Innovation Center of Faculty of Mechanical Engineering

Faculty of Mechanical Engineering, University of Belgrade

Center for Business Trainings

CNN TECH

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

Sponsored by:

MINISTRY OF EDUCATION OF THE REPUBLIC OF SERBIA

Programme

and

The Book of Abstracts

01 July 2025

Belgrade, Serbia

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

CNN TECH 2025

01 July 2025

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

http://cnntechno.com

Programme

and

The Book of Abstracts

Organised by:

Innovation Center of Faculty of Mechanical Engineering

Faculty of Mechanical Engineering, University of Belgrade

Center for Business Trainings

Sponsored by:

Ministry of Education of the Republic of Serbia

Title:	International Conference of Experimental and Numerical Investigations and New Technologies – **CNN TECH 2025** **PROGRAMME AND THE BOOK OF ABSTRACTS**
Publisher:	University of Belgrade - Faculty of Mechanical Engineering Kraljice Marije 16, 11120 Belgrade 35 tel: (+381 11) 3302-346, fax 3370364 e-mail: cnntechno@gmail.com web site: http://cnntechno.com
Editors:	Dr Goran Mladenovic, Associate Professor *University of Belgrade - Faculty of Mechanical Engineering* Dr Aleksandra Mitrovic, Associate Professor *The Academy of Applied Studies Polytechnic, Belgrade* *University "Union - Nikola Tesla", Faculty of Information Technology and Engineering, Belgrade* Dr Isaak Trajkovic, Scientific Researcher *Innovation Center of the Faculty of Mechanical Engineering in Belgrade*
Technical editor:	Dr Goran Mladenovic, Associate Professor
Cover page:	Dr Isaak Trajkovic, Scientific Researcher
Printed in:	University of Belgrade - Faculty of Mechanical Engineering Kraljice Marije 16, 11120 Belgrade 35 tel: (+381 11) 3302-346 Approved for printing by decision of the Dean of the University of Belgrade – Faculty of Mechanical Engineering, Decision No. 9/2025 dated July 9, 2025.
License:	All abstracts in this volume are published under the Creative Commons Attribution 4.0 International (CC BY 4.0) license, permitting unrestricted use, distribution, and reproduction in any medium, provided the original authors and source are properly cited (https://creativecommons.org/licenses/by/4.0/).
Circulation:	150 copies. The end of printing: July 2025.

ISBN: 978-86-6060-218-5

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

CNN TECH 2025

SCIENTIFIC COMMITTEE:

Nenad Mitrovic, Serbia (chairman)
Milos Milosevic, Serbia (co-chairman)
Aleksandar Sedmak, Serbia
Milos Djukic, Serbia
Hloch Sergej, Slovakia
Drazan Kozak, Croatia
Nenad Gubeljak Slovenia
Monka Peter, Slovakia
Snezana Kirin, Serbia
Samardzic Ivan, Croatia
Martina Balac, Serbia
Mládková Ludmila, Czech Republic
Johanyák Zsolt Csaba, Hungary
Igor Svetel, Serbia
Aleksandra Mitrovic, Serbia
Valentin Birdeanu, Romania
Goran Mladenovic, Serbia
Luis Reis, Portugal
Zarko Miskovic, Serbia
Tozan Hakan, Turkey
Traussnigg Udo, Austria
Katarina Colic, Serbia
Peter Horňak, Slovakia
Róbert Huňady, Slovakia
Martin Hagara, Slovakia
Marija Djurkovic, Serbia
Tsanka Dikova, Bulgaria
Ján Danko, Slovakia
Ognjen Pekovic, Serbia
Jelena Svorcan, Serbia
Adriana Peles, Serbia
Jelena Zivojinovic, Serbia
Nebojsa Manic, Serbia
Zorana Golubovic, Serbia
Vera Pavlovic, Serbia
Aleksandra Dragicevic, Serbia
Dragan Milkovic, Serbia
Bojan Cudic, Bosnia and Herzegovina
Vesna Miletic, Australia
Natasa Obradovic, Serbia
Branislav Sredanovic, Bosnia and Herzegovina
Dragana Vujicic Stefanovic, Bosnia and Herzegovina
Bosko Mekinjic, Bosnia and Herzegovina
Milena Milosevic, Serbia
Jelena Jovanovic Sakovic, Montenegro
Aleksandar Vulovic, Montenegro
Nikola Mirkov, Serbia
Ivana Vasovic, Serbia
Jovana Zvicer, Serbia
Isaak Trajkovic, Serbia
Dragica Manojlovic, Serbia

ORGANIZING COMMITTEE:

Milos Milosevic (chairman)
Nenad Mitrovic (co-chairman)
Aleksandar Sedmak
Martina Balac
Igor Svetel
Goran Mladenovic
Aleksandra Mitrovic
Aleksandra Lj. Dragicevic
Zarko Miskovic
Milan Travica
Aleksandra D. Dragicevic
Isaak Trajkovic
Toni Ivanov
Snezana Kirin
Igor Stankovic
Ivana Vasovic Maksimovic
Nina Obradovic
Ivana Filipovic
Jasmina Milenkovic
Ivan Zlatanovic
Dragana Perovic
Jelena Vucicevic
Nikola Mirkov
Natasa Obradovic
Dragica Manojlovic

enterprise europe network
Business Support on Your Doorstep

ACKNOWLEDGEMENT

The organizing committee of the 9th International Conference of Experimental and Numerical Investigations and New Technologies – CNN TECH 2025 wishes to sincerely thank all the institutions and individuals who, by means of personal engagement and constructive action, helped organise this conference.

We would like to extend our gratitude to the **Ministry of Science, Technological Development, and Innovation**, as well as the **Ministry of Education, Government of the Republic of Serbia**, for their ongoing support.

We are also grateful to companies, **3D Republic**, **Shimadzu**, **Altera**, **Novos**, **Superlab** and **Altema** who have significantly contributed to the organization and realization of the conference.

PREFACE

Dear Friends and Colleagues,

welcome to the CNN Tech 2025 Conference, this year again in Belgrade!

With 41 papers (13 by international authors) and contributions by authors from different countries, the International Conference of Experimental and Numerical Investigations and New Technologies CNN Tech 2025 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 2025 focuses on the following topics:

- Mechanical Engineering,
- Engineering Materials,
- Experimental Techniques,
- Numerical Methods,
- New Technologies,
- Dental Materials and Structures,
- Sustainable Design and New Technologies,
- Artificial intelligence.

The organising committee of CNN Tech 2025 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.

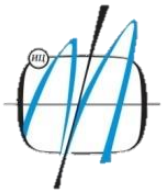
PROGRAMME AND ORGANIZING COMMITTEE

CONTENTS

PROGRAMME

Tuesday, July 01, 2025 University of Belgrade, Faculty of Mechanical Engineering, Kraljice Marije 16, Belgrade		
10:00 to 11:00	Registration and welcome coffee	
11:00 to 13:00	Opening Ceremony Prof. dr Aleksandar Sedmak – Welcome speech REGIONAL INNOVATION FORUM 2025 Chairman: dr Isaak Trajkovic 1. Djordjije Brkuljan – Building Innovation Infrastructure and Supporting Innovation Ecosystem: *How to ensure infrastructure, procure research equipment, organize program activities (meetups, conferences, b2bs, trainings etc.), and form interdisciplinary teams, startups, and spinoffs emerging from research and innovation organizations (RIOs) to enable successful commercialization.* 2. Vladimir Nikic – Developing the Next Generation of Researchers: *Strategies for advancing young researchers through mentoring, structured training, and integration into innovation-focused teams.* 3. Mladjan Stojanovic – Attracting and Matching Investment for Innovation: *How to identify investors, structure investment deals, and align them with the needs of innovative projects, including insights into the new funding program FID. New funding program for AI startups.* 4. Prof. dr Pavle Andjus - The NIMOCHIP story: From the Lab to the EU market. *Real life experience of the bumpy road from an experimentally created biomedical idea to the EU startup arena of innovative diagnostics.*	
13:00 to 14:00	Lunch break	
13:00 to 15:00	Poster session (all papers)	B2B meetings

Supported by:


Interreg Danube Region

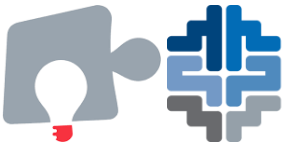
Co-funded by the European Union

Ministry of Education of the Republic of Serbia

Ministry of Science, Technological Development and Innovation of the Republic of Serbia

Business Support on Your Doorstep

REPUBLIC OF SERBIA
INNOVATION FUND



The Intellectual Property Office of the Republic of Serbia

THE ACADEMY OF APPLIED TECHNICAL STUDIES BELGRADE

PRIVREDNA KOMORA SRBIJE

CENTER FOR THE PROMOTION OF SCIENCE

Sponsored by:

ABSTRACTS

Mechanical Engineering

THE KEY FEATURES OF INDUSTRY 6.0

Dragan Kreculj[1] [0000-0003-3268-4024], Djordje Dihovicni[1] [0000-0003-0961-2540], Nada Ratkovic Kovacevic[1] [0000-0001-6398-4391]

[1]The Academy of Applied Studies Polytechnic, 11000 Belgrade, Serbia

*Corresponding author e-mail: dkreculj@politehnika.edu.rs

Abstract

Industry 6.0, referred to as the sixth industrial revolution, is the next, however long-term phase of industrial evolution, with the advancements of Industry 4.0 (digitalization and automation), and Industry 5.0 (human-centricity and sustainability). Artificial intelligence (AI), improved robotics, and irreplaceable human ingenuity will converge to create smart and adaptive production. While still a futuristic concept to be fully implemented by 2050, Industry 6.0 is characterized by the following: hyper-personalization and mass customization, advanced AI and machine learning, intelligence-driven manufacturing, human-robot collaboration, sustainability and environmental responsibility, cognitive computing and intuitive interfaces, biological-tech integration, resilience, and adaptability. All these will make a highly intelligent, deeply integrated work environment with more personalized outcomes and driven by both human ingenuity and the optimal capabilities of advanced autonomous systems. Industry 6.0 will be developed as the convergence and maturation of advanced technologies and research processes. The fundamental technologies that will drive the implementation of such a concept are: Industrial Internet of Things (IIoT) and Edge Computing, Digital Twins and Simulation, Augmented Reality and Virtual Reality, and Blockchain technology. The continuous advancements in AI, robotics, biotechnology, and quantum computing, in conjunction with a strong focus on sustainability and human well-being, are incremental steps toward their implementation in the complex, innovative, and demand-driven approximation. Potential applications of this sophisticated industry include, but are not limited to: advanced manufacturing, energy, transport, healthcare, and agriculture. Industry 6.0 will deeply modify the future of manufacturing operations towards creating a unique and harmonious mix of AI, robotics, and human ingenuity. In essence, Industry 6.0 represents a shift from automation to autonomy, from data analysis to cognitive insights, and from human-machine interaction to seamless intelligent collaboration. Design, examination, and testing of elements (equipment, devices, systems) for the establishment of Industry 6.0 are in progress.

Keywords

Industry 6.0, development, features, technologies, implementation.

Type of publication

Review article.

PRACTICAL STABILITY OF SINGULAR DISTRIBUTED SYSTEMS

Djordje Dihovicni[1] [0000-0003-0961-2540], Nada Ratkovic Kovacevic[1] [0000-0001-6398-4391], Dragan Kreculj[1] [0000-0003-3268-4024]

The Academy of Applied Studies Polytechnic, Boulevard of Zoran Djindjic 152a, 11070 Belgrade, Republic of Serbia,

*Corresponding author e-mail: djdihovicni@politehnika.edu.rs

Abstract

During analyzes and synthesis of control systems, fundamental question which arises is determination of stability. In accordance with engineer needs, the stability definitions could be roughly divided into: Ljapunov and non-Ljapunov concept. The basic difference between Ljapunov and practical stability is set of initial states of system (S_α) and set of permitted disturbance (S_ε). Ljapunov concept of stability, demands existence of sets S_α and S_ε in state space, for every opened set S_β permitted states and it is supplied that equilibrium point of that system will be totally stable, instead of principle of practical stability where are sets (S_α and S_ε) and set S_β which is closed, determined and known in advance. The most useful approach of control systems is Ljapunov approach, when the system is observed on infinite interval, and that in real circumstances has only academic significance. Practical stability, on the other hand, is very important for technical systems because it is observed on a finite time and space interval. Control of distributed parameter systems, which depends of time and space coordinate is called distributed control. Special class of singular control systems is the focus of our scientific paper. A singular system refers to a system of equations where the coefficient matrix is singular, meaning it is not invertible and its determinant is zero. Our main idea is to present a practical stability solution for this type of systems with distributed control which are dependable on time and only one space coordinate.

Keywords

Practical stability, finite interval, distributed control, mathematical models, singular systems.

Type of publication

Original Research Article.

WEB SPEED CONTROL BETWEEN INPUT AND OUTPUT CATEPILLAR DEVICE ON CCV LINE USING PID AND SMC CONTROLLER

Igor Kocic[1*] [0009-0002-8569-1180], Goran Mladenovic[2] [0000-0003-1706-7503], Sasa Nikolic[1] [0000-0003-2745-3862], Dragan Antic[1] [0000-0002-5880-5173], Darko Mitic[1] [0000-0001-9483-0176], Nikola Dankovic[1] [0000-0003-0986-5695], Stanisa Peric[1] [0000-0003-4766-195X]

[1]University of Nis, Faculty of Electronic Engineering, 18000 Nis, Serbia

[2]University of Belgrade - Faculty of Mechanical Engineering, Belgrade, Serbia

*Corresponding author e-mail: igor.kocic@elfak.ni.ac.rs

Abstract

This paper presents speed and cable position control between caterpillar (pulling) device on CCV (Catenary Continual Vulcanization Line) production by Royle for production middle voltage cables using PLC controller CompactLogix L35E by Allen Bradley series and DC converters DCS 6RA80 series by Siemens with PID and sliding mode control (SMC). Input caterpillar device is master device on line its speed is regulated using PID from PLC. Output caterpillar as follower device is regulated using SMC with PID sliding surface which is defined equivalent control plus switching control. SMC controller also realized in PLC in discrete form. In this work was used a direct control method because it was measured current cable position all the time. State space model of system is given using Zero order hold (ZOH) discretization and sampling time was realized using the Timed Interrupt routine. Feedback of cable position is given from a non-contact sensor (SAG measure device) by Scholz placed on the vulcanization tube and it is used in the part of the routine for the output caterpillar. As the original machine is earlier production date, a reconstruction was made using modern components for the control and regulation. During the reconstruction, DC motor with a tachogenerator were change with DC motors with encoders, PLC software was developed and written, new electrical panel were made, and mechanical component was changed and installed. It was conducted redesign of some mechanical component to allow usage of implemented speed control method. After revitalization, the machine was successfully tested in cable production and the functionality of the installed components was experimentally proven. This revitalization was useful and the presented method has shown practical value in industrial applications for producing medium voltage cables.

Keywords

SMC, SMC with PID sliding surface, DC convertor, PLC controller, speed and position regulation.

Acknowledgement

The research work is funded by the Ministry of Science, Technological Development and Innovation of Republic of Serbia (Project Contract 451-03-137/2025-03/ 200105 and 451-03-137/2025-03/200102 from 04.02.2025) and by the Framework of Scientific Research, Innovations and Digitalisation for Intelligent Transformation [grant number BG16RFPR002-1.014-0005].

Type of publication

Original Research Article.

ANALYSIS OF HELICOPTER CHARACTERISTICS DUE TO VIBRATION LOADS FOR DIFFERENT MATERIAL PROPERTIES OF ITS STRUCTURAL ELEMENTS

Mirko Maksimovic[1] [0000-0001-7004-6125], Steva Maksimovic[2] [0000-0001-5485-0105], Ivana Vasovic Maksimovic[3] [0000-0002-8310-7588], Marko Ristic[4] [0009-0005-9621-4584], Aleksandar Stepanovic[3] [0000-0002-6928-1125]

[1]PUC Waterworks and Sewerage, Kneza Milosa 27, Belgrade, Serbia

[2]Military Technical Institute, Ratka Resanovica 1, Belgrade, Serbia

[3]Lola Institute, Kneza Viseslava 70a Belgrade, Serbia

[4]University of Belgrade, Institute Mihailo Pupin volgina 15, 11000 Belgrade, Serbia,

*Corresponding author e-mail: ivanavvasovic@gmail.com

Abstract

The subject of this paper is the analysis of the helicopter's main and tail rotor blade behaviour under vibration and aerodynamic load. In this research, vibration is presented as an effect resulting from the movement of structural elements. Using CFD (Computational Fluid Dynamics) numerical simulations, the helicopter was modeled, including its fuselage, main rotor, and tail rotor. Here were presented the results of the structural elements for two different materials of helicopter blades. The original blades were made of metal, and the redesigned blades were made of composite material. Testing was performed for both types of materials, and the results obtained were compared and analyzed. The focus of the work is primarily on analyzing the influence of the tail rotor on the vibration properties of the helicopter. The experimental test was conducted to determine the impact of vibration on the helicopter fuselage. The estimation of the total life of aircraft structural elements under the influence of a load spectrum is presented in the paper. Results obtained in this research, using CFD and experimental testing, provide a comprehensive and efficient consideration of the properties and behaviours of mechanical parts, as well as a comparison of different materials from which blades are made, in order to improve the overall structure.

Keywords

Experimental Testing, Tail Rotor Blades, Composite Materials, CFD, Numerical Simulations.

Acknowledgement

This research has been supported by the research grant No. 451-03-136/2025-03/200066 of the Ministry of Science, Technological Development and Innovation of the Republic of Serbia.

Type of publication

Original Research Article.

LIFE ASSESSMENT AND ANALYSIS OF CRACK PROPAGATION FOR AIRCRAFT STRUCTURAL ELEMENTS UNDER A GENERAL LOAD SPECTRUM

Mirko Maksimovic[1] [[0000-0001-7004-6125], Ivana Vasovic Maksimovic[2] [0000-0002-8310-7588], Marko Ristic[3] [0009-0005-9621-4584], Aleksandar Stepanovic[2] [0000-0002-6928-1125], Ljubomir Nesovanovic[2] [0000-0002-7265-1596]

[1]PUC Waterworks and Sewerage, Kneza Milosa 27, Belgrade, Serbia

[2]Lola Institute, Kneza Viseslava 70a Belgrade, Serbia,

[3]University of Belgrade, Institute Mihailo Pupin, Volgina 15, 11000 Belgrade, Serbia

*Corresponding author e-mail: ivanavvasovic@gmail.com

Abstract

Aircraft structural components are exposed to cyclic loads during their operational life. Life assessment of structural elements can be divided into two phases. Phase one, life to crack initialization, and phase two, crack growth. The crucial issue is the determination of a reliable computational procedure for life assessment of aircraft structural elements. For this purpose, it is essential to determine fracture mechanics parameters, such as stress intensity factors (SIF). The computational method presented in this investigation uses singular finite elements, incorporating the load spectrum over a number of cycles or blocks up to failure. In this paper, the Strain Energy Density (SED) method is used for crack initialization and for crack growth, with the aim of determining the total fatigue life. SED is a comprehensive and efficient method that uses low cycle fatigue (LCF) properties for crack initiation and crack growth analysis. These advantages reduce the experimental testing. The focus of this research is on establishing the analytical expression for stress intensity factors (SIF). Crack growth analysis of damaged structural elements is based on conventional Forman's low and Strain Energy Density methods. Validation of the computational procedure has been done through experimental testing. In this research, a very good match of those results was obtained.

Keywords

Life Assessment, Crack Growth, Strain Energy Density Method, Cyclic Loads.

Acknowledgement

This research has been supported by the research grant No. 451-03-136/2025-03/200066 of the Ministry of Science, Technological Development and Innovation of the Republic of Serbia.

Type of publication

Original Research Article.

FLUE GAS HEAT RECOVERY FROM A BIOGAS PLANT FOR INDUSTRIAL THERMAL OIL SYSTEMS

Milan Travica[1*] [0000-0003-1156-6563], Martina Balac[1] [0000-0002-2135-0179], Nenad Mitrovic[1] [0000-0001-9296-2669], Aleksandar Petrovic[1] [0000-0003-1366-1898]

[1]University of Belgrade, Faculty of Mechanical Engineering, 11000 Belgrade, Serbia

*Corresponding author e-mail: mtravica@mas.bg.ac.rs

Abstract

This study presents a preliminary assessment of waste heat recovery from flue gases at the biogas plant to reduce fossil fuel consumption in the automotive factory, which uses thermal oil for process and space heating. The proposed solution involves directing 435°C flue gases from the biogas boiler to a gas-to-oil heat exchanger, where thermal oil is heated up to 260–300°C and transported through a 900-meter insulated pipeline to automotive factory. The thermal oil is then partially used to heat process water during winter via an additional heat exchanger. The available thermal energy from the flue gases is estimated at 387.4 kW, which covers approximately 60% of the factory's current demand, reducing the load on the existing 1512 kW fuel oil boiler and two 400 kW solid fuel boilers. The required thermal oil mass flow is calculated at 0.89 kg/s, and the pipeline insulation must be optimized to minimize heat losses due to the significant distance between source and consumer. The study highlights the technical feasibility and energy-saving potential of this system, including reduced CO_2 emissions, enhanced energy efficiency, and increased sustainability. To ensure optimal implementation, a detailed design project is recommended, including heat exchanger dimensioning, pipeline layout with thermal insulation, pump and control system design, and a comprehensive techno-economic analysis. Although the preliminary results are promising, exact values should be validated through detailed field measurements and engineering calculations. This project represents a rational and environmentally responsible approach to energy use, aligning with modern industrial efficiency goals.

Keywords

Heat recovery, energy-saving, techno-economic analysis.

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: 451-03-137/2025-03/ 200105 from 04.02.2025.

Type of publication

Review Article.

UTILIZATION OF POLYMER MATERIALS IN THE CONVEYOR IDLERS

Marko Tasic[1], Zarko Miskovic[2*] [0000-0002-8320-7191], Danilo Pejcic[2] [0009-0007-1661-2924], Jovana Antic[2] [0009-0002-6452-0294], Jan Danko[3] [0000-0002-7193-7728], Igor Kevicky[3] [0000-0002-4994-1827], Tomas Milesich[3] [0000-0002-1294-5429]

[1]Academy of Applied Studies Politehnika, Department Zemun, 11000 Belgrade, Serbia

[2]University of Belgrade, Faculty of Mechanical Engineering, Machine Design Department, 11000 Belgrade, Serbia

[3]Slovak University of Technology in Bratislava, Faculty of Mechanical Engineering, Institute of automotive engineering and design, 81231 Bratislava, Slovakia

*Corresponding author e-mail: zmiskovic@mas.bg.ac.rs

Abstract

Idlers used in conveyor systems, especially in open-pit coal mines, are subjected to extremely harsh operating conditions. Failures of these components can lead to serious consequences, including costly downtime, material damage, and even the risk of fire. Regular maintenance is crucial to avoid such hazardous events. To improve safety and facilitate easier handling during maintenance, this study proposes the use of polymer materials for manufacturing idler shells as an alternative to conventional steel. Polymer idlers offer a significantly lighter weight, making them easier to handle and replace. Additionally, their lower friction and reduced heat generation in the event of bearing failure dramatically decrease the likelihood of fire. Unlike steel, polymer is a softer material and poses no risk of damaging the rubber belt surface. Moreover, it begins to melt at temperatures far below the threshold for combustion, further enhancing fire safety. However, due to the inherently lower modulus of elasticity and tensile strength of polymer materials compared to steel, the structural design of polymer idlers must be carefully optimized to ensure that deflections and angular deformations remain within the limits specified for steel idlers. To achieve this goal, the research employed Finite Element Method (FEM) simulations and generative design techniques to develop a structurally optimized and reliable polymer idler shell that complies with all relevant mechanical performance and safety standards. In addition to the computational work, physical prototypes of conveyor idlers with polymer shells were produced and subjected to experimental testing at the Laboratory for Machine Elements and Systems Testing (LIMES) at the Faculty of Mechanical Engineering, University of Belgrade. The experimental results confirmed the central hypothesis of the study: It is feasible to use polymer materials for the construction of conveyor belt carrying idler shells in open-pit coal mines without compromising their service life or operational performance.

Keywords

Conveyor belt, Conveyor idler, Polymer shell, FEM, Generative design

Acknowledgement.

The results presented in this paper are the results of the study supported by the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia under Contract No. 451-03-137/2025-03/200105, dated February 4, 2025.

Type of publication

Original Research Article.

Engineering Materials

STRUCTURAL INTEGRITY AND LIFE OF RETROFITTED OLD STEEL BRIDGES

Dorin Radu[1] [0000-0001-5043-2723], Simon Sedmak[2] [0000-0002-2674-541X], Ciprian Bratu[1], Mihajlo Arandjelovic[2] [0000-0002-5040-5167], Aleksandar Sedmak[3] [0000-0002-5438-1895]

[1]University of Brasov, Faculty of Civil Engineering, Brasov, Romania

[2]Innovation Center of the Faculty of Mechanical Engineering, Belgrade, Serbia

[3]University of Belgrade, Faculty of Mechanical Engineering, Belgrade, Serbia

*Corresponding author e-mail: asedmak@mas.bg.ac.rs

Abstract

Structural integrity analysis was performed in the form of Engineering Critical Assessment using retrofitted steel bridge as an example. This steel bridge was built a century ago in Transylvania. Retrofitting of this bridge is presented here, taking into account structural integrity assessment. Toward this aim, structural analysis of the existing bridge and of its retrofitted version is performed, including Engineering Critical Assessment of the most common flaws of crack like type and corresponding stress intensity factor values. This bridge is riveted with parabolic truss main beam structure, and an opening of 27.86 m length. Retrofitted version proposed a transversal beam, with main beam box girder 600x1800 mm, made of steel S355, to strengthen the support structure. In addition, critical crack lengths were determined by using the Failure Assessment Diagram and used as limit values for remaining fatigue life assessment, made by applying Paris law and appropriate calculations. It was shown that the suggested retrofit solution provides lower stresses and improves remaning fatigue life.

Keywords

Steel riveted bridge, Structural Integrity, Remaining life, Engineering Critical Assessment.

Type of publication

Original Research Article.

INVESTIGATION OF TRIBOLOGICAL BEHAVIOUR OF PA12 SLIDING BEARINGS PRODUCED BY SELECTIVE LASER SINTERING

Ivan Simonovic[1*] [0000-0002-5097-9486], Aleksandar Marinkovic[1] [0000-0003-1657-4431], Dragan Milkovic[1] [0000-0002-3739-4600], Zarko Miskovic[1] [0000-0002-8320-7191], Isaak Trajkovic[2] [0000-0001-6671-4733], Milos Milosevic[2] [0000-0002-2418-1032], Aleksandar Milivojevic[1] [0000-0003-0641-6835]

[1]University of Belgrade, Faculty of Mechanical Engineering, 11000 Belgrade, Serbia

[2]Innovation Centre of Faculty of Mechanical Engineering, Belgrade, Serbia

*Corresponding author e-mail: isimonovic@mas.bg.ac.rs

Abstract

This research examines dry sliding of journal bearings made of Polyamide 12 (PA12) using additive technologies, addressing the gap in knowledge related to tribological behaviour in real conditions. In contrast to traditional tribological tests on flat surfaces, in this paper, full-scale journal bearings are tested under radial load. Three different pressure-velocity (PV) regimes were used to determine their effect on the coefficient of friction (COF), contact temperature, and surface morphology change. The results show that after a period of running-in, all tested samples reached a steady state with friction coefficients around 0.1 with insignificant oscillations, which indicates a stable and repeatable friction behaviour. Contact temperatures vary with operating conditions, where they reach their maximum at the most loaded regime, around 90 degrees, but it is still below the PA12 Vicat softening temperature (175°C), which indicates thermal stability. Scanning electron microscopy (SEM) analysis of the surface before and after testing confirms microstructural changes at the contact zone, showing a transition from a particulate to a smoother structure. The intermediate mode used in the test shows an optimal balance between frictional performance and thermal stability. The obtained results demonstrate that SLS-printed PA12 bearings can be applied in conditions without external lubrication, thereby enabling maintenance-free systems with operational parameters suitable for use. This work provides significant insight into industrial applicability and provides a basis for future tests that will deal with long-term tests and comparative evaluation with bearings produced via other additive manufacturing techniques.

Keywords

Polyamide 12, Additive Manufacturing, Sintering, Sliding Bearings, Dry Friction.

Acknowledgement

The authors acknowledge the support from the Ministry of Education, Science and Technological Development of the Republic of Serbia (Contract No. 451-03-137/2025-03/200105 and 451-03-136/2025-03/ 200213, dated 04.02.2025). The authors express gratitude to the company "3D Republika" for supplying all specimens utilized in this research.

Type of publication

Original Research Article.

DIGITAL TWINS IN FRACTURE ANALYSIS OF PIPELINE MATERIALS: A REVIEW OF CURRENT APPROACHES AND METHODOLOGIES

Milos Milosevic[1*] [0000-0002-2418-1032], Goran Mladenovic[2] [0000-0003-1706-7503], Francesco Mercuri[3], Andrea Lorenzoni[3]

[1]Innovation center of Faculty of Mechanical Engineering, Kraljice Marije 16, 11000, Belgrade, Serbia

[2]University of Belgrade – Faculty of Mechanical Engineering, 11000 Belgrade, Serbia

[3]ISMN-CNR, Bologna, Italy

*Corresponding author e-mail: mmilosevic@mas.bg.ac.rs

Abstract

This paper presents a review of recent research focused on the application of digital twins for fracture propagation analysis in ring-shaped specimens that simulate the behavior of thin-walled pipeline materials under loading. The emphasis is placed on the integration of the finite element method with fracture mechanics principles to predict stress intensity factors, J-integral values, and crack growth under complex geometries and loading conditions. The reviewed studies utilize numerical tools such as Simulia Abaqus, Ansys, and other commercial and open-source software, along with experimental methodologies for validating digital models. Special attention is given to iterative model calibration, the influence of geometry, material properties, and loading scenarios on prediction accuracy, as well as challenges related to standardizing procedures for structural integrity assessment. The paper identifies key directions for future research, including the development of comprehensive datasets for training AI-based models, advancement of multiphysics simulations, and the broader implementation of digital twins in real-world pipeline systems across the energy, petrochemical, and fluid transport sectors. This review contributes to a deeper understanding of the current state and potential of digital twins in fracture analysis and risk management in engineering practice.

Keywords

Digital twins, Fracture mechanics, AI-based models, Multiphysics simulations, PRNT

Acknowledgement

This research was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (contr. 451-03-136/2025-03/ 200213) and CBC IT-SRB (ref. no. 00203859320251344000300000000102002)

Type of publication

Review Article.

COMPARATIVE ANALYSIS OF METAL AND POLYMER ADDITIVE MANUFACTURING TECHNOLOGIES

Aleksandra Mitrovic[1,2] [0000-0002-5183-6276], Djordje Dihovicni[1] [0000-0003-0961-2540], Dragan Kreculj[1] [0000-0003-3268-4024]

[1]The Academy of Applied Studies Polytechnic, Novi Beograd Section, 11000 Belgrade, Serbia

[2]University “Union - Nikola Tesla”, Faculty of Information Technology and Engineering, 11000 Belgrade, Serbia

*Corresponding author e-mail: amitrovic@politehnika.edu.rs

Abstract

This paper presents a comparative analysis of metal and polymer 3D printing technologies in terms of their material properties, process parameters, mechanical performance, and industrial applications. Additive manufacturing (AM) of polymers is widely used due to lower cost, faster prototyping, and flexibility in design, while metal 3D printing offers superior mechanical strength, thermal resistance, and suitability for high-performance applications in aerospace, automotive, and medical sectors. The study evaluates key differences in printing techniques, including Fused Deposition Modeling (FDM) and Stereolithography (SLA) for polymers, versus Selective Laser Melting (SLM) and Electron Beam Melting (EBM) for metals. A systematic comparison is made regarding surface finish, dimensional accuracy, post-processing requirements, and environmental impact. The results indicate that while polymer AM remains dominant in rapid prototyping and consumer-grade products, metal AM is advancing rapidly due to increased demand for functional, end-use parts. The paper concludes with an outlook on hybrid applications and the future integration of both material systems in multifunctional components.

Keywords

3D printing, polymers, metals, additive manufacturing, process comparison

Acknowledgement

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

Type of publication

Review Article.

EVALUATION OF SPECIMEN GEOMETRY FOR RELIABLE MECHANICAL TESTING OF THERMOPLASTIC ALIGNER MATERIALS

Jelena Markovic[1] [0009-0003-1259-0335], Tina Pajevic[1] [0000-0002-6185-7409], Aleksandra Mitrovic[2,3] [0000-0002-5183-6276], Milan Travica[4] [0000-0003-1156-6563], Aleksa Milovanovic[5] [0000-0003-4668-8800], Nenad Mitrovic[4] [0000-0001-9296-2669]

[1]University of Belgrade, Faculty of Dental Medicine, Department of Orthodontics, 11000 Belgrade, Serbia

[2]The Academy of Applied Studies Polytechnic, Novi Beograd Section, 11000 Belgrade, Serbia

[3]University “Union - Nikola Tesla”, Faculty of Information Technology and Engineering, 11000 Belgrade, Serbia

[4]University of Belgrade, Faculty of Mechanical Engineering, 11000 Belgrade, Serbia

[5]Inovation Center of Faculty of Mechanical Engineering, 11000 Belgrade, Serbia

*Corresponding author e-mail: jelenamarkovic182@gmail.com

Abstract

A thorough understanding of the variuos mechanical properties of thermoplastic materials is crucial for effective aligner treatment. The appropriate testing parameters and specimen shape for mechanical testing of aligners must be determined in order to obtain reliable results and accurate testing conditions. The aim of this study was to evaluate whether the rectangular shaped specimens, as proposed in previous studies, are suitable for Digital Image Correlation (DIC) testing. In this experimental study, a single type of material was used: Leone aligner PET-G sheet. Material was used in its original, uniformed, and flat form without thermoforming process prior to testing. Rectangular specimens of 1 mm thickness were laser cut to 20x5 mm. A total of five specimens were tested. Each specimen was spray painted with white and black acrylic paint to generate high contrast spots. All specimens were tested individually after fixing them manually in the universal testing machine. The tensile test was performed at speed of 1 mm/min. The specimens’ behaviour under load was evaluated using DIC method. The results showed that rectangular specimens did not consistently fracture in the central region where the stress was expected to be the highest. Instead, fractures occurred in the clamping areas, indicating that the stress concentrations were introduced by the fixation, rather than the material itself. Based on these results, rectangular specimens are not recommended for mechanical testing of aligner materials, as they showed inconsistent fracture locations and non-uniform strain distribution.

Keywords

Thermoplastic materials, PETG, mechanical testing, specimen geometry, DIC.

Type of publication

Original Research Article.

CRACK GROWTH ANALYSIS OF WELDED JOINTS USING DIC AND ARAMIS

Jasmina Lozanovic[1] [0000-0002-5717-4269], Nenad Gubeljak[2] [0000-0002-3276-8431], Drazan Kozak[3] [0000-0001-6542-0688], Aleksandar Sedmak[4] [0000-0002-5438-1895]

[1]FH Campus Wien - University of Applied Sciences, Department of Engineering, Austria

[2]University of Maribor, Faculty of Mechanical Engineering, Maribor, Slovenia

[3]University of Slavonski Brod, Faculty of Mechanical Engineering, Sl. Brod, Croatia

[4]University of Belgrade, Faculty of Mechanical Engineering, Belgrade, Serbia

*Corresponding author e-mail: asedmak@mas.bg.ac.rs

Abstract

Welded plates with a surface crack in heat-affected-zone (HAZ) and weld metal (WM) were tested under tension using digital image correlation (DIC) to measure strains and to analyse crack growth. Crack length was 2a=30 mm, crack depth 6.5 mm, plate thickness 13 mm, plate width 40 mm. Material was X60, used typically for pipelines, with yield stress (YS) 450 MPa, tensile strength (TS) 600 MPa, elongation A_5 22% and toughness KV 73 J at room temperature. Plate was loaded by tension until failure (crack in HAZ) or large plastic strains (crack in WM) to follow strain distribution and crack growth by ARAMIS and to obtain Failure Assessment Diagram (FAD). It was shown in both cases that crack growth was not the main mechanism of the failure which was rather due to net section extensive yielding, in accordance with expected behaviour of this type of steel and its welded joints if welding was performed appropriately. The FAD was in excellent agreement with the crack driving forces obtained numerically.

Keywords

Welded plates, Surface crack, Digital Image Correlation, ARAMIS

Type of publication

Original Research Article.

Experimental Techniques

EXPERIMENTAL ANALYSIS OF THE BIOMECHANICAL BEHAVIOR OF THE HEAD AND NECK UNDER IMPACT WITH PROTECTIVE HELMET

Katarina Telebak[1*] [0009-0001-5689-6745], Isaak Trajkovic[1] [0000-0001-6671-4733], Milos Milosevic[1] [0000-0002-2418-1032], Jelena Jovanovic[2] [0000-0001-7814-5216]

[1]Innovation Center, Faculty of Mechanical Engineering, Kraljice Marije 16, 11000 Belgrade, Serbia

[2]University of Montenegro, Faculty of Mechanical Engineering, Podgorica, Montenegro

Corresponding author e-mail: ktelebak@mas.bg.ac.rs

Abstract

This study presents a comprehensive experimental analysis of a protective helmet subjected to uppercut-type impacts directed at three critical anatomical zones: the top of the head, the chin, and the cheek. The primary aim was to assess the mechanical behavior of the helmet and to evaluate the influence of different helmet stabilization conditions on the dynamic response of the head and cervical spine during impact. For each impact zone, three distinct testing conditions were examined: (1) the helmet tightly secured to the shoulders using ropes, (2) the helmet loosely fastened, and (3) the helmet completely free and unsupported.

A physical model of the helmet and head structure was developed and tested in the laboratory of the Faculty of Mechanical Engineering. Controlled impacts were applied to simulate real-world uppercut strikes, while the deformation and motion of the system were precisely recorded using the ARAMIS optical measurement system. This system enabled high-resolution, non-contact tracking of displacement fields, strain distribution, and acceleration profiles across the surface of the helmet, head, and neck region. Special focus was placed on the kinematic behavior of the head and the mechanical response of the cervical vertebrae under different helmet stabilization conditions. The analysis revealed that the method of helmet attachment plays a significant role in the transmission of forces and resulting stress states, not only in the cranial area but also along the neck and spine. These insights are particularly important when considering long-term injury risks such as whiplash or cervical spine trauma, which may not be mitigated by conventional helmet designs.The findings of this study contribute to the ongoing development of next-generation protective headgear, optimized not only for skull protection but also for reducing biomechanical load transfer to the neck. Such designs hold relevance in combat sports, industrial safety, and military applications.

Keywords

Protective helmet, uppercut impact, dynamic analysis, ARAMIS system, head and neck

Acknowledgement

This research work and the presented results were supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia under the Agreement No. 451-03-136/2025-03/200105 dated February 4th, 2025.

Type of publication

Original Research Article.

.

TENSILE STRENGTH ANALYSIS OF POLYMERS FABRICATED USING FUSED FILAMENT FABRICATION

Natalija Lazarevic[1], Kristina Andjelic[1], Aleksandar Lazic[1], Mihajlo Popovic[1] [0000-0003-3607-9243], Goran Mladenovic[1] [0000-0003-1706-7503], Milos Pjevic[1] [0000-0002-4454-8663], Aleksa Milovanovic[2] [0000-0003-4668-8800]

[1]University of Belgrade – Faculty of Mechanical Engineering, Belgrade, Serbia

[2]Innovation Centre of The Faculty of Mechanical Engineering, Belgrade, Serbia

*Corresponding author e-mail: mpopovic@mas.bg.ac.rs

Abstract

This paper presents results of the experimental testing of 3D-printed specimens made from various materials. The applied technology for producing these specimens was Fused Filament Fabrication (FFF). The study was conducted in order to reach a conclusion about certain mechanical properties of examined materials, which find the vastest use in commercial 3D printing using FFF method. These materials include Polylactic acid (PLA), Acrylonitrile Butadiene Styrene (ABS), Acrylonitrile styrene acrylate (ASA) and Polyethylene Terephthalate Glycol (PETG). The specimens were produced according to the ISO 20753 standard in a direction perpendicular to the stretching direction to obtain maximum strength. The printer used for producing these specimens was Sindoh 3DWOX 1X. All the printing parameters remained the same for all specimens, excluding the nozzle and bed temperature, which were adjusted according to recommendations for specific materials. The testing was carried out on Shimadzu AGS-X 100kN universal testing machine with a crosshead speed of 1mm/min. The results were focused on elastic properties of materials and tensile strength. ABS showed the lowest values of ultimate tensile strength. PETG proved to be the least elastic, while PLA exhibited both the highest elastic properties and the highest ultimate tensile strength. However, PLA is not suitable for long-term use in places with elevated temperatures since it is prone to deformation. Based on the desired application and mechanical properties, the most suitable material should be chosen.

Keywords

Additive technologies, Fused Filament Fabrication (FFF), Tensile strength.

Acknowledgement

The research work is funded by the Ministry of Science, Technological Development and Innovation of Republic of Serbia. Project Contract 451-03-137/2025-03/ 200105 from 04.02.2025.

Type of publication

Original Research Article.

DIGITAL IMAGE CORRELATION-ENABLED DIGITAL TWIN FRAMEWORK FOR STRUCTURAL INTEGRITY ASSESSMENT OF WELDED STEEL PIPELINES

Nenad Mitrovic[1*] [0000-0001-9296-2669], Milan Travica[1] [0000-0003-1156-6563], Aleksandar Petrovic[1] [0000-0003-1366-1898]

[1]University of Belgrade, Faculty of Mechanical Engineering, Center for Optical Measurement, 11000 Belgrade, Serbia

*Corresponding author e-mail: nmitrovic@mas.bg.ac.rs

Abstract

Ensuring the structural integrity of welded steel pipe networks that operate under fluctuating pressure and temperature remains a core challenge for mechanical engineers. Point-based sensors capture only a fraction of the complex strain fields that develop around welds, elbows, and other stress concentrators, limiting the predictive accuracy of numerical models used for fitness-for-service evaluations. From a digital image correlation (DIC) perspective, the solution lies in coupling high-resolution, full-field measurements with continuously updating computational twins. This paper presents a practitioner-oriented concept in which a compact 2D DIC module, comprising an industrial camera, LED illumination, and a graphics board, acquires displacement data directly on the pipe surface. Indicators, such as equivalent plastic strain, wall ovality, and local curvature change, serve as update inputs to a physics-informed twin that combines nonlinear finite-element mechanics with data-driven parameter estimation. Planned verification includes laboratory cyclic-loading studies and numerical sensitivity analyses to establish permissible correlation noise, optimal update frequency, and convergence criteria for critical load assessments. By integrating field-deployable DIC instrumentation with an adaptive digital twin, the proposed framework offers a realistic, low-latency pathway for condition-based maintenance of pressure pipeline and aligns with emerging industry standards for asset-integrity management.

Keywords

Digital Image Correlation; Digital Twin; Welded Steel Pipeline; Structural Integrity; Condition-Based Maintenance

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: 451-03-137/2025-03/ 200105 from 04.02.2025.

Type of publication

Review Article.

EDGE-AI-ENABLED 2D DIGITAL IMAGE CORRELATION FOR AUTONOMOUS STRUCTURAL HEALTH MONITORING OF STEEL STRUCTURES AND PRESSURE EQUIPMENT

Nenad Mitrovic[1*] [0000-0001-9296-2669], Milan Travica[1] [0000-0003-1156-6563], Aleksandar Petrovic[1] [0000-0003-1366-1898]

[1]University of Belgrade, Faculty of Mechanical Engineering, Center for Optical Measurement, 11000 Belgrade, Serbia

*Corresponding author e-mail: nmitrovic@mas.bg.ac.rs

Abstract

Continuous assessment of in-service steel structures and pressure equipment has been constrained by the high-bandwidth, workstation-level computation traditionally required for digital image correlation (DIC). The large data volumes produced by conventional optical systems have therefore restricted full-field strain monitoring to controlled laboratory environments. To overcome this limitation, an embedded 2D DIC strategy is recommended in this paper. Displacement and strain fields are evaluated directly on a low-power graphics module positioned at the camera head, eliminating the need to stream raw imagery. A streamlined on-device AI model matches the image pixels in real time, while a second AI model instantly converts the resulting strain maps into early damage warnings and clear estimates of the structure's remaining strength. Only condensed structural health indicators and alarm flags are transmitted, reducing data traffic by more than an order of magnitude. Validation under representative static and cyclic loading scenarios typical of welded joints, pressure vessels and pipework are advised, with particular attention to the rapid detection of critical strain localisations and the early prediction of crack-growth trends. Adoption of such an edge-AI DIC module is expected to deliver a deployable, low-latency pathway toward condition-based maintenance for steel infrastructure and pressure equipment operating under variable service conditions.

Keywords

Digital Image Correlation; Edge AI; Structural Health Monitoring; Steel Structures; Pressure Equipment

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: 451-03-137/2025-03/ 200105 from 04.02.2025.

Type of publication

Review Article.

MECHANICAL CHARACTERIZATION OF 3D-PRINTED EXPERIMENTAL PRTS USING DIC METHOD

Milan Travica[1*] [0000-0003-1156-6563], Martina Balac[1] [0000-0002-2135-0179], Nenad Mitrovic[1] [0000-0001-9296-2669], Aleksandar Petrovic[1] [0000-0003-1366-1898], Aleksandar Vujovic[2] [0000-0002-0011-7722]

[1]University of Belgrade, Faculty of Mechanical Engineering, 11000 Belgrade, Serbia

[2]University of Montenegro, Faculty of Mechanical Engineering, Podgorica, Montenegro

Corresponding author e-mail: mtravica@mas.bg.ac.rs

Abstract

The main objective of this paper is to investigate the mechanical behaviour of 3D-printed Pipe Ring Specimen (PRTS) made of polymer materials, with a focus on the influence of infill density and specimen geometry on tensile performance. Two types of PRTS specimens were analysed—PRTS-T1 and PRTS-T2—manufactured using Fused Deposition Modelling (FDM) technology, with varying infill levels (60%, 90%, and 100%). An additional aim of the study is to assess the applicability and limitations of the Digital Image Correlation (DIC) method in characterizing surface deformations during tensile testing of non-standard geometries. Based on the observed fracture locations and the quality of strain field data, recommendations are made regarding specimen selection for further research. Another goal is to compare the experimental results of PRTS specimens with data from the literature concerning flat tensile specimens produced with similar 3D printing parameters. The comparative analysis includes tensile strength values, strain distribution, and deformation patterns, taking into account differences in cross-sectional areas and infill structures. The paper also aims to identify the optimal combination of specimen type and infill percentage that ensures valid and reproducible results while minimizing material usage and production time. This research contributes to establishing testing procedures for non-standard specimens in additive manufacturing and provides a foundation for the further development of experimental methodologies in the field of mechanical characterization of 3D-printed polymer components.

Keywords

DIC, Pipe Ring Tensile Specimen, 3D printing, Fused Deposition Modelling.

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: 451-03-137/2025-03/ 200105 from 04.02.2025.

Type of publication

Review Article.

Numerical Methods

APPLICATION OF CFD FOR SIMULATION OF TRANSITIONAL FLOW IN SMOOTH CIRCULAR PIPES

Milica Ivanovic[1*][0000-0001-6239-703X], Nemanja Jovanovic [1] [0000-0002-8986-9671], Dragoljub Tanovic[1] [0000-0002-7806-1458], Milan Rakic[1] [0009-0001-1898-9326], Toni Ivanov[1] [0000-0002-8204-4669]

[1]University of Belgrade, Faculty of Mechanical Engineering, Department of Aerospace Engineering, 11000 Belgrade, Serbia

*Corresponding author e-mail: mivanovic@mas.bg.ac.rs

Abstract

The transitional flow regime in internal pipe flow presents unique challenges for accurate computational fluid dynamics (CFD) modelling due to its inherently unstable and intermittent nature. Transitional flows in pipes are encountered in numerous engineering applications, ranging from oil and gas pipelines to biological systems and various industrial processes. Experimental studies investigating the effects of flow transition have been conducted across a broad range of scales, from large industrial setups to microscopic systems. Intermittency, as a hallmark of transition, significantly influences flow characteristics such as velocity distribution, heat transfer, and pressure loss. Capturing the intermittent nature of transitional flows in CFD remains a significant challenge. Emphasis is placed on turbulence models enhanced with intermittency functions, such as the SST Transition (γ–Reθ) model, which is capable of capturing the gradual and spatially non-uniform onset of turbulence. Here, a set of simulations were completed for the case of a straight, circular pipe, long enough to establish fully developed conditions (L/D = 200), for different values of turbulence intensity levels at the inlet and for different Reynolds numbers. Fluid is water. This simulation study highlights the importance of turbulence transition modelling in predicting pressure drop, velocity profiles, and flow development length, providing insight into optimizing fluid transport with systems that can operate within this sensitive flow regime.

Keywords

Transitional flow, CFD, simulation, smooth circular pipe

Acknowledgement

The results presented here are within research project supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, under contract 451-03-136/2025-03/ 200105, dated 04.02.2025.

Type of publication

Original Research Article.

RADIOTRACER METHODS IN INDUSTRIAL PROCESSES: PRINCIPLES, APPLICATIONS, AND LIMITATIONS

Srdjan Vukovic[1] [0000-0001-7573-5712], Danijela Rajic[1] [0000-0002-1169-5755], Aleksandar Vukovic[2] [0000-0003-0549-6183], Svetlana Pelemis[1*] [0000-0001-9682-5899]

[1]University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, 75400 Zvornik, Bosnia and Herzegovina

[2]University of Novi Sad, Faculty of Technical Sciences, Trg Dositeja Obradovica 6, 21102 Novi Sad, Serbia

*Corresponding author e-mail: alannica@gmail.com

Abstract

Radiotracer methods are among the most effective tools for non-invasive investigation of fluid flow, mixing, residence time distribution (RTD), identification of dead zones, short-circuiting, and other mass transport phenomena in complex industrial systems. This review paper provides a comprehensive overview of the fundamental principles, methodologies, safety requirements, and industrial applications of radiotracers, with a particular focus on metallurgical, petrochemical, food processing, and energy sectors.

Through the analysis of recent research and experimental studies, the paper demonstrates how radiotracers are employed for quantitative and qualitative system diagnostics under real operating conditions, including fluid tracking in pipelines, packed columns, reactors, and ventilation systems. Applications also extend to wastewater treatment plants and interwell testing in oil and geothermal reservoirs.

Despite their high experimental value, the broader application of these techniques remains limited due to equipment complexity, procedural requirements, and a shortage of specialized personnel.

There is an increasing need for the standardization of methodologies, institutional support, and further digital integration to enable full incorporation of radiotracer technologies into the development of smart, energy-efficient, and sustainable industrial systems.

This work lays the groundwork for future research and explores the potential for broader application of radiotracer methods in industrial diagnostics and process optimization.

Keywords

Radiotracers, Industrial diagnostics, Residence time distribution (RTD), Process optimization

Type of publication

Review Article.

APPLICATION OF FINITE ELEMENT ANALYSIS (FEA) SIMULATIONS IN MEASURING ROOT SURFACE TEMPERATURE DURING CRYOTHERAPY

Ognjen Radivojevic[1*] [0000-0003-2488-101X], Milica Ivanovic[2] [0000-0001-6239-703X], Toni Ivanov[2] [0000-0002-8204-4669], Jelena Neskovic[1] [0000-0002-1080-7305], Dragica Manojlovic[1] [0000-0002-9653-4255], Milos Milosevic[3] [0000-0002-2418-1032]

[1]University of Belgrade, School of Dental Medicine, Department of Restorative Dentistry and Endodontics, 11000 Belgrade, Serbia

[2]University of Belgrade, Faculty of Mechanical Engineering, Department of Aerospace Engineering, 11000 Belgrade, Serbia

[3]Innovation Centre of The Faculty of Mechanical Engineering, 11000 Belgrade, Serbia

Corresponding author e-mail: ognjen.radivojevic@stomf.bg.ac.rs

Abstract

The aim of this study is to implement Finite Element Analysis (FEA) simulations in order to obtain data that could not be acquired through in vitro experimental setups. Several in vitro experiments conducted at room temperature have shown that cryotherapeutic effects on the root surface of tooth can be achieved using specific root canal irrigation protocols. However, clinical conditions—such as body temperature and tissue moisture—differ significantly from those in a laboratory setting, raising questions about the direct applicability of these protocols in clinical practice.

The initial plan for research involved designing an in vitro experiment that would simulate the real conditions of a tooth embedded in bone. The setup included P1000 temperature sensors attached to the root surface, with the tooth placed in a water bath maintained at body temperature (37°C) to replicate a humid physiological environment. However, the results exhibited significant anomalies, including unexpected temperature fluctuations, which were attributed to inadequate insulation of the sensors from the surrounding fluid. Despite multiple attempts, a reliable method of sensor attachment and waterproofing could not be achieved.

To overcome these limitations, FEA simulations were implemented to computationally recreate the desired clinical conditions. The simulation model was validated using previously published data obtained at room temperature, which had been successfully established in earlier studies. The outcomes of the simulations aim to determine whether cryotherapeutic effects can also be achieved under clinical conditions. Additionally, by manipulating key variables such as fluid volume, temperature, flow rate, dentin wall thickness, and irrigation time, FEA allows for the identification of optimal parameters for inducing cryogenic effects in clinical conditions.

Keywords

Finite element analysis, numerical, cryotherapy, irrigation, tooth.

Type of publication

Original Research Article.

New Technologies

APPLICATION OF RULE BASED PARAMETRIC COMPUTER PRODUCT DESIGN

Mladenovic Goran[1*] [0000-0003-1706-7503], Puzovic Radovan[1] [0000-0003-0552-5247], Milovanovic Marko[2] [0000-0003-1580-0898], Filipovic Ivana[3] [0000-0002-7977-2980], Popovic Mihajlo[1] [0000-0003-3607-9243], Pjevic Milos[1] [0000-0002-4454-8663]

[1]University of Belgrade - Faculty of Mechanical Engineering, Belgrade, Serbia

[2]Physikalisches Institut, Justus-Liebig-Universitaet, Giessen, Germany

[3]Innovation Centre of Faculty of Mechanical Engineering, Belgrade, Serbia

Corresponding author e-mail: gmladenovic@mas.bg.ac.rs

Abstract

The use of Computer-Aided Design (CAD) systems is now ubiquitous in modern industry. Virtually no manufacturing company develops new products without some level of computer assistance. However, conventional constraint-based CAD modelling can be time-consuming—particularly in the context of Industry 4.0, where speed and automation are increasingly critical. This challenge is especially evident in companies that produce families of similar parts, where designers must repeatedly generate models from scratch.

Parametric modelling offers a solution by enabling automation in the development of new products. It allows external data tables to drive CAD models, making them interactive and accessible through web-based applications (e.g., via the World Wide Web). Such systems empower users without CAD expertise to interact with product models, thanks to embedded design rules that enforce constraints and automate calculations. These rules ensure product parameters remain within predefined limits or are derived from existing values.

In this study, a parametric CAD model of a universal press was developed using the commercial software Autodesk Inventor. The model integrates custom design rules and maintains full associativity with data stored in an external table. Automated regeneration of the assembly model was tested by altering input parameters, and the system's rule-enforcement functionality was validated. If rule conditions were violated, the CAD system triggered a user-defined notification window designed by the product developer.

This approach demonstrates a practical method for automating product development workflows, which can be customized to meet specific client requirements.

Keywords

CAD Systems, Parametric Modeling, Rule-Based Design.

Acknowledgement

The research work is funded by the Ministry of Science, Technological Development and Innovation of Republic of Serbia. Project Contract 451-03-137/2025-03/ 200105 from 04.02.2025.

Type of publication

Original Research Article.

DESIGN AND NONLINEAR CONTROL OF A ROBOTIC MECHANISM FOR PRECISION NEEDLE INSERTION IN DEFORMABLE MEDIA

Ivan M. Buzurovic [0000-0001-9632-3434]

Harvard Medical School, Harvard University, Boston, MA, USA

*Corresponding author e-mail: ibuzurovic@bwh.harvard.edu

Abstract

Purpose: The goal of this study is to develop and evaluate a novel, automated needle insertion system aimed at improving accuracy and consistency in interstitial brachytherapy procedures. Manual insertions often suffer from tissue deformation and unpredictable needle deflection, leading to suboptimal placement of radioactive sources. To address these limitations, the study proposes a robotic device paired with a predictive control strategy capable of dynamic adaptation to tissue interaction forces.
Methods and Materials: A portable, multipurpose needle inserter (PIN) was designed with variable degrees of freedom, enabling both translational and rotational motion. The mechanical system was modeled using a hybrid approach that combines rigid-body dynamics and elastic beam theory. A nonlinear mathematical framework was established through the assumed-modes method and Euler–Bernoulli beam assumptions, supporting real-time simulation and control. A model predictive controller (MPC) was implemented to manage insertion force and needle orientation dynamically, using measured and predicted forces to minimize deflection. Simulations incorporated realistic in vivo force profiles, and the system's performance was evaluated through trajectory tracking and force response analyses.
Results: The simulations demonstrated that the proposed MPC method significantly reduced lateral needle displacement compared to conventional PID control. Needle tip errors remained below 1 mm under varying insertion depths and forces. Including rotational control proved essential in maintaining alignment, with reduced torques and improved insertion stability. The system demonstrated stable accuracy despite differing resistance levels. Comparative dosimetric analysis of clinical cases showed negligible impact on treatment outcomes for errors within the observed range.
Conclusion: This research confirms the feasibility of real-time, model-based control for automated needle insertion. The integration of predictive control with a lightweight, adaptable robotic mechanism offers a promising solution for improving precision in brachytherapy and related interventions. Future work will focus on hardware integration, system miniaturization, and clinical validation through clinical trials.

Keywords

Automated needle insertion, Model predictive control (MPC), Robotic system design, Needle trajectory control

Acknowledgement

This research was partially funded through the Taiclet MRI Program award.

Type of publication

Original Research Article.

DEVELOPMENT AND IMPLEMENTATION OFF GRID POWERED HYDROMETEOROLOGICAL STATIONS ALONG THE SAVA AND DANUBE WATERWAYS

Marko Ristic[1] [0009-0005-9621-4584], Zeljko Despotovic[1] [0000-0003-2977-6710], Marko Batic[1] [0000-0002-8443-3932], Marko Tajdic[1] [0009-0002-1187-2988], Ivana Vasovic Maksimovic[2] [0000-0002-4277-9783]

[1]University of Belgrade, Institute Mihailo Pupin volgina 15, 11000 Belgrade, Serbia

[2]Lola Institute,Kneza Viseslava 70a, 11000 Belgrade Serbia

*Corresponding author e-mail: marko.ristic986@gmail.com

Abstract

The primary objective of this project is the development and implementation of a sophisticated system for monitoring hydrometeorological data and changes in physical parameters along the Sava and Danube rivers. These data are essential for the management and control of navigability on these waterways. The system consists of an OFF-GRID power supply unit, a hydrometeorological station, and a floating buoy. The hydrometeorological station (HMS) collects meteorological and hydrological data via sensors (e.g., water pressure and depth and meteo station), which are connected to the main station unit. The floating buoy monitors and measures parameters directly on the water surface. All data collected by the sensors are transmitted—either via wired or wireless communication—to the data concentrator, which serves as the system's central component. The data concentrator is a PLC device, the Atlas Max – RTL Hydra, developed at the Mihailo Pupin Institute in Belgrade. The entire system is powered autonomously using a 12V DC battery, charged through a solar panel and a dedicated solar charger equipped with an MPPT (Maximum Power Point Tracking) controller. This configuration ensures complete independence from the conventional 230V, 50Hz electrical grid. A total of 38 data acquisition hydrometeorological stations will be deployed along the Sava and Danube waterways. This system is not only unique within the national context but also represents a pioneering solution in the broader regional landscape.

Keywords

Hydrometeorological station, waterways, measuring, acquisition, OFF GRID power, measuring station

Type of publication

Original Research Article.

COMPARISON OF GENERATIVE DESIGN AND CONVENTIONAL MECHANICAL MATERIAL PROCESSING TECHNIQUES

Aleksandra Mitrovic[1,2] [0000-0002-5183-6276], Ivana Ilic[2] [0000-0003-0961-2540], Ziad Alamin Emhmed Alhashmi[2] [0009-0008-0698-5919]

[1]The Academy of Applied Studies Polytechnic, Novi Beograd Section, 11000 Belgrade, Serbia

[2]University “Union - Nikola Tesla”, Faculty of Information Technology and Engineering, 11000 Belgrade, Serbia

*Corresponding author e-mail: amitrovic@politehnika.edu.rs

Abstract

This paper examines the differences between generative design and conventional mechanical material processing procedures from a technical and engineering perspective. Generative design utilizes algorithm-driven, iterative modeling methods to explore thousands of design alternatives based on predefined constraints, often optimized for weight reduction, material efficiency, and performance. In contrast, conventional processes such as milling, turning, and forging rely on subtractive or formative techniques grounded in established design geometries and traditional engineering practices. The study compares these approaches in terms of design flexibility, manufacturability, material utilization, production time, and cost-effectiveness. Furthermore, the integration of generative design with additive manufacturing offers new opportunities for creating complex geometries that are not feasible using standard machining. While conventional methods provide reliability and precision in mass production, generative design proves advantageous in prototyping, customization, and performance-driven applications. The paper concludes by discussing the future of hybrid workflows that combine generative algorithms with both additive and subtractive manufacturing methods.

Keywords

Generative design, mechanical processing, material optimization, CAD/CAM, hybrid manufacturing.

Type of publication

Review Article.

OPTIMISING HEAVY METAL LEACHATE FROM WASTE-TO-ENERGY BOTTOM ASH FOR FURTHER APPLICATION

Filip Kokalj[1*] [0000-0001-9234-7834], Vesna Alivojvodic[2] [0000-0002-4578-7519], Niko Samec[1] [0000-0001-8500-5393]

[1]University of Maribor, Faculty of Mechanical Engineering, 2000 Maribor, Slovenia

[2]Academy of Applied Studis Polytechnic, 11000 Belgrade, Serbia

*Corresponding author e-mail: filip.kokalj@um.si

Abstract

Considering the vast scale of waste-to-energy plants, with nearly 500 in the EU and over 2,000 worldwide, these facilities play a pivotal role in efficient processing more than 100 million tons of municipal solid waste annually. This process transforms approximately 20% of the input mass into ash, producing significant amounts yearly.
Since heavy metals are sometimes found in leachate in concentrations that render the ash non-inert or even hazardous, the environmental impact reducing techniques becomes necessary. This reduction is not just a goal, it is a crucial step that enables the reuse of this material.
The samples used in this study were obtained from a waste-to-energy plant in Slovenia and processed using laboratory equipment. The research presented several options for stabilising bottom ash to reduce heavy metal leachability. The ash processing altered the ash structure and reduced heavy metal concentration in leachate, yielding promising results for some heavy metals. This opens up new possibilities for ash utilisation and minimisation of its environmental impact.
As the results of proposed techniques promise to significantly reduce heavy metal leachability, offering a path towards a more sustainable waste-to-energy process, future research should optimise stabilisation processes to balance effectiveness with economic feasibility.

Keywords

Heavy metals, leachate, waste-to-energy plant, bottom ash.

Type of publication

Original Research Article.

REVERSE ENGINEERING OF AN UAV PROPELLER

Rakic Z. Milan[1*] [0009-0001-1898-9326], Ivanov D. Toni[2] [0000-0002-8204-4669], Pandzic Adi[3] [0000-0003-0807-5122]

[1]Innovation Center of Faculty of Mechanical Engineering, 11000 Belgrade, Serbia

[2]University of Belgrade, Faculty of Mechanical Engineering, Department of Aerospace Engineering, 11000 Belgrade, Serbia

[3]University of Sarajevo, Faculty of Mechanical Engineering, Vilsonovo setaliste 9, Sarajevo, 71000, Bosnia and Herzegovina

*Corresponding author e-mail: mzrakic@mas.bg.ac.rs

Abstract

When designing an aircraft propulsion system, knowledge of the aerodynamic and structural characteristics of the propeller is essential. A methodology for obtaining a suitable CAD model of a propeller using reverse engineering techniques is presented here. Due to the complex geometry of propellers, especially considering the cross-sections along the blade (airfoil shape, chord length, twist angle, and thickness), traditional reverse engineering methods can be impossible and/or extremely time consuming. By utilizing 3D scanning a point cloud approximating the propeller's geometry can be obtained which, can then be used for the creation of the parametric 3D model. The parametric 3D model can then be used for aerodynamic and structural analysis as well as for performing optimization procedures.

The steps involved in this process are outlined step by step: starting from laser scanning to obtain data using a 3D scanner, all the way to generating a CAD model in a commercial CAD software.

To get the coordinates of the surface points, the propeller was scanned using the Creality CR-Scan Raptor Pro 3D Scanner. This 3D scanner uses an all-glass lens with a large depth of field, combining laser and photogrammetry scanning techniques, providing the possibility to scan objects from small screws to parts with dimensions up to 2000mm. To minimize the influence of the reflection surface and obtain accurate geometric data, preparation of the propeller was done, including setting up about 30 position recognition points to the propeller surface.

The model is then imported into a CAE software where a mesh model is prepared for future CFD (computational fluid dynamics) and FEM (finite element method) analysis.

Keywords

3D scanning, reverse engineering, propeller analysis, surface tolerance

Type of publication

Original Research Article.

Dental Materials and Structures

APPLICATION OF SEM ANALYSIS IN THE EVALUATION OF SURFACE CHARACTERISTICS OF CONTEMPORARY PROSTHETIC MATERIALS AFTER PROFESSIONAL HYGIENE PROCEDURES

Aleksandra Cairovic[1*] [0000-0001-8807-5426], Mirjana Peric[1] [0000-0003-3667-4253], Igor Djordjevic[1] [0000-0003-2695-4577], Nenad Mitrovic[2] [0000-0001-9296-2669], Danica Popovic Antic[1] [0000-0002-2322-810X], Milan Travica[2] [0000-0003-1156-6563], Luka Zupac[1] [0009-0007-4113-4864]

[1*]University of Belgrade, School of Dental Medicine, Department of Prosthodontics, 11000 Belgrade, Serbia

[2]University of Belgrade, Faculty of Mechanical Engineering, Department of Process Engineering, 11000 Belgrade, Serbia

*Corresponding author e-mail: lukazupac95@gmail.com

Abstract

Scanning electron microscopy (SEM) offers a high-resolution method for detecting microstructural surface changes in dental materials caused by routine professional hygiene procedures. This in vitro study utilized SEM to investigate the effects of ultrasonic scaling and professional brushing on the surface microtopography of zirconia restorations, fabricated by CAD/CAM milling or veneered with ceramic. Specimens (n = 36; 4 × 4 × 2 mm) were obtained from 3Y-TZP-LA zirconia blocks and divided into four groups based on surface finish (polished or glazed) and fabrication method. Each subgroup was subjected to either ultrasonic scaling or brushing with an abrasive polishing paste for 1 minute, repeated in 10 cycles to simulate the effects of five years of clinical maintenance SEM imaging at 150×magnification (Model JSM-6390, JEOL, Japan) was performed before and after treatment to evaluate micromorphological changes. SEM allowed precise identification of surface defects, including microcracks, abrasive wear and glaze degradation. The most significant changes were observed in glazed samples exposed to ultrasonic scaling, with surface alterations measured at 88.31 µm for veneered zirconia and 45.38 µm for CAD/CAM-milled zirconia.The results demonstrate that standard professional hygiene procedures can significantly affect the surface integrity of glazed zirconia restorations. SEM analysis proved to be an essential diagnostic tool for early detection of clinically relevant surface damage, offering insights into material behavior and supporting the development of tailored maintenance protocols.

Keywords

Zirconia restorations, SEM analysis, Surface microtopography, Ultrasonic scaling, CAD/CAM prosthetics.

Type of publication

Original Research Article.

DESIGN AND APPLICATION OF A TWO-PART QUADRANGULAR DEVICE FOR FABRICATION OF UNIFORM TEST SAMPLES FOR BOND STRENGTH TESTING BETWEEN ARTIFICIAL TOOTH AND DENTURE BASE

Luka Zupac[1*] [0009-0007-4113-4864], Aleksandra Cairovic[1] [0000-0001-8807-5426], Nenad Mitrovic[2] [0000-0001-9296-2669], Milan Travica[2] [0000-0003-1156-6563], Igor Djordjevic[1] [0000-0003-2695-4577], Mirjana Peric[1] [0000-0003-3667-4253], Danica Popovic Antic[1] [0000-0002-2322-810X]

[1*]University of Belgrade, School of Dental Medicine, Department of Prosthodontics, 11000 Belgrade, Serbia

[2]University of Belgrade, Faculty of Mechanical Engineering, Department of Process Engineering, 11000 Belgrade, Serbia

*Corresponding author e-mail: lukazupac95@gmail.com

Abstract

To improve the precision and standardization of biomechanical testing of bond strength between artificial teeth and denture bases, an innovative two-part quadrangular device was developed using 3D printing technology (Bambu Lab X-1 Carbon) with polymeric materials. The development was based on a digital model of a scanned artificial tooth (Atos Core 200), which served as a reference for producing uniform and reproducible samples. The lower part of the device is designed for forming the denture base and is filled with wax, while the upper part contains an opening with a specially designed guiding surface matching the dimensions of the scanned tooth, enabling precise positioning at a 90° angle relative to the base. This ensures that each sample is identical in orientation and dimensions, which is crucial for reducing variability in testing. The fabricated samples then undergo a standard dental laboratory waxing procedure identical to the waxing phase of removable denture models. This process ensures full compatibility with real clinical conditions of removable denture fabrication, contributing to the validity and relevance of the obtained results. The unique design of the device allows easy and safe removal of samples without damage, further increasing the reliability of mechanical testing. The produced test samples are then tested on a universal testing machine using a device for bond strength testing under variable loading angles, simulating the complex biomechanical conditions present during functional mandibular movements. This innovative approach enables more precise evaluation of adhesive properties between the tooth and denture base and represents a significant step forward in the development and optimization of removable dental prostheses, with the potential to improve their longevity and clinical reliability.

Keywords

Sample mold, Sample fabrication tool, Angle jig, Standard samples, 3D printed jig.

Type of publication

Original Research Article.

DEVICE FOR TESTING BOND STRENGTH BETWEEN ARTIFICIAL TOOTH AND DENTURE BASE UNDER VARIABLE LOADING ANGLES

Milan Travica[1*] [0000-0003-1156-6563], Nenad Mitrovic[1] [0000-0001-9296-2669], Aleksandra Cairovic[2] [0000-0001-8807-5426], Luka Zupac[2] [0009-0007-4113-4864], Igor Djordjevic[2] [0000-0003-2695-4577], Mirjana Peric[2] [0000-0003-3667-4253], Danica Popovic Antic[2] [0000-0002-2322-810X]

[1]University of Belgrade, Faculty of Mechanical Engineering, Department of Process Engineering, 11000 Belgrade, Serbia

[2]University of Belgrade, School of Dental Medicine, Department of Prosthodontics, 11000 Belgrade, Serbia

Corresponding author e-mail: lukazupac95@gmail.com

Assistant

The presented device is a technically innovative solution designed to test the bond strength between various biomaterials, with specific application in dentistry—especially in analyzing the adhesion between artificial teeth and denture base materials. Conventional bond strength testing methods typically involve uniaxial loading, which does not reflect the complex multidirectional forces acting within the oral cavity during mastication and functional jaw movements. These forces include both vertical (compressive) and horizontal (shear) components, influenced by anterior tooth relationships and incisal guidance angles—factors often neglected in standard tests. This tool is compatible with universal testing machines and allows force application at precise, adjustable angles, there by more accurately simulating physiological conditions. Its adjustable holder geometry and gripping system ensure secure positioning of samples without introducing artifacts or pre-test damage. The device enables systematic analysis of how different loading angles affect bond strength, which is crucial for evaluating adhesive systems, surface treatments, and new materials. By incorporating this device into experimental protocols, researchers can achieve more accurate, repeatable, and clinically relevant results. Its application may significantly improve the understanding and optimization of prosthetic materials, leading to increased longevity and functional reliability of dental restorations, particularly within the scope of digital and CAD/CAM prosthodontic workflows.

Keywords

Bond strength, Testing device, Tooth base adhesion, Load angle, Occlusal load.

Type of publication

Original Research Article.

Sustainable Design and New Technologies

APPLICATION OF 3D PRINTING IN THE DEVELOPMENT OF SUSTAINABLE COSMETIC PACKAGING

Katarina Telebak[1*] [0009-0001-5689-6745], Isaak Trajkovic[1] [0000-0001-6671-4733], Milos Milosevic[1] [0000-0002-2418-1032], Natasa Obradovic[2] [0000-0001-7118-495X], Mina Volic[3] [0000-0002-1743-293X]

[1]Innovation center of the Faculty of Mechanical Engineering, University of Belgrade, 11000 Belgrade, Serbia

[2]Faculty of Technology and Metallurgy, University of Belgrade, 11000 Belgrade Serbia

[3]Innovation centre of the Faculty of Technology and Metallurgy, University of Belgrade, 11000 Belgrade Serbia

*Corresponding author e-mail: ktelebak@mas.bg.ac.rs

Abstract

This paper presents the development of a functional packaging solution for cosmetic products, specifically a facial lotion bottle, using 3D printing technology. The aim of the study was to explore the potential for rapid, precise, and cost-effective prototyping of packaging through modern additive manufacturing methods, with a focus on the aesthetic, functional, and environmental aspects of the final product. The bottle was designed using CAD software, considering ergonomic and volumetric requirements in accordance with cosmetic industry standards, and was fabricated using a Bambu Lab 3D printer with PLA filament. Special attention was given to the optimization of printing parameters (temperature, speed, infill density) to achieve a balance between strength, surface finish, and material consumption. The evaluation of the model included testing for mechanical durability, leak-proof performance, and compatibility with standard pumps and closures. The results demonstrated that it is possible to produce aesthetically pleasing and technically functional packaging for liquid products using 3D printing in home or small-scale conditions. This approach offers wide possibilities for customization, sustainability, and cost reduction in packaging development, especially for small manufacturers or start-up companies in the cosmetics sector. The study highlights the significant potential of additive manufacturing in the design and production of cosmetic packaging, with a special emphasis on rapid iteration and environmentally friendly materials.

Keywords

3D printing, Cosmetic packaging, PLA filament, Additive manufacturing, Sustainable design

Acknowledgement

This research and the presented results were supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia under the Agreement No. 451-03-136/2025-03/200213. The researchers also thank the Ministry of Environmental Protection, the Global Environment Facility and the United Nations Development Programme under the Agreement No. (00131890/1138320/2024/01-05).

Type of publication

Original Research Article.

ECOLOGICAL ANALYSIS OF MAKEUP PACKAGING: LCA APPROACH USING SOLIDWORKS SUSTAINABILITY TOOL

Ermina Cosovic[1*] [0009-0002-7285-2977], Katarina Telebak[2] [0009-0001-5689-6745], Isaak Trajkovic[2] [0000-0001-6671-4733]

[1]University of Belgrade, Faculty of Mechanical Engineering, Belgrade, Serbia

[2] Innovation Centre of Faculty of Mechanical Engineering, Belgrade, Serbia

*Corresponding author e-mail: ecosovic@mas.bg.ac.rs

Abstract

In modern society, sustainable design has become an essential element of product development, especially in industries characterized by high consumption and short product life cycles, such as the cosmetics industry. This paper focuses on the ecological sustainability analysis of a biodegradable makeup bottle using the Life Cycle Assessment (LCA) method through the SolidWorks Sustainability software tool. The aim is to identify the key factors influencing the overall environmental footprint of the product and to improve sustainable design practices in the early stages of development.
The material used for manufacturing the bottle is biodegradable PLA plastic of plant origin, while the selected production technology is 3D printing – a method rarely applied to packaging in the cosmetics industry, making this approach an innovation with potential for future use. It is assumed that the product's manufacturing and use occur locally, to further reduce the environmental impact of transportation.
The obtained results clearly indicate that the largest share of the ecological burden comes from the choice of materials and production technology. These findings may serve as guidelines for improving the sustainable design of cosmetic packaging and for making informed decisions in the early stages of product development. In this context, sustainable design is not merely an added value but a strategic advantage for brands aiming to respond to increasing market and environmental protection demands.

Keywords

Sustainable design, product life cycle, PLA plastic, 3D printing.

Acknowledgement

This research has been financially supported by the Ministry of Science, Technological Development and Innovation of Republic of Serbia (Contract No. 451-03-136/2025-03/200105).

Type of publication

Original Research Article.

SUSTAINABLE VALORIZATION OF FRUIT PROCESSING BY-PRODUCTS FOR COSMETIC APPLICATIONS USING LIPOSOMAL TECHNOLOGY

Natasa Obradovic[1*] [0000-0001-7118-495X], Mina Volic[2] [0000-0002-1743-293X], Bojana Balanc[2] [0000-0002-7859-9979], Steva Levic[3] [0000-0001-8337-3475], Ana Salevic-Jelic[3] [0000-0003-2903-7862], Isaak Trajkovic[4] [0000-0001-6671-4733], Viktor Nedovic[3]

[1] Faculty of Technology and Metallurgy, University of Belgrade, Karnegijeva 4, Belgrade, Serbia

[2] Innovation Centre of the Faculty of Technology and Metallurgy, University of Belgrade, Karnegijeva 4, Belgrade, Serbia

[3]Faculty of Agriculture, University of Belgrade, Nemanjina 6, Belgrade, Serbia

[4]Innovation Centre of Faculty of Mechanical Engineering, University of Belgrade, Kraljice Marije 16, Belgrade, Serbia

*Corresponding author e-mail: ntomovic@tmf.bg.ac.rs

Abstract

Fruit processing industries generate substantial amounts of by-products (peels, seeds, pomace, pulp residues) that are often underutilized or discarded, leading to environmental challenges. In the cosmetic industry, there is a growing demand for sustainability, prompting cosmetic companies to develop innovative solutions that minimize their environmental and economic footprints. Blackberry by-products from the juice industry are a valuable source of anthocyanins and other bioactive phenolic compounds, including flavonoids and ellagitannins. However, the inherent sensitivity of fruit-derived compounds remains a limiting factor in their effective application. This study aimed to develop and characterize liposomal delivery systems loaded with blackberry pomace extract. The bioactive compounds were encapsulated using the proliposome method, followed by modifications via sonication. The prepared liposomes were assessed in terms of vesicle size, polydispersity index, mobility, zeta potential, and chemical composition. Zeta potential analysis indicated that liposome formulations exhibited a negative surface charge with satisfactory stability, while vesicle size ranged from 105 nm to 193 nm, depending on the sonication conditions. Fourier-transform infrared spectroscopy confirmed the successful encapsulation of bioactive compounds within the liposomal systems. Prolonged sonication time and a higher amplitude led to vesicle size reduction. Overall, the findings demonstrate that the proliposome method is an effective approach for the encapsulating of blackberry extract, and the obtained liposomes have suitable physicochemical properties for use in sustainable cosmetic formulations.

Keywords

Cosmetic industry, circular economy, liposomal formulation, blackberry by-products

Acknowledgement.

The project: “Innovative Encapsulation Technologies and 3D-Printed Biodegradable Packaging ", Circular voucher with the financial support of the Ministry of Environmental Protection, UNDP and Global Environmental Fund. Project Number: 00131890/1138320/2024/01-05. This project is being carried out in collaboration with a business entity: Aleksandra Rasovic PR AMELLES, Vrnjacka Banja, Serbia.

Type of publication

Original Research Article.

PREDICTIVE ALGORITHMS FOR SMART DISTRICT HEATING: A PATH TO SUSTAINABLE URBAN ENERGY SYSTEMS

Djordje Karic[1*] [0000-0003-3150-7093], Mirko Komatina[2] [0000-0002-5035-446X], Dragan Kreculj[1] [0000-0003-3268-4024]

[1]The Academy of Applied Studies Polytechnic, 11000 Belgrade, Serbia

[2] Faculty of Mechanical Engineering, University of Belgrade, 11000 Belgrade, Serbia

*Corresponding author e-mail: djordje.karic@yahoo.com

Abstract

Predictive algorithms represent a important component of modern district heating systems within the framework of Industry 4.0, enabling increased energy efficiency, reliability, and optimization of energy consumption. Relying on the analysis of historical data, weather forecasts, consumption patterns, and network conditions, these algorithms allow for precise prediction of future heat demand. As a result, overheating in the system is minimized, energy consumption is optimized, and CO_2 emissions are significantly lowered. Furthermore, predictive models facilitate proactive system maintenance by detecting unusual patterns that may indicate potential faults or irregularities in the network. Thanks to these technologies, district heating becomes more intelligent, stable, and tailored to the real needs of users, which is crucial for the development of sustainable and efficient urban energy systems. Key technologies enabling these innovations include the Internet of Things (IoT), Artificial Intelligence (AI), Big Data analytics, smart sensors, and automated control systems. Smart meters and sensors enable real-time data collection on temperatures, flow rates, and heat consumption, providing precise control and quick response to faults or deviations in the network. All these elements make district heating more efficient and sustainable, contributing to cost reduction and improved user conditions.

Keywords

Predictive algorithms, district heating, energy efficiency, big data, artificial intelligence

Type of publication

Review Article.

INVESTIGATING STUDENTS' INTEREST IN POTENTIALLY AVAILABLE DOCTORAL STUDIES IN PROFESSIONAL HIGHER EDUCATION

Marko Pavlovic[1] [0000-0003-1817-9734], Nada Ratkovic Kovacevic[1*] [0000-0001-6398-4391], Djordje Dihovicni[1] [0000-0003-0961-2540], Dragan Kreculj[1] [0000-0003-3268-4024], Aleksandra Mitrovic[1,2] [0000-0002-5183-6276]

[1]The Academy of Applied Studies Polytechnic, 11000 Belgrade, Serbia

[2]University "Union - Nikola Tesla", Faculty of Information Technology and Engineering, 11000 Belgrade, Serbia

*Corresponding author e-mail: nratkovickovacevic@politehnika.edu.rs

Abstract

The Higher Education (HE) in Republic of Serbia (RS) has two types of studies - academic and professional (vocational) studies. HE in RS has undergone various reforms over the past several decades. In particular professional (vocational) studies were overhauled making the duration of studies longer, from two to three years on a basic level of study. Then specialist professional (vocational) studies were introduced as a year-long second level of study (by now these study programs are mostly abandoned since they are 'demoted' to the first level of study and their accreditation expired). More than a decade ago a legal framework was completed to initiate accreditation of Higher Education Institutions (HEIs) and of master study programs in professional (vocational) HE as the second level of studies in RS. The goal of the paper is to investigate if there would be candidates interested to take the doctoral level in the professional (vocational) studies should this would exist in RS. Survey was performed on a selected group of anonymous volunteers being Students in master or basic level of studies in the HE. The first part of the survey contained questions regarding general information on participants and their quality of experience during studies. The interviewed Students were then asked to respond whether they would be interested to enrol into doctoral level studies should these would be provided in the professional (vocational) studies. Paper explores and analyses results of this survey as well as the potential of professional (vocational) studies to scale up.

Keywords

Higher Education (HE) in Serbia, Communication in Higher Education, Professional (vocational) studies, Potential for extending professional studies to Doctoral professional studies, Students' satisfaction

Type of publication

Original Research Article.

RISK ASSESSMENT IN VAT PHOTOPOLYMERIZATION: ENHANCING SAFETY IN THE AUTOMOTIVE INDUSTRY

Zarko Miskovic[1*] [0000-0002-8320-7191], Danilo Pejcic[1] [0009-0007-1661-2924], Jovana Antic[1] [0009-0002-6452-0294], Zoran Stamenic[1] [0000-0003-3232-6251], Jan Danko[2] [0000-0002-7193-7728], Tomas Milesich[2] [0000-0002-1294-5429], Igor Kevicky[2] [0000-0002-4994-1827]

[1]University of Belgrade, Faculty of Mechanical Engineering, 11000 Belgrade, Serbia
[2]Slovak University of Technology in Bratislava, Faculty of Mechanical Engineering, Institute of automotive engineering and design, 81231 Bratislava, Slovakia
*Corresponding author e-mail: zmiskovic@mas.bg.ac.rs

Abstract

Additive Manufacturing (AM), or 3D printing, is revolutionizing production by building parts layer by layer, offering a significant reduction in material waste compared to traditional subtractive methods. This technology allows the creation of complex geometries that are often difficult or expensive to produce using conventional means. Among the seven process categories defined by ISO/ASTM 52900-21, vat photopolymerization stands out for its precision and ability to fabricate highly detailed parts. Vat photopolymerization techniques, such as stereolithography (SLA) and digital light processing (DLP), cure liquid photopolymer resins with ultraviolet or visible light. This process yields parts with excellent surface finish and accuracy, making it particularly valuable in the automotive industry. Here, vat photopolymerization accelerates prototyping of intricate parts like lighting systems, dashboards, and ventilation components, helping to shorten design cycles and foster innovation. However, the process involves health and safety risks. Photopolymer resins may contain toxic chemicals, and exposure to their vapours or direct skin contact can be harmful. The curing process exposes operators to UV or laser radiation, which poses risks of eye and skin injuries. Additionally, the electrical and mechanical components of used 3D printers introduce hazards such as electric shock and burns. This research applies the Kinney risk assessment method to evaluate these hazards by analysing their probability, frequency, and consequence. Using ISO 12100:2010-based checklists, it identifies key risks and recommends mitigation strategies. These include proper storage of resins in cool, ventilated areas, mandatory personal protective equipment (PPE), adequate machine enclosures with ventilation, regular equipment maintenance, and workload management to prevent fatigue. Equally important is comprehensive operator training and the establishment of standardized procedures. The research highlights the need for dedicated safety standards tailored specifically to additive manufacturing technologies. As vat photopolymerization expands in automotive production – from prototyping to functional part manufacturing – industry-specific guidelines are essential to safeguard workers and ensure environmental responsibility. In summary, integrating structured risk assessments in vat photopolymerization supports the safe adoption of AM technologies in the automotive sector. This approach not only protects user health but also enables the continued innovation and efficiency that define modern manufacturing.

Keywords

Vat Photopolymerization, Risk Assessment, Health and Safety, Automotive Industry, Additive Manufacturing.

Acknowledgement

The authors sincerely appreciate the support of the relevant ministries of the Republic of Serbia and the Slovak Republic in facilitating this research. The research was conducted as part of the bilateral project No. 337-00-3/2024-5/08, within the 2024-2025 bilateral cooperation cycle between Serbia and Slovakia.

Type of publication

Original Research Article.

Artificial intelligence

MAPPING INNOVATION DRIVERS IN EUROPE: AI-BASED INSIGHTS INTO KNOWLEDGE AND TECHNOLOGY OUTPUTS

Snezana Kirin[1*] [0000-0002-2176-3969], Ivana Vucetic[1] [0000-0002-4036-7785], Bojan Cudic[2] [0000-0002-7884-0419]

[1*]Innovation Center of the Faculty of Mechanical Engineering in Belgrade, Serbia

[2]Digital Innovation Hub ONEX, Banja Luka, Bosnia and Herzegovina

*Corresponding author e-mail: skirin@mas.bg.ac.rs

Abstract

Exploring the foundations of innovation performance, this study investigates the primary drivers behind knowledge and technology outputs and their subsequent utilization across 22 European countries during the 2013–2020 period. By applying artificial intelligence methods alongside multiple regression analysis, the research integrates a wide range of variables to assess their individual and combined effects. These include business environment conditions, creative goods and services, the effectiveness of public institutions, human capital and research capacity, access to digital infrastructure, exports of ICT services, patent activity by origin, political and operational stability, and collaboration between universities and industry.

The dataset is derived from the Global Innovation Index (GII), which aggregates and normalizes inputs from international databases to ensure robust cross-country comparability. Innovation performance is captured through a composite Knowledge and Technology Outputs index, encompassing indicators related to knowledge creation, impact, and diffusion.

The findings point to considerable differences in innovation dynamics among countries with varying levels of Gross Expenditure on Research and Development (GERD). Distinct mechanisms appear to drive innovation in low-, medium-, and high-GERD countries, suggesting that innovation systems operate under context-specific conditions. Consequently, the study highlights the necessity for differentiated policy strategies tailored to the R&D intensity and innovation structure of each country. These insights provide valuable guidance for European policymakers aiming to stimulate sustainable technological advancement and close innovation gaps across the continent.

Keywords

Innovation drivers, technology outputs, GERD, ICT

Acknowledgement

The authors gratefully acknowledge the support of the Ministry of Science, Technological Development and Innovation of the Republic of Serbia for funding this research under contract no. 451-03-65/2024-03/200155.

Type of publication

Original Research Article.

POSITIONING OF ARCHITECT IN EMERGING ARCHITECTURE

Sladjana Markovic[1* [0000-0001-6882-360X]], Svetel Igor[2* [0000-0001-7821-1412]]

[1]University of Belgrade, Faculty of Architecture, SaRa Lab (Sustainable and Resilient Architecture), 11000 Belgrade, Serbia

[2]Innovation center of Faculty of Mechanical Engineering in Belgrade, 11000 Belgrade, Serbia

** Corresponding author e-mail: marsladjana@gmail.com; isvetel@mas.bg.ac.rs*

Abstract

This research investigates the evolving role and positioning of the architect within data-driven and artificial intelligence design processes in emerging architecture. As digital thinking continues to reshape architectural practice, the study explores the intersection between computational approaches—exemplified by the “digital chain” as the direct design-fabrication connection (Hovestadt, 2005), AI and traditional, analogue design methods. Through qualitative inquiry, including a focus group of digitally engaged architects, the study emphasizes the enduring relevance of human-centric skills such as intuition, empathy, and creativity in an increasingly algorithmic design environment.

Positioning is interpreted both as the architect's evolving role and their influence within design-realization cycles. Drawing from theorists such as Negroponte, Schoen, Carpo, Lawson, Cross, Leach, and Colomina, the research frames architecture as a hybrid space where the human factor remains an unpredictable yet essential force. Computational design is viewed not merely as automation but as an extension of natural intelligence, enhancing creative potential through artificial intelligence.

Through the lens of leading digital practitioners—Gramazio & Kohler, Burry, Aish, and Menges—the research identifies a shift in architectural authorship: from isolated design stages to integrated, continuous involvement across ideation, digital tooling, and fabrication. Key findings include the redefinition of digital methods through traditional integration, the architect’s expanded control over realization, and the necessity for new competencies among digitally professionals.

Rather than prescribing fixed roles, the study proposes flexible “zones of influence” with(in) the digital and artificial. It argues that architects must act as conduits between human insight and machine precision—preserving creative identity while navigating the demands of a data-driven and AI, collaborative, and technologically mediated future.

Keywords

Data-Driven Design - “digital chain”, Artificial Intelligence, Architectural Positioning, Computational Design Thinking, Human-Centered Creativity

Acknowledgement

The results presented here are partly the result of research supported by the Ministry of Science, Technological Development and Innovation of the RS under Contract 451-03-136/2025-03/ 200213 dated 04.02.2025.

Type of publication

Original Research Article.

ARTIFICIAL INTELLIGENCE IMPLEMENTATION IN HIGHER EDUCATION PRACTICE

Nada Ratkovic Kovacevic[1*] [0000-0001-6398-4391], Djordje Dihovicni[1] [0000-0003-0961-2540], Aleksandra Mitrovic[1,2] [0000-0002-5183-6276], Dragan Kreculj[1] [0000-0003-3268-4024], Sanja Jevtic[3] [0000-0002-2456-7883]

[1]The Academy of Applied Studies Polytechnic, Novi Beograd Section, 11000 Belgrade, Serbia

[2]University “Union - Nikola Tesla”, Faculty of Information Technology and Engineering, 11000 Belgrade, Serbia

[3]Academy of Technical and Art Applied Studies Belgrade, School of Information and Communication Technologies, 11000 Belgrade, Serbia

*Corresponding author e-mail: nratkovickovacevic@politehnika.edu.rs

Abstract

Artificial Intelligence (AI) has been implemented in various use cases for many years by now. AI has permeated everyday life in many ways and on various levels, making some tasks easier, helping navigating traffic or obtaining information fast. Recommender systems, speech generation, automated decision making are examples to name a few. In the field of Education AI has proven to bring huge disruption. Using AI for spell checking is allowed in e.g. writing papers, however creating content using Generative AI is mostly prohibited. There seems to be valuable potential in saving time by implementing AI tool in responding to emails, creating personalized courseware, automated grading, language translation, text to speech conversion. Paper explores strengths and weaknesses of implementing AI and AI tools such as Generative AI in Higher Education practice. The aim is to gain insight in acceptance, way of exploit and frequency of use of AI and AI tools both by the Students and Educators in higher education, and to assess their experience from this; to determine which available AI tools exist; to investigate potential of use and risk of misuse of AI in education. A survey is prepared to be conducted among Students and Educators in higher education.

Keywords

Artificial Intelligence (AI), Higher Education, AI Tools, Analysis, Implementation

Type of publication

Original Research Article.

ADVANCED MACHINE LEARNING-BASED MODELING OF ENERGY CONSUMPTION IN BUILDINGS

Djordje Karic[1*] [0000-0003-3150-7093], Mirko Komatina[2] [0000-0002-5035-446X], Nikola Slavkovic[1] [0000-0002-1241-8944]

[1]The Academy of Applied Studies Polytechnic, 11000 Belgrade, Serbia

[2]Faculty of Mechanical Engineering, University of Belgrade, 11000 Belgrade, Serbia

*Corresponding author e-mail: djordje.karic@yahoo.com

Abstract

Machine learning (ML) represents a important technology in modern approaches to improving energy efficiency in buildings. The focus is on the application of advanced ML algorithms for modeling, analyzing, and optimizing energy consumption in buildings of various types, with particular emphasis on heating, cooling, ventilation, and air conditioning (HVAC) systems, lighting, and device control. Algorithms such as Linear Regression and Support Vector Machines (SVM) enable accurate prediction of energy consumption based on historical data, weather conditions, and user behaviors. Random Forest and XGBoost are used for detecting nonlinear patterns and evaluating the impact of individual factors on overall energy use. In adaptive real-time energy management, reinforcement learning algorithms such as Q-learning and Deep Q-Networks (DQN) support HVAC system optimization by responding to changes in external conditions and occupancy. Neural Networks and Long Short-Term Memory (LSTM) models are applied for multi-day and seasonal energy consumption forecasting, enabling strategic energy planning. The application of these algorithms in buildings demonstrates significant potential for reducing energy consumption, operating costs, and emission of pollutants, while maintaining occupant comfort—contributing to the core objectives of sustainable and smart building design.

Keywords

Energy efficiency, energy consumption, buildings, machine learning, HVAC systems

Type of publication

Review Article.

ARTIFICIAL INTELLIGENCE IN PRODUCTION AND MAINTENANCE SYSTEMS

Ivana Ilic[1] [0000-0001-7364-8236], Aleksandra Mitrovic[1,2*] [0000-0002-5183-6276], Maja Andjelkovic[1] [0000-0002-5507-9831]

[1]University “Union-Nikola Tesla”, Faculty of Information Technology and Engineering, 11070 Belgrade, Serbia

[2]The Academy of Applied Studies Polytechnic, 11000 Belgrade, Serbia

*Corresponding author e-mail: amitrovic@politehnika.edu.rs

Abstract

Artificial intelligence (AI) has emerged as a significant tool in industrial production and maintenance, owing to its capacity to analyse vast quantities of data. Technologies related to the overarching concept of AI, such as machine learning, deep learning, and natural language processing, are also employed to enhance the efficiency of production lines and to optimize the resources required for the seamless operation of production and maintenance. AI is utilized for what is referred to as predictive maintenance, which aims to identify potential failures and the necessity for replacing worn components prior to the occurrence of failures, thereby preventing more significant challenges and extended downtimes. Through the implementation of predictive maintenance, it is possible to strategically plan and oversee production and maintenance processes in a manner that considerably diminishes the likelihood of prolonged downtimes in production. Furthermore, predictive maintenance can ensure less severe and shorter intensity and duration of downtimes when they do occur. The paper investigates several innovative methodologies regarding the application of AI technology, particularly in conjunction with Industry 4.0, the implementation of smart factories, and various other mechanisms where AI technology is poised to play a pivotal role. The overarching objective is to achieve automation in decision-making processes related to production management. This trajectory signifies the future direction of all production facilities, where automated decision-making will become the norm, not only for operational decisions concerning the machining line and production processes but also for maintenance tasks and the automatic procurement of spare parts, even before the necessity for their replacement becomes apparent. The effective incorporation of AI technologies into current production and maintenance frameworks will necessitate advanced technical knowledge and a multidisciplinary approach.

Keywords

Artificial intelligence, technologies, production, maintenance, prediction.

Type of publication

Review Article.

CIP - Каталогизација у публикацији Народна библиотека Србије, Београд

621(048)(0.034.2)
62:519.6(048)(0.034.2)

INTERNATIONAL conference of experimental and numerical investigations and new technologies (2025 ; Beograd)
Programme [Elektronski izvor] ; and The Book of Abstracts / International Conference of Experimental and Numerical Investigations and New Technologies - CNN TECH 2025, 01 July 2025, Belgrade ; organized by Innovation Center of Faculty of Mechanical Engineering [and] University of Belgrade, Faculty of Mechanical Engineering, Center for Business Trainings ; [editors Goran Mladenovic, Aleksandra Mitrovic, Isaak Trajkovic]. - Belgrade : University, Faculty of Mechanical Engineering, 2025 (Belgrade : University, Faculty of Mechanical Engineering). - 1 USB fleš memorija ; 1 x 2 x 5 cm

Sistemski zahtevi: Nisu navedeni. - Nasl. sa naslovne strane dokumenta. - Tiraž 150.

ISBN 978-86-6060-218-5

a) Машинство -- Апстракти b) Техника -- Нумерички методи -- Апстракти

COBISS.SR-ID 172367369