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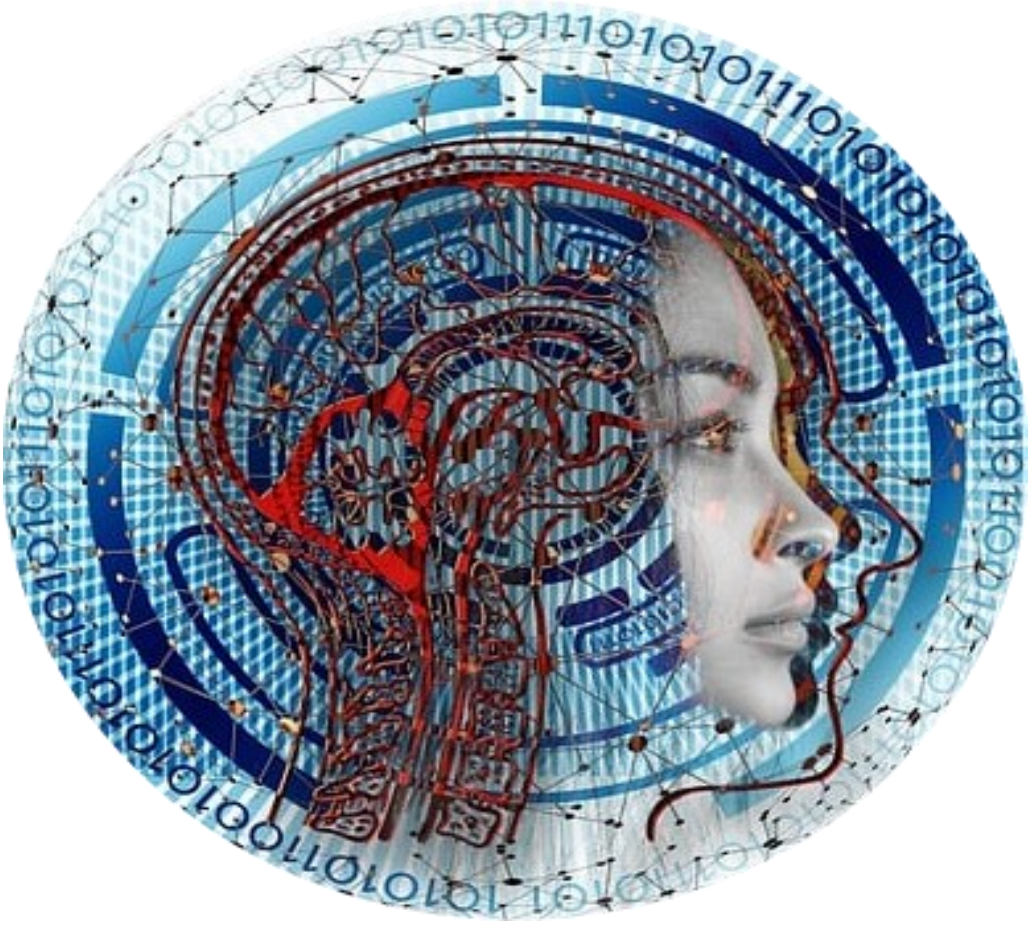
Abstract Book



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Contents

Analysis of Thermocouple Measurement Errors in Various Contact Methods During Turning Operations

Authors: Umidjon Mardonov[1], Ye Yang[2], Xiaojun Wang[2], Otabek Khasanov[1], Sarvar Tursunbaev[1] and Shakhrizoda Ozodova[1]
Affiliation:
[1] Tashkent State Technical University, Tashkent, Uzbekistan
[2] North China University of Technology, Beijing, China
E-mail: u.mardonov@tdtu.uz

Abstract. This manuscript studied several schemes of the installation of natural thermocouples on the metal cutting process in measuring the thermo EMF generated during metal cutting. Absolute and relative measurement errors of thermocouples were analyzed in three diverse installation methods. The contact end of the natural thermocouples on the machined workpiece was installed using a needle, wheel, and brush which are the most popular methods of measuring temperature in machining experiments. Analytical analysis of the experimental results shows that the most accurate method of installment is a brush-contacted thermocouple with 0.18mV and 2% absolute and relative errors respectively. Indicating the highest absolute and relative errors 1.62mV and 165% respectively, the wheel contact method showed the most inaccurate results. Moreover, the influence of the cutting speed on the variability of the data in the measurement ofthermo EMF in the cutting zone was analyzed. Experimental studies were conducted on the three different cutting speeds while feed rate and cutting depth remained constant in tuming cylindrical part. It is concluded that the increase in the cutting speed can cause the improvement of the thermo EMF in the dry tuming process.

Keywords: Absolute error ● Relative error ● Machining ● Measurement ● Thermocouple ● Tuming.
Full text available here: https://link.springer.com/chapter/10.1007/978-3-032-02508-1_1

The Influence of High-Chromium Powder Coatings on Wear Resistance of Working Parts

Authors: Lazizbek Raufov[1], Darob Berdiev[1], Mahmuda Umarova[1], Ravshan Tashmatov[2], Zarip Sadullayev[2], Dustmurat Fazilov[2], Shokhida Khojibekova[2].
Affiliation: [1] Tashkent State Technical University Named after Islam Karimov, Tashkent, Uzbekistan
[2] Aknalyk Branch ofTashkent State Technical University Named after Islam Karimov, Almalyk, Uzbekistan
E-mail: raufov.lazizbek0tdtu.uz

Abstract.The article proposes a method for increasing the workability of a part by creating friction coatings from high-chromium metal powder on the working surface of the working parts. In order to increase the wear resistance of the working parts, tests were carried out in which iron-based powder with a high chromium content was applied using the plasma coating method, the result of which was an increase in its wear resistance by 3U times. A technology for the effi-ciency of high-chromium iron-based powder from local raw materials has been developed, as a result it aUows increasing the efficiency of the powder by 85%.
It was determined that when forming friction coatings from a high-chromium powder mixture using a gas flame, the porosity of the coating decreased to 7%, and the hardness reached 54...56 HRC. Also, the service

hfe of a share made of steel 40X (ahoy carbon steel) increased by 3.5U times compared to a share made of steel L53 ploughshare steel), subject to heat treatment.

Keywords: Wear resistance ● Coatings ● Hardness ● Porosity ● Working body ● Soil ● Ploughshare.
Full text available here: https://link.springer.com/chapter/10.1007/978-3-032-02508-1_2

Highly-Compatible Geometric Calibration Method for Quadrupole Electromagnets Used in Particle Accelerators

Authors: Marius Popa[1], Victor Eduard Albei[12], Dragos Ovezea[1], Cristinel Ilie[1], Nicolae Tanase[1], Daniel Lipcinski[1], Dan Enache[1], Florentina Badea[3], Sorin Ionuț Badea[3]
Affiliation: [1] National Institute for Research and Development in Electrical Engineering ICPE-CA
[2] Center for Research and Training in Innovative Techniques of Applied Mathematics in Engineering "Traian Lalescu" (CiTi UPB), University POLITEHNICA of Bucharest
[3] National Institute of Research and Development in Mechatronics and Measurement Technique (INCDMTM)
E-mails: marius.popa@icpe-ca.ro, eduard.albei@icpe-ca.ro, dragos.ovezea@icpe-ca.ro, cristinel.ilie@icpe-ca.ro, nicolae.tanase@icpe-ca.ro,daniel.lipcinski@icpe-ca.ro, dan.enache@icpe-ca.ro, florentina.badea@incdmtm.ro, sorin.badea@incdmtm.ro

Abstract. This paper aims to demonstrate the method by which a single experimental setup may be used in order to determine the geometric calibration constants and the adherence to manufacturing tolerances for a large number of particle accelerator electromagnet models, regardless of their size or function within the hnear or storage ring accelerator assembhes. Our method is meant to serve as a more flexible alternative to the widely-used rotating search coil magnetometer method, which may be intractable or impossible for harmonic content measurements involving electromagnet apertures which are either oversized or, respectively, undersized relative to the rotating coil assembly. The hereby proposed method is heavily reliant on the usage of a triaxial Gaussmeter Hall probe together with certain signal processing techniques and an application-specific mathematical interpretation of the magnetostatic context within the core of an accelerator electromagnet. As part of this paper, we build upon both fundamental concepts of electromagnetic field theory and recent advancements in order to provide the proofs and mathematical insight on why this method isjustified and how it relates to the rotating coil method, which it attempts to substitute for. Our method's application is showcased on a quadrupole beam-focuser electromagnet model for the linear accelerator (LDTAC) part of Variable Energy Gamma (VEGA) system from ELI-NP. We then compare the results of the experimental activity with FEM simulations of the ideally-occurring field inside the electromagnet apertures and conclude our paper by attempting to explain the inconsistencies between the two sets of results.

Keywords: Electromagnet ● Harmonic content ● Magnetostatics ● Quality assurance ● Calibration, Electron beam ● Quadrupole ● Hall probe.
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Development of an Automated Control System for Laboratory Hydroponic Cultivation

Authors:Pierluigi Rea[1], Giovanni E. Castellet y Ballarà[1], Maurizio Ruggiu[1], Erika Ottaviano[2]
Affiliation: [1] University of Cagliari, Cagliari, Italy
[2] University of Cassino and Southern Lazio, Cassino, Italy
E-mail: pierluigi.rea@unica.it

Abstract. In recent years, the increasing demand for sustainable and efficient agricultural solutions has driven the widespread adoption of innovative techniques. Hydroponics, a soil-free cultivation method that uses aqueous nutrient solutions, offers several advantages, such as more efficient water usage, higher planting density, and the ability to grow in controlled environments. However, the success of hydroponic cultivation largely depends on maintaining optimal growing conditions, which requires precise monitoring and control of variables like temperature, humidity, pH, and nutrient concentration. In this context, automation plays a critical role. Integrating automated control systems can significantly enhance operational efficiency and crop quality while reducing human intervention and minimizing the potential for errors. This work aims to design and develop an automated control system for hydroponic cultivation that incorporates various sensors for real-time data collection and utilizes control algorithms to regulate environmental conditions automaticaUy. The system can continuously monitor key growth parameters, ensuring an ideal environment for plant growth.
The research focuses on developing a laboratory prototype to demonstrate its effectiveness and scalability.

Keywords: Mechatronics ● PLC Programming ● Laboratory set-up ● Hydroponics.
Full text available here: https://link.springer.com/chapter/10.1007/978-3-032-02508-1_4

Modeling of Marine Gas Turbine Rotor Impeller Stress-Strain State Caused by Forced Vibration and Creep Load

Authors: Natalia Smetankina[1], Serhii Morhun[2], Liu Weixing[3] and Zhang Zhiyang[3]
Affiliation: [1] Anatolii Pidhornyi Institute of Power Machines and Systems of the National Academy of Sciences of Ukraine, 2/10, Komunalnykiv Street, Kharkiv 61046, Ukraine
[2] Admiral Makarov National University of Shipbuilding, 9 Heroiv Ukrainy Avenue, Mykolaiv 54001, Ukraine
[3] Jiangsu Ocean University, 59 Cangwu Road, Lianyungang, Jiangsu 222005, China
E-mail: nsmet@ipmach.kharkov.ua

Abstract. The problem of the gas turbine rotor blade stress-strain state caused by creep and forced vibration has been studied. The paper outbnes a finite element refmed mathematical model of the gas turbine rotor creep and can be used for the various types of marine gas turbine engines. The developed mathematical model uses the eight-node curvilinear finite elements ofhexagonal type. With the usage of the developed mathematical model the turbine rotor most highly loaded first impeller displacements and equivalent stresses fields were found for several most dangerous forced vibration modes. The calculated data of the first impeller equivalent stresses and durability has been compared with experimental results and numerical data for the case, that doesn't take creep into consideration. The divergence between

numerical and experimental data is less than 10%. Obtained results will be used for the next stage of studies, concerning the rotor durability and reliability problems.

Keywords: Gas turbine rotor ● Finite Element Method ● Creep ● Equivalent stresses ● Forced Vibration.
Full text available here: https://link.springer.com/chapter/10.1007/978-3-032-02508-1_5

Mathematical Modeling of the Effect of the Lithium Element on the Fluidity of Al-Si and Al-Cu Alloys

Authors: Azizakhon Turakhujaeva[1], Sarvar Tursunbaev[1], Sherzod Tashbulatov[1], Anvar Turaev[1], Sharofuddin Mardonakulov[1], Ravshanbek Murodqosimov[1], Furkat Odilov[2], Mokhinur Rakhmonova, Sobirjon Murodov[1]
Affiliation: [1] Tashkent State Technical University, 100095, Tashkent, Uzbekistan
[2] Andijan State Technical Institute, 170100, Andijan, Uzbekistan
E-mail: toraxojayeva.azizaxon@tdtu.uz

Abstract Mathematical modehng of apphed research, based on the results of initial experiments, aUows to determine further results without conducting experiments. In the article, the technology of increasing the liquefaction property by introducing lithium fluoride element into Al-Si and Al-Cu binary alloys from aluminum alloys is presented. The fluidity property was determined using a spiral sample. Based on the obtained results, a graph of the amount of lithium in the aluminum alloy, depending on its fluidity property, was developed. Using the developed graph as initial information, the effect oflithium element on the fluidity properties of aluminum alloys was mathematically modeled. In this case, a function was developed for the alloy that expresses the relationship between the fluidity and the amount of lithium fluoride included in the alloy. At the end of the article, the authors' conclusions about the conducted research are given.

Keywords: Lithium ● Aluminum ● Fluorine ● Fluidity ● Lagrange polynomials (Lagrange interpolation) ● Mathematical modeling.
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Control of a Mechatronic Device for Measuring the Optometric Parameters of a Spectacle Wearer

Authors: George Baboianu and Cristian Gabriel Alionte
Affiliation: National University of Science and Technology POLITEHNICA Bucharest, Splaiul Independenței 313, 060042 Bucharest, Romania
E-mail: cristian.alionte@upb.ro

Abstract. This article aims to describe software for a mechatronic system employed in the positioning of an optometric system for accurately determining the patienfs anthropometric data at three distinct distances. FoUowing the description of the hardware and software components that constitute the backbone of the proposed mechatronic platform, the focus shifts to the software for the robotic positioning system. The system provides more accurate measurements by allowing you to virtually follow the motions of the patienfs eyes and the location of their pupils. To obtain clear vision and rapid adaption, the proper results of these measures help to the design of an appropriate progressive lens.

Keywords: Optometry ● Positioning mechatronic systems ● Autonomous systems.
Full text available here: https://link.springer.com/chapter/10.1007/978-3-032-02508-1_7

Dynamic Response of a Human Arm Model Using Lagrangian Multipliers Method Under Various Input Displacements

Authors: Zahraa Abd Al-Elah Kahaleel, Fawaz F. Al-Bakri[2], Muslim Ali[3]
Affiliation: [1] Mechanical Engineering Department, University of Kerbala, Iraq
[2] Department of Biomedical Engineering, College of Engineering, University of Babylon, Babylon, Iraq
[3] Prosthetics and Orthotics Engineering Department, College of Engineering, University of Kerbala, Iraq
E-mail: Zahraa.abdalelah@s.uokerbala.edu.iq; fawaz.al-bakri@uobabylon.edu.iq; muslim.m@uokerbala.edu.iq

Abstract. Prosthetics play broadly a significant role to enhance mobility and independence for disabilities people. These mechanical devices are utilized to provide functional movements of a human arm in diverse applications such as rehabilitation, sports, and innovation. Therefore, it becomes essential important to assess the dynamic response of human prosthetics. This study focuses on studying the dynamic response of a five-degree-of-freedom prosthetic human arm. The human system was modeled by using Lagrange-Euler method to obtain a five-second-order ordinary differential equations. Then it was linearized to facilitate the optimization process required to gain local optimal system parameters. A comparative analysis was then conducted between the linear and nonlinear systems responses to ensure that the linearized system can successfully able to compensate for the real system. The arm parameters (masses, damper coefficients, and stiffness) were selected relying on a Lagrangian multipliers method while achieving short settling time and low overshoot Eventually, the system performance of the proposed system was investigated while involving a wide range of initial excitations. The results showed that all parts of the human arm (elbow, forearm, and hand) oscillated, providing well-suited responses with a short settling time and low overshoot, despite varying initial conditions.

Keywords: Modeling ● Linearization ● Optimization ● Lagrangian Multipliers Method
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Modeling of Combined Heating-Ventilating System

Authors: Oleg Krol[1], Vladimir Sokolov[1], Dănuț-Iulian Stanciu[2], Marin Zhilevski[3], Mikho Mikhov[3]
Affiliation: [1] Volodymyr Dahl East Ukrainian National University, 59a Central Avenue, Severodonetsk, 93400, Ukraine
[2] National Institute of Research and Development in Mechatronics and Measurement Technique INCDMTM, 6-8 Pantelimon, 2nd District, 021631-Bucharest, Romania
[3] Technical University of Sofia, 8 Kliment Ohridski Blvd, Sofia 1000, Bulgaria
E-mail: krolos@gmail.com

Abstract. The mathematical model of aerothermodynamic processes for combined heating-ventilating system as an object of automatic control has been developed. In the heating-ventilating system, the supply air comes from the central ventilation unit at its constant temperature. Regulation of the supply air flow is carried out by the special terminal, and additional change of its temperature is made in the heat exchanger. The work processes taking place in the system are reflected on the functional scheme. The structural scheme of the two-circuit automatic control system for air heating has been constructed. In general, the system provides various regulators for the flow rate and temperature of the supply air. The calculation of the transient process in the system is performed when the set temperature changes in the

serviced room. When modeling the system, MPC controller was used in the supply air flow control circuit, and PID controller was used in the temperature control circuit. By combination of controllers for supply air flow and its temperature, with optimal adjustment of their parameters, it is possible to improve the regulation quality indicators of the automatic air heating control system and, as a result, to ensure the increase of the efficiency of the heating-ventilating system.

Keywords: Heating-ventilating system ● Structural scheme ● Controller ● Transient process ● Quality indicators.

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Structural and Parametric Identification of Mathematical Models of HVAC Systems

Authors: Oleg Krol[1], Vladimir Sokolov[1], Dănuț-Iulian Stanciu[2]
Affiliation:
[1] Volodymyr Dahl East Ukrainian National University, 59a Central Avenue, Severodonetsk, 93400, Ukraine
[2] National Institute of Research and Development in Mechatronics and Measurement Technique INCDMTM, 6-8 Pantelimon, 2nd District, 021631-Bucharest, Romania
E-mail: krolos@gmail.com

Abstract. The improvement of HVAC systems requires consideration of the work processes that take place in them. HVAC systems are complex dynamic systems with distributed parameters, and the work processes occurring in them are difficult to formalize clearly. Therefore, the task of identifying mathematical models of HVAC systems as object of automatic control is actual. The purpose of paper is to analyze the methods for structural and parametric identification of complex HVAC systems and to develop recommendations for the construction of mathematical models of HVS. It is shown that HVAC systems are inertial, in which the regulated variable is stabilized at a certain value, and transients have a non-oscillatory appearance and characteristic delay. The identification of mathematical models for working processes of HVAC systems by the transfer functions of the aperiodic links of the first and second orders with delay is recommended.
The authors present the example of mathematical model for heating-ventilating system is presented in the form of the transfer function for the temperature at significant (working) zone of the room by the heat flow power of supply air.

Keywords: HVAC systems ● Structural identification ● Parametric identification ● Transient process.
Full text available here: https://link.springer.com/chapter/10.1007/978-3-032-02508-1_10

Dynamic 3D Mapping of Airborne Pollutants Using UAV with Multiple Data Sensing Instrument

Authors: Karolina Macúchová[1], Tomáš Tichý[1], Dominik Pilnaj[2], Jan Macúch[3]
Affiliation: [1] HiLASE Centre, Institute of Physics CAS, Za Radnicí 828, 25241 Dolní Břežany, Czech Republic
[2] Faculty of Electrical Engineering, Czech Technical University in Prague, Technická 2, Praha, 166 27, Czech Republic

[3] University of Creative Communication (VŠKK / PSCC), Na Pankráci 420/54, 140 00 Prague, Czech Republic
E-mail: karolina.macuchova@hilase.cz
Abstract. Unmanned Aerial Vehicles (UAVs) are increasingly utilized for air quality monitoring due to their ability to access challenging environments and provide three-dimensional pollution profiles. This study explores UAV-based measurements of particulate matter (PM), CO2, volatile organic compounds (VOCs), and other pollutants across diverse terrains in the southeastern part of Prague, including fields, highways, and forests. A novel sensor shielding design was implemented to mitigate rotor-induced airflow interference, ensuring meas-urement accuracy. Data acquisition involved multiple altitude profiles and vertical sampling near pollution sources, with meteorological conditions factored into the analysis. Results revealed pollutant distributions influenced by terrain and wind direction, such as elevated PM concentrations near highways and forests.
The study confirms the effectiveness of UAVs for dynamic airborne sampling while addressing challenges like rotor effects and spatial data processing. These fmdings highlight UAVs' potential for environmental monitoring and underscore their role in advancing air quality research.
Keywords: UAV ● Air quality monitoring ● Particulate matter ● PM2.5 ● Carbon dioxide ● CO2 ● Volatile organic compounds ● VOCs ● Topology ● CFR print ● Environmental monitoring ● Sensor technology ● Rotor-induced airflow interference ● Spatial pollutant distribution ● Meteorological factors ● Three-dimensional pollution profiling ● Real-time data acquisition ● Pollution source tracking ● Terrain influence on air quality ● Air sampling ● Aerial flexibility ● Volumetric cloud.
Full text available here: https://link.springer.com/chapter/10.1007/978-3-032-02508-1_11

Controlling a Magnetorheological (MR) Fluid Brake by Simultaneously Adjusting the Electrical Current and the Fluid-Film Thickness

Authors: Salwan Obaid Waheed Khafaji[1], Hasan H. Ali[2], Fawaz F. Al-Bakri[3], Noah D. Manring[4]

Afifiliation: [1] Mechanical Power Technical Engineering Department, College of Engineering and Technologies, Al-Mustaqbal University, 51001, Babylon, Iraq; Al-Mustaqbal Energy Research Center, Al-Mustaqbal University, 51001, Babylon, Iraq
[2] Medical Instrumentation Techniques Engineering, College of Engineering and Technology, Al-Mustaqbal University, 51001, Babylon, Iraq
[3] Department of Biomedical Engineering, College of Engineering, University of Babylon, Babylon, Iraq
[4] Mechanical and Aerospace Engineering, University of Missouri at Columbia, MO, United States
E-mail: salwan.obaid@uomus.edu.iq
Abstract. In this paper, a method of controlling a MR fluid brake by simultaneously altering both the input current to the electric coil, and the MR fluid thickness between the stationary and rotating part of a single-disk brake was presented.
In the development of the nonlinear torque-model for the brake, nondimensional analysis was used to generalize the problem for any brake configuration with similar attributes, while providing design guidance for making the energized and non-energized brake components comparable in strength. In order to control the brake speed, two saturating proportional-integral (PI) controllers were used in parallel: one for

adjusting the MR fluid thickness, and the other for adjusting the input current to the electric coil. It was shown in this paper that the controller always achieves a steady-state output with zero error; however, the combination of fluid thickness and current is non-unique and depends upon initial conditions and saturation events that occur during the transient response. In conclusion, the control method proposed in this paper is shown to extend the range of torque capacity for the brake without increasing the radial envelope for the brake itself.

Keywords: MR Fluid Brake ● Torque Capacity ● Brake Radial Envelope ● Torque Control
Full text available here: https://link.springer.com/chapter/10.1007/978-3-032-02508-1_12

Design and Simulation of Mechatronic Learning Modules for Solving Mathematical Problems Using Arduino and Tinkercad

Authors: Iulian Sorin Munteanu[1], Liviu Marian Ungureanu[1], Mircea Daniel Popescu[1], Florentina Badea[2], Sorin Ionut Badea[2], Cristian Radu Badea[2]
Afifiliation: [1] National University of Science and Technology Politehnica, 313, Splaiul Independentei, Bucharest, Romania
[2] National Institute of Research-Development in Mechatronics and Measurement Technique - INCDMTM Bucharest, Sos. Pantelimon, 6-8, sector 2, 021631, Romania
E-mail: mihaiflori@yahoo.com

Abstract. This paper presents a modular mechatronic learning environment based on Arduino Uno and simulated in Tinkercad, developed within the Master's level Mechatronics laboratory. The study highlights three C++ applications that solve fundamental mathematical-logical problems: (1) a quadratic equation solver, (2) a multi-operand arithmetic calculator, and (3) a statistical mean calcu-lator (arithmetic and geometric). These digital programs run on an embedded system with LCD and keypad input. The versatility of the Basic Mechatronic Assembly (BMA) encourages interdisciplinary thinking, promotes algorithmic reasoning, and introduces expandable programming models that can be adapted to various STEM educational contexts. The system supports further enhancements with touchscreen HMI displays or sensor-based data acquisition modules.
This educational best-practice model underlines the role of simulation and programming in developing student creativity, engagement, and technical competence in modern engineering education.

Keywords: Arduino Uno ● Tinkercad ● mechatronic simulation ● C++ ● educational application ● Modeling and simulation ● Mathematical problems
Full text available here: https://link.springer.com/chapter/10.1007/978-3-032-02508-1_13

Selective Paint Removal from Plastic Components Using Laser Advanced Techniques

Authors: Alexandru Sover and Markus Zink
Affiliation: Ansbach University of Applied Science, Faculty of Technology, Residenzstraße 8, Ansbach, 91522, Germany
E-mail: a.sover@hs-ansbach.de

Abstract. Laser technology presents a compelling alternative to conventional methods for removing coatings from plastic and metallic parts, offering advantages over chemical solvents and media blasting for component reuse and recycling. This study investigates laser paint removal from thermoplastic materials, particularly those with complex 3D geometries. Utilizing a 1o64 nm pulsed fiber laser, experiments were conducted to analyze paint ablation from plastic substrates and characterize the resulting surfaces. Experimental results on plastic substrates demonstrate the feasibility of complete paint removal while preserving the integrity of the thermoplastic. The laser's energy density, scanning speed, and spot size are identified as key parameters influencing removal efficiency and substrate integrity. The study presents the necessary steps and process conditions and analyzes the resulting quality of the processed surfaces. The study concludes that laser paint removal facilitates the reuse or high-quality recycling of plastic parts and can be an environmentally friendly, flexible, and highly efficient method for paint removal.
Keywords: Paint Removal ● Laser Advanced Techniques ● Paint Stripping ● Polymer Recycling
Full text available here: https://link.springer.com/chapter/10.1007/978-3-032-02508-1_14

Development of a Framework to Coordinate Capacity with Market Demand

Authors: Eduardo Pereira[1], André S. Santos[23], João Bastos[13], Paulo Ávila[13], Leonilde Varela[3], Nuno Leal[4], José Machado[5]
Affiliation: [1] ISEP - School of Engineering, Polytechnic of Porto, 4200-072 Porto, Portugal
[2] Interdisciplinary Studies Research Center (IRSC), ISEP - School of Engineering, Polytechnic of Porto, 4200-072 Porto, Portugal
[3] Algoritmi Research Centre, University of Minho, Guimarães, Portugal
[4] Sonae Arauco Portugal, S.A., Oliveira do Hospital, Portugal
[5] MEtRICs Research Centre, University of Minho, Guimarães, Portugal
E-mails: ecpgoncalo@gmail.com; abg@isep.ipp.pt; jab@isep.ipp.pt; psa@isep.ipp.pt; eonilde@dps.uminho.pt; jmachado@dem.uminho.pt
Abstract. This document addresses and develops a framework tool to solve reliability issues in the calculation of processing times for components, using their di-mensions. This framework was implemented in a real industrial setting, spe-cifically in a multinational company that manufactures highly customizable electric motors according to customer requirements. After identifying the most critical components and their respective process diagrams, a prototype of the proposed framework was developed to calculate production time. Ad-ditionally, another prototype was developed to aid in visualizing the compa-ny's workload. As a result of this work, various improvements were ob-served in the company, including a 42% reduction in the time required to create workflows and an increase in the reliability and dependability of pro-cess times. The framework significantly enhanced operational efficiency, streamlined production processes, and provided a robust solution for manag-ing the complexities of custom manufacturing, demonstrating its effective-ness in a real-world industrial environment. Furthermore, this approach has the potential to be adapted for use in other industries facing similar challeng-es.
Keywords: Process Diagram ● Operation Plan ● Operation Process.
Full text available here: https://link.springer.com/chapter/10.1007/978-3-032-02508-1_15

Traffic Analysis and Optimization of Network Equipment using Artificial Intelligence

Authors: Marius Toderici[1] and Aurel Mihail Titu[23]
Affiliation: [1] National University of Science and Technology POLITEHNICA Bucharest, Faculty of Industrial Engineering and Robotics, Splaiul Independentei no. 313, 6th District, Bucharest, Romania
E-mail: marius@toderici.ro
[2] "Lucian Blaga" University of Sibiu, Faculty of Engineering, Industrial Engineering and Management Department, 10 Victoriei Street, 550024, Sibiu, Romania
E-mail: mihail.titu@ulbsibiu.ro
[3] Academy of Romanian Scientists, 3 Ilfov Street, Bucharest, Romania
Abstract. In the hybrid cloud infrastructure, data networks play a very important role, ensuring the connection between the local infrastructure and the public or private cloud infrastructure. Data traffic increases greatly when using the cloud and this will be achieved by increasing bandwidth and by segregating data on multiple connections. IT management must analyze the types of data and the quantities that are transmitted to the cloud and received from the cloud and, based on this analysis, establish the necessary connections and technical specifications to support communications within the cloud. Depending on the location where the on-premises or cloud data is stored, connections will be established so that communications ensure the data flow necessary for the proper functioning of IT services. IT services and applications used by the organization will use separate, encrypted communication channels to ensure data security. If the cloud email service is used, it is ideal to ensure this on a separate communication channel.
Internet access for browsing and information will be provided separately from the communication channels necessary for IT services serving different applications. Modern communication equipment allows the definition of software networks that have the characteristics of physical networks, share the same physical communication environment but are separate and governed by their own communication rules. Software-defined networks are very versatile and have the great advantage of allowing the implementation of all these requirements in terms of flexibility, versatility and security, but the great advantage is given by the possibility of their automation.
Keywords: Network management ● Hybrid cloud ● Traffic optimization ● Artificial intelligence ● Network cost management.
Full text available here: https://link.springer.com/chapter/10.1007/978-3-032-02508-1_16

Some Considerations on Microfabrication Methods and Simulation of Reliable Si-Based MEMS Devices

Authors: Georgeta Ionașcu[1], Edgar Moraru[1], Lucian Bogatu[1], Tudor Cătălin Apostolescu[2], Elena Manea[3], Vlad-Andrei Stănescu[1]
Affiliatiion: [1] National University of Science and Technology POLITEHNICA Bucharest, 313 Splaiul Independentei, 060042 Bucharest, Romania
[2] Titu Maiorescu University, 189 Calea Vacaresti, 0400511 Corp M, Bucharest, Romania

[3] National Institute for Research and Development in Microtechnologies, 126A Erou Iancu Nicolae Street, 077190 Bucharest, Romania
E-mail: edgar.moraru@upb.ro
Abstract. The paper describes the investigations of the authors on the methods of microfabrication to obtain important silicon MEMS (microelectromechanical systems) devices met in applications of microsensors and microactuators from micromechanics and microrobotics. There are considered an acceleration piezoresistive microsensor performed by bulk micromachining technique using crys-talline anisotropy property of the material, monocrystalline silicon wafer, and as well as some thermal microtweezers made from silicon polycrystalline by surface micromachining using sacrificial layer technique. Simulations of modal analysis, and thermal and static structural analysis of the investigated structures are also performed. We comment on the reliability aspects from the perspective of the performance of the devices under study, imposed by the applications and influenced by the material, the fabrication method, the dimensions of the structures, the modulus of elasticity, the fundamental frequency, the vibration modes, and the thermo-mechanical characteristics, presented through simulations.
Keywords: Bulk micromachining ● Surface micromachining ● Microsensors ● Microactuators ● Reliable MEMS devices ● Fusion 360 package.
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Co-Simulation Techniques for the Dynamic Testing of New Advanced Sandwich Structures

Authors: Roberto Di Bona, Erika Ottaviano, Gabriel Testa, Alessandro Silvestri, Andrea Checcacci
Affiliation: University of Cassino and Southern Lazio, Via Di Biasio 43, 03043 Cassino, Italy
E-mail: ottaviano@unicas.it
Abstract. This work proposes the co-simulation concept applied to the dynamic testing of a new material produced by 3D printing and realized with sandwich structures for being used in the luxury sectors of Made in Italy industries, such as boat interiors, as well as in other key areas of the Italian economy, including cultural heritage restoration and preservation. In particular, this paper explores the material's behavior, which can be produced as the floor of a boat, in response to the dynamic action of the human walking on the surface for assessing the resistance to trampling. The co-simulation technology involves the interaction between two simulations working in sync, namely Multibody Dynamics (MBD) and Finite Element Method (FEM). It can be considered an emerging tool for adopting multidisciplinary integration. Co-simulation technology is essential for improving the connection between physical and virtual tests, optimizing processes, and efficiently managing data.
Keywords: Co-Simulation Techniques ● Dynamic Simulation ● Walking ● Sandwich Structures ● 3D Printing.
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A Prototype Test Stand for Gear Transmissions Obtained Through Additive Technologies

Authors: Alexandra-Gabriela Vasilescu[1], Ionela-Mihaela Popescu[1], Victor Constantin[1], Mihai Avram[1], Bogdan Grămescu[1]
Affiliation: [1] National University of Science and Technology POLITEHNICA Bucharest, 313 Splaiul Independentei, 060042 Bucharest, Romania
E-mail: ionela.baciu@upb.ro
Abstract. Additive manufacturing is increasingly used in mechanical engineering due to its significant advantages, such as reduced material consumption, the ability to create complex geometries, and shorter production times. This paper explores a method for designing and manufacturing gear transmissions using these technologies. To validate the selected transmission model, a dedicated test stand was first developed, providing a controlled environment for performance evaluation. Following the construction of this test stand, future improvements will focus on the integration of high-precision sensors and advanced monitoring systems. These additions will enable accurate measurement and analysis of key operational parameters, including torque, rotational speed, vibrations, and temperature. Monitoring these parameters is essential, as they directly affect mechanical efficiency, dimensional accuracy, operational stability, and system durability. The data obtained from future experimental tests will offer valuable input for optimizing the design, selecting appropriate materials for the additive manufacturing process, and enhancing the overall reliability of the transmission system.
Keywords: Additive manufacturing ● Gear transmissions ● Test stand.
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The Role of Digitalization and 3D Information in the Technological Preparation of Manufacturing for Engineering Components in SMEs

Authors: Basova[1], Sergey Dobrotvorskiy[12], Rafał Talar[3]
Affiliation: [1] National Technical University "Kharkiv Polytechnic Institute," 2 Kyrpychova Str., 61002, Kharkiv, Ukraine
[2] Poznan University of Life Sciences, PL-60637 Poznan, Wojska Polskiego 38/42, Poland
[3] Poznan University of Technology, 2 Piotrowo Str., 61-138 Poznan, Poland
E-mail: Yevheniia.Basova@khpi.edu.ua
Abstract. This article addresses the crucial role of digitalization and the integration of 3D modeling in enhancing the competitiveness of small and medium-sized enterprises (SMEs) within the engineering component manufacturing sector. Adopting advanced digital technologies, including digital twins and 3D information, enables efficient production planning, improved product quality, and cost reduction. The study highlights the significance of 3D models at multiple levels - from nano to global scales - in optimizing production processes and ensuring the sustainability of enterprises under fluctuating market conditions. Special attention is given to developing complex components, such as turbine parts, where implementing digital solutions improves aerodynamics, load resistance, and overall performance. The article also presents a new technological chain incorporating 3D concept tools for creating high-tech engineering products in response to evolving market demands. Through real-time analysis, predictive maintenance,

and precise design modifications, this approach significantly enhances production efficiency, accelerates innovation, and strengthens the adaptability of SMEs in a dynamic global market.

Keywords: Flexibility ● Adaptability ● Modeling ● Sustainability ● Innovation.
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Comparative Study of Power Consumption of Overhead Traveling Crane Based on the Experiment

Authors: Valentyn Kovalenko[1], Maksym Strelkov[1], Vsevolod Stryzhak[1], Magomediemin Gasanov[1], Edl Milan[2]
Affiliation: [1] National Technical University «Kharkiv Polytechnic Institute», 2 Kyrpychova St., Kharkiv, 61002, Ukraine
[2] University of West Bohemia, Plzen, 30100, Czech Republic
E-mails: Vsevolod.Stryzhak@khpi.edu.ua; valentyn.kovalenko@khpi.edu.ua; edl@kpv.zcu.cz

Abstract. The study aims to determine experimentally the dependence of the change in energy consumption on the operating time of cranes equipped with different types of drives - based on a motor with a phase rotor and variable frequency motor. The aim is achieved by solving the following problems: selection of research objects and measuring equipment, determination of the methodology of measurements, ordering of experimental data, and determination of the dependence of the average power consumption on the operating time. In the process of solving the set tasks, it was found that in the long-term study of power consumption of an overhead traveling crane, the average value is reduced to 50%. At the same time, it was found that the crane equipped with a variable frequency drive at the same lifting capacity has better technical and economic indicators, the main of which is the weight of the crane and metal consumption. The most significant result is to obtain the final expressions for determining the dependence of electricity consumption of the crane and the reduction of electricity consumption when switching to an energy-efficient variable frequency drive. The significance of the obtained results is that the obtained dependencies can be applied in justifying the feasibility of modernization of cranes.

Keywords: Overhead travelling crane ● Drive ● Variable frequency drive ● Motor power ● Mechanism.
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Ways to Improve the Quality of Foundry Moulds

Authors: Mikhailo Vorobyov[1], Olga Ponomarenko[1], Tetiana Berlizieva[1], Nataliia Yevtushenko[1], Pavlo Shelepko[1], Andreea Stanciu[2]
Affiliation: [1] National Technical University "Kharkiv Polytechnic Institute", 2 Kirpicheva St., 61002, Kharkiv, Ukraine
[2] National Institute of Research and Development in Mechatronics and Measurement Technique INCDMTM, 6-8 Pantelimon, 2nd District, 021631, Bucharest, Romania
E-mail: natalya_0899@ukr.net

Abstract. The quality of the final product depends on the quality of castings, their accuracy and cost-effectiveness. Given the operating conditions of the casting mold, it must have certain mechanical, chemical and technological properties that ensure the production of high-quality castings. The

development and application of cold-hardening mixtures for casting molds while preserving the indicators of their basic physical, mechanical and technological properties, and the development of their preparation technology are urgent tasks for foundry production.
The aim of the research is to improve the quality of the casting mold by improving the physical and mechanical properties of molding mixtures using the Alpha-set process. The parameters such as compressive strength, tensile strength, bending strength, crumbleness and vitality were studied, which were determined by standard methods. The article presents the results of research and optimization of technological and physical and mechanical properties of mixtures.
The regularities of the interaction of the resin with the hardener and quartz sand weie established. Based on the planned experiment, mathematical models of the properties of mixtures on quartz sand with phenol-formaldehyde resin were developed. The compositions of cold - hardening resin mixtures on quartz sands were optimized, which allows obtaining high-quality forms with high strength properties. Industrial studies have shown that the optimal composition of the mixture is the amount of resin from 0.8 to 2.0%, the amount of hardener - from 0.4 to 1.0%.

Keywords: Foundry Mold ● Quality ● Cold-hardening Mixture ● Physical and Mechanical Properties.
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Additive Manufacturing of Compliant Mechanisms Designed for Small Displacements of Optical Components

Authors: Ciprian-Ion Rizescu, Robert Ciobanu, Maria-Alexandra Mocanu, Dana Rizescu, George Arhip
Affiliation: National Science and Technology University POLITEHNICA Bucharest, Splaiul Independentei 313, District 6, Bucharest, Romania
E-mails: robert.ciobanu@upb.ror, obert.ciobanu@upb.ro

Abstract. This paper primarily investigates the influence of two geometric parameters on the mechanical behavior of a cross-axis flexural pivot (CAFP), which enables motion along two axes. The objective of this study is to explore the potential for optimizing material consumption and reducing the mass of compliant mechanisms that incorporate CAFP structures. To achieve this, a design strategy was proposed in which each blade is replaced by two parallel blades of equal thickness, thereby minimizing material usage without compromising functionality. For reference, structures with whole blades were also studied. The varied parameters are the distance between the outer walls of a bar and, respectively, the distance between the inner walls of the blade. Due to the complexity of the structure, the most suitable manufacturing methods are 3D printing or injection. A Finite Element Analysis (FEA) was used to observe behavior under static loads in the plane of motion of the CAFP and to determine the modal frequencies. The results suggest that blade separation increases the resistance of CAFP against forces that would cause a rotational movement but decreases the resistance against forces that would cause compression. It was also observed that the volume of material used largely determines the modal frequencies of these CAFP structures with separated blades but has a more limited impact on those with whole blades.

Keywords: Compliant Mechanisms ● 3D Printing ● Finite Element Analysis ● Optical Components ● Multi-objective Optimization.
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Cognitive-Aware Retention Algorithms - a Case Study Analysis

Author: Andrei Scurtu
Affiliation: Transilvania University, Brasov Blvd. Eroilor No. 29, Romania
E-mail: andrei-bc.scurtu@student.unitbv.ro

Abstract. Retention algorithms are designed to keep users engaged on a digital platform or service. These mechanisms are used by companies to increase the frequency of user interactions and generate more revenue through ads or subscriptions, collecting and analyzing data on user behavior to personalize the experience and encourage continuous interaction. While this brings significant benefits, excessive use of technology can generate negative effects, especially on the mental and behavioral health of users. The objectives of this study are: (1) to understand the significance and the ethical implications of the problem, (2) to identify methods to measure user's state and build a model that simulates the brain to keep track of its state while scrolling, (3) to build and optimize a recommendation system that keeps user state within safe thresholds, (4) to test and compare the built model to the actual Instagram model.

Keywords: Logical Regression ● Neurobiological Optimization ● User State Quantification ● Neurobiological Indexation
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Theoretical Justification for Increasing the Stability of Trailer Links of a Tractor-transport Train

Authors: Ivan Koliesnik[1], Evgeny Kalinin[1], Juliana Koliesnik[1], Oksana Pankova[2], Vadim Raputa[3]
Affiliation: [1] National University of Life and Environmental Sciences of Ukraine, Kyiv, 03041, Ukraine
[2] Kharkiv National Automobile & Highway University, Kharkiv, 61002, Ukraine
[3] Sumy National Agrarian University, Sumy, 40021, Ukraine
E-mail: ivankolesnik@nubip.edu.ua

Abstract. The paper presents an analysis of studies on the movement of multilink transport trains, which showed that the last links are considered the most unstable. They are especially unstable on turns, because they are most susceptible to the action of not only active disturbing loads, but also in the presence of random influences from the road due to a small number of links they exhibit extreme instability of movement, this leads to an increase in oscillatory processes, which negatively affects traction and coupling properties, controllability, stability, etc. Therefore, reducing dynamic loads and increasing the efficiency of road trains is an urgent task.
It must be said that the conditions under which overturning is possible are also influenced by the stiffness of the suspension, but the need to take this factor into account also leads to the further possibility of increasing the stability of the train as a whole. Consequently, and increasing its basic characteristics by changing the properties of the connections between its links.
Thus, during rectilinear movement, the train links are acted upon by forces only in the longitudinal direction, and transverse vibrations arise as a result of the effects of road irregularities and the elastic interaction of the wheels with the road. It is also desirable to get rid of this phenomenon, and there are already a number of proposals and specific measures. It should be noted that in a turn, a whole group of forces act in the transverse direction, the influence of which cannot be neglected. Unfortunately, this does not help to increase the stability of the train during a turn.

Keywords: Tractor-technological unit ● Dynamics ● Traction and coupling device ● Trailer ● Stability.
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Creative Solution for Flood Response Assessment. A Challenge-based Learning Implementation

Authors: Andreea Dana Alionte[1], Carlos Paredes[2], Cristian Gabriel Alionte[1], Elcin Tan[3], Miguel Llorrente[4], Rogelio de la Vega[2], Luis Iglesias[2], Maria Sonia Medina[5], Marta Ortiz[5], Adrian Rosario[4]
Affiliation: [1] National University of Science and Technology POLITEHNICA Bucharest, Splaiul Independentei 313, 060042 Bucharest, Romania
[2] Department of Geological and Mining Engineering, School of Mines and Energy, Universidad Politecnica de Madrid, Ríos Rosas 21, 28003, Madrid, SP
[3] Department of Climate Science and Meteorological Engineering, Technical University of Istanbul, İTÜ Ayazaga Campus, 34469, Maslak/Istanbul, TK
[4] Instituto Geológico y Minero de España (CN IGME - CSIC), Ríos Rosas 23, 28003, Madrid, SP
[5] Department Economía de la Empresa (ADO), Economía Aplicada II y Fundamentos Análisis Económico, Fac. CC. Economía y Empresa, Universidad Rey Juan Carlos, P. Artilleros s/n, 28032 Madrid, SP
E-mail: cristian.alionte@upb.ro
Abstract. To enhance the evaluation and education of geohydrological risk management, creative activities can be utilized through the deployment of challenge- based learning, which is based on collaborative GIS/hydrodynamical modeling and serious gaming. To answer the demand for efficient flood mitigation techniques in the context of increasing climate-driven threats, this interacts advanced simulation with practical problem-solving. Throughout the process of modeling crisis scenarios, participants create and evaluate response plans in an environment that is within control. The activity is designed to be accomplished in a collaborative manner, and it is assisted by professionals, which helps to enhance the practical application of interdisciplinary scientific and technological knowledge. Therefore, engineers can be prepared to deal with catastrophes from a variety of perspectives. These perspectives are not limited to flood assessment; rather, they must be able to manage the full extent of the hazard. This includes the exploration of floods, the modeling of hydrodynamics, the promotion of resilience to disasters, and the preparation of plans for prevention, mitigation, and evacuation. Consequently, we anticipate that participants will actively learn to apply theoretical concepts in practical situations. Participants will accomplish this by incorporating novel approaches, empathizing, sharing, and focusing on current socio-economic and environmental needs. Additionally, we expect participants to project an interdisciplinary perspective over a practical challenge in a real geohydrological menace case.
Keywords: Academic training ● Challenge-based learning ● Natural geohydrological hazard ● Preparedness ● Resilience.
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Optimal use of Low-power Solar Panels for an Autonomous IoT Soil Monitoring Station

Authors: Valentina-Daniela Băjenaru[12], Constantin Anghel[1], Simona-Elena Istrițeanu[12]

Affiliation: [1] National Institute of Research and Development in Mechatronics and Measurement Technique, 021631, Bucharest, Romania
[2] National University of Science and Technology Politehnica Bucharest
E-mail: valentina.bajenaru@incdmtm.ro
Abstract. Photovoltaic (PV) systems, leveraging the photoelectric conversion of solar radiation into electrical energy, have undergone substantial technological advancements in recent decades. These advancements have yielded increased conversion efficiencies and an expansion of large-scale deployments, ranging from utility-scale power plants to in-situ distributed micro-systems. This paper presents a technical analysis of the efficiency of terrestrial photovoltaic (PV) pan-els. The study evaluates their power performance, focusing on the variable factors that introduce uncertainty in predicting incident solar radiation and its subsequent conversion into electrical energy. Consequently, to optimize the operating point of a photovoltaic (PV) system intended for powering an in-situ Internet of Things (IoT) station, a focused laboratory investigation is necessary. This study aims to determine the optimal utilization of a specific solar panel for powering a soil characteristic monitoring station. Furthermore, this paper will explore the potential and evolutionary trends of IoT applications, encompassing communication technologies and air-to-ground sensors, in enhancing the operating point of in- situ mounted PV systems. The results demonstrate the suitability of the proposed PV system for the autonomous powering of the soil monitoring station. This presents a promising solution for realizing an autonomous IoT pilot station, integrating a solar photovoltaic system for intelligent remote and real-time monitoring of soil parameters.
Keywords: Photovoltaic panel ● IoT ● Autonomous monitoring stations.
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Analysis of Motors Equipped on an Omnidirectional Platform from the Perspective of the Commutation Signal

Authors: Daniel Balc[1], Aurel Mihail Titu[23], Emanuel Balc[4], Ligia Petrescu[5]
Affiliation: [1] National University of Science and Technology POLITEHNICA Bucharest, 313 Splaiul Independentei, București, Romania
[2] Lucian Blaga University of Sibiu, 10 Victoriei Street, Sibiu, Romania
[3] Academy of Romanian Scientists, 3 Ilfov Street, Bucharest, Romania
[4] Lucian Blaga University of Sibiu, 10 Victoriei Street, Sibiu, Romania
[5] National Institute of Research - Development for Mechatronics and Measurement Technique, Romania
E-mails: danielbalc98@gmail.com; mihail.titu@ulbsibiu.ro; emybalc@yahoo.ro
Abstract. This paper presents an analysis conducted on direct current (DC) electric motors used in an omnidirectional mobile platform, with a focus on the commutation signal as a primary indicator of their dynamic behavior and functional condition. Omnidirectional platforms provide significant advantages in mobile robotics applications due to their ability to move in any direction without requiring a change in orientation, a capability made possible by the use of four individually controlled DC motors.
The study emphasizes the commutation signal as a diagnostic tool for evaluating motor performance, as it directly reflects the interaction between the motor's mechanical and electrical components. The analysis aims to identify key variations in current, partial short circuits, and non-uniformity in the commutation process between the brushes and the commutator segments. Furthermore, the behavior of multiple

motors mounted on the same platform is compared in order to assess operational uniformity and its influence on the platform's omnidirectional motion.

Keywords: Motor ● Commutation waveform analysis ● Signal acquisition ● Brush- commutator interaction ● DC motor diagnostics

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The Influence of Soft Value Dimensions on Consumers' Purchase Intentions for Electric Vehicles

Authors: Anita Subotić[1] and Nina Antičić[2]

Affiliation: [1] Coca-Cola HBC Hrvatska, Milana Sachsa 1, Zagreb 10000, Republic of Croatia

[2] RIT Croatia, D. T. Gavrana 15, Zagreb 10000, Republic of Croatia

E-mail: Nina.anticic@croatia.rit.edu

Abstract. The electric vehicle (EV) market has expanded significantly in recent years. As adoption accelerates, understanding the underlying motivations behind EV purchases becomes increasingly important. Functional, economic, and environmental factors have traditionally driven EV adoption. However, recent research highlights the growing importance of soft value dimensions—such as status, symbolism, prestige, exclusivity, and recognition. This research explores how EV ownership aligns with the buyer's personal identity, social standing, and emotional appeal, and how soft value dimensions influence purchase intentions for EVs. The collected empirical data were processed and analyzed using multivariate analysis methods and structural equation modeling with the partial least squares method (PLS-SEM). The findings extend current knowledge of EV adoption by highlighting the role of soft value dimensions in shaping consumer be-havior. A key managerial implication of the research findings is that soft value dimensions may accelerate adoption if effectively integrated into marketing strategies.

Keywords: Electric vehicles ● Purchase intentions ● Perceived value.

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Method for Selecting a Design Scheme for a Continuously Variable Electromechanical Transmission Based on the Principle of an Energy Flow Adder

Authors: Andrii Kozhushko[1], Ievgenii Veretennikov[1], Yevhen Pelypenko[1], Vadym Karpov[1], Vitalii Danylenko[1], Daniela-Doina Cioboată[2]

Affiliation: [1] National Technical University "Kharkiv Polytechnic Institute", 2 Kyrpychova Str., 61002, Kharkiv, Ukraine

[2] National Institute of Research and Development in Mechatronics and Measurement Technique INCDMTM, 6-8 Pantelimon, 2nd District, 021631 Bucharest, Romania

E-mail: Andrii.Kozhushko@khpi.edu.ua

Abstract. Recently, more and more transport and special vehicles have been equipped with hybrid transmissions. The main aim is to reduce fuel consumption and pollutant emissions. Today, hybrid transmissions are available in many design configurations. This state of affairs leads to the provision of

recommendations regarding the structural structure of the hybrid transmission, the dimensions and characteristics of the power control components, which affect the efficiency of the hybrid transmission installation. The objective of this work is to search for the constructive structure of an electromechanical transmission based on the principle of a power flow adder, by analyzing the kinematic and power parameters of the transmission operation, taking into account the peculiarities of the operation of an electric motor and an internal combustion engine. The method used to solve the problem was based on the presentation of the principles of the structure of a continuously variable transmission and the mathematical description of the change in kinematic and force parameters during the operation of a continuously variable transmission. The result of the study is a scientifically based selection of two continuously variable electromechanical transmission schemes based on the principle of an energy flow adder.

Keywords: Vehicle ● Continuously Variable Electromechanical Transmission ● Planetary Gear ● Angular Velocity ● Torque ● Methodology.

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The Impact of Process Audits on Sustainability in Automotive Manufacturing

Authors: Ioan Danut Iuonas[1], Aurel Mihail Titu[23], Camelia Cristina Dragomir-Pânzaru[45], Florin Claudiu Iuonas[6], Florentina Badea[7]

Affiliation: [1] National University of Science and Technology POLITEHNICA Bucharest, Faculty of Industrial Engineering and Robotics, Splaiul Independentei no. 313, 6th District, Bucharest, Romania
[2] Lucian Blaga University of Sibiu, Faculty of Engineering, Industrial Engineering and Management Department, 10 Victoriei Street, 550024, Sibiu, Romania
[3] Academy of Romanian Scientists, 3 Ilfov Street, Bucharest, Romania
[4] Transilvania University of Brasov, 29 Eroilor Street, Brasov, Romania
[5] Academy of Romanian Scientists, 3 Ilfov Street, Bucharest, Romania
[6] National University of Science and Technology POLITEHNICA Bucharest, Faculty of Industrial Engineering and Robotics, Splaiul Independentei no. 313, 6th District, Bucharest, Romania
[7] National Institute of Research - Development for Mechatronics and Measurement Technique - INCDMTM, Bucharest, Romania

E-mails: danut.iuonas@yahoo.com; mihail.titu@ulbsibiu.ro; camelia.dragomir@unitbv.ro; f.iuonas@outlook.com; mihaiflori@yahoo.com

Abstract. Sustainability has emerged as a strategic priority in the automotive industry, driven by increasing regulatory pressures, customer expectations, and the urgent need to minimize environmental impact. In this context, organizations are called to rethink their production processes and quality management approaches to align with sustainability objectives. Process audits, traditionally focused on compliance and operational efficiency, are now evolving to play a key role in promoting sustainable practices. By systematically evaluating production activities, process audits can identify inefficiencies, excessive resource consumption, and opportunities for waste reduction, energy saving, and improved environmental performance. This paper explores the impact of process audits on sustainability initiatives within the automotive manufacturing sector. It highlights how audits contribute not only to compliance with environmental standards but also to fostering a culture of continuous improvement oriented towards

ecological responsibility. Key benefits such as optimized resource use, reduced emissions, and cost savings are discussed, along with challenges like the integration of sustainability metrics into traditional audit frameworks and resistance to change within organizations. Moreover, the paper examines emerging trends, including the use of digital tools and data analytics in enhancing the sustainability outcomes of audits. Through this analysis, the study emphasizes the critical role of process audits in driving sustainable transformation and offers insights into best practices and future directions for companies aiming to strengthen their environmental performance while maintaining high product quality standards.

Keywords: Process Audits ● Sustainability ● Automotive Industry ● Environmental Performance ● Quality Management.

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AI-Driven Supplier Quality Assurance: Enhancing Compliance and Traceability in Automotive Supply Chains

Authors: Aurel Mihail Titu[12], Claudiu-Alexandru Covaci[3], Camelia Cristina Dragomir-Panzaru[45], Dănuț Iulian Stanciu[6]

Affiliation: [1] Lucian Blaga University of Sibiu, Faculty of Engineering, Industrial Engineering and Management Department, 10 Victoriei Street, 550024, Sibiu, Romania
[2] Academy of Romanian Scientists, 3 Ilfov Street, Bucharest, Romania
[3] National University of Science and Technology POLITEHNICA Bucharest, Faculty of Industrial Engineering and Robotics, Splaiul Independentei no. 313, 6th District, Bucharest, Romania
[4] Transilvania University of Brasov, 29 Eroilor Street, Brasov, Romania
[5] Academy of Romanian Scientists, 3 Ilfov Street, Bucharest, Romania
[6] National Institute of Research - Development for Mechatronics and Measurement Technique, Romania
E-mails: mihail.titu@ulbsibiu.ro; covaci_claudiu99@yahoo.com; camelia.dragomir@unitbv.ro; danut.stanciu@incdmtm.ro

Abstract. This paper examines the transformative potential of integrated RFID- EPCIS-AI systems for quality assurance in automotive supply chains. The study demonstrates how combining RFID sensor networks with EPCIS standards and artificial intelligence enables real-time monitoring of critical quality parameters (humidity, shock, temperature) across the entire supply chain - from supplier warehouses to final assembly. Key findings reveal three core advantages of this technological integration: First, it establishes unprecedented supply chain transparency through automated data capture and standardized information exchange.

Second, machine learning algorithms applied to RFID-EPCIS data streams enable predictive quality control, identifying potential defects before they impact production. Third, the system significantly improves operational efficiency by reducing quality incident response times and minimizing manual inspection requirements. The research highlights how AI-driven analysis of sensor data can detect subtle patterns correlating transportation conditions (e.g., vibration levels) with future failure risks. Case evidence shows these systems facilitate proactive interventions at critical control points, transforming traditional reactive quality management into a preventive approach. This study contributes to both academic literature and industry practice by providing a comprehensive framework for implementing smart quality assurance systems that combine physical sensor net-works with digital traceability standards and advanced analytics.

The results demonstrate measurable improvements in defect prevention, compliance assurance, and supply chain resilience in automotive manufacturing contexts.

Keywords: EPCIS ● RFID ● AI ● Machine Learning ● Predictive quality control ● Automotive.
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Statistical and Neural Network Methods for Determining the Weight of a Bridge Crane

Authors: Valentyn Kovalenko[1]*, Oleksiy Zhuravel[1], Vsevolod Stryzhak[1]*, Magomediemin Gasanov[1], Rafał Talar[2], Paweł Zawadzki[2]*
Affiliation: [1] National Technical University «Kharkiv Polytechnic Institute», 2 Kyrpychova St., Kharkiv, 61002, Ukraine
[2] Poznan University of Technology, 2 Piotrowo St., 61-138 Poznan, Poland
E-mails: valentyn.kovalenko@khpi.edu.ua , pawel.zawadzki@put.poznan.pl

Abstract. The article presents a new method for solving the scientific and practical problem of automated calculation of the weight of general-purpose bridge cranes. Numerical data on the weight of existing cranes are given in tables and structured depending on the load capacity and span. Mathematical statistics' hypotheses were used, making it possible to distribute the results according to the normal law under the same accuracy of the obtained data. Based on these assumptions, the least squares method was applied, which made it possible to construct a function of two variables that determines the dependence of the crane weight on the span and load capacity, combining these parameters. A formula was obtained that makes it possible to calculate the weight of cranes programmatically. Based on statistical data, a neural network was built, which, similarly to traditional statistical methods, finds the weight of bridge cranes. The quality of the obtained result was assessed using traditional statistical methods and using a neural network. The work of the statistical model and neural network was studied beyond the data definition area. Functional dependencies for determining the weight of overhead cranes in the range of up to 50 tons are determined based on the regression equation and using a neural network. It is established that forecasting is unacceptable outside the range, but the neural network copes better with the task of extrapolation than traditional methods. The article substantiates the advantages of the proposed method.

Keywords: Neural network ● Bridge crane ● Crane weight ● Automation ● Calculation.
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Investigation of Sedimentation and Flocculation Kinetics of Current-Dispersed Coal Sludge

Authors: Sergii Kulinich[1], Andrii Shkop[1], Alona Bosiuk[1]*, Oleksii Shestopalov[1], Ligia-Luminița Petrescu[2]
Affiliation: [1] National Technical University «Kharkiv Polytechnic Institute», 2 Kyrpychova St., Kharkiv, 61002, Ukraine
[2] National Institute of Research and Development in Mechatronics and Measurement Technique (INCDMTM), 6-8 Pantelimon, 2nd District, 021631 Bucharest, Romania
E-mail: Alona.Bosiuk@mit.khpi.edu.ua

Abstract. The coal industry remains an important energy sector component in many countries. Coal preparation produces large volumes of fine sludge that require efficient disposal and treatment before

being discharged to external sludge ponds or reused. Low settling velocity and complex sludge structure make it difficult to settle them using traditional methods. leading to significant energy costs. loss of useful product (coal) and negative environmental impact. This article investigates the features of the settling processes of model suspensions of coal sludge with a concentration of 5 to 100 g/l. To create the model suspensions. we used the real sludge from a coal preparation plant after sieving on vibrating screens with a particle size of the solid phase of less than 20 pm. from 0 to 40 pm. and particles of 40-80 pm. The regularities of changes in the rate of sedimentation of the solid phase of suspensions without and with the addition of floc- culants depending on the concentration of the solid phase and the content of fine fractions (less than 20 pm. less than 40 pm). as well as a polydisperse mixture of fine fractions (less than 40 pm) and granular particles of 40-80 pm in a ratio of 4:1 were established. The results obtained will help optimise the operation of sedimentation and dewatering facilities of the water-sludge circuit of concentrators. reduce the environmental risks of discharging fine fractions. increase resource efficiency and facilitate the transition to more sustainable production.

Keywords: Polydisperse Suspension ● Water Treatment ● Coal Preparation Sludge ● Wastewater ● Environmental Safety ● Flocculation.

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Mathematical Model of the Process of Air Pollutant Distribution for Multiple Point Sources of Industrial Pollution

Authors: Artem Kovtun[3]*, Iuliia Pershyna[1,2], Vitaliy Mezhuev[3]

Affiliation: [1] Kharkiv National University of Radio Electronics, 14 Nauky Ave., 61166 Kharkiv, Ukraine
[2] National Technical University "Kharkiv Polytechnic Institute", 2 Kyrpychova St., 61002 Kharkiv, Ukraine
[3] NFH Joanneum University of Applied Sciences, Graz, Kapfenberg, Bad Gleichenberg, Austria

E-mail: artem.kovtun1@nure.com

Abstract. A boundary problem is formulated to describe the processes of multicomponent pollutant transport in the air in the presence of point sources. Using the concept of local potential, a theorem is developed that enables the construction of an algorithm for solving the problem via the finite element method (FEM).

The choice of FEM is justified by its key advantages: (1) FEM provides an approximate solution in the form of an analytical expression; (2) it formalizes the procedure for satisfying boundary conditions by selecting a functional where one or both boundary conditions are natural; (3) it allows for constructing an approximation even in cases with discontinuous coefficients or when the non-homogeneous term of the differential operator includes a sum of Dirac delta functions.

Furthermore, an algorithm is developed for solving a nonlinear boundary value problem with variable coefficients, featuring a singularity represented as a sum of unit Dirac delta functions. The mathematical model of air purification above a given surface considers the effect of initial dispersion of polluted air and is formulated as a two-point boundary value problem for a system of differential equations governing the material balance of organic pollutants in the air.

The mathematical model formulated in this work describes the process of purifying polluted airflows around an emission source located on a surface, leading to a nonlinear boundary value problem. The solution is obtained using FEM, which enables the construction of variable approximations in the presence of singularities such as Dirac delta functions. The variational formulation of the boundary problem is

developed using the Ritz method, incorporating the local potential concept proposed by Glansdorff and Prigogine.

Keywords: Multi-component pollutant transport ● finite element method (FEM) ● boundary value problem ● Dirac delta function ● air purification modeling ● pollutant dispersion ● nonlinear differential equations ● Ritz method ● local potential ● modified Newton's method ● Gauss method ● kinetic constant estimation.

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Application of Polyethylene Wax in the Formulation of Lubricating Greases

Authors: Andrii Grigorov[1], Alona Tulska[1]*, Liliana-Laura Bădiță-Voicu[2], Viacheslav Baranov[2]
Affiliation: [1] National Technical University "Kharkiv Polytechnic Institute", 2 Kyrpychova St., 61002 Kharkiv, Ukraine
[2] National Institute of Research and Development in Mechatronics and Measurement, Romania
E-mail: fuel.khpi@gmail.com

Abstract. The article explores the potential use of polyethylene (PE) waxes as multifunctional components in lubricating grease formulations. The main industrial applications of PE waxes are identified. It is substantiated that, within lubricating greases, PE waxes can function as thickeners, stabilizers, and structuring agents, enhance hydrophobicity, and act as anti-friction additives.

Using the example of polymer wax PEW-0200 produced by Nanjing Tianshi New Material Technologies Co., Ltd., experimental studies have shown that increasing the PEW-0200 content from 5% to 20% in the grease formulation results in a higher dropping point, improved consistency, increased dynamic viscosity, enhanced colloidal stability and hydrophobicity, as well as better lubricating performance.

It is proposed to use polymer wax PEW-0200 as a relatively low-cost thickener compatible with used oils, enabling simplified production of cost- effective lubricating greases for various industrial applications.

Keywords: Polymer wax ● Hydraulic oil ● Lubricating grease ● Thickener ● Thermal stability ● Hydrophobicity.

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On Reduction of a Non-Stationary Random Process to a Stationary One in the Study of Dynamic Loads

Authors: Yevhen Kalinin[1]*, Volodymyr Boldovskyi[2], Volodymyr Demianyshyn[3], Kateryna Boldovska[4], Oleksandr Hasiuk[5]
Affiliation: [1] National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
[2] The National Aerospace University "Kharkiv Aviation Institute", Kharkiv, Ukraine
[3] Kyiv Institute of the National Guard of Ukraine, Kyiv, Ukraine
[4] Kharkiv National Automobile and Highway University, Kharkiv, Ukraine
[5] National Technical University "Kharkiv Polytechnic Institute", Kharkiv, Ukraine
E-mail: kalinin@nubip.edu.ua

Abstract. The paper analyses the possibility of studying dynamic loads in transmissions and load-bearing systems of wheeled and tracked machines by bringing a nonstationary random process, which describes

the system, to a stationary one by using a finite-difference method of correlation analysis of a process of additive form. This method is particularly interesting for the study of the widespread methodological approach to the study of load modes of car elements, smoothness of running, in which the amplitude-frequency information about the mode is obtained by processing the records of the car movement on a measured section with a constant speed. For com-parison, we present a graph of the correlation function of the same random process constructed by the method of preliminary smoothing of the initial process with simultaneous approximation by a cubic parabola and subsequent centering of the initial process relative to the parabola. It was found that faster decay of the correlation function indicates larger errors and noise caused by them, inherent in the algorithm of the method with the smoothing operator. The possibility of using the proposed methodology has been analyzed and recommendations for its use have been proposed.

Keywords: oscillatory system ● vehicle ● non-stationary random process ● vibration ● dynamic load.
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Comparative Simulation of Adaptive PID and Feedforward Controllers for Pressure Regulation in Hyperbaric Surgical Chambers Using Neural Adaptation

Authors: Roxana-Maria Motorga, Daniel Moga, Mihail Abrudean, Vlad Muresan*, Mihaela Unguresan
Affiliation: Technical University of Cluj-Napoca, Cluj-Napoca, CO 400114, Romania
E-mails: Vlad.Muresan@aut.utcluj.ro Roxana.Motorga@campus.utcluj.ro, Daniel.Moga@aut.utcluj.ro, Mihai.Abrudean@aut.utcluj.ro, Vlad.Muresan@aut.utcluj.ro, mihaela.unguresan@chem.utcluj.ro

Abstract. Maintaining precise pressure regulation in hyperbaric surgical chambers is critical for patient safety, particularly during dynamic disturbances such as door operations or environmental fluctuations. Conventional control strategies often fail to balance rapid response and stability under such conditions. This study compares two advanced methodologies: an adaptive Proportional- Integral-Derivative (PID) controller with neural network-driven parameter adaptation and a model-based feedforward controller, for hyperbaric chamber pressure regulation. The adaptive PID employs real-time tuning via a model reference adaptive system (MRAS) to dynamically adjust to disturbances, while the feedforward controller leverages a first-principles pneumatic model to preemptively compensate for anticipated disruptions. Both strategies were validated through simulation and experimental trials under realistic scenarios, including abrupt pressure changes and thermal variations. Key metrics - settling time, overshoot, and steady-state error - were quantified. Results demonstrate the adaptive PID reduces settling time by 32% compared to the feedforward method and achieves superior disturbance rejection. Conversely, the feedforward controller exhibits better steady-state precision under predictable conditions but suffers vulnerability to model uncertainties. A hybrid architecture in-tegrating both strategies is proposed to synergize anticipatory and reactive control. This work provides practical guidelines for designing robust pressure regulation systems in safety-critical medical environments.

Keywords: Hyperbaric chamber ● disturbance rejection ● neural networks ● simulation study ● HVAC systems ● closed-loop systems ● biomedical engineering applications.
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