure 5. Grease removal [20]

Grease removal (figure 5) are equipment in which the separation of grease and oil residues under tack at the surface of domestic wastewaters and are placed between grit chambers and primary clarifiers.
Free fats, which tend to rise to the water surface are separated into rectangular tanks, and the method is based on lowering the flow rate of the water. Fats are separated from the basin surface in a specially designed space, from which are discharged manually and the water is discharged by siphoning. Fats found in colloidal state or as emulsions do not have a natural tendency to rise to the surface, and their separation is done by blowing air at low pressure in divided tanks [3].
Primary clarifier (or settling tank) has the role to withold most of the suspensions in wastewater, respectively raw water, by sedimentation – gravity deposit. They are constructions made of concrete; they generally have very large sizes, at about 30 m long and 9 m wide and can have various geometric shapes (rectangular, round).
Rectangular primary clarifier (figure 6) is a tank into which the water stays for 1.5-2 hours. Collection of deposits in the upstream hopper is done several times per day, with the help of a scraper mounted on the bridge, to prevent their fermentation [5].

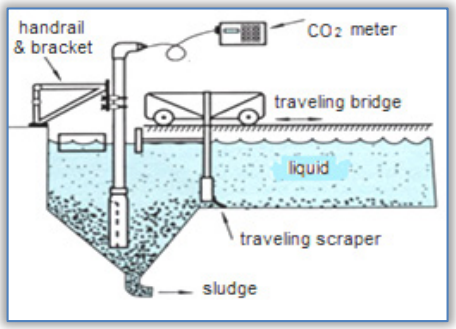

Figure 6. Rectangular primary clarifier [20]

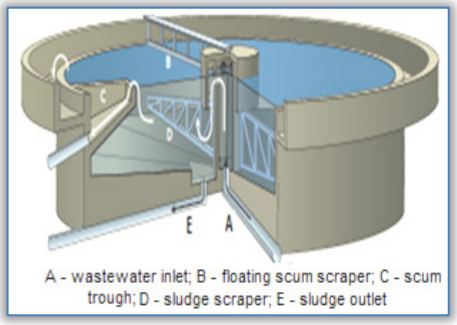

Figure 7. Round primary clarifier [13]

Round primary clarifier (figure 7) is an installation into which the wastewater is fed into the middle and is discharged through a trough on the outer periphery. Above the tank there is a bridge that slowly rotates with sludge scrapers attached. These scrapers move the sludge on the bottom slowly towards the central sludge funnel, where it is removed. The bottom is built with a slight slope. For the effluent trough there is a scumboard or baffle for holding back the floating solids. The floating solids (fat) are pushed into a scum trough by the

floating scum scrapers that are attached to the bridge [13].

Processes in the primary treatment generate primary sludge. The sludge is removed and pumped to the solids treatment process for ultimate removal [9].

RESULTS

In Romania, a major problem is the lack of sewerage network in certain areas and the inadequate treatment system. According to the National Administration of Romanian Waters, the water used by 90% of romanians from the village and 50% from the city does not get into a sewer system, but is thrown directly near the house [11]. Also, in Romania, the degree of connection to the sewerage network and sewage treatment plants is 57% and respectively 46%. In Romania, physically, there are 983 sewers, of which only 631 are functional, the rest being still in various stages of implementation [17].

In 2011 were identified 511 sewage treatment plants, of which only 16 treatment plants comply with the requirements of Directive 91/271 / EEC, for the second stage of treatment. The poorly equipped treatment plants are those in Muntenia and Oltenia (Dolj, Gorj, Giurgiu, Călăraşi), central and southern Moldova (Galaţi and Vaslui) and best equipped treatment plants are in the center and west of the country (Braşov, Cluj Napoca, Mureş) [16]. Figure 8 shows the map of localities provided with wastewater treatment plants in our country, according to estimates made in 2011.

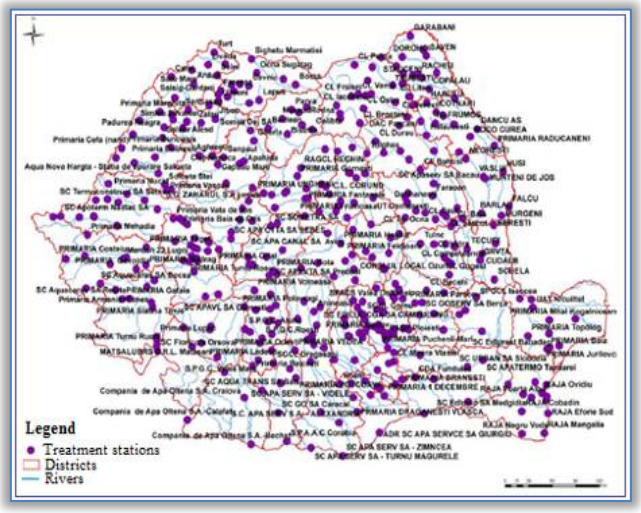

Figure 8. Wastewater treatment plants in Romania in 2011 [19]

Bucharest is served by a mixed system of sewage, spread over about 2400 km, that takes wastewater from approximately 80% of the population of 1.92 million people from the city, but also from most of the industrial units and institutions. The wastewater collected is transported to the treatment plant in Glina, in the south-east of Bucharest [18].

In the wastewater treatment plant from Glina, technological and biological processes occur in three stages of wastewater treatment (figure 9).

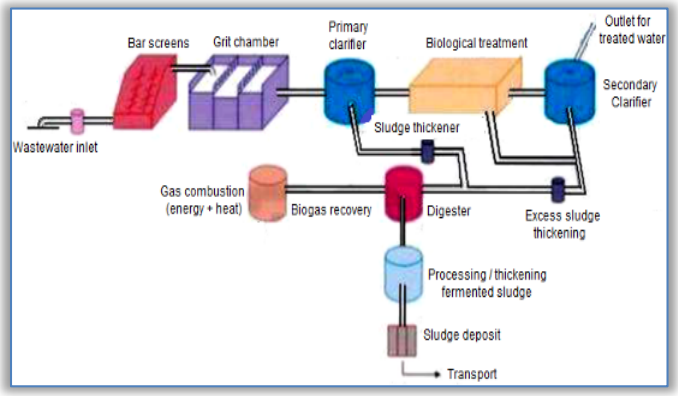

Figure 9. Technological flow at Glina wastewater treatment plant, near Bucharest

In the first stage, larger bodies floating in the waters of Dâmboviţa river are retained by bar screens and sieves. Cleaning of water of these bodies is made in a similar manner to household waste management, being sent to landfill or to sludge incinerator. Then, the separation of sand takes place into grit chambers and the sedimentation of suspensions in the primary clarifier. After decanting, substances collected to surface (grease, hydrocarbons) are removed, and primary sludge deposited on the bottom of the primary clarifier is thickened and sent to digesters [14].

Mechanically treated water reaches the biological stage, where acts microorganisms that break down organic matter. From the secondary clarifier, secondary sludge is obtained, which is thickened (dried) and sent to the digester.

By anaerobic digestion of sludge is obtained the biogas, which is converted by co-generation into heat and electricity. The digestate, namely the remaining solid after fermentation, is dehydrated and can be used as fertilizer on agricultural fields.

Currently, Glina wastewater treatment plant removes mechanically only 85% of the wastewater entering the plant, with a flow of 10 m^3/s, but only half of this quantity is fully treated, according to the European environmental standards.

CONCLUSIONS

Wastewater includes water resulting from residential, industrial and commercial activities.

A wastewater treatment plant consists of various equipment and processes that have the role to remove or destroy harmful materials, chemical compounds, and microorganisms found in the wastewater.

In order to protect the environment, especially the emissary, and also the soil and air, a proper treatment process of wastewater should provide favorable conditions for further possible use of such

water for domestic, industrial or agricultural activities.

Raw untreated wastewater, discharged into rivers, have a devastating impact.

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IMPACT RESISTANCE CONSIDERATIONS OF ROAD RESTRAINT SYSTEM REALISED ACCORDING TO STAS 1948

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Abstract: The paper presents the results of experiment made using a pendulum for road restraint systems with damping elements, according to STAS 1948. Deformable parapets are created to protect the vehicles and other participants at traffic from danger and serious injury. The results of the experiment are very important for the knowledge of the type of parapets that are used on the roads.
Keywords: shock, test, parapets

INTRODUCTION

One of the major tasks in road transport is ensuring an adequate level of safety for road users. To maintain and improve road safety, it is often necessary to install certain devices on the road, which are designed to hold vehicles and pedestrians from entering into hazardous areas. These devices are called railings or protection devices for roads. Shapes, sizes and execution details of metal parapets projects are determined by type, whose diversity is very high. Metal guardrails road is divided into three categories according to technical class of the road and the retention of thereof: semi heavy, heavy and very heavy.

The restraint system studied is semi heavy and was created according to STAS 1948. This is a type of guardrail of metallic elements, with a single row of sliding elements, joined together with screws, mounted on a metal pillar supporting the brake caliper by means of a metal profile and a shock absorber. Deformable parapets metal components are made of S235JR, S275JR, 08kp or other similar instruments, whose characteristics in terms of chemical composition, allows galvanizing immersion in molten zinc bath [1], [2].

STAS SR 1948-1 and 1948-2 present schemes for common types of fences. These types are not limiting. Shapes and sizes to fences, other than the usual are presented in type projects. For these projects it is needed the impact test in authorized polygon according EN 1317.

EN 1317 is a European standard without these schemes, parapets are realized only after the type projects. For these projects is necessary the impact test. It describes in detail the impact test procedures, test site, test vehicle, vehicle equipment, speed and angle of impact or result processing and calculation of indices of severity ASI. It establishes that the test report include detailed descriptions and design specifications of the article tried to allow verification of compliance installed device under test, including performance requirements of the foundation or anchor / fixing soil [3], [4].

PREPARATION OF THE MATERIALS AND THE ACHIEVEMENT OF TESTS

The tests were done in production hall inside BETAK SA. For execution of the tests was chosen using a pendulum weighing 2780 kg. In order to achieve the pendulum was used a crane hook, a support and a roll. The roll has a diameter of 1300 mm and a height of 480 mm. Its height is specially selected in order to comprise entirely slide of the parapet. The pendulum has a length of 9 m and a weight of 2780 kg for the first case and 4000 kg for the second case. Raising it to a height of 800 mm from the ground at the lowest point of the pendulum was made using a forklift truck. Its release was done using an angle grinder. Catching it in the concrete floor was performed using four mechanical anchors on each pole. The slide was caught by pole using M16 screws. Parapet height at the point of impact was 750 mm. In the proximity of center of gravity of the pendulum was installed a system of measurement and data collection with acceleration sensor.

Impact guardrails were made perpendicular to it. The pendulum movement speed was 4.06 m / s.

Given that these types of fences are installed on bridges, in places where the limit the speed of vehicles is 50 km / h, was chosen as a reference a vehicle with an average weight of 900 kg having in the first case the speed about 50 km / h and in the second case the speed about 65 km / h.

Figure 1:2780 kg pendulum

Figure 2: 4000 kg pendulum

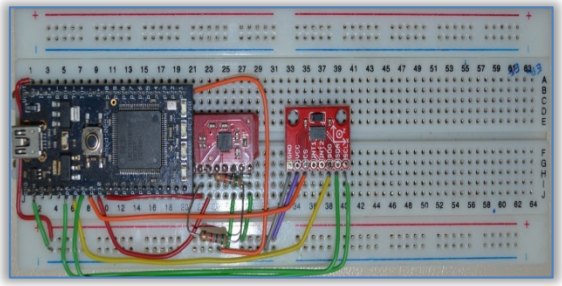

Figure 3: system of measurement

The parapet has a weight of 17, 76 kg / ml and is made by a slide with 7 holes, L = 6200 mm, g = 2.5 mm, 3 pillars I10 with soles, 3calipers g = 3 mm, 3 dampers g = 4 mm. The dampers and the calipers were fixed with screws M16x40 and M12x35 screws on poles. Tested parapet length is 6 m. The pillars are caught up in the concrete floor with mechanical anchors. The distance between the pillars is 3 m. This project is Betak`s property and is protected by law.

The blow was applied to the slide's center on the middle pillar.

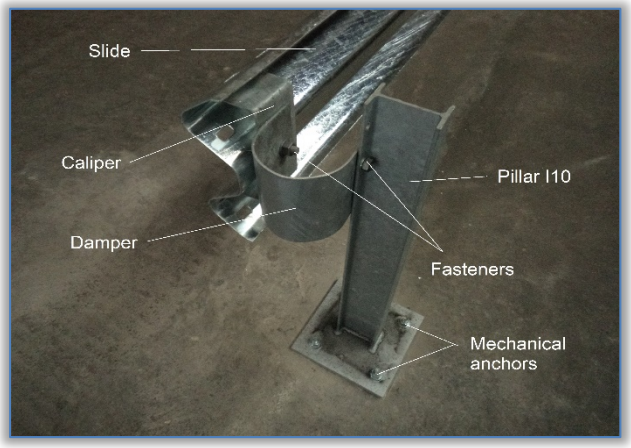

Figure 4: The semi heavy restraint system studied

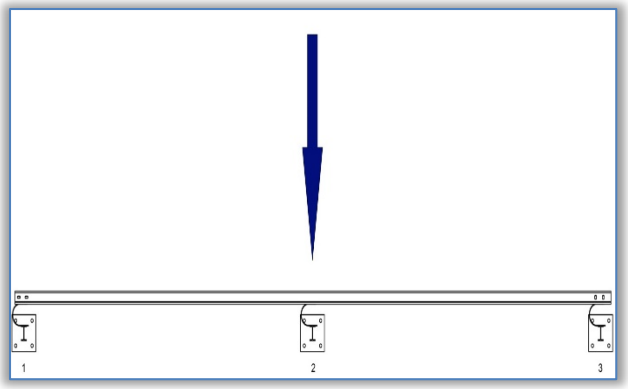

Figure 5: Impact direction

a)

b)

Figure 6: Overview before impact
for case 1 and case 2

a)

b)

Figure 7: Overview after impact
for case 1 and case 2

a)

b)

Figure 8: Top view after impact
for case 1 and case 2

Figure 9: Pillar deformed on the edge

Figure 10: Slide broken in the area of pillar

Deformation of safety barriers during testing is characterized by dynamic deflection, working width and the impact severity index ASI for the evaluation of parapet. For the calculations were taken into account the mathematical formulas presented in SR EN 1317. Table 1 presents the calculated and measured values for the case 1 and case 2.

Table 1: Results

Case	Calculated Dynamic deflection D_N [m]	Measured Dynamic deflection D_m [m]	Calculated working width W_m [m]	Measured working width W_N [m]	ASI
Case 1	0,248	0,240	0,441	0,435	5,86
Case 2	0,305	0,295	0,575	0,566	5,21

CONCLUSION

In the first case the maximum dynamic deflection of the parapet, measured after the test was 0,240 m and 0,435 m of working width. The acceleration severity index (ASI) was calculated using data transmitted by the accelerometer mounted in the pendulum. Using

SMA (Signal Magnitude Area) it can be observed the pendulum motion, from which it may could extract the data used to calculate the index. In this case ASI is 5.80, which indicates that the security impact of the occupant of a car that loses direction of the road is small. It can have major injuries from the impact. In this case, the energy was absorbed most of the shock absorber, damping elements and caliper. Damping elements are deformed considerably, pushing the pillar to rotate about 45 degrees. The pillars at the ends, the calipers and the shock absorber have not been deformed at all.

In the second case, the impact energy is higher, but the barrier has been able to retain the pendulum. The maximum dynamic deflection measured after the test was 0.295 m and 0.566 m working width. In this case ASI is 5.21, which indicates that the security impact to the occupant of a car that loses direction of the road is small in this case too.

In this case, the energy was transmitted mostly in the slide and pillar. The damping elements are slightly deformed, the pillar has stopped rotating, and it was deflected from the base, on the edge. The slide reached the pillar and was broken in that area. The pillars at the ends and the calipers were not deformed at all, only the dampers were deformed.

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BEHAVIOR OF PRESTRESSED SIMPLE AND CONTINUOUS PARTIALLY COMPOSITE STEEL-CONCRETE BEAMS

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Abstract: In this paper, a non-linear finite element analysis (FEA) has been done to analyze the internal stresses and strains under static load up to failure for the concrete slab and steel beam sections for simple and continuous composite beams with external prestressing. The concrete slab is partially connected with steel I-beam section by headed stud (shear connectors). ANSYS computer program (version 15) has been used to analyze the three-dimensional model. The nonlinear material and geometrical analysis based on Incremental –Iteration load method, is adopted. The reliability of the model was demonstrated by comparison with experimental results of simple prestressed composite beam carried out by another author. The results wash obtained by FEA solutions have shown good agreement with experimental results. The analysis for continuous prestressed composite beam covers: load deflection behavior, strain and stress in concrete slab and steel beam, force in shear connector, slipping between concrete and steel, and failure modes.
Keywords: Composite steel-concrete beams, finite element analysis (FEA), external prestressing, shear connection, slipping, uplift

INTRODUCTION

Use of Composite Construction has become increasingly popular due to the economy and speed in construction. The modern era of Composite Systems using steel and concrete for columns began with the work of the late Dr Fazlur Khan in 1966 [1]. Concrete filled steel tubular (CFST) structures have been increasingly used recently owing to good structural performances by their high load-bearing capacity and energy dissipation ability [2]. Leng et al. [3] investigated the structural performance of steel-concrete-steel sandwich beams inter connected by channel connectors with large interval.

Strengthening of existing buildings especially bridges is most important so, the use of external pre-stressing has been used from sixty five years ago because of its perfect and economical solution for many types and circumstances of bridges. This system has been widely spread due to speed and traffic crashes in less time. Continuous steel-concrete composite beams are widely used in buildings and bridges for higher span/depth ratios and less deflection etc., which results in superior economic performance compared with simply supported composite beams [4]

The principle pre-stressing is the application of axial load along with shear bending moment to increase the ability to improve the performance of cracking. It also could have a beneficial effect on shear capacity [5].

Pre-stressed composite beams (concrete- steel) with high strength external tendons have showed many advantages comparing with plain composite beams. These advantages as: expand the elastic behavior prior to yielding for the structures with internal stresses, increasing in capacity of ultimate moment of structures, use the high- strength tendons reduces the yield strength so, then reduces the amount of structural steel used in construction, tends to reduce the cost of construction.

A composite beam (concrete-steel) can be pre-stressed, using a jack, by the tensioning high-strength tendons connected at both ends to brackets or anchorages that are fixed to the composite beam. Pre-stressing a composite beam can introduce internal stresses into the member cross sections that can be defined for different purposes. Such induced stresses can then counteract the external loads applied on the structure. Pre-stressing can be carried out for simple-span or continuous-span composite beams. In the positive moment region, the steel beam is usually pre-stressed before the concrete is cast because the negative moment induced by pre-stressing may be used to counteract the positive moments caused by the concrete's self-

weight. In the negative moment region, the steel beam and concrete deck can also be pre-stressed either separately or jointly along the top flange before or after casting of the deck Saadatmanesh [6] Also Saadatmanesh [7], Ayyub [8], Nie J. [9], Zona A. [10], and Chen Sh. [11] researches have been done on pre-stressed steel and concrete composite beams with external tendons.

The behavior of the composite girders (concrete slab-steel girder) has been the subject of several researches all over the world [12].

It is widely known that laboratory tests require a great amount of time and, in some cases, can even be impractical [13]. The finite element method (FEM) can be used as a very useful tool in predicting the failure load of composite concrete-steel beams and can allow very detailed information for the distribution of stresses and strains in composite beams [14-16]. Ibrahim et al. [17] used a finite element model to study the behavior of simple prestressed composite beams by means of a developed computer program (ANSYS 12) and compared the numerical results to the experimental results. The numerical results showed that the behavior in the concrete slab and steel beam responded well with the experimental results. Patil and Shaikh [18] presented 3D numerical models of steel-concrete composite beams to simulate their structural behavior with emphasis on the beam-slab interface. Simulations were made using version 14.0 of the ANSYS code, based on the FEM. The results were compared with those provided either by standards, experimental work, or found in the literature, and such comparisons demonstrated that the numerical approach followed is a valid tool in analyzing steel-concrete composite beams.

A detailed literature review showed that the studies mostly focused on the behavior of simple prestressed composite beams. Also the review showed that little information was available on the structural analysis of composite continuous beams with external prestressing taking into consideration the effect of slipping and uplift in between concrete slab and steel beam section.

Therefore, the present study is concerned with the behavior of this type of structure (partially composite section), taking into consideration the slipping and uplift between concrete slab and steel beam section. The model using FEM version 15.0 of the ANSYS code.

FINITE ELEMENT MODEL

The analysis of simple and continuous composite beams with external prestressing was performed using ANSYS computer program (version 15). Model components encountered throughout the current study, corresponding finite element representation and corresponding elements designation in ANSYS are presented as follows:

Element type selection

The three-dimensional element SOLID 186 is adopted to discretize the concrete slab, which is able to simulate cracking behavior of the concrete under tension (in three orthogonal directions), crushing in compression and evaluate the material non-linearity and enable the coverage of reinforcement (reinforcement bars scattered in the concrete region). The steel section is modeled using the SHELL 43 element, which facilitates non-linearity of the material and shows linear deformation in the plane in which it is present. The modeling of the shear connectors is done by the BEAM 189 element, which allows the configuration of the cross-section enables consideration of the non-linearity of the material and includes bending stresses. The TARGE 170 and CONTA 173 elements are used to represent the contact slab-beam interface. These elements can simulate the existence of pressure between them in the case of contact and separation between them in the case of no contact. The slab-beam contact materials also take into account slipping and uplift between the parties. The prestressing stress was taken as the initial value and equal to the effective stress. It appears in the analysis as initial strain in link element. Link 8 is used to represent the external cable. Since the cable is located outside the steel section and the prestressing force is transferred to composite beam through end anchorages and stiffeners, the cable is connected to beam only at the anchorage or stiffeners.

MATERIAL MODELING

In this study, the main components of the composite section are modeled with relevant ANSYS elements as follows:

Modeling of concrete

The concrete is considered to be homogeneous and initially isotropic. The adopted stress-strain (fc-□) relation is based on work done by Desayi and Krishnan [17] as shown in Figure 1.

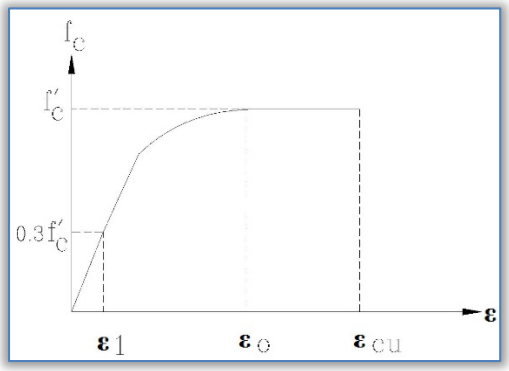

Figure 1. Compressive stress-strain curve for concrete used in ANSYS model

A compressive uniaxial stress-strain relationship for the concrete model was obtained by using Eqs. (1-4) to compute the multilinear isotropic stress-strain curve for concrete.

$$f_c = \varepsilon E_c \quad \text{for} \quad 0 \le \varepsilon \le \varepsilon_1 \tag{1}$$

$$f_c = \frac{\varepsilon E_c}{1+(\frac{\varepsilon}{\varepsilon_o})^2} \quad \text{for} \quad \varepsilon_1 \le \varepsilon \le \varepsilon_o \tag{2}$$

$$f_c = f_c' \quad \text{for} \quad \varepsilon_o \le \varepsilon \le \varepsilon_{cu} \tag{3}$$

$$\varepsilon_1 = \frac{0.3 f_c'}{E_c} \text{ (Hooke's law)} \tag{4}$$

$$\varepsilon_o = \frac{2 f_c'}{E_c}$$

where, ε_1 = strain corresponding to $(0.3f_c')$; ε_o = strain at peak point; ε_{cu} = ultimate compressive strain.

Modeling of steel girder

The bilinear stress-strain relationship indicated in Figure 2 is used in this study [18]. The strain hardening modulus (E_t) is assumed to be ($0.03\ E_s$). This value is selected to avoid convergence problems during iteration.

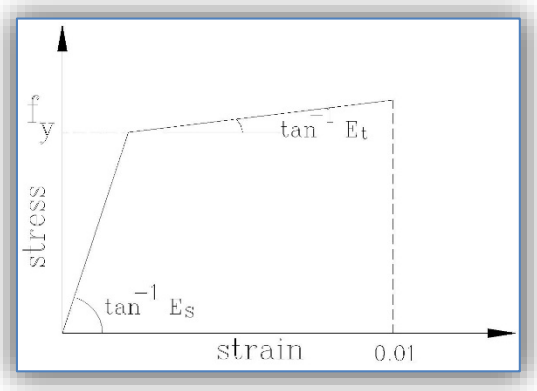

Figure 2. Stress-strain curve for steel girder used in ANSYS model

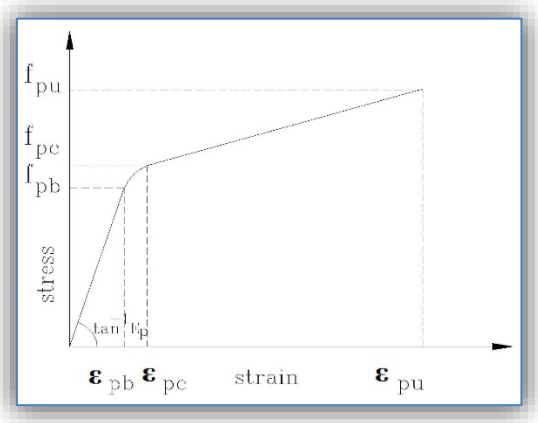

Figure 3. Stress-strain curve for prestressing cable used in ANSYS model

Modeling of prestressing bars

The prestressing cable is slender, they can be assumed to transmit axial force only. Modeling of prestressed steel in F.E. is much simpler; the stress-strain relationship for prestressing tendons can be represented as shown in Figure 3.

Modeling of shear connectors

The qualitative behaviour of shear connectors in respect of: slipping, uplift, and repeated loading.

The push-out, and pull-out curves are shown in Figures 3 and 4 [13].

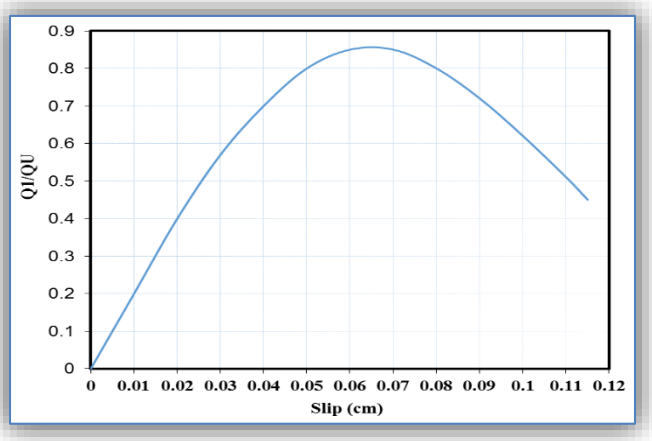

Figure 4. Load-slip curve from push-out test used in ANSYS model

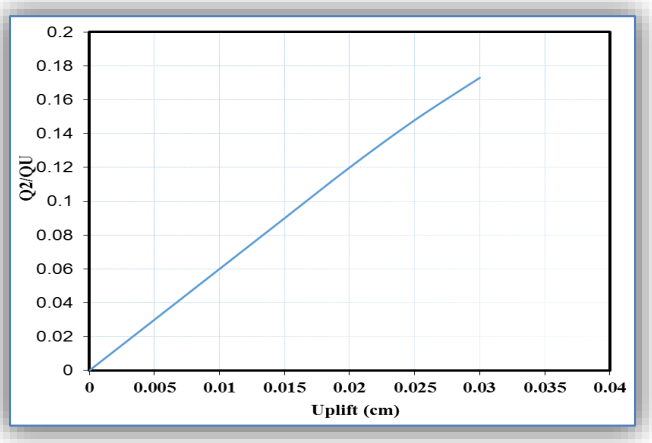

Figure 5. Load-uplift curve from pull-out test used in ANSYS model

The equation for push-out curve [13] is:

$$Q_{1\gamma} = Q_u (1 - e^{-c_1 \gamma})^{c_2} \tag{5}$$

where, $Q_{1\gamma}$ = horizontal force taken by the connector; Qu = ultimate horizontal force taken by the connector; γ = relative slip between concrete slab and steel beam; C_1, C_2 = constants depend on the kind of connector.

and the equation for pull-out curve is:

$$Q_{2\Delta_a \gamma} = R_\Delta . \Delta_t \tag{6}$$

where, $Q_{2\Delta a}$ = vertical force taken by the connector; R_Δ = equivalent secant rigidity of

connector for uplift; Δ_t = uplift between concrete slab and steel beam.

Geometrical modeling and finite element meshing

The numerically modeled beams are typically composed of simple and continuous beams with external prestressing are previously discussed. The model is defined by four types of elements that form the concrete slab with added reinforcements, steel girder, shear connectors and external prestressing. The elements are established separately, but the nodes are coupled one by one on the interface between concrete slab and steel beam. The finite element mesh developed followed the same methodology and degree of refinement presented in Figure 6.

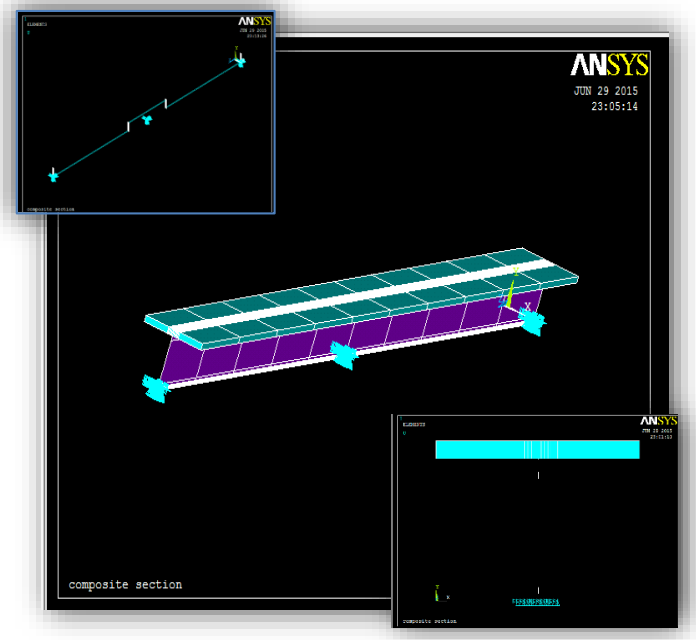

Figure 6 . Finite element model

THE VALIDATION OF THE MODEL

The validation of the model FEA was examined by comparison with experimental results for simple composite beams with external prestressing in the steel section by Ayyub [8]. Also, the results of the theoretical model described by Ayyub [8] are shown in the same graphs for the purpose of comparison.

Two beams (B1 and B2), shown in Figure 7, were tested to failure under positive bending moment, in which the beams were loaded in increments to near the ultimate load. Beams B1 and B2 were tested to study the differences in the structural behaviour when high-strength bars or strands are used as prestressing tendons.

Beam B2 is the counterpart of beam B1 with the same design details except the tendon type. The beam was prestressed with two 15 mm diameter, low-relaxation seven-wire strands, running the full beam length 30 mm above the bottom (tension) flange.

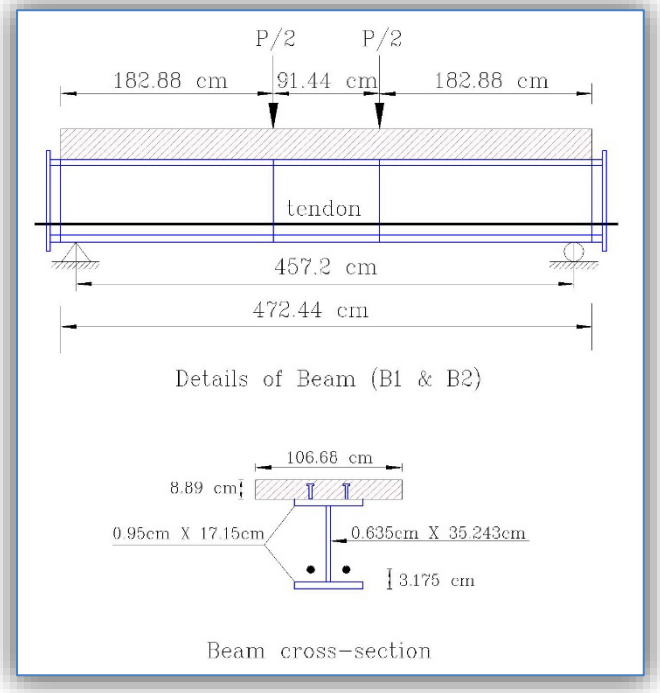

Figure 7. Composite beam (B1 and B2)

The parameters and material properties of the simple prestressed composite beam are shown in Tables 1 and 2.

Table 1. Positive moment specimens for external prestressing tendons for beam (B1 and B2)

Beam	Steel section type	Prestressing type	Tendon area (mm^2)	Tendon force (KN)
B1	W 360*45	Bar	361	267.03
B2	W 360*45	Strand	279	289.00

Table 2. Mechanical properties of materials for beam (B1 and B2)

Element	Mode	Mean value of Yield strength (Mpa)	Mean value of Ultimate strength (Mpa)
Steel beam	Tension	420	576
Prestressing bars 15 mm	Tension	933	1112
Strand	Tension	1651	2056
Concrete	Compression	N.A.	41

N.A. is either not available or not applicable

Ayyub [8] assumed in the theoretical model that there is no slipping or uplift between concrete slab and steel beam (full composite section).

Figures 8-15 shows Load deflection, Load-strain for extreme concrete slab, and steel beam, Load-strain for prestressing bars for B1, and Load-increase in strand force for beam, B2

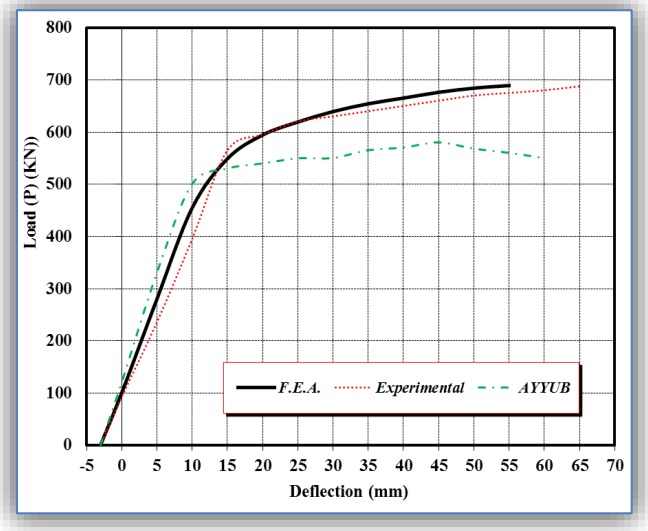

Figure 8. Load deflection results for beam, B1

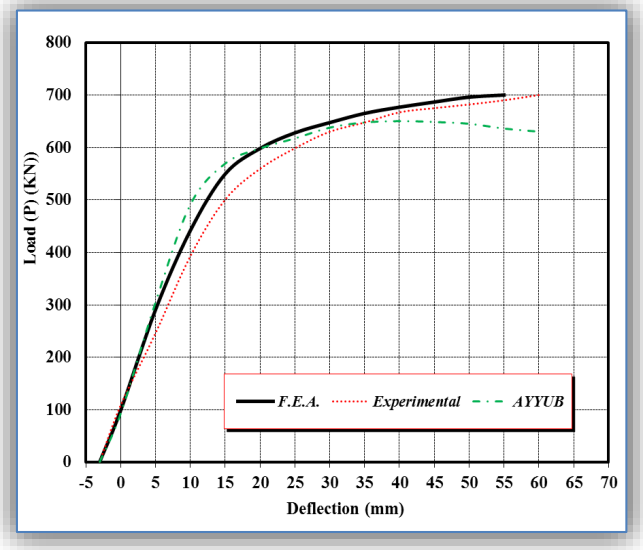

Figure 9. Load deflection results for beam, B2

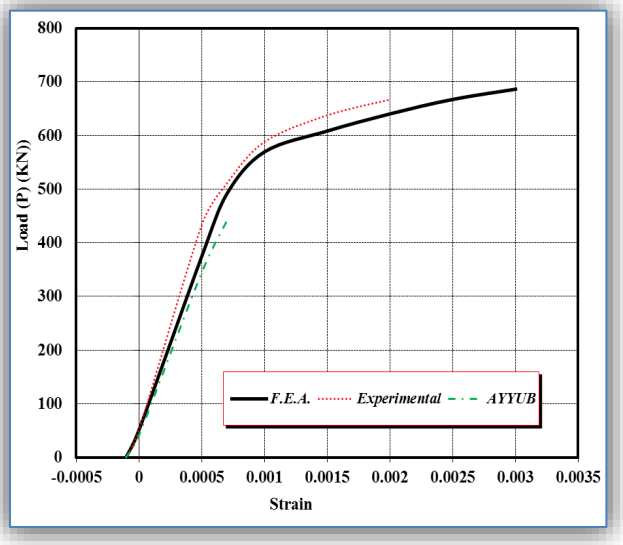

Figure 10. Load-strain curve at top of the concrete slab surface for beam, B1

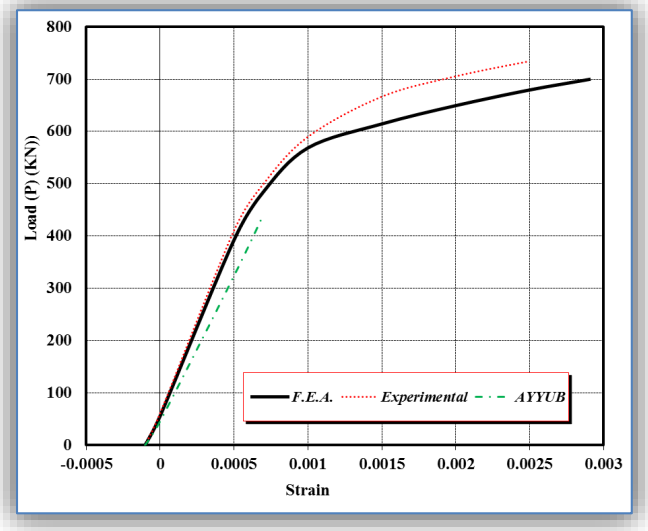

Figure 11. Load-strain curve at top of the concrete slab surface for beam, B2

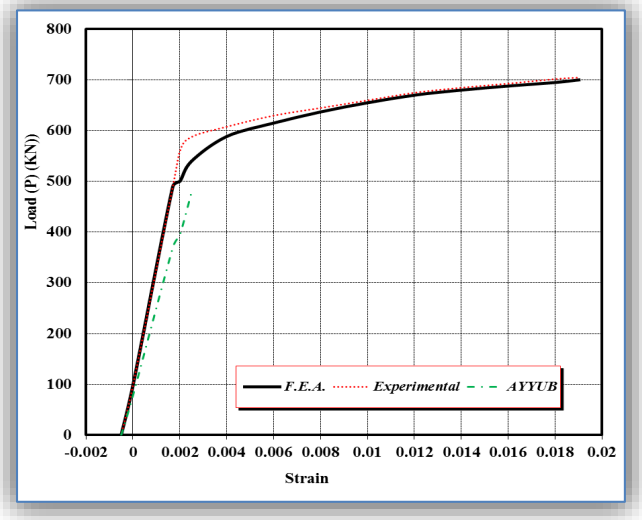

Figure 12. Load-strain curve at bottom fiber of steel beam, B1

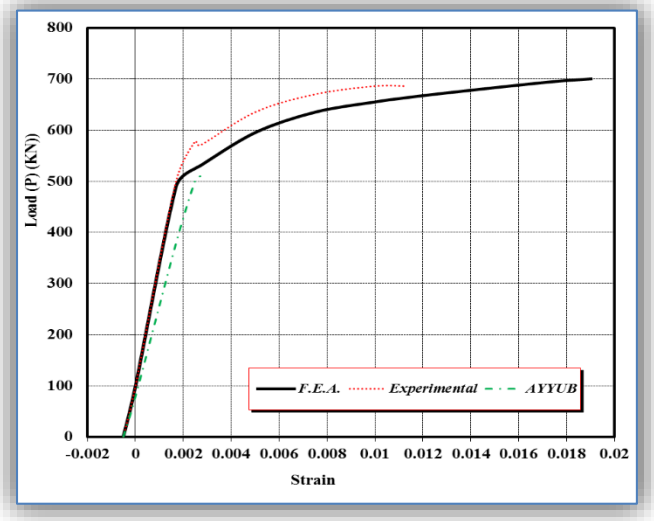

Figure 13. Load-strain curve at bottom fiber of steel beam, B2

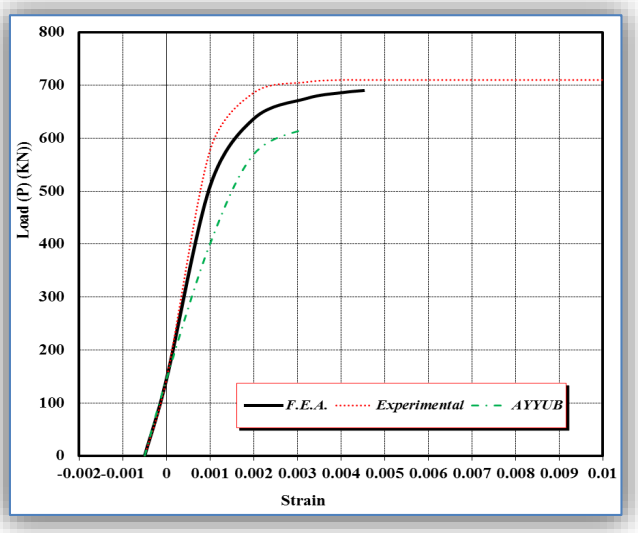

Figure 14. Load-strain curve for prestressing bars for beam, B1

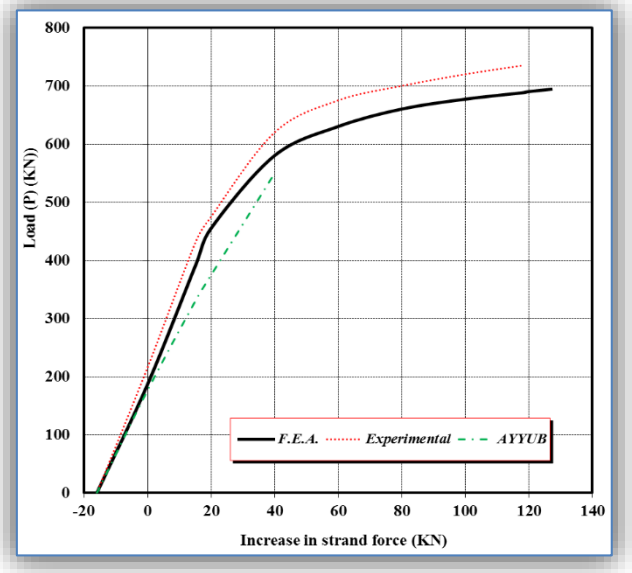

Figure 15. Load-increase in strand force for beam, B2

Discussion of results for beam B1

1- The load-deflection curves for beam B1 are shown in Figure 8. The behaviour of load-deflection curve was initially linear and elastic and become progressively nonlinear when the tension (bottom) flange and prestressing bars began to yield at a load about 588.6 KN (the curve showed a plateau because of reduced beam stiffness duo to the yielding of the steel beam and prestressing bars).the maximum calculated deflection from FEA is about 56 mm at the ultimate load, 692.8 KN, compared to 65 mm measured ultimate deflection.

2- The tested and predicted load versus strain in the top fiber of the concrete slab at mid-span section are shown in Figure 10. The initial behaviour was linear and elastic. After the tension flange yielded, the beam stiffness reduced with nonlinear behaviour until concrete crushed locally at strain of 0.003. The premature crushing of concrete occurred due to high localized stresses near the loading points. The predicted concrete strain for the top concrete surface, agree reasonably with the test results within the elastic range. In the plastic range, the small deviation between the measured and predicted strains may be attributed the differences between the idealized material models and the actual material behavior and/or material strengths.

3- Similarly, the tested load versus strain in the extreme fiber of the bottom (tension) flange of the steel beam were plotted and compared with the analytical results. These curves are shown in Figure 12.

4- The tested load versus strain in the prestressing bars is shown in Figure 14. The strain in the bars increased linearly with an increase in the applied load in the elastic rang. After the bars yielded at a load about 588.6 KN, the slope of the curve slightly reduced, and yielding progressed until the ultimate load was reached.

Discussion of results for beam B2

5- The load-deflection curves for beam B2 are shown in Figure 9. The behaviour of beam B2 was very similar to that of beam B1. It was initially linear and elastic and after the tension flange yielded at a load of 588.6 KN, the stiffness reduced and the behaviour of the beam become nonlinear until failure was reached by concrete crushing. The measured ultimate load for this beam is 693.96 KN slightly larger than the calculated beam B1. The difference can be attributed to the strain hardening of the steel section. The calculated mid-span deflection was 54 mm which is slightly smaller than that of measured value 56 mm.

6- Figure 11 shows the load versus strain in the top fibers (compression) of the concrete slab. The load-versus-strain in the bottom fibers flanges of steel beam are shown in Figure13. Figure 15 shows the load versus increase in the strand force.

7- The force in the cable increased linearly with applied load until the tension flange yielded. Thereafter, the behavior become nonlinear until failure is reached.

Comparison of FEA and experimental results for beams B1 and B2

The prestressing of conventional composite beam can significantly increase the load at which first yielding occurs and the ultimate capacity of the beams. The use of strands as prestressing tendons is preferable to bars duo to their higher strength-to-weight-ratio.

For the two beams B1 and B2, it is shown from the graphs that the present model gives more reliable results than those of Ayyub's [8] theoretical model. Moreover, the present model gives results up to failure.

CONTINUOUS PRESTRESSED COMPOSITE BEAM B3

The study is concerned with non-prestressed and prestressed continuous composite beam with two equal spans (L=20 m), subjected to uniformly distributed load (42.92 KN) Figure 16.

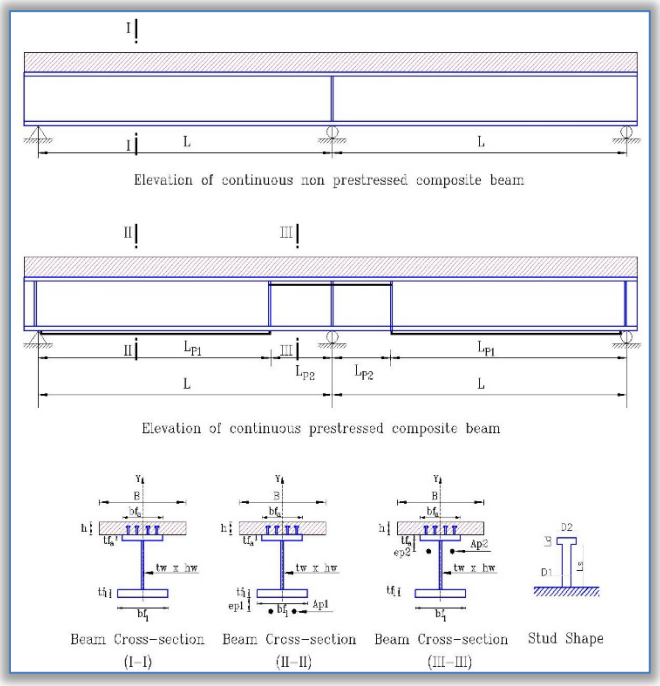

Figure 16. Continuous (two span) Composite beam without and with prestressing subjected to uniform load

The mechanical properties, and section for concrete slab, and steel beam are summarized in tables 3 to 4. Also the distances from bottom and top steel flange and force in cable is show in table 5.

Table (3) Material properties, and dimension of concrete slab cross-section

Material properties		Dimension			
E_c (GPa)	f_c' (MPa)	B_c (cm)	h_c (cm)	Top Mesh Reinf.	Bottom Mesh Reinf.
34.30	30.00	230.0	20.0	(6 Φ 12/m)	(6 Φ 16/m)

Table (4) Material properties, and dimension of steel beam cross-section

Material properties		Dimension					
E_s (GPa)	f_y (MPa)	t_1 (mm)	b_1 (mm)	t_2 (mm)	b_2 (mm)	t_w (mm)	h_w (mm)
214.00	370.00	20.0	300.0	30.0	450.0	15.0	1550.0

Table (5) Distances from bottom and top steel flange and force in cable

Prestressing			
ep_1(mm)	Fp_1(KN)	ep_2(mm)	Fp_2(KN)
86.45	919.1	157.0	1218.7

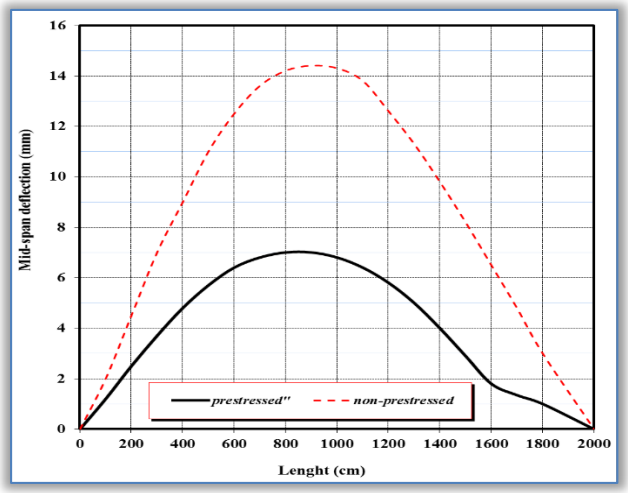

Figure 17. Variation of Mid-span deflection with span length

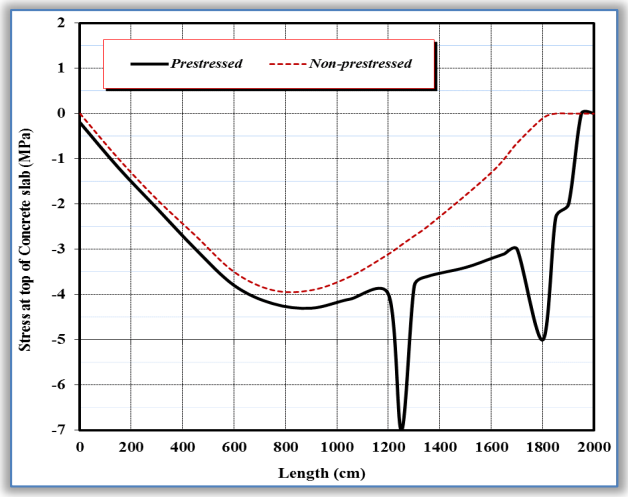

Figure 18. Variation of Stress at top of concrete slab with span length

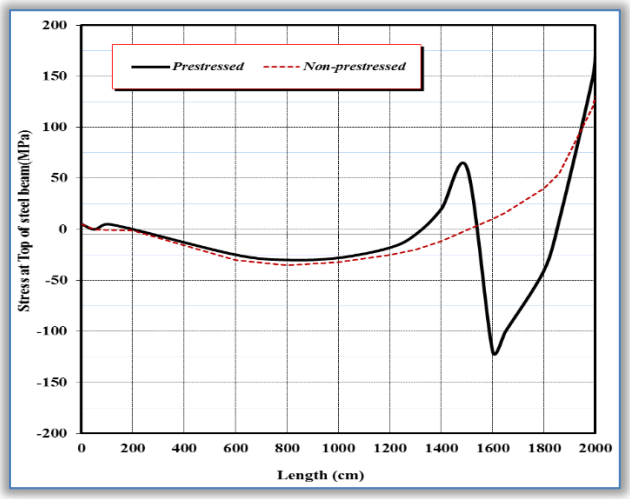

Figure 19. Variation of Stress at top of steel beam with span length

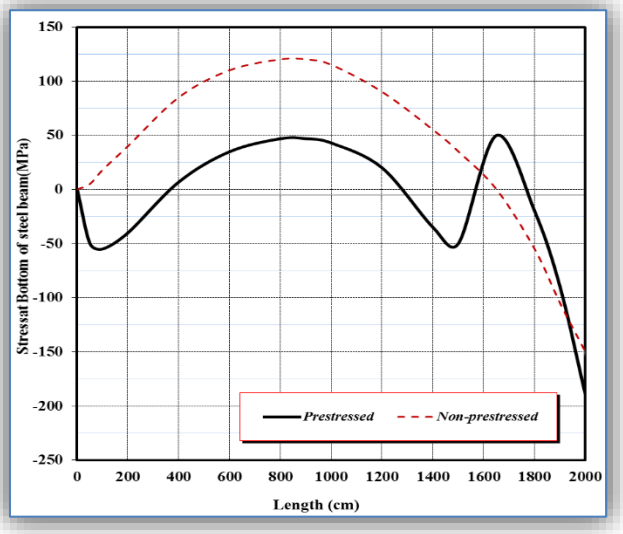

Figure 20. Variation of Stress at bottom of steel beam with span length

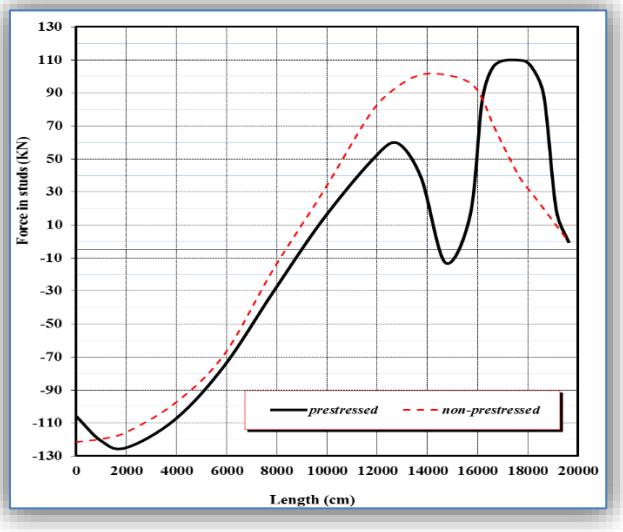

Figure 21. Variation of Force at in studs with span length

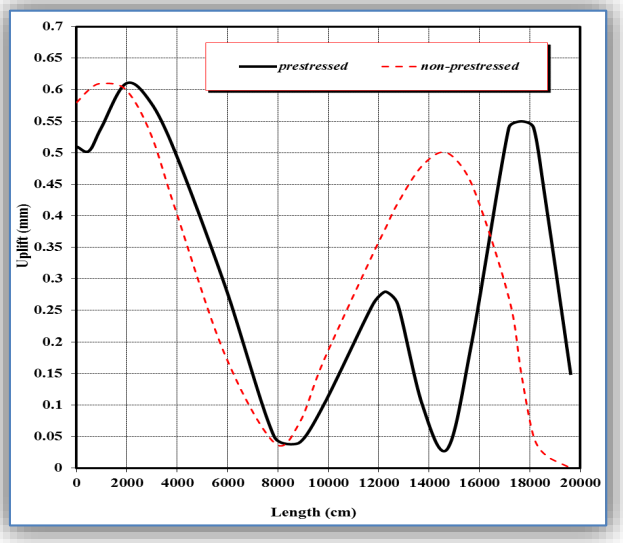

Figure 22. Variation of Uplift between concrete slab and steel beam with span length

Figures 17 to 22 shows typical profiles for two-span continuous beam B3. The profiles are shown for one span only.

Discussion of results for beam B3

1. The load-deflection curves for beam B3 is shown in Figure 17. The prestressing reduced the maximum deflection by about 48%.
2. The compression stress in the top fiber of the concrete slab is shown in Figure 18. The prestressing increase it nearly the intermediate support by about 375%.
3. The stress in the top and bottom fibers of the steel beam are shows in Figure 19 and 20. The prestressing change the tension stress to a compression stresses, and the compression stress to a tension stresses at ends of prestressing cables which nearly at intermediate support (distance Lp2). But the prestressing reduced the bottom stresses by about 75% at the distance Lp1.
4. The Force in studs is shown in Figure 21. It redistribution at the distance Lp2 only since decrease near intermediate support and increase at intermediate support.
5. The uplift between concrete slab and steel beam is shown in Figure 22. It redistribution at the distance Lp2 only since decrease near intermediate support and increase at intermediate support.

CONCLISIONS

1. The computer program (ANSYS 15) used in this paper is able to simulate the behaviour and ultimate load of external prestressed composite steel-concrete beams.
2. The analytical tests carried out for the different cases (high-strength bars or strands are used as prestressing tendons) indicated that the load-deflection, the strain in the top fiber of the concrete slab, the strain in the bottom (tension) flange of the steel beam, the strain in the prestressing bars, and strand force are in good agreement with the experimental results.
3. The prestressing reduced the maximum deflection for continuous beam by about 48%.
4. The prestressing increase the stress in the top fiber of the concrete slab nearly the intermediate support by about 375%.
5. The prestressing change the stress from tension to a compression and the opposite nearly at intermediate support. But the prestressing reduced the bottom stresses by about 75% at the distance Lp1.
6. The prestressing redistribution the force in studs, and the uplift between concrete slab and steel beam near intermediate support, and at intermediate support.

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[1.]Imre KISS

THE CHEMICAL COMPOSITION OF PHOSPHOROUS CAST IRONS BEHAVIOR IN THE MANUFACTURING OF BRAKE SHOES MEANT FOR THE ROLLING STOCK

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Abstract: Friction products are safety–critical items, which must be carefully designed and selected to ensure several performance criteria. The design or formulation selected is a compromise between several conflicting priorities and the trade–offs can be tailored according to the wide range of different customer requirements that exist in the market. Brake blocks, also called "shoes", are made of cast iron, respecting the principle of having a different hardness (and resulting wear) from the other elements of the friction pair, i.e. the wheel (made of steel). Cast iron blocks have specific features, like a rather high weight, limited cost, easy supply and a peculiar friction coefficient dependency on the sliding (vehicle) speed. For making brake shoes are used frequently gray cast iron with lamellar graphite and nodular cast iron, which have a good thermal conductivity (necessary for the proper discharge of heat due to friction), good mechanical properties, good wear resistance. Our research approaches the issue of quality assurance of the brake shoes, from the viewpoint of the quality of materials, which feature can cause duration and safety in exploitation. In this work the investigated subjects are the gray cast iron brake shoes, with lamellar graphite and with a high content of phosphorus (0.8-1.1%), according to requirements for the brake shoes related materials. In order to achieve the chemical composition behavior upon the phosphorous gray cast iron shoe's hardness 100 charges were analyzed.
Keywords: phosphorous gray cast iron, brake blocks (shoes), hardness, Matlab area

INTRODUCTORY NOTES

To encourage train transport, the tendencies of trains do not focus just on delivering the right comfort for passengers, but also on increasing traffic speed, together with the high level of safety, less costs and increased availability. These are the main challenges as regards braking systems. The technological development has permitted these elements, although they are the most exposed equipments of a rail vehicle, to optimize the transport safety level and to act rapidly and efficiently in case of emergencies. The braking system is one of the most important and complex subsystems of railway vehicles, especially when it comes for safety. [3,4,13]

Of all the known braking systems, mechanical braking system, based on tribological principles, is the oldest and the only one able to stop a vehicle or a train of railway vehicles within an area of deceleration and braking space required.[5]

A major problem is the friction between wheel and brake shoes, which leads to severe thermal regimes and special thermal fatigue nature efforts, requiring specific constructive and operating standards. It is still to notice that, regarding the classical systems used for railway vehicles, there are also several major challenges that may affect the braking capacity. These aspects must be very well known and understood. [3,4] Braking capacity of the brake shoe depends on the quality, material properties and friction torque components and in particular by friction lining material.

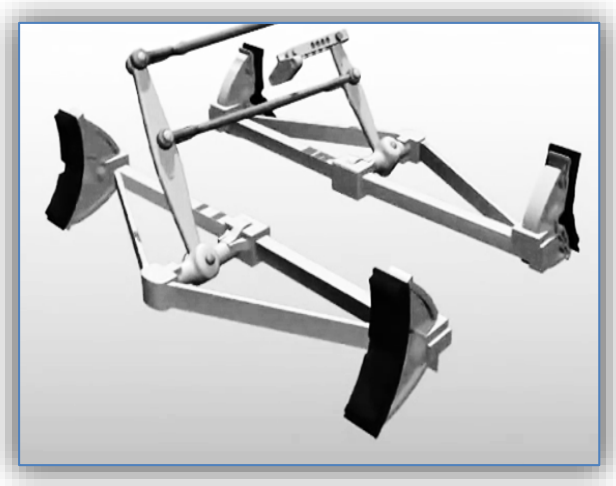

Figure 1. The brake beam mechanism

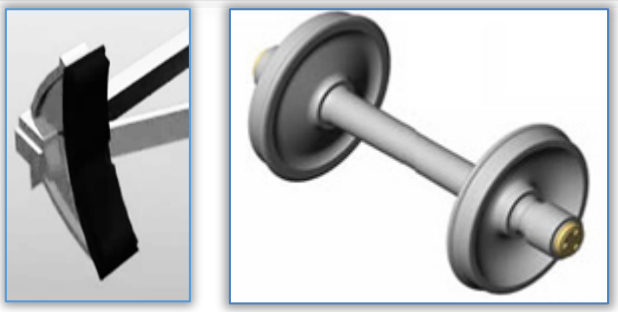

Figure 2. The friction pair (brake shoe – wheel)

Brake shoes work in special service conditions: the materials for them should possess great strength to avoid cracking and low hardness to protect the vehicle wheel from too much wear. [1,3,13] These properties are easily satisfied by the adjustment of the material's microstructure. On the other hand, the tribological properties are even more important, in that the brake shoes must possess not only better wear resistance, but also a high friction coefficient to stop the train in the shortest distance whenever emergency occurs.

To achieve ideal brake friction material's characteristics, such as constant coefficient of friction under various operating conditions, resistance to heat, water and oil fade, low wear rate, possess durability, heat stability, exhibits low noise, and not to damage brake shoes, some requirements have to be compromised in order to achieve some other requirements. [2,4] Consequently, the braking system producers must guarantee:

- stable and reliable coefficients of friction;
- control of the brake fading effect (coefficient of friction reduction);
- braking efficiency and uniform dissipation of heat developed when applying the brakes;
- great match performance–use;
- reduction of noise, in all the operating conditions, thanks to the perfect balance of the chemical/physical properties of the compound components.

However, it is practically impossible to have all these desired properties.[3,4,10,13] Railroad brake shoes are supposed to be light, corrosion-resistant, in line with performance characteristics, as well as having to have a stable friction coefficient, a low wear rate, a low noise, a long use life, and a reasonable cost. Designers have extensive freedom in dimensioning brakes for new vehicles and it is not always necessary to reproduce the friction coefficient of the cast iron brake shoe. The only essential requirement is that equivalent speeds produce equivalent stopping distances. [1,7,8,13] Therefore, some requirements have to be compromised in order to achieve some other requirements. In general, each formulation of friction material has its own unique frictional behaviors and wear–resistance characteristics.

Current trends in the development of railway vehicles (high speed, low weight, high capacity etc.) leads to decrease even at suppressing the use of the wheel (running surface) for the braking function. [5,9] The main directions of future research and investigations in rail vehicle braking are:

- advanced research on the classical brake friction material's characteristics and behaviour;
- finding materials whose coefficient of friction is independent of speed and weather conditions (rain, ice etc.);
- replacement of a standard and well known material (cast iron) with a completely different one (composite blocks) for reducing and possible elimination of the rolling noise emissions of wagons;
- find and research new materials for friction materials in terms of their density, to reduce unsuspended vehicle weight;
- devoted attention to solving problems connected with using modern brake materials and its impact on thermal and mechanical loading of railway wheels.

Brake shoes are made in a variety of materials (cast iron brake shoe, as solid one-piece casting, composite brake shoe, as high friction and low friction brake shoe, and powder metallurgy brake shoe, as sintered), all of which have their own drawbacks (hard on the wheels, friction coefficient, cost). From the standpoint of predictable performance and reliability, the superior friction material applied to a railroad car wheel is the cast iron, particularly where the service requirements are severe. In the modern railway transport, the classical cast iron brake shoes, still widely used on freight wagons, are gradually replaced by the organic composite or sintered composite brake shoes.

Traditionally, freight wagons were fitted with brake systems using cast iron blocks. Passenger wagons still resist and are nowadays equipped with the original solution of cast iron brake blocks.

PHOSPHOROUS CAST IRONS FOR BRAKE SHOES MANUFACTURING

Iron is a friction material used to manufacture brake shoes, because it is easily prepared and put into shape, very inexpensive and has no harmful influence on the wheel-running surface. On manufacturing brake shoes meant for the rolling stock, phosphorous cast irons are largely used.[2,5-8,13,14] Their friction coefficient diminishing dramatically on braking at the relative high speeds (up to 120–140 km/h), while their wear is growing when the temperature in the braking coupling goes up. Therefore, their use as simply cast irons is limited

for railway vehicles running at speeds of up to 120 km/h.

Various kinds of casting iron brake shoes are mainly grouped according to the composition of phosphorus as followings:

- grey cast iron brake shoe
- medium phosphorus cast iron brake shoe
- high phosphorus cast iron brake shoe
- alloy cast iron brake shoe

The difference lies in the content of the phosphorus. The phosphorus content in normal type is 0.7~1.0%, while in high phosphorous cast iron brake shoes, the phosphorus content is above 10%. In the rolling stock, a brake shoe of phosphoric cast iron had a wear resistance and a higher friction coefficient, therefore, phosphorus was a very important element for the performance improvement of brake shoe.

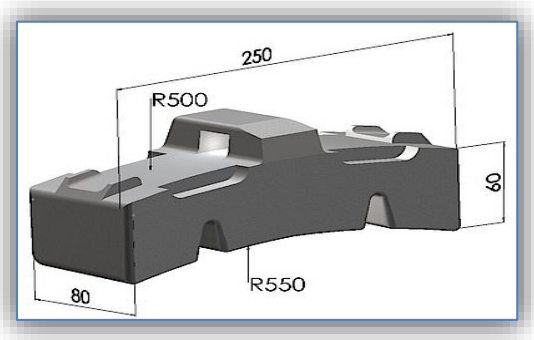

Figure 3. Gray cast iron brake shoes for passenger trains

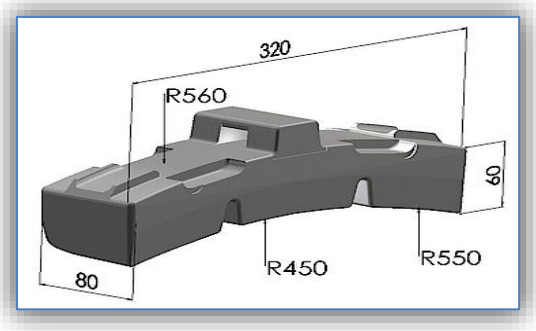

Figure 4. Gray cast iron brake shoes for freight wagons

For making brake shoes are used frequently gray cast iron with lamellar graphite and nodular cast iron, which have a good thermal conductivity (necessary for the proper discharge of heat due to friction), good mechanical properties, good wear resistance. Cast iron brake block enjoys many advantages including hardness, impact strength and so on. It consists of two parts, the cast iron and the steel support. Both the surface and core of the cast iron have the hardness within the range of 197<HB<225. [9,13,14]

The main elements of its chemical composition in Table 1 and Table 2 are presented and mechanical properties fall within the intervals corresponding to the desired purpose.

Table 1. Chemical compositions of cast iron

Main components	Proportion, [%]
Carbon, [C]	3.0–3.5
Phosphorus, [P]	1.3–1.5
Silicon, [Si]	1.5–2.0
Sulphur, [S]	0.1–0.15
Manganese, [Mn]	0.5–0.8

Table 2. Chemical compositions of steel support

Components	Proportion, [%]
Carbon, [C]	< 0.13
Sulphur, [S]	< 0.062
Phosphorus, [P]	< 0.062

Typically, the alloy has a composition corresponding to conventional grey cast iron, except for the high phosphorus content. Preferably, the phosphorus is added to cast iron in the form of ferro-phosphorus, which may be incorporated into cast iron in the proportions necessary to provide an alloy with the desired phosphorus content.

A common characteristic constituent of gray iron microstructures is the phosphorus ternary eutectic known as steadite (Fe_3C+Fe_3P+ P). The characteristic property of this system is a large area of the ternary phosphorous eutectic due to the strong tendency for phosphorus to segregate. The form of the phosphorus eutectic depends on the chemical composition of the gray iron. In irons with an average tendency to graphitization and a phosphorus content of approximately 0.4%. The microstructure of each cast iron destined to the brake shoes was composed of steadite, cementite and flaky graphite distributed in pearlitic matrix. The high content of phosphorous improves the friction – wear behavior of such cast iron. [13,14]

The structural changes occurring under the action of the phosphorus content, able to influence the properties of the cast irons are on the increase of the quantity of graphite and finishing it, the increase in the quantity of phosphorous eutectic and its distribution in the network form and obtaining the more quantity of perlite. Increasing the resistance is favored as long as the phosphorous eutectic is disposed in the form of isolated separation. Also, due to the increase of the perlite's proportion and especially of the phosphorous eutectic, as high hardness constituent (500–600 HB), by the addition of phosphorus the general hardness is increased.

It has been demonstrated that, in the railway breaking system, the shoe's iron graphite, respectively the wheels steel's chromium, are the most helpful structural elements in the materials intended to friction. As regards the graphite form are talking yet whether it is preferable (globular or lamellar), but it is known that the carbon content must represent approximately 3.2% in the final chemical composition of these irons.

SEVERAL STATISTICAL EXPERIMENTS

One of the main chapters of the statistics referring to the ability to predict. Although it is not find the perfect relations, by means of regression, can make statements of a variable, depending on the other values. The present researches are going to establish the influence of the chemical elements in the structure upon the mechanical properties (hardness) of the braking shoe material (gray phosphorous cast iron with lamellar graphite). The technological manufacturing process of the brake shoes, as well as the quality of material used in manufacturing them, can have a different influence upon the quality and the safety in the exploitation.

A major feature with huge impact on sustainability in the brake shoe is the hardness. At the brake shoes, hardness shall be determined in five points, two located at the ends of the shaker (on the same front side section) and three in section of the shaker (diagonal cross–section). [13,14]

Our research approaches the issue of quality assurance of the brake shoes, from the viewpoint of the quality of materials, which feature can cause duration and safety in exploitation. In order to achieve the chemical composition behavior upon the shoe's hardness 100 charges were analyzed. A few interpretations of the correlations between the cast irons chemical components – Carbon (C), Silicon (Si), Manganese (Mn), Phosphorus (P) and Sulfur (S) – and the obtained brake shoes hardness (HB) was enounced. We propose three (4) kinds of correlations, using the Matlab area.

In the first experiment, the general behavior of Carbon (C) content in relation with the Silicon (Si) and Manganese (Mn) contents, which have influence on the hardness of brake shoes, in several Matlab graphic area representations are analyzed. As result, several regression surfaces and correlation diagrams are revealed, presented above, in the Figures 5–10.

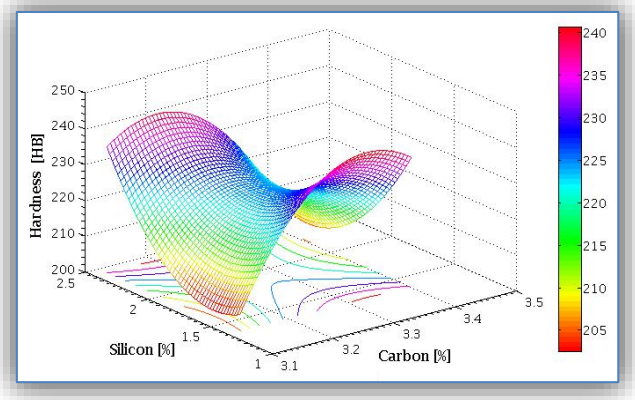

Figure 5. The regression surface, case of HB=f(C,Si)

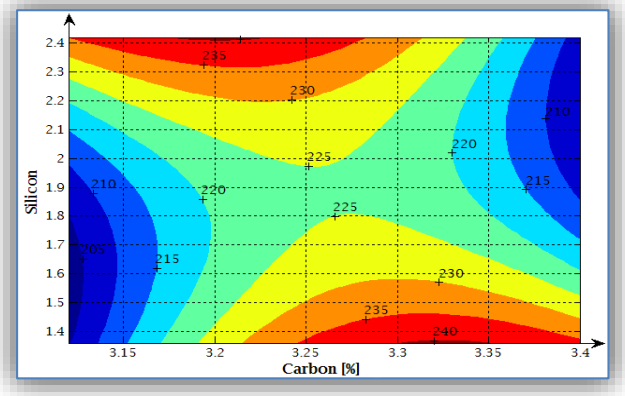

Figure 6. Correlation diagram, case of HB=f(C,Si)

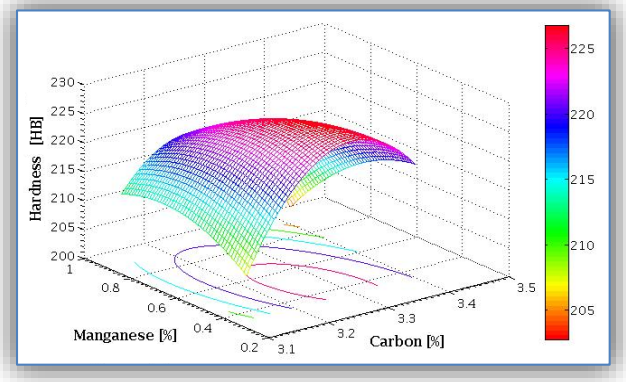

Figure 7. The regression surface, case of HB=f(C,Mn)

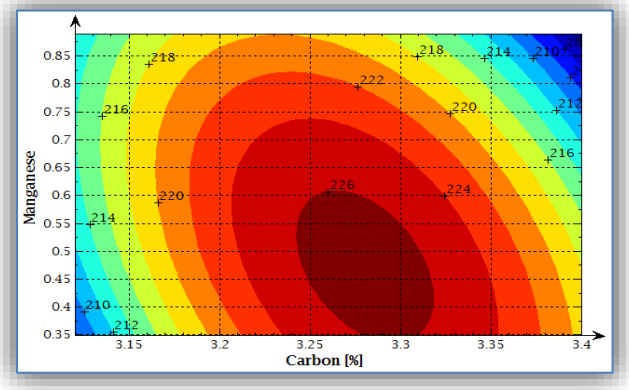

Figure 8. Correlation diagram, case of HB=f(C,Mn)

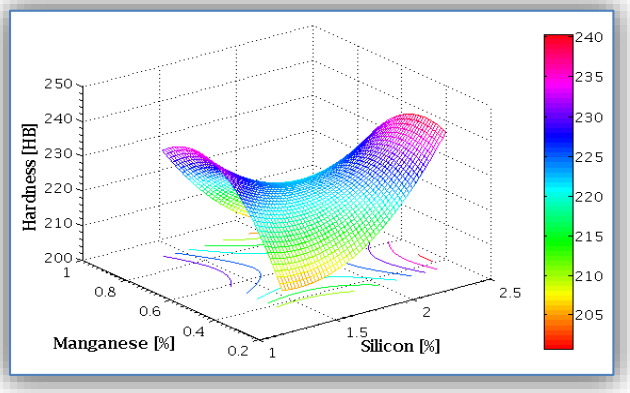

Figure 9. The regression surface, case of HB=f(Mn,Si)

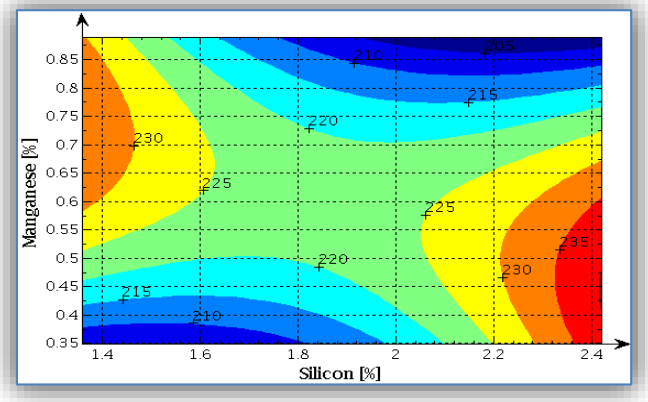

Figure 10. Correlation diagram, case of HB=f(Mn,Si)

As second statistical experiment, followed by the Matlab graphic area representations, the combined behavior of Carbon (C) content in relation with the Sulphur (S) and Phosphorus (P) contents of gray phosphorus cast irons on the hardness of brake shoes, in several correlations are analyzed. As result, several regression surfaces and correlation diagrams are revealed, presented above, in the Figures 11–16.

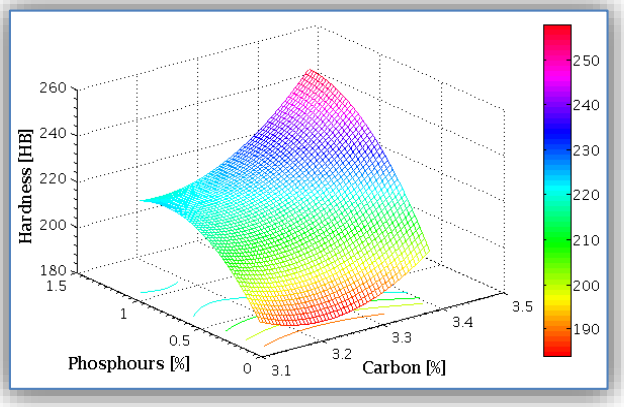

Figure 11. The regression surface, case of HB=f(C,P)

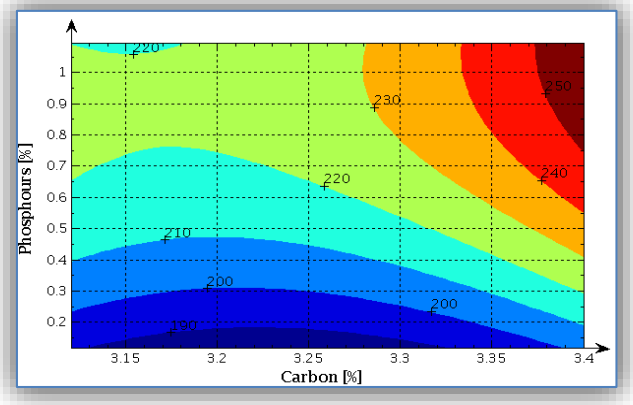

Figure 12. Correlation diagram, case of HB=f(C,P)

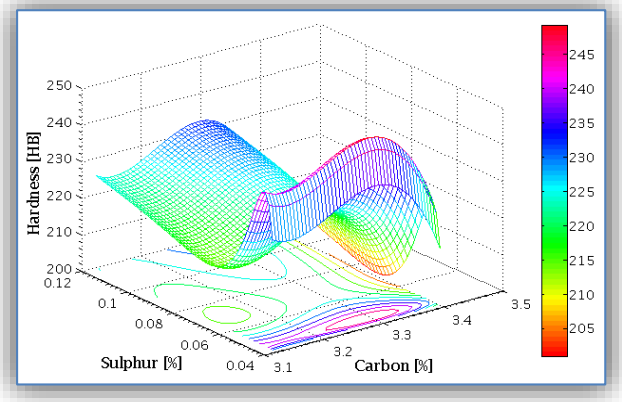

Figure 13. The regression surface, case of HB=f(C,S)

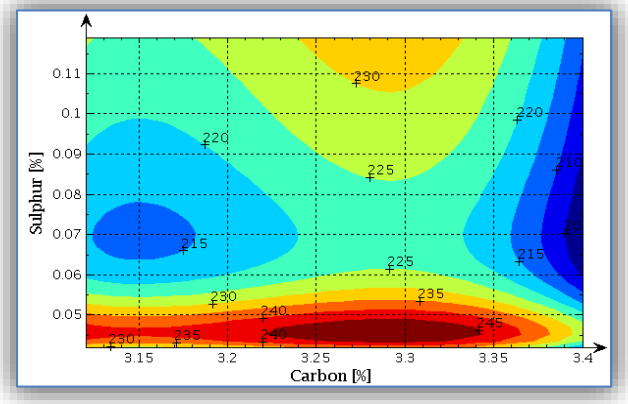

Figure 14. Correlation diagram, case of HB=f(C,S)

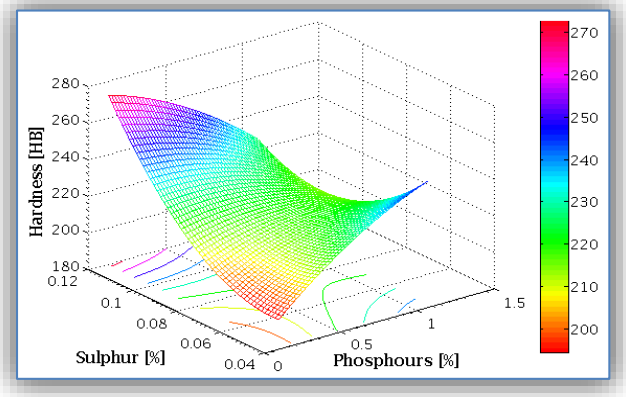

Figure 15. The regression surface, case of HB=f(P,S)

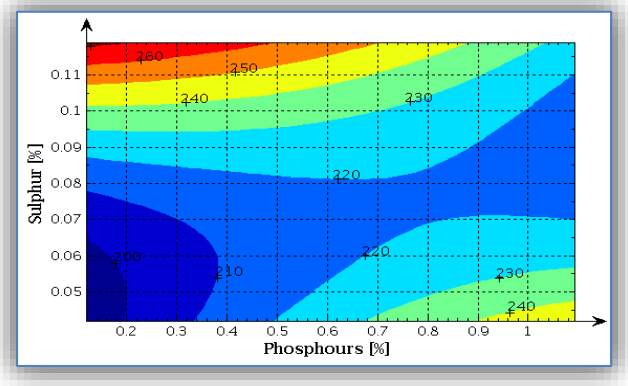

Figure 16. Correlation diagram, case of HB=f(P,S)

As third statistical experiment, followed by the Matlab graphic area representations, we analyzed the combined behavior of Carbon (C) content in relation with the Sulphur (S) and Phosphorus (P) contents of gray phosphorus cast irons on the hardness of brake shoes, in several correlations. As result, regression surfaces and correlation diagrams are revealed, presented in the Figures 15–24, correlated with Figures 9-10.

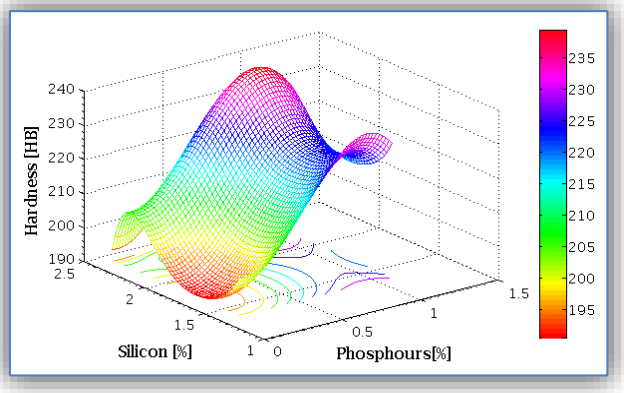

Figure 17. The regression surface, case of HB=f(Si,P)

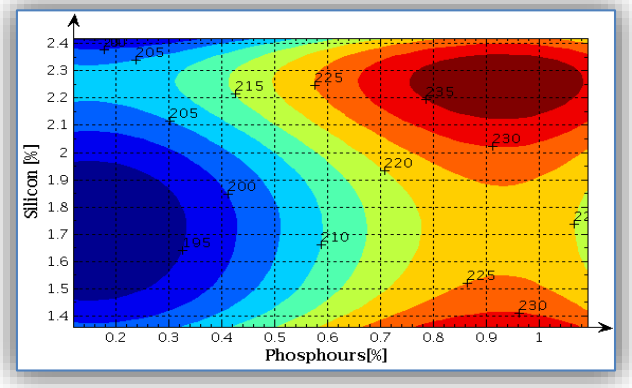

Figure 18. Correlation diagram, case of HB=f(Si,P)

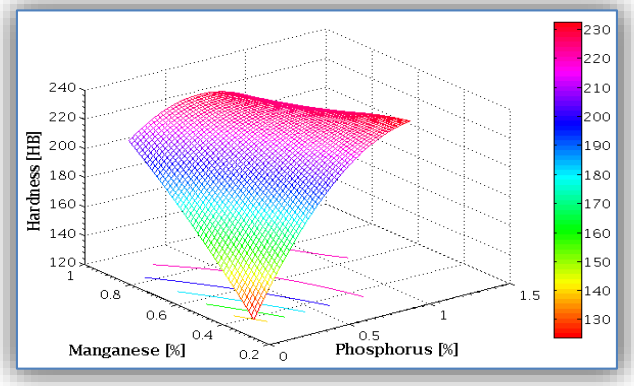

Figure 19. The regression surface, case of HB=f(Mn,P)

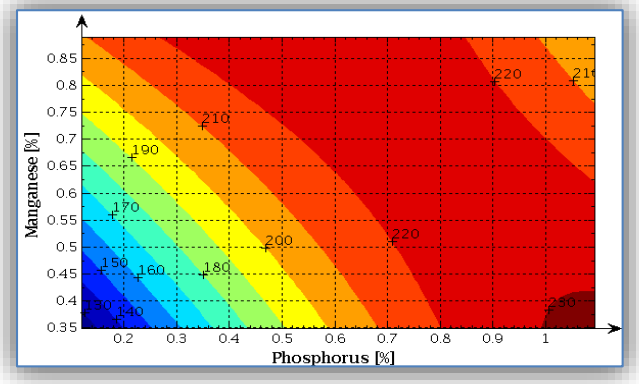

Figure 20. Correlation diagram, case of HB=f(Mn,P)

As final experiment, the equivalent carbon content value behavior on the hardness of cast iron brake shoes is analyzed. As result, several regression surfaces and correlation diagrams are revealed, presented in the Figures 21–22.

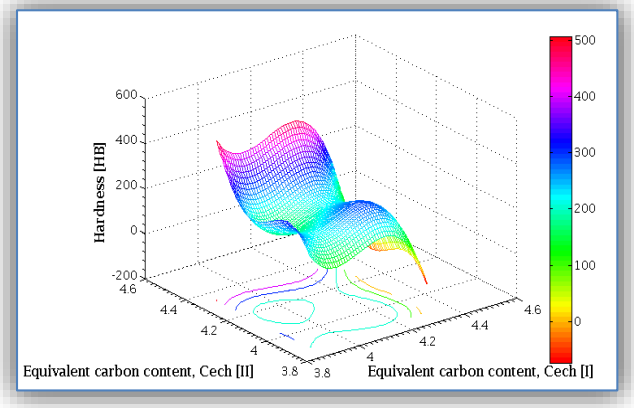

Figure 21. The regression surface, case of HB=f($C_{ech(I)}$,$C_{ech(II)}$)

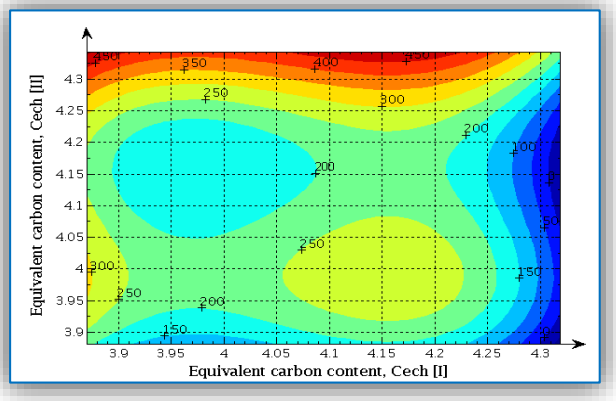

Figure 22. Correlation diagram, case of HB=f($C_{ech(I)}$,$C_{ech(II)}$)

For gray iron destined to brake shoes casting the equivalent carbon content (CE) concept is used to understand how alloying elements affect the casting behavior. It is used as a predictor of strength in cast irons because it gives an approximate balance of austenite and graphite in final structure. The carbon equivalent is invaluable in technological analysis

and it is used in empirical formulas. To determine the equivalent carbon content in the cast irons the following formulas are used:

$$C_{ech\ (I)} = [C] + 0.33\ [Si] + 0.33\ [P] - 0.027\ [Mn] + 0.4\ [S] \quad (1)$$

$$C_{ech\ (II)} = [C] + 0.33\ ([Si] + [P]) \quad (2)$$

Thus, the total carbon equivalent of the cast iron consists of the carbon content and the carbon equivalents for each additional element. The carbon equivalents are usually determined experimentally.

DISCUSSIONS

The performed study had in view to obtain correlations between the hardness of the cast iron brake shoes and its chemical composition, defined by basic and the representative alloying element (phosphorous). The data revealed small variations of the hardness, which is due to variations in the narrow limits of the chemical composition. The values of the hardness are within the range 197–240 HB being in accordance with the international standards.

The chemical and structural homogeneity of the shoes material lead to small variations of the values for the hardness (on both side surfaces and in the cross–section) what will find, finally, in the brake shoe's durability. There is a difference of hardness between the cross–section and the center section's measurement, which was explainable by the conditions of the solidification process, due to the cooling rate.

The values processed were made using Matlab calculation program. Technological engineers and brake shoe's manufacturers can interpret these regression surfaces, belonging to the three–dimensional space, and the correlation diagrams, belonging to the bi–dimensional space, presented in Figures 5–22. By analyze of the results of the experimental research upon a number of 100 charges of phosphorous cast iron brake shoes may be concluded the following:

- the chemical composition of iron used in the manufacture of the brake shoes ensure their hardness within the limits set by the standards.
- the correlation diagrams clearly results the influence of the content of Carbon (C), Manganese (Mn), Silicon (Si), Sulphur (S) and Phosphorous (P) on the hardness of the brake shoes;
- the level curves, obtained into the correlation diagrams allow us to choose the independent parameters (Carbon, Manganese, Silicon, Sulphur and Phosphorous) in such a way as to obtain a desired value of hardness.

For cast iron brake used in high speed train, we can improve the performance by increase the content of phosphorus as alloy element. Typically the alloy has a composition corresponding to conventional grey cast iron, except for the high phosphorus content.

CONCLUDING REMARKS

In cooperation with railway operators and brake system suppliers, the rail vehicle manufacturers develops on optimized friction surface combinations for cast iron shoes and steel wheels, while taking into consideration customer technical specifications, suitable for passenger trains and freight wagon applications.

Most railway companies have agreed that the procurement and operation of freight wagons with composite shoes is practically not more expensive than the procurement and operation of "traditional" wagons with cast iron shoes. The lifetime of composite shoes is much longer than the lifetime of cast iron brake shoes. However, the results of the first few years of operation show that not all problems have been solved yet. Further improvements and new patterns of maintenance seem to be necessary.

But,

While the composition and characteristics of all cast iron brake shoes are similar, the same is not true for composite brake shoes. Due to different compositions and processing methods adopted by different manufacturers, the composite brake shoes exhibit diverse friction characteristics (L-type which exhibit "low" friction coefficients and K-type which exhibit relatively "high" friction coefficients). In this sense, on manufacturing brake shoes meant for the rolling stock, the "traditional" phosphorous cast iron are largely used, due to the main advantages of cast iron brake shoes:

- a small friction coefficient affected by the environment and more stable, so it is „all-weather" operational;
- good thermal conductivity, low thermal damage to the wheels;
- durable, low prices.

So ordinary cast iron brake shoes are generally used for low-speed operation of passenger trains. For cast iron brake used in high speed train, we can improve the performance by increase the content of phosphorus or add some alloy element.

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ANALYSIS OF BIMETALLIC BEAM WITH WEAK SHEAR CONNECTION

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Abstract: In this paper an analytical solution is presented to determine the deflection, slip and stresses in bimetallic beam with flexible shear connection. The thermal load is derived from uniform temperature change. The Euler-Bernoulli hypothesis is assumed to hold for each layer separately and a linear constitutive equation between the horizontal slip and the inter-laminar shear force is considered. An example illustrates the application of the developed analytical method.
Keywords: bimetallic beam, interlayer slip, shear connection, thermal load

INTRODUCTION

There exist several works on bimetallic elastic beams with perfect bond [1,2,3,4,5]. In this paper the bimetallic beam with weak shear connection under the action of uniform temperature change is studied. The present analytical method is based on the Euler-Bernoulli's beam theory and the one-dimensional version of the constitutive equation of linear thermoelasticity (Duhamel-Neumann's law). The considered bimetallic beam configuration is shown in Figure 1.

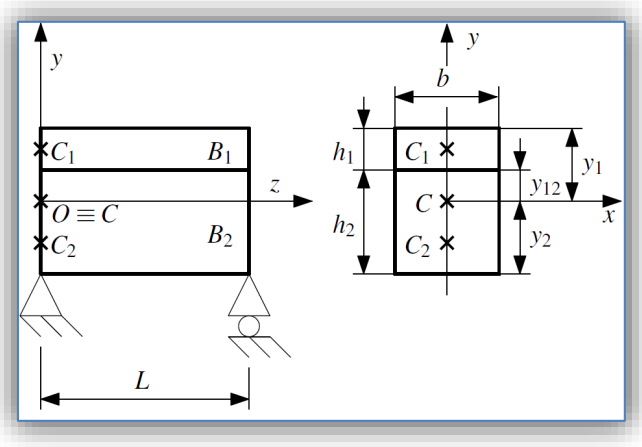

Figure 1. Simply supported bimetallic beam

The beam component B_i has the rectangular cross section A_i whose dimensions are h_i and b $(i=1,2)$. The modulus of elasticity for beam component B_i is E_i and the coefficients of linear thermal expansion is α_i $(i=1,2)$. The length of the simply supported bimetallic beam is L. The origin O of the rectangular Cartesian coordinate system $Oxyz$ is the E-weighted centre of the left end cross section, so that axis z is the E-weighted center-line of the bimetallic beam. A point P in $B=B_1\cup B_2$ is indicated by the position vector $\overrightarrow{OP}=\mathbf{r}=\mathbf{R}+z\mathbf{e}_z=x\mathbf{e}_x+y\mathbf{e}_y+z\mathbf{e}_z$, where $\mathbf{e}_x$, $\mathbf{e}_y$ and $\mathbf{e}_z$ are the unit vectors of the coordinate system $Oxyz$. It is known that the position of E-weighted centre of the cross section $A=A_1\cup A_2$ is obtained from next equation [6]

$$E_1\int_{A_1}\mathbf{R}\mathrm{d}A+E_2\int_{A_2}\mathbf{R}\mathrm{d}A=\mathbf{0}. \tag{1}$$

For cross section shown in Figure 1 we have

$$c_1=\left|\overrightarrow{CC_1}\right|=\frac{A_2E_2}{\langle AE\rangle}c,\qquad c_2=-\left|\overrightarrow{CC_2}\right|=-\frac{A_1E_1}{\langle AE\rangle}c, \tag{2}$$

$$c=\left|\overrightarrow{C_2C_1}\right|=c_1-c_2=\frac{1}{2}\left(h_1+h_2\right), \tag{3}$$

$$\langle AE\rangle=A_1E_1+A_2E_2, \tag{4}$$

$$y_1=c_1+\frac{1}{2}h_1,\quad y_2=c_2-\frac{1}{2}h_2,\quad y_{12}=c_1-\frac{1}{2}h_1. \tag{5}$$

In Eqs. (2), (4) A_i denotes the cross sectional area of beam component B_i $(i=1,2)$ and the position of the common boundary of A_1 and A_2 is indicated by y_{12} (Figure 1).

GOVERNING EQUATION

According to the Euler-Bernoulli hypothesis (kinematic assumption) which is valid for each homogeneous beam components the deformed configuration is described by the displacement field [6]

$$\mathbf{u}=\mathbf{u}(x,y,z)=v(z)\mathbf{e}_y+\left(w_i(z)-y\frac{\mathrm{d}v}{\mathrm{d}z}\right)\mathbf{e}_z, \quad (6)$$

where $(x,y,z)\in B_i$, $(i=1,2)$. Eq. (6) shows that the axial displacement of beam component B_i $(i=1,2)$ is separated into two parts: $w_i(z)$ $(i=1,2)$ describes the rigid translation of the cross section A_i $(i=1,2)$ at z and the second part of the axial displacement of A_i $(i=1,2)$ derived from the deflection of cross section [6]. On the common boundary of B_1 and B_2 the axial displacement has jump which is called the interlayer slip. According to Eq. (6) the interlayer slip $s=s(z)$ can be computed as

$$s(z)=w_1(z)-w_2(z). \quad (7)$$

Application of the strain-displacement relationships of the linearized theory of elasticity gives

$$\varepsilon_x=\varepsilon_y=\gamma_{xy}=\gamma_{xz}=\gamma_{yz}=0, \quad (x,y,z)\in B_1\cup B_2, \quad (8)$$

$$\varepsilon_z=\frac{\mathrm{d}w_i}{\mathrm{d}z}-y\frac{\mathrm{d}^2v}{\mathrm{d}z^2}, \quad (x,y,z)\in B_i, \ (i=1,2). \quad (9)$$

In Eqs. (8), (9) ε_x, ε_y, ε_z are the normal strains and γ_{xy}, γ_{xz}, γ_{yz} are the shearing strains. The normal stress σ_z is computed from the one-dimensional version of Duhamel-Neumann's law [3,4]

$$\sigma_z=E_i\left(\frac{\mathrm{d}w_i}{\mathrm{d}z}-y\frac{\mathrm{d}^2v}{\mathrm{d}z^2}-\alpha_iT\right), \quad (x,y,z)\in B_1\cup B_2. \quad (10)$$

In Eq. (10) T denotes the temperature change. The temperature of the two-layer composite beam initially is the reference temperature. Its temperature is slowly raised to a constant uniform temperature, so that the temperature change is T. Following we define the next section forces and moments [6]

$$N_1=\int_{A_1}\sigma_z\mathrm{d}A=A_1E_1\left(\frac{\mathrm{d}w_1}{\mathrm{d}z}-c_1\frac{\mathrm{d}^2v}{\mathrm{d}z^2}-\alpha_1T\right), \quad (11)$$

$$N_2=\int_{A_2}\sigma_z\mathrm{d}A=A_2E_2\left(\frac{\mathrm{d}w_2}{\mathrm{d}z}-c_2\frac{\mathrm{d}^2v}{\mathrm{d}z^2}-\alpha_2T\right), \quad (12)$$

$$M_1=\int_{A_1}y\sigma_z\mathrm{d}A=A_1E_1c_1\left(\frac{\mathrm{d}w_1}{\mathrm{d}z}-\alpha_1T\right)-E_1I_1\frac{\mathrm{d}^2v}{\mathrm{d}z^2}, \quad (13)$$

$$M_2=\int_{A_2}y\sigma_z\mathrm{d}A=A_2E_2c_2\left(\frac{\mathrm{d}w_2}{\mathrm{d}z}-\alpha_2T\right)-E_2I_2\frac{\mathrm{d}^2v}{\mathrm{d}z^2}, \quad (14)$$

where

$$I_i=\int_{A_i}y^2\mathrm{d}A, \quad (i=1,2). \quad (15)$$

Eqs. (11), (12), (13) and (14) show that the normal stresses acting on cross section A_i $(i=1,2)$ are equivalent to a force-couple system (N_i,M_i) $(i=1,2)$ at C. This force-couple system (N_i,M_i) $(i=1,2)$ is illustrated in Figure 2. The interlayer slip s is assumed to be a linear function of shear force Q transmitted between the two beam components, that is we have [7]

$$Q=ks, \quad (16)$$

where k is a constant, it is called slip modulus. Units of Q and k are

$$[Q]=\frac{\text{force}}{\text{length}}, \quad [k]=\frac{\text{force}}{(\text{length})^2}. \quad (17)$$

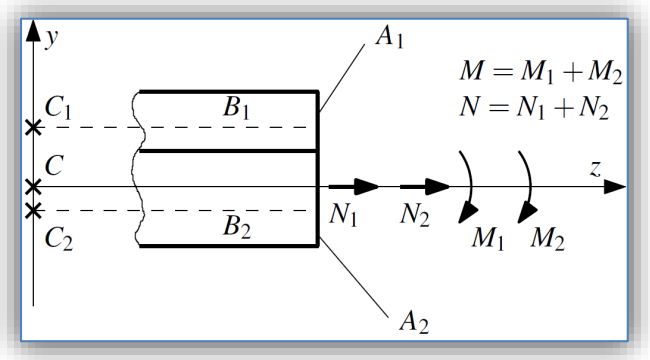

Figure 2. Normal forces and bending moments

In present problem there is no axial force $N=N_1+N_2$, that is

$$N=N_1+N_2=A_1E_1\frac{\mathrm{d}w_1}{\mathrm{d}z}+A_2E_2\frac{\mathrm{d}w_2}{\mathrm{d}z}-\langle AE\alpha\rangle T=0. \quad (18)$$

Here,

$$\langle AE\alpha\rangle=A_1E_1\alpha_1+A_2E_2\alpha_2. \quad (19)$$

From Eqs. (7) and (18) it follows that

$$\frac{\mathrm{d}w_1}{\mathrm{d}z}=\frac{A_2E_2}{\langle AE\rangle}\frac{\mathrm{d}s}{\mathrm{d}z}+\frac{\langle AE\alpha\rangle}{\langle AE\rangle}T, \quad (20)$$

$$\frac{\mathrm{d}w_2}{\mathrm{d}z}=-\frac{A_1E_1}{\langle AE\rangle}\frac{\mathrm{d}s}{\mathrm{d}z}+\frac{\langle AE\alpha\rangle}{\langle AE\rangle}T. \quad (21)$$

A simple computation based on Eqs. (11), (12) and Eqs. (20), (21) gives

$$N_1=\langle AE\rangle_{-1}\left[\frac{\mathrm{d}s}{\mathrm{d}z}-c\frac{\mathrm{d}^2v}{\mathrm{d}z^2}+(\alpha_2-\alpha_1)T\right], \quad (22)$$

$$N_2=\langle AE\rangle_{-1}\left[-\frac{\mathrm{d}s}{\mathrm{d}z}+c\frac{\mathrm{d}^2v}{\mathrm{d}z^2}+(\alpha_1-\alpha_2)T\right], \quad (23)$$

where

$$\langle AE\rangle_{-1}=\frac{1}{\dfrac{1}{A_1E_1}+\dfrac{1}{A_2E_2}}. \tag{24}$$

Application of the condition of equilibrium for forces in axial direction to beam component B_1 gives (Figure 3)

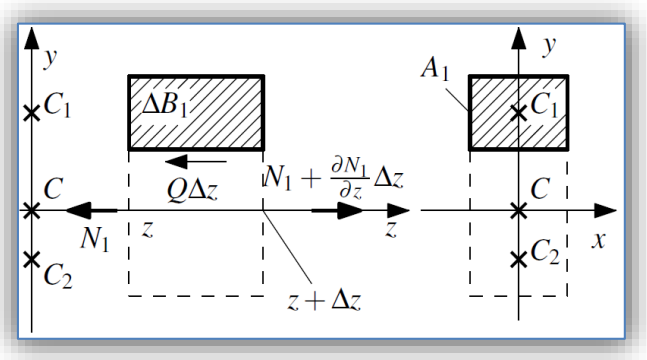

Figure 3. Equilibrium condition in z direction for a small beam element ΔB_1

$$\frac{\mathrm{d}N_1}{\mathrm{d}z}-ks=0. \tag{25}$$

Substitution of Eq. (22) into Eq. (25) yields

$$\frac{\mathrm{d}^2s}{\mathrm{d}z^2}-c\frac{\mathrm{d}^3v}{\mathrm{d}z^3}-\frac{k}{\langle AE\rangle_{-1}}s=0. \tag{26}$$

It is evident the bending moment acting on the whole cross section $A=A_1\cup A_2$ is as follows

$$\begin{aligned}M&=M_1+M_2=\\&=c\langle AE\rangle_{-1}\left[\frac{\mathrm{d}s}{\mathrm{d}z}+(\alpha_2-\alpha_1)T\right]-\{IE\}\frac{\mathrm{d}^2v}{\mathrm{d}z^2}.\end{aligned} \tag{27}$$

Here,

$$\{IE\}=I_1E_1+I_2E_2. \tag{28}$$

There is no applied mechanical load on the whole two-layer composite beam and at both supports there are not any reaction forces, so that

$$M(z)=0,\quad V(z)=\frac{\mathrm{d}M}{\mathrm{d}z}=0 \tag{29}$$

for all cross section. In Eq. $(29)_2$ $V=V(z)$ is the cross-sectional shear force. From Eq. $(29)_2$ we get

$$\frac{\mathrm{d}^3v}{\mathrm{d}z^3}=c\frac{\langle AE\rangle_{-1}}{\{IE\}}\frac{\mathrm{d}^2s}{\mathrm{d}z^2}. \tag{30}$$

Combination of Eq. (26) with Eq. (30) gives

$$\frac{\mathrm{d}^2s}{\mathrm{d}z^2}-\Omega^2s=0, \tag{31}$$

where

$$\Omega^2=k\frac{\{IE\}}{\langle AE\rangle_{-1}\langle IE\rangle},\quad \langle IE\rangle=\{IE\}-c^2\langle AE\rangle_{-1}. \tag{32}$$

DETERMINATION OF THE SLIP AND DEFLECTION

For the simply supported bimetallic beam shown in Figure 1 the following boundary conditions are valid

$$v(0)=0,\quad v(L)=0, \tag{33}$$

$$N_1(0)=0,\quad N_1(L)=0. \tag{34}$$

The boundary conditions for bending moment $M=M(z)$

$$M(0)=0,\quad M(L)=0 \tag{35}$$

are satisfied according to Eq. (29). From the boundary conditions

$$N_1(0)=0,\quad M(0)=0 \tag{36}$$

and

$$N_1(L)=0,\quad M(L)=0 \tag{37}$$

it follows that

$$\frac{\mathrm{d}s}{\mathrm{d}z}=(\alpha_1-\alpha_2)T \tag{38}$$

is valid for $z=0$ and $z=L$. The general solution of the differential equation (31) can be represented as

$$s(z)=K_1\cosh\Omega z+K_2\sinh\Omega z. \tag{39}$$

Substitution of Eq. (39) into the boundary condition (38) leads to the next results

$$K_1=-T\frac{\alpha_1-\alpha_2}{\Omega}\tanh\frac{\Omega L}{2}, \tag{40}$$

$$K_2=T\frac{\alpha_1-\alpha_2}{\Omega}. \tag{41}$$

From Eqs. (27), $(29)_1$ and Eq. (39) it follows that

$$\begin{aligned}&c\langle AE\rangle_{-1}\left[K_1(\cosh\Omega z-1)+K_2\sinh\Omega z+\right.\\&\left.+(\alpha_2-\alpha_1)Tz\right]-\{IE\}\frac{\mathrm{d}v}{\mathrm{d}z}+\{IE\}K_3=0,\end{aligned} \tag{42}$$

where

$$K_3=\left(\frac{\mathrm{d}v}{\mathrm{d}z}\right)_{z=0}. \tag{43}$$

Integrating of Eq. (42) gives

$$\begin{aligned}\{IE\}\left[v(z)-v(0)\right]=c\langle AE\rangle_{-1}&\left[K_1\frac{\sinh\Omega z-\Omega z}{\Omega}+\right.\\&\left.+K_2\frac{\cosh\Omega z-1}{\Omega}+\frac{\alpha_2-\alpha_1}{2}Tz^2\right]+\{IE\}K_3z.\end{aligned} \tag{44}$$

From boundary conditions (33) we obtain

$$\begin{aligned}K_3=-\frac{c\langle AE\rangle_{-1}}{\{IE\}}&\left[K_1\frac{\sinh\Omega L-\Omega L}{\Omega L}+\right.\\&\left.+K_2\frac{\cosh\Omega L-1}{\Omega L}+\frac{L}{2}(\alpha_2-\alpha_1)T\right].\end{aligned} \tag{45}$$

Substitution of Eq. (45) into Eq. (44) gives

$$\begin{aligned}v(z)=\frac{c\langle AE\rangle_{-1}}{\{IE\}}&\left[K_1\left(\frac{\sinh\Omega z-\Omega z}{\Omega}-\frac{\sinh\Omega L-\Omega L}{\Omega L}z\right)+\right.\\&+K_2\left(\frac{\cosh\Omega z-1}{\Omega}-\frac{\cosh\Omega L-1}{\Omega L}z\right)-\\&\left.-\frac{\alpha_2-\alpha_1}{2}T\left(Lz-z^2\right)\right].\end{aligned} \tag{46}$$

COMPUTATIONS OF THERMAL STRESSES

We assume that the state of stresses of bimetallic beam can be characterized by the following stresses $\sigma_z = \sigma_z(y,z)$, $\tau_{yz} = \tau_{yz}(y,z)$, $\sigma_y = \sigma_y(y,z)$. The normal stress σ_z is obtained from Eqs. (10) and (20) as

$$\sigma_z = E_1\left[\frac{c_1}{c}\frac{\mathrm{d}s}{\mathrm{d}z} - y\frac{\mathrm{d}^2 v}{\mathrm{d}z^2} + \frac{c_1}{c}(\alpha_2 - \alpha_1)T\right], \quad (x,y,z) \in B_1, \tag{47}$$

$$\sigma_z = E_2\left[\frac{c_2}{c}\frac{\mathrm{d}s}{\mathrm{d}z} - y\frac{\mathrm{d}^2 v}{\mathrm{d}z^2} + \frac{c_2}{c}(\alpha_2 - \alpha_1)T\right], \quad (x,y,z) \in B_2. \tag{48}$$

Shearing stresses $\tau_{yz} = \tau_{yz}(y,z)$ is computed by the use of equation of equilibrium

$$\frac{\partial \tau_{yz}}{\partial y} + \frac{\partial \sigma_z}{\partial z} = 0, \quad (x,y,z) \in B_1 \cup B_2. \tag{49}$$

A detailed computation yields the next result

$$\tau_{yz} = -E_2\left[(y - y_2)\frac{c_2}{c}\frac{\mathrm{d}^2 s}{\mathrm{d}z^2} - \frac{1}{2}(y^2 - y_2^2)\frac{\mathrm{d}^3 v}{\mathrm{d}z^3}\right], \tag{50}$$

$$(x,y,z) \in B_2,$$

$$\tau_{yz} = -E_2\left[(y_{12} - y_2)\frac{c_2}{c}\frac{\mathrm{d}^2 s}{\mathrm{d}z^2} - \frac{1}{2}(y_{12}^2 - y_2^2)\frac{\mathrm{d}^3 v}{\mathrm{d}z^3}\right] -$$

$$-E_1\left[(y - y_{12})\frac{c_1}{c}\frac{\mathrm{d}^2 s}{\mathrm{d}z^2} - \frac{1}{2}(y^2 - y_{12}^2)\frac{\mathrm{d}^3 v}{\mathrm{d}z^3}\right], \tag{51}$$

$$(x,y,z) \in B_1.$$

Here, the stress boundary condition

$$\tau_{yz}(y_2,z) = 0 \tag{52}$$

and the continuity condition of τ_{yz} at $y = y_{12}$

$$\lim_{\varepsilon \to 0}\left[\tau_{yz}(y_{12} - \varepsilon, z) - \tau_{yz}(y_{12} + \varepsilon, z)\right] = 0 \tag{53}$$

are used. To obtain the normal stress $\sigma_y = \sigma_y(y,z)$ we consider the next equation of mechanical equilibrium

$$\frac{\partial \sigma_y}{\partial y} + \frac{\partial \tau_{yz}}{\partial z} = 0. \tag{54}$$

Integration of Eq. (54) gives

$$\sigma_y = E_2\left[\left(\frac{y^2 + y_2^2}{2} - yy_2\right)\frac{c_2}{c}\frac{\mathrm{d}^3 s}{\mathrm{d}z^3} - \right. \tag{55}$$

$$\left. -\frac{1}{2}\left(\frac{y^3 + 2y_2^3}{3} - y_2^2 y\right)\frac{\mathrm{d}^4 v}{\mathrm{d}z^4}\right], \quad (x,y,z,) \in B_2,$$

$$\sigma_y = E_2\left[\left(\frac{y_{12}^2 + y_2^2}{2} - y_{12}y_2\right)\frac{c_2}{c}\frac{\mathrm{d}^3 s}{\mathrm{d}z^3} - \right.$$

$$-\frac{1}{2}\left(\frac{y_{12}^3 + 2y_2^3}{3} - y_2^2 y_{12}\right)\frac{\mathrm{d}^4 v}{\mathrm{d}z^4}\Bigg] +$$

$$+E_1\left[\left(\frac{y^2 + y_{12}^2}{2} - yy_{12}\right)\frac{c_1}{c}\frac{\mathrm{d}^3 s}{\mathrm{d}z^3} - \right. \tag{56}$$

$$\left. -\frac{1}{2}\left(\frac{y^3 + 2y_{12}^3}{3} - y_{12}^2 y\right)\frac{\mathrm{d}^4 v}{\mathrm{d}z^4}\right] - (y - y_{12})\left(\frac{\partial \tau_{yz}}{\partial z}\right)_{y = y_{12}},$$

$$(x,y,z) \in B_1.$$

Here, we use the stress boundary condition

$$\sigma_y(y_2,z) = 0, \tag{57}$$

and stress continuity condition of σ_y at $y = y_{12}$

$$\lim_{\varepsilon \to 0}\left[\sigma_y(y_{12} - \varepsilon, z) - \sigma_y(y_{12} + \varepsilon, z)\right] = 0. \tag{58}$$

Integration of Eq. (49) leads to next equation

$$\tau_{yz}(y_1,z) - \tau_{yz}(y_2,z) + \frac{\partial}{\partial z}\int_{y_2}^{y_1} \sigma_z \mathrm{d}y = 0, \tag{59}$$

that is

$$\tau_{yz}(y_1,z) = -\frac{1}{b}\frac{\partial N}{\partial z} = 0. \tag{60}$$

By the same method from Eq. (54) we obtain

$$\sigma_y(y_1,z) - \sigma_y(y_2,z) + \frac{\partial}{\partial z}\int_{y_2}^{y_1} \tau_{yz}\mathrm{d}y = 0, \tag{61}$$

that is

$$\sigma_y(y_1,z) = -\frac{1}{b}\frac{\partial V}{\partial z} = 0. \tag{62}$$

Eqs. (60) and (62) show that the stress boundary conditions for τ_{yz} and σ_y at $y = y_1$ are satisfied. In the following we prove that

$$\tau_{yz}(y_{12},z) = \frac{Q(z)}{b} = \frac{ks(z)}{b}. \tag{63}$$

Starting from Eq. (50) we can write

$$\tau_{yz}(y_{12},z) = -E_2\left[(y_{12} - y_2)\frac{c_2}{c}\frac{\mathrm{d}^2 s}{\mathrm{d}z^2} - \frac{1}{2}(y_{12}^2 - y_2^2)\frac{\mathrm{d}^3 v}{\mathrm{d}z^3}\right] =$$

$$= -E_2\left[\frac{c_2 h_2}{c}\frac{\mathrm{d}^2 s}{\mathrm{d}z^2} - c_2 h_2 \frac{\mathrm{d}^3 v}{\mathrm{d}z^3}\right] = \tag{64}$$

$$= -\frac{E_2 A_2}{b}\frac{c_2}{c}\left[\frac{\mathrm{d}^2 s}{\mathrm{d}z^2} - c\frac{\mathrm{d}^3 v}{\mathrm{d}z^3}\right] = -\frac{E_2 A_2}{b}\frac{c_2}{c}\frac{k}{\langle AE\rangle_{-1}}s(z) =$$

$$= \frac{E_1 A_1 E_2 A_2}{\langle AE\rangle\langle AE\rangle_{-1}}\frac{Q(z)}{b} = \frac{Q(z)}{b}$$

according to Eq. (63). Here, Eqs. (2,3,4,5) and Eqs. (26), (50) have been used to prove the validity of Eq. (64).

NUMERICAL EXAMPLE

The following data are used in the numerical example (Figure 1):

$b = 0.03$ m, $h_1 = 0.01$ m, $h_2 = 0.03$ m, $E_1 = 1.22 \times 10^{11}$ Pa,

$E_2 = 8 \times 10^{10}$ Pa, $L = 1.5$ m, $\alpha_1 = 2.8 \times 10^{-6}$ 1/K,

$\alpha_2 = 1.43 \times 10^{-5}$ 1/K, $T = 200$ K, $k = 60 \times 10^6$ Pa.

Figure 4 shows the graph of deflection function and the graph of slip function is illustrated in Figure 5. The stresses $\sigma_z = \sigma_z(y,z)$, $\tau_{yz} = \tau_{yz}(y,z)$ and $\sigma_y = \sigma_y(y,z)$ for some cross section ($z = L/4$, $z = L/3$, $z = L/2$) are shown in Figures 6, 7 and 8.

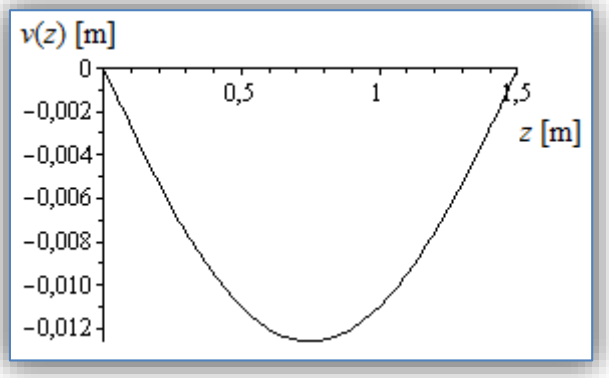

Figure 4. The graph of $v = v(z)$

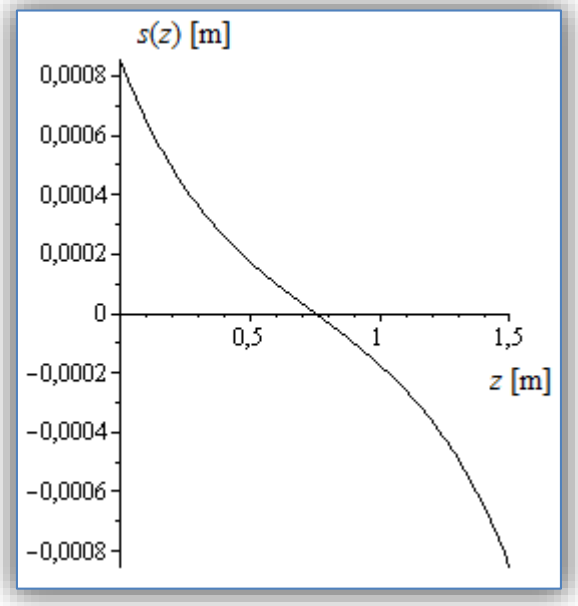

Figure 5. The graph of $s = s(z)$

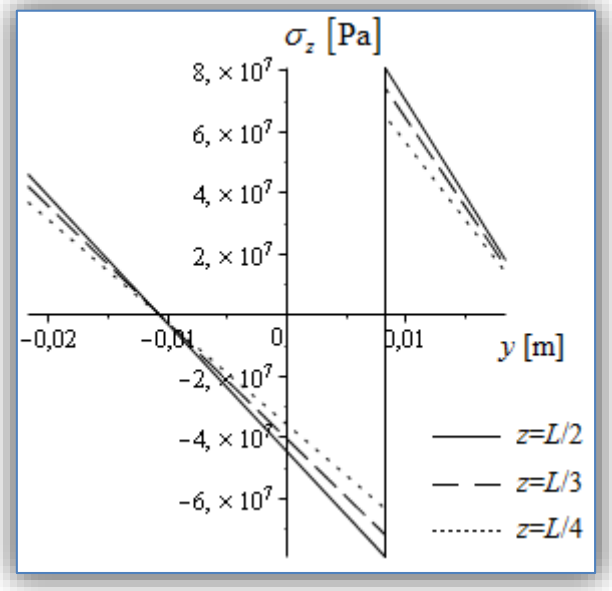

Figure 6. Plots of $\sigma_z = \sigma_z(y,z)$

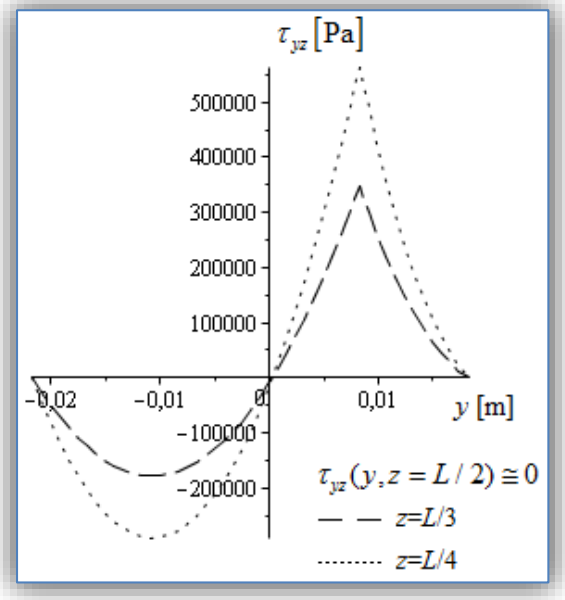

Figure 7. Plots of $\tau_{yz} = \tau_{yz}(y,z)$

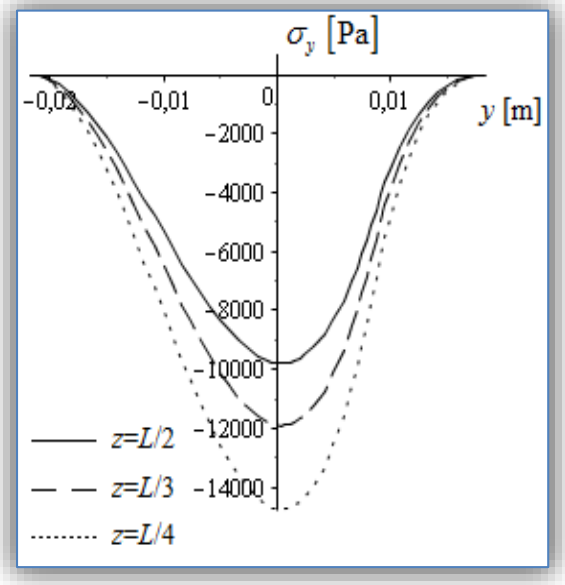

Figure 8. Plots of $\sigma_y = \sigma_y(y,z)$

CONCLUSIONS

In this paper the elastic bimetallic beam with flexible shear connection is analyzed. The applied thermal load is caused by a uniform temperature change.

An analytical method, which is based on slip-deflection formulation, is proposed to get the displacements and stresses.

A numerical example illustrates the application of method developed. Numerical solutions derived by this analytical method can be used as benchmark solutions for solutions obtained by other methods.

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DESIGN AND TEST ANALYSIS OF A MULTI STAGE CANTILEVER BEAM TYPE SUSTAINED LOAD STRESS CORROSION TESTING RIG

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Abstract: The design and test evaluation of a multi stage cantilever beam type sustained load testing rig was undertaken in this research. The aim was to make available to local researchers a cost effective, technically efficient, and easily operated testing facility for stress corrosion cracking studies. The design criteria and materials selection were based on design theory and operational principles, local availability of raw materials and components, material properties, materials and fabrication costs, ease of utilization and maintenance, specimen and testing specifications, and basis for data generation. The testing procedure involved the use of circumferential notch specimens subjected to sustained loads noting the time to failure; with 10 % load shedding used for successive loading of specimens to failure. Macroscopic crack evolution of aluminium samples tested with 5 wt% NaCl solution as specific environment showed promise of the rig for reliable SCC studies. The rig was also observed to be safe for use and the precautions prescribed adequate to guarantee accurate data generation and maintenance of the rig. The cost for the design of the test rig was about 50,000 Naira ($250.00) which is cheaper in comparison to conventional SCC testing equipment operating on similar principles which are designed abroad.

Keywords: Stress corrosion cracking; sustained load fracture; circumferential notch specimens; fracture mechanics; cantilever beam

INTRODUCTION

Stress corrosion cracking (SCC) is a prominent failure mechanism in engineering materials which results from a combined action of stress and specific corrosive environment. This form of failure is the most catastrophic form of corrosion; and occurs as a result of interaction of three factors: an active or residual tensile stress, susceptible material and a specific environment (corrosive media) [1]. It is often characterised by cracking of metals under active or residual tensile (usually below the yield strength of the material) stresses in specific environments from pre-existing defects or defects initiated in the material while in service. Crack initiation in materials can also result from localised corrosions (intergranular, crevice, dealloying) which create sites for stress concentration and amplification within the material [2]. Other variables that decide the extent or nature of SCC failure are the stress state (plane stress or plane strain), loading mode (tension or torsion), chemical composition, microstructure, grain sizes, grain boundaries, solution species, temperature, pressure, pH and electrochemical potential [3][4].Stress corrosion cracking can go undetected in many service applications and can result in loss of lives, reduce production efficiency and increase production cost [5] .The SCC of service components or parts of mechanical systems has been a source of concern in major industries like petrochemical, oil and gas, food processing, spacecraft, nuclear, pulp production, and other production industries [6]. Therefore design against SCC is very paramount in many engineering applications to enhance material functionality and service life.

The design against SCC requires a basis of assessing susceptibility of a material to this failure mechanism. Over the years, several test methods have been developed for evaluation of SCC behaviour of engineering materials [5]. SCC studies in metallic materials have been based on adoption of fracture mechanics principles and often evaluation is based on specimen geometry and loading conditions. In this regards, testing conditions are categorised as; Test on smooth samples under static loading, Test on pre-cracked sample under static loading and Tests on pre-cracked or smooth samples under dynamic loading

[7]. However, most SCC evaluations are based on the static loading technique under the assumption that most materials undergo SCC failure under constant loading conditions.

Several standards have been proposed for SCC investigation in different materials with specified specimen configurations and testing conditions. These are namely ASTM G58 – 85[8], ASTM E1681-03 [9] and ASTM G139 – 05 [10]. The aforementioned standards are based on the principle of constant loading of pre-cracked or smooth specimens. There exist other standards such as ISO 7539-7 [11] and ISO 7539-9 [12] which are based on the assumption that material's maybe subjected to unpredicted dynamic loading and propose slow strain rate testing(ISO 7539-7, ISO 7539-9). However, the existing testing methods for SCC evaluation facilities, specimen configuration and testing procedure which are difficult to attain in many African research environments. This has necessitated studies on developing a more pragmatic approach for SCC studies from an African perspective.

The use of circumferential notch tensile testing technique has been well reported as a less sophisticated and cost effective means for fracture studies of materials [13] [14]. The adaptation of this technique to SCC studies has been proposed with the use of pre-cracked specimens under sustained loading conditions by several researchers [15]. Alaneme [6] applied this technique in the design of a low cost rig for SCC studies of metallic materials with satisfactory data generated for SCC analysis. The test rig developed however, had some limitations which include: having only a single loading arm which increased the overall testing time for materials. This impaired simultaneous study of SCC susceptibility using varied loading conditions on different samples which can hasten the process of data accumulation as the basis of SCC studies naturally demands long periods for specimen fracture to occur.

This research work seeks to address the highlighted problem by designing a low-cost multi loading stage SCC test rig. The testing facility (a multiple loaded test rig) is designed based on the use of cantilever load beam and circumferential notch specimens. The design, testing procedure, interpretation of SCC tendencies from data generated from the use of the test rig and performance evaluations are discussed in this paper.

MATERIALS AND METHOD

Design Theory

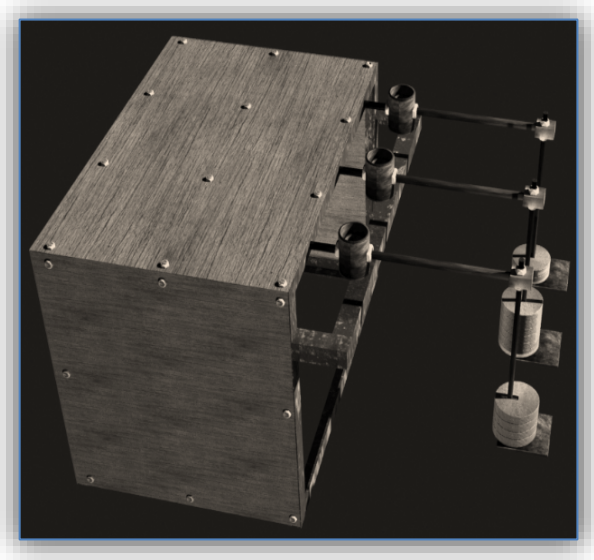
The design theories and testing procedures are in accordance with the cantilever load beam principles and CNT testing techniques, respectively. The design principle is based on cantilever beam loading principle, an approach described in details by Alaneme (2011). It entails the use of circumferential notch samples held in a fixed position at one end and subjected to applied load at the other end of the specimen. The applied load creates stress amplification at the notch, a triaxial stress state is also created at the notch tip which suppresses tendency toward plastic yielding and instigates the process of crack nucleation. The crack nucleation and propagation is accentuated by the specific corrosion environment which the specimen is exposed to at the notch region Figure 1. For each loading condition and specific environment (environment in which the material is susceptible to SCC), the time to failure for each sample is noted and the corresponding stress intensity factor determined.

Design Consideration and Material Selection

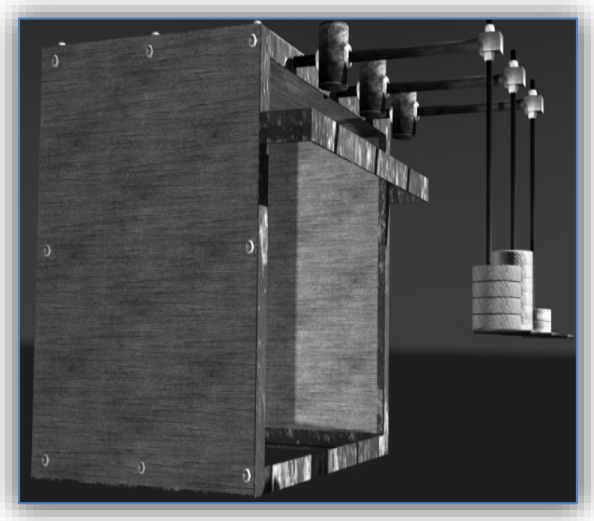
The design criteria was based on several considerations including cost, local availability of potential materials required for fabrication, material properties, rigidity and service life of the rig, ease of adjustment and utilization of the rig, non-reliance on electrical power supply and basis of data generation and evaluation. The design incorporates the main parts of the test rig which include: the test frame (which gives rigidity and balance to the apparatus); loading frame consisting of loading beam and load hanger (which serves as anchor between the applied load and the specimen); timer (which records the time taken for a specimen to fail); corrosion cell (a thermoplastic container holding a specific solution); and dead weights (used to apply known weights to the specimen). The material selection for the test frame, loading arm, loading hanger and corrosion cell were in line with the specifications utilised by Alaneme [6].

The test frame is designed to sustain the applied load to prevent failure of the rig in service; hence high strength low alloy steels which possess high strength and toughness were employed for the design. The loading frame is required to sustain applied loads for long periods without undergoing plastic deformation or change in dimensional integrity. Therefore, high strength low alloy steels were utilised for the design of the loading beam and load hanger to prevent yielding of these component parts in service. The dimensions of the loading frame were also carefully selected so that its weight does not affect the total weight acting on the specimen which would affect the results generated from the test. A portable hour-minute-second timer was selected to record time to failure for accuracy and precision. The corrosion cell was carefully selected to be lightweight, corrosion resistant and non-reacting to reagents; a

thermoplastic material was selected for this purpose. A pictorial representation of the test rig is shown in Figure 1.



(a)



(b)

Figure 1: showing (a): 3D top view of the test rig and (b) 3D side view of the test rig

Specimen Specification

The test specimen is a circumferentially notched cylindrical bar machined following standard CNT specimen configuration. The specimen had a total length of 200mm with gauge length of 160mm, gauge diameter of 8 mm, notch depth of 2.5mm and notch angle of 60°. The specimen configuration and dimensions are presented in Figure 2.

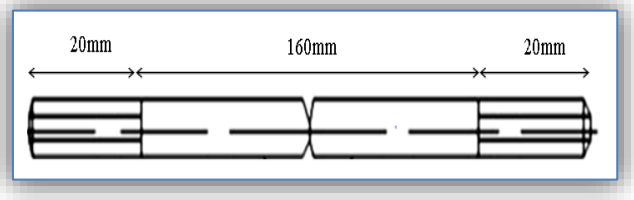


Figure 2: Specimen specification for circumferentially notched cylindrical bar samples

Testing Procedure

The circumferential notch cylindrical bar test specimen is fastened to the grip fixture on the test frame and passed through a thermoplastic container (with drilled holes at the center) which served as the cell for the specific corrosion medium. The drilled ends of the container are sealed after the insertion of the test specimen to prevent dripping of the corrosion solution during testing. It is ensured that the container is situated at the notch region of the sample to help accentuate the process of crack nucleation. The other end of the specimen is screwed to the loading arm which is connected to the load hanger of the testing rig. Pre- determined dead weights are placed on the load hanger and the timer is switched on. The loading conditions are such that the start load is sufficient to induce fracture of the test material within a short time interval. Load shedding of 10% is applied as successive loads to the test specimen and time to failure for each test case recorded. This is done until a threshold load is attained below which it becomes unrealistic to expect fracture of sample after an infinite time interval under a specific environment where the material is ordinarily susceptible to SCC failure. Typical stress intensity factor – time to failure data generated from the sustained load SCC testing is schematically illustrated in Figure 3.

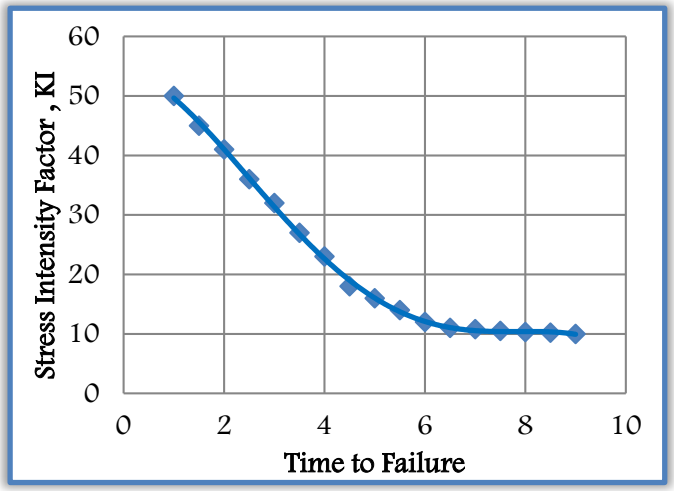


Figure 3: A schematic plot of stress intensity against time to failure (ttf)

PERFORMANCE EVALUATION

Visual Examination of SCC Progression to Failure

Stress corrosion cracking (SCC) data generation using the sustained load cantilever beam principle can take several months depending on the test conditions, specific environment and the susceptible material under study. Thus the use of multiple loading stages helps to speed up the overall time required for data generation since multiple samples can be anchored with varied dead weights

and tested simultaneously. The stress corrosion cracking behaviour of an aluminium test specimen was investigated in 5wt% NaCl solution (a medium in which aluminium shows susceptibility to SCC) using the designed multi stage test rig.

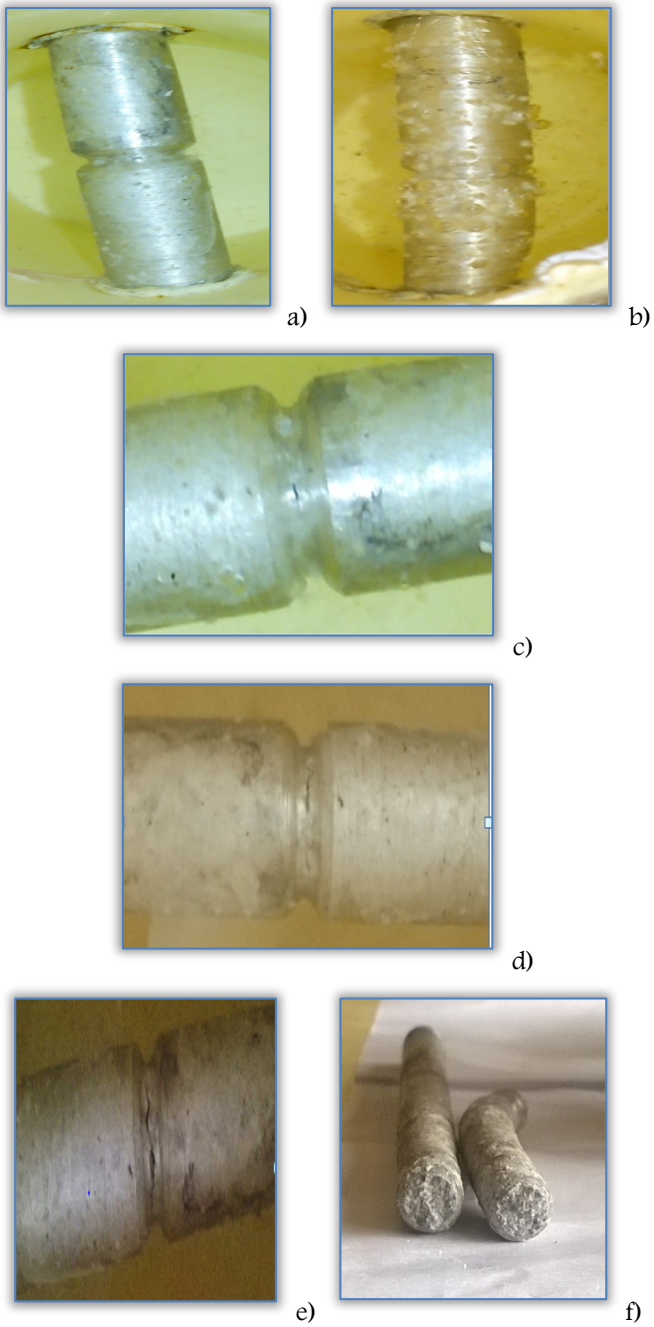


Figure 4: Representative photomicrographs showing the nature of macroscopic crack evolution to final fracture in the test specimen (a) after 4 days of testing, (b) for 9 days of testing, (c) 15 days of testing, (d) 25 days of testing, (e) 35 days of testing, (f) fracture on 40th day of testing

The pace of macroscopic crack manifestation and growth was specifically monitored by visual examination throughout the test period for each specimen. Representative photomicrographs showing the nature of crack evolution in the test specimen with time are presented in Figure 4.

From Figure 4(a) it is observed that surface discoloration due to formation of corrosion products became evident on the fourth day of sustained load testing. On the ninth day of testing, conspicuous sign of bubbles formation which is a macroscopic indicator of crack initiation on the surface of the specimen was noticeable (Figure 4b). The crack became visible after fifteen days (15) days of sustained loading as observed in Figure 4c. The progression of crack growth increased with increase in the test period to 25 days (Figure 4d). The crack advance before fracture was very prominent after thirty five (35) days of sustained load bearing (Figure 4e) and fracture occurred after 40 days of testing (Figure 4f).

Working Efficiency, Safety and Cost Analysis

SCC testing with the rig requires some basic precautions to be taken to ensure reliable results are generated and to safeguard the user and rig from potential harm due to exposure to corrosive medium. In the first place care is exercised by ensuring that the test specimens are securely fastened to the grip fixture of the main frame of the rig to safeguard against removal of specimen when subjected to loading during operation.

Table 1: Bill for Engineering Management and Evaluation

S/N	Material	Specification	Quantity	Unit Cost (N)	Amount (N)
1	Angle iron	2mm	2.5 lengths	2280	5700
2	Cutting disc		2	650	1300
3	Grinding disc		2	650	1300
4	Electrode		Half packet	700	700
5	Bolt	6mm	40	30	1200
6	Bolt	8mm	6	50	300
7	Nut	6mm	48	30	1440
8	Nut	8mm	4	50	200
9	Red oxide		Half bottle	550	550
10	Saw blade		3	250	750
11	Plywood		1 sheet	3350	3350
12	Drill bit	6mm	3	400	1200
13	Adhesive	Aradite			200
14	NaCl	Anapuna	4	60	240
15	Machining	All			13840
16	Transportation/ logistics				3860
17	Labour Cost				10000
18	Total				49530

The thermoplastic container used as corrosion cell is properly sealed to ensure that the specific environment used as test solution does not drain out from the container and result in the gradual

corrosion of the test frame and entire rig with time. The load hanger is also securely fastened to the loading arm of the load frame so that it does not pull out from the loading arm when dead weights are anchored on it. In this regards, it is equally ensured that protective barricades are placed around the load hanger to ensure that if the dead weights accidentally slips off the hanger it does not drop and injure the operator. The operation principles of the test rig are very easily comprehended and does not require complicated basis for data recording. The parts of the machine can be easily dismembered for repairs in the case a part of the rig malfunctions or is damaged. Replacement of any part of the rig and acquisition of fabrication materials required for repair purposes can easily be obtained as all parts used in the design are relatively cheap and can be sourced locally.

The materials and components used for the design of the multi loading stage SCC test rig are presented in Table 1. The materials and equipment used were locally sourced and overall cost of design is approximately 50,000 Naira ($250). The test rig is cheaper in comparison to conventional SCC testing equipment operating on similar principles which are designed abroad.

CONCLUSION

The design and test evaluation of a multi stage cantilever beam type sustained load testing rig was undertaken in this research. The rig was observed to be effective and safe for use. The precautions prescribed for its use were found to be adequate to guarantee accurate data generation and maintenance of the rig. Macroscopic crack evolution observed for aluminium samples tested with 5 wt% NaCl solution as specific environment showed the potential of the rig for reliable SCC studies. The cost for the design of the test rig was about 50,000 Naira ($250.00) which is cheaper in comparison to conventional SCC testing equipment operating on similar principles designed abroad.

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SIMULATION METHOD FOR COLOR VISION ON DRIVERS BY INDUCING VISUAL STRESS

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Abstract: The characteristic of color perception is a functional process established at the level of the adapted cones to light, fact observed on night lighting when only rods are excited, and the eye is unable to distinguish colors. The purpose of this paper is to analyze the behavior of the human eye, in simulated laboratory conditions, by exposing them to different types of colored stimuli. Different types of wavelengths, time and frequency of exposure are taken into consideration, attempting to replicate thus the traffic conditions. For it will use a device self created specifically for these types of experimental simulations. It will track and analyze the reactions of subjects where the eye is protected and unprotected and various psychological conditions (most will track eye fatigue).
Keywords: Driver, Visual Function, Optometric Evaluation, Chromatic Vision, Simulation

INTRODUCTION

According to [1], chromatic sensation, along with the perception of light and shapes, are the three essential elements of vision. The eye perceives color stimuli in the visible spectrum, 375-760 nm range between infrared and ultraviolet, called the visible spectrum. Spectral colors are found only under experimental conditions surrounding world is basically formed from the mixture in varying amounts of several spectral colors.

Color perception is a function of the eye adapted to the light. When the light is weak, the human eye is unable to distinguish colors. In appropriate lighting conditions, color perception is achieved within a special region of the retina called the macula, where there are three types of visual pigments, corresponding to the three types of primary colors: red, green and blue. Color stimuli have certain physical characteristics: wavelength, intensity and purity light source. They correspond to certain sensory characteristics: hue, saturation and brightness.

Each cone is a carrier of one of photopigments and therefore reacts differently to colored light sources. For each of these three types there is a specific absorption curve peaks at different points of colors of the color spectrum (Figure 1) [2]:

- S cones: sensitive to light of short wavelength, with a peak at about 420 nm (blue);
- M cones: sensitive to light with an average wavelength having a peak at about 530 nm (green);
- L cones: sensitive to long wavelength light, with peak at about 560nm (red).

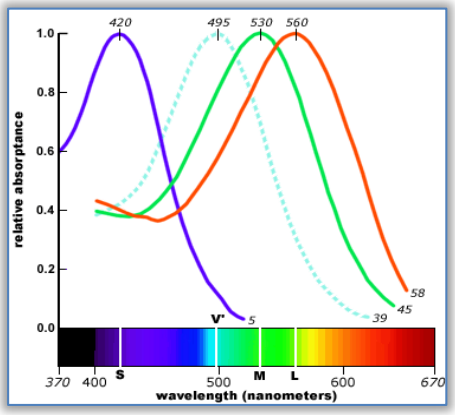

Figure 1: Cone Absorption Curves by Bruce MacEvoy

Color characteristics - brightness, tone and contrast - determined to eyeball a series of psycho-sensory phenomena that can constitute as methods for determining and verifying the color sensation. It has been found that the color sensation occurs only in photopic light, so cones are the photosensitive cells which participate in the formation of the sensations, so they are adapted to the three primary colors and can reproduce all colors in nature by mixing sensations. Experimental data and results of clinical and laboratory confirmed trichromatic theory that the cones are specialized for the three primary colors in their composition, without all three photo-pigments [2]. For a chromatically normal eye, the cones are specialized in a proportion of about 74% for red, approximately 10% for green, and for blue

in a proportion of about 16%. Chromatic message transmission is performed according to Hering's theory of the so called theory of opposing pairs. This system is based on the fact that the first channel transmits gray levels, while the other two are opposed and never interferes; the red signal eliminates the green one by inhibiting the complementary color [3].

In 1931, an international group of experts known as the "Commission Internationale d'Eclairage" (CIE) [1] developed a mathematical model of colors, which represent observable space full of colors and values assigned to each set of three numbers (Figure 2).

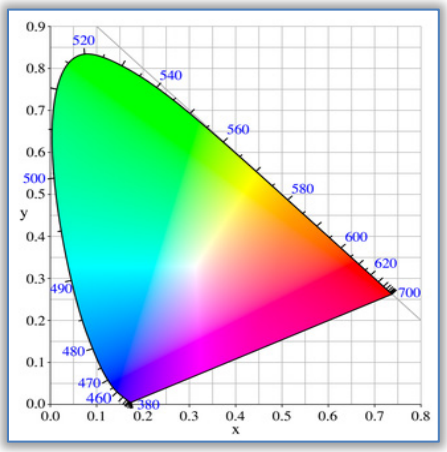

Figure 2: Chromaticity diagram of the visible spectrum provided by CIE in 1931 [1]

Contrast effects occur simultaneously for both blacks and whites stimuli and for chromatic stimuli [3]. For example, a uniform gray background appears brighter if crossed by white lines and darker when it is crossed by black lines; blue appears more intense on a yellow background, and yellow more intense on blue, unless were placed in the vicinity of other colors. After a short and intense stimulation, a series of oscillating processes appears. These are consecutive images or post-images and are highlighting where there is complete darkness. Post images are considered as some chain mechanisms, with the opposite reactions according to wavelength.

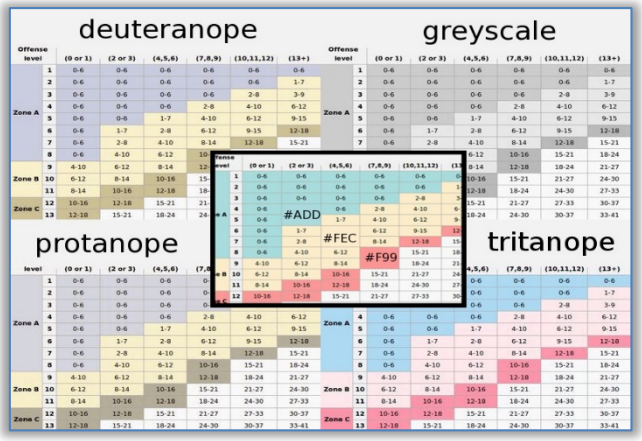

Figure 3: Testing the colors of a web chart [4]

Subjects with disorders chromatic usually have a uniton areas and even bands of gray tones instead that have not perceived (Figure 3) [4]:

a. Trichromacy in which all three cone pigments are present and color vision is normal.
b. Abnormal color sensation called dichromacy, are represented by visual disturbances of the colors by an inability of subjects to observe a certain wavelength of light radiation. Dichromatism occurs in a subject possessing two receptor systems and is blind to one of primary colors.
   ≡ Protanopes is contained in a proportion of 10% among the congenital disorders and consists in shortening of the color spectrum in its upper part, i.e. towards the red.
   ≡ Deuteranopes or Nagel's fault is 14% of congenital chromatic disorders and subjects did not perceive than partial color tone in the area of radiation with small wavelength.
   ≡ Tritanopes represents about 1% of congenital disorders that occur through lack of color receptor blue.
c. Monochromatic means only one cone pigment is functional. Can be easily associated with reduced visual acuity (usually 6/60), photophobia, nystagmus and sluggish pupil reflex to light.
d. Acromatopsy is a chromatic anomaly by which the cones are broken, either completely or partially, for which subjects perceive the world around only in gray levels.

Additionally, acquired dichromatism have the following characteristics: do not occur in isolation, but are closely related to damage other functions as decreased visual acuity or adaptation disorders; can be unilateral or limited to one side of the visual field; evolving with the condition that it imposes.

THE CONNECTION BETWEEN CHROMATIC VISION AND DARK ADAPTATION

The first step in achieving visual function happens in the retina and is converting light energy into luminous excitation. In carrying out this function takes part optical analyzer, including the cerebral cortex, thanks to which the sensations that arise in the occipital lobe photos do not remain isolated, meaningless, but are integrated into the whole process knowledge. The eyeball has the ability to modify the sensitivity of receptors depending on light intensity. Adaptation to low light is achieved through three mechanisms: changes in pupil diameter, increased sensitivity of the retina, optic neural adaptation path. The phenomenon of adaptation to darkness began to be studied since the 1860s because it reveals special functional movement coordination with major impact on the human factor [5].The study of retinal receptors adapt to darkness shows that from the beginning adapts cones, they synthesize photo-pigment faster and increase their

sensitivity in the first 5-6 minutes, then follows the adjustment rods which is achieved more slowly due to the phenomenon of convergence and last all due to the higher number of rods in comparison to that of the cones [6]. This sensitivity is measured as the other sensations of the eye, by means of thresholds. Thus, one can determine the absolute light threshold, which represents the smallest amount of light that can be seen in the dark [7].

In photochemical interpreting of the scotopic vision, i.e. adapting to darkness, it is a matter of identifying chromophore substances of retinal structure. Rhodopsin is the pigment rods, which are found in far greater numbers than cones, so it is understandable why rhodopsin staining gives retina's color. Also in adapting to darkness intervened nervous factors too, pupil dilation and contraction of the retina are modulating the illumination, and inhibition processes in the retina occur.

If after a complete adaptation to darkness, the subject is exposed to light more or less intense, adapting to disappear by un-adopting, this is the reverse phenomenon of adaptation. During adapt to light phenomena occurring in the reverse occurring adaptation to darkness are [8]:

- It produces a decrease in retinal sensitivity;
- Visual purple discoloration;
- Changing the acid alkaline reaction on retina and even structural changes;
- Miosis occurs 0.2 - 0.5 seconds from the start of the trial and achieve maximum value in a few minutes.

For approximately the first 10 minutes in the dark, the cones require less light to reach a threshold response than do the rods. Thereafter, the rods require less light. The point at which the rods become more sensitive is called the rod-cone break (Figure 4).

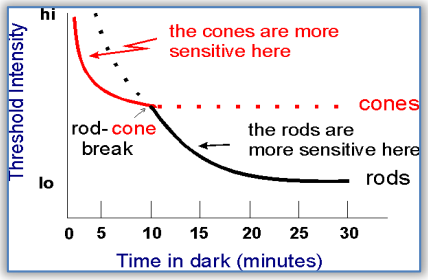

Figure 4: Dark adaptation function [8]

The eye adapts more quickly to light than in the dark. In the first 20 to 30 seconds there is an extreme decrease of the sensitivity, which is then followed by a slower decrease over a period of about 10 minutes [9]. Fogging is an extreme event in adapting to light. This is a transient visual embarrassment and painful, of course accompanied by a decrease in visual function, and is caused by an excess of light radiation in relation to the stage adaptation of the eyeball. Visual discomfort manifests more intense as the light source was stronger, brighter, and closer to the visual axis. The level of fogging varies according to subject status (fatigue, intoxication, alcohol or tanned condition), the diameter of the pupil (drug mydriasis can determines the state of fogging) [9]. Of colors, yellow is the least fogging, yellow light without radiation with short wavelengths (green and blue) causes a reduction in visual embarrassment and a net increase visibility by 10%. successive fogging are manifested as phenomena that occur after the suppression of fogging source and rehabilitation of eye sight before the moment of fogging, thus a short period of blindness occurs, then a gradual recovery of visual functions corresponding photo-pigments regeneration time. In these cases, visual acuity drops below 1/10 and sometimes lowers values [9].

CHROMATIC VISION FOR DRIVERS

Confusion colors (dichromatopsy) have repercussions decisive especially in shipping and rail traffic. Regarding the problem of color vision in the road, views are controversial. Not too call into question their ability to drive assessment in people with dichromatopsy whose visual acuity is reduced for any reason. The receptors sensitive to red or green are missing from the retina of people with dichromatopsy [10]. The auto driving, lack receptors sensitive to red presents special problems. The role of color vision on the road is controversial in different ways. According to some opinions, it has not been registered yet, worldwide, no very serious car accident whose cause has been driver's dichromatopsy. Without much notice, they refer to protanope, people who are insensitive to red and see a darker red rear lights. There is no data that could reveal that people with dichromatopsy would go more often at intersections when the traffic light is red than those without such problems. On the contrary, they are more cautious, aware of this deficiency [1].

The same conclusion applies concerning accident statistics, people with dichromatopsy not been involved in more accidents than those with normal color vision. This can be explained by the fact that these people on the road can also use other sources of information. In this connection, it may be mentioned the issue of recognizing traffic lights. At traffic lights, red is located in the up position, the middle yellow and green below [11]. This standardized settlement, awareness of its position and brightness of traffic lights, are a real help for people with color confusion. Increasing the size of signaling lamps further intensifies the possibility of their recognition. Sometimes red is framed in a circle, green in a triangle, differentiation being made

through form. In adverse weather conditions or when light bulbs brake at low levels, the person with confusion red due to the shortening of the spectrum, evaluates the brake lights of the car in front as a distance greater than the reality, thus approaching too much of it.

In order to recognize color signals [11], some methods have been tried, such as wearing colored glasses, painting a green stripe on top of the windscreen, which thereby the color red appears darker and the lighter green. In many countries, including Romania, perfect color vision is mandatory for professional drivers, while for amateur drivers are allowed and easy dichromatopsy. A person with color confusion must draw attention to this disease and the risks of accidents [12]. Studies conducted in this area, indicate that the person with di-chromatopsy, through compliance with conditions, can become a driver as good as a person with normal color vision. The main condition is not to minimize in any event the suffering anomaly of vision like a principle which must guide them driving mode. The conditions of professional drivers are more severe in terms of possibilities for their views. In the case of amateur drivers can make some concessions, primarily in terms of visual acuity (if is corrected), and the color vision.

As foreseen in Romania, binocular visual acuity of professional drivers must be 100% and color vision must be perfect, determined using pseudo-izochromatics charts (Figure 5, [11]). At amateur drivers, monocular visual acuity should be good in one eye and the other more than 33%. Monophthalms are admitted only after a year of rehabilitation. A low degree of confusion color is admitted to this category [13].

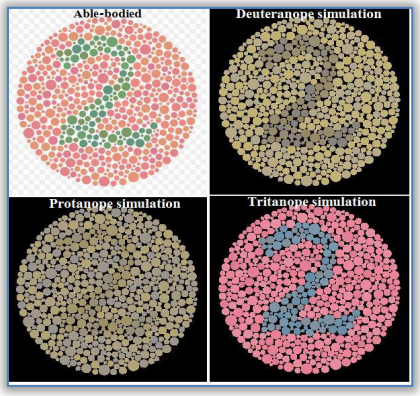

Figure 5: Pseudoizochromatics charts used for drivers

At night, due to lighting roads and intensity of light headlight own automobile, light sensitivity of the cones and rods are almost still pretty good, but the perception of shapes and contrasts decreases taking place and weakening capacity color recognition. Public lighting for economic reasons cannot be intensified. Own car headlights light intensity may be increased, which would be advantageous for the driver, in turn, would create difficulties for drivers coming from the opposite direction. But improved headlight technology solutions could lead to the improvement of sight overnight. Public lighting helps to increase the sense of comfort of the driver, decrease of fatigue and risk of injury. Clear view of the forms is characteristic of a good public enlightenment; this means that on a light background, pedestrians appear dark.

Regarding reflection roads [14], light color concrete is much more favorable than dark asphalt. From the viewpoint of adhesion and in optically terms, rough surface is more favorable. Newer for illuminating road are used aluminum granules that, especially from an oblique viewing angle, make the road looks brighter. In the evening, while driving, is not indicated wearing glasses whose light absorption exceeds 15%. So-called phototrophic glasses, which it gets darkener under the influence of light, are good during the day; are protectors to light because they become total darker only under the influence of ultraviolet rays, thus react slowly to changes in light. In this regard, protective glasses light is a good solution; they are darkens gradually from top to bottom, and make it possible to bring in a few seconds in front of bright area preferred by tilting the head back. The glasses with the polarization effect were found to be promising in the daytime but not at night, because it prevents the development of visual forms. Protective glasses should be in optically in perfect working order, without opacities and scratches. In the case of refractive eye problems, it is necessary to prescribe corrective colored lenses, optically proficient. In the case of refractive eye problems, it is necessary to prescribe corrective colored lenses, optically efficient.

Most upsetting moment, and at the same time generating dangerous driving situations at night, is the meeting with the headlights of oncoming vehicles. Sudden change in lighting intensity, for example, the reflector of oncoming vehicle, determines changes in the accommodative capability. Into movement of pedestrians or cyclists, it does not constitute a disturbing factor, so as the unwanted effect of the light source can be avoided by simply turning the head or line of vision, or even by stopping the move. Because of high speed, in the case of the vehicle, driver's sight is impossible to return long on or off; possibly speed can be reduced. With the change in the duration and level of visual accommodation, for elderly people objects are becoming invisible on the road, which might not have happened some time ago. Also high myopia may contribute to decreased ability to adapt to darkness. The most difficult moment to visual accommodate in the dark is the twilight, when the streets are still not illuminated: shadows are small,

the colors are softened, thus it becomes difficult to recognize the pedestrian or cyclist. The driver, coming from a brightly illuminated room, accommodates hard outer darkness; therefore, it is better to wait a while before starting the vehicle until the eye regains adequate capacity to accommodate. In the case of a high myopia, accommodation is not perfect. Switching from a well-illuminated road on a dark street to the country can have a disruptive action. Into driving a car at night it is recommended dashboard illumination, which provides, in some measure, and the lighting of the car's interior. Colored windshield lowers the quality of night vision; it is no proper for solving the disruptive effects of light coming from oncoming headlights [15].

SIMULATION TESTS FOR VISUAL STRESS ON DRIVING

Abilities of sensory visual, such as measuring spatial resolution, contrast sensitivity, and sensitivity to light across the visual field, are useful for understanding the visibility of objects and events during driving, but they alone are insufficient to understand the complexity of the visual task of driving. Driving visual demands are complicated. Control of a vehicle occurs in an environment cluttered visual and involves simultaneous use of central and peripheral vision and tasks of primary and secondary (both visual and non-visual) [14]. As the vehicle moves through the environment, the visual world is changing rapidly. The driver is often uncertain as to when and where the event will be a critical eye. These applications have the task prompted researchers to examine the relationship between driver safety and performance and attention skills. Moreover, driving while unfit conditions or with eye problems can lead to a form of visual stress [6,8].

Visual Stress term is sometimes used to show symptoms and signs of eyestrain when reading, which can be reduced when color is used as therapy. In other interpretations, Meares-Irlen syndrome and refers to scotopic sensitivity syndrome. It is not yet recognized in medical terms and there is no universal agreement on its behalf. Symptoms related to disorders of visual perception in children with reading difficulty were first described by Olive Meares, but were listed by Helen Irlen.

According to [15], some of the main symptoms that occur during reading are: glare from the page; headaches when reading; sore eyes when reading; movement/blurring of print. Some of the signs may be: rubbing eyes; excessive blinking; poor concentration; inefficient reading; difficulty in keeping place.

In the case of auto traffic, visual stress can have various causes daytime and night:

- during the day:

Blindness due to solar light intensities;
Decreased visual acuity by exposure to high light intensity for a longer period of time;
Eye fatigue;
Distinguishing heavy of the forms and colors;

- during the night:

Blindness due to car headlights for oncoming traffic or event that occurs suddenly light in the visual field;
Pronounced eye fatigue on unmarked roads;
Unable to view the colors and shapes;
Very poor focus visual and accommodation.

The most common symptoms in case of visual stress are accentuated visual fatigue, inability to focus distance, tearing and redness, eye pain, generalized loss of ability to see colors, halos.

Starting at all this, we decided to perform a few experimental tests to expose your eyes to different light radiation and observe their reaction to colored stimuli.

Table 1: Measurements during test

	Distance 2 m in dark		
	Time (red)	Time (green)	Time (blue)
Subject 1	67	48	85
Subject 2	88	45	204
Subject 3	224	116	190
Subject 4	234	91	72
Subject 5	94	69	46

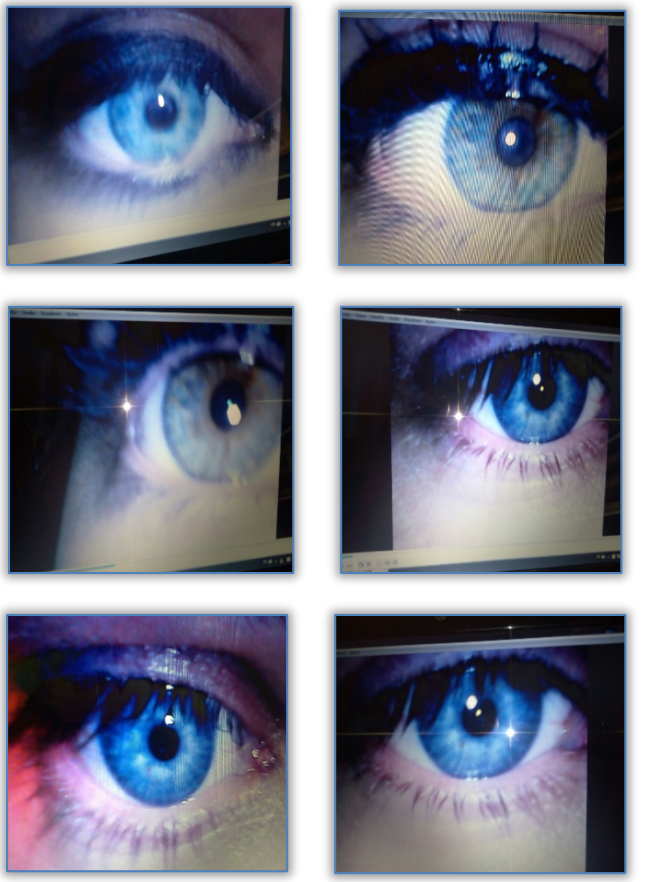

Figure 6: Experimental tests for simulating visual stress

We have used five subjects of similar age (20-23 years), 3 girls and 2 boys. One of the subject ware contact lens. They all pale iris (green or blue) so that

they can view their better pupil. The subject was placed at a distance of 2 meters from the light source, in dark environment, and was successively exposed to stimuli red, green and blue. It measured the time and appeared blindness. Eye reaction to these stimuli was registered using a video camera that recorded the reaction of the pupil (Figure 6).

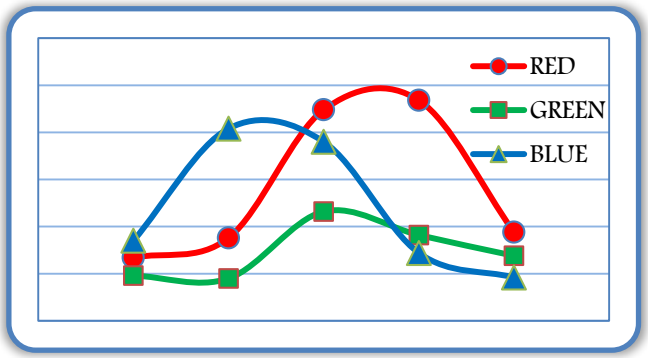

Figure 7: Results of the experimental test

Tests confirmed the theory set forth above. Subjects who had a higher sensitivity to a stimulus have resisted less. Sensations they were charged were great eye fatigue, dyplopia and decreased visual acuity. Eyes became congested and it took time to continue testing. In addition, there were other symptoms of general malaise headache or loss of balance. The method is subjective and based on perceptions and reactions of people tested. The experiment must continued by analyzing video filming. Pupil diameter measurement is essential in correlation with the psychological attitude of the subject.

CONCLUSION

For drivers color vision testing is important because it expresses their ability to properly view light signals and react on time to their appearance in traffic. Even in subjects who have no dichromatopsy, some eye problems can occur in certain situations resulting from special traffic conditions. For example, movement in poor lighting conditions or bright occurrence of events rapidly generated high intensity (light flash). Such situations can generate visual stress. Its symptoms are pressure in the eye; headache; some mild forms of the myopia; dyplopia (double images); changes in color perception; difficulty on focusing.

Note: This paper is based on the paper presented at The 1st International Conference "Experimental Mechanics in Engineering" - EMECH 2016, organized by Romanian Academy of Technical Sciences, Transilvania University of Brasov and Romanian Society of Theoretical and Applied Mechanics, in Brasov, ROMANIA, between 8 - 9 June 2016

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TECHNICAL ASPECTS OF ADSORPTION COOLING SYSTEM

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Abstract: In recent years, adsorption cooling systems are getting attention due to ozone layer depletion issues and global warming potentials related to the conventionally used refrigerants. The adsorption cooling system is the heat driven refrigeration system and hence waste heat energy of the industries or automobiles or solar energy can be used as the heat source in the adsorption system. In adsorption system, the environmental friendly refrigerants such as water, can be used and hence it can cope with the current environmental issues. In adsorption system, different combination of adsorbent-adsorbate pairs is used for successful operation and hence a careful selection of the adsorbent-adsorbate pair is important. With the availability of solar energy and increase in the demand of the air conditioning in the summer, solar adsorption cooling is considered as the best alternative solution to overcome the problems associated with the conventional air conditioning systems. The development in the adsorbent technology provides solution to the shortcomings in solar adsorption systems and helps to achieve higher adsorption capacity per unit mass of adsorbent. In recent years, significant number of simulation work has been carriedout to predict the adsorption system dynamic performance under various operating conditions and accommodate design changes efficiently. This paper discusses the basics of adsorption system and also provides a review of different types of adsorption systems.
Keywords: Cooling system, Adsorption system, engine exhaust powered, solar powered

INTRODUCTION

The use of air conditioners has become almost essential in homes, office, car, I.T Industries, theatre and almost everywhere as it provides more comfortable conditions and improves thermal comfort and indoor air quality. The compressor used in the air conditioning system needs electrical energy and the production of the electricity has an environmental impact, including the release of greenhouse gases. The air conditioning system used in the automobile consumes around 3kW of the engine's power and hence increases the vehicle fuel consumption. Also CFCs, HCFCs and HFCs based refrigerants used in the air conditioning contribute to global warming and also cause ozone layer depletion.

In conventional refrigeration or air-conditioning system, compressor is used to transfer heat from low indoor to the outdoor. The working fluid used in this system is called as refrigerant and it undergoes phase change during heat transfer. During compression process, the refrigerant's pressure and temperature increases and the refrigerant rejects heats to the surrounding and changes it phase from vapour phase to liquid phase. However, the pressure of the refrigerant is high. This liquid refrigerant undergoes expansion from higher pressure to lower pressure and simultaneously its temperature reduces. This low temperature refrigerant goes to the evaporator and absorbs the heat from the indoor and becomes vapour. This low pressure refrigerant goes to the compressor and the cycle repeats. The refrigeration and air conditioning systems are most widely used in the domestic, commercial and industrial applications. Also, the demand of the refrigeration systems are increasing day by day due to change in lifestyle and increase in income level of the families. However the use of refrigeration systems with conventional refrigerants increases the ozone depletion and also increases the global warming. This leads to new environmental regulations which encourage research work in finding suitable refrigeration systems which will be more eco-friendly, cost effective, simple and reliable. Among the different alternative cooling systems, adsorption cooling system is getting popular as it a thermal energy driven system and we can use waste heat or solar energy.

ADSORPTION COOLING SYSTEMS

Adsorption is the process by which molecules of a fluid are fixed on the walls of a solid material. The adsorbed molecules undergo no chemical reaction

but simply lose energy when being fixed to the adsorption bed resulting in an exothermic energy output. The vapour compression refrigeration system consists of a compressor, a condenser, an expansion valve, and an evaporator. In adsorption system, the compressor is replaced by a thermal compressor which is operated by heat instead of mechanical energy. The vaporised refrigerant is adsorbed in the pores of the adsorbent in the reaction chamber. Due to the loading of the adsorbent, the thermal compressor is operated intermittently.

A simple adsorption system consists of desorption chamber (solid adsorbent bed), condenser, adsorption chamber and evaporator. In few systems, valves are used between the various components and some utilize expansion valves between the condenser and the evaporator. Figure 1 shows the adsorption system. 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, the valve between the evaporator and the absorber is closed and 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.

Adsorption refrigeration system uses solid adsorbent beds to adsorb and desorb a refrigerant in order to obtain cooling effect. These adsorbent beds filled with solid material adsorb and desorb a refrigerant vapour in response to changes in the temperature of the adsorbent. The adsorbent bed desorbs refrigerant when heated and adsorb refrigerant vapor when cooled [1].

A basic adsorption cycle consists of four thermodynamic processes which is shown in the vapour pressure diagram, Figure 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.

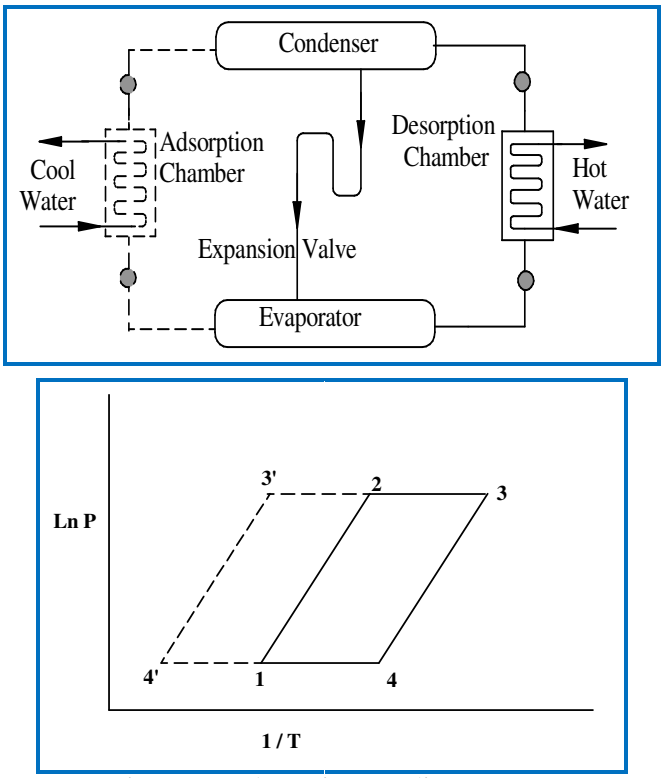

Figure 1. Adsorption Cooling System

Heating, Desorption and Condensation (2-3)

The adsorber continues receiving heat and the desorption process starts from the point 2 and the refrigerant is condensed at a constant pressure in the condenser. The desorption process proceeds until the adsorbent temperature reaches the maximum available desorption temperature and the refrigerant uptake reaches the cycle minimum uptake and end of this process is represented as state point 3. This process is similar to condensation in vapour compression refrigeration system.

Cooling and Depressurization (3-4)

After this process, desorption chamber is cooled and the adsorbent is pre-cooled and becomes able to adsorb refrigerant vapour. This results in decreasing the system pressure, from condenser pressure to the evaporator pressure, without changing the refrigerant uptake within the adsorbent. When the adsorber heat exchanger is further pre-cooled a portion of the previously desorbed and condensed refrigerant is adsorbed and the latent heat of vaporization is drawn from the remaining liquid refrigerant in the evaporator. 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.

Cooling, Adsorption and Evaporation (4-1)

The adsorber continues releasing heat while being connected to the evaporator. The adsorbent temperature continues decreasing, which induces

adsorption of vapor. This adsorbed vapor is vaporized in the evaporator. The evaporation heat is supplied by the heat source at low temperature. The adsorption process, within which the cooling effect is produced, starts from state point 4and proceeds by further cooling the adsorber–desorber heat exchanger until the whole amount of refrigerant is evaporated upon removing the cooling load from the surrounding space (refrigerator's cabin) and adsorbed in the adsorbent. This is equivalent to the "evaporation" in compression cycles. Line 3' to 4' represents the saturation line.

The processes in loop of 1-2-3'-4' is the refrigeration cycle and the processes in loop of 1-2-3-4 is the adsorption cycle which represents the conditions of adsorbent. The basic adsorption cooling system is not a continuous one. An adsorption bed is charged with refrigerant at low temperature and pressure; when adsorption slows down or stops, the adsorption bed is heated and high temperature and pressure gas is released from the bed. To obtain a continuous cooling effect from an adsorption refrigeration system normally two or more adsorbent beds are used in the system [2].

WORKING PAIRS

The selection of the adsorbent-adsorbate pair is essential for the successful operation of adsorption system. The commonly used adsorption pairs are, silica gel – water, zeolite – methanol, zeolite-water and activated carbon and ammonia. In adsorption system, the refrigerant is chosen based on its evaporating temperature and pressure, heat capacity, ability to be adsorbed on solid beds and environmental impact. In general, refrigerants with high heat capacity per unit volume and low environmental impact are selected. Water can be used as refrigerant due to its high latent heat of evaporation and non-toxicity. However, its freezing point and low vapour pressure limits its application.

ADVANTAGES OF ADSORPTION SYSTEMS

The advantages of adsorption cooling systems are

1. Waste heat energy or solar energy can be used
2. Needs few moving parts
3. Low maintenance
4. Small quantity of electrical energy consumption is required
5. Negligible ozone layer depletion potential

PERFORMANCE ANALYSIS OF ADSORPTION COOLING SYSTEM

Tso et al has developed an adsorption cooling system with silica gel as the adsorbent and water as the adsorbate. Their adsorption cooling system contains two adsorbers, an evaporator, two condensers, one heating and one cooling water tank. The coefficient of performance of their system was about 0.3, at the desorption temperature of 80 degree C, adsorber cooling water inlet temperature of about 34 degree C, evaporating temperature of 14 degree C and adsorption/desorption phase time of 15 minutes. Ahmed Elsayed et al results showed that water/silica gel produce more cooling capacity compared to ethanol/activated carbon adsorbents. Ahmed Shmroukh et al developed an effective heat and mass transfer processes for the adsorbate to obtain applicable adsorption capacity using fin and tube heat exchanger core and the adsorbate is adhesive over its surface and located as the core of the adsorber. They reported that the activated carbon powder/R-134a pair is highly recommended to be used as adsorption refrigeration working pair as compared to activated carbon powder/R-407c, activated carbon powder/R-507A, activated carbon granules/R-507A, activated carbon granules/R-407c and activated carbon granules/R-134a. This is because of its higher maximum adsorption capacity than the other tested pairs, to produce a compact, efficient and reliable for long life performance adsorption refrigeration system.

Halder and Sarkar developed a refrigeration cycle using activated carbon granules as an adsorbent and carbon dioxide gas as an adsorbate. Their experiment has demonstrated that it is feasible to produce a low temperature using an activated carbon bed for adsorption/desorption of carbon dioxide. Skander et al studied the activated carbon / CO_2 based adsorption cooling cycles using the pressure-temperature-concentration (*P-T-W*) diagram. They simulated the specific cooling effect and the coefficient of performance for the driving heat source temperatures ranging from 30 °C to 90 °C in terms of different cooling load temperatures with a cooling source temperature of 25 °C. They found that the maximum COPs of Maxsorb-CO_2 and ACF(A10)-CO_2 based cooling systems are found to be 0.15 and 0.083, respectively.

Jribi et al studied the possibility of using CO_2 as the refrigerant for the adsorption cooling systems due to the system compactness and the ability to operate with low driving heat source of 80°C which could be obtained from waste heat or solar energy. They developed and studied the adsorption uptake of CO_2 on highly porous activated carbon of type Maxsorb III, for temperatures ranging from -18 to 80°C and for pressure up to 10 MPa. The two-stage adsorption refrigeration cycle allows the system operation at relatively lower regeneration temperatures and the COP of the two-stage cycle is found to be higher than that of the single-stage cycle for these low regeneration temperatures typically between 50 and 77 degree C. However, the performance of the single-stage is higher than that of the two-stage cycle for regeneration

temperature above 77 degree C. The maximum COP obtained is about 0.16 for evaporation and desorption temperatures of 15°C and 80°C, respectively. Skander et al analysed the dynamic behavior of a 4-bed adsorption chiller using highly porous activated carbon of type Maxsorb III as the adsorbent and R1234ze, as the refrigerant. The simulated results shows that, with 80 kg of Maxsorb III, the system is able to produce 2 kW of cooling power at driving heat source temperature of 85 °C which can be obtained from waste heat or solar energy.

Lu et al studied the feasibility of improving the performance of the adsorption refrigeration of $CaCl_2$–ammonia adsorption system, by distributing activated carbon uniformly in the mass of $CaCl_2$, thereby helping to enhance mass transfer and uplift the cooling power density. They designed and used a multifunctional heat pipe adsorption refrigerator, in which activated carbon-$CaCl_2$ is used as compound adsorbent and ammonia as refrigerant. They used water and acetone as the working liquids in the heat pipe.

Abdual Hadi et al investigated charging and the influence of the key variables on the performance of a 1.5 tons capacity two bed adsorption chiller with activated carbon-methanol as the adsorption pair. The beds functions as methanol generators and the need of using of two generators is to build a nearly continuous adsorption-desorption cycle. The adsorption chiller was driven by hot water, with a temperature range of 70 to 100 degree C. They reported that the COP of this adsorption chiller was about 0.301, at an outdoor temperature of 25 degree C. They reported that the Two beds adsorption unit can give continue cooling effect and suggested that, using the mass recovery process increases the pre desorption concentration, of methanol, in the desorption generator, and hence, improving the cycle COP.

Branka et alreported that the active carbon hollow fibers compared to classic active carbon possess higher ratio of geometric area to volume which improves the heat and a mass transport. Nawel and Hacene reported that the activated carbon can be produced from carbonized olive stones in presence of argon in the temperature range from 700 to 800 degree C and can be activated by $ZnCl_2$ and KOH. Wang et al developed two heat-regenerative adsorption systems, one for ice-making and another for air conditioning. They used activated carbon-methanol adsorption pair and the cycle time is short for the both systems. They also reported that the adsorption systems are capable of producing ice of capability of 6 kg ice per kg-adsorbent per day. Baiju & Muraleedharan determined the adsorption and desorption characteristics of two activated carbon–methanol and activated carbon–R134a, experimentally. Their work shows that the maximum adsorption capacity of activated carbon–R134a working pair is 1.21 times that of activated carbon–methanol.Astina and Bun Kisa,performed experiments on adsorption refrigeration system using activated carbon and propane as the working pair. Two adsorption beds are used to make the refrigeration system working continuously. Each adsorption bed is filled with activated carbon around 2 kg, and refrigerant 0.4 kg. From the experimental results, they reported that the adsorption refrigeration system provides coefficient of performance, cooling capacity and cycle time around 0.15, 50 kJ and 3h30 min, respectively.

Ramji et al simulation results shows that activated carbon-water pair produced the best cooling compared to activated carbon-methanol and activated carbon-ammonia working pairs. The methanol and ammonia showed a COP of 0.37 and 0.4, respectively. The cooling capacity for methanol and ammonia showed a value of 0.65 kW and 0.50 kW, respectively. Tamainot et al developed a model based on the adsorption equilibrium equations of the adsorbent-refrigerant pair and heat flows. The simulation results of 26 various activated carbon-ammonia pairs for three cycles (single bed, two-bed and infinite number of beds) are developed at typical conditions for ice making, air conditioning and heat pumping applications. The driving temperature varies from 80 to 200 degree C. The carbon absorbents investigated are mainly coconut shell and coal based types in multiple forms: monolithic, granular, compacted granular, fibre, compacted fibre, cloth, compacted cloth and powder. Considering a two-bed cycle, the best thermal performances based on power density are obtained with the monolithic carbon KOH-AC. With a driving temperature of 100°C, the cooling production is about 66 MJ m-3 (COP=0.45) and 151 MJ m-3 (COP=0.61) for ice making and air conditioning respectively; the heating production is about 236 MJ per m^3.

CONCLUSIONS

The adsorption air conditioning designed in this work still has some key problems. It requires a high welding technique to keep a high vacuum level in the chambers. The leakage from the exhaust gas flow side to the air flow side in the air/gas switch system is difficult to be avoided. The heat transfer from the heated adsorber to the condenser and even to the evaporator through the heat conduction of the metallic shell cannot be avoided. The adsorber, the condenser and the evaporator are in one vacuum chamber and are not separated in the vapour channel from each other, and so, condensing may occur in the evaporator. Therefore,

more refrigeration power loss is generated. Further improvements are undergoing at present.

present a detailed review on the past efforts in the field of solar refrigeration systems. A number of attempts have been made by researchers to improve the performance of the solar powered adsorption subsystems. It is seen that, for successful operation of such systems, a careful selection of the adsorbent-adsorbate pair is essential apart from the collector choice, system design and arrangement of subsystems.

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CALCULATION OF DIELECTRIC PARAMETERS BASING ON MEASURED ELECTRICAL PARAMETERS

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Abstract: Determination of dielectric properties can provide the electrical or magnetic characteristics of the materials, which useful in many research and development fields improving design, processing, quality and control of product. Many different measurement methods have been developed, but most of them are limited in used frequency and properties of the examined material. At University of Szeged measuring equipment was developed. Measuring method we used is based on reflection method. There are four diodes detecting electrical signs. From these electrical parameters dielectric properties can be determined.
Keywords: dielectric parameters, reflection method, standing wave ratio

DIELECTRIC PARAMETERS

The material making up atoms, molecules are generally electrically neutral, uncharged (except eg. ionic crystals) but their position is not necessarily symmetrical. The centre of gravity of positive and negative charges does not coincide in several molecule, these are polar molecules having permanent electric dipole moment. Without an electric field these moments are placed completely irregularly extinguishing the effect of each other. Symmetrical molecules are non-polar molecules their electric dipole moment is zero. Asymmetric charge distribution is formed, electric dipole moment is induced in the initially symmetrical, non-polar molecules and direction of dipole moment of initially polar molecules is changed by electric field. Dipole moment induced in non-polar molecules can be occurred by two reasons, on the one hand the electron cloud moves relative to the nucleus (electron polarization), on the other hand, the nucleus moves in relation to one another (atomic polarization). In both cases induced dipole moment of the molecule is proportional to the actual local electric field strength. In case of polar molecules a new effect orientation polarization is added to atomic and electron. For studying the dynamics of polarization put the material in harmonically time varying electric field. Using low frequency polarization emerging in the material is in phase with the electric field but in case of quite high frequency polarization isn't able to follow the changes of electric field, behinds in phase and the value of it is reduced as well. Formally it can be described that permittivity is a complex number. [1]

$$\varepsilon = \varepsilon' - \varepsilon'' \cdot j \qquad (1)$$

ε' is the real, ε" is the imaginary part of the complex permittivity. The real part of permittivity is a measure of how much energy from an external electric field is stored in a material. The imaginary part corresponds to the polarization lagging 90° to the electric field. Changing over time it causes displacement current which is in phase with electric field. It means that the material takes up energy from the electric space. Because of it ε" is called dissipation or loss factor. It is a measure of how dissipative or lossy a material is to an external electric field. The imaginary part of permittivity is always greater than zero and is usually much smaller than the real part. The loss factor includes the effects of both dielectric loss and conductivity.

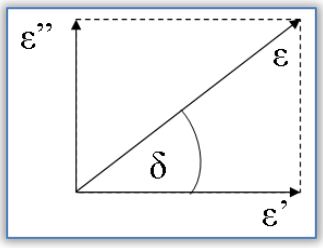

Figure 1. Loss tangent vector diagram

Drawing complex permittivity in a simple vector diagram (Figure 1) the real and imaginary part are 90° out of phase.

The resultant vector forms an angle δ with the real axis (ε'). The relative loss of the material can be defined as the ratio of the energy lost to the energy stored. It is called tangent loss.

$$tg\delta = \frac{\varepsilon''}{\varepsilon'} \qquad (2)$$

TRANSMISSION LINES

Transmission lines are specially designed electrically conducting wires transmitting high-frequency alternating current with low power loss. On a transmission line the voltage and current vary along the structure in time and distance as indicated in Figure 2.

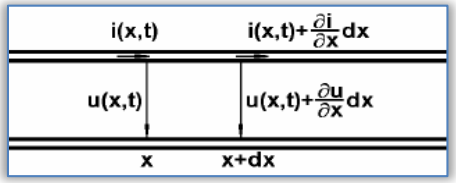

Figure 2. A very short piece of a transmission line

The following distributed parameters characterize the circuit properties of a transmission line.

R = resistance per unit length, (Ω/m) (due to losses in conductors)

L = inductance per unit length, (H/m) (due to current in conductors, and magnetic flux linking current path)

G = conductance per unit length, (S/m) (due t losses in dielectric, between conductors)

C = capacitance per unit length, (F/m) (due to time varying electric field, between the two conductors)

x= increment of length, (m)

Developing the equations for I(x,t) and U(x,t) we need to represent transmission line as a series connection of many small cells containing series inductors and resistors, and parallel capacitors and resistors, as in Figure 3.

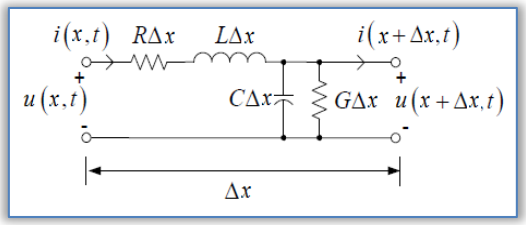

Figure 3. Circuit-theory approximation of a transmission line with losses

Using Kirchoff's laws for this section of transmission line:

$$u(x,t) - R\cdot\Delta x\cdot i(x,t) - L\cdot\Delta x\frac{\partial i(x,t)}{\partial t} - u(x+\Delta x,t) = 0 \qquad (3)$$

$$i(x,t) - G\cdot\Delta x\cdot u(x+\Delta x,t) - C\cdot\Delta x\frac{\partial u(x+\Delta x,t)}{\partial t} - i(x+\Delta x,t) = 0 \qquad (4)$$

If $\Delta x \to 0$, these lead to following equations:

$$-\frac{\partial u(x,t)}{\partial x} = Ri(x,t) + L\frac{\partial i(x,t)}{\partial t} \qquad (5)$$

$$-\frac{\partial i(x,t)}{\partial x} = Gu(x,t) + C\frac{\partial u(x,t)}{\partial t} \qquad (6)$$

In case of sinusoidal varying voltages and currents:

$$-\frac{dU(x)}{dx} = R\cdot I(x) + j\cdot\omega\cdot L\cdot I(x) = (R + j\cdot\omega\cdot L)\cdot I(x) \qquad (7)$$

$$-\frac{dI(x)}{dx} = G\cdot U(x) + j\cdot\omega\cdot C\cdot U(x) = (G + j\cdot\omega\cdot C)\cdot U(x) \qquad (8)$$

After decoupling we get the transmission line equations:

$$\frac{dU^2(x)}{dx^2} = \gamma^2\cdot U(z) \qquad (9)$$

$$\frac{dI^2(x)}{dx^2} = \gamma^2\cdot I(z) \qquad (10)$$

where γ is the complex propagation constant given by

$$\gamma = \alpha + \beta\cdot j = \sqrt{(R + j\cdot\omega\cdot L)(G + j\cdot\omega\cdot C)} \qquad (11)$$

Its real part α is the attenuation constant (Np/m) and its imaginary part β is the phase constant (rad/m). Generally, these quantities are functions of ω.

When a transmission line is terminated by an impedance that does not match the characteristic impedance of the transmission line, part of the incident signal is reflected back down the transmission line. The forward signal mixes with the reverse signal to cause a voltage standing wave pattern on the transmission line. The ratio of the maximum to minimum voltage is known as Voltage Standing Wave Ratio (VSWR). [2]

$$r = \frac{U_{max}}{U_{min}} \qquad (12)$$

If the signals from the diode detectors are quadratic, as is typical, the standing wave ratio will be:

$$r = \sqrt{\frac{U_{max}}{U_{min}}} \qquad (13)$$

The solutions to transmission lines equations are superposition of forward and reverse waves:

$$U(x) = A\cdot e^{-\gamma x} + B\cdot e^{\gamma x} \qquad (14)$$

$$U_f = A\cdot e^{-\gamma x} \text{ (forwarded travelling wave)} \qquad (15)$$

$$U_r = B\cdot e^{\gamma x} \text{ (reflected travelling wave)} \qquad (16)$$

A and B are complex vectors. The ratio of the reflected and the forwarded travelling wave is the voltage reflection coefficient.

$$\Gamma = \frac{U_r}{U_f} = \frac{B\cdot e^{-\gamma l}}{A\cdot e^{\gamma l}} = \frac{B}{A}e^{-2\gamma l} = \Gamma_0 e^{-2\gamma l} = |\Gamma|e^{j\varphi} \qquad (17)$$

The maximum of the amplitude of the standing wave is formed in the transmission lines where the two waves are added and the minimum of the amplitude is where the two waves are deducted. [1]

$$r = \frac{U_{max}}{U_{min}} = \frac{|A| + |B|}{|A| - |B|} \qquad (18)$$

The relationship between VSWR and reflection coefficient is the following:

$$|\Gamma| = \frac{r-1}{r+1} \qquad (19)$$

MEASURING DEVICE

A water cooled magnetron is located at the left side of the measurement unit. The operating frequency of it is 2450MHz ± 30MHz. Output power from the generator (magnetron) enters into the transmission line as form outrivaling wave. The transmission line is a length of about $3\lambda_g$ (where λ_g is the wavelength in the waveguide) rectangular cross-section waveguide with diode detectors placed in specific locations. Sample holder is located in a sufficient distance from the detectors.

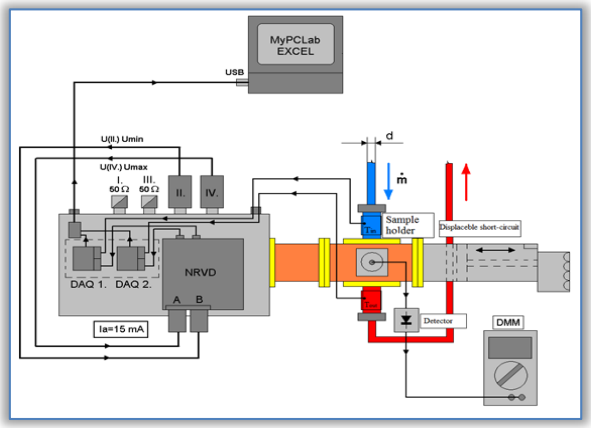

Figure 4. Measuring device

A specially formed reflecting surface can be found at the end of the waveguide from which the incident waves are reflected. The position of short-circuit can be changed. Electromagnetic waves pass through the sample, it modifies wave front emerged in the waveguide and absorbs electromagnetic energy. Reflected waves interfere with forwarded waves and so a special waveform is created in the waveguide by two important factors. One of them is the sample which changes the electromagnetic field; it is polarized and dissipates energy from electromagnetic field. The other is the position of the reflecting surface which affects the phase of the reflected wave. These diodes detect the resultant field strength of the forwarded and reflected waves. Electric signal of the dielectrometer, the inlet and outlet temperature of the material are received by the measurement data collector and recorded on-line by software and displayed in the computer screen.

EVALUATING METHODS

Method 1.

From Maxwell's equations that in the case of a plane wave complex amplitudes of vectors **E** and **H** are linked characteristic impedance of the medium:

$$Z_L = \frac{\omega\mu_a}{\gamma} = \sqrt{\frac{\mu_a}{\varepsilon_a}} \qquad (20)$$

so that the characteristic impedance for the non-magnetic environments ($\mu_a = \mu_0$)

$$Z_L = \frac{\dot{E}}{\dot{H}} = \frac{\sqrt{\frac{\mu_0}{\varepsilon\varepsilon_0}}}{\sqrt{1-jtg\delta_\varepsilon}} = \frac{\frac{120\pi}{\sqrt{\varepsilon}}}{\sqrt[4]{1+tg^2\delta_\varepsilon}} e^{j\frac{\delta_\varepsilon}{2}}, [\Omega] \qquad (21)$$

Given that

$$\varepsilon_a = \varepsilon\varepsilon_0(1-jtg\delta_\varepsilon) \qquad (22)$$

expression of

$$\dot{\Gamma} = \frac{Z_L - Z_0}{Z_L + Z_0} \qquad (23)$$

where

$$Z_0 = \sqrt{\mu_0/\varepsilon_0} = 120\pi = 376{,}99[\Omega] \qquad (24)$$

and $\dot{\Gamma}$-is a complex reflection coefficient, we obtain:

$$\dot{\Gamma} = \frac{1-\sqrt{\varepsilon}(1-jtg\delta_\varepsilon)^{\frac{1}{2}}}{1+\sqrt{\varepsilon}(1-jtg\delta_\varepsilon)^{\frac{1}{2}}} \qquad (25)$$

from

$$\frac{1-\dot{\Gamma}}{1+\dot{\Gamma}} = \sqrt{\varepsilon}(\sqrt[4]{1+tg^2\delta_\varepsilon})e^{-j\frac{\pi}{2}} \qquad (26)$$

Substituting this expression in $\dot{\Gamma} = -|\Gamma|e^{-j\varphi}$, equating phases and modules of both sides, we get:

$$\delta_\varepsilon = 2\left\{arctg\left[\frac{|\Gamma|\sin\varphi}{1-|\Gamma|\cos\varphi}\right] - arctg\left[\frac{|\Gamma|\sin\varphi}{1+|\Gamma|\cos\varphi}\right]\right\} \qquad (27)$$

$$\varepsilon' = \frac{1}{\sqrt{1+tg^2\delta_\varepsilon}}\left(\frac{1+|\Gamma|^2+2|\Gamma|\cos\varphi}{1+|\Gamma|^2-2|\Gamma|\cos\varphi}\right) \qquad (28)$$

$$\varepsilon'' = \varepsilon' tg\delta_\varepsilon \qquad (29)$$

Method 2.

The transmission-line method (TLM) belongs to a large group of nonresonant methods of measuring complex dielectric permittivity of different materials in a microwave range [3,4]. Several modifications to this method exist, including the free-space technique [5], the open-circuit network method (see previous section), and the short-circuited network method.

Usually three main types of transmission lines are used as the measurement cell in TLM: rectangular waveguide, coaxial line, and microstrip line. Analyzed sample is placed near the short-circuited end of transmission line. The dielectric properties of the sample are determined using the following expressions:

$$\varepsilon' = \left(\frac{\lambda}{2\pi d}\right)^2 (x^2 - y^2) + \left(\frac{\lambda}{\lambda_{qc}}\right)^2 \qquad (30)$$

$$\varepsilon'' = \left(\frac{\lambda}{2\pi d}\right)^2 2xy \qquad (31)$$

where λ is the free-space wavelength, λ_{qc} is the quasicutoff wavelength, d is the sample thickness

x=Re(Z_{in}), and y=Im(Z_{in}), Ţ, and Z_{in} is the input impedance of the short-circuited line:

$$Z_{in} = \frac{K_t^2 + tg^2\left(\frac{2\pi}{\lambda_g}1\right)}{K_t\left[1 + tg^2\left(\frac{2\pi}{\lambda_g}1\right) + j\left(1 - K_t^2\right)tg\left(\frac{2\pi}{\lambda_g}1\right)\right]} \quad (32)$$

where 1 is the distance between the dielectric surface and the first minimum of the standing wave, λ_g is the wavelength in unloaded part of transmission line, and K_t is the travelling-wave coefficient that is calculated when $K_t \geq 0.4$ as

$$K_t = \sqrt{\frac{E_{min}}{E_{max}}} \quad (33)$$

where E_{min} and E_{max} are the minimum and maximum values of electric field amplitude.

Method 3

Many aspects of wave propagation are dependent on the permittivity and permeability of a material. Let's use the "optical view" of dielectric behaviour. [6] Consider a flat slab of material (MUT) in space, there will be incident, reflected and transmitted waves. Consider a flat slab of material (MUT) in space, with a wave incident on its surface (Figure 5).

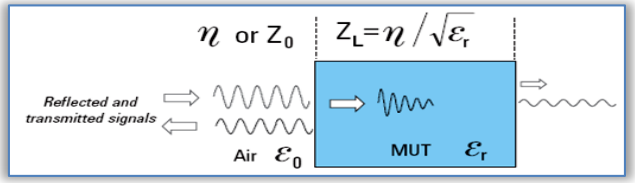

Figure 5. Reflected and transmitted signals

Since the impedance of the wave in the material Z is different (lower) from the free space impedance η (or Z_0) there will be impedance mismatch and this will create the reflected wave:

$$Z_L = \frac{\eta}{\sqrt{\varepsilon_r}} \quad (34)$$

impedance lower, where

$$\eta = Z_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}} = 120\pi \quad (35)$$

Part of the energy will penetrate the sample. Once in the slab, the wave velocity v, is slower than the speed of light c:

$$v = \frac{c}{\sqrt{\varepsilon_r}} \quad (36)$$

The wavelength λ_{MUT} is shorter than the wavelength λ_g in the waveguide according to the equations below:

$$\lambda_{MUT} = \frac{\lambda_g}{\sqrt{\varepsilon_r}} \quad (37)$$

Since the material will always have some loss, there will be attenuation or insertion loss. From these, it follows that

$$\sqrt{\varepsilon_r} = \frac{Z_0}{Z_L} \quad (38)$$

$$\varepsilon_r = \left(\frac{Z_0}{Z_L}\right)^2 \quad (39)$$

and since

$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} \quad (40)$$

this may transform the last expression as follows:

$$\varepsilon_r = \left(\frac{Z_0}{Z_L}\right)^2 = \left(\frac{1+\Gamma}{1-\Gamma}\right)^2 \quad (41)$$

where $\Gamma = |\Gamma|e^{j\varphi} = |\Gamma|(\cos\varphi + j\sin\varphi)$, and $|\Gamma| = \frac{r-1}{r+1}$

SUMMARY

Same electrical parameters are needed to measure in all three evaluation methods, the differences are in the way of evaluation. In case of Method1 from electrical parameters Voltage Standing Wave Ratio, phase shift, and voltage reflection coefficient are counted. Dielectric parameters can be determined on their basis. In case of Method2 travelling-wave coefficient is calculated first, then impedance of the short-circuited line and its real and imaginary part can be determined. According to these and the geometry of the waveguide dielectric parameters are determinable. In case of Method3 Voltage Standing Wave Ratio, phase shift, and voltage reflection coefficient are counted as in Method1, but on their basis complex permittivity can be determined. For comparing the three methods, experiments with materials having well-known dielectric parameters are needed to perform.

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DEVELOPMENT OF AUTOMATED TEST MEASUREMENT SYSTEM FOR DETERMINING LOW PASS FILTER CUT-OFF FREQUENCY

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Abstract: Automated test and measurements systems provides autonomic computation of data that gives high accuracy, efficiency, resolution and precision in the measurement task. This paper presents the development of an automated test and measurement system to determine cut-off frequency of low pass filter. The software coding was carried out in the LabVIEW programming environment and appropriate hardware were setup to conduct test on series of low pass filter to validate the developed system. The test result shows high degree of accuracy which was validated via manual approach to confirm the effectiveness of the developed system.
Keywords: low pass filter, cut-off frequency, measurement, automation

INTRODUCTION

Filters are device that passes electrical signals at certain frequencies or frequency ranges and attenuate other frequencies. Filters are used in electronic circuit to remove unwanted components such as noise or interference from a processing signal [1]. They are broadly classified as linear or nonlinear, time variant or time invariant, analogue or digital, infinite pulse response or finite pulse response, and as passive or active filters [2]. In electrical electronics system applications, the design accuracy of filters to meet specific requirement is culminated by checking the filter frequency response via measurement test for the design validation. The accuracy in determining a filter cut-off frequency ensures that unwanted signal are perfectly removed from the processing signal of interest without attenuation. In sensitive application like communications that requires noise cancellations in modem, filters frequency response is vital due to closeness of noise and processing signal frequencies [3]. Considering the importance of filtering in signal processing for improved system performance, this work is focused on development of automated test measurement system for determining low pass filter (LPF) cut-off frequency that are commonly used in audio application to drive subwoofers.

The process of automation is regarded as a method of transferring engineering knowledge into machines that interprets commands and subsequently performs a task as programmed. Automated measurement systems are characterised with the ability to optimize their own behaviour on different platforms without human intervention to deliver high degree accuracy at shortest possible time [4, 5]. In this work, the basic structure of the automated measurement system consists of the controller and measurement instruments that communicates through GPIB, RS232, and RS432 channels. The developed automated test system for determining the cut-off frequency of a low pass filter has the advantages of high speed measurement, repetitive test ability, high accuracy, and the usage does not require special skill.

METHODS FOR DETERMINING CUT-OFF FREQUENCY

Low-pass filter (LPF) passes signals below the designed cut-off frequency and attenuate higher frequency signals. All the frequencies below the cut-off (f_c) point are unaltered with little or no attenuation [2, 6]. Low-pass filter exists in many forms like electronic circuits such has hiss filter for driving audio subwoofers and loudspeakers. They can also be digital algorithms for smoothing sets of data, acoustic barriers, blurring of images [7]. In low frequency applications up to 100 kHz, passive filters are usually built from simple RC (Resistor-Capacitor) networks while higher frequency filters above 100 kHz are based on RLC (Resistor-Inductor-Capacitor) components. Figure 1 shows a first order low pass RC-filter made of a single resistor and a capacitor in

series across an input signal (V_{in}) with the output signal, (V_{out}) taken from the junction of the two components. As the input signal passes through the circuit, the high frequencies signal will be attenuated and only the signal below cut-off frequency of the filter determined by the RC time constant τ get to the output signal V_{out} .

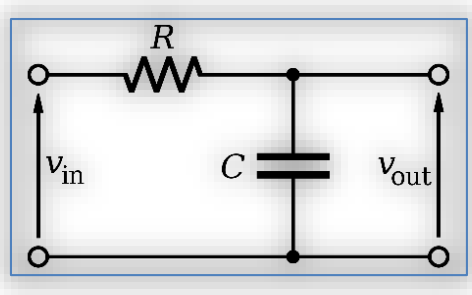

Figure 1. RC Low pass filter

The capacitor reactance of an ac circuit is given by:

$$X_c = \frac{1}{2\pi f}\Omega \tag{1}$$

And the impedance Z opposing the current flow from the input in the circuit (Figure 1):

$$Z = \sqrt{R^2 + X_c^{\,2}} \tag{2}$$

The circuit voltage gain is defined by (3),

$$Gain = \left(\frac{V_{out}}{V_{in}}\right)^2 = \frac{1}{1 + R^2 4\pi^2 f^2 c^2} \tag{3}$$

The cut-off frequency of the low pass filter f_c is defined as the frequency point where the capacitive reactance and resistance are equal, $R = X_c$

$$f_c = \frac{1}{2\pi RC} \tag{4}$$

Therefore,

$$Gain = \left(\frac{V_{out}}{V_{in}}\right)^2 = \frac{1}{1 + 4\pi^2 f^2 c^2 . \frac{1}{4\pi^2 f_c^2 c^2}} \tag{5}$$

$$Gain = \frac{V_{out}}{V_{in}} = \frac{1}{\sqrt{2}} = 0.7071 \tag{6}$$

The popular methods used for determining the cut-off frequency of LPF includes graphical method, phase shift method, and the frequency scanning method. The graphical method involves plotting the gain in decibel (db) against the frequency. The frequency is varied from lower value to the higher value and as the frequency increases as the output voltage (V_{out}) decreases from the initial maximum value to lower value. The gain is calculated from the ratio of the input to output voltage which is plotted against the frequency and the cut-off frequency is defined as the point of 0.7071 which correspond to -3dB of the gain amplitude as shown in Figure 2 [7].

$$Gain(\text{db}) = 20\log\frac{V_{out}}{V_{in}} \tag{7}$$

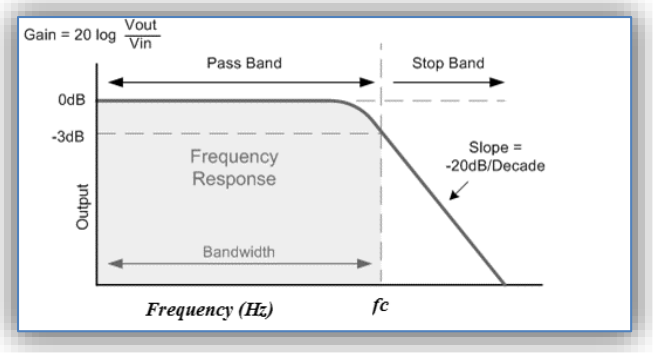

Figure 2. Frequency response of a LPF

The Phase shift method uses bode plot of phase angle against the frequency to determine LPF cut-off frequency. RC low pass filter has capacitor that charges and discharge making the phase angle (Φ) of the output signal V_{out} to lags behind the input voltage V_{in} due to the time taken to charge the plates of the capacitor as the input voltage changes. At -3dB gain amplitude which is the cut-off frequency (f_c) point, the output voltage is -45° out of phase as shown in Figure 3.

$$Phaseshift(\Phi) = -\arctan(2\pi\, fRC) \tag{8}$$

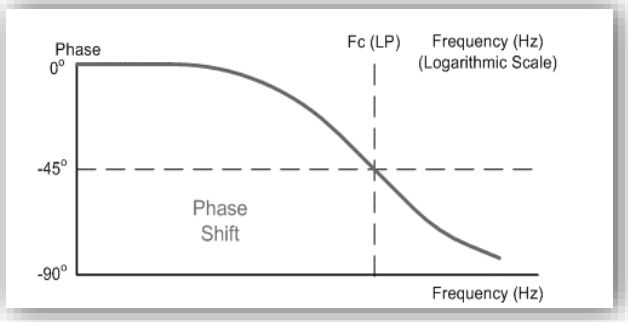

Figure 3. Bode plot of a LPF frequency response

The third method is the frequency scanning method. As the name implies, LPF cut-off frequency is determine by scanning filter frequency from higher to lower range. By scanning frequency to the input voltage at an interval, a technique for monitoring the gain is put in place to indicate when the ratio of the output to the input voltage is equal to 0.7071 which correspond to cut-off frequency (eqn. 6). This method is considered a fast method as compare to earlier discussed ones but it demands careful selection of measurement instruments. Also, the choice of frequency scanning rate must be well consider not to compromise the accuracy in the measurement. A highly sensitive comparator should be use to determining the point of equality between the gain from output to input voltage at the pre determine value of 0.7071. This method is mostly

used in automated test and measurement systems owing to the advantages of fast, accurate and repeated measurement.

TEST AND MEASUREMENT TASK

The task of developing an automated test and measurement system to determine the cut-off frequency of a low pass filter involves an application of computer software program with the appropriate hardware set-up. The software part of the process was achieved using the LabVIEW graphical programming. Set of instructional code developed to communicate with the programmable instrument. The selected instrument for the measurement task are programmable and capable of receiving instructions from computer at fast speed.

Software development

LabVIEW programming software was used to developed set of instructional code to communicate with the programmable instruments. The software part of the measurement task automatically determine the cut-off frequency of low pass filter write the readings and saved on spreadsheet file for further analysis. The frequency scanning approach was adopted in developing the software programme and it covers the filter frequency range of between 50Hz – 10 KHz. This programme has four (4) loops as shown in Figure 4. The input frequency varies from one loop to the next loop where it is scale down to a range within which the cut-off frequency falls until it reaches the exact value. The programme start running from the first loop, as the frequency increases the gain from output to input voltage decreases until the condition of the comparator which is less than or equal to voltage gain of 0.7071 (voltage gain at cut-off frequency) is satisfy before the loop passes the process to the next loop. The measurement result is automatically display and saved in a file path. In the first loop frequency was scanned at the rate of 1000Hz and scaled down to 100 Hz in second loop. The third loop increment the frequency by 10 Hz each time the loop run and loop 4 finally scale it down to 1 Hz to achieve better resolution on the measurement.

The major elements in each loop are the GPIB read that reads byte count number from the GPIB device and GPIB write for writing data to the GPIB device identified by address string. There is a build text block used to create an output string from combination of inputs number entering it from iteration counter of the while loop and case structure. Prompt user interface displays as shown in Figure 5 is a dialog interface that prompts users to enter information about filter to be tested such as a user name or serial number. The write to measurement file save the measurement data to spreadsheet file for easy data management. The PXI controller house the software and provided the platform from where the system can be run to determine the cut-off frequency of the low pass filter and displayed on the screen.

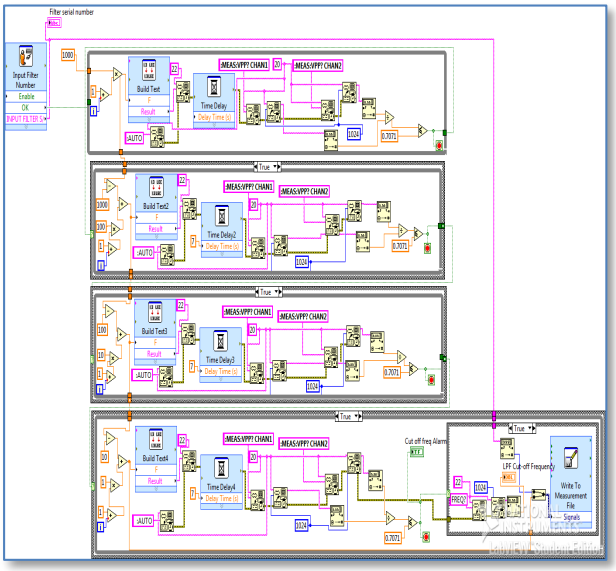

Figure 4. LabVIEW block diagram

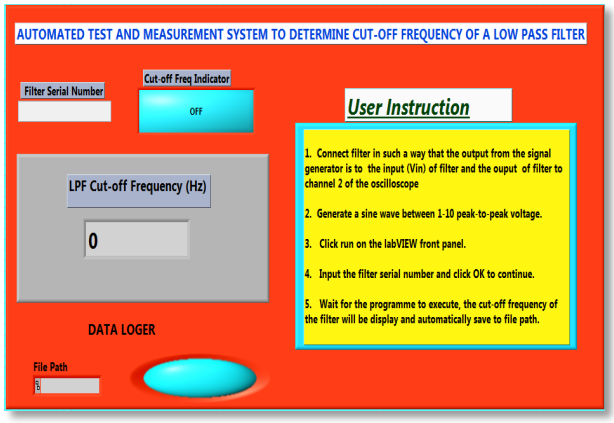

Figure 5. GUI Front Panel

Hardware Setup

The hardware set-up involves the use of programmable instruments that receive instructions from computer and provides the desire output signals with barest attenuation. The IEEE-488 General Purpose Interface Bus (GPIB) connector was used as communication channel between the instruments and NI-PXI computer with E-series data acquisition card to satisfy the high speed data transfer requirement in the automated system. NI-PXI PC-based platform is a Peripheral Component Interconnect (PCI) specially designed to offers a high-performance and low-cost deployment solution for measurement and automation systems [8].

The hardware components connection is shown in Figure 6, GPIB interface bus was used to connect the signal generator to the oscilloscope and also to the PXI. The output channel of the signal generator is connected to low pass filter (LPF) and the output peak-peak voltage from the filter is monitor on channel 2 of the oscilloscope. The application

software programming on the PXI controller determines the cut-off frequency from the output voltage of the low pass filter read from the oscilloscope.

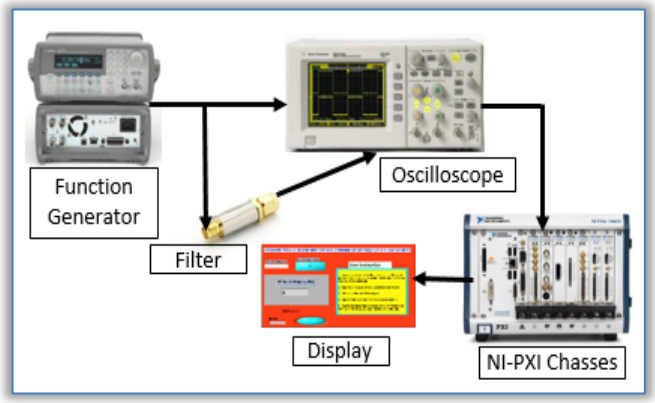

Figure 6. Hardware set-up for automation measurement

RESULT ANALYSIS AND DISCUSSION

An automation test and measurement system to determine the cut-off frequency of low pass filter was implemented using LabVIEW graphical programming language with appropriate hardware setup. The system was used to measure the cut-off frequency of low pas filter with serial number LPF23 and series of measurement was also carried out on 5 other different filters.

Automated Test on LPF23 Cut-off Frequency

The automated measurement system was used to automatically determine the cut-off frequency of low pass filter with serial number LPF23, a series of measurement was carried and the result were analysed to determine the performance of the measurement system. The measurement result is presented in Table 1, showing the cut-off frequency against response time for each measurement.

Table 1. Automated test cut-off frequency of LPF23

Cut-off Frequency (Hz)	Time Response (s)
1012	30
1012	30
1012	30
1013	32
1012	30
1015	33
1010	31
1011	30
1013	30
1012	30

Evaluation of Measurement Uncertainty

Measurement systems are susceptible to errors as a result of difference in measurement time and some external factors like environmental impact or changes in operational conditions. Considering the series of cut-off frequency measurement of LPF23 as shown in Table 2, there were little variation in the measured cut-off frequency.

Table 2. Automated test cut-off frequency of 5-LPF

Filter Name	1	2	3	4	5	Estimated cut-off frequency (Hz)
LPF 14 (Hz)	1594	1611	1603	1603	1607	1603
LPF 10 (Hz)	8201	8206	8225	8198	8101	8186
LPF 16 (Hz)	91	89	88	92	91	90
LPF 06 (Hz)	335	337	336	334	336	335
LPF 02 (Hz)	1371	1381	1374	1371	1370	1373

The difference can be averaged by uncertainty computation for random error in the measurement results to determine the true value of the cut-off frequency. The number of measurement (N) is ten and the best estimate of true value of cut-off frequency is calculated as follows:

$$\text{Mean } \bar{x} = \frac{\sum x_i}{N} = 1012.2\text{Hz}$$

The standard uncertainty S_N in the measured values of the cut-off frequency is:

$$S_N = \frac{\sigma_{N-1}}{\sqrt{N}},$$

where σ_{N-1} is population standard deviation

$$\sigma_{N-1} = \sqrt{\frac{\sum (x_i - \mu x)^2}{N-1}} \qquad (9)$$

$$S_N = 0.4163$$

For the expanded uncertainty, by using 95% confidence with the degree of freedom 9, from the student t-table k has a value of 2.26. The limit of uncertainty in the measurement of the cut-off frequency is 0.4163 by 2.26 which is $\pm$ 0.9409 Hz. Therefore, the cut-off frequency of LPF23 low pass filter is 1012.2Hz$\pm$ 0.9409 Hz.

Analytical Approach to Determine LPF23 Cut-off Frequency

In order to validate the designed automated test and measurement system, an analytical method was then used to determine the cut-off frequency of LPF23 filter for comparison. The manual approach involves varying the frequency of the peak-peak input voltage to the filter and the corresponding output voltage are noted. The voltage gain in decibel (db) was computed from peak-peak output voltage and plotted against the frequency. The peak-peak input voltage V_{in} is 10.4V and Table 3 shows the peak-peak output voltage V_{p-p} against different

frequency obtained during the test measurement on LPF23.

Table 3. Peak-peak output voltage V_{p-p} at different frequency

	Frequency (Hz)	V_{p-p} (V)	Gain: $Gain(\text{db}) = 20\log\frac{V_{out}}{V_{in}}$
1	50	10.4	-0.000835142
2	100	10.4	-0.000835142
3	150	10.4	-0.000835142
4	200	10.4	-0.000835142
5	250	10.201	-0.168646976
6	300	10.201	-0.168646976
7	350	10.01	-0.332820378
8	400	9.801	-0.516094144
9	450	9.601	-0.695172534
10	500	9.401	-0.878020874
11	550	9.201	-1.064801313
12	650	8.801	-1.4508615
13	700	8.601	-1.650523
14	750	8.401	-1.8548822
15	800	8.201	-2.0641657
16	850	8.001	-2.2786165
17	900	7.801	-2.4984964
18	950	7.601	-2.7240873
19	1000	7.401	-2.9556938
20	1050	7.201	-3.1936457
21	1100	7.001	-3.4383004
22	1150	6.801	-3.6900464

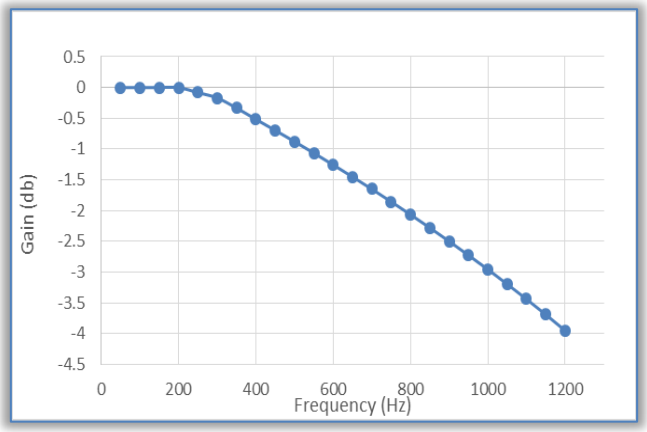

Figure 7. Gain (db) against frequency (Hz)

Due to rigorous of measurement with the manual approach, 22 different measurement was conducted at 50Hz range to reduce the measurement time. Figure 7 shows the plot of voltage gain (db) against frequency (Hz) and the cut-off frequency corresponds to $-3db$ point. In order to read the $-3db$ point accurately from the graph due to large frequency range, the point was interpolated for the corresponding frequency. The cut-off frequency is 1011.59Hz which is very close to averaged value of 1012.2Hz obtained from the automated measurement.

$$\frac{1050 - f_c}{3.1936 - 3.0103} = \frac{f_c - 1000}{3.0103 - 2.955}$$

$$f_c = 1011.59\text{Hz}$$

CONCLUSION

An automated measurement system was successfully developed using LabVIEW programming language as the standard commands for programmable instrument (SCPI) in passing commands to the programmable instruments during the measurement process. Series of measurement were carried out to determine cut-off frequency of low pass filter and the system was found to be accurate and fast for determining the LPF cut-off frequency. The automated test measurement was validated using the manual approach and the two results were almost the same. The automated measurement was achieved in a very short time as compared with the manual approach that was time consuming and it provides for repeated measurement.

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EMBEDDED INTELLIGENT ADAPTRONIC AND CYBER-ADAPTRONIC SYSTEMS IN ORGANIC AGRICULTURE CONCEPT FOR IMPROVING QUALITY OF LIFE

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Abstract: Adaptronics science as scientific and multi-interintegrator strategy is used as a vanguard of opening new possibilities for the design, construction and implementation of innovative products and adaptronics systems. Testing soil and arable land can be improved by adapting existing solutions in different areas. An example is the smart device, drone type that can be used in the testing and monitoring of soil and arable land. Precision agriculture is the key area where drones already proving its economic efficiency. If until now, unmanned aerial vehicles were most often used in military and intelligence area, 2015 was an important year in agribusiness supported by the use of such devices: the price is now accessible and the law clarified some aspects of their detention in civilian purposes. An important aspect is the concept of organic agriculture used to improve quality of life.
Keywords: adaptronic and cyberadaptronic systems, organic agriculture, drones, agribusiness

INTRODUCTION

In a research area defined by many of the biggest challenges faced by specialists in computer science and robotics, today, a big challenge is probably related with creating algorithms and programming language for adaptronic and cyber-adaptronics equipment in order to obtain information and analysis using existing infrastructure. An adaptronic and cyber-adaptronic integrates mechanical, electronic and software components implemented on a PC or MCU to produce a flexible and intelligent performing complex signal and data processing. In many cases, adaptronics and cyber-adaptronics systems can be used to improve the performance of a system beyond what can be achieved using manual or ordinary means. Modern society depends on adaptronics and cyber-adaptronics systems for facilities and luxurious living standard that assures them but also for the accuracy of the information provided by them. From devices to smart safety features in cars (such as air bags and ABS) adaptronics and cyber-adaptronics systems are widely used in everyday life.

STATE OF THE ART

Variety of crop plants growing on different types of soil and prefer a particular type of soil. Soils are characterized by structure, pH, water retention power, structure and chemical composition. Testing the soil and arable land analyzes geotechnical and chemical soil properties, allowing establishing strength, density, compaction, contamination, organic composition and content of sandy soil etc.
Analyses of soil properties helps farmers fiind aut quality of the land used for farming and especially what resources remained unused from fertilizers applied.
In dry years, water shortages may cause some problems with fertilizers and may not solubilize, they remain in the soil and on the following crop may be accessed by plants. As a result the farmer may reduce the dose of fertilizers such as phosphorus or potassium, if they know exactly, from analyzes of soil, which is the content of these elements. Nitrogen nor solubilized not spread deep if we have rain. Then, it is good to know that the nitrogen content of the soil may be higher following the drought, which means that fertilization of spring we apply a smaller amount.
There are companies specialized in soil testing and use various devices: precision balance, digester microwave equipment, conductivity equipment, pH meter, ovens, sipper, spectrophotometer, hammer milled, magnetic stirrer, air-determining ions in the soil, machine for homogenized, device for producing ultrapure water, etc.

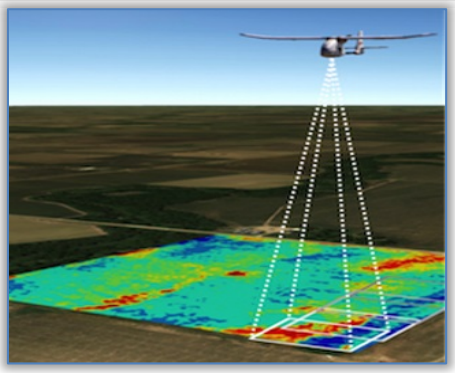

Figure 1: Drone used in agriculture - SLANTRANGE company concept

In Romania: in the last decade, climate change, manifested by periods of drought and flooding, which have become more frequent, occurred on agriculture, resulting in less agricultural production, especially wheat and corn. The data presented in the National Strategic Plan of Romania for the period 2007 - 2013 reveal that due to the high share of cereals (60%) and industrial crops (16.3%) and unfavorable climatic conditions, average grain yields achieved were very low compared to the country average potential (NIS 1998/2003 country level). In the period 1999-2001, the average yield of wheat and rye was 2048 kg/ha, compared with the average country potential of 5500-7000 kg/ha, and the maize production was recorded average of 3,042 kg/ha corn, compared with the average country potential of 8000 kg / ha (NIS 1998/2003 country level) (NIS 1998/2003). Of arable land in Romania prepared for irrigations (2,871 million ha, of which until 2003 were rehabilitated 1.5 million ha (hectares rehabilitated) in 1998-2003 were actually irrigated (at least a watering) between 15,6 and 37,9% of the rehabilitated surface (OECD - 1998/2003 NUTS III), due to lack of irrigation equipment and failure to achieve adequate structures of potentially irrigated crops in optimal conditions.

Due to the fact that Romania is the category of countries poor in water resources, with an average of only 2660 m^3 / place / year (excluding water from the Danube), compared to the average of 4000 m^3 / year / in Europe, and the uneven spatial and temporal distribution requires a well-controlled management and use of this resource, and also the use of all methods (agro-technical, crops structures with genotypes drought-tolerant) for maintaining the stability of crops and agro-ecosystem biodiversity. Moldavian Plain are characteristic of precipitation as rain, which meet in April - May and their uneven distribution during the year.

Multi data from the study found say that every two years droughts can last for 28 days, every ten years can last 42 days, and in five cases out of a hundred, drought can last 48 days. Water scarcity is felt acutely on slopes, where torrential rains favor erosion and reduces the amount of water infiltrated, according to terrain with slope and permeability of 20-75 mm. Actual evapotranspiration is 500 mm, recorded a deficit of 242 mm from June to October. This risk from desertification and drought are amplified due to uneven distribution of water resources and the insufficient flow regularization on watercourses. Process Modeling Training crops in sustainable agriculture systems by controlling all entrances and exits of soil-plant-animal system-the atmosphere at a certain time, depending on system components (rotation cycles, technological inputs, resources technical, etc.), is one of the priority issues for soil and water resource management and for directing agricultural technologies to be subordinated to increasing demand for food and, while facing the proper management of resources and environmental protection.

After Chaussod notion of biological quality agricultural soil has four components namely:

- fertility or directly related agronomic potential biological activity;
- phytosanitary condition of the soil and vegetation;
- environmental impact (externalities) on the functioning of soil;
- resistance or sensitivity to anthropogenic impact soil and environmental and ability to backup the baseline condition.

Sustainable use of soil requires measures to maintain the productivity potential of resources and tracking their progress based on benchmarks and indicators to monitor changes on soil quality. Pieri et al. (1995) believes that these quality indicators are three ways:

- indicators of pressure on soil resources;
- indicators of changes in soil quality status;
- indicators of response to these changes in society.

Some parameters and indicators of soil quality, in economic terms, are already used. These are:

- satisfaction edaphical crops and other human activities;
- behavior of soil as a medium for biomass production;
- suitability of land for different utilities;
- role of soil on urban waste recycling and household waste and residues.

There are companies which are undertaking studies to test soil (eg. SC Minear Laboratories SRL), but most do not offer solutions for improving agricultural yields. The purpose of the project is a study and construction of an experimental model to conduct tests and monitor soil and arable land while providing a set of information that provides solutions to improve organic agricultural yields.

Abroad: numerous studies and surveys over time internationally and nationally have shown that between technological systems of plant cultivation,

state of the environment, economic development and the quality of life there is close interdependence.
The agricultural policies of various countries, especially in the last five decades, huge efforts have been made to modernize agriculture in order to increase the quantity and quality of production, accompanied, however, by a multitude of serious negative effects on the environment.
In European Union countries, the most widespread agricultural system practically generalized, was the conventional one, is characterized primarily by: loosening and processing of excessive soil with the return swath, total removal of plant residues on the surface or even the burning of stubble, fertilizing intense and shorter rotations.
It is widely accepted that conventional energy-intensive agriculture has led to the emergence of negative processes that led to environmental degradation of various resources: soil, water, air, flora, fauna. Of these the soil, which is the bridge between different components of the environment, recorded the most rapid and intense changes due to anthropogenic activities, having a direct and / or indirect effects on other resources in the environment.

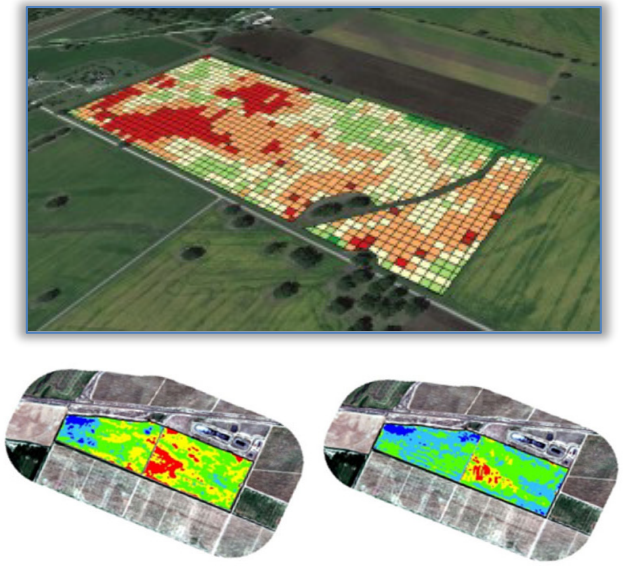

Figure 2: Mapping an agricultural area with a drone

The development and expansion of this new type of system agrotechnological, regarded as ameliorative and conservative was due on the one hand, the progress of the chemical in the diversification of the range of herbicides, and on the other, the emergence of types of agricultural equipment loosening soil modern performance.
The approach at international level regarding the technologies used for monitoring and testing of soil and arable land with the concept of sustainable development, encouraging the use of equipment and non invasive procedures.

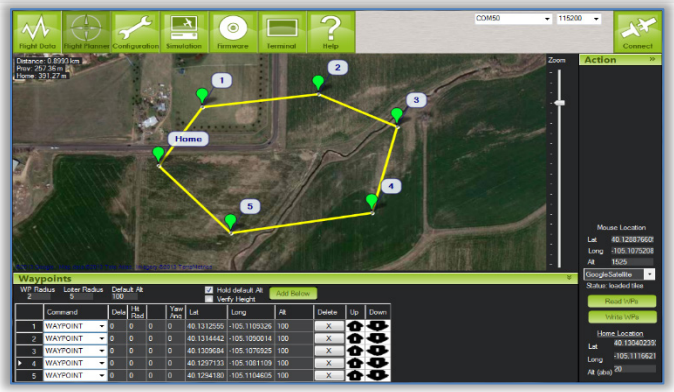

Figure 3: Ardupilot – software for mission planning in agriculture
(according to https://constantgeography.com)

TECHNICAL SOLUTION PROPOSED

In order to support sustainable development and use of new technologies, techniques and intelligent equipment, particularly in Romania, we can use the actual knowledge to conceive a solution that has a good ratio regarding cost - benefit.
The drone will have a body frame / body of light material (fiberglass or aluminum), to reduce the weight and to maximize the time spent in flight. Construction will be done using the 4 arms, which can rotate 360°, each arm having four engines (16 engines for drone).

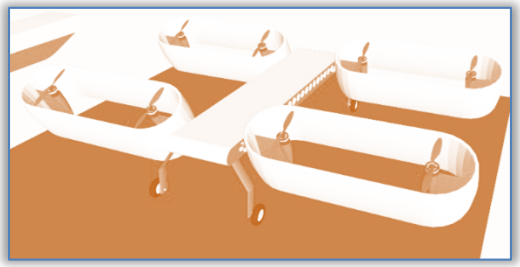

Figure 4: Drone body frame

The engines are important because they raise the entire structure into the air. The models currently on the market, even if they are smaller, are more powerful because it revolves around its own axis. An example of engines capable of providing power for the 4 arms solution, and be able to support the construction of outdoor is WM610 3510H M2, a rotary engine in clockwise (CW) with speed control of electric type.

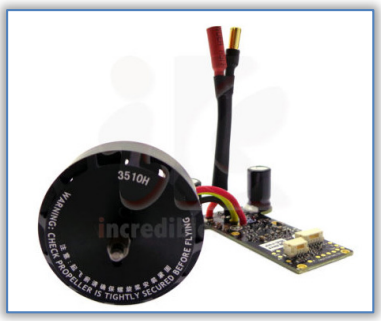

Figure 5:– Motor WM610 3510H M2

To control 16 motors we use wireless controller with integrated video transmission, the frequencies between 2.4GHz and 5.8GHz, control the drone via the controller to be made from a minimum of 1000 meters.

Figure 6: Concept for controller

The battery is an important element in the concept presented. A battery provides flight duration, but can increase the weight of the drone so as to not be profitable. Alongside a classic battery, a solution will be designed to use the mini solar panels, which extend the duration of flight between charging cycles.

Figure 7: Drone battery - classic

The software will be dedicated to this construction, and will provide analyzes for the soil to return for a percentage of future culture analysis on the areas that need to be taken by adding substances or other procedures.

Note

This paper is based on the paper presented at The 1st International Conference "Experimental Mechanics in Engineering" - EMECH 2016, organized by Romanian Academy of Technical Sciences, Transilvania University of Brasov and Romanian Society of Theoretical and Applied Mechanics, in Brasov, ROMANIA, between 8 - 9 June 2016

CONCLUSION

In conclusion, use of new technologies and intelligent equipment monitoring and testing of soil and arable land to improve organic agricultural yields will influence profitability, increasingly more, of land. It is an area of research that will be able to develop and build equipment to ensure sustainable development by using solutions obtained from research.

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DETERMINING THE CRITICAL SUCCESS FACTORS FOR WASTE MANAGEMENT IN CONSTRUCTION PROJECTS IN KHARTOUM CITY, SUDAN

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Abstract: The enormous amount of construction activity in Khartoum city associated with its rapid economic development has produced a large amount of construction and demolition waste over the past three decades. The majority of these wastes has not been well processed, which led to severe damage to the environment. The scenario in Khartoum city showed that there is a clearly need for better construction and demolition of waste management in their construction industry. Thus, this paper aims to determine the critical success factors (CSFs) amongst 18 factors which obtained from the previous studies. A questionnaire survey was conducted in Khartoum city; Sudan in order to conclusively these CSFs can serve as valuable references for stakeholders to develop effective construction and demolition wastes strategies. This also adds to the knowledge on how to reduce adverse environmental impacts caused by construction activities in rapidly developing economics.
Keywords: CSF, waste management, construction, projects, Khartoum city, Sudan

INTRODUCTION

The term construction and demolition waste (C&DW) is commonly used to describe a large number of waste materials generated from the construction and demolition of buildings and civil infrastructure. While many waste materials from construction and demolition projects are the same, the quantities produced will vary greatly with demolition projects often creating 20 to 30 times as much waste as construction projects (Recycling Council of Ontario, 2006). The construction sector has been thriving in Sudan lately. Although it accounted for only 4% of GDP in 2006, it continued to drive economic activity, growing by a healthy 10% (in real terms) last year. Furthermore, construction trends currently allow for too much space between buildings. If buildings are built closer to each other they could conserve cool air better. But they are not and that means we need more electricity to keep air-conditioning running to keep building cool that also creates more pollution (Ahmad, 2007). These views are echoed by Bannaga. A research by Bannaga (2007) stated that contractors have the freedom to do what they want. They are not thinking about how they are endangering the environment. The government runs everything. Once you have its approval nobody cares, and nobody's supervising the government. Agrees that government's control over construction needs to be improved, there's gap between legislation and the monitoring of projects. Bannaga (2007) pointed out that that disregard of the construction industry is part of a broader tendency to sideline the environment in a county that is grappling with widespread poverty as the shantytowns of Khartoum can attest. He said we have difficulty in treating water and waste water. Most households provide their own means of discharging waste water into sub-surface soil and water. There are no wastewater networks. We also do not have systems for refuse collection in many areas. Most of our solid waste is burnt on the ground. We are dependent on mechanical air-conditioning and there is no eco-building (Bannaga, 2007). About two decades ago, Hong Kong Polytechnic (1993) have defined construction waste as the by-products generated and removed from construction, renovation and demolition workplaces or sites of building and civil engineering structures[o]. In environmental terms the latter definition provides the better description as it identifies clearly materials that must be either recycled or re-used or disposed of. Although construction and demolition waste materials are often grouped together under the generic term "C&DW", the materials generated from these

activities can be quite different. One reason for this is that construction activities make use of currently available manufacturing processes and materials while demolition activities often remove older structures. Older buildings can contain materials no longer used in the construction industry today, resulting in a different waste stream. An example of this is asbestos, which was a common insulation material forty years ago, but is now regarded as hazardous waste. Differences between construction and demolition waste are also due to the nature of each process. Demolition procedures typically remove the whole structure, resulting in (20-30) times more waste material than construction activities. Materials such as metal, which is rarely wasted during the construction process, can form a significant percentage of total demolition waste when a building is torn down. Wood, concrete, brick and other masonry typically constitute more than (60%) of residential and (80%) of non-residential demolition waste (Recycling Council of Ontario, 2006).

RESEARCH METHOD

A Quantitative method was used for collecting the data, whereby 65 questionnaires were sent to different companies in the city of Khartoum, targeted the project manager, contractor, consultant and The study was carried out in the city of Khartoum in Sudan as shown in Figure (1). Additionally, the geographical areas selected include the locations where construction activities are high. Questionnaires were distributed to a different construction firms, and a total of (45) were completed returned and analyzed. The distribution of the survey instrument commenced on 1st January 2013 in Khartoum city in Sudan and the survey was completed on 21st February 2013. Moreover, the data were collected by firstly using close ended self-administered questionnaires. And then, this study was employed survey method to obtain the perceptions of the respondents toward the critical success factors for waste management in construction projects in Khartoum city, Sudan. Out of the 65 administered, only 45 useable questionnaires were returned analysed, provided a response rate (69.2%) response rate. The data collected were analyzed with aid of statistical package for social science (SPSS) version 20.0. The data were analyzed in the following order. Cronbach's coefficient alpha was used to determine the reliability of the various items used in the study. The statistical procedures were conducted to find the alpha value of items. Cronbach's alpha was computed and the result for the critical success factors was (0.65). The Relative Importance Index (RII) is used for the followings sections to describe it in greater details.

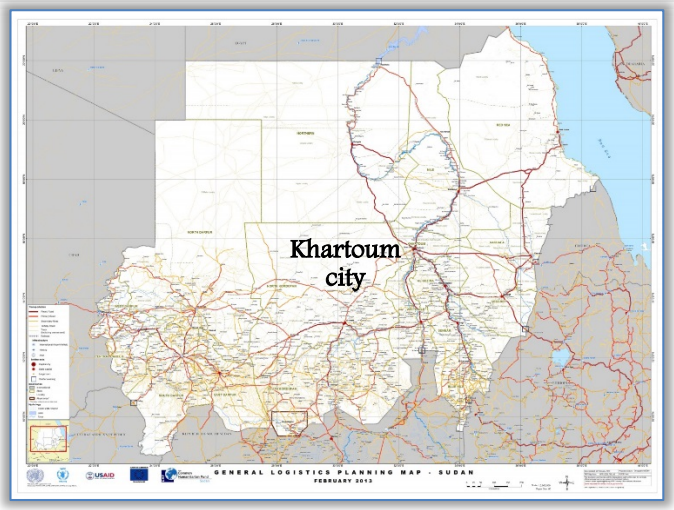

Figure 1. Shows the Study area

RESULTS ANALYSIS AND DISCUSSION

Respondents Background

The first part of the questionnaire was designed for the purpose of eliciting information of the respondents' background where out of 45 (13) of the questionnaires were solved by project managers (28.9%) which is indicating the highest percentage (28.9%) comparing to others, where eleven of the questionnaires were solved by contractors (See Figure 2).

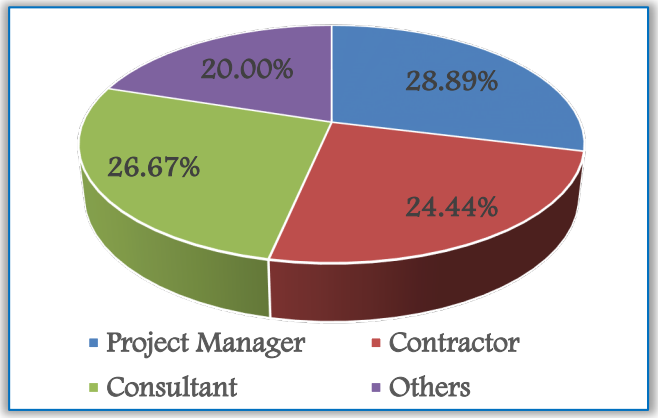

Figure 2. Position of the respondents

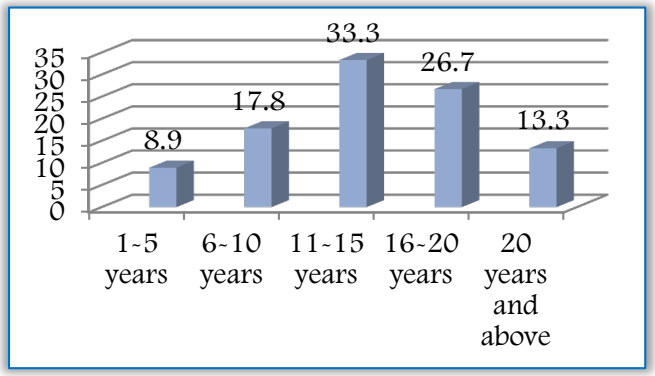

Figure 3. Shows the working experience of the respondents

The information for the respondent's working experience was also elicited. As shown in Figure (4) indicates that only fifteen respondents (33.3%) had

worked for 11-15 and not more than twelve respondents (26.7 %) had worked more than 16 to 20 years. Other different participants had indicated difference working experiences is shown in Figure (3). The last part of the respondents' background was designed for the purpose of eliciting information regarding the respondents' involvement in the construction industry. As shown in Figure (4), less than twenty respondents 19 (42.2%) were involved in buildings project while 15 respondents (33.3%) were heavy engineering (infrastructure).

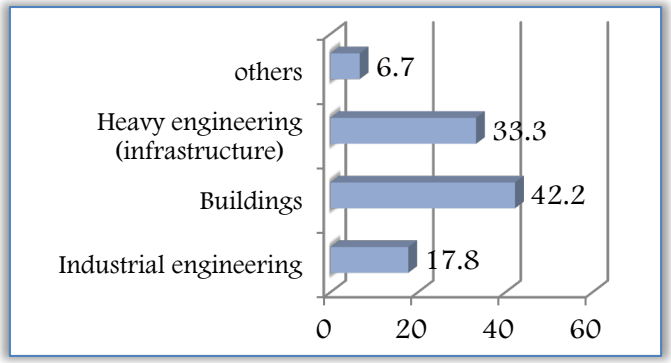

Figure 4. Shows the type of projects

Factors

The results showed that ten factors were found to be as a critical success factors after the analysis had been conducted by using SPSS and Relative Important Index formula (RII). As shown in the Table 1.

Table 1. Presents the Critical Success Factors

Factors	RII	Ranking
Material usage and storage system	0.733	1
Improving communication amongst project participants	0.711	2
On –site waste supervision system	0.688	3
Research and development in WM	0.683	4
Vocational training in WM	0.677	5
Improving conventional construction process	0.672	6
Waste management system (WMS)	0.638	7
Awareness of Construction &Demolition WM	0.638	8
Waste Management regulations	0.622	9
Taking WM into consideration in bidding and tendering	0.622	10

DISCUSSION OF THE FINDINGS

Waste Management Regulations

It is not surprising to see that a good policy system formulated by waste management regulations is ranked among the most significant success factor for conducting C&D WM in Khartoum. This is in line with Jaillon and Poon (2008) and Karavezyris (2007) who suggested that government generally plays a crucial role in promoting C&D WM practice by enforcing policies for the whole industry. As the result from the survey reflected that current policies for C&D WM are generally effective, although the promulgation of various C&D WM laws and regulation since decades ago has improved the situation. The biggest qualm is that most current policies are not detailed enough for guiding and enforcing C&D WM.

Waste Management System (WMS)

The establishment of WMS is also among the most significant success factors for C&D WM in Khartoum. As a clear definition of the term WMS appears to be absent in the literature, the working definition for this research was taken from the following definition of a Environment Management System (EMS) as stated in ISO 14000: an overall management system which includes organization structure, plan responsibilities , practices, procedures, processes and resources for managing C&D waste. It formulates an internal system for contractor to conducting C&D WM. Given that C&D waste is one of the major pollutants of the environment, a WMS for construction can be considered as sub-system of an EMS. Some of the respondents have commented by emphasizing the importance of a waste management plan, which has already been implemented in some countries UAE, and Hong Kong. According to Poon et al. (2001), effective on –site WM usually involves scheduling the waste clearance, arranging collection and scheming removal to appropriate disposal sites. All this can be developed in pre- arranged WMP by project managers. The plan should clarify the possible WM issues and actions in advance, for waste streams being encountered, necessary resources and suitable scheme for dealing with possible waste problem, and selected waste disposal sites, the most important step for developing a WMS is to encourage the development of a C&D WMP for construction projects.

Awareness of C&D Waste Management

This factor also considered among the most significant CSF. This resonates with the studies which have pointed out that the practitioners' awareness of resource saving and environment protection is a vital driver for C&D waste minimization (Osmani et al., 2008; Yuan, 2008). Nevertheless, what was observed from the respondents that both managers and contractor have little awareness of saving resources and protecting the environment through waste management. The development of C&D WM awareness is a lengthy process that requires vocational training and education practitioners. The research shows that C&D WM is incorporated in many training course provided by universities, research institutions, and government departments. The respondents suggested that a change of the current C&D WM mindset can be enhanced by the enforcement of government policies, the development of C&D WM systems within

companies, and recognition of the importance of WM by clients and general public. While conducting this research, it is suggested that raising C&D WM awareness will be more effective if economic concerns can be recognized in developing regions. The economic is often high on the agenda of these local governments and they believe that environmental protection will slow down economic development. Conversely, research in other regions shows that good WM through reducing, reusing, and recycling does not necessarily add to project costs (Tam, 2008 a,b). In developing economies, it might be more effective to provide companies with solid evidences of the benefits and cost savings of C&D WM.

Research & Development in Waste Management

Identification of research and development (R&D) as a CSF for conducting C&D WM resonates with research by Weng and Liu (2008) and Yuan (2008) suggested that that R&D can provide guidelines and technical support for waste reduction reuse, recycling and disposal. The result from the survey by some comment of the respondents indicated that R&D should focus on the following: (1) government policies; (2) effective WMS within companies; and (3) waste management technologies.

Vocational training in WM

In support of this CSF, other studies have also revealed that the skill-level of construction workers has a major influence on C&D waste generation (Tam and Tam 2008; Yuan 2008). Activities such as construction formwork, plastering, and handling deliveries will cause large amounts of waste if the workers involved are unskilled (Wang et al., 2008). Most workers in the construction industry in Khartoum are from rural areas. They have limited skills that have not been trained sufficiently before starting work on construction projects. Findings from the research indicate that the training time for most construction workers is less than what is really meant to be.

CONCLUSION & RECOMMENDATIONS

The aim of this paper was to determine the most CSFs among the 18 factors that are most important for waste management in construction projects in Khartoum, Sudan. This paper determines ten critical success factors that are important and will impact positively on the waste management in construction projects in Khartoum city, Sudan if they focus on the ten determined CSFs by all the stakeholders. The score of the ten factors ranges from (0.733) being the heights and the least (0.622). Since this is the first research to determine the critical success factors for waste management in construction projects in Khartoum, Sudan, there are some results are the same of past researches with which to compare the results of this research such as It should be noted that reduction and reuse of waste is given as a national average and that considerable variation occurs between states. For instance, building rubble alone has contributed as much as (27.4%) of the total waste stream in Perth (Department of Commerce and Trade (Western Australia) and WA Municipal Association 1993). It should be remembered that the CFSs in this study were identified within the context of Khartoum's construction industry and that is Sudan is large country with many different cities and levels of economic development. The CFSs cannot be therefore simply applied to other parts of Sudan without considering the regional variations. However, further research could be conducted to investigate C&D waste management problems in other different parts by using CFSs as a reference. The CSFs could also be used as a reference to conduct research in other fast developing countries such as India and China, with aiming of helping those countries reduce the negative impact of C&D activities on their environment.

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SURVEY OF PASSENGERS' BEHAVIOR TRAVELLING BY PUBLIC TRANSPORT IN SZEGED

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Abstract: In Horizon 2020 Program University of Szeged, Faculty of Engineering and Szeged Transport Ltd. as partners involved in the ELIPTIC (Electrification of Public Transport in Cities) [5] project. (Figure 1; 17) Their aim is to learn about more travel behaviour, environmental-friendly passengers point of view and public transport quality in Szeged, the development of electric-powered modes. Participants are more than 30 partners, from different countries include transport operators, authorities, research centres, universities and other organizations. The problems, so that the tasks are similar, but they differ from each other significantly as well due to the local circumstances. After the test, scheduled for the trolleybus-network wireless and more electric-powered modes of development
Keywords: public transport, environmental protection, Szeged, traveling behaviour

INTRODUCTION

Basic idea is extendation of trolleybus and tram network, which makes environmental friendly mode of transportation. This paper presents some results of a survey, which based on Smart City project (TÁMOP-4.2.1.D-15/1/KONV-2015-0002) [6]. For this purposes, for investments good to know environmental friendly transportation looks good idea to use electric powered public transportation as trams or trolleybuses. Problem is the network, and interesting inhabitants' point of view. Two additional possibilities can be interesting as battery powered trolleys where there is no network.

Electric public transport can also be highly cost efficient for the operator, when a long-term perspective is taken. A number of new vehicle concepts has been introduced over the last years, innovative energy management and storage technologies are being tested and public transport energy networks are expected to make a major contribution to the smart grid of the future. Exciting tram-like bus systems, the renaissance of the trolleybus, as well as autonomous electric buses are examples of the innovation capacity of Europe's public transport sector.

Figure 1. ELIPTIC Project logo

Among the ELIPTIC (Figure 1) partner cities, all modes of electric public transport are covered and these will be the basis for analysing the potentials for upgrading and/or regenerating electric public transport systems while ensuring the safe integration of electric vehicles into infrastructure. This approach will overcome the main barriers for further integration of electric vehicles in cities with existing electric public transport infrastructure by cost-effective principles of double- or even multi-use of this existing infrastructure. In particular, the often lacking city-wide coverage of charging infrastructure (due to high investment cost) and the limited driving range of electric vehicles – the two biggest challenges for electro mobility – will be overcome by providing different options for opportunity charging along the existing infrastructure thus extending driving ranges and/or reducing the size of the required battery packs.

2. LITERATURE REVIEW

Europe's bus fleet, which transports 30 billion people per year in the EU, is still approx. 95% diesel-fuelled. Electro mobility is a trend, but a lack of expensive city-wide charging infrastructure and the limited driving range of electric vehicles are barriers for deployment. But rather than building new and costly stand-alone charging infrastructure, ELIPTIC aims to further electrify road vehicles (in particular buses) using existing electric public transport infrastructure. To date, the only

demonstration in Europe of electric bus operation using tram infrastructure is in Vienna. In order to exploit the full potential of existing electric public transport infrastructure as a basis for further safe integration of electric road vehicles, ELIPTIC will provide a range of options for opportunity charging along existing infrastructure (en route or at sub-stations) extending driving ranges and/or reducing the size of the required battery packs. The technical development in the field of electric storage (e.g. trolley-hybrid-buses equipped with battery and supercapacitors) and power management allow for new solutions for practical operation. [3; 4]

Furthermore, zero-emission public transport systems, in particular electric (trolley)bus systems, are often neglected in national electro mobility investment and research programmes. And although significant research efforts are underway to develop and demonstrate innovative electric bus concepts across Europe in real life contexts, public transport operators and authorities too often launch stand-alone test projects to gain initial experience with electric buses. This trial and error approach can however be inefficient and the likelihood of costly mistakes being made by selecting sub-optimal electric buses and charging station solutions is high. ELIPTIC aims to avoid these pitfalls through a moderated software-based planning process based on validated ELIPTIC use cases and available information and data of demos from outside the project, e.g. through exchange with the ZeEUS Observatory. More and more, public transport operators are not just public transport providers but mobility providers. They facilitate seamless multimodal travel, often by partnering with providers of shared cars or bikes to create a full chain of mobility. ELIPTIC's objective of analysing the potential of multiple-use infrastructure to facilitate seamless multimodal door-to-door electric travel (e.g. linking e-bike charging to tram or bus infrastructure) will give an important new dimension to clean mobility options. This is also important as a shift from individual car traffic can make a large impact on fossil fuel consumption and air quality. By introducing more electric options, both mobility and access to urban areas will improve. [1; 2]

3. ASSESSMENT OF THE RESEARCH RESULTS

Passengers were asked about the use of the frequency of public transport. The respondents said bus, trolleybus or tram, because all three modes of transportation are available in Szeged with extensive network. It is a characteristic in Szeged – but not unique in Hungary – that two companies are in the service of passengers, during operation passengers cannot take difference when travelling, but causing significant accounting technical tasks to be solved. The recently formed DAKK (Southern Great Plain Transport Center Ltd.) has the same duties of accepting and operating former Tisza Volán Transport Ltd. bus lines and Szeged Transport Company Ltd. (SZKT) trolleybus and tram lines. Both companies are state-owned, profit-making supply obligation in the form of work, but they work according to local government order too. The common purpose of transport companies to organize transport are available to meet the needs of passengers. The obvious fact that this is an important task to determine optimum. In the case of companies, very important is operating the control, economic -organizational issues as well. Since the interests of the passengers are frequencies of vehicles, but this can be financed, which is a difficult task, since it can disencumber limited central budget, local government budget, and the price of the tickets, season tickets to passengers are also limited.

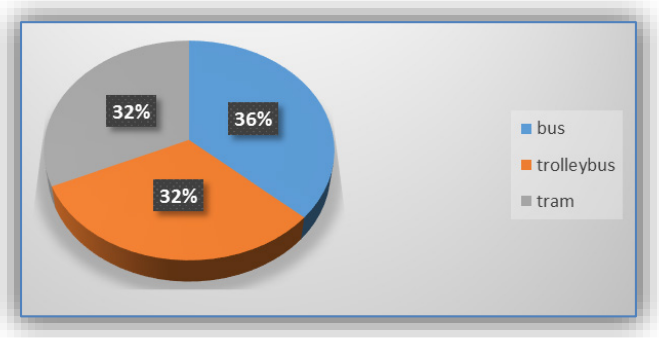

Figure 2. Distribution use of public transport

This survey was made in 2015, which is a star point of development of public transport development in Szeged using modern environmentally friendly forms of it. There are hybrid vehicles (powered electricity online or batteries), but offline mode has not been used yet. To learn more about travel habits of passengers gives more information for transport companies (DAKK and SZKT) to develop public transport network in Szeged.

How often do you travel by local public transport (tram, trolleybus, bus)? – was the question. Respondents could select one or more options with mentioning frequency. Optional answers were daily; once or twice a week; once or twice a month; rare and almost never. Respondents could choose just one option. Further options were 'don't know' and the 'did not respond' technical categories.

In the case of this survey – inspected 1002 individual measures – can be processed taking into account average shows that 94% of the interviewed at least a monthly basis, the services of at least one type of public transport in Szeged. However, the numbers in this form distort, since it can be assumed that some of them transfer to different lines. Questionnaire does not focus how

representative is the sample in this respect. A more detailed examination is suggested.
First approximation can be read from the data (Figure 2 and 6) that the three technology in carriage of passengers cannot be discussed, passengers use them about the same proportion. At this stage remains to be seen is the frequency at which significant deflection effect.
Figure 3 shows most of passengers travel on a daily basis (218) by bus, but you can also use other 80 people once a week or several times.

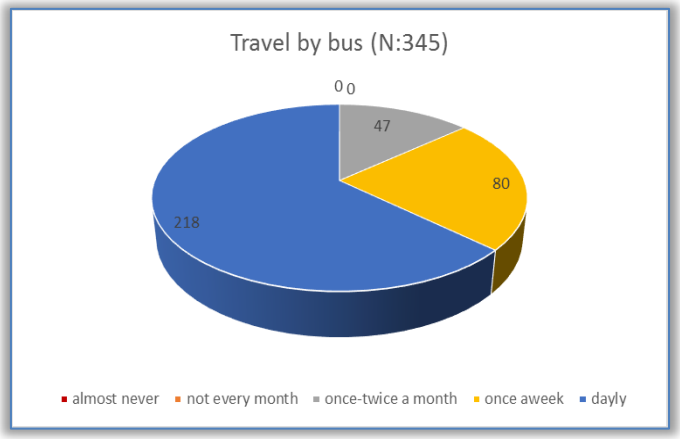

Figure 3. Travel by bus

Figure 4 illustrates similar rates travelling by trolleybus, so the values you see are most likely to suggest that it is also possible the significant overlap between different types of vehicles.

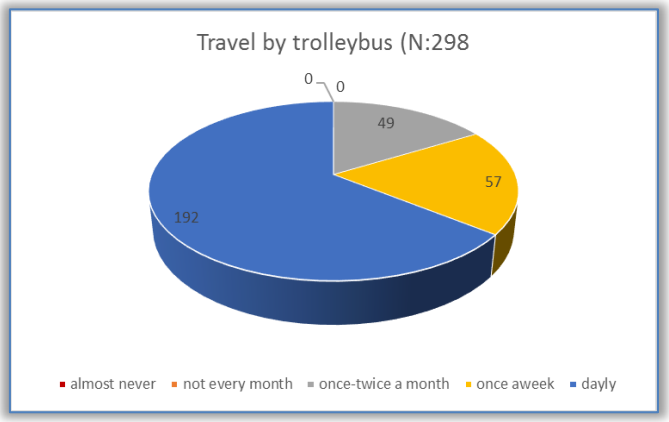

Figure 4. Travel by trolleybus

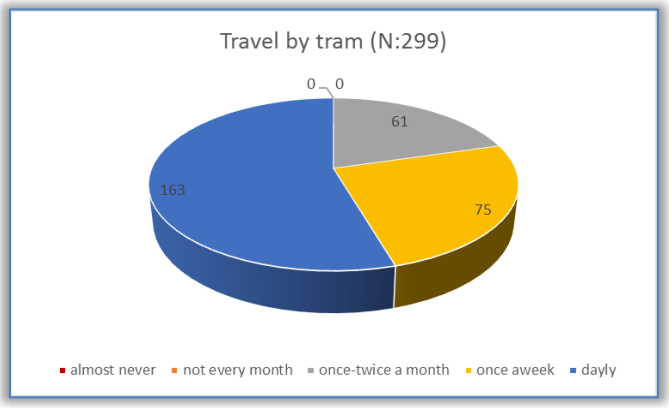

Figure 5. Travel by tram

Figure 5 confirms this, using the tram. Well you can see that a lot less trolleybus and tram lines, which represent big proportion of the major travel flows.
This can be generalized by the interviewees get real information in order to organize developments.

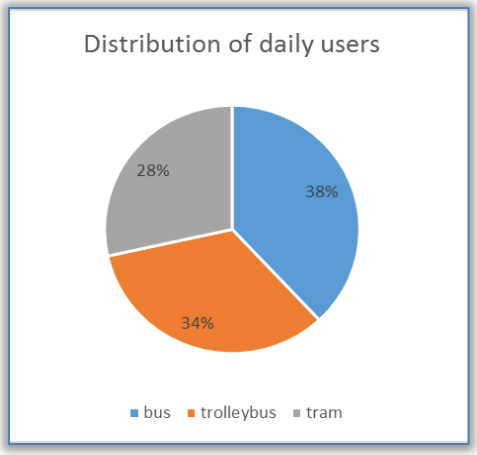

Figure 6. Distribution of daily users

Interesting and useful ideas for the development come from the survey. The interviewees were already among those who have used one form of public transport or even more. The number of respondents are between 529-559, which are among 1002 previously indicated respondents, so answers can be authoritative value, since nearly half of the remaining respondents not or very rarely use the trams, trolleybuses and buses, so that they cannot be of the same regarding the development.
Increasing frequency (Figure 7) might appear important and goal to the users, so it's no surprise that the blue field, characterized by "it is not particularly important" category is below 25%, regardless of the frequency.

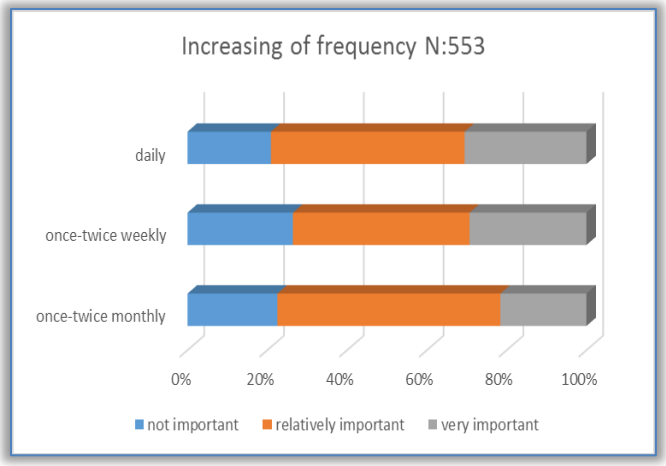

Figure 7. Increasing of frequency

It should be noted that the passenger full demand cannot meet, so unrealistic goal, since the passenger does not want to bear the extra cost – perhaps – they do not even think of this. Of course, legitimate expectation, that the service providers follow the utilization of vehicle capacity and usage of vehicles

(present them to the local government) in order to reach constantly more streamlined and better reflecting the changes.

Figure 8 illustrates opinions on the environmental protection. just a little ratio of the population is non-sensitive on this area. Majority of them prefers gas buses instead of diesel powered. Although, the idea is absolute eligible, it should be noted that the majority of the buses currently have adequate diesel ones, so early changes would be a significant additional cost of distributed applications, the lack of promotions should be enforced. In recent years, SZKT and DAKK focus significant attention (otherwise, the law also required) to buy more and more advanced, far under from the limit value emission engines, so with less carbon gas emission in new vehicles.

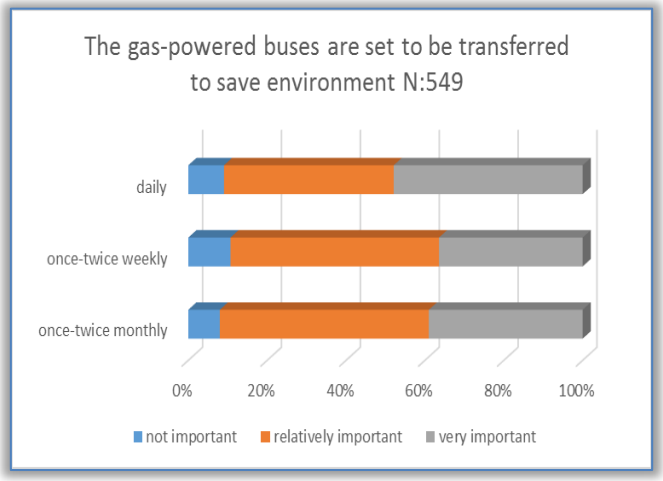

Figure 8. Gas-powered buses

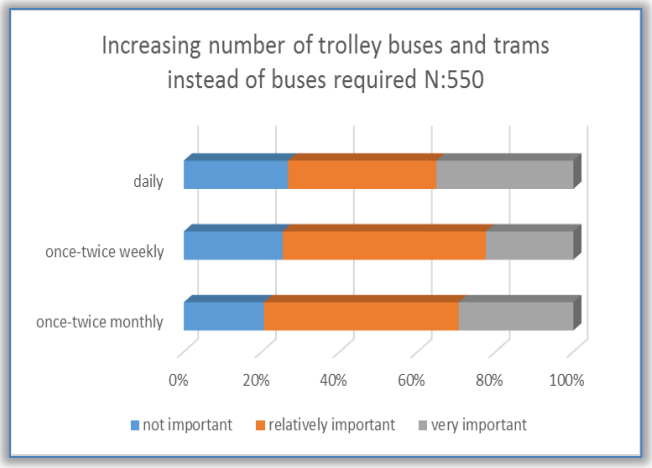

Figure 9. Change buses to trolley and tram

This is a kind of alternative to the next group of answers. Figure 9 shows that for respondents is acceptable alternative expansion of tram and trolleybus network. However, due to the rail transport infrastructure development may have a significant footprint and costly. I'd like to point out that a tender H2020 is on-going on some extension of trolleybus lines in such a way that the vehicles without overhead contact line and pantograph contact, powered with a battery between networks or in districts where overhead wires cannot be built.

Today's legitimate need to public transport for people with mobility disabilities also available alternative. Figure 10 illustrates expected daily frequency of vehicles for disabled people assuming the eventual losses, longer running time is also accepted.

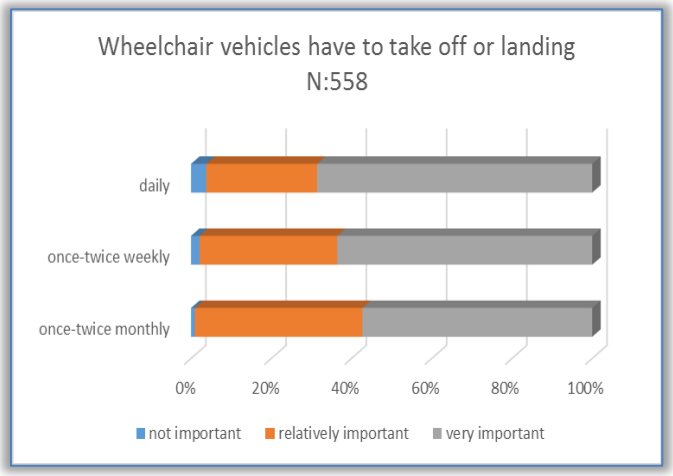

Figure 10. Easy access by wheelchair

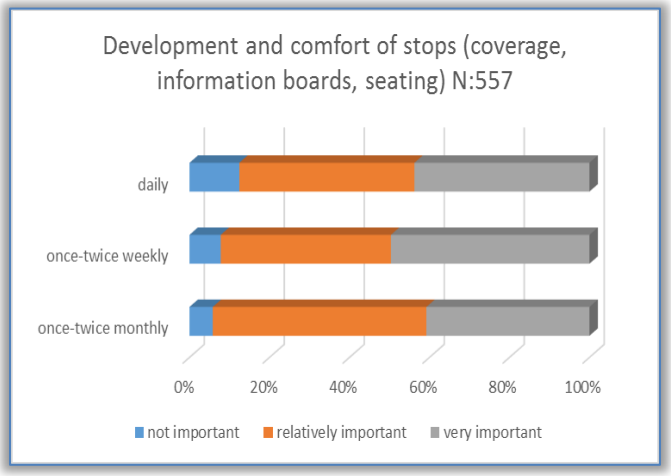

Figure 11. Development of comfort of stops

Passenger comfort solutions not only must cover the vehicles. A significant part of the total duration of the trip can be – especially during off-peak hours – long, therefore convenience aspects important. According to Figure 11 shows, that majority of passengers have great importance for weather protection and the to be well-informed. Of course, here also the realities within the boundaries of worth, since they cannot be expected to, as the United Arab Emirates that come from a variety of local bus stops are with air conditioning. It is interesting that the largest number of travellers on a daily basis 'is not particularly important' category, the proportion of which suggest that these passengers are familiar with the timetable for the vehicles and to spend less time at stops.

It is worth a little attention is paid to the Figure 12 as well, since the development of the passenger information system is included in it. The responses received some criticism, and suggest a little differently to understand. Of course, it is important to the information in stops, but less busy places – because of the availability of today's mobile technology – public mobile application operation of passenger information system more realistic, not to mention the cheaper development and less running costs. This – of course – is shared between the experts' opinion, to expect a passenger to have access and use of the mobilnet. Maybe it's becoming less and less possible obstacle.

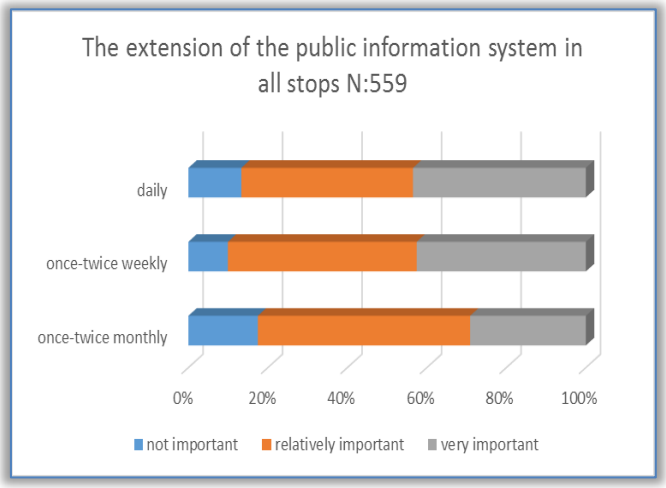

Figure 12. Information system in stops

This view seems to be supported by Figure 13 the distribution of responses published. Practically, more than 70% of those who specifically would like access to the passenger information system by Internet, Smartphone use. From this it can be assumed that the passengers do not poses a significant problem for the query needs to use a device or application.

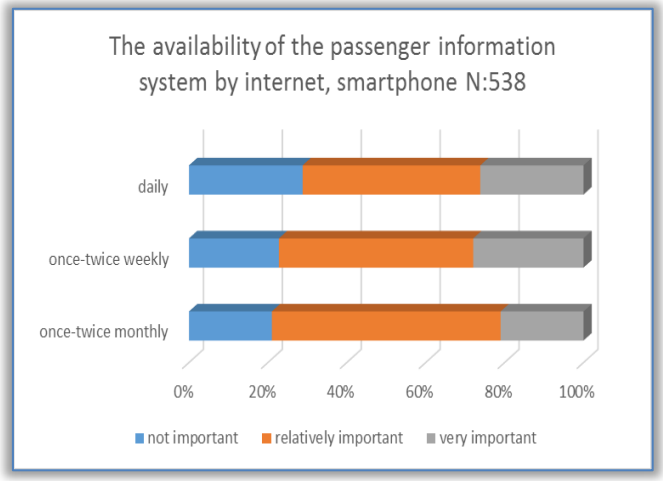

Figure 13. Information system by internet, smartpone

Proposed improvements require more or less budget. It is interesting to consider how the views of passengers on fares? (Figure 14) Different ticket types and fares are interesting for passengers depending on distance, workday or weekend, etc. In this case, however, there is also the issue that the passengers – mainly during peak hours – expect that to the right, forward or use pre-payed ticket, sometimes different types of ticket or pass. This structure only the e-wallet functions may be a reasonable solution.

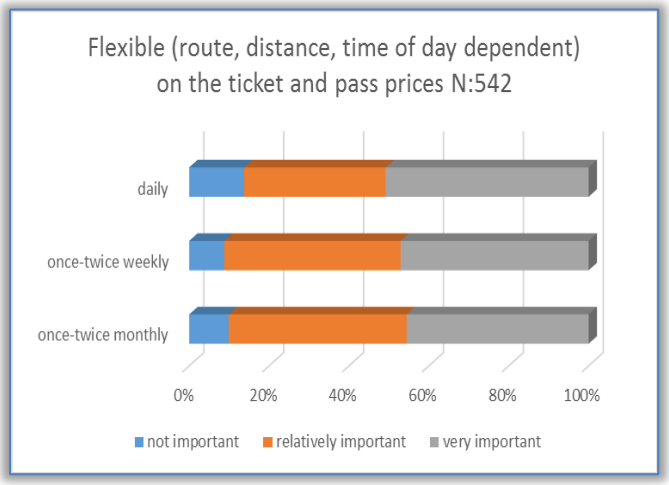

Figure 14. Flexible fares

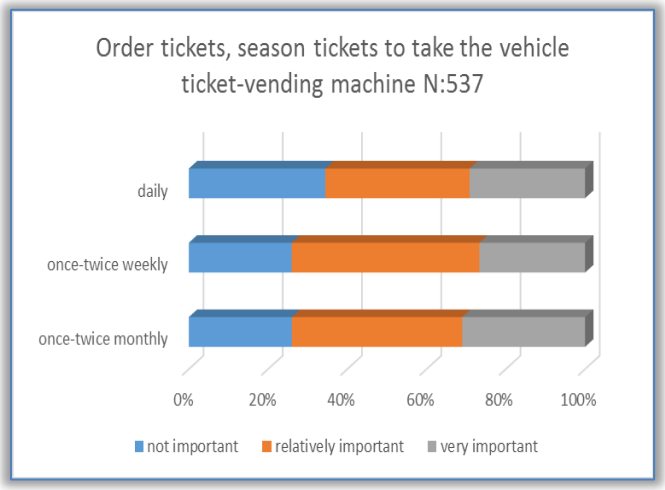

Figure 15. In vehicle vending machines

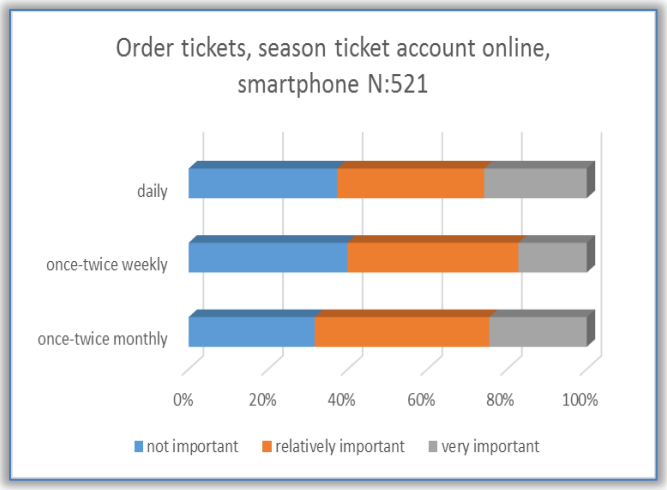

Figure 16. Internet and smartphone sales

4. CONCLUSIONS

It is important for the development of easy purchase tickets or monthly pass. Figure 15 and 16 on diagrams illustrate this development. Despite the fact that the drivers sell for higher price, but it is not the best and not the real solution. The driver will interfere with this activity, distract attention from driving time, and the other passengers not keen on the travel time loss due to delay. Not a new idea, or technical solution, since in many countries also now practice of accepting credit cards often have ticket vending machines at the cabin.

This option is extended by Smartphone or Internet sales option, which is technically already realized in many places. However, you must see and understand paper-based ticket system is used in Szeged, so it is difficult to find the best form of it. The situation is complicated by two transport companies operate in Szeged, so the settlement on the basis of ticket sales and lease parameters should also think about.

Passengers are open to accept and use modern, environmentally friendly technology and it is a common goal for transport companies, local government as well. Operating new trolleybuses combining different bus a trolley lines looks a good idea for the future.

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Note

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CONCEPT OF AN AUTOMATING OLIVE HARVESTING SYSTEM

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Abstract: The agricultural industry is very complex and need a lot of attention and qualified employments. Agriculture is a seasonal, highly mechanized activity. The only activity that takes place throughout the year is farming. For other types of activities, the use of automated systems is not always profitable. Harvesting using manpower requires employing a large number of people for a limited time, which may lead to social problems in addition to high labor costs. The big problems of employments are that there is activity only seasonal and are hands work. The same think is in grove-olive, where necessary many workers with experience to collect olives with their hands. In this case take a lot of time to collect the entire olive grove. For increase production of olives is necessary to collect the olives mechanics with robots. The use of such robots is also justified by people's need to adjust to their environment, adjustment to a certain purpose meaning the increase process of the interaction productivity, by decreasing the necessary effort and increasing the quantity and quality of the environment output.
Keywords: agricultural industry, olives, production, collects, seasonal

INTRODUCTION

Today we can find the automated systems and the robots in a large range of purposes like home appliances, medicine, and mechanical industry. In last years automated systems and robots have find range also in agricultural industry.

The use of such robots is also justified by people's need to adjust to their environment, adjustment to a certain purpose meaning the increase process of the interaction productivity, by decreasing the necessary effort and increasing the quantity and quality of the environment output.

Agriculture is a seasonal, highly mechanized activity. The only activity that takes place throughout the year is farming. For other types of activities, the use of automated systems is not always profitable. Harvesting using manpower requires employing a large number of people for a limited time, which may lead to social problems in addition to high labor costs.

Market competition in agricultural products demands low production costs, and this is achieved by using automated systems. Considering the complexity of the harvesting operations, there are special requirements such as hand-eye-brain type interventions. Therefore, these automated systems should consist of robots.

Fruit and vegetable harvesting is mainly carried out by mobile robots, which are fitted with shape, quality, and location-recognition devices, and with suitable equipment.

Figure 1. Olive trees in plantations.

Olive trees are currently grown in plantations (picture 1, 2). All the physical features of the soil, as well as of the people and technology involved in the processing must be taken into consideration for such a plantation. The olives are picked manually, beginning with September 24th, for 15 to 20 days,

from 07:00 until 16:00. A group of 3-4 people is necessary for each tree.

Figure 2. Olive trees in plantations
natural harvested

A group harvests 6-7 trees per day, which yield 260 kg of olives. Therefore, a plantation with thousands of trees requires a large number of people, which leads to high costs of the harvesting process.

Olives have been harvested and processed in much the same way, ever since ancient times (picture 3). After they are harvested, in order to prevent them from being bitter, the olives are sunk in water and salt, then held in vinegar for several hours, and then stored in oil.

Due to the economic and social importance of olive trees, it is necessary to design and manufacture an olive-harvesting robot, thus eliminating human operators, which are employed in large numbers for a limited time. Consequently, harvesting costs decrease, this being reflected in the final product.

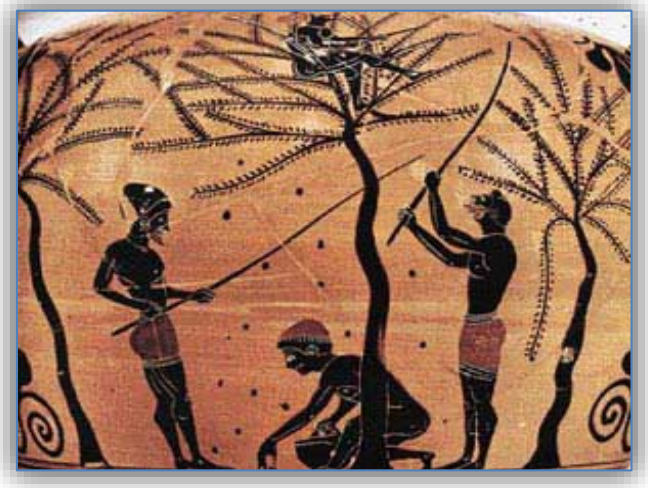

Figure 3. Olive trees and their harvested
and processed.

ROBOT SCHEMATIC

The robot consists (picture 4) and principle are the shaker which shakes the olive tree branches, the net which is operated by an arm, the shaker and the net being connected by sensors, the mobile platform and the trailer in which the harvested olives are discharged. The video camera recognizes the work area for the shaker, if we use an autonomous system, or it recognizes the work area for the human operator, if we use a remote-controlled system.

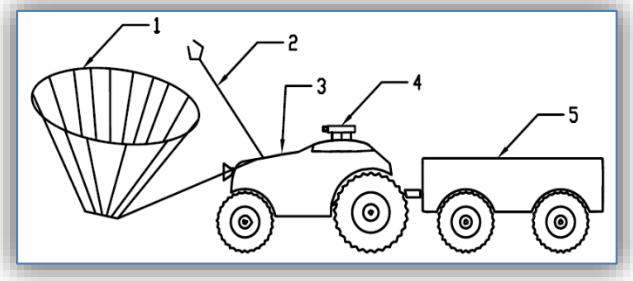

Figure 4. The concept of harvesting robot.
1. Net "umbrella"; 2. Shaker for olive tree;
3. Autonomous (or with driver) mobile platform;
4. Data transmitter and receiver with video camera;
5. Trailer for olives.

DESCRIPTION OF THE TECHNOLOGICAL PROCESS

The robot (2) recharges its battery from the power supply (5) located in the storage area (1) where the olives are stored. The robot harvests the olives from each tree separately, and when the trailer is full (approximately 50 trees, at 60 kg/ tree), the robot goes to the storage area using the reference points.

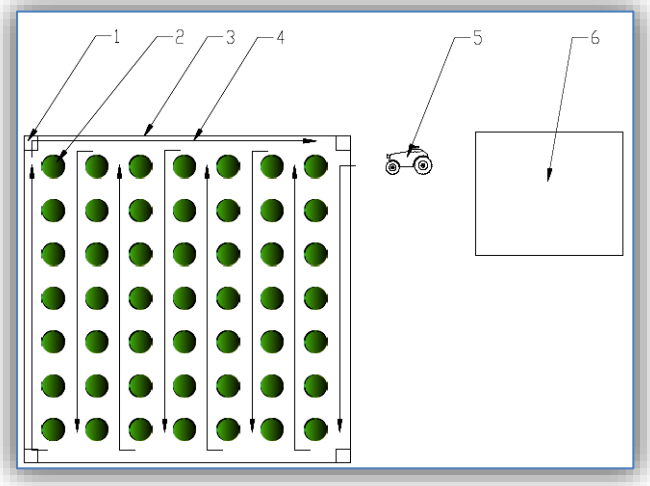

Figure 5. Description of the technological process.
1. Reference points Storage area - power supply; 2. Olive trees Robot; 3. Olive trees plantation; 4. Harvesting flow Reference point; 5. Robot – harvest machine; 6. Storage area, power supply and robot control room.

The olives are harvested by shaking the olive tree branches. This robot can operate autonomously, the greatest advantage in this case being the

elimination of the human operator, and therefore higher productivity, but also extremely high development and manufacture costs for such a robot, or it can be remote-control operated (picture 6).

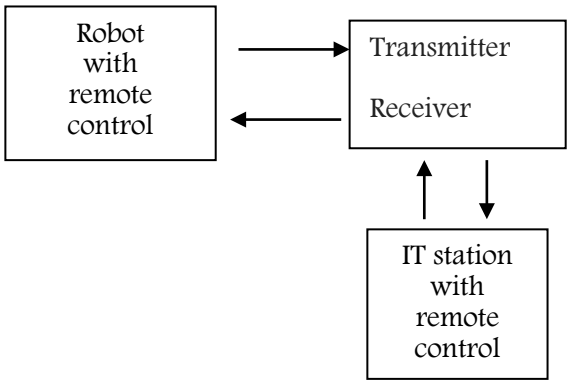

Figure 6. Remote control systems, this system can be used by one human operator

CONCLUSIONS & REMARKS

In the latter case, a human operator is necessary to operate the system. The robot will be fitted with two video cameras, one used by the robot to move around the plantation, and the other to recognize the olives and shake the tree branches.

This robot should be designed with a built-in olive storage bin. It will have a mobile platform fitted with a shaker arm, which will have a sensor to detect the branches and the olives. An additional arm is necessary, fitted with a net to collect the olives which fall off the trees, and with sensors which will allow it to position itself under the braches shaken by the shaker. A trailer is also necessary, to store the harvested olives. The navigation system can be autonomous, using the global positioning system, or remote-controlled by a human operator. It is powered by electricity from batteries, which are recharged at the end of the day.

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PAIRED COMPARISON METHOD WHEN ANALYZING MACHINERY

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Abstract: The assessment of the eco-friendly level of machinery and equipment is currently commonplace. Eco-friendly levels of each product are defined in the pre-production stages of the product's lifecycle. Pair comparison method is one of the several ways of assessing the environmental quality of the product. The assessment is based on four factors - technological, economic, environmental and social. The article provides specific examples of assessments carried out on the impact drills with different technical parameters made by one manufacturer.
Keywords: Environmental quality, product, impact drill, paired comparison

INTRODUCTION

Short-term thinking motivated by the idea of maximum profit often had had wide-ranging consequences lasting to the present. The Earth will probably never recover from the impact of heavy industrialization. On the one hand there is a heavy consumption of non-renewable resources, and on the other hand people use substances which are harmful and contaminate Earth's closed ecosystem. Devastation of natural resources and the nature itself has led to attempts to repair or preserve natural resources through the introduction of protected areas. However, these attempts merely dealt with the consequences of the harmful human behavior.

The efforts to preserve natural sources and eliminate adverse effects on the environment are already incorporated in the process of equipment design and penetrate to the manufacture, distribution, use and disposal of particular equipment. That is why efforts to control the risk at its source should be an integral part of the design phase during the innovation or development process of equipment.

The main aim of the article is through the method of paired comparison determine the environmental quality level of selected types of impact drills.

DESCRIPTION OF EQUIPMENT

For the purposes of the assessment we used Bosch impact drills with different technical parameters. Their graphic representation is shown in Figure no. 1-4.

Figure1. BOSCH GSB 13 RE Professional [2]

Figure 2. BOSCH GSB 16 RE Professional [3]

Figure 3. BOSCH GSB 1600 RE Professional [4]

Figure 4. BOSCH PSB 750 RCE [5]

PAIRED COMPARISON METHOD

This method is used in the assessment of the impact of technological processes on the environment. However, it can be easily modified to suit the needs of the assessment of the environmental quality of the equipment and its impact on the environment.

Factors reflecting the impact of the equipment on the environment can be divided into four basic groups:

- technological factors - describe the technological process in the manufacture or use of the equipment
- economic factors - involve substantial investments and operating costs throughout the life cycle of the equipment
- environmental factors - the effect of the equipment on the environment
- social factors - an attempt to integrate social effects of the equipment use into the decision-making process. [1]

Table1. Factors describing the equipment

Technological factors	Economic factors
1. Consumption of basic material 2. Energy consumption 3. The rate of a construction-dismantling practices 4. Energy efficiency of the technological process (equipment)	5. Cost of upkeep of machinery and equipment 6. Price of the equipment on the market 7. Storage costs
Social factors	**Environmental factors**
8. Accident rates 9. Monotony of the working cycle 10. Physical demands of the process	11.Air pollution by SOx 12.Radiant heat 13.Noise 14.Vibrations 15.Dust in the workplace 16.Waste amount 17.The need for waste separation

The paired comparison method involving two or more equipment can feature as many as 80 factors. For the practical assessment, however, we have set the minimum number of environmental quality factors to 17. The number of factors should not be further reduced. [1] The complete list of factors used in the evaluation is to be found in Table 1.

After selecting the factors on the basis of Fuller triangle the frequency of the different factors is assessed. After obtaining the total frequency for each factor the factors are ranked and weighted. The frequency of the factors determines the weight of the criterion - "WJ". Then we rank the factors according to their frequency of occurrence from the highest level to lowest. The results are shown in Table 2.

The scale used for the assessment of the suitability of the equipment:

- Excellent 5b
- Good 4b
- Average 3b
- Acceptable 2b
- Unacceptable 1b

Table2. Ranking and weighting of factors

Factor no.	Weight	points	GSB 13	GSB 16	GSB 1600	PSB 750
1.	7,5	10	5	3	3	3
2.	13	10	5	3	4	3
3.	6	12	4	3	3	3
4.	9,5	6	3	4	3	3
5.	2	15	4	4	4	4
6.	9	9	5	3	3	3
7.	4,5	13	4	3	3	3
8.	7,5	10	5	5	5	5
9.	1,5	16	4	4	4	4
10.	14	1	3	2	2	1
11.	14	1	3	4	3	3
12.	9,5	6	3	3	3	3
13.	10,5	5	3	3	3	3
14.	1,5	16	4	4	4	4
15.	12,5	4	4	4	4	4
16.	4	14	3	3	3	3
17.	9,5	6	3	4	3	3

By summing weight of individual factors and their points we get the "synthetic suitability indicator of a technological process" - "Usi"Table 3. This figure clearly indicates which of the evaluated equipment should be given priority by a consumer.

Table 3 shows the partial values for determining the synthetic suitability of the equipment. The sum of the factors gave the following total values:

» BOSCH GSB 13 RE Professional reached US_i = 510
» BOSCH GSB 16 RE Professional reached US_i = 459,5
» BOSCH GSB 1600 Professional reached US_i = 439,5
» BOSCH PSB 750 RCK reached US_i = 412,5

Table 3. Synthetic suitability indicator determination

Factor no.	GSB 13 "US_i"	GSB 16 "US_i"	GSB 1600 "US_i"	PSB 750 "US_i"
1.	37,5	22,5	22,5	22,5
2.	65	39	52	52
3.	24	18	18	18
4.	28,5	38	28,5	28,5
5.	8	8	8	8
6.	45	27	27	27
7.	18	13,5	13,5	13,5
8.	37,5	37,5	37,5	37,5
9.	6	6	6	6
10.	42	28	28	28
11.	42	56	42	42
12.	28,5	28,5	28,5	28,5
13.	31,5	31,5	31,5	31,5
14.	6	6	6	6
15.	50	50	50	50
16.	12	12	12	12
17.	28,5	38	28,5	28,5

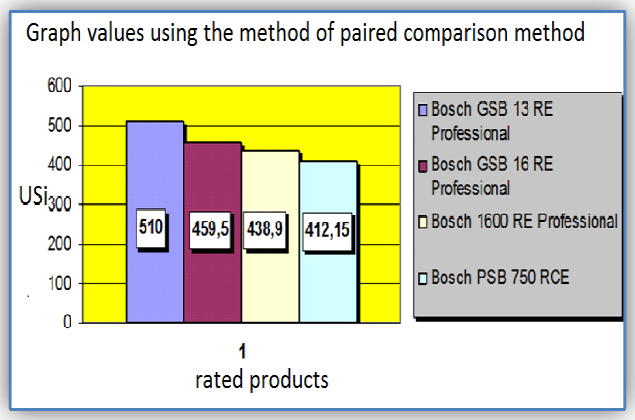

Figure 5. „US_i" values of the assessed equipment

The above results show that in terms of the suitability the best and the most environmentally friendly equipment is BOSCH GSB 13 RE Professional (Figure 1).

This ranking also confirms the environmental quality of the equipment. The graphic presentation of the results is shown in Figure 5.

Despite its easy use, the paired comparison method is not widely used. Some of its advantages and disadvantages include:

Advantages:

» 80 assessment factors,
» the possibility of replacing the existing factor with other similar factor in the case some factors cannot be assessed,
» social factors involved.

Disadvantages:

» ranking method,
» long assessment procedures,
» subjective approach,
» does not work with specific data.

CONCLUSION

The main aim of the article was to determine the level of environmental suitability of impact drills. The analysis was conducted using the paired comparison method. This method of assessment features 80 factors (environmental, technological, economic and social). Such assessment process offers a wide range of factors and choices while permitting modifications and changes to certain factors. This method also features social factors such as ergonomic criteria or the risk of damaging workers' health when operating the equipment, which means that the overall assessment may also include aspects of OSH. Clear results may convince the reader to buy the impact drill BOSCH GSB 13 RE Professional.

Special Thanks

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MODELING OF HYPER-ELASTIC MATERIALS IN CONTACT

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Abstract: Current technology in machine and equipment industry frequently employs components made from hyper-elastic materials such as rubber, various polymeric foams etc. When pressed against another body, such materials illustrate different behavior by comparison to the contacts of linear elastic materials. It is therefore of interest to investigate the mechanical behavior of such materials in contact. The present paper advances a finite element model of the circular contact between a spherical punch made from a hyper-elastic material and a rigid half-space. The numerically obtained results are then compared to previously advance experimental results.
Keywords: rubber, hyper-elastic behavior, simulation, circular contact

INTRODUCTION

As the practical situations are extremely different, numerous studies can be found in literature, [1-8] that investigate, either theoretically or experimentally, the behavior of bodies pressed against each other under different conditions.

The literature of the last half-century contains various models for hyper-elastic behavior of materials, [1-5].

Rivlin and Mooney advanced such a model, [1-4] that was found to be suitable for investigations upon the behavior of rubber and other similar materials.

The present paper advances a finite element model of the circular contact between a spherical punch made from a hyper-elastic material and a rigid half-space.

HYPER-ELASTIC MATERIAL MODELING

Most of the models currently employed for the characterization of materials with nonlinear elastic behavior are based upon specific strain energy expressions, [1]. The most commonly used model that characterizes hyper-elastic materials is the generalized Rivlin model. The general equation for specific strain energy is according to [2], as follows:

$$W=\sum_{p,q=0}^{N} C_{pq}\left(\bar{I}_1-3\right)^p\left(\bar{I}_2-3\right)^q+\sum_{m=1}^{M} D_m\left(J-1\right)^{2m}, \qquad (1)$$

where, C_{pq} represent material constants that depend on shape modifications of the investigated material and D_m are material constants that depend on volume variations. In the case of compressible materials, $N=1,\ M=1$, $C_{00}=C_{11}=0$, and W becomes:

$$W=C_{01}\left(\bar{I}_2-3\right)+C_{10}\left(\bar{I}_1-3\right)+D_1\left(J-1\right)^2, \qquad (2)$$

where, $\bar{I}_1=J^{-2/3}I_1$, $I_1=\lambda_1^2+\lambda_2^2+\lambda_3^2$, $J=\det\left(\hat{F}\right)$, $\bar{I}_2=J^{-4/3}I_2$, thus resulting that $I_2=\lambda_1^2\lambda_2^2+\lambda_2^2\lambda_3^2+\lambda_3^2\lambda_1^2$.

In the case of incompressible materials, equation (2) is rewritten as:

$$W=C_1\left(\lambda_1^2+\lambda_2^2+\lambda_3^2-3\right)+C_2\left(\lambda_1^2\lambda_2^2+\lambda_2^2\lambda_3^2+\lambda_3^2\lambda^2-3\right). \qquad (3)$$

Due to material incompressibility, $C_{01}=C_2$, $C_{10}=C_1$, and $\lambda_1\lambda_2\lambda_3=1$, while the term that characterizes volume strains annuls. Mooney, according to [3], defines nonlinear elastic behavior of materials by aid of an expression similar to the one given in equation (4). The material constants C_1 and C_2 employed by this model can be determined from the stress – uniaxial strain under traction, Figure 1, with the assumption that the material is incompressible, homogenous and isotropic, as showed in [3]. The model advanced by Mooney is a particular case of the generalized Rivlin model for incompressible materials. The specific strain energy is defined by aid of two invariants of the Cauchy – Green strain tensor.

$$W=C_1\left(\bar{I}_1-3\right)+C_2\left(\bar{I}_2-3\right), \qquad (4)$$

where, C_1 and C_2 are material constants, $\bar{I}_1$ and $\bar{I}_2$ represent the first and second invariants of the Cauchy – Green strain tensor, respectively.

Literature, [2], presents rubber as being an incompressible material and having a transverse contraction coefficient value in the vicinity of 0.5.

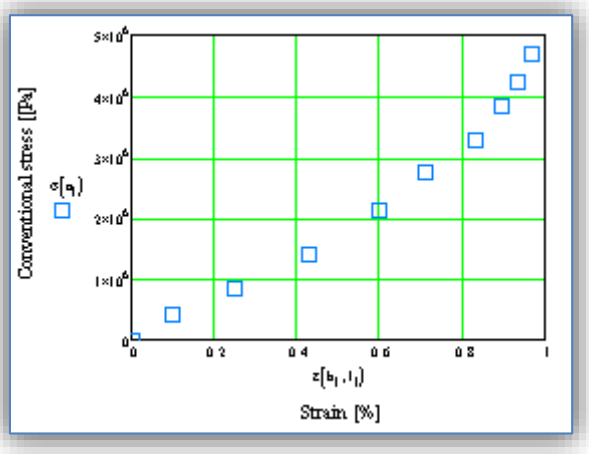

Figure 1: Stress – strain characteristic for rubber, experimentally obtained under uniaxial traction, [4, 5].

For incompressible materials with hyper-elastic behavior, Vossoughi, [3] advanced a representation of the specific strain energy as follows:

$$W = C_1\left(\lambda^2 + \frac{2}{\lambda} - 3\right) + C_2\left(2\lambda + \frac{1}{\lambda^2} - 3\right), \quad (5)$$

where, constants C_1 and C_2 are obtained by derivation of the specific strain energy by report to the two invariants of the Cauchy – Green strain tensor, $\bar{I}_1$ and $\bar{I}_2$, respectively, as shown in [3]. By derivation of equation (5) by report to λ, it results that, [3]:

$$\sigma = \frac{\partial W}{\partial \lambda} = 2C_1\left(\lambda - \frac{1}{\lambda^2}\right) + 2C_2\left(1 - \frac{1}{\lambda^3}\right). \quad (6)$$

In order to obtain a linearization of the characteristic, equation (6) can be rewritten as:

$$\frac{\sigma}{2\left(\lambda - \lambda^{-2}\right)} = C_1 + \frac{1-\lambda^{-3}}{\lambda - \lambda^{-2}} C_2. \quad (7)$$

If it is considered that $Y = \frac{\sigma}{2\left(\lambda - \lambda^{-2}\right)}$ and $X = \frac{1-\lambda^{-3}}{\lambda - \lambda^{-2}}$, equation (7) can be rewritten as shown in, [3], as:

$$Y = C_1 + C_2 \cdot X. \quad (8)$$

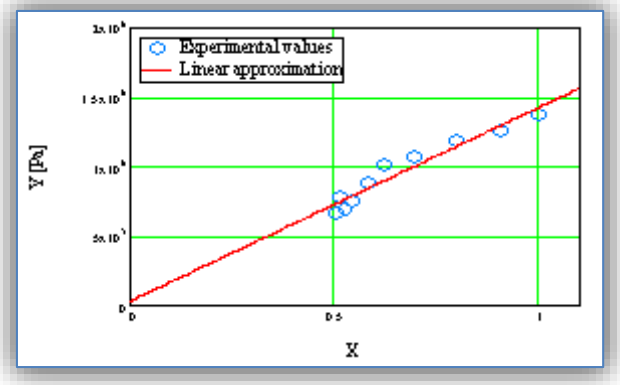

Figure 2: Y – X characteristic for rubber, obtained under uniaxial traction.

By graphically representing Y as a function of X, a linear plot is obtained as shown in Figure 2. The slope and intersection with the ordinate axis of this plot represent the values of C_2 and C_1 constants, respectively, [4].

Using a calculus methodology previously described in [3], the following material constants were obtained for the investigated rubber: $C_1 = 33{,}9\ kPa$, and $C_2 = 1{,}395\ MPa$. The obtained material constants were then used as input data in finite element analysis (FEA) software, in order to model the nonlinear elastic behavior of materials.

MODELING OF HYPER-ELASTIC SPHERICAL BODY – RIGID HALF-SPACE CONTACT

For the present study, a contact between a hyper-elastic spherical punch and a rigid half-space was modeled using the FEA software Femap.

In order to reduce the necessary time for calculus in such a model, only a 10° sector of a hemisphere was modeled from the total punch volume, as illustrated in Figure 3.

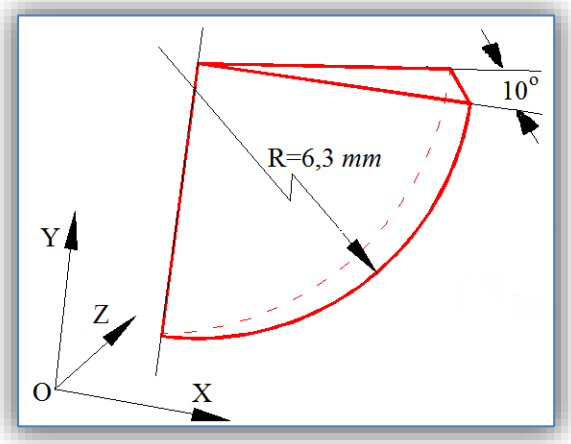

Figure 3: Geometry of the hemisphere sector created to model the 12.6mm rubber ball.

This simplification of the geometry was possible as it was taken into account that such a contact presents axial symmetry. The present study was conducted considering a rubber ball with a diameter of 12.6 mm.

As previously stated, it was considered that the punch is a ball made from rubber. Material elastic properties are defined by aid of the material constants from the Mooney-Rivlin model. For the present study, the material constants taken into consideration were $C_1 = 33{,}9\ kPa$, and $C_2 = 1{,}395\ MPa$, as previously described.

For the generation of finite elements in the described model, an automatic meshing was employed. Hexahedral elements of variable dimensions were placed on the considered geometry as follows: 40 elements unevenly placed over the length of the

circle arc, 30 elements evenly placed along the hemisphere symmetry axis and 20 elements evenly placed along a radius considered perpendicular to the symmetry axis.
The node corresponding to the initial point of contact between the rubber sphere and the rigid half-space was fixed (all degrees of freedom were removed). The displacements of nodes corresponding to the two lateral faces are restricted to their respective planes. Nodes placed on the symmetry axis can only move along the vertical axis, Y. The nodes corresponding to the upper surface of the geometry are allowed to have displacements along radial directions and also along the Y axis.

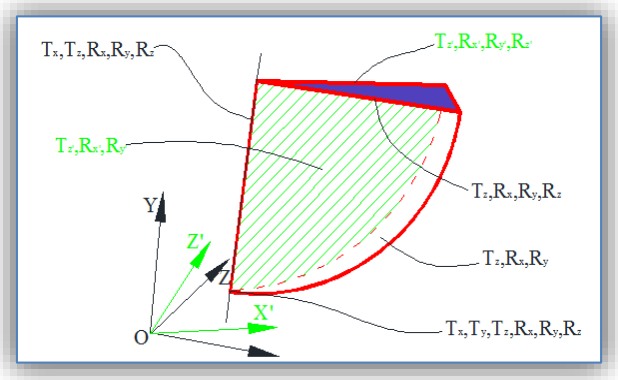

Figure 4: Constraints applied to the various geometry elements

In the representation of the constrained geometry illustrated by Figure 4, $T_x, T_y, T_z, T_{x'}, T_{y'}, T_{z'}$ denote the translations constrained (not allowed) along the X, Y, Z, X', Y', Z' directions, while $R_x, R_y, R_z, R_{x'}, R_{y'}, R_{z'}$ represent the constrained rotations around the X, Y, Z, X', Y', Z' directions.
The contact is loaded by means of imposed displacements of the nodes from the upper plane of the considered hemisphere sector.

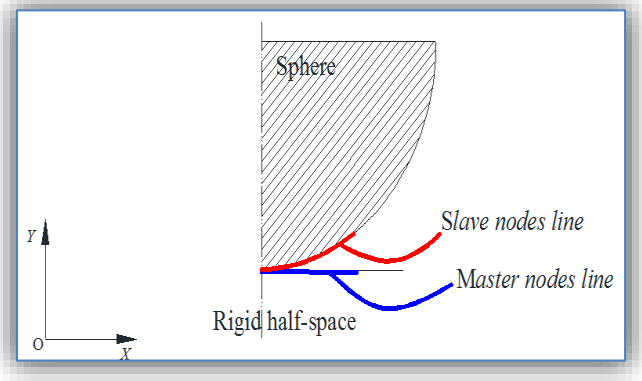

Figure 5. Nodes corresponding to the master and slave sliding lines.

For the present contact model, the creation of two sliding lines was necessary. These were defined by selection of corresponding nodes from the two geometries of contacting bodies. Slave sliding lines were defined on the ball geometry, while master lines were defined using the half-space geometry, as illustrated by Figure 5.
The presented contact model was analyzed using a static-nonlinear analysis that uses 30 steps.

RESULTS AND DISCUSSIONS

After the simulations were conducted as described above, the obtained results were represented graphically and interpreted. Figure 7 illustrates a spatial distribution of σ_y stresses corresponding to the considered hemisphere sector.

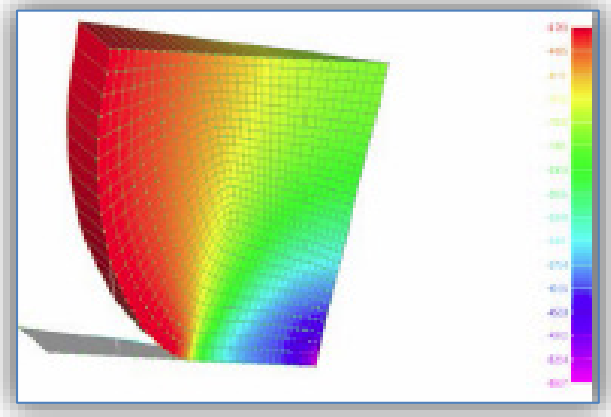

Figure 6: σ_y stress distribution corresponding to an imposed normal approach of 1,42 mm, for the contact between a rubber ball with $D = 12,6\ mm$ and a rigid half-space.

From the stress distribution plot illustrated in Figure 6, it can be noticed that the σ_y stresses take negative values in the contact region and become positive outside it. Also, as expected, it can be observed that the absolute values of these stresses are more important in nodes placed inside the contact region than in the ones outside it.

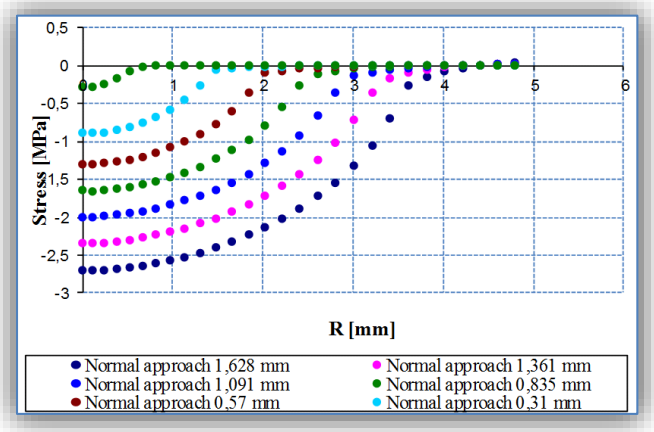

Figure 7: σ_y stress distribution along radial direction, corresponding to several imposed normal approach values, for the contact model between a $D = 12,6\ mm$ - rubber ball and a rigid half-space.

In order to evaluate the σ_y stress radial distribution, the values corresponding to nodes placed on one of the two circular contours limiting the hemisphere sector were represented graphically. Figure 7 illustrates such stress distribution plots, corresponding to various imposed displacements.
In order to assess whether the σ_y stress distribution obtained in this study is similar to the one yielded by the Hertz model for point contacts, several σ_y stress values were selected and interpolated by a function given by: $p(x) = p_0\sqrt{1-\frac{x^2}{r^2}}$.

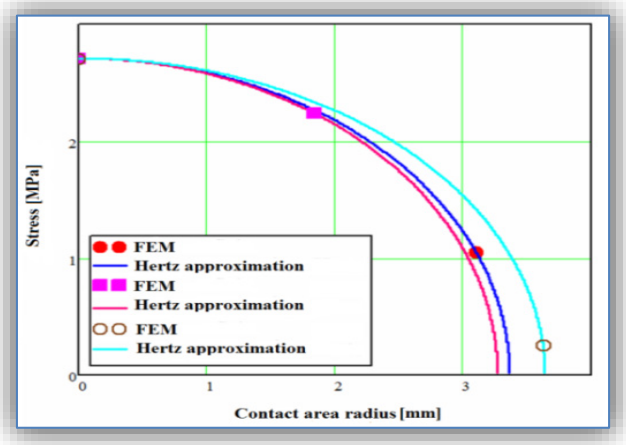

Figure 8: Interpolation of the FEA results for comparison to Hertz contact model.

The graphical representation of stress radial distribution illustrated in Figure 8 show that the three plots do not coincide. If the σ_y stress distribution in the investigated contact model were similar to a Hertz distribution, the three plots would overlap. It can therefore be stated that the stress distribution in the case of a circular contact between nonlinear elastic materials is different from the one yielded by Hertz theory.

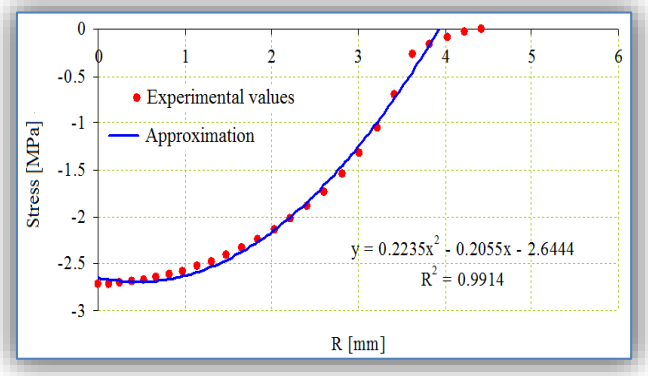

Figure 9: σ_y stress distribution corresponding to an imposed normal approach of 1.628 mm, for the contact model between a $D = 12,6\ mm$ - rubber ball and a rigid half-space.

Figure 9 illustrates the σ_y stress distribution corresponding to an imposed normal displacement of 1.628 mm.
The presented finite element model and conducted analysis allows the assessment of the approximate value of the contact area radius at the intersection of the interpolation curve illustrated in Figure 9 and the X-axis.
Using this method, contact area radii were determined at various imposed normal displacements and their evolution was plotted as shown in Figure 10.

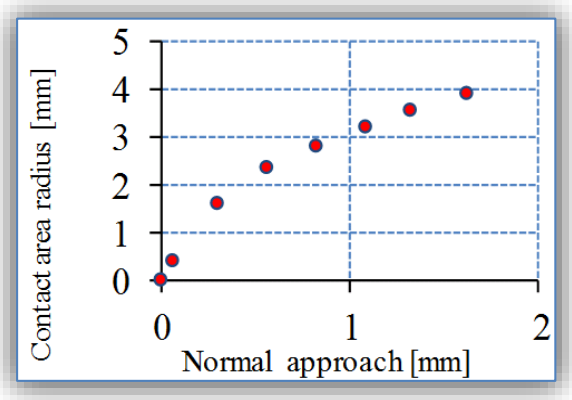

Figure 10: Correlation between contact area radius and normal approach for the contact model between a $D = 12.6\ mm$ - rubber ball and a rigid half-space.

The plot illustrated in Figure 10 shows a nonlinear evolution of the contact area dimensions as the imposed normal approach increases. The shape of the numerically obtained stress evolution plot is similar to previously advanced experimental results. Further analysis of the σ_y stress distributions shown in Figure 8 illustrate that maximum stresses are reached in the center of the contact area. Figure 11 graphically illustrates the evolution of these maximum stresses as normal approach increases.

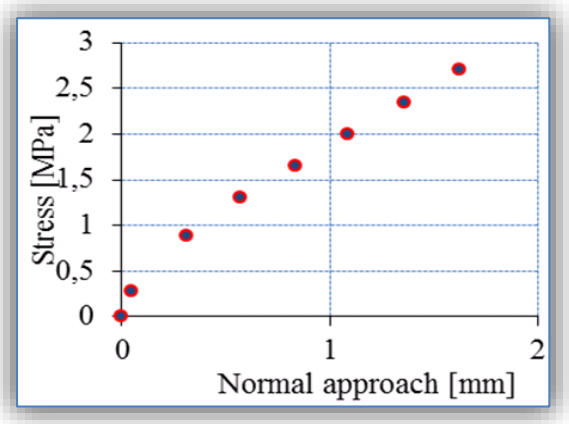

Figure 11. Correlation between maximum stress value and normal approach for the contact model between a $D = 12.6\ mm$ - rubber ball and a rigid half-space.

The numerical results yielded by this model were compared to experimental investigations conducted on the circular contact between a rubber sphere with a diameter $D = 12.6mm$, compressed between the flat surfaces of two parallel optically transparent sapphire plates. By report to the rubber ball, the two diametrically opposed plates can be assimilated to rigid half-spaces, as previously described in [5]. This experimental setup and methodology, as described in [5], generates two rubber ball – flat rigid surface, identical contacts (top and bottom), one of which is investigated.

The obtained contact area was investigated optically and its dimensions were determined. For that purpose the contact area was visualized and photographed by aid of an optical microscope. The obtained images of the contact area were then analyzed and its dimensions were determined by comparison to a sample with known size (1.34mm), as shown in Figure 12.

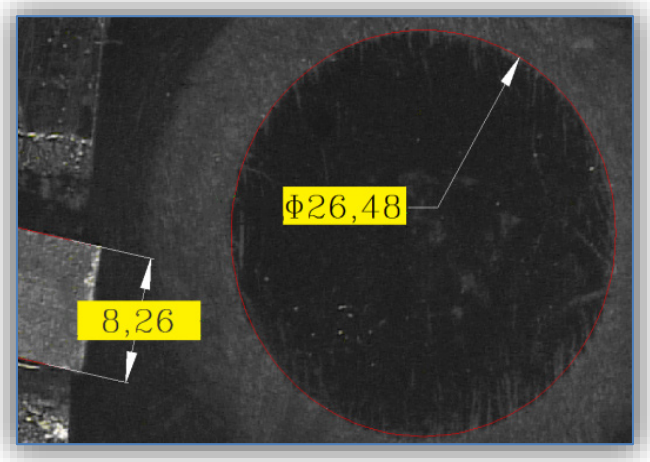

Figure 12: Contact area for an applied load of 13.05N, corresponding to a normal approach of 0.64mm

The normal approach between the two sapphire plates, which gives the rubber ball deformation along the vertical axis, was determined by aid of a laser profilometer.

The laser beam from the optical sensor of the profilometer was focused on the same sapphire surface before and after application of normal load to the contact. The difference between the two focus points, yields the total deformation of the rubber ball along the vertical axis.

The measured value represents double the value of the normal approach corresponding to one of the two rubber ball rigid surface contacts.

The correlation between experimental results obtained as described above and numerical simulations yielded by FEM analysis is shown in Figure 13.

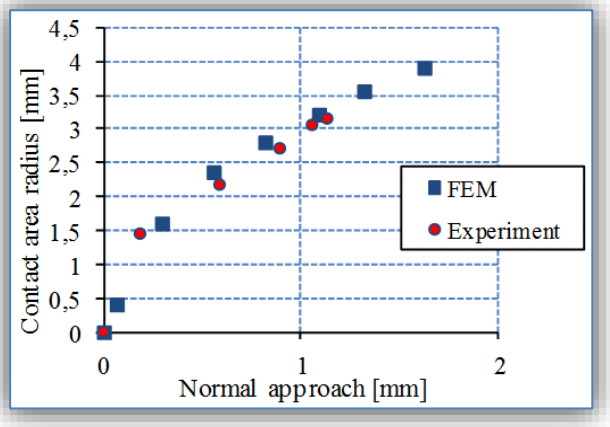

Figure 13: Comparison between the contact area radii obtained experimentally and FEM simulations, for the contact model between a $D = 12,6\ mm$ rubber ball and a rigid half-space.

CONCLUSIONS

In order to simulate the behavior of a hyper-elastic, homogenous isotropic and incompressible material using a Mooney-Rivlin model, it is necessary to determine the corresponding material constants. This can be accomplished by conducting a uniaxial traction test on the investigated material and following the procedure previously described in [3] and [4].

In order to simulate a circular contact between bodies with hyper-elastic behavior it was found to be sufficient to model only a part of the total punch volume. In the present paper, a 10° sector of a hemisphere was considered for the modeling of a ball pressed against a flat rigid surface. The good agreement found between numerical simulations and experimental results confirm this possibility.

The normal stress distribution found in the case of hyper-elastic bodies in contact was found to be different from the one yielded by a Hertz model of a circular contact, which considers elastic behavior.

Note

This paper is based on the paper presented at The 1st International Conference "Experimental Mechanics in Engineering" - EMECH 2016, organized by Romanian Academy of Technical Sciences, Transilvania University of Brasov and Romanian Society of Theoretical and Applied Mechanics, in Brasov, ROMANIA, between 8 - 9 June 2016

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REASON OF THE UNSUSTANIBILITY OF COMMUNITY BASED PROJECTS: A CRITICAL REVIEW

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Abstract: Pakistan, being a least developed and economically sluggish country, cannot widely support and implement the community projects for its nation. Community development projects in Pakistan mostly rely on foreign aids. The agenda behind this support to the least developed countries is to facilitate them in achieving the Millennium Development Goals. The Charter of United Nations also encourages the promotion of social progress and better standards of life by the employment of external machinery.In Pakistan, the community development professionals design projects in a closed room without doing the practical need assessment with the people, in the field and serve projects in a plate for the community. The aim of this paper is to analyze the factor which affects the sustainability of the community projects. The study has found that the projects which were designed without the consultation, involvement and participation of the community people could not be sustainable. Based on the outcome of the study, I conclude that for the sustainability of community projects it is necessary that community should identify their problems in facilitation of the social researcher by using different tools and should also propose solution to these problems. On the basis of this collected data community projects should be initiated.
Keywords: Community; Community based projects; Sustainability; MGDs

INTRODUCTION:

Communities have their own syndromes and these syndromes are found in the shape of socio-economic problems. These issues and problems need treatment. When these problems are properly identified, analyzed and treated, they get vanish and other new problems arise. This cycle continues. Likewise, no community in the world is safe from such kind of problems whether they are developed, developing or under developed communities. Pakistan is also hosting many social and economic problems. Dealing with these problems needs resources and economic capacity which is unfortunately lacking in the country.

In view of this scenario, the government has given permission to UN Agencies and Donors to invest in the socio economic development sector of the country in order to mainstream its nation in the development progress. These Donor Agencies fund the community projects but most of these projects do no remain sustainable.

The main factor responsible for this failure is TopDown Approach. Mostly projects do not come from the communities directly and do not reflect community's problems. This is the primary hurdle in the sustainability of community projects. There is a need to do practical need assessment with the community and know from them what problems they are facing in their localities. Every community project should be designed and formulated within the community by knowing their perception of problems and then forwarding the report to the donors and ask them for the community projects.

Sustainability is derived from the Latin *sustinere* (*tenere*, to hold; *sus*, up). Sustainability has different meaning in different disciplines. Sociologist, economist and ecologists have offered different meaning of sustainability.

Economists tend to treat sustainability in terms of ways to keep the production system more viable; environmentalists and ecologists tend to focus on the perpetuation of the environment and its subsystems; sociologists are more concerned with the impact on cultural and social systems [2].

According to Brunt land Commission report (Our Common Future) sustainable development is defined as 'development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs'(World Bank, 2005).

According to Roy, sustainable development is for the people by the people (2003). It is the people who determine the essence of sustainable development which brings change in their attitude and leads to a change in their habits. According to International Fund for Agricultural Development sustainability is "Ensuring that the institutions supported through projects and the benefits realized are maintained and continue after the end of the project …. (IFAD Strategic Framework 2007-2010).

According to Top down Approach, 'the starting point is authoritative decision' in which centrally located actors are seen as most relevant to producing the desired effect (Matland, 195, p.146). The main actors are considered to be the decision makers who are responsible to formulate an efficient statute to the kind of existing problem. The top-down theory defends that, on the one hand, policy formulation and decision-making are made at the top level institutions. While, on the other hand, policy implementation and evaluation is done at the national level of member states (Sabatier, 1986). The top-down model is structured around the use of professional leadership provided by external resources that plan, implement, and evaluate development programs (Macdonald, 1995).

If development experts choose indicators simply to comply with the requirements of funding agencies, then this top-down process may alienate local community members and fail to capture locally important factors. It creates ambiguity when development experts choose sustainability indicators for the local situation because it may not be relevant to the local community.

Local engagement builds community capacity to address future problems which may be more important than the results of the actual development project [3].

For example, in community based environmental management workin Bangkok, the act of inventorying land and identifying problems played a key educational role in the community (Fraser, 2002). The methods used to collect, interpret and display data must be easily and effectively used by local communities so all stakeholders can participate in the process [3]

In Baluchistan, most foreign funded development projects such as National commission for human development, Minor community irrigation project, Baluchistan area development program which strategized women empowerment as their complementary goalfailed to achieve their objectives because of the poor performance of participatory development projects especially in terms of women empowerment [4].

METHODOLOGY

The methodology includes a critical review of the local Community Based Disaster Risk Management (CBDRM)project in district Charsadda, after 2010 flood.

CBDRM PROJECT OVERVIEW

Flood 2010 affected 20 million people all over Pakistan and disrupted more than 1.8 million households [5] while in Khyber Pakhtunkhwa (KP) province it affected 545,739 households [6]. After flood many reconstruction and rehabilitation projects were initiated in severely hit 'Charsadda' districtof KP.

District Charsadda is administratively divided into three Tehsil i.e. Charsadda, Shabqadar and Tangi. District Charsadda consists of areas which are highly prone to floods during monsoon season. High floods hit the district in July 2010 inundating many areas in the district and causing loss to life and property. Three main rivers i.e. Kabul River, Swat River, Jindai River flow in district Charsadda, which are the main Hazards to this district. Total area of Charsadda is 996km square. In Charsadda, out of 49 union councils (UCs) 34 UCs affected. The total population of district Charsaddais 1.431 million and affected population 545,739 [6].

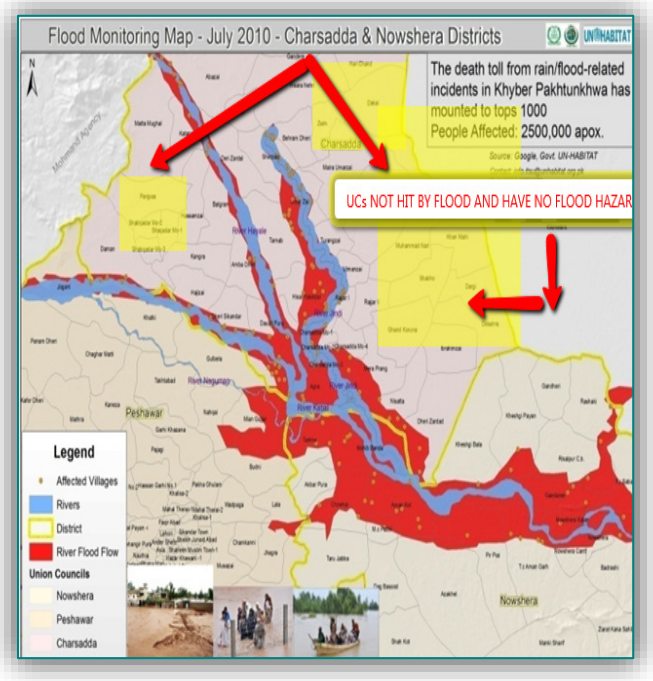

Figure 1. Flood monitoring map, 2010 - Charsadda and Nowshera Districts

Community Based Disaster Risk Management (CBDRM) was proposed for the vulnerable people of Charsadda. The project aim was to increase the capacity and reduce vulnerability of the local vulnerable community.

The project was designed for the whole district i.e. 49 UCs. This project also included those union

councils (Muhammad Nari, Shaikho, Rjar II, Ghundakankana, Zaim, Harichand, Khan Mahi, Dhaki, MCI, MCII and MCIIIof *Tehsil* Shabqadar) of the district which were far away from the river and were not hit by the flood 2010. When social mobilizers would visit these union councils and asked them to participate in disaster risk reduction activities for avoiding future threats of the floods, the community would show a pathetic behavior towards this project. They would usually reply that we do not need such projects and do not waste your resources in such places where it is not needed. These community people were of the view that they have not faced any flood disaster and do not have a threat of flood because their UCs are far away from the flood hazard. In view of this situation the DRR facilitators refused to conduct vulnerability capacity assessment within these UCs and just held few awareness sessions. Despite of this entire scenario, the stoke pile items (related to flood hazard) were distributed in these UCs as a formality because it was in project design that every UC would receive the stoke pile items.

ANALYSIS

The analysis drawn from this study is that if the above mentioned CBDRM project would designed within the communityin the presence and facilitation of project designer, then the chances of sustainability of theproject would be higher.

This project did not attain sustainability because it was designed on the basis of secondary data, lacking theinvolvement of the community people. All community projects should be planned by doing practical need or vulnerability assessment by the community people.

Project designer should visit the area first and should extract the grass root problems. Research designer should provide facilitation in data collection by introducing simple tools e.g. focus group discussions, interview, mapping etc.

On the basis of this collected data, the community problems should be ranked and prioritized. The solution to these problems should come from the community. On the basis of this process, community projects should be designed. This down up approach will ensure sustainability of the project.

RECOMMENDATIONS

Most community projects in Pakistan miss the element of sustainability. Whenever the fund stops or NGO phase out from the project, the community interest in the project fades. They do not continue the project in the long run because mostly projects do not involve the local community's will and consent and that's the reason whenever the external support stops the community also loss interest in carrying the project in the long run.

Community projects need ownership and this ownership comes when the project arise from the community.

Though assessment done by the community is time consuming but it scratches out the sustainability indicators from the community which ensures sustainability of projects.

Engaging community people in the identification and treatment of their problems ensure empowerment and leads to sustainability.

Project designing within community diffuses knowledge from the researcher to the community and provides valuable opportunity of education and awareness of the local people.

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THEORETICAL STUDIES (FEA) AND EXPERIMENTAL DETERMINATIONS USED AT A TOWING ASSEMBLY

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Abstract: This paper contains theoretical studies with Finite Element Analyses for a complex coupling consisting of a towbar (for Audi Q5), a transverse frame to grip on vehicle chassis and the necessary elements for fitting (flanges, screw-nut system, welding). It was proceeded first with the conception and design of all components but also the assembly and fastening system. For the execution and analyze of the model, it was started by shaping it, meshing it with shell and solid type of elements and analysis of the state of tension and deformation under load; it will simulate and determine experimentally the behavior of the towing assembly in compression conditions (braking). The sample contains fastening elements by welding. Finally, it was done a comparison of theoretical and experimental results; further work will follow on some optimization of the components from the studied assembly.
Keywords: towbar, displacement, load, stress

INTRODUCTION

This paper contains dynamic tests at a towing assembly used at Audi Q5 vehicle, fig. 1-1. The experimental determinations were made by a MTS traction machine; the models are made in Inventor and Finite Element Analyses with HyperMesh software.

Additional there will be done some comparisons between a dynamic test at $2x10^6$ cycles and FEA on the regions where the maximum stresses appear.

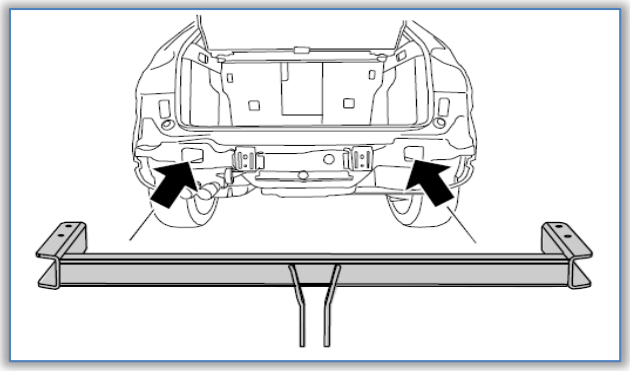

Figure 1-1: Audi Q5 – Towing assembly

The towing assembly is assembled on the vehicle with 4 (four) screws M10x100, and it contains two pairs of flanges and a square pipe in the middle, fig. 1-2. The all 4 flanges are welded on the square pipe and the towball is fixed with two M12x70 screws and two M12 nuts. All components are from S355J2 material.

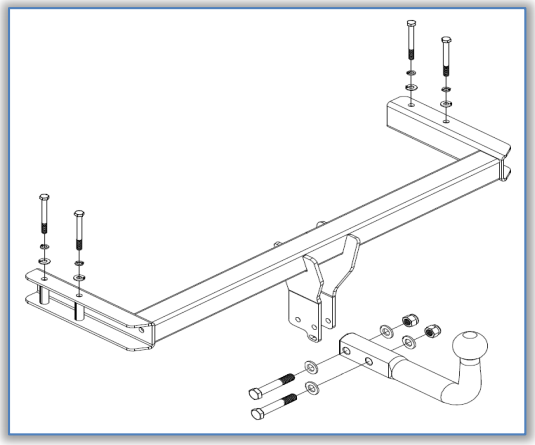

Figure 1-2: Towing components

EXPERIMENTAL DETERMINATIONS

In general, this type of towing assembly is tested with an approximate 7,5 [kN] load at $2x10^6$ cycles, on all three axes, the name of the test is Carlos. In picture no. 2-2 is appeared a sample from this test and there they can see the areas where appear cracks after the $2x10^6$ cycles, at a dynamic load. The pink color represents regions where the maximum stresses appear.

In our tests we tested a little bit differently. It simulated only the moment when the car is braking and the trail pushes the car entering stress on the towing assembly. The loads were: 7,5 [kN] – 20 cycles, 15 [kN] – 10 cycles, 25 [kN] – 10 cycles and 50 [kN] – 5 cycles.

Figure 2-1: Towing assembly on the test bench

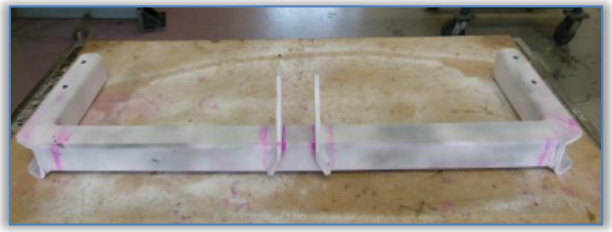

Figure 2-2: Towing components

For the experimental determinations, there were used some devices to adapt this type of project at the traction machine. There was made a rigid base plate with 20 [mm] thickness, fig. 3-1, and two other devices to fix the towing assembly, fig. 3-2.

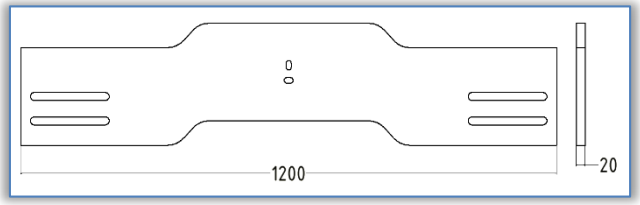

Figure 3-1: Rigid base plate

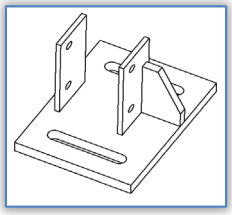

Figure 3-2: Left – Right devices

Most of the parts of the devices are made by a cutting laser machine and after that they are welded to form a new component, fig. 3-2. The sample is fixed with 2 devices (fig. 3-2), then the two devices will be fixed on the rigid base plate (fig. 3-1) and finally, all assembly will be fixed on the traction machine, fig. 4-1.

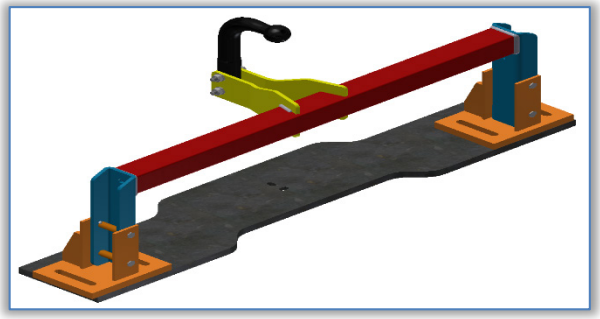

Figure 4-1: Assembly for traction machine

Figure 4-2: MTS traction machine

The assembly from figure 4-1 will be fixed on the support of traction machine with 2 screws. The rigid base plate has 2 holes to be fixed on the traction machine support.

The traction machine is from MTS (fig. 4-2) and it has 1.000 [kN] maximum capacity. This machine was adapted to do cycles and to give diagrams.

All the assembly was tested at the all loads until it was destroyed. The towing assembly was not broken, but the material was in plastic region. For the 7,5, 15 and 25 [kN] load the assembly worked only in elastic region, but it remained residual stress field.

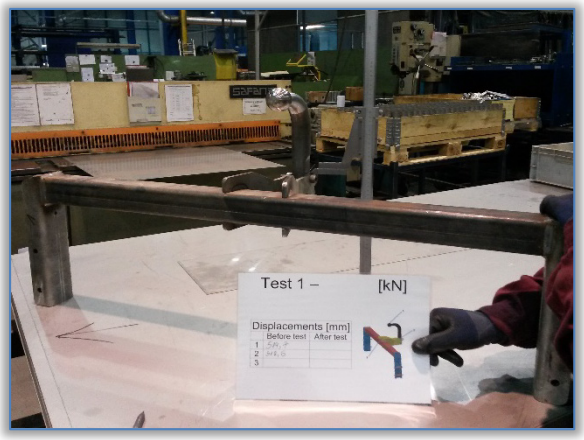

Figure 5-1: Vertical caliper measurement

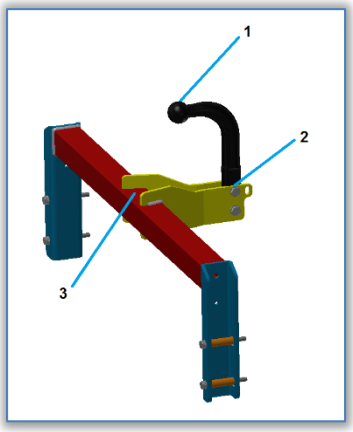

Figure 5-2: The 3 points measured

Before and after the tests the towing assembly was measured with a vertical caliper (fig. 5-1) in 3 points (fig. 5-2), to see the deformations resulting from residual stress. The results are in Table 1, where it can be seen the measurement before and after the 4 tests and in figure 6-1 it can see how the towing assembly is fixed on the traction machine. For the last column from Table 1, Ball displacement, the values were read from diagrams.

Table 1: Experimental determinations values

Load [kN]	Point	Before test [mm]	After test [mm]	Measured deformation [mm]	Ball displacement [mm]
7,5 – 20 cycles	1	514,70	512,76	1,94	5,43
	2	312,60	311,36	1,24	-
	3	310,62	310,78	-0,16	-
15 – 10 cycles	1	512,76	511,84	0,92	8,37
	2	311,36	311,16	0,20	-
	3	310,78	311,70	-0,92	-
25 – 10 cycles	1	511,84	511,00	0,84	14,06
	2	311,16	310,82	0,34	-
	3	311,70	310,74	0,96	-
50 – 5 cycles	1	511,00	497,00	14	35,00
	2	310,82	308,64	2,18	-
	3	310,74	309,32	1,42	-

For the last test (at 50 [kN]) the towing assembly could not touch 50 [kN] because it was in plastic region, the maximum load was 42 [kN]. After this load the material started to flow, the strain was very high and also there was only one cycle.

Figure 6-1: Towing assembly fixed on traction machine support

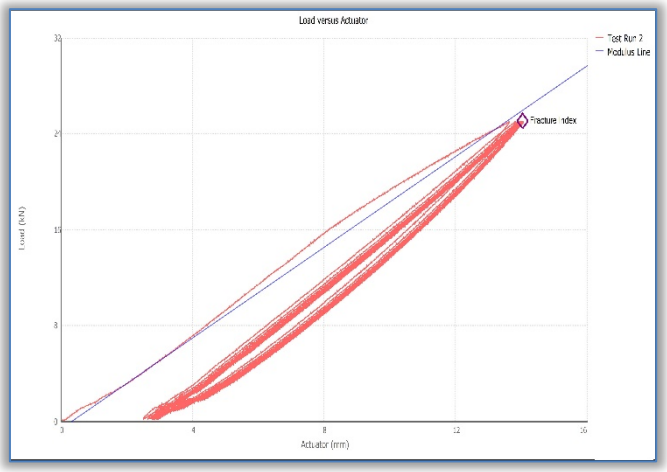

Figure 6-2: Load – Displacement diagram

In figure 6-2 is attached a diagram from traction machine with 25 [kN] load and 10 cycles. For all the tests the traction machine gives this type of diagrams. On diagrams it can read the maximum load and the maximum displacement. The dates for Table 1 are from these diagrams. Only for 50 [kN] test the diagram appears without cycles, it shows like a normal diagram load – strain or stress – strain.

For simple traction the machine can make the stress and strain diagram, if it is known the section area.

In Table 1 are 2 negative values because in the square pipe appears a torsion strain, higher than bending strain and the edge of the pipe is moving up. After a higher load the pipe starts to bend and the deformations are positive.

After the last test, when the load was the highest and material was in plastic region, it was discovered that the most deformed part of the assembly was the towbar, and only the towbar was in plastic region. In the past, the same authors demonstrated the strongest section for the towbar is with trapezoidal section and the weakest is with rhombic section. In these experiments there was used a towbar with round section which is between the two others, but it is the cheapest solution, fig. 7.

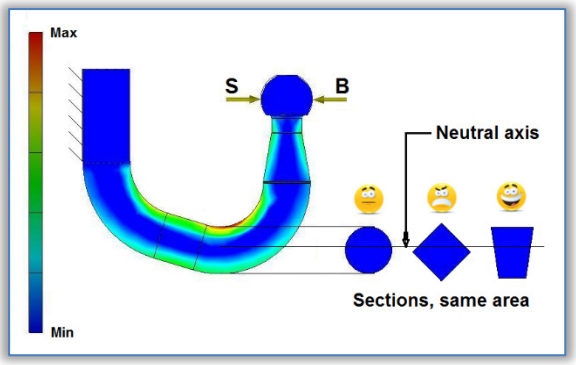

Figure 7: Different sections for towbar

Maybe if we used a towbar with trapezoidal section, the assembly could have been tested at a higher load.

FINITE ELEMENT ANALYSIS

This analysis was done with the same conditions and loads as the experimental determinations. The towing assembly was considered fix in the 4 M10x100 screws and the load pushed in the center of the towbar's ball. The loads were similar, 7,5 [kN], 15 [kN], 25 [kN] and 50 [kN].

For this analysis we did not use cycles, because the software is not capable to do this type of test without the material curve, and it worked only in elastic region, without residual stress.

To simplify the analyzed model, the assembly was considered without ball, it had only one point. It could do this thing because the highest stress is in the curvature radius, not in the ball, fig. 8-2.

For this FEA the mesh was with elements solid type and they were used 324263 elements and 389167 nodes.

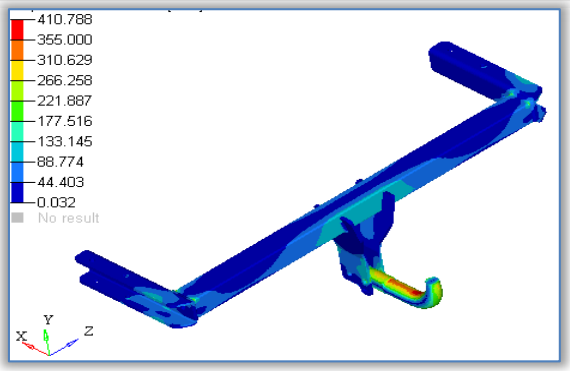

Figure 8-1: Area with maximum stress

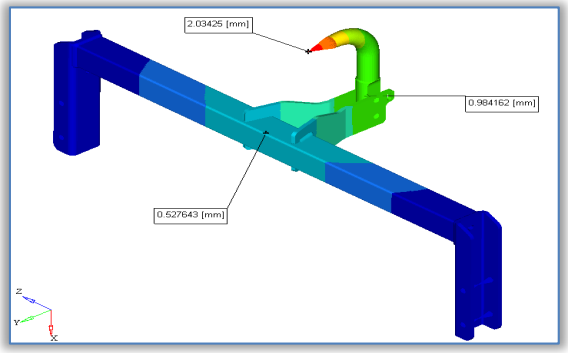

Figure 8-2: Area with maximum strain

For the maximum strain there is attached a table, where can be seen the displacements for each load. In Inventor software the sample was measured (without deformations) and in HyperMesh software the displacements were measured with the allocated load, in all the 3 points (see fig. 8-2).

In Table 2 the results are attached and they will be compared later.

Table 2: FEA values

Load [kN]	Point	Before test [mm]	Strains [mm]	After test (with load) [mm]
7,5	1	520,92	2,03	522,95
	2	312,50	0,98	313,48
	3	311,00	0,53	311,53
15	1	520,92	4,06	524,98
	2	312,50	1,96	314,48
	3	311,00	1,06	312,06
25	1	520,92	6,77	527,69
	2	312,50	3,27	315,77
	3	311,00	1,77	312,77
50	1	520,92	13,54	534,46
	2	312,50	6,54	319,04
	3	311,00	3,54	314,54

It can be seen in the Table 3 the displacements are linear, but in experimental determination the sample's material is in plastic region and the strains higher.

The experimental strains are higher (approximate double) than virtual strains. In the future is interesting to do some classical calculations to determine why these high differences exist and to use strain gauges. Also in the future the authors want to develop a similar system, but with composite elements, to do the sample lower weight, because the car makers tendency is to do the auto vehicles increasingly lighter.

Table 3: Comparison experimental determinations & FEA

Load [kN]	Point	Experimental Strains [mm]	Virtual Strains [mm]	After test (with load) [mm]
7,5	1	5,43	2,03	522,95
15	1	8,37	4,06	524,98
25	1	14,06	6,77	527,69
50	1	35,00	13,54	534,46

CONCLUSION

Comparing the pictures no. 2-2 and no. 8-1 they can see some similarities. The maximum stresses appear in the same areas, except only the towbar. In Carlos's test appeared stresses (micro crakes) only near welding regions.

Note

This paper is based on the paper presented at The 1st International Conference "Experimental Mechanics in Engineering" - EMECH 2016, organized by Romanian Academy of Technical Sciences, Transilvania University of Brasov and Romanian Society of Theoretical and Applied Mechanics, in Brasov, ROMANIA, between 8 - 9 June 2016

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THE EXAMINATION OF THE COMPOSITION OF WASTE TAKEN TO THE REFUSE DUMP

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Abstract: The communal solid waste refuse dump of the „A·S·A Hódmezővásárhely Köztisztasági Ltd." Is located on the outskirts of Hódmezővásárhely on the area No. 01957/1. The refuse dump is situated south of Hodmezovasarhely, west of no. 4414 road, about 5-6 kilometres from the centre. In terms of public service obligation the communal solid waste of Hódmezővásárhely and six other settlements is taken to the refuse dump (Csanytelek, Mindszent, Mártély, Földeák, Békéssámson, Makó, Nagyér), its area of responsibility is 200.000 people. It is operating in accordance with the Waste Management Law of 2000 No. XLIII and the related legislation and the public service contracts signed with the municipalities. The refuse dump and its facilities are built on the basis of an impact assessment of 1994. The refuse dump of Hódmezővásárhely is situated on 20 ha of land and the top height of the landfill is 30m. The refuse dump can store 3,9 million m3 of refuse and will provide environment friendly storage for the refuse of Hódmezővásárhely and its environs for 50 years. The refuse dump is provided with technical protection, leachate collection system and landfill gas drainage system constructed on the base of Austrian standards. Its cultivation is done by heapmaking technology. Based on the permission of ATIKÖFE the waste that may be delivered to the refuse dump are the following: household waste, not hazardous industrial waste, sewage sludges, debris and soil.
Keywords: landfill gas, alternative energy, environmental conditions, EWC codes, waste composition

INTRODUCTION

The The examination was carried out on the A.S.A. Hódmezővásárhely refuse Ltd.'s second and third landfill sites where I analysed the unloaded waste. When laying down the boundaries of the areas for the surveys it had to be taken into consideration where the waste is produced. The areas covered in the examination are the following:

- Hódmezővásárhely public domain,
- Hódmezővásárhely downtown,
- Hódmezővásárhely suburb.

This method represents the waste composition for the entire landfill site. During the examination I examined the first loads which arrived each day. On the basis of the entire daily delivery the composition of the total amount of waste can be concluded. Due to this the waste delivered within a day is aggregated by EWC codes. A.S.A. Hódmezővásárhely Ltd. carried out the compulsory winter, sping, summer and autumn monitoring provided in the standard environmental performance permissions by the notice of the Environmental inspectorates (Table 1). Waste composition examination was made by MSZ 21420-28 and MSZ 21420-29 standards where I divided the total waste into 13 fractions and their sub fractions and from these I specified biodegradable proportion in the refuse dump.

Table 1. The amount of waste covered in the examination of waste composition in 2007

		winter 3. site	spring 2. site	summer 3. site	autumn 1. site
A	Gross mass of the collecting vehicle [kg]	11540 kg	28220 kg	11540 kg	28220 kg
B	Raw nett mass [kg]	1040 kg	11740 kg	1040 kg	11740 kg
C	Mass of average sample [kg]	504,7kg	499,57kg	501,5kg	503,5kg

WASTE POTENTIAL GENERATED IN THE REGION OF HÓDMEZŐVÁSÁRHELY

As the result of the waste analysis by MSZ 21976 standard to determine the biodegradable organic matter content of municipal waste it can be stated that 53% of the total collected amount (19.322.24

tons) of solid municipal waste (EWC 200301), that is 10240.78 tons can be considered biodegradable and it can be considered as biomass potential. (Table 2) Usable biomass potential and speculative landfill gas yields produced from municipal waste from Hódmezővásárhely and its region for 2007 are shown in table 3.

Table 2. Amount of municipal waste by A.S.A. weight data

Year	Household waste (t)	Industrial waste(t)	Construction waste (t)
2005	31 071,33	13 516,56	11 414,32
2006	28 203,54	14 517,83	19 355,94
2007	19 322,24	21 201,81	36 599,36
2008	19 253,24	20 930,55	14 192,47
2009	20 974,66	17 403,90	12 479,42
2010	36 646,02	21 364,48	12 982,00
	Sewage sludge (t)	Oily waste(t)	All (t)
2005	3 209,93	11 970,97	71 183,11
2006	4 691,90	10 796,56	77 565,77
2007	3 396,94	10 481,13	91 001,48
2008	2 565,82	10 334,30	67 276,38
2009	2 984,42	6 888,89	60 731,29
2010	2 452,29	11 423,96	84 868,75

Table 3. Produced municipal waste by areas and energy recovery

Area	Biomass potential [t]	Landfill gas recovery [m³/t]	Landfill gas produced [m³]	Landfill gas caloric value [MJ/m³]
Hmvhely	7574,94t	256	1.939.184	21
Mindszent	826,36t	256	211.456	21
Mártély	151,04t	256	38.666	21
Székkutas	188,34t	256	48.215	21
Green waste	1500t	190	285.000	21
Sewage sludge	713,16t	310	221.079	21
Oily waste	524t	190	99.560	21
All	11477,94t		2.843.160	21

Speculative amount of landfill gas produced from municipal waste is 2,244,424 m³. During my calculations I considered the most favorable yield, which are the following: municipal waste 256m³/t, sewage sludge 310m³/t, oily waste 190m³/t, green wastes 190 m³/t. The amount of landfill gas produced depends on the composition of the waste and is 40-300m³/t (by organic content of waste), by practical experience the actual amount of landfill gas that can be produced is 2-3 m³/t annually. It has to be considered that depending on the gas convey system and its operation only 30-50% of the total amount of landfill gas can be utilized. Differences between theoretical and practical amounts can be because of the changes of the environmental parameters, the organic matter content of waste, the type and composition of the waste and its physical characteristics, degradation conditions and the consistency of waste.

Amount of landfill gas generated in Hódmezővásárhely refuse dump: V_t [m³/t waste] according to Tabasaran/Rettenberge formula:

$$V_t = 1.868 \cdot Co \cdot (0{,}014 \cdot T + 0{,}28) \cdot (1-10^{-kt})$$

[Tabasaran/ Rettenberger, 1987]

C_o: proportion of organic carbin of waste [kg/t waste], 1.868: gas production of organic matter [m³/kg],

T: waste temperature [°C], k[-]: degradation constant, t: time [year]

EXAMINATION RESULTS OF THE ORGANIC MATTER CONTENT OF THE DELIVERED WASTE

≡ Composition of waste in 2007 winter

The mass of the waste at the primary sorting was 504,7 kg, the weight of waste remaining on the upper sieve (D>100) was 146,2 kg, the weight of biodegradable waste was 5,4 kg (3.7%) and there was 31,5 kg paper (21,5%) (Diagram 1).At the secondary sorting the mass of waste was 358,5 kg, the weight of waste remaining on the middle sieve (20<D<100) was 42,55 kg, the sample diminution ratio is 8,425. During secondary sorting the weight of biodegradable waste was 22,1 kg (51.9%) and the weight of paper was 1,5 kg (3.5%).

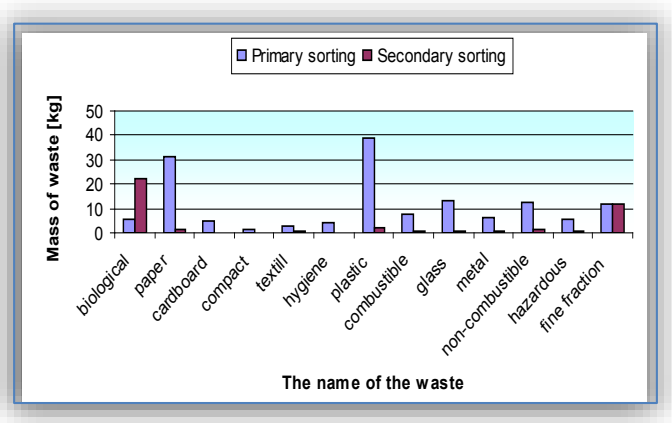

Diagram 1. Composition of remaining waste on the upper and middle sieve examination results

≡ Composition of waste in 2007 spring

The mass of waste at the primary sorting was 499,5 kg, the weight of waste remaining on the upper sieve (D>100) was 196,35 kg, the weight of biodegradable waste was 22,6 kg (11,5%) and there was 48,5 kg paper (24,7%) (Diagram 2). At the secondary sorting the mass of waste was 303,5 kg, the weight of waste remaining on the middle sieve (20<D<100) was 40,1 kg, the sample diminution ratio is 7,56. During secondary sorting the weight of biodegradable waste was 6,9 kg (17.2%) and the weight of paper was 8,2 kg (20.6%).

≡ Composition of waste in 2007 summer

The mass of waste at the primary sorting was 501,5 kg, the weight of waste remaining on the upper

sieve (D>100) was 160,5 kg, the weight of biodegradable waste was 16,8 kg (10,5%) and there was 36,1 kg paper (22,5%) (Diagram 3).
At the secondary sorting the mass of waste was 341 kg, the weight of waste remaining on the middle sieve (20<D<100) was 41,5 kg, the sample diminution ratio is 8,21. During secondary sorting the weight of biodegradable waste was 11,62 kg (28,1%) and the weight of paper was 7,4 kg (18%).

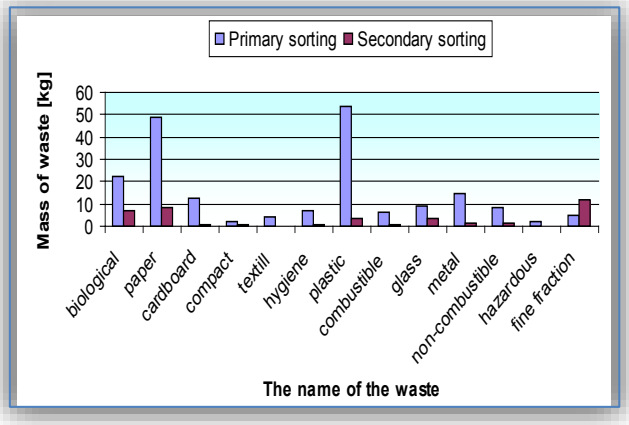

Diagram 2. Composition of remaining waste on the upper and middle sieve examination results

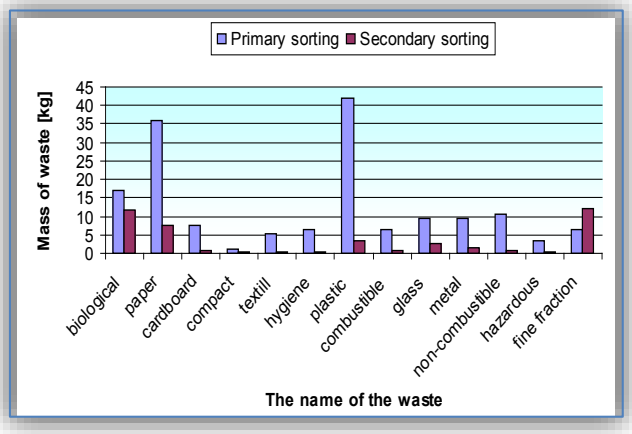

Diagram 3. Composition of remaining waste on the upper and middle sieve examination results

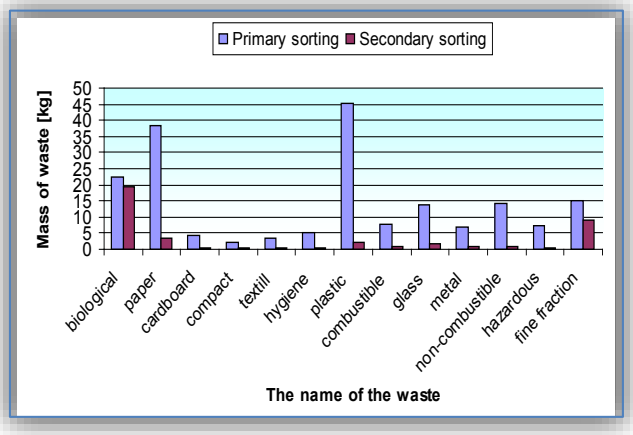

Diagram 4. Composition of remaining waste on the upper and middle sieve examination results

≡ Composition of waste in 2007 autumn

The mass of waste at the primary sorting was 503,5 kg, the weight of waste remaining on the upper sieve (D>100) was 186,5 kg, the weight of biodegradable waste was 22,5 kg (12,1%) and there was 38,24 kg paper (20,5%) (diagram 4). At the secondary sorting the mass of waste was 317 kg, the weight of waste remaining on the middle sieve (20<D<100) was 40,6 kg, the sample diminution ratio is 7,80. During secondary sorting the weight of biodegradable waste was 19.4 kg (48%) and the weight of paper was 3,37 kg (8,3%).
The determining factor of the biodegradable waste is the household waste and the green waste. Sewage sludge contains 30% of degradable organic matter, but municipal waste contains only 3-4% so it does not change significantly the organic matter concentration. Oily waste does not change the organic matter concentration either, as it can cause only about 1.5% concentration rise with the permitted oil concentration by the Environment Performance permission.

DISCUSSION

In our country and world-wide the amount of waste is growing rapidly due to economic development. It is true that the amount of selectively collected waste is also increasing and also the quantities of secondary materials as recycled materials quantities - so they can get back into the manufacturing process – however it is an important task to dispose of the waste at an up-to-date and environmentally friendly location. The other aspect is to protect the environment, and therefore use measures and technologies, which provide possibility for minimizing the potential environmental problems during the placement and disposal of waste.

CONCLUSIONS

In the recent years in Hungary the continuous increase of solid waste, as a result of private consumption, has become a serious issue. In Hungary currently about 23 million m^3 solid urban waste is formed annually. Sixty-two percent (62%) of this waste is household waste and the remaining is waste produced at institutions or service providers which can be treated together with the household waste. Waste management plays a key role in the quality of environment, protecting natural resources and developing environmental security. There can be two basic environmentally harmful effects of waste disposal. One of them is leachate, which percolates through the deposited waste and pollutes ground water, the other is the landfill gas from decomposed organic materials. Landfill sites should have deponia gas discharge duct system in order to comply with the environmental standards. Overall, in a particular

landfill, the meteorological parameters are always changing; the organic matter input parameters are characteristic of the region therefore the extraction efficiency can only be changed by the control of the exhaust capacity. Therefore, research has great importance in this area of research to show which landfill gas parameters are generated with the climatic parameters and organic matter intake.

Note

This paper is based on the paper presented at International Conference on Science and Technique based on Applied and Fundamental Research – ICoSTAF 2016, organized by University of Szeged, Faculty of Engineering, in Szeged, HUNGARY, 2 June 2016

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THE IMPORTANCE OF USING RENEWABLE ENERGY IN THE FORM OF BIOMASS

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Abstract: Currently, many countries in the world face the serious consequences of global warming, such as: floods, landslides, excessive heat during summer, drought and many others. The material consequences of climate changes on the economy, on human life and on the environment are very serious. Human activity overloads the atmosphere with carbon dioxide and other emissions that cause global warming, capture heat, slowly increase the planet's temperature and have a significant and harmful impact on our heath, on the environment and on the climate. The increase of providing renewable energy would allow replacing energy sources that have high carbon emissions and would lead to the reduction of global warming. The paper presents aspects regarding the importance of using renewable energy, as alternatives to using conventional energy sources (coal, petrol, wood, etc.).
Keywords: renewable energy, global warming, greenhouse gas, biomass

INTRODUCTION

Nowadays, more and more countries worldwide are confronting the consequences of global warming, such as floods, storms, landslides, excessive heat during summer, drought and others. The material consequences of climate changes on the economy, on people's lives and on the environment are very serious. Global warming by 1.8 - 4.0° C by 2100 could lead in this century to a rise in the sea level of 18-59 cm. According to the Stern Review, climate changes, caused by greenhouse gas emissions from the energetic sector, are considered as being "the greatest and the widest-ranging market failure ever seen" and a major threat to the global economy [1, 8].

Greenhouse gas emission is a serious threat in terms of producing climate changes, with potentially disastrous effects on humankind. The use of renewable energy sources (RES), together with improving energy efficiency (EE) can contribute to reducing fuel consumption, reducing greenhouse gas emissions and, therefore, to preventing dangerous climate changes [3].

These two severe problems – energetic crisis and the impact on the environment – represent global humankind problems whose solution lies on the shoulders of engineers. Because the world is so dependent on energy, because the majority of the world population uses fossil fuels to satisfy their energetic needs, a fact causing a high degree of pollution for the environment, arises the strict need to search for new sustainable and environment friendly sources of energy. All traditional energy sources used pollute the environment, whereas renewable energy is basically devoid of this negative effect of polluting the environment.

The potential of renewable energy sources is huge, because these sources can surpass many times the global demand for energy. Renewable energy sources such as biomass, wind energy, solar energy, water energy and geothermal energy can supply sustainable energy services, based on the regular use of available native resources. The transition towards renewable energy systems seems more and more possible as their costs decreases while the price of oil and natural gas continues to fluctuate [9].

Human activity is overloading the atmosphere with carbon dioxide and other emission that cause global warming, capture heat, slowly increase the planet's temperature and have a significant and harmful effect on our health, on the environment and on the climate. The increase of supplying renewable energy could allow replacing the energy sources

that have high carbon emissions and could lead to the reduction of global warming.

MATERIAL AND METHOD

The use of renewable energy is one of the most effective ways to ensure a more clean character to the supply of energy. Numerous citizens desire to be better informed about what renewable energy sources mean and how they can use them optimally. Romania has the capacity to produce energy from a multitude of sources, but the most important are biomass and water energy, as shown in table 1.

Table 1 [10]. Renewable energy production in Romania by type

Energy type	2010	2011	2012	2013
	-equivalent for 1 ton of oil-			
Water energy	1709.6	1266.4	1037.5	1286.1
Wind energy	26.3	119.3	227.0	388.7
Solar energy	0.1	0.0	0.1	0.2
Photovoltaic energy	0.0	0.1	0.7	36.1
Solid bio-fuels (excluding coal)	3900.0	3475.9	3795.1	3656.7
Biogas	3.1	13.1	27.3	19.6
Urban waste (reusable)	0.0	0.0	0.0	0.2
Bio-gasoline	35.4	34.8	42.5	26.5
Biodiesel	10.8	94.1	88.7	120.8
Geothermal energy	23.0	23.8	23.3	26.0
TOTAL renewable energy	5708.3	5027.5	5242.2	5560.9

Different sources of renewable energy are situated in different stages of technological and commercial development. In favorable conditions, wind energy, water energy, biomass and solar-thermal energy are viable alternatives from the economic point of view. Other types, such as photovoltaic energy (the production of electricity from sunlight using silicon panels) require an increase in demand in order to improve their economies of scale [7].

EU has committed, to reduce, by the year 2050, greenhouse gas emissions by 80-95% compared to the levels registered in 1990, in the context of the necessity to reduce emissions by developed countries. In the 2050 energy perspective, the Commission examines the challenges linked to fulfilling the EU objective in terms of decarbonisation ensuring, in the same time, the safety of energy supply and the competitiveness.

Table 2 [5, 6]. The share ofrenewable energy ingross final energyconsumption

Country	RE share in 2005 -%-	RE share in 2012 -%-	Objective on RE share for 2020 -%-
Romania	17.8	22.9	24
Total EU-28	8.7	14.1	20

In the view of the year 2050, the European Commission announces very ambitious targets for reducing greenhouse gas emissions with 80-95% and relies especially on reducing them by increasing the share of energy from renewable sources.

Romania has a diversified, but reduced quantitatively range of fossil and mineral resources for primary energy: petrol, natural gas, coal, uranium, as well as an important potential of renewable resources that can be valorized.

Romania remains an economy with a big consumption of energy, despite the tendency to decrease registered in recent years (a decrease of energy consumption of 36.4% between 1999 and 2010, and as an effect of reducing industrial activity due to the economic crisis).

Table 3 [5, 6]. Final energy consumption in Romanian Households %

Product	2007	2008	2009	2010	2011	2012	2013
Total petrol products	8.0	3.7	4.0	2.9	3.0	2.5	2.6
Gas	27.5	27.1	26.8	27.2	29.7	31.6	31.7
Solid fuels	0.1	0.6	0.2	0.1	0.2	0.3	0.3
Electric energy	11.9	11.1	11.8	12.0	12.7	12.8	13.2
Renewable energy	35.8	42.5	42.5	43.7	40.2	40.9	40.4
Derived heat	16.7	14.9	14.7	14.0	14.3	11.9	11.7

According to the Romanian Energetic Strategy for the period of 2007-2020, the national potential for renewable energy sources is estimated at 14,718 ktoe and is larger than Romania's import of primary energy in 2010 (11,239 ktoe) and is as follows:

- Solar thermal energy - 1433 ktoe;
- Solar photovoltaic energy - 103 ktoe;
- Wind energy - 1978 ktoe;
- Water energy - 3440 ktoe;
- Biomass and biogas - 7597 ktoe;
- Geothermal energy – 167 ktoe.

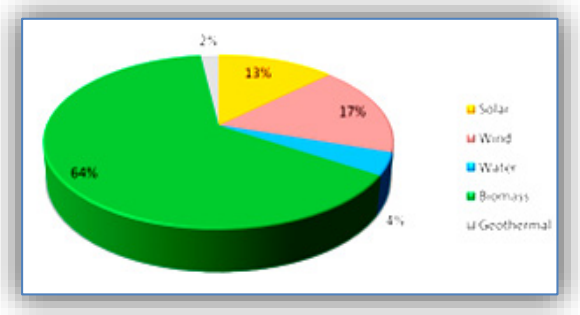

Figure 1 –Romania's renewable energy potential [12]

For Romania, harnessing the potential of renewable energy sources aims at increasing the safety of energy supply by diversifying sources and decreasing the share of imports of classic energetic

resources, aiming at a sustainable development for the energetic sector and the protection of the environment. Reducing the dependency for imports of energy resources is a goal all the more important as strategic documents in the field (among which The Romanian Energetic Strategy for 2010-2035) brings forward the perspective of an increase of the dependency for energy imports from about 35-40% presently to 60-70% on medium term, if the current structure and dynamics of consumption are maintained.

Biomass is the biodegradable part of products, waste and residues from agriculture, including plant and animal substances, forestry and related industries, as well as biodegradable part of industrial and urban waste (Definition given in HG 1844 from 2005 on promoting the use of bio-fuels and other renewable carburant for transport).

Biomass comprises all forms of plant and animal material grown on the surface of the earth, in the waters or on waters, as well as substances produced by biological development.

Biomass is the most abundant renewable resource on the planet and includes absolutely all the organic matter produced by the metabolic processes of live organisms.

Energy stored in biomass is released through various methods, which however, represent the chemical process of burning (chemical transformation in the presence of molecular oxygen, which is an exergonic process).

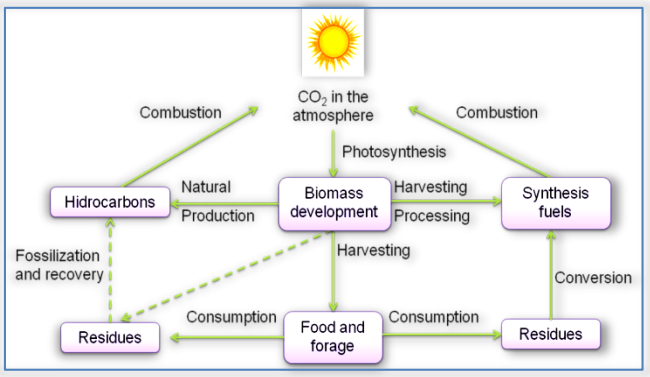

Figure 2 – The circuit of biomass energy [2]

There is a large variety of sources of biomass, among which are counted the fast growing trees (poplar, willow, eucalyptus), sugar cane, rape, fast growing herbaceous plants and various types of residues, such as wood from trimming trees and from constructions, straws and stems of cereals, residues resulting from wood processing, paper waste and used vegetable oils. The main biomass resource is however represented by wood.

RESULTS

The use of biomass has several advantages: offers an efficient solution for eliminating solid household residues and reduces emissions of carbon dioxide and nitrogen acids by replacing coal in thermal plants, thus contributing to decreasing environment pollution. Also, is presents an economic benefit. According to a study conducted by the Institute of Political Economy of Energy and Environment, conducted by specialist from the Bocconi University in Milano, electricity produced using biomass has the lowest cost of generating compared to any other source of renewable energy.

Fresh biomass is used for the production of energy, for nutrition and as raw material for the industry, but these applications imply a powerful interaction with the biosphere and its damage. Heat production from biomass is carried out through combustion processes, whose efficient production requires prior drying, the energy necessary for this process being significant in ratio to the energy value of the product, being recommended to use solar energy for drying biomass.

Table 4 [10]. Forecasted production of electric energy from renewable sources for 2015 compared to 2010

Renewable energy sources	2010 (GWh)	2015 (GWh) -estimates-
Solar energy	1860	1160
Wind energy	314	1001
Water energy – total, out of which: Low power hydro-energy (max. 10 MW)	18200 1100	18700 1600
Biomass	1134	3654
Geothermal energy	-	-
Total	22608	26115
Share of ERES in the consumption of electric energy	30.00%	30.40%

Wet biomass represents biomass with a relatively high content of water and a low content of lignin. Wet biomass is adequate for the production of biogas by anaerobic conversion due to these composition properties.

Dry biomass is represented by biomass with a high content of lignin and a low content of water. This type of biomass is not adequate for anaerobic treatment in the purpose of producing biogas, because the content of lignin cannot be converted anaerobically and so it does not contribute to the conversion into useful energy. Due to the low content of water, these residues are ideal for thermal use. For this purpose, the following types of residues are used: residues from forestry, community waste or trees and bushes cut from private properties, old wood, wood waste and fire wood.

Regional distribution of dry biomass (wood) in Romania varies: approximately 90% of the fuel wood and 55% of wood residues are found in the area of the Carpathians and Sub-Carpathians. Over

54% of agricultural waste is found in the South part of Romania and in Moldavia [11].

In Romania, large quantities wood residues in the form of small pieces are found, but it lacks the organization of collecting and transporting them. Studies conducted show that these waste represent highly valuable resources.

Biomass is currently used in Romania for the production of heat, especially in furnaces (0.8 – 4 kW) for cooking and heating water. 95% of biomass is used like this at the moment, the rest of 5% being used industrially to generate hot water and steam, for example in wood processing factories. The average installed power for industrially used biomass is from 3.3 MW to 4.7 MW.

Renewable energy can be used for all energy requirements: producing electricity, transport and household heating. Different types of renewable energy can be used in different ways, not all being adequate for every application. Water energy and wind energy are used exclusively for generating electricity, while other sources, such as biomass (organic matter), geothermal energy and solar energy can be used both for electricity and for heating.

CONLUSIONS

Romania has wide research experience in the agricultural field, including in cultivating biomass. There is a strong scientific base that can be used for improving the existing energy plants and introducing new plants in plantations.

The optimal valorization of biomass can contribute to increasing revenues from agricultural exploitations.

Forestry exploitations can supply an important quantity of biomass from forestry waste (branches etc.) to which are added those resulted from wood processing (wood chips, sawdust).

In Romania there is a high quantity of agricultural waste (ex. straws) available for producing bio-fuels.

The high costs of energy require finding a solutions for reducing them, by valorizing local resources (much cheaper).

Currently, the problem of replacing fossil fuels is heavily posed, both from the point of view of reducing CO_2 emissions, but also as an alternative to the inherent decrease of fossil fuel reserves. The demand for natural resources has grown rapidly, surpassing long-term capabilities ensured by the planet.

The main difference between the two forms of energy is the following one: fossil fuels can only be transformed into usable energy after thousands of years, while the energy from biomass is renewable, being possible to use it year by year. The simplest method of producing heat from biomass is that of burning it. This method is known as direct combustion. Other technologies used to convert biomass into usable energy include: gasification, combined combustion and modular systems.

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EVALUATION OF WASTE BIOMASS FROM OAT CULTIVATION FOR ENERGY

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Abstract: Energy demand of the world is increasing day by day as the population increases. Plant origin agri-wastes have an important energy potential, and are environmental friendly with low emission values. Solid biofuels from agri-wastes in the form of briquettes can be a good alternative renewable energy resource to fossil fuels. In this study, biomass waste from oat cultivation were dried till 10-14 % moisture content and chopped till 10 mm particle size and converted to briquettes by a hydraulic press under 240 MPa pressure. Some parameters for briquettes like density, breaking resistance[shatter index), shaking resistance[tumbler index), moisture resistance of briquettes, water intake resistance, ash content, calorific values and chimney gas emission values were determined.
Keywords: biomass, agricultural residue, energy, oat

INTRODUCTION

Biomass is the name to given all Earth's living matter. Biomass is general term for material derived from growing plants or from animal manure which is effectively a processed form of plant material such as wood from natural forests, waste from agricultural and forestry processes, and industrial, human or animal wastes. The stored energy in the plants and animals, or the waste that they produce is called biomass energy [14]. Energy production from biomass is becoming very important since there's a huge potential on the world, especially from agricultural production. Biomass energy potential of Turkey is estimated as 32 Mtoe[4], [17] and the total recoverable potential was estimated to be about 16.9 Mtoe[4], [15].

Side products from agricultural production are a very good source of alternative energy. Some of these side products such as residues or wastes from a particular crop can be converted to biofuels but, the productivity of agricultural resources used for production of biomass for energy purposes depends on the further development of biomass conversion technologies. Besides, the use of biomass resources which are defined as "CO2 neutral" [6] in the energy sector is important for Turkey to fulfil the possible future commitments based on the Kyoto Protocol.

Moreover, the use of indigenous resources such as coal and bio wastes for energy production is of critical importance in reducing energy imports. Among the combustion technologies, fluidized-bed technology has become more important because of its ability to burn different types of fuels due to the good mixing in the combustor and the high combustion efficiency achieved with less air given into the combustor [5], [16]. So, the potential to build power plants using coal as main fuel and various biomasses as supplementary fuel appear to be a promising choice for Turkey. Thus, the disposal of biowastes will be achieved and the energy content of the biowastes will be used beneficially in the country's energy production.

Briquetting is the process of conversion of agricultural waste into uniformly shaped briquettes that are easy to use, transport and store. The briquetting of biomass improves its handling characteristics, increase the volumetric calorific value, reduces transportation costs and makes it available for a variety of application.

The aim of this study is to investigate utilization possibilities of biomass residue from oat cultivation for energy in the form of solid biofuel. Some parameters of oat residues briquettes such as; density, breaking resistance [shatter index), shaking resistance [tumbler index), moisture resistance of briquettes, water intake resistance, ash content, calorific values and chimney gas emission values of oat straw briquettes were determined.

MATERIAL AND METHOD

This study was conducted in laboratory of OndokuzMayıs University Agriculture Faculty, Agriculture Machinery and Technologies Engineering Department in Samsun, Turkey. Cultivation residues of oat biomass were used as material. The material was dried in natural conditions until the moisture contents of 10-14%.

Material was primarily chopped and grinded by a hammer mill to 10 mm particle sizes. Then the dried and milled materials were briquetted by a hydraulic type press under 240 MPa pressure without using any adhesive. Heating values of the samples were determined according to European Committee for Standardization [13]. Before testing, the moisture contents of the milled samples were determined according to [10], and [11].

Before briquetting, material was filled in a certain capacity container from a certain height [about 4 cm) to determine the density of the material and the filled material was recorded by weighing. The material density was calculated by dividing the material weight by the volume of the container. Hectoliter and precision scales were for measuring briquette's volume weight. To determine briquette density, water flooding method was applied. Briquettes were covered with stretch film to prevent water absorption [Figure 1). The mass of covered briquettes were recorded. By dipping the covered briquettes into water container, volumes of briquettes were calculated.

Figure 1 - Briquettes from oat biomass

For shatter resistance, briquettes weights were recorded before testing than the briquettes were dropped from a certain height [1-1.8 m) to hard ground for 10 times and the weights were recorded again. The shatter resistance was calculated as a percent [Figure 2).

Figure 2 - Shatter test

For determining Tumbler resistance 5 briquettes were weighed before settled test apparatus according to in ASAE S269.4 standards [3]. Then briquettes were placed test apparatus and rotated 40 min^{-1} for 3 minutes. At the end of rotation, briquettes were weighed again. Tumbler resistance was calculated as a percentage depending on the weight loss that occurs during the test.

Water intake resistance is a measure of the percentage of absorbed water by briquette immersed water. In this test each briquette weight before immersion in water was weighted and recorded. Then, each briquette was weighted and recorded again about 11°C by immersion in normal tap water, with 30 second intervals for a total period of two minutes. Water intake resistance, depending on the increase in weight was calculated as a percentage.

The ash content was determined according to EN14775 standard [12] results are given in Table 1. Emission measurement contains measurements of exhaust gases discharged into the atmosphere as a result of various activities. Briquettes was measured

with flue gas temperature flue gas analyser to determine flue gas emission values burned in conventional type stove used in household heating and flue gas emission values [O_2, CO, CO_2, SO_2, NO_x) coming out as a result of burning [Figure 3).

Figure 3 - Gas emission measurement test

At the beginning of combustion carbon monoxide [CO) and carbon dioxide [CO_2) emissions were increased rapidly because of the decrease in oxygen content [O_2). Then CO and CO_2 emissions began to decline with the increaseof O_2 content in the combustion chamber as a result of steady-state the combustion process.Similar results were achieved withthe research of [8], [7], [1].

RESULTS and DISCUSSION

At the end of the study, briquettes having lengths from 75 to 95 mm long and 50 mm diameter without central hole were produced. It's observed that well shaped briquettes were produced under high pressure values by hydraulic type briquetting machine.

Selected particle size and moisture content of material were suitable for briquetting. Average density of obtained briquettes were suitable as a briquette [higher than 1000 kg/m^3 which given in literature). This was proved by the results of Shatter and Tumbler tests.

Water intake resistance of briquettes was not so good, because they started to dissolve in the water at the second attempt.

Ash content of the oat biomass briquettes was good enough for a solid biofuel according to [12] EU Standard. Heating value of briquettes were higher than normal wood and gas emission values were below the allowed limits given in Heating Air Pollution Control Regulations.

Some parameters of oat biomass in the form of briquettes were given in Table 1.

Table 1. Some parameters of oat biomass

Specification	Unit	Value
Density of material	[kg/m3)	45.55
Density of briquettes	[kg/m3)	1044.37
Ash content	[%)	9.32
Heating value	[cal/g)	4250
CO	[ppm)	1982
NOx	[ppm)	136.33
SO2	[ppm)	0
CO2	[%)	4.65
O2	[%)	7.6
Tumbler index	[%)	17.91
Shatter index	[%)	4.72
Water intake resistance	[%)	Dissolved

CONCLUSIONS

The results showed that, heating values and ash contentsof briquettes were appropriate to be used as a solid biofuel according to [9]. This means that oat biomass obtained after harvesting can be effectively used as an alternative energy source in combustionsystems. Briquettes of oat biomassafter burning in a traditional stove remainedbelowthe specifiedlimit valuesdetermined by Heating Air PollutionControl Regulation [2]. It is seen that oat biomass is very suitable for briquetting without the use ofany adhesive materialwith a hydraulic type briquetting machine.

This study supported that converting agricultural residues/wastes to solid biofuels is an effective way of creating environmental friendly alternative energy sources. The last but not least, the number of such researches must be increased to stress on this energy potential.

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THE INFLUENCE OF HYDROGEN ON THE COMBUSTION VELOCITY OF SOLID BIOMASS

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Abstract: Solid biomass combustion is characterized by two main issues: fuel high moisture weight (that generates some ignition failures) and the high rate of carbon monoxide from flue-gasses (that diminishes the efficiency of the burner an increases the pollution). Hydrogen injection (with a higher combustion velocity) disables the disadvantages mentioned above, allowing the design and operation of more efficient and less pollutant biomass boilers. The paper enhances the theoretical and experimental issues related to the hydrogen use during solid biomass combustion.
Keywords: combustion, solid biomass, efficiency, pollution

INTRODUCTION

Romania has a huge potential to produce and use the solid biomass for energy purposes. Related to the agricultural biomass, we mention important achievements in the use of straw briquettes in hot water boilers up to 300 kW [7].

The both agricultural and wooden biomass is characterized by a high volatile matters amount, which influences the whole combustion process. The combustion is also dependent on the high moisture content of the fuel, especially the ignition phase. The large difference between the combustion velocity of volatile matters and respectively those of solid mass (fix carbon) composed of lignin and cellulose leads finally to a high Co concentration in the flue-gasses. This is the main obstacle to achieving an efficient combustion of solid biomass [2], [5].

According to the measurements, the higher calorific value (HCV) of the cellulose is lower than the lignin. In relation to the fixed carbon content C_f, HCV can be computed using (1), C_f being reported at anhydrous status of the fuel:

$$HCV = 196\,C_f + 14{,}119 \quad [kJ/kg] \qquad (1)$$

The hydrogen, with its own very high combustion velocity, contributes to the increase of volatile matters velocity combustion, canceling the combined combustion of volatile and fixed carbon. In this manner, a better control of the fixed carbon combustion is achieved, leading to a significant diminution of the CO emission content.

In paper [6] it was used a mixture of hydrogen, named hydrogen enriched gas (HRG), produced by an electrolytic system. This electrolytic system is a dynamic one, keeping thefluid in a permanent flow and it is producing a quasi-stoichiometric gaseous mixture of hydrogen and oxygen. In fact this gas consists of a mixture of hydrogen and oxygen molecules,almost respecting the stoichiometric water ratio [3].

HRG is a gas with a high degree of reactivity which, by adsorption, diffuses into the biomass. Thus, the ignition and combustion rate are improved and the pollutant emissions are reduced. HRG is a colorless gas which has a density of 0.503 kg/m^3, molecular weight 12.3 kg/kmol, auto-ignition temperature 591-605 °C and flammability limit concentration between 7.3–100 % [4]. The free diffusion process (equation Legendre) is the basis for HRG/porous biomass combustion technology. Maximum capacity of producing HRG is 1500 litters/h. Electricity consumed to produce 1000 litters of HRG is between 3–3.5 kWh. This means approximately 0.4 Euro/1000 litters.

HRG injection in solid biomass [4] contributes to reducing the carbon monoxide concentration (OH radical having leading role) by reactions (2) [1]:

$$\begin{aligned} &CO + OH \rightarrow CO_2 + H; \\ &H + O_2 \rightarrow OH + O; \\ &O + H_2O \rightarrow 2\,OH. \end{aligned} \qquad (2)$$

The improvement of the biomass combustion performances by hydrogen injection is possible to be made for all known combustion technologies, such as:

» Fixed bed combustion systems: with fixed grate, with mobile-rolling grate, with forward or backward push, with inferior supply for pellets;
» Fluidized bed systems: stationary or recirculating;
» Air-driven system (fuel is milled and pulverized);

For biomass with high moisture content and ash, with particle dimension larger than 1 mm, it is recommendable to select boilers provided with fixed bed furnaces, with a maximum output of 20 MWt.
Some mixtures between agricultural biomass with wooden biomass can be prepared for combustion, excepting the mixture straw-wood, due to some large differences between combustion characteristics, such as moisture and ash melting temperature.

MATERIAL AND METHOD

The release and burning velocity for volatile matters is described in paper [8] by the differential equation (3):

$$\frac{dV_c}{d\tau} = (V_i - V_c)\cdot\alpha_v \qquad (3)$$

where: V_i is the initial content of volatile, V_c – volatile burnt content in period τ, α_v - release and burning velocity of volatile matters (processes ruled by gaseous diffusion and the combustion reactions kinetic).

$$\alpha_v = \frac{1}{\frac{1}{\alpha_{v,dif}} + \frac{1}{\alpha_{v,cin}}} \quad [1/s] \qquad (4)$$

$$\alpha_{v,dif} = \frac{2{,}22\cdot 10^{-6}}{d^2} \quad [1/s] \qquad (5)$$

$$\alpha_{v,cin} = K_{ov}\, e^{-\frac{E_v}{RT}} \quad [1/s] \qquad (6)$$

Equation (5) is very common in literature [8], but not so accurate for biomass as it is for coal
However, due to bale or briquette breakage due to the swelling phenomenon in the first phase of combustion occurs an auto-correction by reconsidering the particle's diameter value; the hydrogen contributes too for reducing the diameter in the ignition phase.
For equation (6), the values are:
d - particle diameter, [m]; K_{ov} - volatile release value, [1/s]; E_v - activation energy, [kJ/mol], T - temperature, [K]. For solid biomass, the reaction constants have the values: K_{ov} = 80-111 [1/s], E_v = 38.4-60.12 [kJ/kmol]
For fixed carbon combustion, the equation is given by (7), while for the combustion velocity was used equation (8) [8] :

$$K_c = 8710\, e^{-\frac{35700}{RT}} \quad [1/s] \qquad (7)$$

$$C_{CO_2} = \tau(\alpha_v + K_c)S\cdot d^2 \quad [m/s] \qquad (8)$$

where: $\tau = \frac{12}{32}$ is the stoichiometric ratio $O_2 \longrightarrow CO_2$, and S the specific reaction surface, [m^2/m^3].
For the solid biomass, according to the physical process of densification, $\alpha_{v,dif}$ is dominant versus $\alpha_{v,cin}$. In such manner, it appears as necessary a limitation criterion for briquette dimension. The expertise allows to asses the optimal domain: $\alpha_{v,dif} = \max(10\,\alpha_{v,cin})$.

RESULTS

In the paper [6] are presented the results of some experimental tests for the fixed bed combustion of five types of solid biomass injection HRG in the primary air.The following biomass categories have been tested: sawdust (1), wooden pellets (2), cereal straw briquettes (3), vineyard wastes (4), corncobs (5). Biomass power characteristics taken into account were: low calorific value – Q^i_i [kJ/kg]; moisture – W^i_t [%]; ash – A^i [%]. The results of the analysis are:

» Fuel 1: Q^i_i=16500 kJ/kg; W^i_t =14 %; A^i =2,5 %;
» Fuel 2: Q^i_i=17500 kJ/kg; W^i_t =10,5 %; A^i=0,5 %;
» Fuel 3: Q^i_i=14700 kJ/kg; W^i_t =10,2 %; A^i=4,7 %;
» Fuel 4: Q^i_i =13600 kJ/kg; W^i_t=16,1 %; A^i=4,9 %;
» Fuel 5: Q^i_i =12800 kJ/kg; W^i_t=18,8 %; A^i=3,9 %;

A constant thermal load of the boiler presented in figure 1 has been maintained during tests, by controlling the fuel mass-flow rate.

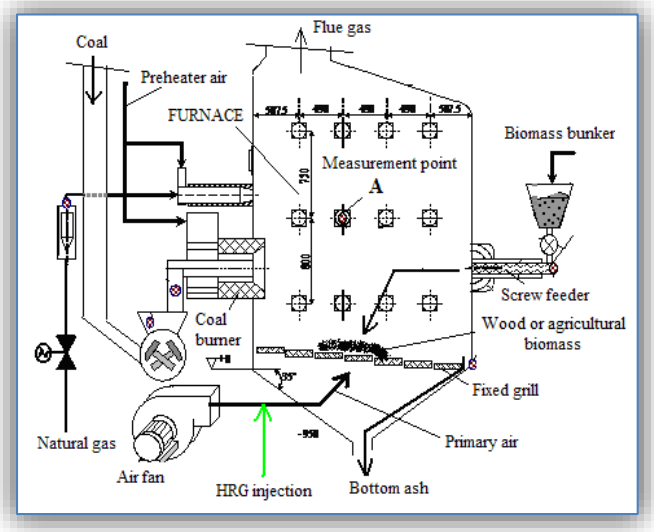

Figure 1 - Pilot plant of 2 MWt used to test the hydrogen injectionin biomass combustion

Findings:

» Significant reduction of CO emissions for wooden biomass derivates (reduction limit until 158 ppm);

» Lower reduction for agricultural biomass (upper limit to 1700 ppm);

In figures 2 and 3 is shown the flame shape for wooden and agricultural biomass, with and without HRG injection.

We found as remarkable the diminution of the flame length in the case of HRG combustion, due to a higher intensity of the oxidation processes in the inferior zone of the fuel bed.

a) wooden biomass

b) agricultural biomass

Figure 2 - Flame shape without HRG injection

a) wooden biomass

(b) agricultural biomass

Figure 3 - Flame shape without HRG injection

Finaly, an elemental analysis of the ash was performed, presented in Table 1, in order to draw a conclusion related to future possible use.

The high phosphorus, potassium and calcium contents, related to very low concentrations of heavy metals, indicate the possibility to use the biomass ash as agricultural fertilizer. Such approach is very important not only for economic reasons, but give the hope to eliminate a potential hazard.

Table 1. Elemental analysis of the ash

Chemical Species	Wooden Biomass	Agricultural Biomass
Si	19.14 %	19.72 %
Ca	6.66 %	6.04 %
Fe	3.65 %	5.61 %
Al	2.88 %	4.30 %
Mg	1.44 %	1.26 %
S	1.31 %	1.23 %
P	0.81 %	0.59 %
Na	0.28 %	0.36 %
Ti	0.27 %	0.29 %
Cl	0.16 %	0.15 %
Ba	0.10 %	0.10 %
Zn	0.03 %	0.03 %
Cu	0.01 %	0.01 %
Cr	86 ppm	95 ppm
Ni	68 ppm	83 ppm

CONCLUSIONS

In order to challenge some obstacles occurred in biomass combustion, such as the ignition difficulties due to high moisture content, respectively the high concentration of carbon monoxide in flue-gasses, we have tested a new technology – hydrogen injection as HRG in the primary air flow, at a permissive cost in comparison to the advantages. The research is fully original, according to our knowledge there are no similar paper in the literature.

The effects of this procedure were:

» Separation between the volatile and fixed carbon combustion trough high burning velocity of the hydrogen;
» Reduction of the flame length and flame stabilization;
» Decrease of pollutant emissions, especially carbon monoxide.

Beside these advantages, the ash resulted from biomass combustion is a good fertilizer for agriculture and horticulture.

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DEVELOPMENT OF CHEMICALLY TREATED OIL PALM FIBER/ARABA (seiba pentandra) WOOD DUST PARTICULATE REINFORCED CEMENTITIOUS COMPOSITES

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Abstract: This work was carried out to investigate the effects of chemical treatment on the mechanical and water absorption properties of wood sawdust reinforced cementitious composites. Araba (*seiba pentandra*) wood, a specie of softwood sawdust was selected and treated with KOH solution at an elevated temperature of 50 °C for 4 hours followed by washing with distilled water and sun drying for 5 days. The dried sawdust was further pulverized and sieve to obtained particle size of 150 µ and oven dried at 65 °C for 1 hour. The composites were developed by mixing the particulate wood dusts with oil palm fiber and the cementitious matrix in predetermined proportions. Mechanical and physical properties tests were carried out on the cured samples to determine properties such as compressive, flexural and water absorption properties respectively. From the analysis, it was found that both chemically treated and untreated fiber and filler serves as good reinforcement materials where chemically treated samples gave the best results in compressive properties while untreated samples gave the best results in bending and water absorption properties.
Keywords: sawdust; oil palm fiber, cementitious, particulate, chemical treatment, composites

INTRODUCTION

A composite is composed of two or more individual materials which come from either metal, ceramics or polymer. A composite material is formed when two or more materials are combined so that the properties of the composite are better than those of individual constituents. The design goal of a composite is to achieve a combination of properties that is not displayed by any single material and also to incorporate the best characteristics of each of the component materials. The properties of composite are a function of the properties of the constituent phases, relative amount and the geometry of the reinforcing phase. Reinforcing phase geometry in this context means the shape of the reinforcement, the size, distribution and orientation of the reinforcing phase [1, 2]. It is by this principle that most composites have been designed to achieve a combination of mechanical characteristics such as stiffness, toughness, ambient and high temperature strength. Composite materials are classified on the basis of the matrix component into three broad types; Metal Matrix Composite (MMC), Ceramics Matrix Composite (CMC), and Polymer Matrix Composite (PMC) [3]. The fracture toughness of ceramics have been improved significantly by the development of a new generation of ceramics matrix composites (CMC)- particulates, fibers, or whiskers of one ceramics material that have been embedded into a matrix of another ceramics. The tremendous interest in composites exists because they can be used to make things that are better and cheaper than those made from traditional in recent times.

The innovative development of high temperature damage-tolerant composite materials with lower cost of processing and fabrication has become imperative as a result of increasing demand for improved materials to replace traditional stocks such as metals in a wide range of application. Cement is an adhesive or glue, which when set binds particles of fine aggregate together to produce mortar. When mixed with water, cement forms a paste which is called the fine matrix and when coarse aggregate is added as in concrete production, the matrix is described as fine and coarse matrix. Cements are hydraulic materials, this means that they depend upon a reaction with water rather than air for strength development. When water is added to cement a chemical reaction called hydration commences immediately and continues while water is still present.

Research directed towards the development of composite materials for both structural and non-structural applications has increased considerably in current years. It is also applicable in areas like aircraft frames, automobile parts, engine components, rocket, satellite and structural buildings. The spur to this rapid expansion over the last few decades was the development in United Kingdom of fibers and in United State of America of boron fibers in the early 1960s. These fibers which have high elastic constants, a significant stiffness, gave very high strength-to-weight and stiffness-to-weight ratios to the composite materials manufactured with them [4]. These synthetic fibers are expensive because of the difficulties in their processing thereby leading to the thought of replacing them with readily available natural organic materials which can almost serve the same purpose of reinforcement. Despite the fact that natural fibres generally have poor mechanical properties as compared with synthetic fibres [5], their use as reinforcement material has been adopted by mankind [6]. The rapid growth has been achieved mainly by the replacement of traditional materials. In the continuing quest for improved performance of materials, this research is being carried out.

Wood fibre (WF) is an attractive reinforcement material because of its low density, low cost, high specific strength and modulus, renewable and biodegradable character due to low degradation when recycled and reasonable process-ability. Wood is natural three-dimensional polymeric composites and consists primarily of cellulose, hemi-cellulose and lignin. In addition, wood is an original and natural composite. Cellulose is the main component. The trees used as raw material by the forest industry are often classified as either softwoods or hardwoods. Softwoods or conifers belong to the group of plants known as gymnosperms (flowerless seed-bearing plants). These include pines, cedars larches, araba and firs. On the other hand, hardwoods belong to the group of plants called angiosperms (flowering plants). They include broad-leaved tree species such as oak, maple, beech, walnut, mahogany, teak and balsa [7].

The name softwood does not imply that wood of such a tree is softer than that from a hardwood. Indeed, the wood of some softwood trees can be harder than that of some hardwood trees. All trees are formed mostly of cells whose length runs parallel to the stem. A smaller number of cells run perpendicular to the stem. However, this work seeks to look into the effect of the selected soft wood dust on the reinforcement potential in cementitious composites. This was with the aim of benefitting from the numerous advantages that are embedded in using agro fibers which are; high mechanical performance, significant processing advantages, low cost and abundance of natural fibre [8]. Natural fibres are relatively cheap, pose no health hazards and finally, provide a solution to environmental pollution by finding new uses for waste materials. Fibres obtained from the various parts of the plants are known as vegetable fibres. Many of the plant fibres find application as a resource for industrial materials [9]. The aim of the work is to add value to some agro wastes that are readily available around us in Nigeria. Wood dust for example, are being produced, dumped and later burnt on daily basis in the Country without any conservation for their use as engineering materials. This work therefore seeks to use them so as to create the awareness for scientists and producers to really adopt their use.

MATERIALS AND METHODS

The materials used in carrying out this research were softwood sawdust from Araba (*seiba pentandra*) wood, Oil palm fiber, Cement, Potassium hydroxide (KOH) and Distilled water.

Processing of Sawdust and Oil Palm Fiber

The wood sawdust used for this research was obtained from sawmill during milling operation in Akure, Ondo State, Nigeria. Also, the oil palm fiber was obtained from Aponmu in Ondo State, Nigeria. Both the wood saw dust and the oil palm fiber were sun dried for 3 days before chemical treatments were carried on them.

Mass of wood sawdust prepared- 1200 g which was divided into two equal mass of 600 g.

Mass of wood oil palm prepared- 500 g which was divided into two equal mass of 250 g.

Chemical treatments were carried out using a solution of 2 M KOH maintained at 50 ^{O}C for 4 hours. This was used to treat the wood sawdust and oil palm fiber which are all lignocellulose materials so as to reduce the lignin and hemicellulose contents that are present for effective binding at the fibre/matrix interface and as well preserved them from fungi attack. Some other parts of the sawdust and oil palm fiber were left untreated.

Pulverizing of the Sawdust

The dry sample of the sawdust was pulverized using ball mill and sieved with mesh of grain size 150 μm.

Composites Formulation

The process employed in mixing the various constituents: cement, sawdust and oil palm fibers reinforced cementitious composites were as shown in Table 1 for treated wood saw dust and oil palm fiber. The same compositions were also used for the untreated wood saw dust and oil palm fiber

composites. Where; TS - Treated Soft, US - Untreated Soft, CS - Control Samples.

Table 1. Experimental Composition

Sample	Cement (g)	Treated Wood sawdust (g)	Treated Fiber (g)
TS_1	1485	15	10
TS_2	1455	45	10
TS_3	1425	75	10
TS_4	1395	105	10
TS_5	1365	135	10
TS_6	1335	165	10
CS	1500	-	10

Production of Composites

The composites were developed by mixing the wood saw dust which serves as filler with oil palm fiber that serves as reinforcement and the cement as binder in predetermined proportions. After thorough stirring to obtain homogeneous paste, the mixture was poured into the mould of the flexural and compressive test samples. The filled moulds were compacted with laboratory compression machine maintained at constant load 20 KN for 10 minutes before being removed. The compacted samples were removed from the moulds and were allow to further cured and solidified for 30 days in the laboratory at ambient temperature.

Testing for the Mechanical and Physical Properties

Following the moulding of the composites, samples were prepared and subject to flexural, compressive and water absorption tests.

Determination of the flexural property of the materials

Flexural test was carried out by using Testometric Universal Testing Machine in accordance with ASTM D790. To carry out the test, the grip for the test was fixed on the machine and the sample that has been cut into the test piece dimension of 150 mm x 50 mm x 3 mm, was hooked on the grip and the test commenced. As the specimen is stretched the computer generates the required data and graphs. The Flexural Test was performed at the speed of 100 mm/min.

Determination of the compressive property of the materials

Compressive test was carried out using universal testing machine machine. The compressive strength is usually obtained experimentally by means of a compressive test. The machine used for this test is the same as that used in a tensile test. However, rather than applying a uniaxial tensile load, a uniaxial compressive load is applied. As can be imagined, the specimen (usually cylindrical) is shortened as well as spread laterally. A stress-strain curve is plotted by the instrument.

Determination of the water absorption property of the materials

Water absorption test was carried out in accordance with International Organisation for Standardisation, ISO 175-1981 (E). To carry out the test, clean plastic containers were procured into which 250 cm^3 of water media were measured using measuring cylinder. The initial weight of each of the sample is taken using chemical weighing balance; FA2104A Model which is of high precision ± 0.0001 g accuracy before dropping inside distilled water medium used and readings are taken at an hour interval for 7 hours. To take the readings, the samples were brought out, clean with white cloth and weighed. The data collected was used to determine the % water absorption using the formula in equation 1 below.

$$\text{Water Absorbility (\%)} = \frac{\text{Final Weight} - \text{Initial Weight}}{\text{Initial Weight}} \times 100 \quad (1)$$

RESULTS AND DISCUSSION

Bending Test Results

Figure 1 revealed the results of the flexural test at peak performed on the developed composites. From the results, it was observed that both treated and untreated fiber reinforced cementitious composites developed exhibit similar trend in the values of the bending strength at peak. Also, noticed was that, all composites developed with the addition of filler material possess better strength than the one without the filler material that was used as the control. This shows that the addition of this filler material has actually aid the enhancement of the strength at reduced cement content which justified the reason why the composites were developed.

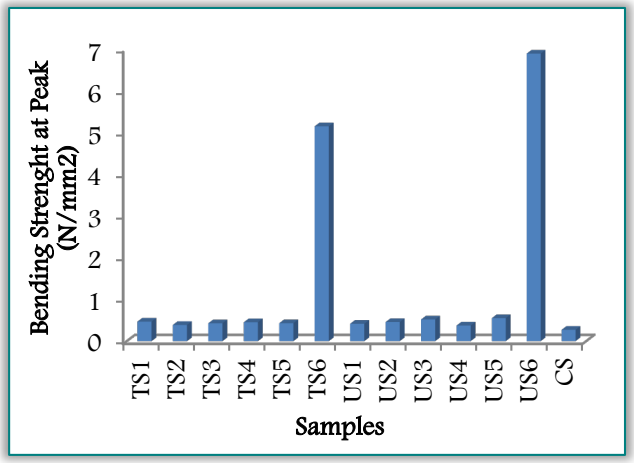

Figure 1. Graph of Bending Strength at Peak against Samples

Best performance was obtained at 1335:165 g of cement to wood dust in both cases which implies that, the best strength at peak was attainable at the maximum filler content since the fiber was kept constant. However, sample denoted as US_6 has the optimum value of 6.98 N/mm^2 followed by sample denoted as TS_6 which has a value of about 5.15

N/mm² compared to the control sample with a value of 0.27 N/mm². Considering the % increase that this amounted to, it was > 1000 from the best result.

The result of the bending modulus was as shown in Figure 2 from where it was observed that the two sets of the developed composites respond to the property differently. While the samples from the untreated fiber/filler reinforced cementitious composites tend to increases as the weight content increases, the treated fiber/filler reinforced cementitious composites did not show any trend. It can be seen from the results of the untreated fiber/filler reinforced cementitious composites that from US_3-US_6, the bending modulus was better enhanced compared to the control. Nevertheless, the best two samples happened to be those that were the best from Figure 1 above but unlike the results, the control sample was able to perform more than some of the composites with filler. The response of the composites was better in modulus than strength at peak as can be seen from Figures 1-2. These results demonstrated that, some materials may be weak in some properties and be strong in another and, therefore can be tailored towards their areas of strength. Best performance was obtained at 1335:165 g of cement to wood dust in both cases which implies that, the best bending modulus was attainable at the maximum filler content. Sample denoted as US_6 has the peak value of 1.66 N/mm² which marginally exceed sample denoted as TS_6 which has a value of about 1.64 N/mm² compared to the control sample with a value of 1.00 N/mm². This amounts to about 66 % increase from the best result.

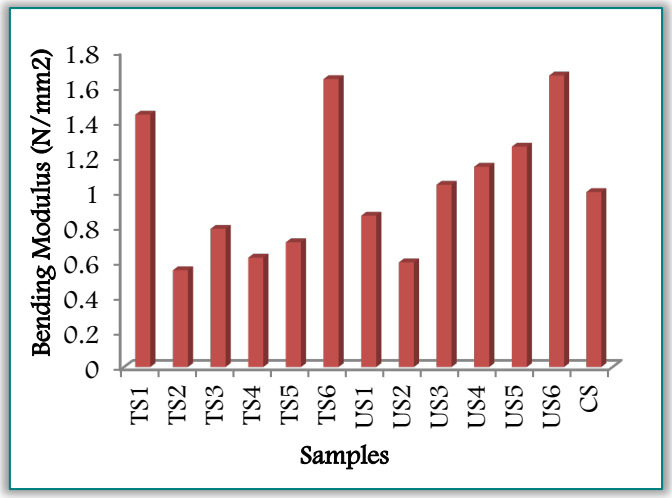

Figure 2. Graph of Bending Modulus against Samples

Compressive Test Results

The response of the materials to compression test was as shown in Figure 3 for compressive strength at peak. It was noticed that the treated fiber/filler reinforced cementitious composites performed better than the untreated fiber/filler reinforced cementitious composites. Composite sample denoted as TS_2 which has a composition of 1455: 45 g of cement to wood dust has the optimum value of about 12962 N/mm² followed by sample denoted as US_4 which has a composition of 1395: 105 of cement to wood dust with a value of 10368 N/mm² compared to the control with a value of 9634 N/mm². By this performance, the addition of the filler material to the composite has aid 35 % increase in the compressive strength at peak from the treated sample.

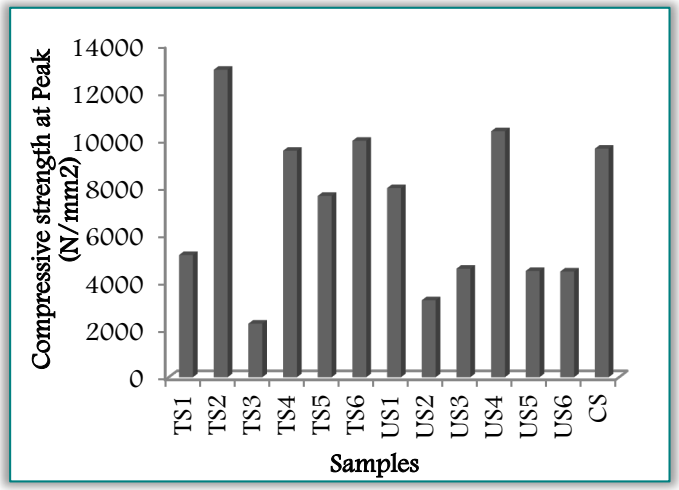

Figure 3. Graph of Compressive Strength at Peak

The response of the materials to compressive modulus was as shown in Figure 4. The modulus of the treated fiber/filler reinforced cementitious composites performed better than the untreated fiber/filler reinforced cementitious composites where they reflect weak behavour compared to the compressive strength at peak.

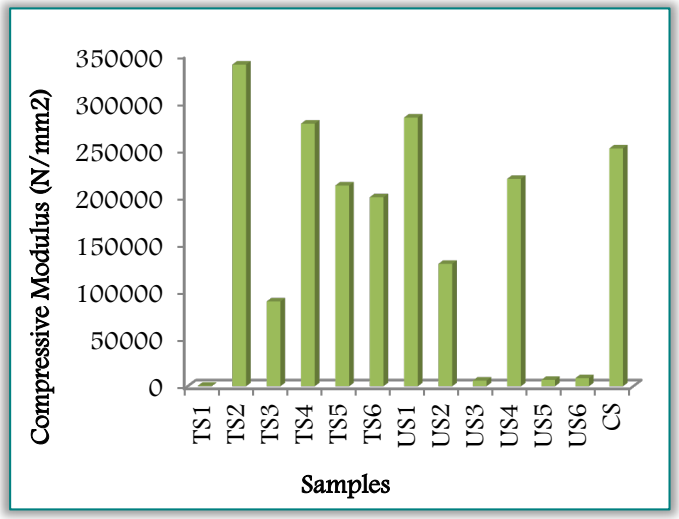

Figure 4. Graph of Young Modulus against Samples.

From the results, composite sample denoted as TS_2 which has a composition of 1455: 45 g of cement to wood dust has the optimum value of about 339985 N/mm² followed by sample denoted as US_1 which

has a composition of 1485: 15 of cement to wood dust with a value of 284160 N/mm^2 compared to the control with a value of 251607 N/mm^2. By this performance, the addition of the filler material to the composite has aid 35% increase in the compressive modulus from the treated sample.

Water Absorption Property Response

The results from the water absorption test were shown in Figure 5 from where it was observed that the materials respond in a similar manner to the test. All the samples were noticed to absorbed more water as the time increases. However, the untreated fiber/filler reinforced cementitious composites performed better than the treated fiber/filler reinforced cementitious composites by absorbing less amount of water within the time limit examined. This good performance was highly noticed within the range of US_4-US_6. The control sample was observed to absorb the highest amount of water being majorly dominated by cement.

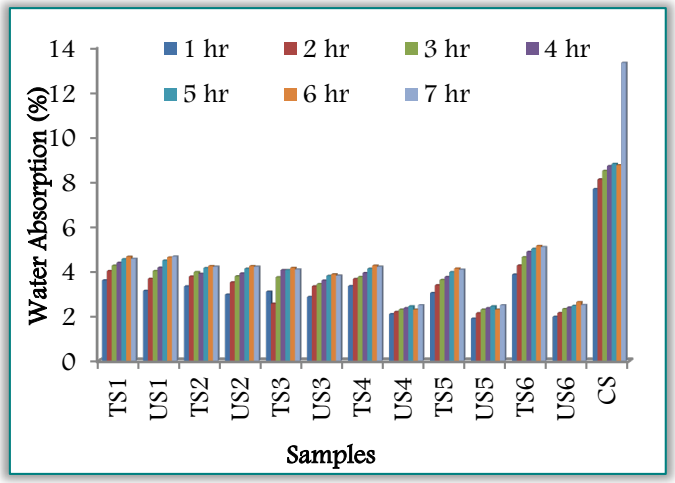

Figure 5. Graph showing the Response of Samples to Water Absorption in Hours.

CONCLUSION

Investigations of the mechanical and physical properties of the developed composites from this research have shown that the use of wood dust as fillers in cementitious composites is a promising technological advancement. This was possible since the outcome of the research have shown that;

Both chemically treated and untreated fiber and filler serves as good reinforcement materials where chemically treated samples gave the best results in compressive properties while untreated samples gave the best results in bending and water absorption properties. As a result of this, the use of these agro-wastes makes the research and the developed composites environmental friendly and economical.

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