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CNN TECH

„International Conference of Experimental and Numerical Investigations and New Technologies“

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Programme

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The Book of Abstracts

24 – 27 June 2024

Belgrade, Serbia

„International Conference of Experimental and Numerical Investigations and New Technologies“

CNN TECH 2024

24 – 27 June 2024

Hotel Mona Plaza, Cara Urosa 62-64, Belgrade, Serbia

University of Belgrade – Faculty of Mechanical Engineering, Kraljice Marije 16, Belgrade, Serbia

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Programme

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CNN TECH 2024

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The organizing committee of the 8th International Conference of Experimental and Numerical Investigations and New Technologies – CNN TECH 2024 wishes to sincerely thank all the institutions and individuals who, by means of personal engagement and constructive action, helped organise this conference.

We particularly wish to thank **The Ministry of Education, Government of the Republic of Serbia** for the continuous support.

We would like to thank the University of Belgrade - Faculty of Technology and Metallurgy for supporting the young researchers of this conference.

We are also grateful to companies, **3D Republic**, **Shimadzu**, **Altera**, **Minel**, **Novos**, **Superlab**, **Analysis**, **Labena**, **Coca-Cola HBC** and **Limodex** who have significantly contributed to the organization and realization of the conference.

PREFACE

Dear Friends and Colleagues,

welcome to the CNN Tech 2024 Conference, this year in Belgrade!

With 127 papers (20 by international authors) and contributions by authors from different countries, the International Conference of Experimental and Numerical Investigations and New Technologies CNN Tech 2024 successfully sets a high level for future conferences. Participation of a large number of domestic and international authors, as well as the diversity of topics, justifies our efforts to organise this conference and contribute to the exchange of knowledge, research results and experience of industry experts, research institutions and faculties which all share a common interest in the field in experimental and numerical investigations.

This year CNN Tech 2024 focuses on the following topics:

- Mechanical Engineering,
- Engineering Materials,
- Chemical and Process Engineering,
- Agricultural and Food Engineering,
- Experimental Techniques,
- Numerical Methods,
- New Technologies,
- Clear sky,
- Dental Materials and Structures,
- Sustainable Design and New Technologies,
- Advanced Materials and Technology,
- Artificial intelligence,
- Student session.

For the first time, we have a new section “Agricultural and Food Engineering” dedicated to this topic and new trends in this area of research. The organising committee of CNN Tech 2024 would like to express gratitude to the Ministry of Education and the Ministry of Science, Technological Development and Innovation for the financial support of the Conference. On behalf of the Innovation Center of the Faculty of Mechanical Engineering, Faculty of Mechanical Engineering and Center for Business Trainings, we wish this to be a splendid CNN Tech conference filled with many memorable moments.

PROGRAMME AND ORGANIZING COMMITTEE

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PROGRAMME

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10:00 to 10:45	Opening Ceremony – HALL A *Moderator: dr Aleksandra Dragičević* *dr Aleksandar Sedmak, prof. emeritus* *dr Nenad Mitrović* *dr Vladimir Popović, Dean of the Faculty of Mechanical Engineering in Belgrade* *dr Nenad Zrnić, Director of the Innovation Center of Faculty of Mechanical Engineering in Belgrade* *Ministry of Education of the Republic of Serbia* *Ministry of Science, Technological Development and Innovation of the Republic of Serbia*
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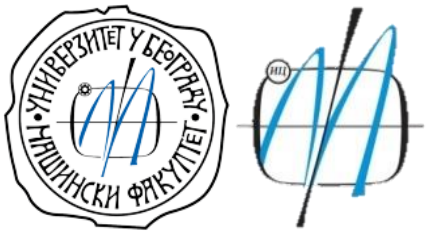

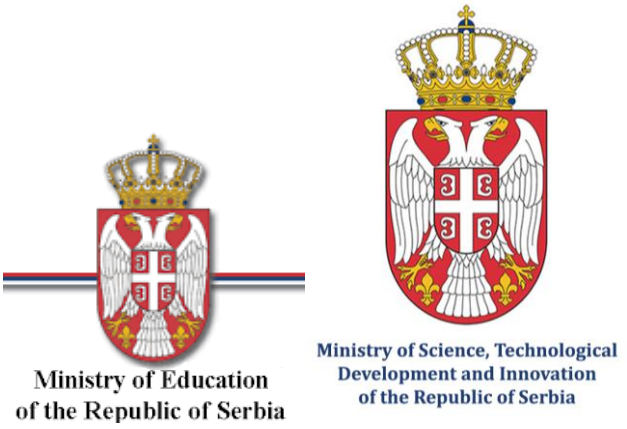

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ABSTRACTS

Mechanical Engineering

Invited lecture

DEVELOPMENT OF EXOSKELETON FOR HANDHELD POWERTOOLS

Žarko Z. Mišković[1*]

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Abstract

Handheld power tools, such as electric drills and electric screwdrivers, are widely used today. They are applied in households, the furniture industry, the automotive industry, and even in construction and interior design. Major companies that produce handheld power tools (e.g., BOSCH, MAKITA, BLACK&DECKER, STIHL, HILTI) invest significant material and financial resources in improving existing products and developing new ones to outperform the competition in the international market and achieve greater profit. One way to overcome existing problems in the use of handheld power tools is to develop and design external systems for their easier use and control – exoskeletons. This is precisely the goal of the prototype developed at the Faculty of Mechanical Engineering, University of Belgrade, within the proof-of-concept project funded by the Innovation Fund of the Republic of Serbia. It has been observed that almost all handheld power tools available on the market require the use of both hands during operation, demand significant physical strength from the user, and generate substantial vibrations that are transmitted to the user, making the use of handheld power tools even more challenging. To overcome these problems, the primary function of the developed exoskeleton has been broken down into elementary functions, for which appropriate actuators have been defined, followed by the development of several alternative solutions, from which the best was further developed into a functional prototype with multiple benefits for the user. The developed exoskeleton transfers the loads typically handled by the user's second hand to the forearm of the first hand using a lever system, preventing wrist overload while maintaining precise control and handling of the tool. This allows the user's second hand to remain free for other tasks, such as holding the workpiece. Additional force in the tool's direction is provided by the exoskeleton being supported on the user's upper arm, utilizing body mass along with the biceps and other arm muscles during operation. Vibrations from the tool are minimized by incorporating a vibro-elastic element in the exoskeleton, significantly reducing vibration transfer to the user. Additionally, the handheld power tool can be used in various positions – above the head, downwards (towards the floor), at shoulder, or waist level. Also, during the development of the exoskeleton, special attention has been paid to the safety of the user, so the handheld power tool is connected to the exoskeleton by a detachable joint, allowing the tool to be quickly discarded if necessary. It is important to note that during the development of the exoskeleton, all guidelines of the German association VDI were applied, significantly accelerating the product development process, along with the use of available rapid prototyping and 3D printing technologies. Finally, all solutions presented have been submitted for patent protection, with registration currently underway (patent application no. 2024/0025).

Keywords

Handheld power tools, Exoskeleton, Product development.

Acknowledgement

The author would like to thank the Innovation Fund of the Republic of Serbia for the support in the realization of the proof-of-concept project No. 5665, 2020-2021.

ATLAS ROMAN POT HEAT SINK DEVELOPMENT FOR LOW PRESSURE WORKING CONDITIONS

Dejan Jevtic[1*], Goran Mladenovic[1], Mihajlo Popovic[1], Maciej Trzebinski[2], Marko Milovanovic[3]

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Abstract

The development of a heat sink for Atlas Roman Pots for the purpose of ATLAS Forward Proton (AFP) detector upgrade in 2024, is presented in this paper. During proton collisions, the Roman Pots (RP) used in the Large Hadron Collider (LHC) move very close to the beam. Since beam intensity had been gradually increased over the years, the temperature increase was also observed on the RP wall and bottom. Eventually, it started raising concerns that it would compromise surrounding vacuum conditions. Hence, in order to reduce RP temperature, a heat sink needed to be developed which would transfer the excessive heat from the RP wall and bottom to the flange, which remains roughly at room temperature even during beam conditions. The RP and the flange are made of stainless steel and due to their low thermal conductivity it is impossible to avoid overheating of the RP bottom. A few concept designs were developed and the temperature field change with time was simulated in ANSYS Fluent. Since the heat sink has no symmetry planes, the simulations was performed in 3D numerical domain. The influence of Roman Pot movement on heat transfer was analysed. Operating conditions are very close to vacuum, so natural convection can be disregarded. Heat transfer mechanisms that were taken into account are radiation and conduction. Experimental investigation of the prototype was done at CERN at atmospheric and low pressure conditions. Furthermore, the temperatures are continuously being remotely monitored in LHC working conditions. Temperature distribution obtained by numerical simulations showed very good agreement with the experimental results.

Keywords

Heat sink, Numerical simulation, Experimental results, Temperature distribution.

Acknowledgement

The research work is funded by the Ministry of Science, Technological Development and Innovation of Republic of Serbia. Project Contract 451-03-65/2024-03/200105 from 5.2.2024.

WORKPIECE DETECTION AND SORTING USING DISTANCE SENSORS IN ROBOCELL AND CELLSETUP

Djordje Dihovicni[1*], Milos Vujosevic[2], Petar Jakovljevic[2], Nada Ratkovic Kovacevic[1]

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Abstract

This paper describes a flexible cell that is used for detecting and sorting different materials by colour using distance sensors in Robocell and Cell setup software's. Cell setup is used to create the work environment for the robot arm, where Robocell is used to import the created 3D work environment and establish the control of the robot and peripheral devices. Peripheral devices are two gravity feeders where objects are located, two distance sensors and a conveyor device. A robot arm has six degrees of freedom while the conveyor device will represent the additional mobile axis. The process of material sorting is first picking the red object from the gravity feeder and placing it on the conveyor device, where robot is returning to the safe distance. The conveyor device is activated and moves the object to the first sensor where the object colour is detected. Robot picks up the object and places it on the location for red objects. Same principle is repeated for blue object where the second sensor is used to detect its colour. The goal of this paper is to show an example how to control conveyor device movement using movement instructions and synchronization between conveyor device and distance sensors that are predicted to detect materials of different colours and shapes where the application can be in industrial environment for different manufacturing parts, especially in mass production.

Keywords

Robot, flexibility, sensors, synchronization, software.

SMART BEEHIVE WITH ARDUINO MONITORING

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Abstract

The aim of this work was to make a protective system of the beehive, with automatic measurement of the mass of the beehive, construction of the alarm system and detection of the movement in the vicinity of the apiary. The steps of making and protecting a smart beehive are shown. The paper describes the components of the system and lists their technical characteristics. The Arduino Uno board as hardware and Arduino IDE (Integrated Development Environment) as software are exploited in order to develop the system described here and to monitor selected parameters of the beehive. The sensors are chosen to measure the mass of the beehive, to detect the opening or tilting of the hive lid, to make sound alarm in case the hive is being tampered with, to make sound alarm in case intruder(s) are detected in the hive vicinity. Implementation and mounting of electrical components in the housing of the hive and the protective system are shown. It is explained how the alarm system works for protection of the beehive. The scale that reads the mass of the hive is used to assess the yield of honey as well as to detect if the beehive is lifted to be taken. A practical experiment was performed in order to test subsystems and integration into a system.

Keywords

Alarm Systems, Beekeeping, Electronics, Mechatronics, Sensors.

Acknowledgement

Acknowledgements are extended to The Academy of Applied Technical Studies Belgrade for their support.

THE SOFTWARE CHALLENGES OF THE AUTOMATED SYSTEM FOR BOOKSHELF SCANNING

Nada V. Ratkovic[1*], Goran Z. Vojnovic[1], Djordje N. Dihovicni[1], Dragan D. Kreculj[1], Petar D. Jakovljevic[2]

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Abstract

The paper explores software challenges within the implementation of the automated system for bookshelf scanning. The scanner is used to read the barcodes of the books placed on the shelf. The stroke (or the path) of the mechanism bearing the scanner is controlled by a stepper motor and two mechanical limit switches. The stepper motor and its driver are controlled by a microcontroller board using suitable program. Scanner reads the barcodes of the books placed on the shelf and communicates the identifiers of those books to a program on a desktop computer. Those identifiers should be compared with the library inventory e.g. to find if some book on a shelf is being misplaced. In order to be able to recognize if all books from the shelf are being scanned and identified, the software system should be capable of recognizing if the barcode of all the books were properly placed and read. To help find if some book is placed upside down the system can use additional sensor – camera. From the snapshot of the bookshelf it could be determined using edge detection and image segmentation if one or more books are placed wrong way so that scanner can't grasp their barcodes.

Keywords

Barcode scanning, Digital Image Processing, Mechatronics, Sensors, Software.

Acknowledgement

Acknowledgements are extended to The Academy of Applied Technical Studies Belgrade for their support.

ANALYSIS OF FAILURES OF ELEMENTS OF DRAW GEAR AND IMPACTS ON THE SAFETY OF RAIL VEHICLES

Jagoš M. Stojanović*[1], Jovan D. Tanasković[1], Jovana D. Ranković[1], Marija Vukšić Popović[2], Srđan L. Rusov[3]

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Abstract

Rail transportation is one of the most efficient ways of transporting goods and passengers. Alongside modern and reliable infrastructure systems, special emphasis is placed on the reliability, availability, and safety of rail vehicles. The draw gear device plays a pivotal role in ensuring operational safety and efficiency. However, failures within this system can lead to catastrophic consequences, compromising the safety of both passengers and goods. This paper analyzes the root causes and impacts of draw gear failures on rail vehicle safety through a comprehensive analysis of historical data, current data, and simulation of failure by numerical analysis.

The analysis reveals that draw gear failures stem from various factors, including material fatigue, design deficiencies, improper maintenance, and operational conditions. These failures can result in the breakage of elements that can cause derailments, collisions, and other accidents. Such incidents pose significant risks to human life, property, and the environment. Furthermore, the economic implications of such failures, including repair costs, service disruptions, and legal liabilities, underscore the importance of proactive mitigation strategies.

By identifying common failure modes and their underlying mechanisms, this research provides valuable information and data for enhancing the reliability and safety of draw gear systems. Results obtained from these analyses can be used to improve design, material selection and characteristics, maintenance, and monitoring technologies. Additionally, the analyzed data emphasize the importance of industry collaboration in mitigating the risks associated with draw gear failures and ensuring the continued safety and efficiency of rail transportation systems.

Keywords

Rail Vehicles, Failure Analysis, Draw Gear, Safety, Risk Mitigation.

Acknowledgement

The publishing of this paper was supported by Ministry of Science, Technological Development, and Innovation of Republic of Serbia. Contract No. 451-03-65/2024-03/200105 from February 5th, 2024.

ANALYSIS OF FAILURES OF POWER PACK OF DIESEL HYDRAULIC MULTIPLE UNIT SERIES 711

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Abstract

The passenger diesel-hydraulic train series DMU 711 is one of the newer trains in Serbia, owned by “Srbija voz”. The train consists of two coaches. Each coach is equipped with one driving bogie powered by a diesel engine coupled with a hydraulic transmission and one free bogie. Diesel engines, hydraulic transmissions, cooling and heating systems, and many other pieces of equipment and devices were placed in one assembly - a power pack. During operation, the owner noticed that the train was often out of service because of failures in the power pack. The main reason for the failure of the power pack is overheating. Radiators, as a part of the cooling and heating system, were placed along one side of the power packs. During the inspection, it was observed that the radiators are heavily contaminated with vegetation, dust, and debris picked up during operation. The maximum designed speed of the train is 120 kilometres per hour, but most often running speed is significantly lower. The owner informed the producer that DMU has had problems with overheating from the start of service. Analysis of the train behaviour in different weather conditions and seasons, over the years, gave a clearer image of the overheating problem. The most common problem caused is the low running speed in combination with dust, grass, and other dirt that trains collect in the cooling radiators. This leads to radiator clogging, decreasing cooling capacity, and therefore overheating. When the operating temperature of the diesel motor exceeds the limit value, the safety system of the power pack is activated, causing it to shut down. Next to the mentioned problem, one more is directed to the common cooling-heating system for the power pack and passenger area, which is obvious under-dimension, especially for the summer days. Considering the reasons for the power pack frequently malfunctioning, one of the solutions for resolving the problem is the separation of a cooling-heating system for the power pack and passenger area. Additionally, analyses showed that displacement of the cooling system on the roof is an even better solution, to exclude dirt impact and improve airflow and cooling. Both solutions can be implemented during regular repair or modernization of DMU. Additional analyses will be conducted after the owner provides source documentation from the producer. Finally, the possibility of replacing the power pack with one of the improved generations installed in the newer DMU 711 should be explored for efficiency, although it may not necessarily be the most cost-effective solution.

Keywords

Failure Analysis, Power Pack, Cooling System, Regular Repair, Modernization.

Acknowledgement

The publishing of this paper was supported by Ministry of Science, Technological Development, and Innovation of Republic of Serbia. Contract No. 451-03-65/2024-03/200105 from February 5th, 2024.

NEW APPROACHES TO HIGH-G AND SPATIAL DISORIENTATION TRAINING

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Abstract

The objective of this research is to offer a comprehensive overview of the devices utilized for training pilots of modern fighter aircraft and to explore their potential application in astronaut training. Both pilots and astronauts require extensive and specialized training. This study focuses on two specific training devices: a human centrifuge and a spatial disorientation trainer, both designed for training and material testing purposes.
This research provides a brief analysis of the direct kinematics of the centrifuge and the device that induces spatial disorientation in pilots. The human centrifuge is an advanced device capable of subjecting occupants to an onset rate of 9G in just one second, simulating longitudinal, lateral, and vertical G-loads for cutting-edge training. The centrifuge is modeled as a three-degree-of-freedom robotic manipulator, while the spatial disorientation trainer offers four degrees of freedom of motion. The Denavit-Hartenberg convention is utilized to establish coordinate systems, and homogeneous transformation matrices are included.
Training accuracy and efficiency are ensured by employing the pilot's head as the end-effector, positioned at the intersection of the roll, pitch, and yaw axes. The paper introduces sophisticated training profiles that facilitate the simulation of complex supermaneuvers and sustained G-loads, which could potentially be utilized for astronaut training in the future.

Keywords

Human centrifuge, Spatial Disorientation, High-G, fighter pilots, training profiles.

Acknowledgement

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PROCESS PARAMETER IDENTIFICATION BY SOUND SIGNAL PROCESSING AND DEEP LEARNING IN WOOD MACHINING

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Abstract

Sounds or noise generated during the idle and cutting of wood with specific cutting tools can provide valuable inputs for deep learning networks to identify cutting speed, feed rate, cutting depth, tool type, tool bluntness, and even the type of wood being processed. The analysis of idling noises provides a starting point for a better understanding of the interaction noises. When interacting with wood, a tool also produces characteristic noises that provide information about the fracture mechanics occurring during the cutting process, allowing us to identify cutting parameters, wood species and tool types. The wood species selected for this study were beech and fir (hardwood and softwood). The tools selected were circular saw blades (Freud LU1C 0100, LU2B 0500 and LU2C 1200), an SCM planer head with Tersa M+ blades and custom-made Gatech milling cutters (radius 125 mm, width 40 mm and rake angles of 16°, 20° and 25°). The sound signals were recorded using a DBx RTA-M measuring microphone connected to a Focusrite Scarlet SOLO USB audio interface and a PC. The signals were cut and trimmed using the WavePad Sound Editor developed by NCH Software. The measurements were performed at a sampling rate of 44100 Hz. These recordings were converted into power spectra using a one-sided Fast Fourier Transform (FFT) and later into spectrograms using a wavelet transform. All these tasks were performed with the software MatLab R2023b, Campus Edition. Various neural networks were used to classify the sounds, including MobileNetV2, VGG19, Dense-Net, Squeeze-Net, Res-Net, InceptionV3 and GoogleNet.

Keywords

Wood machining, Sound signal, Machine learning, Decision making, Neural network.

Acknowledgement

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QUALITY OF BEECH WOOD SURFACE SANDING UNDER DIFFERENT REGIMES

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Abstract

Sanding is a widely used method for processing solid wood and wood-based panels in the final stage of machining. The goal is to remove irregularities caused by previous machining processes or to calibrate the workpiece to a specified dimension. Wood and wood-based panels are sanded before further surface treatment to achieve a flat surface with reduced roughness, which is necessary for the subsequent application of coatings needed for surface protection and decoration. This study investigates the impact of different sanding regimes on certain machinability criteria of beech wood (Fagus sylvatica). The criteria for assessing machinability included cutting power and the quality of the processed surface, expressed through the roughness parameter Ra (arithmetical mean roughness value). The main objective of the research was to compare two-stage and three-stage sanding under various sanding pad pressures to determine the optimal combination that ensures the best surface quality with minimal costs. The tests were conducted on narrow-belt sanding machine, where the sanding power was measured during sanding using different abrasive grit sizes (P80, P120, P180) and different contact pressures (12,000 and 18,000 Pa). The cutting power was measured indirectly, through the power input of the propulsion electric motor using measuring-acquisition device with a sampling frequency of 100 Hz, while the quality of machined samples was evaluated by surface roughness using a stylus-based surface roughness tester.

Keywords

Beech Wood, Machinability, Sanding, Cutting Power, Surface Roughness.

Acknowledgement

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DRONE INSPECTION AS AN ADVANCED NDT METHOD IN THE OIL AND GAS INDUSTRY

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Abstract

The paper presents drone inspection as an advanced non-destructive testing method in the oil and gas industry. This type of monitoring is performed where visual inspections are required as part of maintenance or inspection procedures. By using a drone to collect visual data, we can assess the structural integrity of constructions without placing inspectors in dangerous situations, thus reducing risk and significantly lowering costs.

Drone inspections are increasingly used in refineries and on oil platforms. Particularly for offshore inspections, drones save time, improve safety, and reduce mobilization costs. This paper will discuss the application of drone inspections at methanol tanks in a refinery in Norway, which are part of the regular inspection program according to the API 563 standard.

The results of both external and internal inspections of the tank will be presented, covering general visual inspection (GVI) and closer visual inspection (CVI). The use of drones in regular API inspections greatly reduces inspection time, increases efficiency, and eliminates the need for scaffolding and rope access personnel. Additionally, high-resolution video inspection data and high-quality captured images can be used for detailed condition assessments.

Keywords

Integrity, NDT, new technologies, risk, inspection.

Acknowledgement

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Engineering Materials

Invited lecture

EVALUATION OF ENERGY ABSORPTION AND DUCTILITY INDICES OF CELLULAR STRUCTURES AT BENDING

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Abstract

Porous materials are widely present around us and play a role in many aspects of our daily lives. They can be found in fields such as energy management, vibration suppression, heat insulation, sound absorption, and fluid filtration. Highly porous solids possess relatively high structural rigidity and low density, making them suitable as structural components in nature, including wood and bones. However, humans often utilize porous materials more for functional than structural purposes, developing many applications that integrate both structural and functional uses.

As part of the research, the energy absorption properties and ductility indices of three types of porous structures Fisher-Koch S, Schopen IWP and Schoen F-RD, produced by additive manufacturing from aluminium alloy were studied. Five different specific weights were considered during experimental bending tests, which were performed to compare the influence of topological characteristics on the investigated properties. Based on force-deflection dependences, the energy absorption and ductility indices were calculated for individual samples. It could be concluded that the largest amount of energy to failure was consumed by the Schoen IWP_0.375 sample absorbed and the least amount of energy was absorbed by the Schoen F- RD_0.500 sample, while the Fisher-Koch structure shows relatively stable behavior in both ductility indicators. The failure propagation exhibits two directions - the tension-induced crack demonstrates the crack growth in the direction parallel to the thorn of the testing machine; whereas the tortuous growth is visible in the cellular direction at which the induced crack tends to propagate in the first phase along the shortest path between neighboring pores connecting the places of greatest stress.

Keywords

Cellular structure, bending test, energy absorption, ductility index, failure.

Acknowledgement

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DEGRADATION OF THE SURFACE OF SINTERED SAMPLES BASED ON CORDIERITE AND TALC UNDER THE EFFECT OF CAVITATION

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Abstract

In the paper, the cavitation resistance of refractory cordierite samples with the addition of 10%, 15% and 20% talc, sintered at 1200º C, was investigated. The quality control method of the obtained sintered samples was investigated using the ultrasonic vibration method with stationary sample according to the ASTM G 32 standard. The formation and development of damage to the surface of the samples was monitored using a scanning electron microscope and the level of damage to the surface of the samples was quantified using image analysis. The change in the mass of the samples as a function of the cavitation time was monitored and the cavitation rate was determined. By measuring the mass loss and morphological analysis of the pits formed on the surface of the sintered samples of the mixture of cordierite and talc, the mechanism of degradation and resistance to the effect of cavitation was monitored. The obtained results were compared with the results of earlier tests of cavitation resistance of sintered cordierite samples. It was shown that the addition of talc in the mixture with cordierite significantly improved the properties of the sintered material compared to sintered pure cordierite. Small mass losses, small surface damage of samples of sintered cordierite with the addition of talc, indicate the possibility of obtaining a refractory materials with imroved properties of resistance to the effect of cavitation. The tests were done primarily to see the potential application of this material in hydrodynamic conditions, and especially because of the strong corrosion resistance of these refractory materials. Tests have shown that the application of the ultrasonic vibration method is suitable for a quick assessment of the quality of sintered samples and a forecast of resistance and stability during exploitation under cavitation conditions.

Keywords

Sintered material, cordierite and talc, cavitation resistance.

Acknowledgement

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CAVITATION RATE OF LASER-SINTERED MS1 STEEL

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Abstract

The research within this study focuses on analyzing the surface characteristics of samples obtained through laser sintering of MS1 steel powder without subsequent reinforcement (as built). Test samples are produced by an EOSINT M280 machine in a nitrogen environment using the method of Direct Metal Laser Sintering (DMLS). Surface layer characteristics in terms of cavitation resistance were examined using the ultrasonic vibration method according to the ASTM G32 standard. Based on the microstructure of the samples obtained using Scanning Electron Microscopy (SEM), the experiment duration was estimated. The morphology and microstructure of the samples were then examined during and after the experiment, also using SEM. The mass loss of the samples over time was measured, to calculate the cavitation rate. This research aimed to analyze the potential future applications of laser-sintered MS1 steel powder in the fabrication of machine elements and parts operating under cavitation erosion conditions, due to a series of advantages of the additive manufacturing technology compared to conventional technologies.

Keyword

Cavitation rate, laser sintering, maraging steel MS1, additive manufacturing, direct metal laser sintering (DMLS).

Acknowledgement

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OPERATING TEMPERATURE EFFECT ON THE RESISTANCE OF LOW CARBON MICROALLOYED STEEL FOR THERMAL POWER PLANTS TO CRACK INITIATION AND GROWTH

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Abstract

The aim of this work was to collect data on the effect of operating temperature on the mechanical and structural properties of a low carbon microalloyed steel for use at elevated temperatures, which can be used to evaluate the lifetime of thermal power plant components. The material was analyzed by testing specimens made of unused material at two temperatures, the ambient temperature and the operating temperature of 540 ℃, under static and dynamic loading conditions.

The main objective of the study was to determine the resistance to crack initiation and fracture strength of the tested material. The results of the experimental investigations also helped us to understand the cracking behavior at operating temperature.

In addition to the experimental analysis, a numerical simulation of the behavior of the samples under static and dynamic loading was performed. The numerical calculations were carried out using the finite element method. The simulations were based on experimentally determined values of the J-integral and the values of the Paris law coefficients. There was good agreement with the experimental results, which confirmed the use of the finite element method for the load cases under consideration.

The experimental results obtained provide a practical contribution to the evaluation of the effects of the operating temperature on the behavior of the tested material under static and dynamic loading in order to assess the integrity and residual life of the construction.

Keywords

Steam lines, Fracture Mechanics, FEM, Structural Integrity, Operating Life.

Acknowledgement

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GLASS SINTERING FOR CURVED GLASS STRUCTURES: DESIGN CONCEPT AND CONSIDERATION

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Abstract

Fabrication of glass elements of curvilinear architectural structures by sintering of glass is considered. The classification of sintering processes includes: (a) sintering by fused deposition modelling; (b) sintering by stereolithography and digital light processing; (c) selective laser sintering/melting; (d) sintering by direct ink writing. The most interesting class of processes is fused deposition modelling (FDM) that includes an additive manufacturing (AM) technique suitable for manufacturing (printing) complex elements that has smooth surface and high optical transmittance. Although, the geometric complex form has no formal definition, it can be identified by smooth curves of the unique and different shapes that flow, as well as the lack of inherent symmetry. This paper aims to provide an overview of currently used glass sintering technologies for production of geometrically diverse but optimally balanced design solutions of surface panelization with respect to the original design idea, and their design assessment in relation to the transparency of the glass surface, panel and surface geometry, simplicity of nodal connection and surface smoothness.

Based on defined goal, eight hypothetical models are created - models of different design variants of glass envelope by different geometry and size of the glass panels, as well as different geometries of the entire envelope surface. Parameters of geometrical characteristics that vary according to models refer to the individual panels and include: panel shape; curvature of the panel surface; shape of the panel edges; and panel size. In order to evaluate the design and visual characteristics of the different models, the defined criteria consider two groups: 1. Design criteria from the aspect of geometry (form, transparency, complexity of the node, light effects); 2. Design criteria from the aspect of perception (surface contours and smoothness, visual distortion).

Finally, ranking of hypothetical models of geometrically complex form of glass envelope is done according to obtained results. This review highlights the prospects of glass sintering in the façade construction, as well as establishes the methodological approach to realization of complex form of glass envelope, the method of evaluation that enables the assessment of different design solutions and the selection of aesthetically satisfying models of geometrically complex form of glass envelopes.

Keywords

Glass sintering, curved and flat glass, geometrically complex form of building envelope, geometry, perception.

SPECIFIC PHYSICAL, CHEMICAL, AND METALLURGICAL PROPERTIES OF MATERIAL USED FOR CONTACTS IN AUTOMATIC DEVICES

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Abstract

Physical, chemical, and metallurgical properties belong to the fundamentals of Material Science, and could not be neglected in many engineering applications. For implementation in making electrical wiring and contacts in automatic devices, there is a wide variety of possible contact types. Depending on the specific device, from its size to the types of materials, the choice of materials with appropriate physical, chemical, and metallurgical properties has to be investigated. Often only a few of those properties are considered to solve concrete problems in contacts while others frequently remain less known. In reality, all of these properties are of importance. For obtaining any of the desired or designed properties, all of the properties proposed must be considered from the point of view of the feasibility of production and shaping of such material and required technological processes. Pure metals were used at the earliest applications as a contact material. However, in further implementations, it was observed that the alloys have shown numerous advantages. The mechanical properties of the materials for electrical and electronic contacts are important but not of primary interest, while the possible corrosion behaviour of contact elements also must be taken into consideration.

Keywords

Contact Materials, Service Demands / Operating Specification, Physical Properties, Chemical Properties, Metallurgical Properties.

Acknowledgement

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MARAGING STEEL MANUFACTURED BY DIRECT METAL LASER SINTERING - EVOLUTION AND APPLICATIONS REVIEWS

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Abstract

Maraging steel parts obtained by direct metal laser sintering (DMLS) have garnered significant attention due to its unique combination of properties and its potential applications in various industries. Additionally, maraging steel is a type of ultra-high-strength steel alloy, initially developed in the 1960s. It derives its name from "martensite" and "aging," referring to the process of strengthening through precipitation hardening. Traditional manufacturing methods involve casting and subsequent heat treatment. Direct metal laser sintering (DMLS), a form of additive manufacturing or 3D printing, has revolutionized the fabrication of the maraging steel components. This process involves melting thin layers of metal powder using a high-powered laser according to a digital design. DMLS offers precise control over the melting process, allowing for the creation of complex geometries and fine-tuning of mechanical properties. Maraging steel is renowned for its exceptional strength, with yield strengths often exceeding 2000 MPa. Despite its high strength, maraging steel maintains good toughness, making it resistant to crack propagation and impact. Maraging steel possesses excellent corrosion resistance, especially compared to other high-strength steel. It also offers good wear resistance, making it suitable for abrasive applications. Maraging steel retains its mechanical properties at elevated temperatures, making it suitable for high-temperature applications.

This material has exceptional mechanical properties, including machinability, plasticity, strength, toughness, corrosion resistance, and crack resistance. These features make it an excellent choice for various manufacturing processes and industry-specific applications. However, despite its advantages, maraging steel presents challenges during manufacturing: Due to its high strength and hardness, machining maraging steel can be demanding. Maraging steel is still lacking in the market despite increasing demand, mainly due to limited suppliers. High nickel content makes maraging steel typically non-weldable.

Keywords

Direct Metal Laser Sintering, maraging steel, microstructure, mechanical properties, corrosion resistance.

Acknowledgement

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STRESS ANALYSIS OF WELDED JOINT IN STRUCTURAL STEEL USING FINITE ELEMENT METHOD

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Abstract

The stress in welded joints is examined using the finite element method, a widely used numerical analysis tool for simulating and assessing structures under different loads. This study specifically investigates the applicability of this method in analysing and sizing welded joints within steel structures, adhering to Eurocode 3 standards. Various aspects of designing welded joints using the finite element method are covered, including joint modelling, stress analysis, strength and stability assessment, and design optimization. Furthermore, the impact of factors such as joint configuration, material properties, and applied loads on welded joint performance is explored.

The primary aim of this research is to enhance the understanding and methodology of designing welded joints, ensuring their reliability, safety, and durability. By leveraging the finite element method, the objective is to refine welded joint designs and reduce the potential for damage or accidents. Through comprehensive analysis and case studies, guidelines are provided for engineers and designers in the application of the finite element method for designing welded joints. These findings can contribute to improved engineering practices in the field of steel structures, ensuring more efficient and safer welded joint designs.

Keywords

Welding, steel, structural stress, finite element method, model verification, Eurocode 3.

DEEP CRYOGENIC TREATMENT OF ROLLING BEARINGS – INITIAL EXPERIMENTAL RESULTS

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Abstract

Rolling bearings are among the most commonly used standardized machine elements today. They have largely replaced sliding bearings in the majority of mechanical systems where precise rotational motion is required. This is the main reason why rolling bearings remain a focal point of scientific research, with the world's leading bearing manufacturers investing significant financial and material resources to improve their characteristics, aiming to increase their reliability and energy efficiency by enhancing dynamic load capacity, wear resistance, and reducing friction in rolling bearings. All these characteristics can be positively influenced by appropriate Deep Cryogenic Treatment (DCT). This process involves one or more cycles of cooling the bearing assembly parts (or the entire bearing) to a temperature significantly below zero degrees Celsius, maintaining that temperature for a predefined time period, and then gradually returning them to room temperature. Although a large number of relevant scientific studies have been conducted worldwide, the precise parameters of DCT that would ensure optimal bearing characteristics have not yet been defined. The problem lies in the complexity of the phenomena occurring in the bearing materials during DCT. Considering that, two teams from the Faculty of Mechanical Engineering at the University of Belgrade and the Fraunhofer – Institute for Machine Tools and Forming Technology (IWU), Chemnitz, Germany, have joined forces and designed a series of experiments to define the appropriate parameters of DCT for bearings. As objects of preliminary research, balls (rolling elements) of bearing types 6306, 6308, and 6310 were selected, as they are the most commonly used in conveyor idlers and the spherical shape particularly exhibits residual stresses that DCT positively affects. The balls were made of 100Cr6 steel, previously quenched and tempered, which limited the possibility of applying DCT between previous thermal treatment phases. Based on previous experience and available literature, parameters for three DCT cycles have been defined: two dynamic and one static, with dimensions, Rockwell C hardness, and surface roughness measured on all ball samples before and after the DCT. The results showed that static DCT is the most optimal for application, as it positively affects all measured characteristics, requiring only one DCT cycle. In the next phase of experimental testing, this DCT will be applied to the most important parts of the rolling bearing assembly, as well as to the bearing as a whole. The idea is to test four groups of samples: rolling bearings with cryogenically treated balls, rolling bearings with cryogenically treated rings, rolling bearings with both the rings and balls cryogenically treated, and rolling bearings without any DCT. During testing, the bearings' vibrations and temperatures will be measured, and, if feasible, the time to failure will also be recorded. The bearings with the best characteristics will then be installed in conveyor idlers, potentially leading to significant energy and financial savings in both surface and underground mining operations, as well as in other idler applications.

Keywords

Deep Cryogenic Treatment, Cryogenic cycle parameters, Rolling bearings, Ball bearings, Conveyor idlers.

OPTICAL METHODS APPLIED FOR TESTING PIPE RING SPECIMENS

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Abstract

The Optical methods can be highly useful for analysing Pipe Ring Tensile Specimens (PRTS) since they offer an accurate and non-destructive method of evaluation. Optical technologies have several uses, such as Digital Image Correlation method (DIC method), thermal imaging camera, and 3D scanning. The DIC method is used to measure stresses and full-field displacements. DIC analyses a speckle pattern that is applied to the surface of the specimen and can provide detailed information on strain distribution, deformation gradients, and likely failure spots. An infrared thermal imaging camera can be used to detect defects in pipe specimens, such as fractures or delamination, by tracking the distribution of surface temperatures. Temperature anomalies can indicate areas of intense stress or material degradation. A 3D scanner is a device that uses the shape, size, and texture of physical objects to digitise them into three-dimensional digital representations. The investigation focused on five distinct PLA PRTS. The study describes how to evaluate PLA PRTS using DIC method, thermal imaging camera, and a 3D scanner. The evolution of strain was monitored using the 3D Digital Image Correlation approach. Using a thermal imaging camera, the temperature field change in the PRTS was investigated during the test. In order to verify the cross-sectional shape of the PRTS after a fracture, 3D scanning was performed on each specimen.

Keywords

Pipe ring tensile specimen, Digital Image Correlation, 3D DIC, 3D scanner, thermal imaging camera.

INTEGRITY OF THE STEAM COLLECTOR MADE OF STEEL 12X1MF

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Abstract

The method of proving the integrity of the output collector of the steam super heater manufactured from the material 12X1MF, presented in the paper, is a material for working at elevated temperatures that is most often used in facilities of thermal power plants. Proving the integrity of the assembly was performed primarily using non-destructive testing methods, software processing of metallographic samples, conventional methods of proving the stress state in the material, application of the finite element method for the entire assembly and hydrostatic testing of the assembly with cold water pressure. Each collector segment is individually tested for the overall integrity of the super heater outlet collector. In addition to conventional methods of testing with/without destruction, software processing of the microstructure was also used in order to evaluate the proportion of the beanie phase in the structure, which is the main quality feature of the 12X1MF material. The qualification of the welding technology with additional materials available on the European market was an indispensable part of the proof of the integrity of the welded joints as the most critical segments of the assembly. The final stage of the assessment of the integrity of the assembly was the finite element method and hydrostatic testing of the assembly with cold water pressure.

Keywords

Heat resistant steel, Steam collector, Integrity, NDT, FEM, Hydrostatic test.

Acknowledgement

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ENERGY EFFICIENCY OF VENTILATION MILLS IN THERMAL POWER PLANT KOSTOLAC B

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Abstract

Ventilation mill for grinding coal is one of the main steam power plants in the system that makes a significant influence on the level of energy efficiency with its work. The aim of this paper is, to increase the energy efficiency of thermo power plant Kostolac B by reducing the problem of wear in ventilation mill for coal grinding. Idea of this research is to investigate the optimum hardfacing technologies to increase wears resistance of impact plates in ventilation mill. To extend remaining life of impact plates, hardfacing was performed in the form of a "honeycomb" and fish bones, using two processes and three types of a filler material. Before of applying hardfacing on impact plates in the exploitation conditions, it is necessary to test hardfaced samples and filler material for revitalization The experimental tests of the extend working life suction plates during the exploitation show that the proposed solutions, process of hardfacing give good results. The relative weight loss of the impact plates after 1440 h period of exploitation in real conditions is very small 5-8%. The application of this approach can reduce the number of possible repairs and extends the period between them, resulting in significant economic effects. Before and after revitalization, the monitoring and analyses of failure ventilation mills is done. Time of repair of ventilation mills number 22, 23, 24 and 25, the number of repairs before and after revitalization and cost of repairs is also presented in the paper.

Keywords

Ventilation mill, energy efficiency, hardfacing, wear, impact plate, monitoring.

Acknowledgement

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ANALYSIS OF THE ADVANTAGES AND DISADVANTAGES OF SILICON SOLAR CELLS: A TECHNOLOGY OVERVIEW AND PERSPECTIVE

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Abstract

Amorphous silicon solar cells (a-Si) represent one of the technological innovations in the field of photovoltaic systems. This paper analyses the advantages and disadvantages of a-Si cells compared to crystalline (monocrystalline and polycrystalline) silicon solar cells. A higher coefficient of sunlight absorption compared to crystalline cells enables better efficiency in different lighting conditions, which is an advantage of a-Si technology. Additionally, the production of a-Si cells requires a smaller amount of material, and they can be produced on different substrates. It is possible to connect cells in series and in parallel to create panels, which facilitates installation and increases the potential for practical applications. One of the main disadvantages of a-Si solar cells is their lower efficiency (around 5-7%) compared to crystalline cells which have an efficiency of 14-15%. Also, over a long period of time, the optical and electrical characteristics of a-Si cells may degrade. This analysis provides insight into the characteristics and capabilities of a-Si solar cells, highlighting their advantages and disadvantages compared to traditional crystalline technologies, as well as perspectives for further development of this technology in the field of photovoltaic systems.

Keywords

Amorphous solar cells, photovoltaic systems, solar cells efficiency.

Acknowledgement

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Chemical and Process Engineering

Invited lecture

PYRIDINE IMINES DERIVATIVES: BIOLOGICAL ACTIVITY, THEORETICAL CALCULATION AND ANTICORROSIVE POTENTIAL

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Abstract

The designing and syntheses of new compounds that can be used in medicinal chemistry, biochemistry, materials research or other industries are challenging mission. Heterocyclic compounds which contain pyridine and its derivatives possess various biological properties including antioxidant, antitubercular, antimicrobial, and anticancer activity. Many of these compounds can be used as building block in organic synthesis, polymer and nano materials, corrosion inhibitors, catalysts preparation etc. Therefore, comprehensive study on the synthesis and structural characterization of a series of N,N'-(pyridin-2,6-diyl) bis[1-(substituted phenyl)] methaneimines (bis(imino)pyridines, BIP), and examination of their biological activity and anticorrosive potential, supported by results from quantum chemical calculations, was performed. In order to better understand the radical scavenging and antimicrobial mechanism, and to get deeper insight into corrosion inhibition mechanism quantum-chemical calculations, using Density Functional Theory (DFT) method, was applied. Target fishing and molecular docking indicated possible antibacterial targets for BIPs. The highest antioxidant activity in DPPH and ABTS assays and anticorrosive efficiency showed BIP derivatives with 2-quinolyl, 4-hydroxyphenyl, and 4-dimethylaminophenyl moiety, while compound with 2-pyridyl group showed the highest antimicrobial effect. Better understanding of antioxidative mechanism was obtained from structure-antioxidant capacity relationships using correlation method and DFT calculation of spin electron density distribution map. It was proved that biological activity of BIPs depends on the structural characteristics, electronic properties of substituent and used test. Anticorrosive potential was determined on iron at various pH, inhibitor concentration and times. Besides, QSAR (Quantitative Structure Activity Relationship) modeling was applied to the ecotoxicological properties of BIP compounds in order to evaluate their potential impact to environment. Additionally, the possible application of the most efficient anticorrosive BIP with 2-pyridyl moiety was additionally justified with the lowest acute toxicity to aquatic organisms. The results of this study represent a good basis for further research and development of newly designed iminopyridines with improved biological and anticorrosive properties.

Keywords

Bis(imino)pyridines; Antioxidant and Antimicrobial activity; Anticorrosive potential; Density functional theory.

Acknowledgement

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MECHANICAL PROPERTIES OF FOOD-GRADE HYDROGEL CARRIERS WITH ENCAPSULATED DAIRY STARTER CULTURE

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Abstract

This study investigates the application of biopolymers as a carrier material for the encapsulation of dairy starter cultures, focusing on hydrogels derived from proteins and polysaccharides. The natural-based hydrogels are essential for applications in the food industry due to their biocompatibility, low toxicity, and biodegradability. The food-grade hydrogels with encapsulated culture were developed by combining sodium alginate, whey, and whey protein concentrate at a concentration range from 2.4% to 4.8% (w/v), using an extrusion encapsulation technique. Mechanical properties of the carriers were evaluated through compression testing, analyzing engineering stress-strain curves. Additionally, the encapsulation efficiency of the materials, as well as cell leakage and viability during the fermentation process, were assessed. The SEM cross-sectional analysis indicates successful cell encapsulation within the carrier structure. The protein presence enhanced carrier strength and improved cell viability by 1.22±0.05 (log CFU g^{-1}) after the fermentation process. The addition of whey proteins significantly increased the elastic modulus of the carriers, a crucial factor for their potential application in fermented beverage production. Our results indicate that whey proteins provided the necessary conditions for cell growth and improved the stability of the hydrogel carriers.

Keywords

Dairy starter culture, hydrogels, extrusion technique, fermented beverages.

Acknowledgement

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MODERN CONCEPTS OF SUPERVISORY CONTROL SYSTEMS, BASED ON THE PLC AND SCADA SYSTEMS

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Abstract

Modern control structures, based on PLC (Programmable Logic Controller) and SCADA (Supervisory Control and Data Acquisition) systems, are reliable, have great programming flexibility, enable changes in basic parameters or the concept of the entire control system, quick adaptation to new situations and implementation of new knowledge to which are reached during work monitoring, thanks to the fact that all these changes are made by software. PLCs are the most frequently applied devices, in the last three decades, in solving tasks related to the automation of industrial plants and process control. The processor, memory capacity and computer capabilities of the controller enable the application of very complex algorithms and the management of very complex processes. Modern SCADA systems incorporate the most modern technologies at the moment, with the Internet of things (IoT), industrial internet of things (IIoT) and industry 4.0 having a significant impact. Today's industry development is characterized by the transition from digitization of production platforms to cyber-physical systems. SCADA systems now allow access to data, about the operation of process equipment, in real time from anywhere in the world. These modern platforms allow users to quickly and easily design and develop different applications, even without in-depth knowledge of the software. The introduction of modern IT standards, practices and technologies, such as Structured query language (SQL) and web-based applications in SCADA software, optimizes the efficiency, security and reliability of the SCADA system. Along with the development of supervisory control systems, the need to protect the data that is acquisiited, processed and transmitted also arose. Presented are the current problems and trends in this area and the protective measures taken to overcome the problems. The paper presents an example of supervisory control of a complex industrial plant.

Keywords

Control system, supervision, industrial plant.

MEASURING THE TEMPERATURE DISTRIBUTION IN PROCESS INDUSTRIES

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Abstract

The process industry encompasses any aspect of production, whether it be in the food, chemical, metallurgical, pharmaceutical, paper, plastic, rubber, or many other industries. Essentially, wherever there is a continuous process, it falls under the process industry. The process industry utilizes automation, robotics, and numerical control to manage industrial machinery and processes. Considering that friction and heat are integral parts of process industry, and it is precisely because of them that problems and failures occur, the question arises as to which non-contact preventive maintenance method can identify problems in time and thus eliminate potential future failures. Thermography is one of the fastest methods for identifying thermal gradients on recorded equipment or machinery. Thermography enables the determination of temperature through infrared radiation. Infrared rays are converted into a signal, which is later transformed into an image in the device so that the user can see the temperature distribution on the recorded equipment. Its applications are numerous; in the food industry, it can detect deviations in the operation of refrigeration units, verify whether the desired temperature has been reached during food cooking, and measure deviation when two machine parts move in relation to each other, and one is not functioning properly. For example, if the part is not properly positioned, resulting in excessive heating on one side, thermography can identify this issue. The application of thermography as a preventive maintenance method brings numerous benefits, such as longer and more efficient operation of machines and the entire system, avoiding part failures due to inadequate use, less system downtime due to sudden failures and therefore repairs, and ultimately, fewer financial losses.

Keywords

Temperature distribution, Thermal Imaging Camera, Process industry, Heat dissipation.

ANALYSIS OF EXAMINATION OF THE CONE STRAINERS FOR REMOVING IMPURITIES AS CONSTITUENCY PARTS OF THE COMPRESSOR DURING REGULAR OVERHAULING OF TURBINE FOR PURIFIED GAS

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Abstract

In upstream Oil and Gas plant, turbine system for purified gas has shut down for regular overhauling. On that occasion it was performed examination of the main turbine which included the following items: such as rotor compressor, main bearing of the first turbine stage, main bearing of the second turbine stage, bearing seats, blades, journal pads of bearing, shaft with blades, radial pads, axial pads, guided vanes, turbine disk of first stage, turbine disk of first second stage, compressor guided vane segments, inner combustion chambers, gas manifold, rotor tie bolts, case hg, inner and outer ring of the case, and cone strainers on the first and second stage suction lines of turbine system. During examination it was observed that one the highest blade has cracked and that on the cone strainers (26" and 24") cracks has noted on their conical shell and on their circular holder plates. Cracked blade has removed from the shaft and the same new one has installed. WPS for remediation of cone strainers has prepared and repair welding has performed after removing of observed cracks on the strainers. After repair welding process by relevant NDE examinations of the repaired area has conducted by which has confirmed that damaged areas on the strainers has successfully repaired. Gas turbine has successfully assembled after all necessary activities and put in service. Measurements of noise level and vibration has proved that all activities have performed on a proper way.

Keywords

Turbine overhauling, cone strainer.

Acknowledgement

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THE IMPORTANCE OF INDUSTRIAL ECO-PARKS FOR THE ENVIRONMENT OF THE WESTERN BALKANS

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Abstract

Industrial eco-parks are specialized industrial zones designed to enhance environmental sustainability by promoting collaboration among businesses to optimize resource use, reduce waste, and minimize environmental impact. The aim of this paper is to explore and elucidate the significance of industrial eco-parks for environmental sustainability and economic development in the Western Balkans. This study analyses how industrial eco-parks contribute to the reduction of environmental pollution, enhancement of resource efficiency, promotion of sustainable industrial practices, and compliance with environmental regulations. Additionally, the paper seeks to highlight the potential economic benefits and improvements in community health associated with the establishment of industrial eco-parks in the region. Through a comprehensive review of current practices and case studies, the paper aims to provide insights and recommendations for policymakers and stakeholders on the strategic implementation and management of industrial eco-parks to achieve long-term environmental and economic objectives. In conclusion, the establishment of industrial eco-parks in the Western Balkans is vital for enhancing environmental sustainability in the region. By promoting resource efficiency, reducing pollution, and encouraging sustainable industrial practices, these parks play a crucial role in protecting the environment while also supporting economic development.

Keywords

Industrial eco-parks, industrial symbiosis, environment, pollution, western Balkan.

THE INFLUENCE OF INDUSTRY ON ENVIRONMENTAL POLLUTION

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Abstract

Industry is an economic activity that machanically processes raw materials into semi-finished products and finished goods. Each country has certain conditions for the development of industry, and it depends on how the country will utilzes those conditions.Today, people pay more attention to environmental issues and their protection. One of the reasons why the ecology of our planet is suffering is the negative impact of industry.This is a very important topic.

There are several causes of man-made environmental degradation, and industry is the number one cause of our environment slowly becoming “less green”. Although industry is important for economic growtth, it brings significant damage to nature and even to ourselves. Many factors pollute the air, water and soil. We are losing natural resources and cannot get them back. Humanity seems to be leading itself to self-destruction. We are taking more and more from nature and giving too little back.

Various industries cause soil degradation, water pollution, deforestation, emission of dangerous pollutants into the air, acid rain, and global warming. The impact of the industry is evident in the eflects on soil, atmosphere, flora and fauna, and water. The consequences of excessive gas emissions lead rising sea level, melting glaciers, and an increased frequency of droughts, stoorms, and floods. The impact of environmental protection on the industry is very significant. In different parts of the world, the use of natural resources represents the basic source of existence, such as fishing forestry, agriculture.

Keywords

Industry, air, water and soil pollution, environmental protection.

Agricultural & Food Engineering

Invited lecture

ADVANCES OF MACHINE LEARNING IN DRYING PROCESS

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Abstract

Drying is the oldest and one of the most common techniques for preserving food. Although it looks like a simple, easy process to carry out, it is a demanding process in which heat, mass and momentum are transported simultaneously and the product is also deformed. Compared to modern food preservation techniques, drying is a process that requires less energy and can be considered a "green technology" due to the use of renewable energy sources. In the mathematical modelling of drying kinetics, which is strictly based on physical models, mainly semi-empirical formulas are used to determine the time-moisture ratio. These models are limited in terms of predictive ability and are also unsuitable for real-time process control and optimization of industrial drying. Unsupervised and supervised machine and deep learning techniques are able to incorporate data-driven models, but also non-linear control and multi-objective optimization. This article provides an overview of the most commonly used machine learning techniques and the state of the art in machine learning applications in food and biomaterial drying. "Smart" drying systems are based on experimental data sets – input parameters and results - and the ability of image recognition of sensory features such as shrinkage, color change and shape. The accuracy between the machine learning models and the input data is based on three metrics: Coefficient of determination (R2), mean squared error (MSE) and mean absolute error (MAE). Machine learning analysis as a sophisticated computational tool for modelling can provide more realistic and accurate results of the drying process.

Keywords

Convective drying, Drying kinetics, Machine Learning, Deep Learning.

MATHEMATICAL AND DEEP LEARNING MODELLING OF THE BLACKBERRIES AND RASPBERRIES DRYING KINETICS

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Abstract

Raspberries and Blackberries are among the most important viticultural products in Serbia. Most of them are marketed in a frozen state. Depending on the further use, to preserve nutrients as well as possible, other conservation techniques can be successfully used. Convective drying, as widely accepted method for fruit preservation is good alternative to preserve quality of these berries, primarily, and secondarily as being less demanding in terms of energy consumption. Hence, this study aims to model the drying kinetics of the selected berries using the usual semi-empirical formulas based on time-moisture ratio dependence, and with deep learning models which can include multiple parameters. Experimental part of the study was carried out in a convective dryer at different temperatures (50°C, 60°C and 70°C) and different air velocities (2 and 2.5 m/s). The effects of the operational parameters were evaluated with several quality criteria: shrinkage, color change and shape. Mathematical modelling of the drying kinetics was based on adjusting experimental data using 12 known semi-empirical models and one proposed. Besides, the experimental results were modeled with supervised deep learning techniques, a machine learning approach. The Static ANN model, RNN, and CatBoost model were selected for machine learning modelling. Optimization of the selected deep learning models was based on hyperparameter tuning. The accuracy of the evaluated and deep learning models was assessed using three metrics: coefficient of determination (R2), Mean Squared Error (MSE), and Mean Absolute Error (MAE).

Keywords

Convective drying, Drying kinetics, Mathematical Modelling, Machine Learning, Deep.

Acknowledgement

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SUPER SWEET CABBAGE FROM SERBIA CONQUERS THE WORLD

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Abstract

Cabbage is a plant of low nutritional value with a high water content and a low content of dry matter and carbohydrates, predominantly sugars. In directing the breeding program of cabbage to increase its nutritional value, the Institute for Vegetable Crops in S. Palanka created a large number of lines from the population of Izpscc. These lines are characterized by a high sugar content ranging from 6.1% to 9.6%, compared to the world average of 3.8% to 4.2%. The selection process began with the method of individual selection from the population and continued with the Pedigree method.

The basic selection criteria were: erectophilic rosette, leaves with long petioles that facilitate phototropism, internal stem shorter than 50% of the head height, total sugar content higher than 7.5%, well-compacted head, and head weight over 1.6 kg. To select the final genotype, a multi-year study on sugar stability was conducted, using AMMI analysis as a statistical method to assess the significance of genotype and environmental stability. The selection process was supported by the project "New variety of cabbage with increased yield and content of total sugars" funded by the Innovation Activity Fund, 2017 - 2018. The super sweet cabbage Zahar SP was recognized on the EU variety list on April 7, 2020, and was listed in the Republic of Serbia on July 28, 2020. International cooperation was achieved with the help of the Fund for Innovation Activities in collaboration with Syngenta. This collaboration focused on selecting supersweet cabbage hybrids resistant to biotic and abiotic stress. Numerous hybrids were developed by hybridizing DH lines of supersweet cabbage from the Institute for Vegetable Crops with stress-resistant CMS lines. Four hybrids were selected to begin the process of recognition in the EU variety list, with market realization expected from 2027. Economic teams will manage the commercialization plans and strategies for the global market.

Keywords

Cabbage, sugar, new variety, hybrids, resistance to stress.

Acknowledgement

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GENOME EDITING TECHNOLOGIES AS POWERFUL TOOLS IN FOOD ENGINEERING AND BIOTECHNOLOGY

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Abstract

Food engineering designs sustainable and environmentally responsible food processes for manufacturing safe, tasty, healthy, and convenient food products. Methods that target inserted genes to exact sites within the genome of the living organism have been designed, leading to a new era in biotechnology, and the introduction of genome editing technologies. The procedure of gene editing is accomplished using nucleases engineered to target an explicit DNA sequence and form DNA double-strand breaks, allowing for the removal of existing DNA and the insertion of replacement DNA. There are various gene editing techniques, but irrespective of the specific technique used, all are grounded on the use of nucleases: zinc-finger nucleases, TALE nucleases, meganucleases, and CRISPR-associated endonucleases. Gene editing tools offer a potential for a completely new approach in the production of crops with desirable genetic traits, providing many advances compared to technology used in genetically modified plants. Here we discuss genome editing technologies, the advances and obstacles in their application in food engineering and biology, and the further challenges in their future development.

Keywords

Genome Editing Technologies, Food Engineering, Biotechnology, CRISPR/Cas9, nucleases.

RECENT ADVANCES IN THE FIELD OF BEEHIVE TEMPERATURE MONITORING

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Abstract

The most significant pollinator insect is the honey bee (Apis mellifera), which also provides honey and other valuable products. The goal of smart apiculture is to assist beekeepers in remotely monitoring honey bee colonies and recognising various colony states. Given that swarming can significantly reduce productivity, one of the monitoring objectives through temperature measurement is the remote identification of this phenomenon. Experiments show that before swarming, there is a warm-up phase of 1.5–3.4°C, approximately 20 minutes before takeoff, which varies from the usual range of 34–35°C in beehives. The temperature of beehives was significantly impacted by the presence of bees. Hives missing bees had mean temperatures that were 5.5°C lower and had wider temperature variations than hives with bees. Regardless of colony strength, hives without bees attain their highest temperature earlier than hives with bees. Using wireless sensing technologies, this apiculture method could be applied to monitor various bee colony parameters in real-time. This would improve the detection of colony collapse disorder (CCD), which is an important issue in managing the honey bee population. Machine learning algorithms are developed to predict temperature fluctuations in bee colonies using daily thermal patterns with a root mean square error (RMSE) of less than 0.5%.

Keywords

Smart apiculture, Temperature, Honey bee, Monitoring.

Acknowledgement

Special thanks to all our colleagues, family and friends for supporting and believing in our work. None of this would be possible without them.

Experimental Techniques

Invited lecture

DESIGN PARAMETERS FOR ORTHOPAEDIC IMPLANTS FROM FRACTURE MECHANICS ASPECTS

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Abstract

The research presented in this paper focuses on determining crucial design parameters for orthopedic implants, with a primary emphasis on fracture mechanics aspects. It has been observed that fatigue-induced fractures are prevalent issues in orthopedic applications, particularly in fracture fixation plates and hip prostheses, associated with the loosening of the bone-prosthesis joint and eventual implant failure. It has been shown that linear elastic fracture mechanics can be applied in the design of orthopedic implants when the fracture mechanics parameter, specifically the measure of material strength in the presence of a crack of finite size in the area of validity of Hooke's law, is the stress intensity factor KcKc.

Experimental investigations involve analyzing the behavior of actual orthopedic implant structures using a three-dimensional optical system, GOM, and Aramis software, to understand the deformation field on the implant under realistic physiological loads. For further research purposes, two numerical models of chosen orthopedic implants were created which, after numerical analysis of the selected implants under characteristic loads, yield results close to the obtained experimental values.

The results indicate that the initiation of cracks in the material can be expected in places of increased stress concentration, due to the fact that stress values obtained in those areas are very close to or even higher than the yield stress of the analyzed biomaterials. It can be concluded that damage and fracture may occur, particularly in active individuals experiencing higher loads, primarily in regions of the highest stress concentration along the implant, which can lead to catastrophic implant failure.

Keywords

Fracture mechanics parameters, stress intensity factor, orthopaedic implants, finite element method, three-dimensional optical system.

Acknowledgement

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INTEGRATION OF ADDITIVE TECHNOLOGY AND MECHANICAL TESTING FOR THE ANALYSIS OF AUXETIC STRUCTURE CHARACTERISTICS

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Abstract

The Materials with a negative Poisson's ratio are recognized as Auxetics materials. Compared to conventional materials it has the counter-intuitive property that during the compression the structure tends to contract and stretch when it expands. These particular attributes identified in the literature have encouraged further research on this topic. The flexible photopolymer resin is used for the test specimens, which have a cylindrical-shell based Auxetics structure. The test specimens are printed on an LCD printer with resin which gives structure ductile properties during the compression test. Using an industry camera the dimensional changes are captured for further research. With Digital Image Correlation method experimental results show different scenarios in varying the dimensions of the structure. Analyzed results give a foundation for future research, giving it a special focus on improving the quality of future tests and giving a perspective of potential applications and manufacturing variations of Auxetics structures.

Keywords

Auxetics structures, Additive technologies, Compression testing.

Acknowledgement

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THE INFLUENCE OF PRINTING ORIENTATION ON TENSILE STRENGTH IN SLS 3D PRINTED SPECIMENS

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Abstract

This study delves into the mechanical characteristics of specimens manufactured through Selective Laser Sintering (SLS) technology, focusing on the tensile strength properties of PA12 materials. The test specimens were prepared according to the ISO 527 standard. Using the specialized Fuse 1 machine by FormLabs, all specimens were produced. Notably, the research encompasses six distinct specimen batches, each comprising five specimens, varying in printing orientation. To properly evaluate the mechanical characteristics of the specimens, a Shimadzu universal testing machine was used, with a unique additional tool for tensile testing with spherical joint. This multifaceted approach offers a comprehensive understanding of how printing orientation impacts the tensile strength of PA12 specimens, thus contributing valuable insights to the field of additive manufacturing and material science.

Keywords

Selective Laser Sintering, Polyamide 12, Tensile strength, Printing orientation.

Acknowledgement

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THE INFLUENCE OF PRINTING POSITIONING ON SURFACE ROUGHNESS PARAMETERS OBTAINED BY SLS TECHNOLOGY FOR PA12 MATERIAL

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Abstract

This article aims to investigate the influence of sample positioning on surface roughness parameters fabricated using Selective Laser Sintering (SLS) technology known for its ability to produce complex parts with high precision. All samples were produced using a specialized machine, the Fuse 1 (FormLabs, Summerville, MA). The material used for the samples is PA12 (Nylon12). Different positions of the tested surface were considered, ranging from horizontal to vertical orientation for both sides of the surface samples (bottom and top surface). The surface texture of the tested samples was characterized according to ISO 4287 standard. The roughness measurement direction on each sample is in three directions with the Mitutoyo Surface Roughness Measuring Instrument and according to ISO 3274 standard.

Keywords

Selective Laser Sintering, Polyamide 12, Printing orientation, Surface roughness.

Acknowledgement

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APPLICATION OF THERMAL IMAGING CAMERA IN THE WELDING PROCESS

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Abstract

Welding is the process of joining two pieces by melting them using thermal and/or mechanical energy to create an inseparable bond. Since joining parts in machinery is essential across all industry sectors, welding has proven to be one of the best methods due to its minimal mass addition; unlike screws or rivets, welding does not add any mass to the structure. Welding is a highly complex metallurgical process that requires to melt the two desired pieces. Therefore, the amount of added heat, the type of metal being melted, and the additional material added during welding are crucial parameters in the welding process.

Thermography is non-contact, non-invasive, and preventive method that can be used to check the quality of welding before, during, and after the process. Thermography uses infrared rays to measure the temperature of an object or process. The infrared rays are converted into a signal by the infrared device, which is then transformed into an image, allowing the user to see the temperature distribution at the welded joint. The application of thermography in welding is extensive; it can measure the temperature of the weld metal and verify its acceptability. Additionally, thermography can detect in the weld metal, as the heat dissipation is lower at the inclusion site compared to other areas of the weld metal where heat dissipation is greater.

During thermal processing, thermography can verify whether a part has been heated to the appropriate temperature and whether cooling has been performed adequately. The application of thermography brings numerous benefits to the welding process, such as error checking in the welded joint, ensuring the correctness and accuracy of the thermal processing process, and verification the welding process itself. These benefits lead to fewer errors and better joint quality, ultimately resulting in reduced financial losses.

Keywords

Thermal Imaging Camera, welding, heat dissipation, Thermography, infrared radiation.

APPLICATION OF 2D DIGITAL IMAGE CORRELATION METHOD IN FRACTURE MECHANICS

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Abstract

Fracture mechanics, a fundamental field in materials science and engineering, deals with the study of crack initiation, propagation, and fracture resistance of materials. Traditional methods in fracture mechanics analysis often rely on analytical or numerical approaches, which may have limitations in capturing crack behavior under various loading conditions. To overcome these challenges, the 2D Digital Image Correlation (2D-DIC) method, a noncontact, full-field measurement technique, is employed to precisely quantify displacement and strain values. This paper investigates the application of the 2D-DIC method in the field of fracture mechanics. Through an experimental investigation that involves fracture toughness testing, crack growth monitoring, and fatigue crack propagation analyses, the effectiveness of 2D-DIC in capturing crack behavior is demonstrated. The results showcase the method's ability to accurately track crack propagation, providing valuable insight into crack growth mechanisms, and offering new data for understanding fracture mechanics phenomena. This paper contributes to advancing the field by highlighting the utility of 2D-DIC as a powerful tool for studying crack behavior and improving the overall understanding of fracture mechanics.

Keywords

2D Digital Image Correlation; Fracture mechanics; crack propagation; fracture toughness.

Acknowledgement

The results presented in the paper are the result of research supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia under Agreement No: 451-03-65/2024-03/200105 from 05.02.2024.

EXPERIMENTAL AND NUMERICAL ANALYSIS OF MATERIALS FOR FOLDING BELLOWS

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Abstract

The production of bridges for transferring passengers from an airplane/ship to terminal facility presents a serious engineering challenge in terms of material savings, fabrication of a simple yet stable structure whose weight will not be excessive. In addition to calculating the stiffness of the structure, which values depend on the mechanical properties of the material of folding bellows, certain segments of the structure may have unpredictable strength values such as the fabric, the seams on the fabric, and the connections between the fabric and the structure. Due to unforeseen circumstances such as a sudden and strong lean of passengers against the wall of the structure or the fabric located between the aluminum profiles of the side wall, material failure can occur. Material failure at the seam, in the fasteners, or in the base material of the fabric in this case can be fatal for a passenger who can lean and fall from a great height onto a hard surface. To predict such scenarios, the tensile properties of the seams and fasteners of the tarp in the side walls of the structure were tested, and the values obtained in this experiment will be used in further numerical analysis. According to the results of this study, the tear resistance of the seam is approximately two and a half times lower compared to the fasteners of the tarp in the side walls of the structure. Solutions for these critical areas will be proposed in the paper after detailed numerical analysis of the structure.

Keywords

Fabric, folding bellow material, tensile strength, the tear resistance.

Acknowledgement

The authors acknowledge the support from the Ministry of Education, Science and Technological Development of the Republic of Serbia (contracts: 451-03- 65/2024-03/200105).

MECHANICAL PROPERTIES OF PA12 SPECIMENS PRODUCED USING SLS TECHNOLOGY

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Abstract

In this study, the research focuses on tensile PA12 specimens with CAD model dimensions selected according to the ISO 527-2 standard, with bulk dimensions of 170x20x4 mm. The study utilizes a Fuse 1 (FormLabs, Summerville, MA) 3D printer that employs SLS technology. This printer is capable of producing objects with different shapes and dimensions simultaneously, provided that they are printed at a minimum distance of 5 mm apart.

The research involves producing two batches of specimens, each differing in printing orientation (i.e., horizontal and vertical). After printing, the specimens are tested using a Shimadzu AGS-X universal testing machine with a capacity of 100 kN to evaluate the mechanical characteristics of the materials. The findings reveal that horizontally printed specimens have a modulus of elasticity about 9.3% higher than the manufacturer's stated value, while vertically printed specimens show an increase of approximately 11.4%. This enhancement is likely due to the thermal and cooling cycles during printing. The difference in modulus of elasticity between the orientations is around 2%, indicating a minor impact on mechanical properties.

Keywords

SLS, PA 12, Universal testing machine, tensile specimens.

Acknowledgement

This research was financially supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia by Contract No. 451-03-66/2024-03/ 200213 from 05.02.2024.

Numerical Methods

DESIGNING OF SPECIAL PURPOSE CRANE - MANIPULATION OF CONTAINER TERMINALS

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Abstract

This paper presents the results of research based on the construction of a hydraulic crane used for handling container terminals. In particular, the purpose of this crane is to transport special purpose containers. When designing such a crane, the conditions in which the crane will work must be taken into account, ambient temperature, dust, humidity, presence of dangerous gases, etc. This type of crane must be classified in the driving class according to the Serbian standard for cranes. It is a one-piece mobile crane with a load capacity of 25 tons. An analysis of the existing structural solutions was done, and then a new solution was given. Analytical and numerical methods were used in the work. Analytical calculations were made according to valid regulations and standards. The numerical calculation was done using the finite element method. A comparative analysis of the obtained results was done in the discussion and conclusion. At the end, obtained results showed that the calculated one-piece mobile crane can safely transport the container terminal of the mentioned maximum mass.

Keywords

Mobile crane, structural solutions, analytical calculation, finite element method.

RECONSTRUCTION OF A CRANE WITH A LOAD CAPACITY OF 12.5 TONS - EXTENSION OF THE CRANE BEAM

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Abstract

This paper presents the results of the research, which are based on the single-row crane beam reconstruction. This type of crane is mostly used in production halls for the manipulation of materials, semi-finished products and finished parts. Introductory considerations and an overview of the literature in this area are given in the paper. Primarily, the reconstruction of the crane beam implies its extension from 9 meters to 14 meters. An analysis of the current state of the crane was performed, which refers to the analytical calculation of stresses and deformations according to valid regulations and standards. Numerical calculation was made using the finite element method. After that, the search for new project solution was started. All knowledge and calculation methods as with the original crane beam were applied. A new construction of the crane beam was adopted, which has a longer length and a different cross-sectional shape compared to the original crane beam. Numerical calculation of stress and deformation of the new design solution was done using the finite element method. Analytical calculations were also made for the new crane. In the discussion and conclusion of this paper, a comparative analysis of the results obtained by analytical and numerical calculation, which refers to the new solution of the crane, is presented. The obtained results showed a high percentage of agreement, which confirms the validity of the numerical calculation.

Keywords

Crane beam, finite element method (FEM), equivalent stress, deformation, cross-section.

NONLINEAR ANALYSIS OF STEEL FRAMES AT ELEVATED TEMPERATURES

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Abstract

The paper presents the newly developed 1D finite element model for fast assessment of the performance of steel frames at elevated temperatures. The element (GP) is based on the Generalized plasticity material model and considers the nonlinear geometry, gradual yielding of a cross-section and strength and stiffness degradation. The element is highly computationally efficient because of the implemented return-mapping algorithm with quadratic convergence. The analysis is performed in Matlab, connecting the heat transfer analysis with the quasi-static analysis performed in FEDEASLab. In the paper, the displacement-temperature response of the GP element is compared with the response of the distributed plasticity fiber-based frame element and the 3D numerical model from commercial software SAFIR on a small steel frame example. The GP element has shown great accuracy while being computationally more efficient than the other two models. The last part of the paper discusses the element limitations and directions for further improvements.

Keywords

Fire analysis, nonlinear frame models, concentrated plasticity, distributed plasticity.

Acknowledgement

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NUMERICAL ANALYSIS OF SHORT CONCRETE-FILLED STEEL TUBULAR COLUMNS UNDER AXIAL COMPRESSION

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Abstract

The paper presents a three-dimensional numerical model for the analysis of circular concrete-filled steel tube columns exposed to axial compression. The model is created in ABAQUS. The most challenging problem in modelling this structural member is modelling concrete within the steel tube, which is in the triaxial state of stress, while the steel tube remains in the biaxial stress state. The presented study evaluates the most used material models for concrete and steel. The material models for concrete include the newly proposed model that extends the Eurocode 2 model. The evaluation is performed on a set of experimental results from the literature with a wide range of column parameters, and the axial force vs. axial strain diagrams are compared. The extended Eurocode 2 model has shown benefits over other analysed material models. Finally, the paper discusses the advantages and limitations of different modelling strategies and gives practical recommendations for modelling.

Keywords

Composite column, nonlinear analysis, 3D FEM model, nonlinear concrete material model.

Acknowledgement

The financial support of the Ministry of Education, Science, and Technological Development, Republic of Serbia, through Project 200092, is acknowledged.

INTEGRATION OF LOOP HEAT PIPE ANTI-ICING SYSTEM IN THE AIRFOIL LEADING EDGE

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Abstract

Integration of heat pipes into the leading edge of airfoils presents a viable option for anti-icing applications, owing to their lightweight, compact design, passive operation, and heat transfer characteristics. Aircraft operation is greatly influenced by ice formation, which can cause aerodynamic performance deterioration and generally present a threat to flight safety. Complex heat transfer processes due to evaporation and freezing of water droplets, sensible heat loss, but also heating due to kinetic energy of water droplets hitting the airfoil and pneumatic heating, variable weather conditions, etc, all make the analytic solution unattainable for prediction of ice formation. Simulation methods today are affirmed for aircraft's icing/de-icing system prediction, from small ones – UAVs, over helicopter rotors, to large passenger planes' airfoils. Insights gained from the numerical simulation study can provide valuable guidance for optimising the design and operation of heat pipe-based anti-icing and deicing systems in the aerospace industry. One of the primary ways to evaluate the anti-icing effect is to predict the temperature of the wing skin on the outside. Here presented numerical simulation deals with the loop heat pipe integrated into the wing's leading edge. The volume of fluid method (VOF) was employed for simulating the condensation process inside the loop heat pipe, leading to further investigation of temperature distribution over the leading edge outer surface. In perspective, results can be the basis for further customised solutions of anti-icing operations for particular aircraft.

Keywords

Heat pipe, anti-icing, numerical simulation, heat transfer.

Acknowledgement

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FATIGUE CRACK GROWTH ANALYSIS AND RESIDUAL LIFE PREDICTIONS OF AIRCRAFT STRUCTURAL COMPONENTS SUBJECTED VARIABLE-AMPLITUDE LOADINGS

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Abstract

This paper aims to develop a suitable computational method for estimating the fatigue life of structural elements exposed to varying load spectra. It examines the fatigue crack growth behavior of cracked wing skin panels under variable-amplitude loading conditions, which include single and periodic tensile or compressive loads, single tensile overload followed by a single compressive load, multiple tensile and compressive overloads, and high-low or low-high block loading.
Special attention is directed to the formwork field with initial cracking under the influence of load spectra with peaks. The paper presents load spectra for which calculations were made, as well as the effects of individual peaks on the retardation of crack propagation in relation to cyclic loads of constant amplitude.
The conventional approach to estimating total life requires using low-cycle fatigue characteristics of the material until initial damage occurs, followed by dynamic characteristics of the material for the remaining life. This work focuses on developing efficient computational methods and software for estimating the residual fatigue life of metal aircraft structural components. Efficient computational methods utilize the same fatigue low-cyclic material properties for crack initiation and crack growth, combined with the finite element method (FEM) for stress analysis. Computation results are compared with experimental data to validate the quality of the computational methods and in-house software for fatigue life estimation. The results show that the predicted results agree well with the test data.

Keywords:

Welding, Tubes, Fatigue, Initial fatigue life, FEM.

Acknowledgement

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INITIAL FATIGUE LIFE ESTIMATION OF WELDED STRUCTURAL COMPONENTS USING FINITE ELEMENT METHOD

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Abstract

The subject of this work is connected to the fatigue assessment of welded components, where the finite element method (FEM) represents an indispensable method today. Welded constructions are usually exposed to cyclic loads, making the precise determination of residual stresses crucial for assessing the fatigue life of welded structures. The computational study of welding requires solving an extremely complex thermo-mechanical process involving transient heat flow due to a moving electrode and the ensuing quasi-static mechanical state of welding stresses and deformations. The highly localized heat-affected zone is of primary concern because it is subjected to severe heating-cooling cycles responsible for high residual stresses and progressive embrittlement during rapid cooling.

In this work, FEM is used to analyze thermo-mechanical behavior and to evaluate residual stresses in weldments. An effective computation procedure for the initial fatigue life estimation of welded structures has been developed. The computation method combines FEM for thermo-mechanical stress analyses, strain-life methods, and considerations of the residual stress effect to predict fatigue crack initiation life in weldments. Computation results are compared with experimental data to validate the quality and reliability of in-house software for initial fatigue life estimations.

In this study, the software code ANSYS is used to simulate temperature fields and residual stress distribution, along with the in-house software code WELD for initial fatigue life estimations. Good agreement between the present computation results and experimental data for the initial fatigue life estimations of welded structural components has been obtained.

Keywords:

Welding, Tubes, Fatigue, Initial fatigue life, FEM.

Acknowledgement

This research has been supported by the research grant No. 451-03-66/2024-03/ 200066 of the Ministry of Science, Technological Development and Innovation of the Republic of Serbia.

USING CFD AS A REPLACEMENT FOR EXPENSIVE EXPERIMENTS IN EDUCATION

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Abstract

In this paper, the authors analyzed the use of computational fluid dynamics (CFD) in education. The teaching of fluid mechanics today is mostly based on the theoretical approach. Although, throughout history, it has been shown that the earliest knowledge of fluid mechanics was gained through practical experience and experiments. Apart from this advantage, laboratory exercises and experiments also have numerous disadvantages. Experiments require significant financial resources, equipment and device maintenance. Many complex and specific experiments are not easy to perform in laboratory conditions. This leads to repeating the same experiments over generations. Student safety is also an important factor. During certain experiments, an increase in pressure or temperature may occur, leading to the risk of explosion or fire. Here we consider the possibility of replacing laboratory exercises by using CFD software. Computational fluid dynamics is gaining more and more importance as an alternative to classical laboratory exercises. This technology enables reliable virtual simulation of various fluid phenomena. The application of CFD in education would allow students to experiment with different parameters and scenarios without exposure to hazards, with more accurate and deeper data analysis. The paper also compares CFD software. Software is generally classified into two groups: open source and commercial software. Two open source software are presented in detail: OpenFOAM and SimFlow. On the example of airfoil NACA 0012, in both software, the simulation results were analyzed.

Keywords

Computational fluid dynamics, education, laboratory exercises, experiments, virtual laboratories, fluid mechanics.

APPLICATION OF EXTENDED FINITE ELEMENT METHOD TO NUMERICAL ANALYSIS OF THE MECHANICAL BEHAVIOR OF PARTIAL HIP IMPLANT

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Abstract

This paper presents the results of a numerical analysis of the mechanical behaviour of orthopedic implants in the presence of a crack within the biomaterial. Numerical models of partial hip prostheses were created based on geometric data obtained from computer tomography (CT) scans. For each model (using the material Ti-6Al-4V), boundary conditions and mechanical properties were defined, considering different loads corresponding to normal body weight (80 kg). In each calculation step, the change in the stress intensity factor along the crack front, defined in three-dimensional space by x, y, and z coordinates was determined. The variations of the KI parameter along the crack front were numerically determined and presented diagrammatically.

Additionally, the change in KI relative to the number of walking cycles leading to the final failure of the prosthesis stem with the initial crack was investigated. Finally, the number of walking cycles during the service life of the prosthesis required to cause fracture due to the existence of a crack in the biomaterial was calculated. To simulate crack growth, classical finite element methods (FEM) face limitations because they require creating a new network after each growth step. In this research, we employed modern modeling techniques, the extended finite element method (XFEM), which introduces significant improvements in the numerical modeling of crack growth. By introducing additional degrees of freedom attached to the nodes of elements intersected by the crack geometry, combined with special functions, accurate modeling of the crack behavior becomes possible. It is shown that by applying this method it is possible to assume the behavior of orthopedic implants with the existence of a crack-type error and to determine the number of walking cycles that will lead to the final failure of the prosthesis.

Keywords

Partial hip implant, extended finite element method (XFEM), numerical simulations, stress intensity factor, titanium alloys.

Acknowledgement

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EXPERIMENTAL ANALYSIS OF FRACTURE BEHAVIOR OF BIOMATERIALS FOR ORTHOPEDIC APPLICATIONS

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Abstract

The experimental tests presented in this work aim to identify and analyse factors influencing the mechanical behaviour of biomaterials for orthopaedic applications, with a crack-type error that leads to failure due to fatigue in real operating conditions. The study involved experimental tests and fracture resistance analysis of two selected biomaterials 316L stainless steel and Ti-6Al-4V alloy, performed using standard fracture mechanics tests.Standard procedures were conducted to determine the fracture toughness KIc at plain strain conditions, and specimens with notches and prescribed fatigue crack lengths were used for this purpose. Compact tension specimens C(T) defined by the ASTM E399-06 and ASTM E1820-08 standards were chosen for the experimental research. After obtaining the experimental Kc values, parameters such as CTODc or Jc were determined using the same standard tests and procedures according to the ASTM E1820 standard. Laboratory tests were performed on test specimens extracted from S316L steel plates and Ti-6Al-4V titanium-based alloy plates to determine the critical stress intensity factor, KIc.

The influence of structural heterogeneity and mechanical properties of biomaterials during exploitation primarily manifests in the position of the fatigue crack tip and the properties of the surrounding area where fracture occurs and propagates. The results of this experimental research can be applied to evaluate the mechanical behaviour of biomaterials used in orthopaedic implants in the presence of crack-type defects, which are the most critical defects in structural materials. It can be concluded that understanding the behaviour of orthopaedic biomaterials under external physiological loads is crucial for ensuring implant integrity and safe operation. Research shows that the worst characteristics in relation to fracture toughness are titanium-based alloys, which also show a very high sensitivity to notches, however, it should be taken into account that when choosing materials for implants, the effects of material biocompatibility have a significant impact.

Keywords

Fracture mechanics parameters, stress intensity factor, experimental analysis, orthopaedic biomaterials, titanium alloys.

Acknowledgement

The results here presented are the result of research supported by the Ministry of Science, Technological Development and Innovation of the RS under Contract 451-03-66/2024-03/ 200213 dated 05.02.2024.

COLLAPSE AND DAMAGE TO BUILDINGS DURING THE 1995 KOBE EARTHQUAKE AND THE DEVELOPMENT OF TECHNOLOGIES

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Abstract

The paper describes cases of collapse and damage to buildings during the 1995 Kobe earthquake in Japan. Some characteristic cases of damage and demolition are explained in the light of old and new knowledge, related to similar events and technical-technological solutions. Work presented here involves the JMA station, previous earthquakes and the main shock, the fault mechanism, as well as the ***Akashi Kaikyo (****Pearl Bridge), Hanshin Expressway. Fault mechanisms considered here included liquefaction, lateral soil expansion (lateral spreading), along with the advantages and disadvantages of various methods of testing pile damage. In addition, present-day appearance of some of these locations is shown in order to illustrate the effectiveness of considered methods.*

Keywords

Akashi Kaikyo Bridge or Pearl Bridge, Hanshin Expressway, liquefaction, fault mechanism (earthquake rupture), JMA station.

Acknowledgement

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THE VERTICAL INTERACTIONS OF PILE GROUP AND REDISTRIBUTION FORCES DUE ITERATION

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Abstract

The paper describes cases of vertical interactions within a pile group and the redistribution of forces during iteration. The problem of vertical interactions in pile groups can be addressed in various ways. This paper presents several characteristic models and the application of accompanying formulas. Different models (formulas) yield different results, with varying degrees of deviation from real values. The study considers soil with a linear change in modulus with depth. The stiffness of piles obtained was discussed in the context of Vesic and Lehan experiments. For the redistribution of forces and settlement, two software applications were used: one employing the formula provided by Budhu and Davies, and the other using an analogy of the soil layer as a flat plate. The advantages and disadvantages of these methods were highlighted during their application to the specific case of a 3x3 pile group distribution.

Keywords

Vertical interactions, pile group, forces redistribution, settlement, iterations.

Acknowledgement

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New Technologies

Invited lecture

FEASIBILITY STUDY OF ADDITIVE TECHNOLOGIES FOR SMALL-BATCH PRODUCTION OF ESD-SAFE PARTS

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Abstract

Polymer components in industries like electronics often require materials resistant to electrostatic discharge (ESD) to protect sensitive electronic parts. This paper explores the feasibility of employing additive technologies for manufacturing ESD-safe parts in small-batch production. The impetus for this research emerged from the critical need to retrofit the conveyor system of an automotive electronic component assembly machine, involving the replacement of 800 polymer top plates on a stainless-steel base chain with new ones made from ESD materials.

The paper examines Fused Filament Fabrication (FFF), a type of material extrusion additive technology, chosen for its cost-effectiveness and the availability of ESD materials in filament form. These materials typically comprise base polymers for 3D printing, infused with carbon nanoparticles. Additionally, the paper proposes suggestions for future research for vat photopolymerization technology, particularly in producing mold inserts that necessitate adaptable mold bases and injection molding machines.

Two types of PETG base filament materials – Zortrax Z-ESD and Raise3D Industrial PETG ESD – were utilized for simulations and experiments to determine the optimal printing settings, including temperatures, speed, cooling, and printing orientation concerning the direction of load and assembly/disassembly on the base chain. Due to the abrasive nature of carbon nanoparticles, a steel nozzle is necessary. Based on experimental results, it was concluded that top plates made from ESD-safe material for conveyor chains can be satisfactorily fabricated with the required surface resistivity, dimensional accuracy, and strength using FFF additive technology. Simulations indicate that each top plate can be printed within half an hour, and with a 3D printer farm comprising four printers, the production of 800 parts would be achievable within four days.

This research concludes by highlighting additive manufacturing's potential to meet urgent production needs, particularly in producing ESD-safe materials, and underscores the importance of leveraging additive technologies effectively for enhanced production capabilities.

Keywords

Additive technologies, FFF, ESD material, Retrofitting, 3D printer farm.

Acknowledgement

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COMPUTER CONTROLLED MILLING MACHINES IN INDUSTRY 4.0

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Abstract

The subject of research in this paper is a flexible production cell consisting of CNC milling machines served by an industrial robot and artificial intelligence. It is seen how each part improves the work of the milling machine itself and thus the production. Artificial intelligence is progressing rapidly, but companies in Serbia still use machines that are old and unsuitable for modern production. This research is of great importance in improving and modernizing the production of companies that use CNC milling machines. The aim of this paper is to examine the use of artificial intelligence and robots and to compare the operation of a milling machine with and without artificial intelligence.
Humans are substituted with robots in industry and with their use processes are faster. This scientific paper is explaining the positive impact that Industry 4.0 has on improvement of CNC milling machines. Comparison is made with their effectiveness and their impact on production process. Production process is greatly improved with the use of Industry 4.0 as well as CNC milling machine set up. In future the use of Industry 4.0 will increase, not only in industry but in others common day to day things.

Keywords

Robot, smart production, Industry 4.0, CAD/CAM, Artificial Intelligence.

ENHANCING EDUCATIONAL ENGAGEMENT:EXPLORING ADVANCED ACTIVITY MONITORING IN LMS MOODLE

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Abstract

This paper explores the need for efficient attendance tracking and grading on the LMS Moodle platform, as well as monitoring students' activities on e-learning systems. It also investigates the need for recording students' access to assignments, as well as entering test and quiz results. In order to improve these processes, a web application for facilitating data entry and management. This application integrates various types of databases and machine learning models with intention to achieve a high level of accuracy in grading and data analysis from the LMS Moodle system. The main motivation for developing this application was the automation of the grading and scoring process into a central repository, with an expectation of high precision in data analysis. The goals of this research include adopting an efficient attendance scoring system, improving monitoring of student engagement with the learning system, efficient input of test and quiz results, and enhancing business processes through the use of this web application. The overall aim is to enable fairer, more realistic and faster student tracking during exercises, as well as predicting their attendance.

Keywords

Moodle LMS, Data analysis, Data mining, Machine learning, Predictive models, Regression, Log files, UML models.

APPLICATION OF 3D PRINTING IN ORTHOPEDICS

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Abstract

The integration of 3D printing technology into orthopedic practice addresses the critical problem of enhancing surgical precision and improving patient-specific treatment. Traditional orthopedic methods often involve generic implants and extensive preoperative planning, which can lead to suboptimal fit, prolonged surgery times, and varied patient outcomes. To solve this problem, patient-specific 3D anatomical models and custom implants can be used. High-resolution imaging data from patients can be converted into 3D-printed models, allowing for detailed preoperative planning and the creation of implants tailored to individual anatomical structures. This method also uses biocompatible materials and advanced printing techniques to ensure structural integrity and functionality. The use of 3D-printed models facilitated an enhanced preoperative understanding of complex anatomies, leading to reduced operative times and increased surgical precision. Customized implants result in better fit and integration with the patient's body, contributing to faster recovery times and higher patient satisfaction. Case studies indicate that this approach minimizes complications and optimizes overall orthopedic care. Despite promising results, challenges such as regulatory limitations, cost considerations, and the need for interdisciplinary collaboration remain. However, ongoing research and technological developments are expected to further refine these applications, paving the way for greater adoption and more widespread benefits in orthopedic practice.

Keywords

3D printing, orthopedics, personalized medicine, patient-specific implants, surgical planning, anatomical models.

Acknowledgement

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FREE FORM SURFACE MACHINING – COMPARATION OF MACHINING STRATEGIES USING COMMERCIAL CAM SOFTWARE

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Abstract

Free-form surface machining is commonly performed using a ball end mill cutter on 3, 4, or 5-axis CNC machines. For this purpose, the use of commercial CAD/CAM software is indispensable, as it allows for the analytical description of the surface and the generation of NC code for machining. There are many commercial CAM software packages that facilitate tool path generation for free-form surface machining, enabling the use of various machining strategies according to the chosen CAM system.
This paper presents a comparison of machining strategies using Creo Parametric© software packages for free-form surface machining with a ball end mill cutter in 3-axis machining. For a generated CAD model of a free-form surface, a comparison of machining strategies was performed with special reference to machining time for different strategies, using the same input data to ensure consistent machining quality. High-speed milling (HSM) strategies were also included in the comparison.
In conclusion, it can be stated that the selected machining strategy has a significant impact, particularly on machining time, which in turn affects overall machining efficiency and cost.

Keywords

Free form surface machining, CAD/CAM systems, machining time.

Acknowledgement

The research work is funded by the Ministry of Science, Technological Development and Innovation of Republic of Serbia. Project Contract 451-03-65/2024-03/200105 from 5.2.2024.

ANALYSIS OF DROSS FORMATION IN CO_2 LASER AXYGEN CUTTING USING MACHINE LEARNING MODEL

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Abstract

Dross formation is a multifaceted issue in laser cutting. It not only requires post-processing operations but also entails a wider heat-affected zone and poses additional health hazards in the working environment. In this study, a machine learning model using multiple binary logistic regression was developed to predict the conditions for dross formation in CO_2 laser cutting of mild steel. Laser power, cutting speed, and oxygen pressure were considered as input variables. The model was developed using experimental data from two crossed experimental designs: Taguchi's L_{25} orthogonal array and a full factorial design 3^3. Statistical analysis showed no significant difference between the model predictions and the observed outcomes.
The study revealed that the most decisive input variable for dross formation is the cutting speed, with the probability of dross formation increasing as cutting speed increases. After developing the logistic regression model, laser cutting process windows were created for different combinations of laser cutting parameters within the experimental hyper-space. It was observed that cutting speeds over 5.5 m/min result in dross formation, and that with an increase in laser power, it is necessary to further decrease cutting speed to prevent dross formation.

Keywords

Logistic Regression, Machine Learning, Dross Formation, CO_2 Laser Cutting.

Acknowledgement

This research was financially supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Contracts No. 451-03-65/2024-03/200109, 451-03-65/2024-03/200102 and 451-03-65/2024-03/200105).

NOVEL TECHNIQUES IN MAGNETIC RESONANCE IMAGING (MRI) FOR HIGH-DOSE-RATE (HDR) BRACHYTHERAPY

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Abstract

High-dose-rate (HDR) brachytherapy is a radiation therapy technique which places radioactive sources within or adjacent to the tumour tissue. It is commonly employed to treat gynaecological and skin cancers, using applicators featuring catheters into which the sources are inserted for short dwell times. Precise catheter localization within 1 mm is crucial for accurate dose delivery. Catheter detection is performed manually on computed tomography (CT) images of the applicators in situ. Magnetic resonance imaging (MRI) offers superior soft tissue contrast to CT, but brachytherapy applicators are not visualized on standard sequences. Pointwise encoding time reduction with radial acquisition (PETRA) sequences have recently demonstrated the potential to identify brachytherapy applicators and catheters.

In this study, PETRA was compared to a Volumetric Interpolated Breath-hold Examination (VIBE) sequence on an endometrial adenocarcinoma patient treated with HDR brachytherapy. Interstitial catheters and a Syed-Neblett interstitial template were better discerned on PETRA than on VIBE. A newly developed algorithm for automated catheter detection successfully identified all catheters inside tissue by their minimum intensity on the PETRA images.

A PETRA and a Dixon VIBE sequence were also compared for a healthy volunteer with a Freiburg Flap (FF) surface applicator around her leg. Dixon opposed phase (OP) images offered the highest contrast between applicator spheres and empty catheters and allowed for skin identification and cutaneous thickness quantification. Chemical shift induced geometric distortions of the FF applicator spheres on Dixon OP images were assessed on a flat FF applicator phantom and amounted to 1 mm on average. Building the geometric mean of the Dixon IP and OP images reduced the shifts from the corresponding sphere positions on CT images to below 0.5 mm. Automated detection of all catheters tunnelling a flat FF applicator was achieved with submillimetre accuracy using signal intensity characteristics on PETRA images.

Keywords

Magnetic resonance imaging, High-dose-rate brachytherapy, Radiation therapy, Catheter detection, Biomedical imaging.

INTEGRATED ADAPTIVE MICROLEARNING SYSTEM FOR HEALTHCARE PROFESSIONALS

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Abstract

Microlearning system providing up-to-date and on-time information relevant to the current work of the (bio)medical professionals was developed. The system uses microlearning approach and adapts to the working procedure of the medical professionals. Microlearning system for healthcare professionals is built in Java programming language and Spring framework and supports three different (bio)medical knowledge sources: clinical practice guidelines documents, classification data from databases, and prepared content for specific diseases and drugs. Microlearning system enables integration of the learning process into the (bio)medical working procedure. It aims to help medical workers gaining additional information about a patient and his condition or prescribed medication. Unlike existing microlearning systems for healthcare professionals that are mostly used outside the working hours and mobile based, the microlearning system developed in this research is designed to be used during the consultation with the patient within the (bio)medical professional's workflow.

Keywords

Computer science, microlearning, healthcare, education.

Clear sky

EXPERIMENTAL INVESTIGATION OF THE AERODYNAMIC PERFORMANCE OF A DUCTED PROPELLER

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Abstract

In flight conditions up to transonic speeds (M < 0.8), there is no more effective element for creating thrust than a propeller. However, duct-free propellers have significant flaws that can affect flight performance: higher thrust demands necessitate a larger propeller diameter, leading to increased mass; noticeable losses at the blade tips occur when local velocities reach transonic speeds (0.8 < M < 1.2); and there are large aero-acoustic emissions due to flow instability and separation on the blades.

Installing a duct around the propeller reduces the propeller load by changing the stream tube flow field. Another benefit of the duct is the creation of additional thrust force, further increasing the efficiency of the propeller of a given diameter. Tip losses can be significantly reduced, and many studies have shown that ducted propellers offer significant potential in reducing sound emissions.

In this study, several test ducts with different exit diameters and inlet lip radii were designed to determine their effect on ducted propeller performance. The ducts were 3D printed using an FDM printer, then sanded and painted to prepare them for testing. All ducts were integrated onto a commercially available 12-inch diameter propeller driven by an electric BLDC motor.

Static and dynamic tests of the propulsion system were performed on a test stand at the wind tunnel facility of the Faculty of Mechanical Engineering in Belgrade. During testing, measurements of thrust force, rpm, and electrical power were performed. Additionally, to investigate the propulsion system's noise emission, sound volume measurements were performed and compared to those obtained for the duct-free propeller. Preliminary analysis of the results shows an improvement in efficiency and noise emission in some test cases, demonstrating the potential for enhancing aerodynamic performance through relatively simple modifications to the propulsion system.

Keywords

Ducted propeller, noise emission, electric propulsion, wind-tunnel testing.

DESIGN AND ANALYSIS OF A VARIABLE PITCH UAV PROPELLER

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Abstract

The interest in UAV technology and applications has skyrocketed in recent years establishing a growing trend in research and development in the field. One of the main areas of interest in UAVs is the energy efficiency of the aircraft with better energy efficiency meaning longer flight durations or larger payload capacity. Hence, a lot of effort is invested in the aerodynamic and structural optimization of UAVs, however, the principal contributor to energy savings would be the increase in efficiency of the propulsion system. Most of UAVs today employ constant pitch propellers driven by an electric or an internal combustion engine for thrust generation. Constant pitch propellers have become a standard due to their simplicity and reliability, however, they have limitations that can be exceeded by the use of variable pitch propellers. This is especially emphasized for fixed wing UAVs, VTOL (Vertical Take-Off Land) and UAVs requiring higher maneuverability where different operational ranges and high agility are expected. Two different methods were considered for the design of the variable pitch propeller: active and passive variable pitch. In the active method, the pitch is controlled via a servo actuator, providing the possibility of optimal matching with the propeller driver and advanced control in different operating regimes but with the introduction of higher weight and additional complexity in the system. In the passive variable pitch propeller, there is no need for an actuation system since the propeller is designed in such a way as to use the aerodynamic moments as a mean to change the pitch. This reduces the operational complexity of the system, however, it increases the design complexity since more complex aero-structural optimization methods need to be utilized. By considering the design and analysis of both variable pitch methods, a better understanding of the design approach and the advantages and disadvantages of each is established. The analysis of obtained results provides an insight into the applicability of each system as well.

Keywords

UAV, Variable pitch propeller, aircraft propulsion, BEMT, CFD.

WIND TUNNEL TESTING OF A SMALL UAV ELECTRIC PROPULSION SYSTEM

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Abstract

The purpose of this work was to gather experimental data and validate numerical results of the propulsion system behaviour intended for powering the light UAV “Putnik”, designed by the Beoavia Student Association. The Putnik aircraft was designed and manufactured for the ACC2024 (Air Cargo Challenge) competition. According to the competition rules, the use of a T-MOTOR AT2826 KV900 BLDC motor and 3S LiPo battery is mandatory with free choice left for the ESC and propeller. For this purpose, several commercially available propellers were selected and numerically analysed. With the data obtained, Motor-Propeller matching was performed and a few of the most suitable propellers were chosen for testing. In the testing phase, the propulsion system was tested in static conditions after which wind tunnel tests were performed at the wind tunnel facility at the Faculty of Mechanical Engineering in Belgrade.

Wind tunnel tests were done to validate the numerical results and investigate the thrust force as a function of wind speed (flight velocity). Tests were performed at the following velocities: 0, 5, 10, 12, 14, 16, and 20 m/s. Every test lasted approximately 60 seconds, with a linear variation of power between 50 and 100%, defined by a custom PWM (Pulse Width Modulation) script. For data acquisition, custom software was developed by team members. In both static and dynamic testing, the following parameters were measured and obtained: thrust force, current, voltage, RPM, pressure and temperature.

After analysing the experimental results, it was noticed that at lower velocities, the maximal thrust obtained during tests was lower than numerically predicted, however, the thrust change was more linear, resulting in a smaller loss of thrust at greater velocities. Finally, the APC 13x6.5E was chosen, as it had good thrust reserve through the whole velocity range, as well as showing great overall efficiency at the designated cruising speed.

Keywords

Wind tunnel, propulsion testing, electric propulsion, propeller, UAV.

LIGHT SAILS AND LASER SAILS

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Abstract

Light sails, also known as solar sails, are spacecraft propelled by the pressure of sunlight. Utilizing large, lightweight reflective sails, these vehicles harness the momentum of photons emitted by the Sun to generate thrust. Unlike traditional propulsion methods, such as chemical rockets, light sails offer the potential for continuous acceleration without the need for onboard fuel. This innovative technology has garnered interest for its potential to enable long-duration space missions, interstellar travel, and exploration of the outer reaches of the solar system and beyond. Ongoing research and development aim to enhance the efficiency and scalability of light sails technology for future space exploration endeavors. The force acting upon a sail few hundred meters in length is very small, order of magnitude in Newtons. But this force is constant because there is no fuel used just radiation which is always present. This mean the radiation pressure can give a very high speed over time. Other than solar sails, electric and magnetic sails have also been proposed. These types of sails don't use radiation pressure from the Sun, they instead deflect particles from solar wind using their electric and magnetic fields respectively.

Keywords

Solar sails, Photon sails, Reflectiveness, Solar energy.

Dental Materials and Structures

Invited lecture

STATE-OF-THE-ART BIOMATERIALS FOR ALVEOLAR BONE REGENERATION

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Abstract

When the process of bone repair requires additional assistance, bone grafting materials are used to provide an osteoconductive, osteoinductive, and/or osteogenic environment to promote bone healing and mechanical support for future oral rehabilitation. Bone grafting materials can be divided into those of biologic (e.g. osseous grafts) and synthetic origin. These materials are available in different forms and shapes, such as particles, 3D scaffolds, injectable pastes or composites in combination with polymeric materials. The osseous grafts suffer from different disadvantages such as the need for second-site additional surgery and limited availability, the risk of disease transmission, and unpredictable results. In recent decades, synthetic biocompatible materials have gained increasing interest due to their attractive characteristics, including controlled degradation, osteoconductivity, osteoinductivity, customized mechanical properties, and relatively easy shapability to match the defect dimensions. Since the regeneration of alveolar bone poses significant challenges because of its intricate structure, functional requirements, and innate regenerative limitations; this lecture aims to critically review properties of various alveolar bone grafting materials, as well as advancements in biomaterials and tissue engineering strategies that can provide solutions to these challenges.

Keywords

Bone grafting, alveolar bone regeneration, biomaterials.

DYNAMIC PROPULSION ORAL APPLIANCE IN THERAPY OF MILD TO MODERATE OBSTRUCTIVE SLEEP APNEA PATIENTS

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Abstract

Obstructive sleep apnea (OSA) is one of the most common sleep disorders, which is present in 1-5% of the adult population. It is characterized by repeated episodes of complete (apnea) or partial (hypopnea) obstruction of the upper airways. Modalities of therapy for patients with OSA syndrome depend on the degree of severity of OSA, which is reflected by five or more obstructive events per hour during sleep - apnea, hypopnea or awakenings caused by respiratory effort. In the last fifteen years, oral appliances (OA) have been emerging as the option of choice in therapy of patients with mild to moderate OSA syndrome due to their capabilities and characteristics. All oral appliances designed for repositioning the lower jaw have the ability to fix the mandible in only one, previously determined propulsive position, during the sleep. A possible problem of sudden and incomplete accommodation of the orofacial structures complex and the upper airways to the new conditions in the oral cavity was observed, which can be reflected in the results of the therapy. Therefore, the innovation of our research is the design of a dynamic oral appliance with gradual automatic movement of the mandible in propulsion during the sleep. The gradual and continuous movement of the mandible during sleep enables maximum accommodation of the orofacial complex. Dynamic propulsion oral appliance in the therapy of patients with mild to moderate OSA in a pilot study provides much better results than previous methods of therapy. This pilot study, using the dynamic propulsion oral appliance in the therapy of patients with mild to moderate OSA, provides much better results than previous methods of therapy.

Keywords

Obstructive sleep apnea, Dynamic propulsion oral appliance, gradual automatic movement.

DIMENSIONAL ACCURACY OF SINTERED DENTAL METALWORK: EVALUATING 3D PRINTING PRECISION FROM INTRAORAL SCANS TO FINAL FIT

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Abstract

The precision of 3D printing in the fabrication of sintered dental metalwork is critical for successful clinical outcomes. However, during the initial trial of these metal components on the patient, a dimensional discrepancy often manifests itself, indicating a poor fit despite being modeled from precise intraoral scans. This necessitates additional corrections or reprinting, thus extending the duration of treatment, increasing costs, and raising concerns about the reliability of 3D printing and subsequent processing techniques. This study aims to quantitatively analyze the dimensional changes in sintered dental metalwork from the original intraoral scan to the final product and to evaluate whether these changes are influenced by the complexity of the metalwork design. Using a 3D scanner (Atos Core 200, GOM, Germany), the dimensions of the sintered metalwork were compared to the corresponding CAD models. Preliminary results indicate significant dimensional deviations, particularly in more complex designs, underscoring the need for improved accuracy in the 3D printing process to enhance clinical outcomes and efficiency.

Keywords

3D printing; Sintered dental metalwork; Dimensional accuracy; Intraoral scans; CAD model.

Acknowledgement

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Sustainable Design and New Technologies

Invited lecture

GREEN TECHNOLOGY PATHWAYS FOR OBTAINING ANTIMICROBIAL HYDROXYAPATITE-CELLULOSE COMPOSITE MATERIAL

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Abstract

Due to the growing number of skin infections globally, there is an increase in the production of different cosmetic products to help with skin regeneration. New knowledge about simple and low-cost synthesis methods of materials with good structural and antimicrobial properties is of great importance nowadays. Also, green pathways for obtaining composite materials that can be potentially used in cosmetics are important. A combination of bio-ceramic nano Hydroxyapatite (HAp) material incorporated by simple precipitation synthesis ex-situ with cellulose hydrogel (CH) represents novel ceramic composite material. A novel ceramic composite material has been developed by combining nano HAp material with CH through simple precipitation synthesis ex-situ. The main objective of this work is to investigate the microstructural and antimicrobial properties of the hydroxyapatite-cellulose hydrogel composite (HAp-CH). The incorporation of hydroxyapatite in cellulose was examined using EDX mapping, whereas the morphology and semi-quantitative chemical analysis were characterized using scanning electron microscopy (SEM). The IR spectroscopy confirmed the vibrational bands characteristic of HAp and cellulose. Structural and phase characterization of the composite material was determined using the X-ray powder diffraction method (XRD). Based on the phase analysis by XRD characterization, the peak mostly indicates the presence of cellulose broad peaks, which largely cover the peaks of hydroxyapatite. The microstructural studies confirmed that the nanosized HAp is incorporated into cellulose hydrogel. The investigated HAp-CH material showed satisfactory antimicrobial properties, especially for Staphylococcus aureus, which is a common bacterium responsible for skin infections.

Keywords

Hydroxyapatite, cellulose, green technology, microstructure, antimicrobial properties.

Acknowledgement

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ENHANCING CIRCULARITY METRICS THROUGH THE 9R FRAMEWORK

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Abstract

The transition to regenerative, sustainable, and closed-loop industrial systems, moving away from the current linear economic model, is a pressing goal for modern societies. This shift focuses on reducing reckless resource consumption and minimizing waste generation, which is crucial for promoting sustainable production and consumption. It aims to establish a complex mechanism that integrates the activities of various actors, modifies predominant production-consumption patterns, adapts institutional frameworks and environmental regulations, and increases social awareness about the importance of resource conservation. Employing strategies that maximize resource efficiency and minimize waste aligns with the principles of a circular economy.

Circularity strategies, encapsulated in the 9R framework — discard, rethink, reduce, reuse, repair, return, restore, repurpose, recycle, and recover — offer a hierarchical approach to closing material loops and becoming more sustainable. Each step in this framework is a crucial part of a complex puzzle.

This paper addresses the drivers and barriers of circular economy practices both generally and within specific sectors. It proposes a unique metric framework that integrates official statistical data with the 9R circularity strategies to facilitate easier monitoring of the system's degree of circularity, ultimately leading to a circular economy index.

Keyword

R strategies, metrics, CMU rate, circular economy index.

ADDITIVE AND SUBSTRACTIVE TECHNOLOGIES USED AT TECHLAB TEHNOPOLIS

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Abstract

3D technologies such as 3D modeling, 3D printing and 3D scanning are indinspancible tools of every manufacturing process, especially important for developing innovation ideas and functional prototypes. Our poster will present capabilities of those technologies as well as the most important projects we managed to manufacture so far, for the purpouses of agriculture activities, medical department and IT sector.
One of the main objectives of our laboratory is giving support to the innovators, start-up companies and Master and PhD students, mainly for converting their ideas into the 3D CAD model and/or functional prototype which they can use for functionality testing or scientific investigation. During the previous year we gave support to the several start-up companies and innovators, by employing capabilities of SolidEdge 3D modeling softvare and Artec Space Spider 3D scanner, Dynamical DT 60 industrial FDM 3D printer and sophysticated Markforged Metal X 3D BMD metal printer. Together with innovators and partners, we managed to finish several projects which has great chances to go into the production in small series based on market demands. Our prototypes were made from several types of printing thermoplastics, plexiglass, alubond, resins and 17-4 PH stainless steel. During some projects we incorporated 3D scanning process together with basic implementation of reversed ingeneering techniques.

Keywords

3D modeling, 3D scanning, 3D printing, functional prototyping.

WHO USES BIM INFORMATION?

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Abstract

Most of the current efforts in the BIM sector are focused on the proper and complete structuring of all data on AECO (Architecture, Engineering, Construction, and Operations) projects in order to provide all the necessary information. The ISO 19650-1 and ISO 7817 (Level of information need) standards state that attention should be paid to who, when, why and to what extent will use information. In doing so, only information relevant to the AECO sector is taken into account, while broader social needs are neglected. This problem has become more pronounced recently with the need to include in BIM models information that warns future users of possible dangers, as well as information relevant to regulatory bodies.

The paper outlines current initiatives to include information of importance to the wider community such as Golden thread of information and Regulatory Information Requirements. Existing studies on the possibility of including information on the ways of use and users of facilities in the BIM model are presented. These researches refer to areas such as building performance analysis and representation of the building use. Finally, new technologies such as IDS and ICDD are presented. The IDS is developed for the specification and verification of information requirements, and ICDD to support effortless access to archived documents. Both rely on metadata to define ways of using information. However, as both use natural language text for this purpose, the paper advocates the formalization of metadata that describes ways of using information.

Keywords

Information, BIM, Information requirement, Information use.

Acknowledgement

The results presented here are the result of research supported by the Ministry of Science, Technological Development and Innovation of the RS under Contract 451-03-66/2024-03/200213 dated 05.02.2024.

STRATEGIC MANAGEMENT OF THE RISKS OF RESTRUCTURING OF A COMPANY IN AN INTERNATIONAL ENVIRONMENT

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Abstract

Strategic risk management of enterprise restructuring in an international environment is a key process for organizations undergoing changes to adapt to the global market. This process includes a series of steps and strategies to identify, assess and manage the risks associated with the restructuring. Companies must carefully analyze the global business environment to identify key risk factors. This includes economic, political, regulatory, technological and other factors that may influence restructuring. The aim of the board is to assess the financial consequences of restructuring, such as the costs of layoffs, loss of income, costs of adjusting to new markets or exchange rate differences. Companies should assess market dynamics and competition in order to understand how the restructuring will affect their position in the market and how they will cope with competition in the international environment. The key is to establish an efficient change management process in order to minimize resistance and the negative impact of restructuring on employees and organizational culture. The analysis includes research on the situation in Bosnia and Herzegovina in relation to the countries of the European Union. Diversification of business activities and geographic diversification can help reduce exposure to risks in the international environment. Strategic risk management of company restructuring in an international environment requires a systematic approach to the identification, assessment and management of risks in order to ensure the successful implementation of changes and the achievement of the organization's strategic goals.

Keywords

Strategic management, risks, restructuring, business result.

OVERVIEW OF BUSINESS MODELS AND SUSTAINABILITY OF DIGITAL INNOVATION HUBS IN WESTERN BALKAN REGION

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Abstract

The Digital Innovation Hubs (DIHs) in Europe are created to support the digital transformation of small and medium enterprises (SMEs). The network of DIHs is in the process of establishing throughout Europe. However, the work of DIHs is not sufficiently investigated neither in developed nor in developing economies. In the Western Balkan region (the WB-6), there are 25 registered DIHs, but only six of them are fully operational. Throughout the survey, the authors investigated the work of the WB-6 DIHs and compared their performance with their EU-28 counterparts. The results of the survey and interviews with the WB-6 DIHs indicate their main challenge of providing financial sustainability in their work. This issue is related to the quality of the services provided to clients. Nevertheless, DIHs possess a substantial capacity to enhance collaboration among industries, academic institutions, and governments.

Keywords

Digital Innovation Hubs, Sustainability, Small and Medium Enterprises.

ASSESSING THE IMPACT OF R-STRATEGIES ON CIRCULAR ECONOMY PERFORMANCE

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Abstract

The circular economy is more than just a concept; it represents a powerful mechanism for converting linear value creation into a circular model through a comprehensive and systemic approach to sustainable development. This model can contribute to the transformation of the economy by shaping production, consumption and disposal processes to close material loops and establish a long-term regenerative system that ensures security of supply within planetary boundaries. Efforts are underway to promote sustainable production and consumption by influencing economic trends, establishing institutional frameworks, harmonizing environmental regulations and raising social awareness. The primary goal of the circular economy is to improve resource efficiency. A significant body of literature on monitoring the implementation of the circular economy has identified various challenges and incentives for improving the circularity of the system. The R-framework, which includes steps such as discard, rethink, reduce, reuse, repair, restore, remake, reuse, recycle, and recover, provides a hierarchical approach to closing material loops and achieving greater sustainability. Each step in this framework is a crucial component of a complex puzzle. This paper delves into the drivers and obstacles to the practice of the circular economy and underscores the importance of R-strategies in the context of simpler monitoring of the realized degree of circularity of the system.

Keywords

R framework; taxonomy; metrics; circular material use rate.

Advanced Materials and Technology

Invited lecture

DIELECTRIC AND STRUCTURAL PROPERTIES OF Fe-DOPED MECHANICALLY ACTIVATED $SrTiO_3$ CERAMICS

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Abstract

$Fe_2O_3/SrTiO_3$ activated ceramics have been prepared via solid-state method to investigate how doping with various amounts of iron influences the microstructural and dielectrical properties of $SrTiO_3$. These properties were examined by X-Ray diffraction analysis (XRD) and Scanning electron microscopy (SEM). A solid-state method was used for the preparation of mechanically activated (10, 30 and 120 min) Fe-doped $SrTiO_3$ ceramics with various iron(III) oxide (Fe_2O_3) weight percentages (1.5, 3 and 6 wt%). SEM image of the Fe-doped $SrTiO_3$ ceramics showed that depending on the time of mechanical activation, a more or less porous structure is obtained. The dielectric permittivity of the material was investigated in a function of frequencies at different temperatures. The obtained results indicate that the combination of the presence of iron(III) oxide as a dopant and mechanical activation have a important influence on the dielectric properties of $SrTiO_3$ ceramics. It was noticed that the combination of doping and mechanical activation makes the $Fe_2O_3/SrTiO_3$ ceramic sample a good choice for further dielectric research.

Keywords

Fe-doped $SrTiO_3$ceramics, mechanical activation, structural and dielectrical properties.

Acknowledgement

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HYDROXYAPATITE NANO MATERIAL AS A POTENTIAL UVA/UVB FILTER

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Abstract

Hydroxyapatite (HAp) in nano form represents one of the most used material from calcium-phosphate group. Increasing interest in green and sustainable technologies lead to using simple and low cost synthesis methods. Main goal of this investigation was to synthesize HAp material with good structural and potential UVA/UVB filter properties. Hydroxyapatite nanomaterial has been prepared by precipitation synthesis route. The morphology and semi quantitative chemical analysis were characterized by scanning electron microscopy with energy dispersive X-ray analysis (SEM-EDX). Phase and structural characterization of obtained material were determined using X-ray powder diffraction method (XRD). The crystallite sizes of the obtained material were evaluated in the average range from 8 nm to 15 nm. Based on XRD peaks positions the hexagonal hydroxyapatite phases were formed. The microstructural studies confirmed that the nanosized HAp was obtained. EDX analysis confirmed presence of Ca, P, O with Ca/P ratio of 1.67. The IR spectroscopy confirmed vibrational bands characteristic for HAp. Obtained results regarding HAp UVA/UVB absorption showed that HAp based sunscreen filters represents as an emerging future cosmetic material.

Keywords

Hydroxyapatite, structure, morphology, filter properties.

Acknowledgement

The project: "Green technologies for obtaining antimicrobial composites for use in cosmetics", "EU for Green Agenda in Serbia", with the technical and financial support of the European Union and in partnership with the Ministry of Environmental Protection, is implemented by UNDP in cooperation with the Embassy of Sweden and the European Investment Bank (EIB), with additional funding from the Governments of Sweden, Switzerland, and Serbia.” Quantum Project Number: 00136377/00127312/2023/24.

ANIONIC WASTE HEMP FIBERS-BASED MEMBRANES: CATIONS AND CATIONIC DYES REMOVAL

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Abstract

The main goal of this work is the production of a membrane from treated waste hemp fibers and citric acid to provide a cation exchange adsorbent (MHC). Waste hemp fibers were treated with a dimethyl sulfoxide/tetra-n-butylammonium hydroxide (DMSO/TBAOH) system to perform delignification and defibrillation to increase surface area. The structure, morphology, and surface chemistry of MHC were analyzed using SEM, FTIR, the point of zero charge (pH_{PZC}), and porosity and pore size were determined by Image analysis and the dry-wet weight method. The removal of cation was achieved at 149.39 mg g^{-1} for Pb^{2+}, 87.86 mg g^{-1} for Cd^{2+}, 80.47 mg g^{-1} for Ni^{2+}, 378.65 mg g^{-1} for Methylene Blue (MB) and 418.92 mg g^{-1} for Malachite Green (MG), obtained using the Langmuir model. The low endothermic and spontaneous equilibration of the system, as well as the effective applicability of MHC, indicate its potential in a water purification process. The ten adsorption/desorption cycles provided effluent waters rich in desorbed pollutants. The photocatalytic degradation of dyes in the presence of catalyst TiO_2 provides water with qualities that satisfy actual legislative requirements for discharge in water courses. The transformation of cations in effluent water by chemical precipitation into solidified form in that way resulted in an extraordinary decrease in negative environmental impact. The results of the biodegradability test of the exhausted membrane reveal that it was possible to find an effective solution for its disposal into the environment without a negative impact. This study presented the use of green chemistry in waste bio-material transformation into an adsorbent with high adsorptive potential for use in a wastewater purification process as an environmentally friendly technology.

Keywords

Hemp membrane; cations; cationic dyes; sustainable technology; photocatalytic degradation.

Acknowledgement

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Artificial intelligence

INTERPOLATION NEURAL MESH IN MATLAB WITH LINEAR AND NOLINEAR FUNCTION

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Abstract

The human brain operates in a fundamentally different manner from conventional digital computers. Neurons, the basic units of the brain's computational power, function at a significantly slower pace compared to the high-speed operations of digital logic circuits. Within the realm of neural networks, both natural and artificial varieties exist. Artificial neural networks are designed to mimic the structure and function of the human brain, offering promising avenues for solving complex problems in various domains. In this study, we delve into the intricacies of neural networks, presenting models of neurons, mathematical formulations, and simulation techniques implemented using the MATLAB programming environment. MATLAB, renowned for its comprehensive suite of high-level mathematical tools, provides an ideal platform for the development and analysis of neural networks. Leveraging MATLAB's capabilities, we explore the implementation of artificial neural networks and the algorithms for training them. Through extensive simulation experiments, we arrive at insightful conclusions regarding network architectures. Notably, our findings suggest that a two-layer network outperforms its single-layer counterpart, showcasing the importance of network depth in capturing complex relationships within data. Furthermore, we demonstrate the efficacy of two distinct types of neural networks: ADALINE and NANR, representing linear and nonlinear architectures, respectively. Varying the number of iterations in training nonlinear networks leads to improvements in network topology, ultimately enhancing the network's ability to produce accurate and meaningful outputs. Overall, our research sheds light on the capabilities and potential applications of artificial neural networks, offering valuable insights for future advancements in the field of computational intelligence.

Keywords

Neuron, Neural Networks, Mathematical Model, Matlab, Simulation.

APPLICATION OF INFORMATION TECHNOLOGIES AND BIOLOGICALLY INSPIRED ALGORITHMS IN THE OPTIMIZATION OF CARRYING CONSTRUCTION

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Abstract

This paper explores an innovative approach to optimizing supports by combining bio-inspired algorithms (BIA) and information technologies (IT), focusing on the application of the firefly algorithm and bat algorithm. Through a review of theoretical foundations of optimization, the paper analysis traditional and contemporary approaches, investigating how fireflies and bats can effectively optimize mechanical structures. Information technologies bring advanced tools such as simulations, artificial intelligence, and big data analysis that can revolutionize design and optimization processes in mechanical engineering. The aim of this research is to examine the efficiency of firefly and bat algorithms in support optimization and to compare the results obtained by applying these two different algorithms. Through practical implementation of software tools, such as MATLAB, for analysis results and experimental data, it explores how these algorithms solve complex optimization problems in the context of mechanical structures. This analysis explores the optimization of supports with one and three independent variables, aiming to minimize the height of cross-sections of support elements within the given model, which includes dimensional profile constraints and vertical displacement of a point, considering continuous loading (q1, q2) on horizontal members and a horizontal force F on the vertical element. This paper contributes to a better understanding of the application of information technologies in optimizing mechanical structures, highlighting the benefits of using firefly and bat algorithms in solving complex optimization problems in the field of mechanical engineering.

Keywords

Biologically inspired algorithms, MFO, BA, Optimization, Simulation.

APPLICATION OF DEEP REINFORCEMENT LEARNING IN PORTFOLIO MANAGEMENT

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Abstract

Financial portfolio management aims to allocate resources for optimal returns while mitigating risk. Traditional methods, which rely on assumptions like normal return distributions and simplistic risk measures, have limitations. Deep reinforcement learning (DRL) combines deep learning for feature representation and reinforcement learning for optimal decision-making. It offers advantages such as reduced assumptions, the ability to handle complex environments, automated feature learning, improved sample efficiency, online learning, and scenario simulation. However, DRL for portfolio management faces challenges in financial risk management, overfitting, data quality, reward design, and generalizing to unseen scenarios. Potential improvements include enhanced algorithms and neural architectures, richer state/action spaces, multi-objective reward functions, regularization, and incorporating real-world constraints.
Other goals are to improve generalization through sufficient representative data, manage training anomalies, and bridge gaps between simulated and live environments. Verifying state-of-the-art performance lacks established benchmarks. Common metrics used are cumulative returns, risk-adjusted returns like Sharpe, Sortino, and Omega ratios, and comparisons to prior work reproduced in-house. Isolating the impact of individual model components through theoretical analysis, ablation studies, module replacement, and intermediate validation is difficult. Improving interpretability by integrating traditional financial principles and extracting trading logic is important for investor acceptance. Despite the challenges, DRL shows promise for enhanced portfolio management.

Keywords

Portfolio management, Deep reinforcement learning, Financial Markets.

A DATAFLOW FRAMEWORK FOR CARDIOVASCULAR ASSESSMENT USING SMARTPHONES

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Abstract

Cardiovascular disease (CVD) prevention requires an integrated, patient-centered, interdisciplinary approach from several disciplines, beginning with CVD risk assessment and identification of specific risk conditions. The present study aims to develop a toolchain contributing to preventive efforts in early, presymptomatic diagnostics of cardiovascular diseases with the highest public health impact. The framework discussed here comprises a web application with a web form for data acquisition, a moderated database with aggregate statistical records that are machine-learning ready, a series of statistical and machine learning models, and a framework for model deployment.

The main effort focuses on photoplethysmography (PPG), a non-invasive optical technology that measures volumetric blood flow changes. Contrary to established techniques of using optical signals for PPG in the infrared part of the spectrum, our ongoing research assesses the utilization of the visible part of the spectrum. This allows wider practical application possibilities, as it can bring statistical and machine learning models to mobile devices, primarily smartphones.

In this paper, we present the conceptual framework of interdependent steps, starting from data collection for a specifically tailored data science application, discussing challenges of data acquisition and validation, preparing a machine-learning ready dataset, and finally, model development. We discuss derived cardiovascular assessment parameters (e.g., heart-rate variability, perfusion index, respiratory rate, SpO_2) and the possibilities of blood pressure estimation from the PPG signal as a main goal. The research results may prove important for the efficient estimation of associated cardiovascular system risks.

Keywords

Photoplethysmography (PPG), cardiovascular diseases, machine learning-ready databases, statistical models, machine learning.

STUDY OF NEURAL NETWORK MODELS AND TECHNIQUES ON LINEAR AND NON-LINEAR FUNCTIONS USING MATLAB SOFTWARE

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Abstract

Unlike the rapid operations of conventional digital computers, the human brain processes information through neurons that function at a much slower pace. In the realm of neural networks, both natural and artificial variants exist. Artificial neural networks are designed to emulate the structure and functionality of the human brain, offering promising solutions for complex problems across various fields. This study delves into the intricacies of neural networks, presenting models of neurons, mathematical formulations, and simulation techniques using the MATLAB programming environment. Renowned for its extensive array of high-level mathematical tools, MATLAB is an ideal platform for the development and analysis of neural networks. Using MATLAB's capabilities, we explore the implementation of artificial neural networks and their associated training algorithms. Through extensive simulation experiments, we derive insightful conclusions regarding network architectures. Notably, our results indicate that a two-layer network outperforms its single-layer counterpart, underscoring the importance of network depth in capturing intricate data relationships. Additionally, we demonstrate the effectiveness of two distinct types of neural networks: ADALINE and NARN, representing linear and nonlinear architectures, respectively. By adjusting the number of iterations in training nonlinear networks, we improve their topology, ultimately enhancing the network's ability to produce accurate and meaningful outputs. Overall, our research highlights the potential and capabilities of artificial neural networks, providing valuable insights for future advancements in computational intelligence.

Keywords

Neural Networks, Artificial Intelligence, MATLAB, ADALINE, Network Architecture.

USING ARTIFICIAL INTELLIGENCE FOR EARLY PREDICTION OF WHEAT YIELDS

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Abstract

One of the challenges in the innovation ecosystem in Serbia and Eastern Europe, in general, is the gap between academia and industry. While research teams produce excellent output, the roll-out of innovations to the market is still very slow. This lag is one reason why the World Economic Forum has ranked Serbia as a nascent country with a low level of readiness for the future.

This paper presents a case study of Cropt, a company founded based on research results from the BioSense Institute. The initial spark for the company and its AI-driven research was participation in the Syngenta Crop Challenge, a global data competition where research teams from renowned institutions such as MIT, Stanford, Fraunhofer, and others apply. BioSense's team won this challenge in 2017, was awarded a CGIAR grant for replicating a similar use case in Africa, and soon founded Cropt.

The technology developed involves modeling crop growth with AI using satellite, soil, weather, and other data. The resulting yield, risk, and productivity maps provide actionable insights for optimal decision-making. Today, Cropt's Space Garden platform is used by banks, insurance companies, distributors, and seed companies, showcasing how technology developed in Serbian academia can be turned into market-ready innovation.

Keywords

Artificial Intelligence, agriculture, AgTech, Big Data Analytics.

Acknowledgement

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ADVANCED PREDICTIVE MODELING OF CODE CHURN WITH HYBRID NEURAL NETWORKS

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Abstract

Effectively navigating code churn, marked by frequent and substantial code alterations, remains a persistent challenge in software development. This research introduces an innovative approach to proactively manage code churn by integrating version control systems (VCS) with artificial intelligence (AI). Utilizing a hybrid neural network architecture, the study predicts the code churn ratio—a metric that measures the proportion of modified code lines within a project. The model achieves a notable Mean Absolute Error (MAE) of 0.0213, highlighting its accuracy in code churn prediction. By integrating convolutional layers for feature extraction and recurrent layers for sequence modelling, this hybrid methodology establishes a robust framework for predictive analysis.

Keywords

Code Churn Management, Version Control Systems, Artificial Intelligence, Hybrid Neural Networks, Predictive Modelling.

EVALUATION AND APPLICATION OF K-NEAREST NEIGHBORS ALGORITHM FOR PREDICTING CERVICAL LYMPH NODE METASTASIS IN PAPILLARY THYROID CARCINOMA

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Abstract

There was no universally accepted surgical approach for treating clinically node-negative (cN0) papillary thyroid carcinoma (PTC) patients staged as T1-T2. Due to the low sensitivity (Sn) of ultrasound in preoperative lymph-node evaluation, cervical lymph-node metastases (LNM) often went undetected, potentially leading to persistent or recurrent disease requiring further treatment. These challenges underscored the need for accurate predictive tools to identify patients at higher LNM risk. To address this gap, a k-Nearest Neighbors (KNN)-model was constructed based on clinicopathological characteristics of 288 cN0 T1-T2 PTC patients who underwent total thyroidectomy, prophylactic central neck dissection, and sentinel lymph-node biopsy performed to identify lateral LNM. The KNN model exhibited promising performance with an area under the receiver operating characteristic curve of 0.72 and Sn, specificity (Sp), positive and negative predictive values (PPV, NPV), F1, and F2 scores of 98%, 27%, 56%, 93%, 72%, and 85%, respectively. These results demonstrated that the KNN model, with its high NPV, accurately identified patients without LNM, suggesting that additional therapy may not been necessary for these patients. Based on these results, a user-friendly web-application was developed utilizing the KNN model to enhance its usability in clinical practice. The application was then tested on 15 completely new PTC patients to validate its performance in real-world scenarios, demonstrating a Sn, Sp, PPV, NPV, accuracy, F1 and F2 score of 100%, 27%, 34%, 100%, 47%, 50%, 72%. These results confirm that the KNN-model maintains a high NPV in clinical setting, indicating its potential for adequate planning of future therapeutic interventions.

Keywords

Papillary thyroid carcinoma, Cervical lymph-node metastasis, k-Nearest Neighbors model.

Acknowledgement

This research was supported by the Serbian Ministry of Science, Innovation and Technological development (451-03-47/2023-01/200043).

ADVANCING DIABETIC RETINOPATHY DIAGNOSIS THROUGH DEEP CONVOLUTIONAL NEURAL NETWORKS: HARNESSING DL FOR PRECISE DETECTION AND MANAGEMENT

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Abstract

To anticipate diabetic retinopathy, machine learning techniques will be combined with retinal image analysis. More trustworthy detection techniques are obviously needed, as existing systems utterly fail to identify this medical issue in its early phases. By utilizing deep-CNN principles, our proposed methodology combines transfer learning, ensemble techniques, data augmentation, and convolutional neural networks (CNNs) to significantly increase prediction accuracy. The developed model is able to distinguish between various phases of diabetic retinopathy with remarkable rates of accuracy, sensitivity, and specificity above 95%. Improvements in algorithms, like modifying hyper parameters and optimizing pre-trained models, help the model recognize subtle changes in the retina associated with diabetic retinopathy. The results of this study offer diabetics potential preventive measures that could lead to a significant advancement in the early diagnosis of diabetic retinopathy. Thanks to our technology that leverages deep neural networks and machine learning, diabetic retinopathy can now be diagnosed and treated with much more potential. In the end, this will enhance the quality of life for people affected and reduce the financial strain that this crippling eye condition puts on society.

Keywords

Diabetic retinopathy, Deep-CNN, Deep learning, ResNet 50, DenseNet 169, Efficientnet B3, Transfer learning, Accuracy, Sensitivity, Specificity, Diagnosis, Fundus images.

Student session

OPTIMIZATION OF STANLEY PLUM DRYING PROCESS USING SOLID FUEL BATCH DRYER WITH TRAYS

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Abstract

Drying fruit is a traditional preservation method that has been used for thousands of years. This technique allows for long-term storage of fruit, keeping it fresh and usable under ordinary storage conditions. In this research, the drying process of the selected variety of Stanley plums was analyzed in a batch dryer with trays using solid fuel. The research aimed to calculate the optimal air temperatures at the inlet and outlet of the heater, as well as the temperature at the outlet of the dryer itself. The constructed dryer has double trays, allowing drying capacities from 1550 kg to 3100 kg of Stanley plums. The main focus was on achieving efficient drying with minimal heat loss. The selection of basic equipment, such as a hot water boiler, circulation pump, heat exchanger, and fan, was tailored to the specificities of the dryer to maximize energy efficiency. The heat exchanger utilizes compact lamellar Cu-Al technology, while the fan is equipped with a filter section for a cleaner drying process. The use of solid fuels such as biomass brings significant economic benefits, reducing the costs of dried products. However, manual labor and detailed equipment inspection are necessary for each drying cycle, which is the main drawback of this method.

Keywords

Batch dryer, hot water boiler, circulation pump, heat exchanger, plums.

TESTING INSERTS IN MONOCOQUE CHASSIS FOR FORMULA STUDENT TEAM ROAD ARROW

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Abstract

The testing in this abstract was performed for Formula student competition as a proof of structural integrity needed for SES (Structural Equivalency Spreadsheet). Formula Student (FS) is Europe's most established educational engineering competition, taking part of over 100 university every year.
The testing samples were aluminum insert in carbon sandwich structure and tensile specimen made from overlapping carbon skins, which have to satisfy required safety factor. Aluminum insert is glued to the honeycomb core, not laminated. Carbon fiber orientation is previously determined from perimeter shear test and three point bend test. Numerical calculation have shown expected behaviour.
Samples were tested on SHIMADZU AGS-X 100kN, tensile testing machine with wedge grips used for clamping tested samples. Main machine parameter used during testing was primary movement of wedged grips, 5 mm/min in axial direction. Every 10 ms data was recorded.
Force preformed during testing the aluminum insert in carbon sandwich structure was 23kN, which was expected from calculation. The force required from SES was 13 kN, that means safety factor is over 1.7. Greatest force while testing tensile specimen on lap joints didn't surpass 18kN.
Obtained results gave us green light for competition strictly required rules, which means that these types of joint can be used for production of carbon monocoque chassis. Driver harness and other components can be securely mounted to aluminum insert, glued to the carbon monocoque chassis

Keywords

Competition, tensile testing machine, carbon fiber, inserts, monocoque.

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PROACTIVE CODE CHURN MANAGEMENT WITH VERSION CONTROL SYSTEMS AND ARTIFICIAL INTELLIGENCE

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Abstract

This research paper presents a novel approach to proactive code churn management by integrating version control systems (VCS) with artificial intelligence (AI), specifically employing a hybrid architecture of neural networks to predict the code churn ratio, defined as the proportion of code lines changed to the total number of code lines in a project. The proposed model achieves a Mean Absolute Error (MAE) of 0.0213, demonstrating its high accuracy in forecasting code churn. The hybrid neural network architecture combines the strengths of different neural network layers, including convolutional layers for feature extraction and recurrent layers for sequence modeling, resulting in a robust and effective churn prediction framework. Through empirical evaluations and real-world case studies, this research contributes to enhancing software development processes by addressing code churn challenges proactively.

Keywords

Code Churn, Version Control Systems, Artificial Intelligence, Neural Networks, Predictive Modeling.

ENHANCING INDUSTRIAL WATER MANAGEMENT: INNOVATIONS IN WASTEWATER RECYCLING

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Abstract

Water treatment is the process of raising water quality so that it can be used for drinking, industrial activities, irrigation, and other uses. There are several physical, chemical, and biological procedures used to remove contaminants from water.
This paper examines cutting-edge techniques for recycling wastewater in commercial buildings to reduce water usage. Industrial facilities face challenges in managing water resources sustainably and minimizing their negative environmental impact due to the growing global demand for water and the implementation of more stringent environmental standards. Various wastewater recycling methods are analyzed, such as biological treatments, membrane processes, advanced oxidation techniques, and the incorporation of renewable energy sources.
The effectiveness, long-term viability, and environmental impacts of diverse recycling techniques are investigated by examining case studies from various industrial sectors. The research findings highlight the benefits and drawbacks of each approach, providing best practices and ways to implement them in industrial facilities. This paper aims to show improvements in industrial water treatment procedures to accomplish the objectives of sustainable development and water resource protection.

Keywords

Water, recycling, energy, industry.

OPTIMAL CO2-BASED DEMAND-CONTROLLED VENTILATION SYSTEM IN A PASSIVE HOUSE

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Abstract

Indoor air quality (IAQ) is closely linked to occupants' health and is a significant concern in residential buildings with variable occupancy that are often overcrowded. Effective ventilation is essential to mitigate these issues, especially in a Passive House, which is highly insulated and has an airtight envelope. Heat/energy recovery ventilators (ERV/HRV) are designed to meet the minimum ventilation rates specified by standards such as ASHRAE 62.2. However, under-ventilated homes face numerous problems, including deteriorated IAQ, mold growth, moisture issues, and related health problems.

To address this, a strategy was implemented using a CO_2 sensor network connected to an ERV, which continuously exhausts stale air from kitchens and bathrooms. This method was simple yet effective in adjusting the ventilation rate based on occupancy levels. The CO_2-based demand-controlled ERV significantly improved the regulation of indoor CO_2 concentrations on the main floor, resulting in lower CO_2 levels in bedrooms during nighttime. This approach demonstrates a practical solution for maintaining adequate IAQ and ensuring the health of occupants.

Keywords

Passive house, ventilation, CO_2 level control.

FORMULA STUDENT ROAD ARROW

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Abstract

The Road Arrow team, the first Serbian Formula Student team, gathers a group of ambitious students from the University of Belgrade who are working on the development of their second electric vehicle. They have previously built one electric vehicle and nine vehicles with internal combustion engines. For the past 13 years, they have represented their university and the Republic of Serbia at one of the most prestigious global engineering competitions – Formula Student.

For the first time in the team's history, they have constructed an electric racing car to compete under the name of Road Arrow. With their previous vehicle, they had the opportunity to participate in three competitions in the Netherlands, Hungary, and Croatia, where their vehicle could demonstrate its performance on the tracks. Throughout the entire season, our project focuses on developing and enhancing the potential of young people by encouraging them to find the best possible engineering and other solutions to the specific problems they encounter during the project.

With the aim of optimizing and establishing a stable foundation for future generations, the E-vehicle RAE24 project has been launched, with a duration of 2 years. The vehicle concept features rear-wheel drive, two electric motors with a total power of 120 kW, a monocoque chassis made of composite materials, and a DRS system.

Keywords

Road Arrow, Students' Technical Tournaments, Formula Student, Electric Vehicles, Students

THE APPLICATION OF POLYOXYMETHYLENE IN THE PRODUCTION OF TELESCOPIC DENTURES

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Abstract

Polyoxymethylene (POM) is a material that is intended for widespread use in many branches of industry. It is mainly used for technical parts (gears, housing parts, bearings, clips, zippers) whose good mechanical properties (high rigidity, low wear, good resistance, low water absorption) are an advantage over other plastic materials. According to its chemical structure, POM is a thermoplastic polymer. In addition to its good mechanical properties, POM is used in prosthetic dentistry for the fabrication of partial dentures with clasps, due to its biocompatibility with the tissues of the oral cavity, its hypoallergenic properties, its excellent aesthetic results and its affordability. As POM offers good detail reproduction, high abrasion resistance, high elasticity and durable colour stability, it is suitable for the fabrication of telescopic dentures, where the outer crowns and framework of the denture are made of POM, but the inner crowns are made of cobalt-chromium alloys. POM is a material with a lower modulus of elasticity (2200-2400 MPa) than cobalt- chromium alloys and is therefore well suited as a secondary crown in this telescopic structure. The POM denture is produced using the injection technique, but the polymerization process ensures high homogeneity of the material. The retention force of the telescopic dentures must be checked and corrected before clinical use, by measuring it under laboratory conditions using a dynamometer as a measuring instrument.

Keywords

Polyoxymethylene, double crowns, telescopic denture.

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