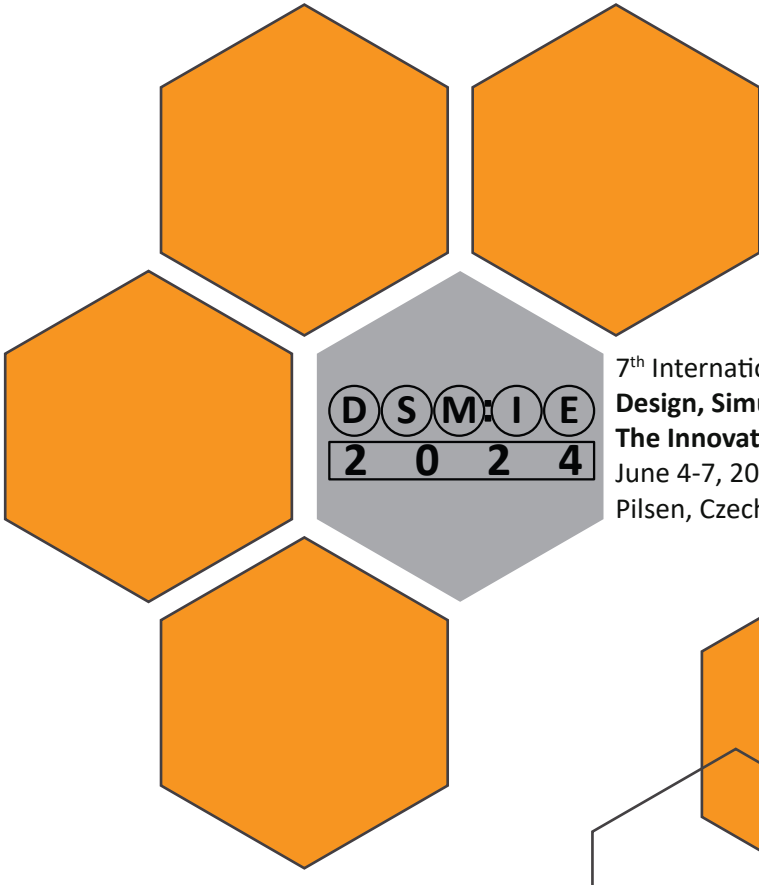
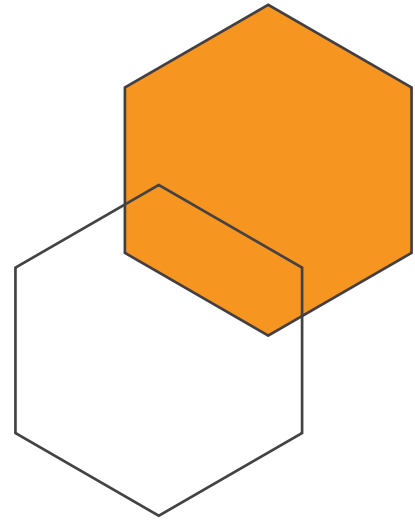
DSMIE Conference Series



7th International Conference on
Design, Simulation, Manufacturing: The Innovation Exchange
June 4-7, 2024
Pilsen, Czech Republic



Book of Abstracts

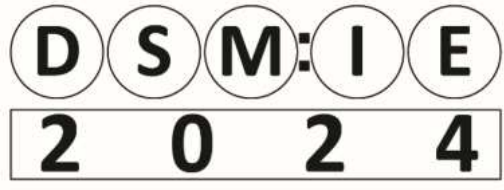
iATDi International Association for Technological Development and Innovations

UNIVERSITY OF WEST BOHEMIA

Sumy State University

Together we can do more for science, technology, engineering, and education.

International Association for Technological Development and Innovations



7th International Conference on Design, Simulation, Manufacturing: The Innovation Exchange (DSMIE-2024)

June 4-7, 2024 | Pilsen, Czech Republic

Book of Abstracts

Pilsen
2024

Editors:

Vitalii Ivanov[1] and Milan Edl[2]

[1] Sumy State University, Ukraine
[2] University of West Bohemia, Czech Republic

Design, Simulation, Manufacturing: The Innovation Exchange: Book of Abstracts of the 7th International Conference, Pilsen, Czech Republic, June 4-7, 2024 / Vitalii Ivanov, Milan Edl (Eds.). – Pilsen: IATDI, 2024. – 160 p.

Recommended by the Coordination Board of the
International Association for Technological Development and Innovations
(Protocol No. 9, February 19, 2024).

The content of this book is based on the 7th International Conference on Design, Simulation, Manufacturing: The Innovation Exchange (DSMIE-2024), held on June 4-7, 2024, in Pilsen, Czech Republic. This book reports on advances in manufacturing, with a special emphasis on smart manufacturing and information management systems. It covers sensors, machine vision systems, collaborative technologies, industrial robotics, digital twins, and virtual and mixed reality. Further topics include quality management, supply chain, agile manufacturing, lean management, and sustainable transportation. Chapters report on theoretical research and experimental studies concerning engineering design, simulation, and various machining processes for subtractive and additive manufacturing. It also discusses key aspects related to engineering education and competence management in the Industry 4.0 era. Furthermore, this book reports on topics related to the interface between mechanical and materials engineering, emphasizing design, simulation, and manufacturing aspects. It covers advanced methods in design and process engineering applied to mechatronic systems, industrial equipment, turbines, and drives. It covers cutting-edge theoretical and experimental findings relating to material behavior, composites, nanomaterials, and coatings design. This book provides academics and professionals with extensive information on trends, technologies, challenges, and practice-oriented experience in all the areas mentioned above.

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Welcome Message

Prof. **Vitalii IVANOV**,
General Chair

Dr. **Milan EDL**,
General Co-Chair

The 7th International Conference on Design, Simulation, Manufacturing: The Innovation Exchange (DSMIE-2024), held in Pilsen, Czech Republic, on June 4-7, 2024. The conference was organized by the International Association for Technological Development and Innovations, University of West Bohemia, and Sumy State University, in partnership with Poznan University of Technology (Poland), Kielce University of Technology (Poland), Technical University of Kosice (Slovak Republic), Association for Promoting Innovative Technologies – Innovative FET (Croatia), and Society for Robotics of Bosnia and Herzegovina (Bosnia and Herzegovina).

DSMIE-2024 received 148 contributions from 33 countries around the world. After a two-stage single-blind review, the Program Committee accepted 83 papers written by 324 authors from 28 countries. Thank you very much to the authors for their contribution. These papers are published in the present book, achieving an acceptance rate of about 56%. Extended versions of selected best papers will be published in scientific journals: Management and Production Engineering Review (Poland), Journal of Engineering Sciences (Ukraine), Advances in Thermal Processes and Energy Transformation (Slovak Republic), Assembly Techniques and Technology (Poland), International Journal of Precision Technology (Switzerland), International Journal of Product Sound Quality (Switzerland), Journal of Coating Science and Technology (Canada), special issue of Machines (Switzerland) "Innovations in the Design, Simulation, and Manufacturing of Production Systems", and a special issue of Materials (Switzerland) "Novel Approaches in the Design, Simulation, and Manufacturing for Processes and Systems".

We want to thank members of the Program Committee and invited external reviewers for their efforts and expertise in contributing to reviewing, without which it would be impossible to maintain the high standards of peer-reviewed papers. 97 Program Committee members and 13 invited external reviewers devoted their time and energy to peer-reviewing manuscripts. Our reviewers come from around the world, representing 21 countries, and are affiliated with 39 institutions.

Thank you very much to the keynote speakers: Prof. Arkadiusz Gola (Lublin University of Technology, Poland); Dr. Foivos Psarommatis (University of Oslo,

Norway; Zerofect, Switzerland); Prof. Jinyang Xu (Shanghai Jiao Tong University, China); Prof. Francisco J.G. Silva (Polytechnic of Porto, Portugal); and Prof. Andre Batako (Liverpool John Moores University, UK).

We are deeply grateful to the invited speakers who contributed to the Business to Science session: Dr. Miroslav Zetek (University of West Bohemia, Czech Republic), Tomas Cholinsky (Information Technology Administration of the City of Pilsen, Czech Republic), Gerhard Meindl (Es geht!, Germany), Prof. Belal Dawoud (East Bavarian Technical University of Regensburg, Germany), and Prof. Andy Gradel (Hof University of Applied Sciences, Germany).

We sincerely appreciate the invited lecturers of the DSMIE Workshops: Dr. Bohdan Haidabrus (Riga Technical University, Latvia) and Prof. Katarzyna Antosz (Rzeszow University of Technology, Poland).

Thank you very much to Co-Chairs, Dr. Vladimir Duchek (University of West Bohemia, Czech Republic) and Prof. Oleksandr Liaposhchenko (Sumy State University, Ukraine) for their coordination with the program committee members, Prof. Ivan Pavlenko (Sumy State University, Ukraine) and Dr. Justyna Trojanowska (Poznan University of Technology, Poland) for the ensuring high quality of research papers, Prof. Oleksandr Gusak (Sumy State University, Ukraine), Dr. Jan Zdebor (University of West Bohemia, Czech Republic), and Dr. Khrystyna Berladir (Sumy State University, Ukraine) for organizational issues.

DSMIE-2024 is under the patronage of the Governor of the Pilsen Region, Mr. Rudolf Spotak.

We appreciate the partnership with Springer Nature, iThenticate, EasyChair, Daikin Industries Czech Republic s.r.o., The Polish National Agency for Academic Exchange (NAWA), International Innovation Foundation (IIF), Get Smart, Metals (MDPI), Machines (MDPI), and Materials (MDPI) for their essential support during the conference preparation.

Thank you very much to the DSMIE Team. Their involvement and hard work were crucial to the success of the conference.

DSMIE's motto is ***"Together we can do more for science, technology, engineering, and education"***.

Vitalii Ivanov,
General Chair

Milan Edl,
General Co-Chair

About DSMIE-2024

7th International Conference on Design, Simulation, Manufacturing: The Innovation Exchange (DSMIE-2024) is the international forum for fundamental and applied research and industrial applications in engineering.

The conference focuses on research challenges in the fields of Manufacturing Engineering, Materials Engineering, and Mechanical Engineering, addressing current and future trends in design approaches, simulation techniques, and manufacturing technologies, highlighting the growing role of smart manufacturing systems, artificial intelligence, standards-based integration, and innovations implementation to the transition to sustainable, human-centric and resilient engineering solutions.

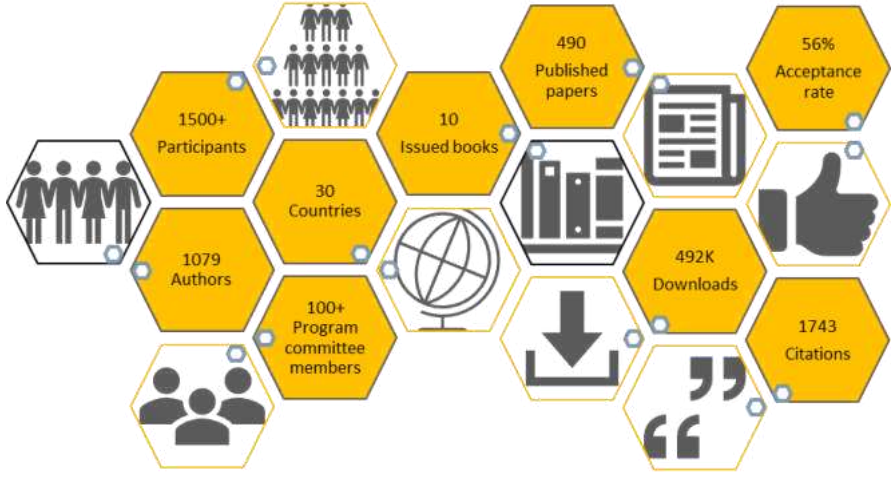
DSMIE brings together researchers from academic institutions, leading industrial companies, and government laboratories worldwide to promote and popularize the scientific fundamentals of engineering.

The official language of the conference is English.

History

The history of the DSMIE Conference Series started in 2018. Since then, DSMIE has become a regular annual event, pursuing the goal of exchanging ideas, spreading innovations, and attracting more participants and institutions. DSMIE Conference Series changed several locations in Ukraine (Sumy, 2018; Lutsk, 2019; Kharkiv, 2020; Lviv, 2021). In 2022, due to the inhuman intervention of the Russian Federation in Ukraine, we were forced to relocate the conference from Ukraine to Poland. Thanks to long-term and reliable cooperation, Poznan University of Technology has become a venue that has allowed us to go beyond the borders of Ukraine. In 2023, the conference was held in High Tatras, Slovak Republic, in cooperation with the Technical University of Košice. In 2024, the DSMIE Conference Series will be organized with the University of West Bohemia (Czech Republic).

We are proud of our achievements over the past six years. It is a result of a reliable long-term partnership with all our partners and host institutions of the DSMIE Conference Series and due to the significant contribution of participants.



Organizers

International Association for Technological Development and Innovations

The International Association for Technological Development and Innovations (IATDI) is a non-profit organization that promotes technological development and innovation across various industries and sectors. The association is committed to advancing research and development efforts in technology, engineering, and applied sciences and fostering collaboration and knowledge sharing among its members. IATDI aims to bridge the gap between academia and industry and create a conducive environment for developing and adopting new technologies through its various programs and initiatives. The association also provides a platform for its members to network, collaborate, and share knowledge, fostering a community of like-minded individuals committed to advancing technology and innovation.

✉ 5/30, M. Lushpy Ave., Office 29, 40035, Sumy, Ukraine
🖳 http://iatdi.org/

University of West Bohemia

The University of West Bohemia (UWB) is a beacon of academic excellence and innovation. Since its establishment in 1991, UWB has emerged as a leading institution, offering various undergraduate, graduate, and doctoral programs across various disciplines, including engineering, natural sciences, humanities, economics, and social sciences. With a strong emphasis on research, UWB houses cutting-edge facilities and collaborates with industries and institutions globally to address real-world challenges. Its commitment to internationalization fosters a rich multicultural environment, attracting students and scholars worldwide. UWB's dynamic student life, modern facilities, and dedication to academic excellence make it a vibrant hub for learning and discovery in Central Europe.

✉ 2732/8, Univerzitni, 301 00, Pilsen, Czech Republic
💻 https://www.zcu.cz/

Sumy State University

Sumy State University (SumDU) is a leading university of a classical type in Ukraine. It cooperates with more than 300 partners from 55 countries worldwide. SumDU is a reliable partner for joint projects in frames of international grant programs of the EU, United Nations Development Programme, NATO, DAAD, American Councils, British Council, NAWA, JICA, the World Bank, bilateral scientific and research projects, and grants of private foundations. The University accomplishes more than 300 grants annually.

✉ 116, Kharkivska St., 40007, Sumy, Ukraine
💻 https://sumdu.edu.ua/

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DSMIE-2024 is under the patronage of the Governor of the Pilsen Region **Mr. Rudolf Špoták**

Conference Committees

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Co-Chair

Milan Edl	University of West Bohemia, Czech Republic

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Vladimir Duchek	University of West Bohemia, Czech Republic

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Justyna Trojanowska	Poznan University of Technology, Poland

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Khrystyna Berladir	Sumy State University, Ukraine
Jan Zdebor	University of West Bohemia, Czech Republic

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Dmytro Zhyhilii	Sumy State University, Ukraine
Justyna Zywiolek	Czestochowa University of Technology, Poland
Predrag Zivkovic	University of Nis, Serbia

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Sergii Kotliar	National Technical University of Ukraine "KPI named after I. Sikorskyi", Ukraine
Emmanouil Lazaros Papazoglou	National Technical University of Athens, Greece
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Volodymyr Topilnytskyy	Lviv Polytechnic National University, Ukraine
Ihor Yakovenko	National Technical University "Kharkiv Polytechnic Institute", Ukraine

DSMIE Team (in alphabetical order)

Vladyslav Andrusyshyn	Sumy State University, Ukraine
Khrystyna Berladir	Sumy State University, Ukraine
Yuliia Denysenko	Sumy State University, Ukraine
Vladimir Duchek	University of West Bohemia, Czech Republic
Milan Edl	University of West Bohemia, Czech Republic
Oleksandr Gusak	Sumy State University, Ukraine
Vitalii Ivanov	Sumy State University, Ukraine
Eva Kozakova-Krauzova	University of West Bohemia, Czech Republic
Oleksandr Liaposhchenko	Sumy State University, Ukraine
Martin Melichar	University of West Bohemia, Czech Republic
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Marketa Pribylova	University of West Bohemia, Czech Republic
Oleksandr Sokolov	Sumy State University, Ukraine
Justyna Trojanowska	Poznan University of Technology, Poland
Jan Zdebor	University of West Bohemia, Czech Republic

Conference Topics

Manufacturing Engineering

- Product Design and Advanced Manufacturing Processes
- Digital Twins, Intelligent Manufacturing Systems, Automation, and Robotics
- Smart Manufacturing and Industry 4.0 Strategy
- Decision-Making in Manufacturing Control and Optimization
- Information Management Systems and Standard-Based Integration
- Engineering Education and Professional Growth

Materials Engineering

- Methods and Technologies for Additive Manufacturing
- Advanced Materials for Industrial Applications
- Materials Modeling, Simulation, and Optimization

Mechanical Engineering

- Mechanics of Fluids, Solids, and Structures
- Dynamics, Acoustics, and Vibrations
- Process Technology and Engineering
- Numerical Simulations of Coupled Problems

Publishing Opportunities

Conference Proceedings

Full papers of selected contributions of DSMIE-2024 were published in two volumes in the book **"Advances in Design, Simulation and Manufacturing VII"**. It belongs to the Lecture Notes in Mechanical Engineering series (ISSN 2195-4356). The books of this series are published by Springer Nature, indexed by Scopus and EI Compendex, and submitted to the Web of Science Core Collection.

Volume 1 – Manufacturing Engineering

Editors:

- Vitalii Ivanov, Sumy State University, Ukraine
- Justyna Trojanowska, Poznan University of Technology, Poland
- Ivan Pavlenko, Sumy State University, Ukraine
- Erwin Rauch, Free University of Bolzano, Italy
- Ján Piteľ, Technical University of Košice, Slovak Republic

Volume 2 – Mechanical and Materials Engineering

Editors:

- Vitalii Ivanov, Sumy State University, Ukraine
- Ivan Pavlenko, Sumy State University, Ukraine
- Milan Edl, University of West Bohemia, Czech Republic
- Jose Machado, University of Minho, Portugal
- Jinyang Xu, Shanghai Jiao Tong University, Shanghai, China

To read the full papers, please visit the official webpage of the Publisher via the following link: https://link.springer.com/conference/dsmie or DSMIE's website: https://dsmie.sumdu.edu.ua/schedule/proceedings.html.

Partner Journals

Extended versions of the best papers, presented at DSMIE-2024, will be considered for publication in the special issues and partner journals, subject to further review and article processing charges (if applicable):

- MDPI Machines (ISSN 2075-1702): Special Issue "Innovations in the Design, Simulation, and Manufacturing of Production Systems", Q2, IF 2.899, section "Advanced Manufacturing" https://www.mdpi.com/journal/machines/special_issues/4B18Z53KN1;
- MDPI Materials (ISSN 1996-1944): Special Issue "Novel Approaches in the Design, Simulation, and Manufacturing for Processes and Systems", Q1, IF 3.748, section "Manufacturing Processes and Systems" https://www.mdpi.com/journal/materials/special_issues/8YH041O372;
- Management and Production Engineering Review (ISSN 2080-8208, e-ISSN 2082-1344), http://mper.org;
- Journal of Engineering Sciences (ISSN 2312-2498, e-ISSN 2414-9381), http://jes.sumdu.edu.ua;
- Advances in Thermal Processes and Energy Transformation (ISSN 2585-9102), http://atpetjournal.com;
- Assembly Techniques and Technologies (e-ISSN 2450-8217), https://tiam.prz.edu.pl;
- International Journal of Precision Technology (ISSN 1755-2060, e-ISSN 1755-2079), https://www.inderscience.com/jhome.php?jcode=ijptech;
- International Journal of Product Sound Quality (ISSN 1742-6758, e-ISSN 1742-6766), https://www.inderscience.com/jhome.php?jcode=ijpsq;
- Journal of Coating Science and Technology (e-ISSN 2369-3355), https://www.lifesciencesglobal.com/journals/journal-of-coating-science-and-technology.

Venue

Plzeň (Czech pronunciation), also known in English and German as Pilsen (German), is a city in the Czech Republic. About 78 kilometers west of Prague in western Bohemia, it is the fourth most populous city in the Czech Republic, with about 181,000 inhabitants and about 323,184 people in its urban area. Founded as a royal city in the late 13th century, Pilsen became an important town for trade on routes linking Bohemia with Bavaria. By the 14th century, it had grown to be the third-largest city in Bohemia. The city was besieged three times during the 15th-century Hussite Wars when it became a center of resistance against the Hussites. During the Thirty Years War in the early 17th century, the city was temporarily occupied after the Siege of Plzeň. In the 19th century, the city rapidly industrialized and became home to the Škoda Works, which became one of the most important engineering companies in Austria-Hungary and later in Czechoslovakia.

The city is known worldwide as the home of Pilsner beer, created by Bavarian brewer Josef Groll in the city in 1842. Today, the Pilsner Urquell Brewery is the largest brewery in the Czech Republic. Pilsen serves as the main business center of West Bohemia and the capital of the Pilsen Region. The city is a cultural heritage zone known for its Baroque architecture and was the European Capital of Culture in 2015. Pilsen is home to football club FC Viktoria Plzeň, one of the most successful clubs in the Czech league, and ice hockey club HC Škoda Plzeň.

Agenda

Agenda online

Day 1 | June 4, 2024

0^{00}–23^{59}	Day of Arrival
14^{00}–15^{00}	Welcome Reception
15^{00}–16^{30}	University Tour (Regional Technological Institute and Research Laboratories)
18^{00}–19^{30}	City Center Tour

Day 2 | June 5, 2024

8^{00}–9^{00}	Registration
9^{00}–9^{30}	Opening Ceremony
9^{30}–11^{00}	Keynote Session I
11^{00}–11^{30}	Coffee Break
11^{30}–13^{00}	Business to Science Session
13^{00}–13^{10}	Official Conference Photo
13^{10}–14^{00}	Lunch
14^{00}–15^{00}	Sessions (1) and (2)
15^{00}–15^{15}	Coffee Break
15^{15}–16^{00}	Sessions (3) and (4)
16^{30}–18^{00}	Social Program – Pilsner Urquell Brewery Tour
18^{00}–22^{00}	Social Program – Get Together Party

Agenda (continuous)

Agenda online

Day 3 | June 6, 2024

10^{30}–11^{00}	Keynote Session II
11^{00}–11^{30}	Coffee Break
11^{30}–13^{00}	Workshop / Networking & Ideas Exchange
13^{00}–14^{00}	Lunch
14^{00}–15^{00}	Sessions (5) and (6)
15^{00}–15^{15}	Coffee Break
15^{15}–16^{45}	Sessions (7) and (8)
16^{45}–17^{00}	Discussion & Summary
17^{00}–17^{30}	Awards & Closing Ceremony
19^{30}–23^{00}	Gala Dinner

Day 4 | June 7, 2024

08^{30}–10^{30}	Industry Tour
10^{30}–11^{30}	Lunch
11^{30}–19^{00}	Cultural Program

Day 1 | June 4, 2024

0^{00}–23^{59} **DAY OF ARRIVAL**

14^{00}–15^{00} **WELCOME RECEPTION**

15^{00}–16^{30} **UNIVERSITY TOUR (REGIONAL TECHNOLOGICAL INSTITUTE AND RESEARCH LABORATORIES)**

18^{00}–19^{30} **CITY CENTER TOUR**

Day 2 | June 5, 2024

8^{00}–9^{00} **REGISTRATION**

9^{00}–9^{30} **OPENING CEREMONY**
Vitalii Ivanov
General Chair of the Conference
Milan Edl
Co-chair of the Conference
Rudolf Špoták
Governor of the Pilsen Region
Miroslav Lavicka
Rector of University of West Bohemia, Czech Republic
Vasyl Karpusha
Rector of Sumy State University, Ukraine
Representatives of Partners and Sponsors
Daikin Industries Czech Republic s.r.o.; Poznan University of Technology

9^{30}–11^{00} **KEYNOTE SESSION I**
Chair: Olaf Ciszak
Poznan University of Technology, Poland

Challenges in Manufacturing Systems Designing in the Aspect of Industry 4.0 and Industry 5.0 Assumptions
Arkadiusz Gola
Lublin University of Technology, Poland

Quality Management in the Era of Industry 4.0/5.0 Towards Zero Defect Manufacturing
Foivos Psarommatis[1,2]
[1] *University of Oslo, Norway;*
[2] *Zerofect, Switzerland*

Green Automation
Francisco J.G. Silva
Polytechnic of Porto, Portugal

11^{00}–11^{30} **COFFEE BREAK**

11^{30}–13^{00} **BUSINESS TO SCIENCE SESSION**
Chair: Milan Edl
University of West Bohemia, Czech Republic

Use of MAM (Metal Additive Manufacturing) in Toolmaking
Miroslav Zetek
University of West Bohemia, Czech Republic

Pilsen Regional Ecosystem
Tomáš Cholinský
Information Technology Administration of the City of Pilsen, Czech Republic

Linking Industry and Research Initiatives in the Rural Area of the WUNsiede
Gerhard Meindl
Es geht!, Germany

RCER – University Research for Enterprise and Innovation in Energy
Belal Dawoud
East Bavarian Technical University of Regensburg, Germany

Hydrogen – A Triangle of Research Organizations for the Development of Our Region
Andy Gradel
Hof University of Applied Sciences, Germany

13^{00}–13^{10} **OFFICIAL CONFERENCE PHOTO**

13^{10}–14^{00} **LUNCH**

14^{00}–15^{30} **SESSION 1**
Chair: Andre Batako
Liverpool John Moores University, UK

Cyber-Physical Production System Design Decomposition for Internal Disruption Avoidance
Tanel Aruväli[1], Matteo De Marchi[1], Erwin Rauch[1] and Dominik T. Matt[1,2]
[1] Free University of Bozen-Bolzano, Italy
[2] Fraunhofer Research Italia, Innovation Engineering Center, Italy

Advancing Circular Economy: The Product Circularity Index as a Tool for Sustainable Design

Foivos Psarommatis[1], Fotios K. Konstantinidis[2], Victor Azamfirei[3] and Gökan May[4]

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Simulation Driven Evaluation of Reward Systems in Activity-Based Manufacturing Environments

Unais Sait, Marco Frego, Antonella De Angeli and Angelika Peer

Free University of Bozen-Bolzano, Italy

Generative AI in Agile, Project, and Delivery Management

Bohdan Haidabrus[1,2,3]

[1] *Accenture Baltics, Latvia*

[2] *Riga Technical University, Latvia*

[3] *University of Applied Science, Latvia*

14^{00}–15^{30} **SESSION 2**

Chair: Natalia Hornakova

Comenius University Bratislava, Slovak Republic

Surface Hardness Improvement of AISI D2 Tool Steel by Laser Transformation Hardening Process Using High-Power Disk Laser

Vitaliy Dzhemelinkyi[1], Matej Hruska[2], Bohdan Mordyuk[3,4], Daniel Grochala[5] and Dmytro Lesyk[1,3,6]

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[3] *G.V. Kurdyumov Institute for Metal Physics of the National Academy of Sciences of Ukraine, Ukraine*

[4] *E.O. Paton Electric Welding Institute of the National Academy of Sciences of Ukraine, Ukraine*

[5] *West Pomeranian University of Technology, Poland*

[6] *University of the Basque Country, Spain*

The Influence of the Geometry of High-Performance Cutters on the Profile Accuracy of Large-Pitch Tapered Threads: Theoretical Study
Iuliia Medvid, Oleh Onysko, Lolita Pituley, Zinovii Odosii and Olena Kornuta
Ivano-Frankivsk National Technical University of Oil and Gas, Ukraine

Spindle Vibration Prediction for the CNC Machining Center Using ANFIS System
Pichai Janmanee and Suthep Butdee
Rajamangala University of Technology Krungthep, Thailand

Adaptive Fluid Jet Support Technique for Variable Stiffness Thin-Walled Parts End Milling
Serhii Kononenko, Sergey Dobrotvorskiy, Yevheniia Basova, Oleksandr Kharchenko and Dmytro Trubin
National Technical University "Kharkiv Polytechnic Institute", Ukraine

15^{00}–15^{15} **COFFEE BREAK**

15^{15}–16^{00} **SESSION 3**
Chair: Justyna Trojanowska
Poznan University of Technology, Poland

Integration of Statistical Analysis and Machine Learning Techniques for Enhanced Quality Control in Candle Oil Cartridge Manufacturing
Monika Kulisz[1], Katarzyna Antosz[2] and Edward Kozłowski[1]
[1] *Lublin University of Technology, Poland*
[2] *Rzeszow University of Technology, Poland*

Risk Assessment at Unsignalized Intersections Based on Human-Road-Environment-Vehicle System Applying Fuzzy Logic
Ievgen Medvediev[1,2], Dmitriy Muzylyov[3], Vitalii Ivanov[4,5], Jakub Montewka[1] and Justyna Trojanowska[6]
[1] *Gdansk University of Technology, Poland*
[2] *Volodymyr Dahl East Ukrainian National University, Ukraine*
[3] *State Biotechnological University, Ukraine*
[4] *Sumy State University, Ukraine*
[5] *Technical University of Košice, Slovak Republic*
[6] *Poznan University of Technology, Poland*

Green Logistics System: Cargo Bikes as an Alternative to Cars
Natalya Shramenko[1], Christoph Hupfer[1], Vladyslav Shramenko[2] and Piotr Trojanowski[3]
[1] *Baden-Württemberg Institute of Sustainable Mobility, Germany*
[2] *Vytautas Magnus University, Lithuania*
[3] *West Pomeranian University of Technology in Szczecin, Poland*

15[15]–16[00] **SESSION 4**
Chair: Katarzyna Antosz
Rzeszow University of Technology, Poland

An Analysis of Machined Surface Quality Using TiAlTaN-Coated Tools in AMPCO® Milling Operations
Francisca Nogueira[1], André Pedroso[1], Francisco Silva[1,2], Raul Campilho[1,2] and Rita Sales-Contini[1,3]
[1] *Polytechnic of Porto, Portugal*
[2] *Associate Laboratory for Energy, Transports and Aerospace (LAETA-INEGI), Portugal*
[3] *Technological College of São José dos Campos, Professor Jessen Vidal, Brazil*

Empirical Data-Based Failure Rate Assessment Methodology for Metal Cutting Tools
Mykhaylo Frolov, Volodymyr Tsyganov and Vasyl Solokha
National University "Zaporizhzhia Polytechnic", Ukraine

ANFIS System for Stress Prediction of Cold Heading Fastener Body Process for a Steel Base Composite Aluminium
Suthep Butdee[1] and Uten Khanawapee[2]
[1] *Rajamangala University of Technology Krungthep, Thailand*
[2] *King Mongkut's University of Technology North Bangkok, Thailand*

16[30]–18[00] **SOCIAL PROGRAM – PILSNER URQUELL BREWERY TOUR**

18[00]–22[00] **SOCIAL PROGRAM – GET TOGETHER PARTY**

Day 3 | June 6, 2024

10^{00}–11^{00} **KEYNOTE SESSION II**
Chair: Vitalii Ivanov
Sumy State University, Ukraine

Machining of Composite/Metal Stacks: Challenges, Principles and Solutions
Jinyang Xu
Shanghai Jiao Tong University, China

Development of Advanced Machine Tools for Machining New Hard-to-Machine Aerospace Composite Materials Including Notorious Abrasive CMC/MMC and their Derivatives
Andre Batako
Liverpool John Moores University, UK

11^{00}–11^{30} **COFFEE BREAK**

11^{30}–13^{00} **WORKSHOP / NETWORKING & IDEAS EXCHANGE**

Industrial Agile
Bohdan Haidabrus
Riga Technical University, Latvia

Machine Learning: Theory and Practice
Katarzyna Antosz
Rzeszow University of Technology, Poland

13^{00}–14^{00} **LUNCH**

14^{00}–15^{00} **SESSION 5**
Chair: Francisco J.G. Silva
Polytechnic of Porto, Portugal

Tribological Tests of Nanometric Coatings Used for Mechatronic Components With Increased Wear-Resistance
Liliana-Laura Badita-Voicu, Adrian-Catalin Voicu and Aurel Zapciu
National Institute of Research and Development in Mechatronics and Measurement Technique, Romania

Enhancing Service Life and Durability of Machine Parts Through Surface Plastic Deformation
Anastasiia Symonova, Volodymyr Drahobetskyi and Viktoriia Kulynyc
Kremenchuk Mykhailo Ostrohradskyi National University, Ukraine

Wear Behaviour and Machining Performance in Milling of INCONEL® 718 of TiAlVN and TiAlN/TiAlVN Coated Tools: A Comparative Study

Naiara Sebbe[1,2], Filipe Fernandes[1,3], Rúben Costa[2,4], Rita Sales-Contini[1,5] and André Pedroso[1,2]

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[2] *University of Porto, Portugal*
[3] *University of Coimbra, Portugal*
[4] *Associate Laboratory for Energy, Transports and Aerospace (LAETA-INEGI), Portugal*
[5] *Technological College of São José dos Campos, Professor Jessen Vidal, Brazil*

Surface Morphology and Microstructural Features of LPBF-Printed Superalloy Turbine Blade Subjected to HIP, Heat Treatment and Shot Peening

Dmytro Lesyk[1,2,3], Silvia Martinez[1], Bohdan Mordyuk[3,4], Vitaliy Dzhemelinkyi[1] and Aitzol Lamikiz[1]

[1] *University of the Basque Country, Spain*
[2] *National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Ukraine*
[3] *G.V. Kurdyumov Institute for Metal Physics of the NAS of Ukraine, Ukraine*
[4] *E.O. Paton Electric Welding Institute of the NAS of Ukraine, Ukraine*

14^{00}–15^{00} **SESSION 6**

Chair: Dagmar Caganova
Comenius University Bratislava, Slovak Republic

Designing the Educational Content for the Industry 4.0 Competency Model

Peter Arras[1] and Galyna Tabunshchyk[2,3]

[1] *KU Leuven, Belgium*
[2] *National University "Zaporizhzhia Polytechnic", Ukraine*
[3] *FH Dortmund, IDiAL, Germany*

Statistical Comparison of Manual and Automatic Sampling at Enterprises

Jozef Trojan[1] and Milan Fiľo[2]

[1] *Technical University of Kosice, Slovak Republic*
[2] *Ecoinvestment, Czech Republic*

Management of Information Resources at Industrial Companies
Dmytro Gorovyi[1], Yevheniia Basova[1], Olena Lynnyk[1], Ivan Pavlenko[2] and Justyna Trojanowska[3]
[1] *National Technical University "Kharkiv Polytechnic Institute", Ukraine*
[2] *Sumy State University, Ukraine*
[3] *Poznan University of Technology, Poland*

Creation of a Localization Project in RTLS Studio for the Need of an Industrial Data Collection Application
Peter Trebuňa, Marek Mizerák, Miriam Pekarčíková and Jozef Trojan
Technical University of Košice, Slovak Republic

15^{00}–15^{15} **COFFEE BREAK**

15^{15}–16^{45} **SESSION 7**
Chair: Oleh Onysko
Ivano-Frankivsk National Technical University of Oil and Gas, Ukraine

Optimizing the Process of Obtaining and Maintaining Rainforest Alliance Certification in the Sri Lankan Supply Chain
Kavitha Wickramaarachchi[1], W. Madushan Fernando[1], Amila Thibbotuwawa[1], H. Niles Perera[1] and Peter Nielsen[2]
[1] *Center for Supply Chain, Operations and Logistics Optimization, University of Moratuwa, Sri Lanka*
[2] *Aalborg University, Denmark*

Evaluation of Cutting Fluid Penetration into the Cutting Zone During Grinding of Rolling Rolls
Mykhaylo Stepanov[1], Leonid Polonsky[2], Volodymyr Korniienko[1], Tetyana Tretyak[1] and Maryna Ivanova[1]
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[2] *Zhytomyr Polytechnic State University, Ukraine*

Thermodynamic and Exergetic Analysis of the Coolers for Mineral Fertilizers
Ruslan Ostroha[1], Mykola Yukhymenko[1], Artem Evtuhov[1], Ivan Dehtiarov[1] and Jozef Bocko[2]
[1] *Sumy State University, Ukraine*
[2] *Technical University of Kosice, Slovak Republic*

Design of the Technological Routes for Sustainable Machining of Functional Surfaces for the Automotive Engineering Parts
Yaroslav Kusyi[1], Nazarii Kusen[1], Andrii Slipchuk[1], Iryna Schuliar[2] and Lolita Pituley[2]
[1] *Lviv Polytechnic National University, Ukraine*
[2] *Ivano-Frankivsk National Technical University of Oil and Gas, Ukraine*

The Influence of Cutting Forces on the Cracks Formation during the Grinding of Products from Materials Prone to Defect Formation
Maksym Kunitsyn, Anatoly Usov and Yuriy Zaychyk
Odesa Polytechnic National University, Ukraine

The Model for Professional Competence Development of Engineering Teachers at Colleges
Petro Luzan[1], Olena Titova[1,2], Iryna Mosia[1], Tetiana Pashchenko[1] and Gulshan Navruzova[3]
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[2] *Dmytro Motornyi Tavria State Agrotechnological University, Ukraine*
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15^{15}–16^{45} **SESSION 8**
Chair: Ivan Pavlenko
Sumy State University, Ukraine

Dynamic Analysis of a Tennis Ball Launcher System
Jakub Sikora and Jan Gorecki
Poznan University of Technology, Poland

Hysteresis Compensation of Pneumatic Artificial Muscles Using Correctional Curve Offset: Case Study
Oleksandr Sokolov[1,2], Sandor Csikos[3], Alexander Hosovsky[2], Jozsef Sarosi[3] and Serhii Sokolov[1]
[1] *Sumy State University, Ukraine*
[2] *Technical University of Kosice, Slovak Republic*
[3] *University of Szeged, Hungary*

Research of Static Stiffness of Flexible Fixtures for Y-Fork Type Parts
Ivan Dehtiarov[1], Vitalii Ivanov[1,2], Artem Evtuhov[1], Ruslan Ostroha[1] and Olaf Ciszak[3]
[1] Sumy State University, Ukraine
[2] Technical University of Kosice, Slovak Republic
[3] Poznan University of Technology, Poland

Assessing External Supply Risk: Perspectives from a Low Middle-Income Country
Praveena Somaweera, Dilina Kosgoda and H. Niles Perera
University of Moratuwa, Sri Lanka

Real Time Driver Drowsiness Detection Using Transfer Learning
P.M. Fernando[1], Ranil Sugathadasa[1], M. Mavin De Silva[1,2], Amila Thibbotuwawa[1] and T. Sivakumar[1]
[1] University of Moratuwa, Sri Lanka
[2] Nagaoka University of Technology, Japan

Analyzing the Locomotion Conditions of a Wheeled Vibration-Driven System with a V-Shaped Suspension
Vitaliy Korendiy[1], Pavlo Krot[2], Oleksandr Kachur[1] and Volodymyr Gurskyi[1]
[1] Lviv Polytechnic National University, Ukraine
[2] Wroclaw University of Science and Technology, Poland

16^{45}–17^{00} **DISCUSSION & SUMMARY**

17^{00}–17^{30} **AWARDS & CLOSING CEREMONY**

19^{30}–23^{00} **GALA DINNER**

Day 4 | June 7, 2024

8^{30}–10^{30} **INDUSTRY TOUR – DAIKIN INDUSTRIES CZECH REPUBLIC S.R.O.**

10^{30}–11^{30} **LUNCH**

11^{30}–19^{00} **CULTURAL PROGRAM – KARLŠTEJN CASTLE**

Posters List

1 **Experimental Justification of the Technological Parameters for the Mobile Branch Trimmer**
Viktor Sarana, Sergey Fryshev, Volodymyr Vasyliv, Roman Mukoid and Maxim Gudzenko

2 **Elastic Bending of a Strip under the Action of Applied Forces**
Ali Kadhim Ahmed, Serhii Pylypaka, Tetiana Volina, Vyacheslav Hropost and Tetiana Kresan

3 **Anti-Friction Products from Composite Materials Based on Lh15 Steel Powder**
Tetiana Halchuk, Oleksandr Povstyanoy, Roman Polinkevych, Olha Redko and Nataliya Zubovecka

4 **An Increase in the Durability of Pumping Equipment**
Mikhailo Mushtruk, Natalia Slobodianiulk, Yuriy Boyko, Volodymyr Matseiko and Roman Chuiuk

5 **The Influence of Texture Discreteness on the Stress-strain State of the Tribosurface after Preliminary Profiling**
Kostyantyn Holenko, Aleksandr Dykha, Volodymyr Dytyniuk, Maksym Dykha and Orest Horbay

6 **Optimization of Surfacing Modes for a Wear-Resistant Alloy**
Khrystyna Berladir, Tetiana Hovorun, Olena Bilous, Vita Pavlenko and Szymon Wojciechowski

7 **Improvement of the Assembly Technology Quality by Determining the Closing Link Size Under Thermal Stress**
Hanna Hrinchenko, Roman Trishch, Viktoriia Kniazieva and Nataliia Antonenko

8 **An Increase in the Service Life and Reliability of Machines' Structural Components Using Innovative Engineering Solutions**
Olena Deviatko, Mykola Denisenko, Mikhailo Mushtruk, Nataliia Kanivets and Natalia Slobodyanyuk

9 **Changing the Output Characteristics of a Planetary Hydraulic Motor**
Anatolii Panchenko, Angela Voloshina, Aleksandr Fatyeyev, Kseniya Rezvaya and Krzysztof Mudryk

10 **Efficient Models of Turbopump Units for Evaluating Dynamic Characteristics**
Sergey Krasnikov, Andrii Rogovyi, Irina Hrechka, Ivan Chyzhykov and Olga Viunyk

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The posters in the form of video presentations are published online at the YouTube channel of the International Association for Technological Development and Innovations as an open-access source.

Keynote Speakers

Keynote Speaker

Arkadiusz GOLA,
DSc., Ph.D., Associate Professor,
Lublin University of Technology (Poland)

Arkadiusz Gola, DSc, Ph.D. Eng., works as an Associate Professor at the Department of Production and Computerization at the Faculty of Mechanical Engineering of the Lublin University of Technology (Poland). In 2011, he received a Ph.D. degree from Lublin University of Technology (Poland), and in 2019, he received a habilitation from Cracow University of Technology (Poland). He is a specialist in manufacturing systems design, operation management, and intralogistics. He is an author or co-author of 9 scientific monographs, 117 research papers, 121 chapters, and 9 patents. His actual H-index in Web of Science is 21 and 23 in Scopus databases. Arkadiusz Gola is an Editor-in-Chief of the Applied Computer Science journal, a President of the Polish Association for Knowledge Promotion, and a member of the Polish Society for Production Management. Since 2014, he has been an expert at the Polish National Centre of Research and Development.

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Keynote Speech Topic

Challenges in Manufacturing Systems Designing in the Aspect of Industry 4.0 and Industry 5.0 Assumptions

The 20th century was a period of continuous challenges that both production companies and designers of manufacturing systems had to stand up to. It was a result of technical and technological progress unknown in history so far, the process of globalization moving forward at a frantic pace, increasing level of competition, and also changeable and more and more superior requirements of customers. The same, both methods of production and organization of manufacturing systems were a subject of constant evolution. The presentation is focused on emphasizing the importance of flexibility factor in the process of manufacturing systems development during the 20th century. In particular, craft manufacturing, dedicated manufacturing systems (DMS), and flexible manufacturing systems (FMS) were characterized. Finally, actual problems and trends in production system design were noticed and probable directions and challenges of development of manufacturing systems in the aspect of Industry 4.0 and Industry 5.0 assumptions were indicated.

Keynote Speaker

Foivos PSAROMMATIS,
Ph.D., Researcher,
University of Oslo, Norway,
Zerofect, Switzerland

Foivos Psarommatis is a passionate engineer and a highly active researcher in the area of quality management and sustainability in manufacturing systems. Currently, he is the founder and CEO of Zerofect, a company based in Switzerland that focuses on providing digital technologies for sustainable manufacturing, including dynamic production scheduling and Digital Product Passports. Additionally, he is a researcher at the University of Oslo (UiO). More specifically, it is a pioneer in the area of Zero Defect Manufacturing (ZDM), as it is the first to modernize and set the foundation of modern ZDM. His scientific interests, motivation, and vision, are around Industry 4.0 and how ZDM can be applied efficiently to production systems, focusing on the decision-making, scheduling, and design of a system or a product, with the ultimate goal of achieving truly sustainable manufacturing. Regardless of his age, he was listed in the world's top 2% of Scientists for 2022. He is actively involved in EU research programs in the area of Factories of the Future and Enabling ICT for Sustainable Manufacturing. Foivos holds a BSc. and an MSc. in Mechanical Engineering with specialization on design and manufacturing engineering from the University of Patras. He also has a second MSc. from the National University of Athens in Automation Systems with a specialization in manufacturing and production systems. He did his Ph.D. around the topic of Zero Defect Manufacturing École Polytechnique Fédérale de Lausanne – EPFL. Foivos is the chair of a CEN/CENELEC working group responsible for standardizing ZDM.

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Keynote speech topic

Quality Management in the Era of Industry 4.0/5.0 Towards Zero Defect Manufacturing

Quality management is a vital process in the manufacturing domain highly impacting the overall sustainability of a manufacturing system. Quality does not refer only to product quality but to all aspects of a manufacturing entity, such as services or processes. Therefore, for every business to succeed, quality should be maintained at every level. Every product, service, process, task, action, or decision in an organization can be judged in terms of quality. The traditional quality management methods, such as Six Sigma, lean, etc., cannot meet the needs of the contemporary market. This is due to the fact that have been created many decades ago as a result of not being able to fully utilize all the modern digital technologies coming from the Industry 4.0 concept. The alternative is called Zero Defect Manufacturing (ZDM), the latest approach for quality management, which aims to eliminate defects and ensure that no defective products leave the production site. The implementation of ZDM is straightforward due to the simple but comprehensive framework, composed of four strategies: Detect and Predict, which are the triggering strategies, and Repair and Prevent, which are the action strategies. The implementation of those strategies has created new constraints in the production problem. ZDM is a holistic approach, meaning that all the aspects of the manufacturing system are considered, including the business, scheduling, supply chain, and the actual shop floor. Scheduling is the link between all those aspects, as it is the tool that coordinates all aspects and translates them into the production schedule. Finally, information and data availability are vital aspects. Therefore, the use of the Digital Product Passport is essential for advanced analytics, transparency, and data exploitation.

Keynote Speaker

Francisco J.G. SILVA,
Dr. Habil, Ph.D.,
Polytechnic of Porto, Portugal

Francisco J.G. Silva is Dr. Habil, Ph.D., MSc. and BSc. in Mechanical Engineering by FEUP and ISEP (Portugal). He is Post-Graduated in Materials and Manufacturing as well. Currently, he is the Head of the Mechanical Engineering Research Center at ISEP, Polytechnic of Porto. He also was Head of the Marter's Degree in Mechanical Engineering of ISEP (2014-2022) and Head of the Bachelor's Degree in Mechanical Engineering at ESEIG, Polytechnic of Porto (2003-2006). He has supervised more than 10 PhD students at FEUP (Portugal) and the University of Vigo (Spain), as well as more than 200 MSc. students at ISEP, and co-supervised more than 40 MSc. students at ISEP and FEUP. He has more than 300 papers (ISI+SCOPUS), and 17 international books published. He has reviewed over 800 papers, being Editor-in-Chief, Associate Editor, and Editorial Board Member of more than ten indexed international journals.

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Keynote speech topic

Green Automation

Sustainability is something essential so that we can aspire to a better future. However, sustainability depends on all of us. Our behavior and consumption habits strongly affect the environment and are not in line with the renewal induced by nature itself. Automation can contribute to reducing natural resources, greenhouse gas emissions, and waste production. In fact, we normally associate environmental degradation with the intense industrial activity of more developed countries. However, consumption habits generate the need for an exacerbated production of goods from the primary to the tertiary sector. This production can be more or less environmentally friendly, depending on how it is carried out. To this end, although automation cannot directly intervene in consumption, it can minimize the damage caused by production that aims to respond to demand. Therefore, consumption habits can be the first factor to consider in preserving the environment. These consumption habits extend to our homes, where automation can also play a fundamental role in saving energy and consuming resources, among others. There is still a long way to go, but it is clear that automation can be considered fundamental for us to aspire to a better future. This work reflects on how automation can reduce environmental degradation and save resources.

Keynote Speaker

Jinyang XU,
Ph.D., Associate Professor,
Shanghai Jiao Tong University, P.R. China

Jinyang Xu, Ph.D., FIAAM, MSCS, is an Associate Professor and a Doctoral Supervisor of Mechanical Engineering at Shanghai Jiao Tong University, China. He leads the Research Group "Intelligent Manufacturing and Surface Technology" at SJTU. He received his M.Sc. in Mechanical Manufacturing & Automation from Shanghai Jiao Tong University (China) in 2013 and obtained his Ph.D. in Mechanical Engineering & Materials from Arts et Métiers ParisTech (France) in 2016. His research interests include composite machining, numerical modeling, micro/nano cutting, and surface texturing. He has published over 140 peer-reviewed articles in international journals and edited 3 monographs, 5 book chapters, 9 international conference proceedings, and 9 special issues. His publications have been cited over 3500 times with an h-index of 34, according to Google Scholar Citations. He now serves as the Editor-in-Chief of Journal of Coating Science and Technology (JCST), International Journal of Precision Technology (IJPTech), and International Journal of Product Sound Quality (IJPSQ). He is an Associate Editor of Proc. Inst. Mech. Eng. Pt. E - J. Process. Mech. Eng. (SCIE/EI), Simulation - Transactions of the Society for Modeling and Simulation International (SCIE/EI), and Frontiers in Materials (SCIE/EI). He holds over 700 peer reviews and over 100 editor records for various international journals, including IJMTM, JMPT, IJAMT, IJMS, COST, WEAR, etc., verified by the Web of Science (WOS) (https://www.webofscience.com/wos/author/rid/G-8731-2011). He is the PI of 12 national and provincial projects, including the NSFC funds. He is also the Conference Chair of the 2nd and 3rd International Conference on New Materials, Machinery, and Vehicle Engineering (NMMVE2023/2024). He has been invited as Keynote/Invited Speaker, Section Chair, and TPC member for numerous international conference series (e.g., APMAS, DSMIE, ICMEM, ICMTM, ICMSOA, ICEM, ICMD, ICMAT, etc.) with themes in materials science and manufacturing processes. He is the National Committee and Deputy Secretary-General of the Advanced Manufacturing Technology Research Branch of the China Metal Cutting Tool Engineering Association and the Vice-Chairman of the

Composite Materials Expert Committee of the National Think Tank for Materials and Devices Scientists. For his research contributions to the machining science of composite/metal stacks, he was elected as a Fellow of IAAM. He was honored with the IAAM Scientist Medal (2020) and the Shanghai Pujiang Talents Program (2017).

https://www.researchgate.net/profile/Jinyang_Xu

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Keynote speech topic

Machining of Composite/Metal Stacks: Challenges, Principles and Solutions

Multilayer composite/metal stacks constituted by carbon fiber reinforced polymers (CFRPs) and titanium alloys are advanced high-performance materials being extensively used in the modern aerospace industry due to their improved mechanical/physical properties and enhanced structural functionalities. However, the machining of hybrid composite stacks has posed significant challenges to the manufacturing community because of the different properties of each stacked material involved. The keynote lecture aims to report the existing challenges faced by the current machining industries and then present the potential solutions by introducing the innovative works carried out by the speaker's research group. The fundamental mechanisms of chip removal and defect formation of CFRP/Ti6Al4V stacks are first illustrated. Issues of hole quality attributes and tool wear progression are discussed. Performances of several innovative cutting methods involving the MQL machining and the vibration assisted drilling to improve the stack machinability are detailed. Eventually, the future perspectives in the fields of high-performance machining of aerospace-grade composite/metal stacks are outlined.

Acknowledgments:
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Keynote Speaker

Andre D.L. BATAKO,
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research in natural fibre reinfoece composites, renewable energies and laser applications in industrial manufacturing and plant biology.

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Keynote speech topic

Development of Advanced Machine Tools for Machining New Hard-to-Machine Aerospace Composite Materials Including Notorious Abrasive CMC/MMC and their Derivatives

The global socio-economic landscape requests that all human activities to be sustainable in absolute terms. In manufacturing, this manifests itself as a demand for higher productivity, which is usually achieved via faster machining speeds. However, environmental issues have led the world bodies (COP26), to set up guidance and regulations on sustainability and the management of the carbon footprint. This increases the pressure on all businesses to remain at the competitive edge. Manufacturing processes can be highly energy intensive resulting in a significant contribution to pollutant emissions. Therefore, the world asks for new materials and new "smarter" manufacturing methods that simultaneously increase productivity and drive down carbon emissions. This has set material scientists into an endless race to make the lightest, the hardest, the toughest – Yes, the most of the most. This led to the combination of various materials to create "Super Materials", that will solve the world's problems. As such, in their race for "Super Materials", researchers in this field have been mixing different components to create composites with excellent physical and mechanical properties. However, there is a loophole here - the material scientists have long forgotten that these new composites, to be used for the purpose they were created for, need to be cut, shaped, and machined to given forms with the required accuracy. These super-materials are super-abrasives, and they abrade the hardest material known by human – the diamond; Yes they wear out diamond tools in not time. So how can we cut and shape these new materials? This is the challenge Today. This talk will cover these challenges along with an approach as to how to machine these tough materials using "Resonance machining" and suggest an example of Machine tool design that resolves these challenges, regardless of the nature of the material.

Invited Speakers

Invited Speakers

Miroslav ZETEK
University of West Bohemia, Czech Republic

Tomáš CHOLINSKÝ
Information Technology Administration of the City of Pilsen, Czech Republic

Gerhard MEINDL
Es geht!, Germany

Belal DAWOUD
East Bavarian Technical University of Regensburg, Germany

Andy GRADEL
Hof University of Applied Sciences, Germany

Invited Lecturers

Invited Lecturers

Bohdan HAIDABRUS
Riga Technical University, Latvia

Katarzyna ANTOSZ
Rzeszow University of Technology, Poland

Abstracts
Part I
Smart and Sustainable Manufacturing

Cyber-Physical Production System Design Decomposition for Internal Disruption Avoidance

Tanel Aruväli[1][0000-0003-2077-6642], Matteo De Marchi[1][0000-0001-7965-4338], Erwin Rauch[1][0000-0002-2033-4265] and Dominik T. Matt[1,2][0000-0002-2365-7529]

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A growing number of manufacturing companies are undergoing digital transformation and moving towards Cyber-Physical Production Systems (CPPS). To ensure the long-term resilience of CPPS by avoiding internal disruptions, the starting point is the proper design of a functional digital shadow. Therefore, the goal was to provide decomposed design guidelines for the digital shadow implementation. The Axiomatic Design (AD) method was applied to discard systems-based categorization and decompose design parameters from functional requirements, which guided a novel approach covering digital shadow design guidelines. Through the zigzagging process, we elaborated collectively exhaustive and mutually exclusive conceptual design parameters. The received results were applied to a cyber-physical demonstrator. The practical value of the received design parameters guided towards alternative digital solutions, and based on AD axioms, the selection of digital solutions was implemented on the demonstrator. Such an approach enabled us to cover the full concerned functionality while avoiding decoupling and overlapping in implemented solutions.

Keywords: Digital Shadow, Axiomatic Design, Resilience, Industrial Growth.

Implementation of the Technological Capabilities of the Testbed 4.0 Laboratory in Cooperation with Simulation

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Technologies such as simulations, detailed modeling, and data collection with the help of sensors and feelers are familiar in industrial practice and industrial engineering. It is more important to apply and integrate all these technologies correctly. If we connect all available options and use all available data sources, we can create authentic digital models of actual operations, the so-called digital twin. Such a relatively perfect simulation can, with the correct configuration and connection of external devices such as PLCs, not only receive but also physically influence the environment. The paper deals with integrating simulation and technological means within the TestBed 4.0 laboratory, such as PLC converters, different types of servers, and devices that can be connected to them. The TestBed 4.0 laboratory dramatically facilitates the verification of the modification of production processes and the creation of various types of digital twins, making it possible to verify various variants of the modification of processes in a digital environment. After tuning the twin and verifying all the advantages and disadvantages of the modification, this already verified one is implemented in actual operation, eliminating production losses. In a way, the post is a guide to connecting the simulation software Tecnomatix Plant Simulation using the available means with a PLC converter, with the help of which it is possible to control the elements of the simulation and, conversely, to control the elements of the physical world with the help of the simulation.

Keywords: Simulation, Testbed 4.0, PLC, Server, Connection, Industrial Growth.

Studies on Streamlining Processes Using Industry 4.0 Elements

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Industry 4.0 is redefining manufacturing paradigms through the integration of advanced digital technologies. This study takes a theoretical and practical look at the implementation of Industry 4.0 elements to increase the efficiency of manufacturing processes through simulation and visualization in the manufacturing sphere of the enterprise. Industry 4.0 concepts are analyzed, highlighting their impact on the transformation of business models. It also describes a specific workplace that has successfully integrated these technologies, detailing their implementation and benefits. The article discusses digitalization in the Tecnomatix Plant Simulation software, which enables real-time modeling. It details its use for optimizing production processes, reducing lead times, and streamlining supply chain efficiency. It concludes with an analysis of the improvements achieved and their impact on the production cycle, presenting concrete results regarding increased efficiency, minimization of errors, and optimization of resources. Overall, it provides a comprehensive view of successful Industry 4.0 implementation through simulation and visualization.

Keywords: Process Innovation, Simulation, Visualization, Tecnomatix Plant Simulation.

Material Removal Rate Determination Based on a Laser Displacement Sensor

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The non-contact measurement method was used to determine the parameters of the cut layer of material during grinding and other mechanical machining methods. One of these parameters is the specific grinding energy, which equals the ratio of grinding power to the material removal rate. The latter is determined by the cross-sectional area of the material layer being cut. The paper proposes a non-contact method for measuring instantaneous height parameters of the cross-section of the cut layer using a laser displacement sensor with subsequent determination of the cross-sectional area. This is relevant for defectless grinding implants and workpieces with free-form surfaces made of hard-to-machine materials. Studies have been carried out on the accuracy of non-contact measurement of instantaneous height parameters of the cross-section of the cut layer of material by comparing the obtained data with the results of contact measurement of standard block gauges. The developed non-contact distance measurement system has been shown to have a resolution of 0.01 mm with the same standard deviation regardless of the absolute value of the height parameters. The relative error of non-contact indirect measuring of the difference in the height parameters has been established.

Keywords: Industrial Growth, Laser Displacement Sensor, Complex-Shaped Surface, Block Gauges, Non-Contact Method, Cross-Section Area, Measurement Bases.

Advancing Circular Economy: The Product Circularity Index as a Tool for Sustainable Design

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The rise of the fast-consuming era, marked by manufacturers continuously increasing production rates, has led to the design and manufacturing of products without due consideration for sustainability aspects. Despite the overall reduction in production costs, this approach harms the environment and circumvents circularity methodologies. To bridge the gap between traditional design practices and sustainability, we propose a structural method for measuring circularity in design. The introduced Product Circularity Index (ProdCircIn) serves as a quantifiable measure to assess a product's alignment with circular economy principles and functions as a key performance indicator (KPI) for evaluating and comparing products based on their circularity attributes. Specifically, ProdCircIn evaluates products in six pillars: design philosophy, usage of materials, design for manufacturing, design for quality, design for warranty, and design for the future. These pillars are quantified through relevant questionnaires, as analytical solutions and formulas could be more practical due to the distinct characteristics of each product.

Keywords: Circularity Index, Sustainable Design, Product Design, Circularity, Sustainability, Product Innovation.

Simulation-Driven Evaluation of Reward Systems for Activity-Based Manufacturing Environments

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The rise of automation in the manufacturing sector and the transition from traditional role-based to activity-based shop floor management systems have brought greater flexibility and skill utilisation among shop floor workers. The vast array of task choices in activity-driven environments can overwhelm employees, potentially leading to sub-optimal decisions. Moreover, determining the optimal tasks in such a dynamic environment is complicated, and there is a risk that lower-priority tasks will be neglected. In this circumstance, it is crucial to impart knowledge to the workers about the value of a task through rewards. This study advocates for using simulations to assess the impact of various reward systems on worker performance in activity-based shop floor management systems. Simulations offer a cost-efficient and risk-averse means to explore scenarios, enabling organisations to make informed decisions about reward strategies. The paper aims to compare two reward systems based solely on worker skills and another incorporating historical skill utilisation and task unacceptance ratios. The simulation results demonstrate that the reward system considering unacceptance ratios leads to reduced unacceptance of tasks and a decrease in the number of open tasks compared to the skill-based reward system. The findings of this simulation could assist manufacturing sectors in selecting the most effective reward system for their employees and could act as a preliminary investigation to understand the reward system before testing it in the real world on the shop floor.

Keywords: Digital Manufacturing, Simulation, Automation, Reward Systems, Manufacturing Innovation.

Creation of a Localization Project in RTLS Studio for the Need of an Industrial Data Collection Application

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This article deals with creating a localization project in RTLS (Real-Time Locating System) Studio to optimize the process of collecting production data in an industrial enterprise. RTLS Studio is part of the innovative RTLS technology that enables real-time tracking and device location. This project aims to use RTLS to improve the efficiency and accuracy of data collection in an industrial environment. Implementing this localization project will provide accurate information about equipment location in an industrial plant, allowing better monitoring and management of production processes. This has the effect of reducing response time, minimizing errors, and optimizing the overall performance of the production facility. The article examines the creation of this project directly in a manufacturing company that deals with heavy engineering for further use in the creation of various types of analysis and technical aspects of the implementation of RTLS technology to obtain the maximum sound output. Emphasis is placed on data security and the transfer of information between devices to ensure the safe and reliable operation of the entire system. The results of this work represent potential benefits for industrial enterprises, including increased productivity, better inventory tracking, and faster response to changes in the production environment. In this way, the article benefits the industrial sector and supports further research and implementation of localization projects within RTLS systems.

Keywords: RTLS, Industry, Location, Project, Industrial Growth.

Part II
Information Management Systems

Directions of IT Systems Development in Warehouses Management: Polish Practitioners Viewpoint

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During the last two decades, a rapid development of information technology (IT) systems used by logistics companies has been observed. These systems facilitate decision-making processes, reduce operation duration, save costs, and integrate data users. Suppliers are creating and delivering systems to the market, considering the varied and stringent customers' requirements. Considering the practitioner's viewpoint, the article examines the directions of IT systems development in warehouse management. Practitioners' opinions in companies located in selected voivodeships in Poland were analyzed. The barriers to the expansion of IT systems were identified, and the directions of their development in logistics companies were investigated. It was concluded that the development of IT systems used to support operations performed in warehouses should be perceived in a complementary manner because the move towards systems integration will facilitate the execution of tasks not only in the warehouses but also within the company and consequently in the whole supply chain. The research results show the desired directions of IT systems development that may interest logistics companies, IT systems suppliers, and users.

Keywords: IT System, Development Directions, Warehouse Management, Logistics Company, Supply Chain, Cognitive System, Industrial Innovation.

Generative AI in Agile, Project, and Delivery Management

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Generative Artificial Intelligence (AI) is poised to revolutionize Agile delivery by introducing unprecedented levels of efficiency, innovation, and adaptability. As Agile methodologies emphasize iterative progress, customer collaboration, and response to change, Generative AI offers a suite of tools that align with these principles by automating and creating tasks, generating a wealth of potential solutions to complex problems, and facilitating rapid prototyping. This article explores the intersection of Generative AI with Agile practices, identifying the enhancements and challenges this integration presents. The discussion is grounded in current trends, practical case studies, and strategies for implementation. The potential benefits and limitations of incorporating Generative AI into Agile frameworks are weighed, with considerations of technical and ethical nature. The article concludes by considering future directions for both Generative AI advancements and the evolution of Agile methodologies. The implications for teams, project management, and overall delivery of products and services are substantial, signaling a transformative phase in the Agile culture, especially for Information Management Systems delivery.

Keywords: GenAI, Agile Framework, Delivery Management, Artificial Intelligent, Industry, Innovation, Infrastructure, Data Science, Machine Learning, Product Innovation.

Management of Information Resources at Industrial Companies

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Information became the third critical issue for the company with material and labor resources. Therefore, its role is significant, but the features of information as an industrial resource are still not pointed out. They do not have a specific methodology for their valuation. The paper examines the role and specific features as a part of their management at the company. The study compares information resources with other companies' resources, highlighting the unique features of information resource descriptions. It also helps close the research gap regarding the management of information resources at the company in the field of their unique features determination, synergistic effect influence, and methods of their estimation and assessment. A fundamental feature of information is its replication. As a result, the need to organize a system of protecting and ensuring information security at the company becomes urgent. However, these measures are not always relevant for companies due to the small use of electronic document management and the traditional paper bureaucracy of processes. In addition, the question of information value is clarifying. Mainly, score methods were applied previously. As a result of the research, the estimation methods of profit on informational resource values were developed using the entropy method. The results highlight the influence of the value of information resources on the company's profit.

Keywords: Information Management System, Small and Medium-sized Companies, Estimation Theory, Synergy, Entropy, Value of Information, Sustainable Manufacturing.

Deployment and Release Management Process in Agile Digital Projects

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This article explores the multifaceted dimensions of executing technical and commercial go-live phases in digital projects, specifically within Agile frameworks. Agile methodologies have become pivotal in managing complex project lifecycles in the rapidly evolving digital technology landscape. The go-live phase, a critical juncture in project deployment, presents unique challenges and opportunities, particularly in Agile environments. A scientific novelty of the research is to provide a comprehensive analysis by integrating empirical evidence and theoretical models, offering insights into best practices, strategies, and common pitfalls associated with these pivotal phases. Drawing on a blend of case studies, academic research, and industry reports, the paper provides a nuanced understanding of the Agile go-live process, offering valuable insights for practitioners and scholars in project management. Ultimately, this article contributes to the broader discourse on Agile methodologies, underscoring their transformative impact on the planning and executing technical and commercial go-live phases in digital projects. It aims to guide project managers, Agile practitioners, and organizational leaders in navigating these complex but critical stages of project deployment.

Keywords: Agile Framework, Delivery Management, Scrum, Go-Live Process, Project Management, Decent Work, Economic Growth, Industrial Growth.

Part III
Manufacturing Technologies

An Increase in the Vibration Resistance of Finishing and Boring Machines When Cutting Ends Using the Plunge-In Method

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The article examines the operation of trimming the free end using the cutting-in method. This operation is widely used in the technological process of manufacturing parts. The vibration resistance of the delicate tuning process during the finishing trimming of solid ends has been studied. The experiments were carried out on a special stand with the ability to change the parameters of the elastic system. Inductive and inductive sensors were used to measure vibrations. A method has been developed for calculating the maximum cutting width with a cutter shovel when changing the rigidity of the part-device subsystem, feed, and workpiece material. It has been established that the rigidity of the part-device subsystem largely determines the occurrence of vibrations. The article mainly examines vibrations along the axial coordinate in the feed direction, which determines the cleanliness of the machined surface and the feasibility of the end-trimming operation. A calculation model of the operation has been developed. In this model, the cutting process is described by a dynamic characteristic reflecting the inertial properties of the process. The stability of the cutting process is determined by the Routh-Hurwitz criterion. Calculations make it possible to determine the dimensions of a given device's maximum permissible width of the machined end. The experiment and corresponding calculations were done using a device with variable parameters. The results of the work are presented in the form of tables and graphs.

Keywords: Vibration Resistance, Cutting of Solid Ends, Rigidity, Vibration Amplitude, Frequency, Cutting Method, Industrial Growth, Process Innovation.

Use of the Processing Arrays Theory of Experimental Data for the Analysis of the Technological Scheme in the Rolled Metal Production – Controlled Rolling

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Formulation of the problem. Establishing a quantitative relationship between the temperature parameters of the traditional controlled rolling scheme and the mechanical properties of thick-rolled metal is an urgent problem. It can significantly affect the production of domestic rolled products with increased operational properties due to the formation of a given structural state of the finished thin-rolled product by adjusting the temperature-deformation parameters of rolling in the cleaning cage. The article aims to build mathematical models of the relationship between the parameters of the controlled rolling technology at the final rolling stage and the main mechanical properties of rolled metal. Conclusion. Mathematical models of the relationship between temperature parameters of controlled rolling and basic mechanical properties of rolled metal from low-carbon low-alloy steel 10Mn2VNb. At the same time, it is shown that the temperature increase at the beginning of the finishing process rolling will lead to an increase in the level of strength characteristics. The analysis of the results of the conducted research showed the perspective of correcting the formation of structural and substructural components based on reduction to a minimum of the cooling period on the bypass roller conveyor and further continuous deformation in the intercritical temperature interval. Simultaneously, lowering the temperature of the end of hot rolling to the lower limit of the intercritical interval will allow further improvement and stabilize the set of mechanical characteristics of rolled steel for building structures.

Keywords: Controlled Rolling, Low-Carbon Low-Alloy Steel, Mechanical Properties, Industrial Growth.

Research of Static Stiffness of Flexible Fixtures for Y-Type Fork Parts

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Modern machining centers with broad technological capabilities require the development of flexible fixtures that ensure one-setup machining with high-performance cutting modes and maximum tool accessibility. It is especially crucial for multiproduct and batch manufacturing. The article experimentally proves the scientific approach based on the machining Y-type forks using fixtures with incomplete locating and clamping on unmachined surfaces in one setup, which ensures machining accuracy. The research presents an improved fixture configuration and theoretical substantiation. The experimental studies of the stress-strain state in the static mode were performed. The obtained values of stresses and displacements proved the advantages of the proposed approach. It was experimentally proven for the first time that the design of the improved fixture for machining Y-type forks provides the necessary machining accuracy under static load and, simultaneously, has a margin of accuracy that exceeds the value of deformations by 1.2...2.3 times. Theoretically and experimentally, it has been proven that the scientific approach to designing fixtures with incomplete locating allows the specified machining accuracy to be obtained while ensuring the necessary stable position exclusively by clamping forces.

Keywords: Accuracy, Deflection, Stress, Numerical Simulation, Error, Industrial Growth, Process Innovation.

Surface Hardness Improvement of AISI D2 Tool Steel by Laser Transformation Hardening Process Using High-Power Disk Laser

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The remote laser phase transformation hardening process is an effective and fast self-quenching method of surface modification to provide a uniform hardening depth over the treated surface. To enhance the surface integrity of the AISI D2 tool steel, a robot-assisted laser hardening process using a high-power disc laser was applied in this work. Using a constant power strategy, the D2 steel flat specimens were selectively processed by a laser phase transformation hardening technique. The effects of laser power and scan speed on the surface roughness, hardness, and hardening intensity were studied. The scan speed from 9 to 15 mm/s and laser power from 1050 to 2550 W were selected to estimate the influence of the related effective parameters on surface hardness improvements. The results indicated that the hardness HV values in the subsurface layer achieved 550–670 HV by the optimized laser heat treatment parameters.

Keywords: Advanced Technology, Remote Laser Surface Hardening, High-Power Disc Laser, Robot-Assisted 3D Scanning, AISI D2 Tool Steel.

Ensuring Tool Run-In When Milling AISI321 Steel in Various Technological Environments

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The article shows the results of various process fluids used in production and alternative environmentally friendly options on the durability of cutting tools during the milling process. In addition, the influence of the running-in process on the wear resistance of the cutting tool was taken into account. Considering the process of cylindrical milling with counter feed, dependencies were obtained based on the analysis of the horizontal component of the cutting force to find optimal running-in conditions. The article aims to evaluate the conditions for tool break-in when lubricating and cooling liquids of various compositions are supplied to the cutting zone to ensure tool durability. The task of constructing mathematical models of power characteristics Ph for various running-in conditions was formulated to establish a functional relationship between the variable and horizontal cutting force for various running-in conditions. The influence of coolant on the strengthening and formation of wear-resistant structures has been established, providing an almost 4-fold reduction in the wear rate of the tool concerning predetermined structures formed in the air. It is shown that the running-in of a cutting tool depends on the environment in which it occurs. Based on the data analysis, practical recommendations were determined for the selection of compositions of cutting fluids and running-in modes for specific milling conditions when processing AISI 321 stainless steel with subsequent transition to production cutting modes.

Keywords: Run-In, Tool Wear, Milling, Technological Environments, Stainless Steel, Process Innovation.

Empirical Data-Based Failure Rate Assessment Methodology for Metal-Cutting Tools

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The type of distribution law and its parameters reflect the physical essence of the technical object failure. Simultaneously, the failure rate is the leading component of this process as it solely defines the type of distribution law. The paper analyzes the nature of the failure rate function in the context of research and assurance of technical object reliability. It was shown that several approaches exist to determine the failure rate based on empirical data. Still, assessment of these approaches from the point of view of their adequacy is absent. No attention was paid to analyzing distribution laws from the point of view of failure rates compliance with empirical data. A criterion based on the maximum likelihood method was proposed for evaluating the empirical failure rate compared with the one obtained based on the theoretical distribution laws. It was shown that the most plausible estimate of empirical failure rate can be obtained using the average number of operational objects in a specific time interval, compared to its theoretical value obtained based on theoretical distribution law as a function of the middle of the same interval. It was shown that the proposed criterion can be used as an additional argument when choosing a theoretical distribution law based on empirical data when the goodness-of-fit criteria do not allow for drawing an unambiguous conclusion. In this case, the correspondence of the theoretical distribution law to the physical processes causing the failure of the technical object will be ensured.

Keywords: Weibull Distribution, Gamma Distribution, Maximum Likelihood Method, Chi-squared Distribution, Industrial Growth.

Spindle Vibration Prediction for the CNC Machining Center Using ANFIS System

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Machining requires high precision and accuracy, whereas the machined parts rely on the machine's quality as its stability. Unbalanced and eccentric components cause machine vibration, which is a significant problem with machining. However, such problems should be detected early in process design. This paper proposes the spindle vibration of CNC machining center prediction by simulation using the ANFIS system. Three main parameters are concerned: working load, bearing life, and spindle speed. Membership functions are designed and created using machine capability. The case studies are illustrated by emphasizing the workload analysis of each cutting path and feature. Cutter loads are calculated, and determined the stress occurrence using FEM. The contributions are spindle vibration estimation related to the workloads and spindle speed usage. Adjudgment data based on vibration prediction can assist machinists in controlling the quality of the machine part and utilizing the longer machine life.

Keywords: Spindle Vibration Prediction, CNC Machining Center, ANFIS System, Process Innovation, Industrial Growth.

Adaptive Fluid Jet Support Technique for Variable Stiffness Thin-Walled Parts End Milling

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To reduce machining errors in thin-walled parts manufacturing, the adaptive fluid jet support technique for variable stiffness thin-walled parts during the milling process was presented. The analysis of existing methods to avoid deflections in milling thin-walled parts was made. Along the tool path in the milling process, the stiffness of the thin-walled parts varies. The technique proposed was a single-point fluid jet support and implied variable impact force that considers the complex curvature of the part geometry. The behavior and the efficiency of the supporting fluid jet provided by the flow surface, including the flow features around different surface cross-section profiles and the concave and convex sides, were considered. An iterative algorithm of the adaptive adjustment of fluid jet support impact during milling considering variable stiffness of the thin-walled part was developed. The analytical errors prediction model was presented. The smoothed-particle hydrodynamics (SPH) method was applied to model the fluid jet flow. The finite element method was applied to model the thin-walled part's cutting forces and stresses under fluid jet impact. The comparison between applications of fluid jet support at different tool positions is performed. The technology is helpful from the point of view of uniform stabilization of allowance removal and approximates the machining of thin-walled low-rigid parts to the machining of completely rigid ones. The result data of sample parts showed that fluid jet support meets the requirements of thin-walled parts machining with decreased processing errors.

Keywords: Thin-Walled Parts, End Milling, Fluid Jet Support, SPH Method, Machining Errors, R&D Investment.

The Influence of Cutting Forces on Cracks Formation during the Grinding of Products from Materials Prone to Defect Formation

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This study examines how cutting forces impact the formation of cracks and chips on surfaces during the grinding of products. Understanding the structure of the grinding process is crucial for identifying ways to increase the output of suitable parts from materials prone to defect formation during final grinding operations, as primary defects such as cracks and chipping occur precisely during final processing. Friction between the abrasive and the processed metal plays a significant role in forming radial and tangential stresses in the surface layer. As the friction coefficient increases, the zone of maximum stress moves closer to the surface of the part being ground, which affects the formation of grinding cracks. The depth of grinding is one factor determining the appearance of these cracks. Stresses generated in the surface layer during processing with a significant grinding depth with solid circles are tensile, contributing to an intensive cracking process. We considered the stress-deformed state of the surface layer of the processed parts under the action of the component grinding forces of cutting force and friction force to clarify their role in the formation of grinding cracks. Using lubricating and cooling technological media reduces the grinding temperature and friction forces between the wheel and the processed material, thereby reducing the intensity of cracking and chipping.

Keywords: Grinding, Cutting Forces, Friction, Defects, Crack, Abrasive, Surface Layer, Grain, Manufacturing Innovation.

Stiffness of Underpinning Supports for Fixtures

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Machining of large-sized workpieces with low stiffness is an urgent task. Auxiliary supports are used in machine tools to reduce deformations and vibrations of workpieces due to the action of cutting forces. Auxiliary underpinning supports are preferable to self-installing ones since they have a higher intrinsic stiffness. The stiffness of the underpinning support with a vertical support pin and with improved ergonomic properties was determined experimentally using a spring dynamometer and simulation. The stiffness coefficients were calculated, and a graph of the support displacement's dependence on the force's magnitude was constructed. A rotary underpinning support with a spherical base is also considered. This support allows for rotating its moving part in two planes and, accordingly, changes the angles of inclination of the support pin. This expands the technological capabilities of the support since it becomes possible for the support pin to contact inclined or curved surfaces of the workpieces. This support's stress, displacement, and strain at a force of 4 kN were analyzed. Studies have shown the high stiffness of the underpinning support with a spherical base. Modeling of the underpinning support deformations with a spherical base and the workpiece, where the support pin is brought to the inclined inner surface of the workpiece, was also carried out. A comparative analysis of the stiffness coefficients of the considered supports was carried out: the highest stiffness coefficient underpins a vertical support pin.

Keywords: Rigidity, Experimental, Modeling, Pin, Displacement, Spherical Base, Coefficient, Manufacturing Innovation.

Design of the Technological Route for Sustainable Machining of Functional Surfaces for Automotive Engineering Parts

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Toughening the important demands for the competitiveness of industrial products in general and automotive engineering parts, in particular, requires searching for new effective methods of designing technological routes for machining their functional surfaces. Object-oriented technologies are characterized by using typical technological routes and choosing machining methods based on the criterion of accuracy and quality of surface layers without considering the operation conditions of products and estimation of the level of material degradation of parts. Functionally-oriented technologies consider a large set of technological indicators that affect the formation of operational parameters and reliability characteristics. Sustainable production developing the demands of Industry 5.0 considers economic and social factors and environmental protection when introducing highly efficient technologies. The developed technique of design of the technological route at sustainable machining of functional surfaces for the automotive engineering parts makes it possible to assess the level of parts material exhaustion of a significant area of the specific surface layers by the material homogeneity criterion based on the dispersion of micro-hardness characteristics. Using this technique, the physical processes are analyzed according to the coefficient of variation and the homogeneity coefficient (m) and its derivatives. The machining of a steel shaft is accompanied by a change of the constructively heterogeneous layer of the initial material after blank production to a constructively homogeneous layer of the material of the workpiece with a decrease in the material's susceptibility to its technological damageability from rough treatments to finishing ones.

Keywords: Automotive Engineering, Object-Oriented Technology, Functionally-Oriented Technology, Sustainable Manufacturing, Sustainable Machining, Industrial Growth.

Surface Morphology and Microstructural Features of LPBF-Printed Superalloy Turbine Blade Subjected to HIP, Heat Treatment, and Shot Peening

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Laser-based powder bed fusion (LPBF) is one of the attractive methods of powder bed fusion additive manufacturing technology to produce lightweight metal products with complex shapes for the aviation/aerospace industry. In this work, the turbine blades were manufactured applying an industrial LPBF system and commercial Inconel 718 powder. The LPBF-built turbine blade superalloy parts were then thermomechanically post-processed to provide surface integrity and material properties. The hot isostatic pressing and heat treatment were applied to provide the required grain structure and density. The subsurface nanostructuring, compressive residual stress, and a new surface microrelief formation were obtained by a surface shot peening. The results show that the applied combined thermomechanical post-treatment increased the hardening intensity in the subsurface and bulk by ~68% and ~35%, respectively. Shot peening led to a ~50% decrease in surface roughness.

Keywords: Process Innovation, Selective Laser Melting Technology, Additive Manufacturing Post-Processing, Inconel 718, Turbine Blade, Thermomechanical Treatment, Precipitation Hardening, Surface Nanostructuring.

Study of Power Parameters of the Screw Spirals Forming

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Based on the study of the technological processes of screw spirals manufacturing, the article derives analytical and empirical dependencies for calculating the bending moment, force, and design parameters of the screw spirals manufacturing process by the method of tape winding using a forming tool with a rotating sleeve, which allows distributing the load on the forming rollers. The forming tool with a rotating sleeve for screw spirals winding is designed. The analytical dependence for determining the thickness of the spiral after forming by winding method is developed. The bending moment and force parameters for screw spirals winding are determined. The experimental study of the screw spirals winding processes by the forming tool with a rotating sleeve is conducted. After processing the experimental data, the regression equations have been obtained. The response surfaces and two-dimensional cross-sections of the response surfaces of the dependence of the tape winding bending moment on the outer radius of the mandrel, tape thickness, and tape width for 08kp steel and St 3 steel are presented.

Keywords: Forming Tool, Screw Spirals, Bending Moment, Force Parameters, Manufacturing Innovation.

The Influence of the Geometry of High-Performance Cutters on the Profile Accuracy of Large-Pitch Tapered Threads: Theoretical Study

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Modern tool manufacturers offer fully profiled cutting cutters with an edge profile identical to the standard. The situation for large-pitch thread screws is significantly bigger because, for the most part, such tools have, at their disposal, special means for setting the cutting carbide insert and adjusting it to create an angle of inclination of the edge λ. This angle is required for an even load on both sides of the edge and to ensure the stability of the cutter before it is worn entirely. The modern scientific theory of the cutting process indicates the need to use another angular parameter - the rake angle, which enables the use of difficult-to-machine materials. Methodologically this theoretical study is about the functional influence of the combination of two angles: the inclination of the cutting edge and the back rake angle, on the accuracy of a large-pitch tapered screw thread made of heavy-duty steel. In this work, it is theoretically proven that for the smallest diameter drill-string tool-joint thread (NC10 thread), the combined influence of the geometric parameters of the back-rake angle γ=12 ° and the cutting-edge inclination angle λ=3,74° on the accuracy of the half-profile angle of the thread is significant. At the same time, the deviation is 62.7 % of the tolerance (±0.75°) according to the standard half-profile angle of 30°, which obviously indicates the minimum possibility of using high-performance cutters for the production of large-pitch tapered threads made of difficult-to-machining materials.

Keywords: Process Innovation, Pin, Box, Drill-String Tool-Joint Tapered Thread, Threading Lathe Tool, Rake Angle, Inclination Angle, Cutting Edge.

Theoretical Justification for Increasing Efficiency of Grinding Technological Processes Based on the Reduction of Cutting Temperature

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The aim of the work is a generalized theoretical substantiation of conditions for reducing the cutting temperature during grinding to develop effective technological processes for grinding products made of materials with increased hardness. A theoretical solution was obtained, the main parameter of which is the maximum cutting temperature from heating the formed chips. It was theoretically established that when this temperature is reached, it is possible to increase machining productivity many times. By calculation and experiment, it was established that the maximum cutting temperature is many times higher than the melting point of the machined material. Calculations proved an increase in machining productivity by providing a relatively small grinding temperature and applying multi-pass grinding with a relatively high speed of the workpiece. They also proved an increased grinding temperature by applying depth grinding with a relatively low workpiece speed. Based on an effective process of face grinding by diamond wheels on metal bonds of sealing rings made of hard alloy "Relit" with the application of electroerosion dressing, reducing energy consumption and increasing quality and productivity of processing was developed. An effective process of gear grinding by profile copying (depth grinding) with a highly porous abrasive wheel was developed. This made it possible to reduce the energy consumption of processing, increase productivity up to 5 times, and ensure defect-free processing.

Keywords: Processing Performance, Energy Consumption During Machining, Metal-Bonded Diamond Wheels, Process Innovation.

Wear Behaviour and Machining Performance in Milling of INCONEL® 718 of TiAlVN and TiAlN/TiAlVN Coated Tools: A Comparative Study

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INCONEL® 718 is considered a difficult-to-machine material due to its superior mechanical properties. The milling process is the most suitable for machining this alloy due to its flexibility in generating complex shapes. Coated tools doped with some elements, such as Vanadium, have been used to improve process performance. Thus, this work aimed to compare two coatings, TiAlVN and TiAlN/TiAlVN, deposited by the Direct Current Magnetron Sputtering (DC MS) method when milling INCONEL® 718. The analysis was carried out concerning their structure and performance, in terms of surface roughness and wear mechanisms, in the milling process. The parameters changed in the process were the cutting length (L_{cut}) and feed per tooth (f_z). Both coatings were found to have a columnar structure, with the multilayer coating having a smaller grain size. Furthermore, the multilayer coating featured better wear behaviour. The main wear mechanisms identified for both coatings were abrasive and adhesive, with higher intensity in the TiAlVN monolayered coating.

Keywords: Nickel Alloys, Tool Wear Mechanisms, PVD Coatings, Machining, Wear Resistance, Vanadium, Manufacturing Innovation.

Evaluation of Cutting Fluid Penetration into the Cutting Zone During Grinding of Rolling Rolls

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The process of cutting fluid penetration into the contact zone of the grinding wheel and workpiece at circular external grinding of rolls of rolling mills and the main factors influencing this process are investigated. It is established that cutting fluid penetration into the contact zone of the grinding wheel and the workpiece is a complex hydromechanical process occurring due to the capillary effect using the finest network of capillaries formed in the contact zone of the grinding wheel and workpiece. It is established that dynamic phenomena in the technological system accompanying the cutting process when grinding rolls exert a significant influence on the penetrating ability of cutting fluid. Based on the research results, recommendations on selecting grinding modes of rolls providing the maximum degree of cutting fluid penetration into the contact zone of the wheel and workpiece are offered. In this case, the maximum increase of "useful" cutting fluid consumption is achieved, which reduces the grinding process's heat intensity at a minimum cutting fluid consumption, thereby increasing the grinding efficiency.

Keywords: Industrial Growth, Grinding, Rolling Rolls, Penetrating Ability, Cutting Fluid, Contact Zone, Arc Length of Contact, Process Innovation.

Enhancing Service Life and Durability of Machine Parts Through Surface Plastic Deformation

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This scientific article explores innovative methods for enhancing the surface strength of machine components to extend service life and durability. The focus shifts to nanostructuring surface layers, introducing impact-friction hardening as a dual-action method without equipment dismantling. Experimental investigations on alloy 110G13L validate the method, showing a 30% increase in the reinforced layer's depth. The research demonstrates the technique's potential for preserving structural integrity, offering prolonged equipment lifespan, heightened operational efficiency, and a positive economic impact. Integrating mathematical models and experimental validations provides a comprehensive understanding of the outcomes of this surface plastic deformation technique. The study introduces impact-friction hardening with torsion, aiming to combine impact and friction elements for enhanced surface strength and operational efficiency in machine components. The literature review highlights the effectiveness of combining impact and friction, while the research methodology details the experimental approach. Results indicate a significant depth increase in the reinforced layer, showcasing the technique's promise for various sectors, including agriculture and mining. The study concludes with insights into future research directions, emphasizing the need for broader material exploration and parameter variation to understand the method's applicability comprehensively.

Keywords: Impact-Friction Hardening, Nanocrystalline Structure, Ultra-Fine-Grained Structure.

Statistical Comparison of Manual and Automatic Sampling at Enterprises

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The presented article deals with a detailed analysis of the state of the issue. It is about the characteristics of the organization and the description of its current state, as well as the description, procedure, and comparison of the sampling process in organizations. Next, the specific problems of the process are defined, and in connection with them, a new sampling system is designed, which is fully automated. The article is more specifically focused on statistically significant differences between manual and automatic sampling of business commodities such as coal ore, concentrate, and pellets, which are then submitted for comparison. Sample tests are necessary to make a comparison. The test results are subsequently recorded in the sample test reports. Both manual and automated samples are analyzed using statistical tests to determine if there are statistically significant differences between the data. Such tests were also done in organizations.

Keywords: Industrial Growth, Automatic Sampling, Manual Sampling, Statistical Characteristics.

Part IV
Quality Assurance

Improvement of the Assembly Technology Quality by Determining the Closing Link Size Under Thermal Stress

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The study aims to improve the quality of the thermal assembly technology of engineering elements by introducing a methodology for determining the size of the closing link in the calculation of assembly dimensional chains, taking into account the influence of temperature gaps. The presented analysis of the technological preparation of production revealed the need to include the calculation of dimensional chains as one of the elements of dimensional analysis, which is determined by a set of calculation and analytical procedures carried out during the development and analysis of structures and technological processes. The effectiveness of dimensional chain calculation using the probabilistic method largely depends on the extent to which the influence of random factors on the values of the component links and the closing link is considered. Studies have confirmed that the calculation of the nominal value of the closing link does not meet the requirements set forth when compared with the results obtained during the calculation without considering the influence of temperature gaps. However, the practical assembly of the feed pump rotor, taking into account the influence of temperature gaps, can lead to an improvement in the axial assembly accuracy by 5% to 13% and a decrease in the gap between the ends of the rotor wheel and the discharge disk by 6% to 10% without the need to use additional technological equipment.

Keywords: Technology Quality, Thermal Assembly, Dimensional Chain, Assembly Accuracy, Manufacturing Innovation.

Integration of Statistical Analysis and Machine Learning Techniques for Enhanced Quality Control in Candle Oil Cartridge Manufacturing

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Quality control is crucial in production and plays a key role in ensuring the delivery of superior products. The research presented in this paper aimed to establish a robust decision-support tool to enhance the production oversight process in candle oil cartridge manufacturing. The study included two stages. The first stage was concentrated on isolating and identifying the critical factors that have a significant statistical influence on product quality. Following this, advanced machine learning techniques such as the Support Vector Machine, Regression Trees, K-Nearest Neighbors, and the Artificial Neural Network were harnessed. These models showcased validation accuracies that ranged from 84.5% to 86.9%. Notably, the ANN model emerged as the best due to its unmatched AUC value, which indicates its effectiveness for accurate classification. These insights shed light on the enormous potential of state-of-the-art methods in overcoming manufacturing challenges and pave the way for industries to adopt and integrate rigorous quality control mechanisms.

Keywords: Quality Control, Support Vector Machine, Regression Trees, K-Nearest Neighbors, Artificial Neural Network, Industrial Innovation.

An Analysis of Machined Surface Quality Using TiAlTaN-Coated Tools in AMPCO® Milling Operations

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Over the years, a consistent evolution has been observed in developing materials for industrial applications and chip-start cutting processes. Improving cutting tools by applying advanced coatings has demonstrated great significance by extending tool life (TL) and ensuring improved surface quality. With the development of a wide range of coatings, it is crucial to analyse, understand, and investigate the phenomena that occur during metal cutting. The primary objective of this study is to assess, identify, and quantify the evaluation of the machined surface quality of milled AMPCO® (a Cu-Be alloy) with WC-Co uncoated and TiAlTaN-coated tools using Physical Vapour Deposition (PVD). Regarding this, milling tests were performed, and surface roughness (SR) evaluations were assessed while varying cutting length (Lcut) and feed rate (f) at three distinct levels. The results obtained with WC-Co uncoated differed from those obtained with TiAlTaN-coated tools. Parameters f and Lcut significantly influenced the quality of the machined surface. TiAlTaN-coated tools performed notably worse than uncoated tools, indicating that the coating did not provide any advantages, mainly due to the lack of adhesion.

Keywords: Cu-Be Alloys, Machining Processes, PVD-Coated Tools, Uncoated Tools, Surface Analysis, Surface Integrity, Surface Roughness, Manufacturing Innovation.

Metrological Support of the Thermal Vision Method of Defectoscopy

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Various non-metallic heterogeneous materials and structures are widely used in many industries. Undoubtedly, the use of such mediums and the quality of construction materials require the development of countermeasures and measurement of their parameters. The most promising are non-destructive methods, among which thermal control methods can be singled out. The article is devoted to studying the influence of mechanical stimulation parameters on the distribution of temperature fields with the acoustic infrared thermometric method of counter products made of non-metallic heterogeneous materials. This method is based on the emergence of temperature fields in materials with structural defects under the influence of vibration. Experimental studies of carbon plate defects in the form of "dull drilling" were carried out on a specially designed stand for the excitation of mechanical vibrations. The dependence of the parameters of thermal processes on the frequency of mechanical vibrations, the time of their impact, and the distance from the point of application of the vibrations to the defective zone was determined. At the same time, the temperature contrast was used as an optimization criterion, as a natural characteristic of comparing thermal control procedures. Considering the anisotropy of the physic and mechanical properties of the material under study, the control was carried out in two positions of the plate relative to the direction of propagation of mechanical oscillations: at an angle of 45 ° to the fibers and perpendicular to it.

Keywords: Non-Metallic Heterogeneous Materials, Non-Contact Measurement, Acoustic Infrared Thermometric Method, Defectoscopy, Metrological Support, Mechanical Stimulation, Anisotropy, R&D Investment.

Virtual Device for Assessing the Geometric Parameters' Reliability Control for Mechanical Products Depending on the Tool Accuracy

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There is an urgent need for remote tools and research methods in the current conditions of training qualified specialists for work in the engineering industry. Therefore, this work aims to create a virtual device for assessing the reliability of control of the product's geometric parameters. The Monte Carlo approach was applied jointly with the simulation of control procedures. The software environment NI LabVIEW 7.1 is used to automate the computer modeling. The virtual device opens up the possibility of predicting the range of values of the selected control reliability criterion depending on the technological forming system's accuracy. It limits the measuring device's error under certain assumptions about the type of random argument distribution. The ratio of the sum of correctly rejected and correctly accepted products to the total statistical sample is proposed as a control reliability criterion. An algorithmic model of a computer experiment was proposed. It was also implemented in the Flat Sequence Structure of the LabVIEW program, which consists of a certain number of subdiagrams or frames executed sequentially. The study aims to determine the dependence of the selected reliability criterion on the maximum permissible limit of random measurement error. Scientific novelty: graphs showing the dependence of the selected reliability criterion on the maximum permissible limit of random measurement error under specific initial data and limitations in process modeling. Practical implementation: The created virtual device allows a series of computer experiments.

Keywords: Monte Carlo Method, Reliability Criterion, Limiting Error, Computer Experiments, NI LabVIEW, Industrial Innovation.

Part V
Supply Chain and Transportation

Real-Time Driver Drowsiness Detection Using Transfer Learning

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Among the primary causes of traffic accidents, drowsy driving is identified, which poses a significant threat to road safety on a global scale, emphasizing the need to address this issue effectively to ensure road safety. The consequences of drowsy driving are far-reaching, impacting numerous lives and underscoring the urgent need for a real-time system capable of early and accurate detection of driver sleepiness. Addressing this critical issue, this research introduces a machine learning model to monitor driver drowsiness and classify the drowsiness status. Leveraging the advancements in Transfer Learning techniques and utilizing the ResNet50 model specifically trained for drowsiness detection. Through extensive evaluations conducted using the NTHU-DDD dataset, the proposed machine learning model has consistently demonstrated superior performance compared to recent advanced approaches in drowsiness detection. The achieved validation accuracy of 87.8% with the optimized ResNet50 model highlights the system's reliability and potential to impact road safety significantly.

Keywords: Deep Learning, Drowsiness Detection, ResNet50, Road Safety, Process Innovation.

Risk Assessment at Unsignalized Intersections Based on Human-Road-Environment-Vehicle System Applying Fuzzy Logic

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The constant increase in motorization level and traffic density increases risks due to dangerous situations for road participants. Therefore, assessing the accident level of road network elements has been an urgent task over the past decades. However, existing approaches mainly rely on traffic flow parameters and account for dynamic vehicle characteristics. The research aims to design a model accounting for uncertain factors (weather conditions and pedestrian wear color) that directly impact the accident rate. For this, the mathematical toolkit of fuzzy logic is used. The study presented in this paper has yielded a model for assessing accident risk at unsignalized intersections. This model, known as the Fuzzy Model, considers various factors such as human behavior, road conditions, environmental factors, and vehicle characteristics. The model proposes accounting for the factors included in the four subsystems (Human-Road-Environment-Vehicle) that determine the transport mega system. Fuzzy Logic MATLAB Toolbox was used for modeling, and the model was assembled using Simulink Environment tools. The simulation used a full-factor experiment 34 for four factors at three variation levels for each parameter. A set of accident risk factors was obtained for 81 conducted tests. Based on the modeling, a 3-level table of accident risk measurement was formed at unsignalized intersections depending on the pedestrian's clothing color, intersection equipment level (illumination), weather conditions, and vehicle speed. The study results are due to a novel accident risk system that can be used for operational measures to increase safety levels at an unsignalized intersection.

Keywords: Sustainable Traffic, Pedestrian, Wear Colors, Car, Safety, Highway, Road, Risk Factor, Fuzzy Model, Sustainable Supply Chain.

Green Logistics System: Cargo Bikes as an Alternative to Cars

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To reduce the negative impact of transport on the climate, important steps are the transition to more sustainable energy sources, the development of public transport, and the promotion of electric and other environmentally friendly modes of transport. Various mobility concepts (such as delivery with electric vans, cargo bicycles, the use of mobile micro-hubs, and automated deliveries using robots, drones, or autonomous vehicles) demonstrate approaches to creating a foundation for alternative and environmentally friendly urban logistics. In densely populated cities, electric cargo bicycles are becoming increasingly popular as a replacement for vans and cars to deliver groceries and parcels. The research aims to assess the effectiveness of using cargo bicycles as an alternative to cars for transporting small consignments within city limits. A simulation model has been developed to form cargo transportation routes within the city. The model is based on applying a genetic algorithm and considers specified constraints on time, distance, and available resources (vehicles and personnel). The study compared different technologies for serving customers of a supermarket chain (pendulum routes and distribution-assembly routes). At the same time, modeling was carried out for the conditions of use of various vehicles (an electric cargo bike and a car). The experiment results showed that the use of cargo bicycles significantly reduces emissions of harmful substances, decreases energy consumption, leads to lower delivery costs, provides companies with greater flexibility in organizing logistics processes, and, at the same time, has a significant positive social impact.

Keywords: Greenhouse Gases, Delivery Routes, Last Mile, Optimization, Genetic Algorithm, Small Consignment of Goods, Simulation Model.

Assessing External Supply Risk: Perspectives from a Low Middle-Income Country

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Global disruptions due to causes such as the COVID-19 pandemic and the Russia-Ukraine conflict have highlighted the vulnerability of the agri-food supply chain and its impact on food security. Sri Lanka, facing its economic crisis and food scarcity due to these disruptions, ranks 79th out of 113 countries regarding food security. Wheat is the second most consumed cereal in the country. Thus, Sri Lanka must assess the external risks associated with wheat imports to ensure a smooth supply. However, there needs to be more comprehensive research on the risks of relying on imported food in the extant literature, particularly regarding factors including import dependence, supplier country reliability, and transit risks. To address this research gap, the study employed the Herfindahl-Hirschman Index and Shannon-Wiener Index to assess the external wheat supply risk in Sri Lanka. The analysis showed that despite the relatively low overall risk, high dependence on Russia and other high-risk countries increased the wheat supply risk. This study recommends reducing import percentages from high-risk countries and diversifying supply to low-risk countries to mitigate risks. The study also found that the level of political risk in supplier countries had a more significant impact on supply risk than the distance and import shares of the supplier countries. Further, the study provides valuable insights into Sri Lanka's external wheat supply risk and recommends measures to mitigate risks and enhance food security. The findings are generalizable to low and middle-income countries with similar characteristics.

Keywords: Food Security, Supply Chain Risk Assessment, Supply Chain Resilience, Import Dependency, Herfindahl-Hirschman Index.

Optimizing the Process of Obtaining and Maintaining Rainforest Alliance Certification in the Sri Lankan Supply Chain

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This research aims to optimize acquiring and maintaining the Rainforest Alliance certification in the Sri Lankan tea supply chain by introducing a blockchain framework. To address the challenges in the certification process, a specialized blockchain framework is developed by conducting unstructured interviews with industry experts. The main challenges identified during the unstructured interviews were limited resources and knowledge for smallholders, coordination and record-keeping complexities for tea estates and stakeholders, and the time-consuming and expensive adaptation of practices for manufacturers, particularly those with complex supply chains. To assess the influence of various blockchain success factors on the proposed network within the tea industry, Interpretive Structural Modeling (ISM) and Matrice d'Impacts Croisés Multiplication Appliquée à un Classement (MICMAC) analyses are employed. The ISM analysis highlights "immutability" as the foremost driving factor for blockchain success, closely followed by "transparency" and "data accuracy." In terms of dependence on power, "efficiency" emerges as the most influential factor, complemented by the significance of "trust" and "integrity." The structured level partition reveals three categories of success factors: bottom-level factors are highly influential, intermediate-level factors act as facilitators, and top-level factors, while less influential individually, are vital for overall success, relying on lower-level alignment. While relying on expert opinions and subjective judgments, a foundational step is taken toward advancing sustainable supply chain management practices in the tea industry.

Keywords: Blockchain Framework, Rainforest Alliance, Sustainability Certifications.

Part VI
Engineering Education

Designing the Educational Content for the Industry 4.0 Competency Model

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In this paper, authors reflect on the methodology used in the Work4Ce-project (Cross-domain competencies for healthy and safe work in the 21st century) to build a competency model for Industry 4.0 in an Education 4.0 environment. The competency model is a tool that clarifies the skills, knowledge, and attitudes a person needs to perform a job in a particular environment and describes what is necessary for a student for a learning module. The methodology of building this model can generally be used to define competency models and build courses in a setup with distributed stakeholders. In a co-creation setup with OpenCops and a Joint Educational system, the different international partners create open educational resources on the different topics for Industry 4.0. The educational resources should serve different target groups: (engineering) students and professionals needing to update and extend their knowledge on the topic.

Keywords: Work4ce, OpenCop, Open Educational Resources, Sustainable Education.

Implementation of the Methodical System for the Development and Application of Eco-Oriented Pedagogical Technologies

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The article discloses a methodical system that could enable the designing and introduction of eco-oriented pedagogical technologies (EPT) into professional engineering education, which is a subsystem of the methodical eco-oriented education system and the following characteristics: integrity, components, structurality, compactness, functionality, multi-level, controllability and connection with the environment. It includes a set of interrelated components: methodology (methodological approaches: activity, competence, technological, systemic and personality-oriented approaches and principles: humanization of prognostication, design of conditions for preserving the gene pool of the biosphere; compensability; interdisciplinary and systematic; concept: use methods of development and application of EPT in the professional training of engineering students, which include complex of techniques with their specific forms, methods and means environmental knowledge and formation of appropriate behavior in solving pedagogical, environmental, environmental and health-preserving tasks, which will contribute to the achievement of harmony in relations between people, society, technologies, machines and environment); content (definition and terms for the development and application of EPT in professional education; information-theoretical knowledge about the state of development and application of EPT; knowledge about the processes of development and application of EPT); methods (forms of training; methods of eco-oriented training, eco-oriented training technology; training tools); evaluation and results (components of the formation of the teacher's readiness to implement EPT in his own professional activity are: value-motivational, informational-knowledge, reflective-active, control-evaluative). The result of implementing a methodical system for developing and applying EPT was predicted to improve the teachers' readiness level to implement them in their professional activities.

Keywords: Vocational Education, Training, Engineering Students, Methodical System, Eco-Oriented Technology, Methodological Approaches, Ecological Competence, Sustainable Education.

The Model for Professional Competence Development of Engineering Teachers at Colleges

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The main task for engineering teachers at college is to organize a specific environment that could provide students with creative and professional development. So, the teachers must be well prepared to perform their professional activities effectively and supply their students with essential knowledge and skills, preparing them for innovative engineering activities, diverse paths in their field, and engineers' leading roles. Therefore, the research aimed to model the college engineering teachers' professional development process. To achieve the research goal at the first stage, the teachers' competence composition was clarified based on an analysis of the psychological structure of teachers' activity and its subject-specific side. For that purpose, 389 respondents (teachers, instructors, managers from public Ukrainian colleges, and employers) were interviewed in 2023. Then, the structural and content model for developing the teacher's professional competence was designed. The developed pedagogical model reflected and imitated the studied phenomenon's process and specific properties and characteristics. The model could be used in further research devoted to the features of the competence development of an engineering teacher at college to define the process stages, scientifically substantiate the effective technologies and means, and develop diagnostic methods for assessing the levels of teacher's competence.

Keywords: Engineering Education, Teaching Skills, Engineering Students, Pedagogical Model, Continuing Professional Developmen.

Motivation Principles of Self-Management in the Professional Training of Engineers Under the Conditions of Forming the Creative Competence

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The article aims to model the motivational mechanisms of the formation of the creative experience of future engineers based on the identification of contradictions in the management of educational activities and the development trends of the pedagogical process of training specialists in the engineering field. Modern methodological approaches and theoretical and empirical methods were used in the research: questionnaires, testing, time series analysis, modeling creative situations, pedagogical experiment, statistical analysis, and reference comparison (to identify the system of student motivation for engineering professional activity. The proposed model of forming engineering personnel's creative experience depends on the motivation level. The motivational structure of the engineer's professional competence in the system of his professional training is analyzed. Didactic methods of activating the motivational support of the educational process and components of educational management in the self-management conditions of students' educational and creative activities were studied. A justified structure of the technological stages of students' self-motivation in the conditions of the digital educational space. The effectiveness of the proposed self-motivation model in future engineers' educational activity by means of self-correction and self-development of personality is proven.

Keywords: Motivation, Management, Self-Organization, Educational Activities, Managerial Competence, Professional Training, Engineering Creativity.

Part VII
Design Engineering

Optimization of the Counterweight Mass of a Passenger Elevator

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The article develops a universal machine algorithm and program for calculating the energy consumption of a traditional elevator winch with an asynchronous motor and a thyristor voltage converter. It has been determined that the generally accepted expression for calculating the counterweight mass does not consider the parameters of dynamic modes. According to the criterion of minimizing the energy consumed by the electromechanical system, the counterweight has been optimized. Applied to the elevator winches of traditional design with two-speed asynchronous motors with regulation from thyristor control stations, optimization of the counterweight mass, based on the proposed algorithm, can lead to a reduction in its mass by 8–15% (for the elevator mechanism under study by 13.4%). At the same time, the installed winch motor power, energy consumption, and maximum load torque can be reduced by an average of 4–10%. (5.4, 6.2, and 4.4% for the passenger elevator under study, respectively). Using the example of elevator lifting mechanisms with winches of traditional design and parametric control, the recommendations for optimizing the mass of counterweights according to the criterion of minimum energy consumption are given. It is demonstrated that the following indicators can be reduced: the mass of counterweights, energy costs and the installed power of winch motors.

Keywords: Lift Winch, Counterweight Mass, Minimum Criterion, Optimization, Machine Algorithm, Calculation of Energy Consumption, Product Innovation.

An Increase in the Service Life and Reliability of Machines' Structural Components Using Innovative Engineering Solutions

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The wear and formation of tribocontact surface layers are fundamental processes inherent in any friction or tribosystems. Wear and tear changes the geometric shape, mass, and dimensions of parts, and the state of their working surfaces changes, leading to a gradual decrease in the functional qualities of parts and the productivity of machines as a whole. The processes of formation and destruction of oxide coverings are often used as a basis for building models of the wear process. The data obtained in work on the structure of the surface layer, in comparison with the studies of other authors, confirm that secondary structures (SC) perform protective functions, limiting the internal interaction of friction bodies and reducing the intensity of this interaction. Therefore, their formation corresponds to the Le Chatelier principle. In secondary structures, more than 90% of all system energy is concentrated in the friction process. The surface layer is enriched with alloying elements due to their diffusion from the deep layers of the metal (thermal diffusion, upward diffusion) and the external environment. Both types of secondary structures can slow down the destruction of the surface layer in the friction pair and physicochemical transformations (formation of secondary structures in the metal), which can stimulate destruction at the boundary: "surface (textured) layer of the friction pair - deep layer of the metal." Secondary structures of the first type have properties beyond plasticity, easily flowing over the friction surface.

Keywords: Friction Surface, Secondary Structure, Structural Adaptation, Abrasive Wear, Microstructural Analysis, Manufacturing Innovation.

Modernization of the Drive Belt Transmission for the Machining Center

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The article discusses the issues of creating 3D models of the main movement drive of a horizontal machining center with a portal layout and improving the design of the drive belt. In creating a three-dimensional model, the expanded functionality of the computer-aided design system and specialized modules for the design of mechanical transmissions were used. A procedure for parametric modeling of a belt drive and creating parameterized design solutions in developing new transmission designs are proposed. A modified belt drive design with a toothed V-belt has been developed. The main idea of the modification is related to the presence of teeth in the transmissions on the sides of the V-belt and the transition from friction to engagement, as in toothed belt transmissions. A calculation algorithm for the toothed V-belt transmission has been developed. This algorithm can be the basis for comprehensive research of the proposed transmission, including full-scale testing to create a methodology for its design. A verification criterion for belt performance is proposed by assessing the pressure on the sides of the belt teeth. Options for adjusting design solutions in case of failure to comply with verification conditions are listed. An experimental calculation of the comparative efficiency of the proposed new design of a toothed V-belt transmission has been carried out, and its advantage according to some technical and economic criteria has been shown.

Keywords: Multioperational Machine Tool, 3D Modeling, Toothed V-belt Drive, Parametric Modeling, R&D Investment, Industrial Growth.

An Increase in the Durability of Pumping Equipment

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This study analyzed the cavitation-erosive wear of pump parts used for pumping aggressive substances with sodium chloride at different concentrations. The robot used structural materials to produce parts that may come into contact with these aggressive media and are subject to intense wear. It has been established that the leading cause of cavitation-erosive wear is a micro-impact cyclic infusion of liquid and its corrosive activity, which leads to further destruction of materials. To carry out this process and select appropriate materials, an experimental setup was set up, which made it possible to carry out mechanical reinforcement of parts and the corrosive infusion of media onto them. The fluid influx into the parts' surface energy and dislocations' discharge in a thin surface ball was observed. It has been shown that the presence of chlorides in the media sharply reduces the corrosion resistance of materials. Cavitation leads to accumulations of dislocations, which destroy the surface of parts inherited from the cyclic process. The intensity of this process depends on the concentration of sodium chloride in the medium. The work proposes a solution based on the structural-energy theory to increase the intensity of cavitation-erosive wear. It is recommended that, before preparing pump parts that come into contact with sodium chloride, be prepared to ensure more significant resistance to cavitation-erosive wear.

Keywords: Sea Water, Saline Solution, Impellers, Fatigue Failure, Cavitation, Wear-Resistant Materials, Industrial Innovation.

Design Improvement and Computer Modeling of the Finger Grain Crusher

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Crushing of grain and grain materials is widespread and one of the most responsible and energy-intensive processes in the technological lines of modern enterprises. Analyzing the designs of the most common hammer, crushers enabled the determination of the most promising grain crushing scheme, which is its preliminary separation with the subsequent crushing of a separate fraction in different parts of the rotor. We described the method and device for crushing grain material by the method of direct impact of the metal fingers of the rotor, which have a vertical axis of rotation with the preliminary use of grain separation. Computer modeling of the grain crushing process in the developed crusher was carried out with the help of ANSYS and SolidWorks software complexes to establish optimal ratios of the design parameters of the crusher. As a result of the modeling, the fields of speed distribution and the lines of movement of grain particles along the internal volume of the chopper have been obtained, which in turn makes it possible to conclude about a small range of speed distribution at the place of crushing and a smaller number of circulation movements, about other types of hammer crushers. The results of computer modeling correlate well with experimental studies of the grain grinding module, the value of which is 1.4–2.2 mm, fully meeting modern technological requirements.

Keywords: Product Innovation, Grain Crushing, Finger Crusher, Direct Impact, Grain Crushing, Simulation, Computer Modeling, Industrial Growth.

Investigation of Cylindrical Particles Sphericity and Roundness Based on the Extreme Vertices Model

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In this scientific investigation, the article's authors have created a three-dimensional computer simulation model to explore the sphericity and roundness of elements, specifically particles. The authors elucidated the detailed calculation of the sphericity of elements and roundness of elements for cylindrical particles through the application of the extreme-vertex 3D model. Based on the proposed extreme vertex model theory, the points at which linear constraints intersect were optimized, allowing for the maximum approximation of the form factor to unity. Furthermore, the proposed theory of extreme vertices in the context of modeling elements, particularly in voxel-based modeling, is of significant importance in defining the boundaries and limits of objects in three-dimensional space. Moreover, it was discovered that this idea holds importance in the context of the simplex-complex method, a commonly employed algorithm for addressing linear programming problems. Additionally, correlations between the sphericity and roundness of elements and the particle diameter were examined, enabling the prediction of particle shape. This is because the obtained sphericity values mostly approximate 1, which implies that the elements have a spherical or nearly spherical shape.

Keywords: Spherical Particles, Parameters, 3D Model, Shape Factors, Linear Programming, Mathematical Modelling, Correlation Dependence, Manufacturing Innovation.

Design Improvement of the Rotary-Pulsation Device by Resonance Phenomena

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Design improvement for increasing the energy efficiency of machines and equipment in the food industry is particularly relevant to the current state of the world's economies. If the energy consumption for the homogenization process is reduced to 1.5–2.5 kW/h, the total energy consumption in the drinking milk production line will decrease by 40–50%. For this purpose, the rotor-pulsation device is proposed to be improved by applying vibrations to the processed medium due to the vibrations along the rotor's axis. For such a homogenizer, the characteristic variants of the synchronization of the rotation and oscillation phases of the rotor are analyzed, which include the ratio between the rotation frequencies of the rotor and the crank and the shift between the rotation angles of the rotor and the crank. To increase the efficiency of the milk emulsion dispersion process, based on the sliding speed of the fat globule relative to the milk plasma, the optimal synchronization option has been determined, in which the frequency of pulsations caused by the rotational and oscillating movements of the rotor is the same. The nature of the speed change is similar. This leads to the emergence of pulsation resonance, which increases the amplitude of oscillations, the speed of sliding, and, therefore, the degree of dispersion. The rate equation for this operation mode of the homogenizer has been derived.

Keywords: Design Improvement, Homogenization, Rotor-Pulsation Device, Vibrating Rotor, Milk Emulsion, Resonance Phenomena, Industrial Growth.

Experimental Justification of the Technological Parameters for the Mobile Branch Trimmer

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Based on a complex technical and economic evaluation of machines for grinding cut branches of fruit trees of a compacted garden, it can be noted that it is more appropriate to use single-stage two-rotor shredders with vertical axes of rotation of the rotors, the working organs of which are hinged hammers. Simultaneously, the energy performance of wood shredders is quite different and depends on some factors. In this regard, the research was aimed at determining whether the rational operating modes of the shredder based on energy indicators are relevant. The purpose of these studies was to improve the efficiency of the mobile shredder of fruit tree branches in compacted orchards by substantiating the technological parameters of its operation. The research was conducted at different speeds of hammers and diameters of branches. Work costs for obtaining, circulating, and exiting the chamber of one chopped piece of wood at different rotation frequencies of the rotors, changes in the specific weight of the bundle of branches, and the gradual speed of movement of the unit were also determined. These operating modes of the chopper coincide with the rational range from the point of view of the minimum energy consumption of chopping branches. The gradual increase in the speed of the grinder determines the growth of the specific work for obtaining one crushed particle as the supply of material to the hammer increases.

Keywords: Work Costs, Destructive Speed, Kinematic Parameters, Energy Indicators, Product Innovation.

An Approach for Modeling City Defense Means: Sumy Region Case Study

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During the unauthorized full-scale russian invasion of the territory of Ukraine, the largest military conflict since the Second World War was provoked. This led to the massive destruction of Ukrainian cities' critical and civil infrastructure. Therefore, the problem of ensuring the defense capability for cities and communities is highly topical. Moreover, the inconsistency of the modern spatial organization with the need to place defense means in the city's space emphasizes the problem's relevance. The paper presents studies on how to introduce the model of city defense into the structure of a modern Ukrainian city using the Sumy region case study. Methods for analysis of data and scientific, archival, library, and cartographic sources were applied during the research. Further classification and systematization made it possible to create prerequisites for modeling city defense structures. The application of modern software, in combination with the proposed approach, provides an opportunity to develop the principles and methods of the spatial organization of the city defense means. As a result, ways of implementing the corresponding means in the architectural and city-building fields were proposed. They are necessary to ensure the safety of the cities by preventing the destruction of infrastructure and further implementing the proposed city defense means.

Keywords: Infrastructural Development, Built Environment, Smart Cities, Sustainable Architecture.

Hysteresis Compensation of Pneumatic Artificial Muscles Using Correctional Curve Offset: Case Study

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This paper proposes a new method for increasing the control accuracy of a pneumatic muscle by reducing hysteresis. A special feature of this method is the use of several proportional–integral controllers for more precise control of the position of the pneumatic muscle. As shown by the comparison results with other models, this method is more accurate, achieving a standard deviation of only 0.3 mm. Despite the advantages, this method also has disadvantages, such as it is very dependent on the static characteristics of the muscle, as well as the airflow. The comparison results with similar models indicate the high accuracy of this method despite its strong dependence on the static characteristics of the muscle and airflow parameters. The proposed approach opens new perspectives in developing control systems for pneumatic manipulators, providing more efficient means of control despite the limitations associated with the environment and the physical properties of the muscle.

Keywords: PI-Controller, Position Control, Biomechatronic, Stability, Modeling, Process Innovation.

Part VIII
Dynamics and Strength of Machines

Elastic Bending of a Strip Under the Action of Applied Forces

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The flexural deformation of the rod involves restoring its elastic axis to its original state once the deforming forces cease. Typically, the initial position of the elastic axis is assumed to be rectilinear, reflecting the common use of rectilinear structures in the construction industry, serving various roles such as bridges and spans. Excessive deflection in such structures can lead to failure, making it crucial to establish permissible deflection limits for these building elements. The allowable deflection for rectilinear elements is extremely small, disproportionate to the element's length. As a result, simplified theoretical formulas were employed to calculate deflection values that align with practical considerations. This simplification entails replacing the second-order differential equations of the elastic axis with first-order differential equations, providing acceptably accurate results for the deflection of rectilinear elements with minor deformations. However, in engineering practice, rectilinear rods undergo significant deformations, making the use of simplified formulas inappropriate for calculating their deflections. Moreover, curvilinear elastic elements with an initial curved shape of the elastic axis become prevalent. These include risers of cultivator tines designed to smooth pulsating dynamic loads and springs and piston rings. The article focuses on determining the shape of the elastic axis of the piston ring.

Keywords: Industrial Innovation, Flexural Deformation, Piston Ring, Rod, Distributed Force, Moment.

ANFIS System for Stress Prediction of Cold Heading Fastener Body Process for a Steel Base Composite Aluminum

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The cold heading process has been widely used for metal forming with different types of materials, particularly for producing fastener bodies, which are applied to various industrial applications. Presently, new material composite types are considered to obtain lightweight designs. However, the process parameters are needed by the experiment, but it takes time and high effort. This paper proposes the development of the ANFIS system for the prediction of stress in the cold heading process of the fastener body by modeling. Three parameters are considered: heading ratio, material strength, and step of heading. The result is then tested on the stress flow of the composite material to confirm workable parameters. The stress represents the perfect strength of the fastener. The originality of the article is applied modeling simulation to find a new raw material for cold forging using for the fattener body production which required the strength and light weight for a given application.

Keywords: Adaptive Neuro Fuzzy Inference System, ANFIS, Stress Prediction, Cold Forging Process, DEFORM, Composite Steel Base, Aluminium Core, Industrial Growth.

The Influence of Texture Discreteness on the Stress-Strain State of the Tribosurface after Preliminary Profiling

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The study of surface interaction in contact, the subject of friction and tribology as a science, has become increasingly important in various industries, from automotive to medicine. In the research presented below, we will simulate a part of the technological process of rolled steel surface strengthening during its sequential contact with a roller and subsequent drawing under a press (tribocontact). Moreover, contact with a roller is performed with two variations: a smooth surface of the roller and a surface with notches to achieve the effect of texture discreteness on the surface of rolled steel by profiling it. Such an approach makes it possible to reveal the dependence of the surface configuration and its profiling with plastic deformation on the model maximum and average stresses. The hypothesis of average surface stress decrease by the growth of the discreteness index is confirmed: 322 MPa (smooth surface) vs 307 MPa (profiled). The situation with the max stresses is the opposite – they are higher by 34% in the case of the profiled surface with notches than the smooth one (590 MPa vs 440 MPa). Before FEA, the suggested mathematical modeling algorithm allows the determination of the notches stress based on the geometry of the surface irregularities and the von Mises stress magnitude calculated for a smooth surface (which is significantly more accessible). The final tribocontact of rolled steel at flat press pressure gives positive results – the surface is smoothed: the max amplitude of irregularities decreased from 0.12 mm to 0.049 mm while the stresses even dropped by almost 2%.

Keywords: Tribocontact, Profiled Surface, Rolled Steel, Stress, Von Mises, Yield Criterion, Plastic Deformation, Ansys, Industrial Growth.

Analyzing the Locomotion Conditions of a Wheeled Vibration-Driven System with a V-Shaped Suspension

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Wheeled vibration-driven platforms have taken a prominent place among mobile robotic systems. Numerous investigations are dedicated to developing novel designs and analyzing mobile vibratory robot's dynamic behavior and performance. The present paper is dedicated to the locomotion conditions of a wheeled platform equipped with the V-shaped spring-damper suspension and driven by the centrifugal vibration exciter (unbalanced rotor). This research methodology contains mathematical and numerical modeling, computer simulation, and full-scale experimental investigations on the dynamic behavior of the semi-definite single-mass vibration-driven system at the specified design parameters and excitation conditions. The obtained results present the time dependencies of the system's motion trajectory, horizontal and vertical velocities, and accelerations. The main scientific novelty of the performed investigations is the development of the generalized mathematical model that describes the locomotion conditions of the wheeled vibration-driven system for the specified design parameters of a V-shaped spring-damper suspension. The results of this research can be practically implemented while defining the optimal geometrical, inertial, damping, and excitation parameters of suspensions of various mobile vibration-driven locomotion systems, particularly those intended for cleaning and inspecting the internal surfaces of pipelines, tubes, and vessels.

Keywords: Mobile Robotic System, Vibratory Robot, Inertial Vibration Exciter, Mathematical Model, Numerical Modeling, Computer Simulation, Process Innovation.

Methods of Calculating the Basis Reinforced with Horizontal Elements

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The destruction of the reinforced soil base by horizontal flexible elements can be represented in the form of three schemes: due to the soil displacement between the base of the foundation and the first layer of the reinforcing element, from the sliding of the reinforcing elements, and their rupture. Mohr's circle will touch the envelope of limit states at a specific stress ratio if a two-dimensional sample of loose soil is subjected to comprehensive compression. If the reinforcement is introduced into the sample in the direction of tensile deformations and the pressure is gradually increased, then due to the friction of the soil on the surface of the reinforcement, further deformations of the sample in this direction will stop and will be absent until the frictional forces are exceeded and slippage does not occur. The studies carried out in this work show that, in the absence of slippage, for non-cohesive soils, the effective position of the reinforcement practically does not depend on its strength. The comparison of the obtained dependencies with the calculations of the stress-strain state of the samples leads to the conclusion that the maximum strength occurs when the direction of reinforcement insertion coincides with the direction of action of the main tensile deformations. This fact makes it possible to determine the optimal scheme of reinforcement of any structure based on the data of the stress-strain state calculation.

Keywords: Reinforcing Elements, Reinforced Bases, Reinforced Soil, Load, Stress, Deformation, Friction Coefficient, Horizontal Elements, R&D Investment.

Research of the Stress-Strain State of Anisotropic Parts of Interference Fits Based on the Variational RVR-Method

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A variational RVR method was proposed for calculating the stress-strain state of statically loaded interference parts that fit in the automated design of critical structural elements. The method is based on Reissner's variational principle, the Vekua method, and the theory of R-functions. The application of Reissner's principle made it possible to increase the accuracy of solving boundary value problems due to independent variation of the displacement vector and stress tensor. The Vekua method allowed for replacing a 3D problem with a regular sequence of solutions to two-dimensional problems. The theory of R-functions at the analytical level considered the geometric information of boundary value problems, which was necessary for constructing solution structures. The RVR-method algorithm was used in the computer program CylShell_RVR, developed by the authors, designed to calculate anisotropic (in particular, isotropic) elastic cylinders of arbitrary thickness. To evaluate the RVR-method's effectiveness, its numerical implementation was performed for a joint part (bandage) made first of an isotropic material (for comparison with solutions to the Lame problem) and then of fiberglass. Depending on the number of approximations and nodes of Gaussian quadrature formulas, as well as the anisotropy of the material, the required displacements and stresses along the thickness of the bandage were presented in tabular and graphical forms.

Keywords: Anisotropic Part, Joint, Strength, Rigidity, Reissner's Principle, Structure of Solutions, “Hub-Bandage”, Industrial Innovation.

Study of the Stress-Strain State in the Contact Zone of the Cylinder Liner's Working Surface

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One of the reserves for increasing the durability of cylinder liners of internal combustion engines is the achievement on their working surface after technological processing of a set of geometric characteristics and physical-mechanical properties favorable from the point of view of wear resistance. Simulation of the "liner – ring" mating using the finite element method allowed for obtaining a qualitative picture of changes in the main parameters of the stress state. However, this approach did not allow for clarifying and studying the main regularities of the stress-strain state in the contact zone more thoroughly. In this connection, the paper proposes a study of the regularities of stress changes in the surface layer of the "liner – ring" mating using an analytical solution. The study of the regularities of the stress state in the contact zones using the analytical approach allowed us to confirm the main regularities obtained by the finite element method: at the boundaries of the contact areas, there are peaks of axial stresses – tensile and compressive at different ends of these areas. Simultaneously, new regularities have been established: the magnitude of the peaks strongly depends on the contact friction forces and the length of the transition section, and the shorter the length of the transition section, the larger the peak magnitude. The established regularities allowed us to present the actual interaction scheme between the piston ring and the working surface of the liner. To reduce the value of axial stress peaks in the contact zone "liner – ring", it seems reasonable to apply antifriction coatings on the working surface of the liner.

Keywords: Contact Problem, Stress State, Cylinder Liner, Piston Ring, Actual Interaction Scheme, Stress Concentration Zones, Manufacturing Innovation.

Dynamic Analysis of a Tennis Ball Launcher System

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This article introduces a Lagrangian equation notation of the second kind for a tennis ball launcher, providing a comprehensive analysis of the system's energy dynamics. In the initial segment, all energy types within the system were meticulously considered and incorporated into the formulas, culminating in the formulation of a Lagrangian equation of the second kind. The second part of the paper focuses on solving the derived equation. This involved determining the maximum torque within the system, subsequently enabling the calculation of the maximum drive power required for the launcher system. The outcome of these calculations facilitates the selection of an optimal electric drive motor for the device. By accounting for various energy components and employing Lagrangian equations, this study offers a systematic approach to understanding the energy dynamics of a tennis ball launcher. Determining maximum torque and drive power is a crucial step in the design process, allowing for the strategic selection of components to achieve optimal performance. The presented Lagrangian equation notation contributes to the literature on sports device development, providing a novel and comprehensive methodology for analyzing and optimizing the energy aspects of a tennis ball launcher. This research lays the foundation for future work in refining and enhancing the efficiency of sports training equipment.

Keywords: Tennis Ball, Ball Launcher, Dynamics Analysis, Lagrangian Equation, Sports, Process Innovation.

Simulation of Thermal Stresses in Multiplayer Plates of Non-Canonical Shape

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Based on the embedding method, the problem of stationary thermoelectricity for multilayer plates of non-canonical shape in the plan is solved under the influence of interlayer heat sources. The solution is presented in analytical form. The plate with constant thickness isotropic layers and various physical properties is considered. The structure of the layer package is arbitrary. Convective heat transfer is considered on the surfaces of the plates. No additional hypotheses are introduced on the temperature distribution. Due to this, the temperature fields obtained to solve the unsteady heat conduction problem are very close to real ones. An improved plate theory is used to describe the behavior of plates. Due to this, the temperature fields obtained from the solution of the unsteady heat conduction problem are very close to the real ones. A comparison of numerical results with the experimental data showed that they agreed. For example, the stressed state of a five-layer glazing of a cockpit canopy under thermal influence is analyzed. The offered method can be implemented in developing aviation and ground transportation de-icing systems.

Keywords: Multilayer Structure, Heat Sources, Thermal Stress Analysis, Industrial Growth.

Part IX
Process Engineering

Vibroextraction from Pre-Treated Amber by Electro-Impulse Discharges

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Amber, a natural source of succinic acid, essential oils, and various micro- and macroelements, holds great potential for applications across industries. This study investigates the efficacy of electro-impulse pre-treatment in enhancing substance extraction from amber. The results reveal a significant 50% relative discrepancy in organic acid content favoring treatment with a total energy of 250 kJ compared to 125 kJ. Notably, electro-impulse treatment with 312.5 J discharge energy led to a 23% higher total extraction of organic acids, indicating potential benefits for subsequent processes. Furthermore, analysis of pH levels in the extracts aligns with organic acid content, affirming a correlation between these indicators. This study underscores the importance of energy parameters in electro-impulse treatment, providing valuable insights for optimizing amber processing techniques. It suggests that completing treatment with 300 discharges at 312.5 J, followed by vibro-extraction, may yield extracts with significantly higher organic acid content than alternative methods, showcasing a 16% difference in total content. These findings offer a pathway to harnessing the full potential of amber for diverse industrial applications.

Keywords: Fossil Resin, Succinite, Mass Exchange, Solid-Liquid, Underwater Shockwave Pre-treatment, High Voltage Electric Discharge, Process Innovation.

Study of Thermophysical Processes in the Thermopressor for Contact Cooling System

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One promising approach to enhance the efficiency of the air compression process between compressor stages involves the application of contact intercooling technologies. The proposed solution includes using a thermopressor in the air intercooling system between compressor stages. A computational model based on the finite volume technique was used to examine the complex thermophysical phenomena occurring within the thermopressor. The discrete phase models enabled the simulation of water evaporation. The simulation results obtained the output parameters representing the primary characteristics of the two-phase flow (air-water) at the exit of the thermopressor. The findings indicate that the thermopressor facilitates the effective fine-dispersed atomization of water, resulting in an isothermal compression process in the compressor. Therefore, applying the thermopressor can be an alternative to traditional air-cooling methods and reduces work and, consequently, the compressor's power by approximately 10% while simultaneously increasing the quantity of operating fluid in the cycle. This enhancement contributes to improved gas turbine effectiveness.

Keywords: Water Droplet Diameter, Pressure Increase, Incomplete Evaporation, Process Innovation.

The Influence of the Impeller Inter-Blade Channels Roughness on the Energy Parameters of the Submersible Pump

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In the research, it was practically proven that the roughness of the inner surfaces of the inter-blade channels has a high influence on the head created by the blade impeller of the submersible pump. The study was conducted due to the method of numerical research using Ansys CFX software. It was determined that the roughness of the inner surfaces of the inter-blade channels has a high influence on the head created by the impeller of the centrifugal (submersible) pump. The research data complement the existing knowledge base on the comprehensive determination of the head created by the impeller. The authors added mechanisms for determining the head created due to viscous fluid friction and hydraulic pressure losses due to friction in the impeller inter-blade channels. The study results can be used to more accurately predict the head created by the blade impeller of the pump and, if necessary, to increase or decrease the head by changing the roughness of the inner surfaces of the impeller inter-blade channels.

Keywords: Process Innovation, Energy Efficiency, Dynamic Pump, Submersible, Power Consumption, Energy Consumption, Material Intensity, Specific Speed.

Efficient Models of Turbo Units for Evaluating Dynamic Characteristics

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The problem of modeling a low-pressure cylinder of a steam turbine is considered. The complete model of medium and low-pressure cylinder bodies is the base model. Two simplified hull models with different rigidity properties were taken as alternative models. This approach makes it possible to simplify the modeling process significantly. Spectra of natural frequencies and amplitude-frequency characteristics of forced oscillations are taken as comparative criteria. The study was carried out on all three steam turbine housing models. The foundation was modeled through a system of rods. The holder and rotor were considered through the system of masses. The subject of the study is natural and forced vibrations of the cylinder bodies of a steam turbine. The object of the study is a system of the most flexible casings of a medium-power steam turbine. The problem was solved using the methods of the oscillations theory and the finite element method. The simplified models are compared with the full one. Conclusions are drawn about the possibility of using various models of steam turbine casings.

Keywords: Turbine, Low-Pressure Cylinder, Simplified Model, Eigenvalue, Vibration, Industrial Growth.

Assessing the Reliability of a Mathematical Model of Working Processes Occurring in a Hydraulic Drive

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When studying the work processes occurring in the hydraulic drives of mechatronic systems of self-propelled vehicles, one of the most critical tasks is to assess the correspondence of the developed mathematical models to real objects. The developed dynamic model allows for mathematical modeling of changing the pressure of the working fluid and the rotational speed of the hydraulic motor shaft during acceleration of the hydraulic drive with a given probability. The developed methodology for bench testing a planetary hydraulic motor allows for experimental studies of the hydraulic motor during the acceleration of the hydraulic drive. The developed computer program allows for determining the adequacy of theoretical and experimental studies, expressed by the corresponding curves, using the Fisher criterion. Research has established that the results of modeling the acceleration process of a hydraulic drive of a mechatronic system with a planetary hydraulic motor describe the process adequately under study with the probability of 0.95. Consequently, all the results obtained by modeling the working processes occurring in a hydraulic drive are reliable, and the model itself can be recommended for studying hydraulic systems and their elements.

Keywords: Hydraulic Drive Acceleration, Steady Motion, Fisher Criterion, Reliability, Mathematical Model, Adequacy, Industrial Growth.

Thermodynamic and Exergetic Analysis of the Coolers for Mineral Fertilizers

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The importance of the granule cooling technique in producing mineral granulated fertilizers is determined. Literature data on the main types of convective coolers used in the technology of granular mineral fertilizers are given. It is noted that the presented devices have various performance characteristics, including cooling efficiency and energy consumption. It is emphasized that one can perform thermodynamic and exergy analyses when determining the optimal parameters. The technique of this analysis is presented, namely the equation for determining the main indicators of the analysis: cooling coefficient (or thermal efficiency) and exergetic efficiency. Calculation results of thermodynamic and exergetic indicators of convective coolers of the main types: drum, fluidized bed, and gravity shelf coolers are presented. Exergy analysis of the main technological stages of ammoniated superphosphate production was carried out. The results of thermodynamic and exergy analysis prove the advantages of using a gravity shelf cooler, characterized by the lowest exergy losses and the highest efficiency.

Keywords: Convective Cooling, Fluidized Bed, Shelf Apparatus, Cooling Coefficient, Exergetic Efficiency, Process Innovation.

Changing the Output Characteristics of a Planetary Hydraulic Motor

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The effective use of self-propelled equipment depends on the high-quality operation of mechatronic systems with the hydraulic drive of active working bodies, for the drive of which hydraulic machines of the planetary (orbital) type are used. The factors determining the output characteristics of a planetary hydraulic motor under operating conditions were substantiated. The torque range is 45…1070 Nm; the working fluid flow rate is 70…110 l/min; the diametrical gap is 0.02…0.23 mm. Regression equations were obtained that describe changes in the hydraulic motor's technical condition by measuring the working fluid's flow rate, rotation speed, and pressure drop and confirm that a change in the diametrical clearance in the range from 0.02 mm to 0.16 mm does not affect its efficiency. The main parameter characterizing the technical condition (operability) of a planetary-type hydraulic motor is the rotation speed of its output shaft, which decreases not only with a decrease in flow rate but also with an increase in load and diametrical clearance. It has been established that with a diametrical gap of 0.23 mm and a working fluid flow rate of 110...90 l/min, a sharp drop in the shaft rotation speed occurs, and at values of 70 l/min, the planetary hydraulic motor does not work at all.

Keywords: Torque, Fluid Flow, Diametrical Clearance, Rotation Speed, Full-Factorial Experiment, Industrial Innovation.

Analysis of Cooling Air at the Inlet of Marine Engine with Exhaust Gas Recirculation by Ejector and Absorption Refrigeration

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The ecological exhaust gas recirculation leads to deterioration in the engine fuel efficiency caused by a slowdown in the combustion process and a decrease in the operating cycle temperature. Energy losses are also associated with the recirculation and cleaning gases in scrubbers by removing their heat from seawater. Considering the analysis, the approach to increasing the energy and environmental efficiency of a ship's diesel power plant due to cooling the cyclic air at the engine inlet by refrigeration machines that utilize the heat of exhaust and recirculating (ecological) gases is justified. This will compensate for energy losses caused by the recirculation of exhaust (ecological) gases and further reduce fuel consumption. The article shows the results of an analysis of the effect obtained from cooling the air at the inlet of an engine turbocharger by thermal refrigeration machines that utilize the heat of the exhaust and environmental (recirculated) gases. It is shown that inlet air cooling in ejectors and absorption refrigeration machines can considerably reduce engine-specific fuel consumption.

Keywords: Process Innovation, Internal Combustion Engine, Ejector Chiller, Absorption Chiller, Inlet Cooling, Exhaust Gas Recirculation, Ecology, Fuel Consumption.

Improving the Performance of a Centrifugal Compressor Through Computer-Aided Design and Optimization of Blade Thickness

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Improving the characteristics of centrifugal compressors is a very urgent task since compressors are one of the most common pneumatic machines in industry and transportation. Numerical modeling can significantly reduce the research process and find the best design options in the shortest possible time when conducting a certain process of mathematical model verification. The characteristics of the impeller of a high-pressure centrifugal compressor with a vaneless diffuser were improved by designing a modified impeller by optimizing the blade thickness and using calculation methods of modern computer-aided design (CAD) software included in the Ansys Engineering Simulation Software. The adequacy of the mathematical model was confirmed by comparing the calculation results with the results of experimental studies of a basic industrial compressor. The maximum discrepancy in determining the ratio of total to total pressures is equal to 8 % in the zone of optimal flow rates with a flow offset. Due to the design of the compressor using CAD and optimization of the blade thickness, it was obtained that the polytropic efficiency of the designed impeller is 6% higher. At the same time, the ratio of total pressures is reduced by 9%. To further improve the optimized compressor and increase its efficiency, it is planned to replace the vaneless diffuser with a vaned one.

Keywords: Centrifugal Compressor, Numerical Simulation, Vaneless Diffusor, CAD, Efficiency, Industrial Innovation.

Part X
Advanced Materials

Application of Expanded Perlite in the Composition of Paper for Writing and Printing

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The method of increasing the opacity and mechanical strength of writing and printing paper due to the search for effective ratios of cellulose fibrous semi-finished products, their development during grinding, and the use of mineral fillers are considered in the article. A study aims to choose paper pulp, conditions for grinding softwood, and leaf sulfate bleached cellulose was conducted. The influence of the composition of the paper mass on the parameters of opacity, strength, and whiteness of the paper was investigated. The effectiveness of using the composition of sulfate-bleached cellulose from coniferous wood with a grinding degree of 42-44°SR and sulfate-bleached cellulose from deciduous wood with a grinding degree of 24-26°SR in the ratio of 85-90 and 15-10 wt.%, respectively, has been proven, which can provide increased opacity with maximum mechanical strength and paper whiteness. As a mineral filler in paper composition, it is proposed to use expanded perlite, a highly dispersed filler with a highly developed porous structure and an open hydrophilic surface. It was established that using expanded perlite with a 2-3 µm particle mass fraction of 90-92% in the amount of 4-6% of the completely dry fiber may increase the opacity of the paper while maintaining the level of mechanical strength and whiteness. Perlite added to the fibrous paper mass as a filler increases the optical heterogeneity of the medium and promotes light scattering to a greater extent than light absorption.

Keywords: Paper Materials, Mineral Fillers, Sulfate Bleached Cellulose, Grinding Degree, Mechanical Strength, Opacity, Whiteness.

Tribological Tests of Nanometric Coatings Used for Mechatronic Components With Increased Wear-Resistance

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Choosing a material or a combination of materials that is light and features a high resistance to wear and tear is a main concern of tribological studies undertaken worldwide nowadays. By integrating revolutionary combinations of a substrate and a thin layer deposited on top of it or just adding several layers of the same material as a coating, the objective of increasing the lifespan of the mechatronic applications can be attained. Thus, several studies were conducted to find better material combinations or the number of layers needed for building a certain part that will be embedded in a mechatronic system subject to intense mechanical wear. Using electronic beam evaporation, several types of materials were used to deposit thin layers on a number of types of substrates and latter, the resistance of the coatings, situated in the nanometer range (from 50 to 100 nm), was studied. The materials used for the coatings were Cr, Ti, Al, and Ti+Al multilayered, while those that served as substrates were RUL1, OLC45, C120, and OSC8 steel. A complex tribological study and physical-mechanical characterizations were undertaken, both dynamically and in real conditions, in which the authors demonstrated that the Cr deposited layer displayed the best resistance to wear regardless of the materials used as substrates even if its thickness had a twice smaller value than that of the Ti layer (second-best choice).

Keywords: Thin Layers, Nanostructures, Roughness.

Optimization of Surfacing Modes for a Wear-Resistant Alloy

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Using optimization in the modernization of existing surfacing materials for various load conditions and surfacing technology is relevant and was considered in this paper. The technology was proposed, and the surfacing mode was calculated with the resulting flux-cored wire composition containing carbon, titanium, and yttrium. This made it possible to carry out the surfacing process with good stability of the arc process. An experimental study of the surfacing metal with a flux-cored wire of tubular construction showed that it had a martensitic-austenitic structure with inclusions of titanium and yttrium carbides and had high abrasion resistance. The average microhardness of the carbide phase was 11 GPa, and the martensitic phase was 7.5 GPa. The weld metal obtained during welding with flux-cored wire of the optimal composition for the calculated welding mode had a 1.6–1.7 times higher abrasion resistance than the metal welded with “Sormite-1” alloy. The developed flux-cored wire and surfacing technology was implemented at the Sumy region enterprises.

Keywords: Process Innovation, Surfacing, Flux-Cored Wire, Microhardness, Abrasion Resistance, Industrial Growth.

Application of Nanomaterials and Nanotechnologies to Increase the Durability of Agricultural Machinery Working Bodies

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In the agro-industrial complex, several problems can be solved with the help of nanotechnology. A characteristic feature of the development of the leading economically developed countries is the transition to an innovative economy, the introduction of promising developments, and fundamentally new progressive technologies in all spheres of human activity. The article highlights the benefits of using nanocomposites and nanoprotective coatings in the production of agricultural machinery. In particular, their potential to reduce wear, increase strength, and ensure optimal working conditions is highlighted, contributing to a significant increase in the service life of working bodies. The results of the conducted research confirm the high efficiency of using nanotechnology in agriculture, taking into account the positive impact on the productivity and economic efficiency of machines and equipment. The article not only analyzes the scientific aspects of using nanomaterials but also sets the task of important practical implementation of these technologies in the production of agricultural machinery. The results of studies confirming the positive impact of nanotechnology on the productivity and economic efficiency of agricultural machinery are presented. The work highlights the prospects of introducing nanomaterials into the production of agricultural machines. It contributes to the further development of modern approaches to improving the quality and duration of their operation. According to the research results, it was established that the use of nano-sized membranes on the proposed components can have a significant effect, as they give them new properties that expand the range of operating conditions of the relevant equipment units.

Keywords: Nanomaterials, Surface Engineering, Composite Materials, Surface Modification, Material-Environment System, Tungsten Carbide, Industrial Growth.

Anti-Friction Products from Composite Materials Based on Lh15 Steel Powder

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The work considers the possibility of manufacturing and using sintered composite products from a metal component in the form of alloy steel powder obtained from grinding waste of bearing production. The research was conducted at optimal pressing parameters of 400...800 MPa, sintering at 1200°C for 2 hours from the specified temperature. The results of the first systematic studies of the strength and tribotechnical properties of sintered materials based on LH15 steel powder obtained from grinding slurries with copper and graphite additives are presented. It was established that the tribotechnical characteristics of sintered products under medium loads mainly depend on the composition's hardness. It has been experimentally verified that the high wear resistance and friction coefficient, which is on average 0.09, has a composition of 2% graphite and 4% copper at a sliding speed of 5 m/s and a pressure of 10 MPa. It has been experimentally confirmed that the increase in the linear dependence of stress on deformation, in particular when the strain is 8%, the stress is 1200...1400 MPa. This makes it possible to predict higher operational properties of products made from material of this composition. The resulting anti-friction products have a significantly lower cost and a higher material utilization ratio than traditional materials.

Keywords: Friction, Wear, Technology, Sintered Products, Bearing Production Waste, R&D Investment.

Improving a Process for Completing a Positive Connection of Hub-Shaft Type Using Combine Methods

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This paper describes an improved process for manufacturing a positive-locking hub-shaft joint. The process involves forming coatings on the contacting surfaces of the steel parts using the combined technology of electrospark alloying (ESA) followed by surface plastic deformation (SPD). In practice, it is suggested that the SPD treatment be carried out after the internal surfaces of the hub have been machined in the areas adjacent to its ends using the ESA method with copper or tin bronze. The SPD would cause compressive residual stresses to occur on the surface and increase the fatigue strength of the hub. It is also suggested that after ESA carburizing the hub shaft surface, it should be further processed by SPD. Further application of a soft antifriction metal layer of copper, silver, or tin bronze to the carburized layer by the ESA method and machining by the SPD ball rolling method will increase the fatigue strength of the shaft. In this case, the layer of soft antifriction material between the solid carburized layer and the indenter will be deformed.

Keywords: Integral Connection, Hub-Shaft, Electrospark Alloying, Surface Plastic Deformation, Carburizing, Residual Stresses, Fatigue Strength, Rolling with a Ball, Diamond Smoothing, Process Innovation.

Nanocomposites for Protection Against Thermal Infrared Imaging Detection Systems

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The article aims to examine polymeric ceramic-inorganic nanocomposites against thermal infrared imaging detection systems. A literature review was conducted on modern materials and composites that are effective against thermal infrared imaging detection systems. The thermal infrared imaging spectral properties of polymer ceramic-inorganic nanocomposites based on epoxy resin were determined and modified with ceramic-inorganic graphite-ferromagnetic fillers such as potassium titanates, silicon carbide, chromium oxide, and graphite. The scientific novelty of the study established that modification with potassium titanates of composites based on epoxy resin is optimal for enhancing thermal infrared imaging characteristics. The degree of thermal screening for the epoxy resin system with 20% wt. potassium titanates is almost 80%, and the maximum temperature reduction for those systems is from 26.6 to 23.5 °C. Likewise, the nanocomposites modified with poly potassium titanates were the most successful in lowering the intensity of thermal infrared imaging spectrum bands through analysis of the findings of comparative experiments. The practical significance of the study of all tested nanocomposites is the ability to shield the human body from detection by thermal infrared imaging systems and can be recommended for creating masking screens, sheets, textiles, and constructions.

Keywords: Polymer, Nanocomposite, Ceramic-Inorganic, Epoxy, Thermal Infrared Imaging, Detection System, Absorption, Industrial Growth.

Propagation Speed Simulation of Waves in Polymer Auxetics

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The article aims to study the change in vibration-absorbing characteristics of open-cell foam in the presence of auxetic properties based on the developed analytical approach of speed analysis within the framework of Cosserat elasticity. The apparatus of wave mechanics was applied to solve the given problem. This made it possible to obtain analytical formulas for evaluating shear-rotational waves in foam with different internal microstructures. Numerical results confirm the significant change in shear-rotation wave velocity in a foam with a re-entrant microstructure compared to a porous honeycomb cell. The use of analytical approaches and direct application of the basic principles of wave mechanics made it possible to obtain research formulas that can be used for a wide range of frequencies. The developed approach can be used to predict mechanical behavior and optimize the mechanical characteristics of materials with a negative Poisson ratio. The practical significance of the research results lies in the possibility of using the proposed approach to estimate the degree of compression of foam materials to ensure optimal values of the mechanical and vibration-absorbing characteristics of the obtained foam materials.

Keywords: Cosserat Elasticity, Auxetics, Shear-Rotation Wave, Industrial Growth.

Features of the Formation and Characterization of ZrN Coatings Using Vacuum-Arc Deposition

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The influence of pulse potential and nitrogen pressure in the chamber on the phase-structural state and hardness of vacuum-arc ZrN coatings has been studied. With increasing pressure under the conditions of a constant potential and without the influence of pulsed stimulation, observed the growth of the [111] texture and the appearance of the bittextured state [111]+[311]. Under pulse stimulation observed, the appearance of the [110] texture and the bittextured state affect the stability hardness provided the bonds are saturated with nitrogen atoms. The nitrogen pressure directly affects the grain size, microdeformation, and texture of ZrN coatings. At the substructural level, pulsed stimulation promotes the relaxation of deformation and growth of crystallite sizes, which increases the perfection of the structure with increasing pressure of the nitrogen atmosphere. The hardness of the nanocrystalline ZrN coatings varies with nitrogen pressure, which is related to the variation of preferred orientation, average grain size, and microdeformation. Hardness, without pulse stimulation, increases with increasing pressure and reaches a value of 42 GPa.

Keywords: Pulse Potential, Pressure, Diffractogram, Texture, Hardness.

Controlling the Gas Mode of a Mold for Producing Thin-Wall Castings

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In foundry production, there is a tendency to increase the share of thin-walled castings. The formation of their quality is significantly influenced by the parameters of the thermal gas mode of the casting mold, which are still insufficiently studied. The work aims to develop a mathematical model of the gas mode of casting molds for producing thin-walled and artistic castings with developed relief and to optimize the process of filtering gases from the elements of the casting mold closed by liquid metal. Based on the optimization of the following technological process parameters: the gas permeability of the facing layer of the molding mixture and the diameter of the ventilation duct, it is possible to remove gases from the mold relief element by filtration entirely. The work developed and implemented a method, algorithm, and recommendations for optimizing the gas mode of casting molds to produce thin-walled castings.

Keywords: Manufacturing Innovation, Thin-walled Casting, Gas Mode, Molding Sand, Filtration, Mathematical Model, Optimization, Quality.

Comparative Study of Corrosion Resistance of Cold Spraying Aluminum-Based Coatings on Magnesium Alloy

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The study aims to determine the capabilities of cold spraying aluminum-based coatings to protect magnesium alloys from corrosion. Three aluminum-based powder mixtures – Al + Zn, Al + Al2O3, and Al + Zn + Al2O3 – were selected as the spraying material. Coating spraying was performed on prepared samples of magnesium alloy ML10 according to GOST 2856-79 using the DYMET-405 cold spraying machine. The corrosion resistance of coatings was tested in the salt chamber following ASTM B117. The mass loss of the samples was determined by weighing them before and after the tests. After nine days of testing, the mean value of mass loss of ML10 magnesium alloy samples without coating was 1.851 g, and 0.147 g, 0.13 g, and 0.141 g for samples with Al + Zn, Al + Al2O3, and Al + Zn + Al2O3 coatings, respectively. This indicates that cold spraying aluminum-based coatings do not have through porosity, are characterized by high adhesion strength to the substrate, and provide reliable protection of magnesium alloys against the influence of an aggressive corrosive environment. The scientific novelty of the obtained results is that the dependence of the corrosion resistance of the cold spraying aluminum-based coatings is obtained. The practical value is that the obtained results can be used to select powder material for cold spraying while developing technological processes for applying protective and restorative corrosion-resistant coatings.

Keywords: Product Innovation, Powder, Corrosion Test, Magnesium Alloy, Corrosion Protection, Mass Loss, Industrial Growth.

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Proceedings of the International Conference on Design, Simulation, Manufacturing: The Innovation Exchange, DSMIE-2018, June 12-15, 2018, Sumy, Ukraine

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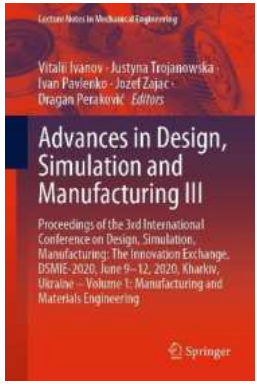

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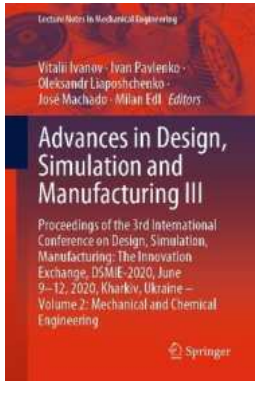

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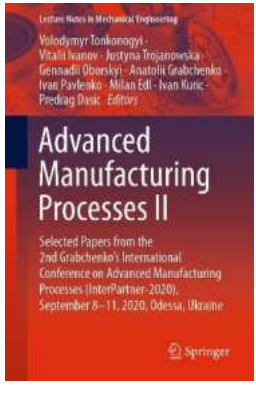

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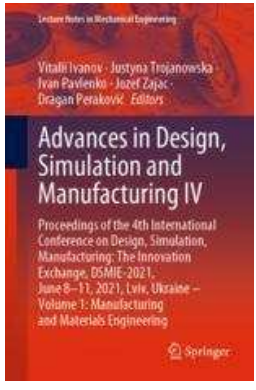

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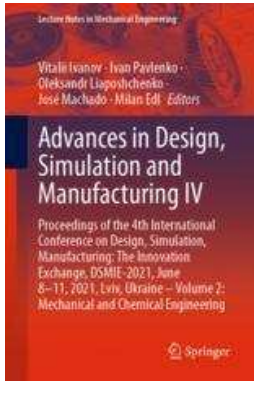

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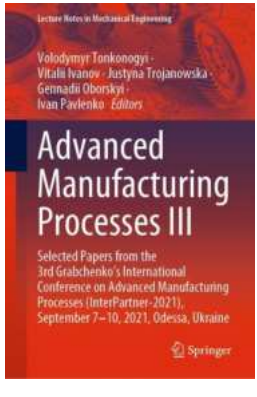

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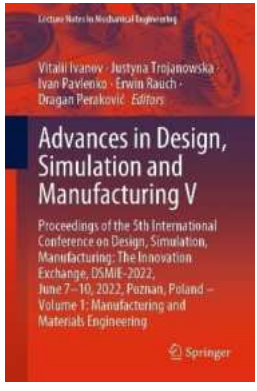

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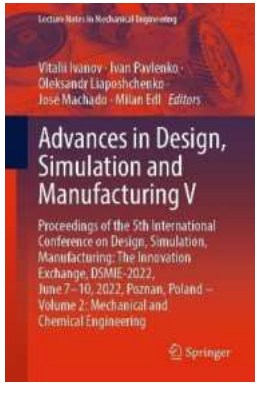

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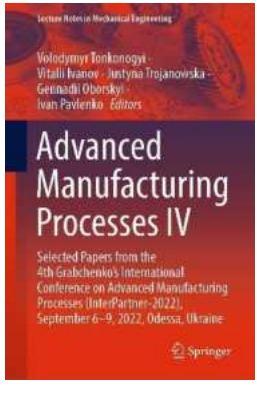

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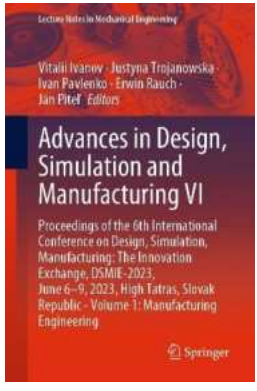

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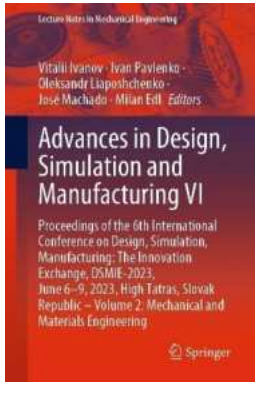

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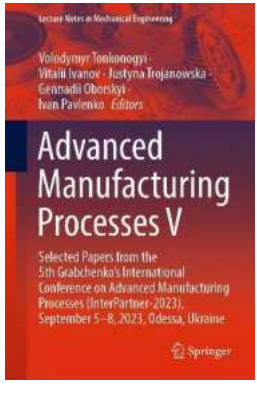

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7th International Conference on Design, Simulation, Manufacturing: The Innovation Exchange (DSMIE-2024)

Vitalii Ivanov
Milan Edl

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