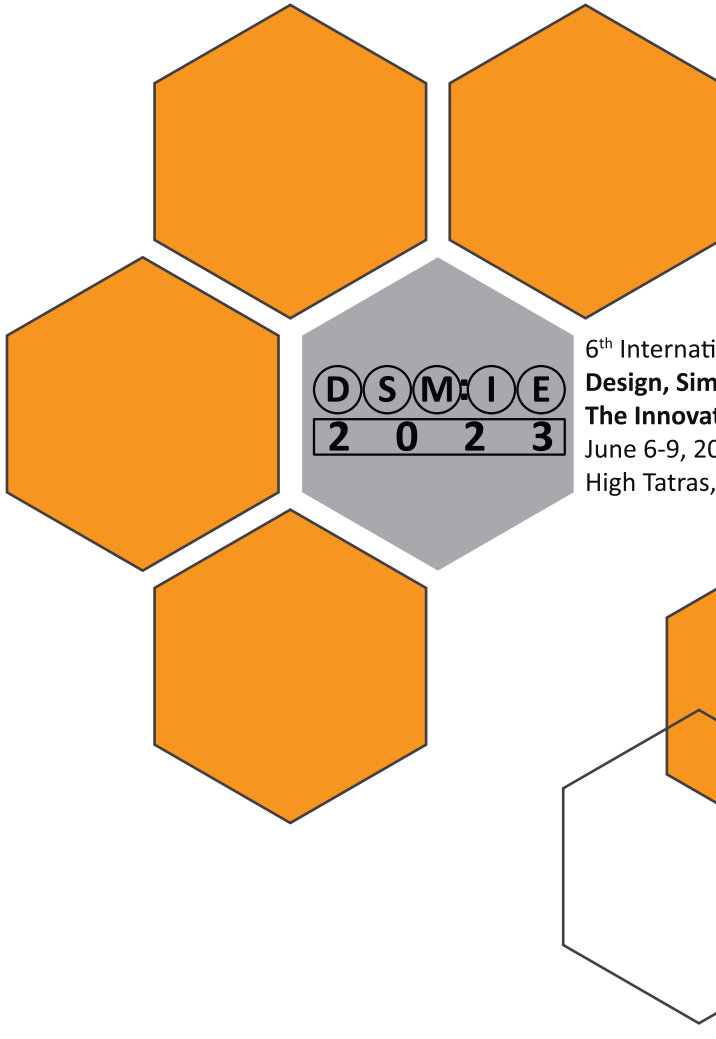
DSMIE Conference Series



6th International Conference on
Design, Simulation, Manufacturing: The Innovation Exchange
June 6-9, 2023
High Tatras, Slovak Republic

Book of Abstracts

Sumy State University

iATDi International Association for Technological Development and Innovations

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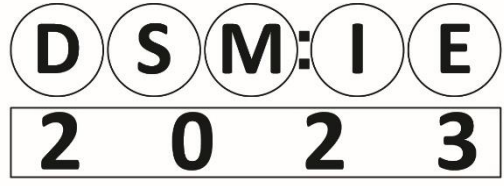
International Association for Technological Development and Innovations



6th International Conference on Design, Simulation, Manufacturing: The Innovation Exchange (DSMIE-2023)

June 6-9, 2023 | High Tatras, Slovak Republic

Book of Abstracts

Sumy
2023

Editors:

Vitalii Ivanov[1], Jozef Zajac[2], Ivan Pavlenko[1], Justyna Trojanowska[3]

[1] Sumy State University, Ukraine
[2] Technical University of Košice, Slovak Republic
[3] Poznan University of Technology, Poland

Design, Simulation, Manufacturing: The Innovation Exchange: Book of Abstracts of the 6th International Conference, High Tatras, Slovak Republic, June 6-9, 2023 / Vitalii Ivanov, Jozef Zajac, Ivan Pavlenko, Justyna Trojanowska (Eds.). – Sumy: IATDI, 2023. – 132 p.

Recommended by Coordination Board of International Association for Technological Development and Innovations (Protocol No. 4, February 1, 2023).

The content of this book is based on the 6th International Conference on Design, Simulation, Manufacturing: The Innovation Exchange (DSMIE-2023), held on June 6-9, 2023, in High Tatras, Slovak Republic. This book reports on topics at manufacturing engineering, with a special emphasis on smart manufacturing and information management systems, particularly sensors, machine vision systems, collaborative technologies, industrial robotics, digital twins, and virtual and mixed reality. It covers quality management, supply chain, agile manufacturing, lean management, and sustainable transportation. The book describes innovative research in manufacturing technology, covering design, simulation, and experimental studies during various machining processes and additive manufacturing. It also discusses key aspects related to engineering education and competence management. Furthermore, this book reports on topics at the interface between mechanical and materials engineering, emphasizing aspects related to design, simulation, and manufacturing. It covers recent findings in design engineering, particularly for mechatronics, industrial equipment, energy machines, and transportation systems. Further, it reports on innovative separation, prilling, and energy equipment solutions and realized processes. It describes design issues and simulation techniques of the advanced materials and coatings, including chemical-thermocycling treatment, plasma deposition, strengthening, and other processes. This book provides academics and professionals with extensive information on trends and technologies, and challenges and practice-oriented experience in all the above-mentioned areas.

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Welcome Message

Prof. Vitalii Ivanov,
General Chair of the Conference

This volume of Lecture Notes in Mechanical Engineering contains selected papers presented at the 6th International Conference on Design, Simulation, Manufacturing: The Innovation Exchange (DSMIE-2023), held in High Tatras, Slovak Republic, on June 6-9, 2023. The conference was organized by the Sumy State University, Technical University of Košice, and International Association for Technological Development and Innovations, in partnership with Poznan University of Technology (Poland), Kielce University of Technology (Poland), University of West Bohemia (Czech Republic), Association for Promoting Innovative Technologies – Innovative FET (Croatia), and Society for Robotics of Bosnia and Herzegovina (Bosnia and Herzegovina).

DSMIE Conference Series 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.

DSMIE-2023 received 135 contributions from 14 countries around the world. After a thorough peer-review process, the Program Committee accepted 66 papers written by 259 authors from 12 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 49%. 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), and a special issue of Machines (Switzerland) "Innovations in the Design, Simulation, and Manufacturing of Production Systems" and Materials (Switzerland) "Novel Approaches in the Design, Simulation, and Manufacturing for Processes and Systems".

We would like 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. 83 Program Committee members and 10 invited external reviewers devoted their time and energy to peer-reviewing manuscripts. Our reviewers come from around the world, representing 17 countries, and are affiliated with 39 institutions.

Thank you very much to Co-Chairs: Prof. Jozef Zajac (Technical University of Košice, Slovak Republic) for general support of conference organization, Prof. Michal Hatala (Technical University of Košice, Slovak 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. Svetlana Radchenko Technical University of Košice, Slovak Republic), and Dr. Khrystyna Berladir (Sumy State University, Ukraine) for organizational issues.

Thank you very much to the keynote speakers: Prof. Fazel Ansari (Vienna University of Technology, Austria), Prof. Michał Wieczorowski (Poznan University of Technology, Poland), and Prof. Alexander Hošovský (Technical University of Košice, Slovak Republic).

The book "Advances in Design, Simulation and Manufacturing VI" was organized in 2 volumes according to the main conference topics: Volume 1 – Manufacturing Engineering, and Volume 2 – Mechanical and Materials Engineering. Each volume is devoted to research in design, simulation, and manufacturing in the main conference areas.

We appreciate the partnership with Springer Nature, iThenticate, EasyChair, and our sponsors for their essential support during the preparation of DSMIE-2023.

Thank you very much to 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 of the Conference

About DSMIE-2023

6th International Conference on Design, Simulation, Manufacturing: The Innovation Exchange (DSMIE-2023) 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 a 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, and 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 are 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 held in High Tatras, Slovak Republic in cooperation with Technical University of Košice.

We are proud of our achievements and metrics for these 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.

2000	•Participants
30	•Countries
10	•Issued books
490	•Published papers
401 630	•Downloads
1351	•Citations

5th Anniversary (2018-2022)

Organizers

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

Sumy State University
(Faculty of Technical Systems and Energy Efficient Technologies)

Sumy State University is located in Sumy city in the North-East of Ukraine. Its history began in 1948. Today, SumDU is a leading university of a classical type with the III-IV accreditation level in the region.

The University currently serves about 12,000 students pursuing bachelor's and master's degrees in 55 majors and 24 fields of knowledge. About 1900 international students represent about 50 countries worldwide.

The University is a signatory of the Magna Charta Universitatum and Talloires Declaration, a reliable member of the International Association of Universities, European University Association, IREG Observatory on Academic Ranking and Excellence, IIENetwork, and other international organizations.

Sumy State University cooperates with more than 300 partners from 55 countries worldwide, including the USA, Great Britain, Germany, Austria, France, Belgium, Sweden, Poland, Lithuania, Bulgaria, the Czech Republic, Slovakia, Romania, Japan, South Korea, China and other countries of the world.

SumDU is a reliable partner for joint projects in frames of international grant programs of EU (Erasmus+, Horizon 2020), United Nations Development Programme, NATO, DAAD, American Councils, British Council, the World Bank, bilateral scientific and research projects, grants of private foundations. The University accomplishes more than 300 grants annually.

The University actively develops academic mobility programs, including long-term and short-term studies, internships and placement programs for undergraduate

and postgraduate students, professional development, teaching, and research mobility for staff with substantial scholarship and grant support using technologies of credit transfer and recognition of academic results.

✉ 2, Rymskogo-Korsakova St., 40007 Sumy, Ukraine
💻 https://teset.sumdu.edu.ua/

Technical University of Košice (Faculty of Manufacturing Technologies with a seat in Prešov)

Technical University of Košice (TUKE) is a public research university located in Košice, Slovak Republic. It was established in 1952 and has since become one of the leading universities in the Slovak Republic, particularly in engineering, technology, and natural sciences.

TUKE offers undergraduate, graduate, and doctoral programs in various fields, including electrical engineering, computer science, civil engineering, mechanical engineering, environmental engineering, and applied sciences. The university has several faculties, including the Faculty of Electrical Engineering and Informatics, the Faculty of Mechanical Engineering, the Faculty of Civil Engineering, the Faculty of Mining, Ecology, Process Control, and Geotechnologies, and the Faculty of Manufacturing Technologies.

TUKE is known for its cutting-edge research and development activities, particularly in the fields of automation and control, sustainable energy systems, materials science, and applied mathematics. The university has several research centers and institutes, including the Institute of Control and Industrial Informatics, the Institute of Materials Research, and the Institute of Sustainable Energy.

TUKE is committed to promoting international collaboration and has established partnerships with several universities and research institutions around the world. The university is a member of the European University Association and participates in several international research and development projects.

Overall, TUKE is a renowned institution in Slovakia and beyond, recognized for its high-quality education, innovative research, and commitment to promoting technological advancements and innovation.

✉ 1, Bayerova St., 080 01 Prešov, Slovak Republic
💻 https://fvt.tuke.sk/

International Association for Technological Development and Innovations

The International Association for Technological Development and Innovations (IATDI) is a non-profit organization that aims to promote 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 to foster collaboration and knowledge sharing among its members.

IATDI organizes various international conferences, workshops, and symposia to facilitate knowledge exchange and dissemination among researchers, engineers, and practitioners. The association also publishes high-quality research papers, technical reports, and books related to technology and innovation.

IATDI has a global community of professionals and academicians from diverse backgrounds and engineering disciplines, including manufacturing, mechanical, chemical, and materials engineering. Members of IATDI include researchers, educators, industry leaders, entrepreneurs, and government officials who share a common interest in promoting technological advancements and innovation.

Through its various programs and initiatives, IATDI aims to bridge the gap between academia and industry and create a conducive environment for the development and adoption of new technologies. The association also provides a platform for its members to network, collaborate, and share knowledge, thereby fostering a community of like-minded individuals committed to the advancement of technology and innovation.

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

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Natalya Shramenko	Lviv Polytechnic National University, Ukraine
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Svetalna Radchenko	Technical University of Košice, Slovak Republic
Justyna Trojanowska	Poznan University of Technology, Poland
Jozef Zajac	Technical University of Košice, Slovak 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-2022 were published in two volumes in the book **"Advances in Design, Simulation and Manufacturing V"**. 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 submitted to the Web of Science Core Collection.

Volume 1 – Manufacturing Engineering

(ISBN 978-3-031-32766-7; ISBN eBook 978-3-031-32767-4; DOI 10.1007/978-3-031-32767-4)

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

Vol. 1

Volume 2 – Mechanical and Materials Engineering

(ISBN 978-3-031-32773-5; ISBN eBook 978-3-031-32774-2; DOI 10.1007/978-3-031-32774-2)

Editors:

- Vitalii Ivanov, Sumy State University, Ukraine
- Ivan Pavlenko, Sumy State University, Ukraine
- Oleksandr Liaposhchenko, Sumy State University, Ukraine
- Jose Machado, University of Minho, Portugal
- Milan Edl, University of West Bohemia, Czech Republic

Vol. 2

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-2023, 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.

Venue

National Park High Tatras (Vysoke Tatry) is situated in the north of Slovakia, shared partly with Poland. The only mountains of Alpine type in the whole Carpathian Mountain range are often called “the smallest alpine mountains in Europe”.

When we say High Tatras, we mean majestic peaks touching to the sky, dark turquoise mountain lakes of glacier origin, waterfalls, unique plants, rare animals like chamois (mountain goat) or marmot, exceptionally clean air and environment great for healing respiratory conditions.

There are three main parts of High Tatras: The Western Tatras; The (central) High Tatras; The Belianske Tatras. They differ in their geological composition and location. The inhabitants of the High Tatras live in the settlements situated along the “Road of Freedom“, which joins Western, High and Belianske Tatras together.

Gerlachovsky Stit (2.655 m / 8.710 ft) is the highest of the High Tatras and of Slovakia. For of its height and breathtaking scenery it is one of the most visited and challenging peaks. Hire a skilled mountain guide to lead you, otherwise it’s hardly possible (and forbidden) to get there.

Lomnicky Stit (2.634 m / 8.642 ft) is possibly the most visited peak, probably because of its accessibility by cable car. You will find the highest situated Astronomical and Meteorological Observatory in Slovakia on the top.

Krivan (2.494 m / 8.182 ft) belongs to the Western Tatras and is the most popular amongst Slovaks. It is said that every Slovak has to climb to the top at least once in his lifetime. Krivan became the symbol of the freedom of Slovaks and since 1955, traditional national walks have been devoted to the Slovak National Uprising and the local heroes.

Agenda

Agenda online

Day 1 | June 6, 2023

0^{00}–17^{00}	Day of Arrival
17^{00}–18^{00}	Registration
18^{00}–20^{00}	Welcome Reception

Day 2 | June 7, 2023

9^{00}–10^{00}	Registration
10^{00}–10^{30}	Opening Ceremony
10^{30}–11^{30}	Keynote Session I
11^{30}–12^{00}	Official Conference Photo
12^{00}–13^{00}	Lunch
13^{00}–14^{45}	Session 1 – Smart Manufacturing
14^{45}–15^{15}	Coffee Break
15^{15}–16^{45}	Session 2 – Manufacturing Technology
16^{45}–18^{00}	Poster Session
19^{30}–23^{00}	Gala Dinner

Agenda (continuous)

Agenda online

Day 3 | June 8, 2023

09^{00}–10^{00}	Session 3 – Information Management Systems
10^{00}–10^{30}	Keynote Session II
10^{30}–11^{00}	Coffee Break
11^{00}–13^{00}	Business to Science Session
13^{00}–14^{00}	Lunch
14^{00}–15^{30}	Session 4 – Mechanical and Materials Engineering
15^{30}–18^{00}	Cultural Program
19^{30}–20^{00}	Awards Ceremony
20^{00}–22^{00}	Get Together Party

Day 4 | June 9, 2023

09^{00}–11^{30}	Session 5 – Ideas Exchange & Discussion
11^{30}–12^{00}	Closing Ceremony

Day 1 | June 6, 2023

0^{00}–17^{00} **DAY OF ARRIVAL**

17^{00}–18^{00} **REGISTRATION**

18^{00}–20^{00} **WELCOME RECEPTION**

Day 2 | June 7, 2023

9^{00}–10^{00} **REGISTRATION**

10^{00}–10^{30} **OPENING CEREMONY**

Vitalii Ivanov

General Chair of the Conference

Ján Piteľ

Co-chair of the Conference, Vice-Dean for Development and External Relations of the Faculty of Manufacturing Technologies with a seat in Prešov, Technical University of Košice, Slovak Republic

Oleksandr Gusak

Co-Chair of the Conference, Dean of the Faculty of Technical Systems and Energy Efficient Technologies, Sumy State University, Ukraine

10^{30}–11^{30} **KEYNOTE SESSION I**

Chair: Olaf Ciszak

Poznan University of Technology, Poland

Cognitive Digital Twins in Sustainability-Driven Maintenance Planning

Fazel Ansari[1,2]

[1] *Vienna University of Technology, Austria;*

[2] *Fraunhofer Austria Research GmbH, Austria*

Current Trends in Soft Robotics for Smart Machines Development

Alexander Hošovský

Technical University of Košice, Slovak Republic

11^{30}–12^{00} **OFFICIAL CONFERENCE PHOTO**

12^{00}–13^{00} **LUNCH**

13^{00}–14^{45} **SESSION 1 – SMART MANUFACTURING**
Chair: Ján Piteľ
Technical University of Košice, Slovak Republic

Evolution of Competence Management in Manufacturing Industries
Markus Steinlechner[1], Fazel Ansari[1,2] and Sebastian Schlund[1,2]
[1] Fraunhofer Austria Research GmbH
[2] Vienna University of Technology, Austria

Machine Vision Systems for Collaborative Assembly Applications
Vladyslav Andrusyshyn[1,2], Vitalii Ivanov[1,2], Ján Piteľ[1], Kamil Židek[1] and Peter Lazorik[1]
[1] Technical University of Košice, Slovak Republic
[2] Sumy State University, Ukraine

PLC Control of a 2-axis Robotic Arm in a Virtual Simulation Environment
Martin Pollák, Marek Kočiško and Karol Goryl
Technical University of Košice, Slovak Republic

Sensor Selection for Smart Retrofitting of Existing Plants
Dmytro Adamenko
University of Duisburg-Essen, Germany

Designing a Workplace in Virtual and Mixed Reality Using the Meta Quest VR Headset
Adrián Vodilka, Marek Kočiško, Simona Konečná and Martin Pollák
Technical University of Košice, Slovak Republic

A Digital Twin for Remote Learning: A Case Study
Kateryna Kovbasiuk, Jakub Demčák, Jozef Husár, Alexander Hošovský and Vratislav Hladký
Technical University of Košice, Slovak Republic

Digital Twins for Industrial Robotics: A Comparative Study
David Fait and Václav Mašek
University of West Bohemia, Czech Republic

14^{45}–15^{15} **COFFEE BREAK**

15^{15}–16^{45} **SESSION 2 – MANUFACTURING TECHNOLOGY**

Chair: Michal Hatala

Technical University of Košice, Slovak Republic

CAD, Laser Powder Bed Fusion Fabrication and Post-Processing of Customized Metal Dental Products

Dmytro Lesyk[1,2,3], Oleksandr Lymar[4], Vitaliy Dzhemelinskyi[1], Dariusz Grzesiak[3] and Bartosz Powalka[3]

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Preliminary Study of Mass Material Removal for Aluminum Alloy by Low Pressure AWJ

František Botko[1], Jozef Zajac[1], Svetlana Radchenko[1], Dominika Botkova[1] and Dagmar Klichova[2]

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Turning of NC10 Threads for Drill Pipes: Theoretical Study of the Designed Profile

Oleh Onysko[1], Volodymyr Kopei[1], Jaroslav Kusyi[2], Olena Kornuta[1] and Iryna Schuliar[1]

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Conductivity Measurement Verification of Additively Manufactured and Bulk Metals

Matúš Geľatko[1], Michal Hatala[1], Radoslav Vandžura[1], Martin Kasenčák[2] and Dušan Manduľák[3]

[1] *Technical University of Košice, Slovak Republic*

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Modeling and Surface Modification of AISI 321 Stainless Steel by Nanosecond Laser Radiation

Sergey Dobrotvorskiy[1], Borys A. Aleksenko[1], Mikołaj Kościński[2], Yevheniia Basova[1] and Vadym Prykhodko[1]

[1] *National Technical University "Kharkiv Polytechnic Institute", Ukraine*

[2] *Poznan University of Life Sciences, Poland*

Improvement of the Quality of Wear Zones for Cutting Tools Textures Classes Recognition based on Convolutional Models

Oleksandr Fomin, Oleksandr Derevianchenko, Natalya Volkova and Natalia Skrypnyk

Odessa Polytechnic National University, Ukraine

16^{45}–18^{00} **POSTER SESSION**

19^{30}–23^{00} **GALA DINNER**

Day 3 | June 8, 2023

09^{00}–10^{00} **SESSION 3 – INFORMATION MANAGEMENT SYSTEMS**

Chair: Justyna Trojanowska

Poznan University of Technology, Poland

Agile Framework as a Key to Information Management Systems Delivery

Bohdan Haidabrus[1,2], Janis Grabis[2], Oleksandr Psarov[3] and Evgeniy Druzhinin[4]

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[3] *Sumy State University, Ukraine*

[4] *National Aerospace University, Ukraine*

Quality Management at the Manufacturing Enterprise: Repair Processes Case Study

Yuliia Denysenko[1,2], Filip Górski[2], Olaf Ciszak[2], Khrystyna Berladir[1,3] and Pavlo Kushnirov[1]

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[2] *Poznan University of Technology, Poland*

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Agile in Context of Manufacturing SMEs

Angelina Iakovets, Michal Balog and Kamil Židek

Technical University of Košice, Slovak Republic

Tracking of Trucks Using the GPS System for the Purpose of Logistics Analysis

Peter Trebuňa, Marek Mizerák, Miriam Pekarčíková, Marek Kliment and Matúš Matiscák

Technical University of Košice, Slovak Republic

A Model of Formation of Professional and Creative Competences for Engineers Based on Information and Digital Technologies

Viktor Nagayev[1], Viktoriia Vertegel[2], Galyna Nagayeva[1], Oksana Kovalenko[3] and Olena Smihunova[1]

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Efficiency of the Production Process in the New Production Facility
Matúš Matiscsák, Peter Trebuňa, Marek Kliment, Marek Mizerák and Jozef Trojan
Technical University of Košice, Slovak Republic

10^{00}–10^{30} **KEYNOTE SESSION II**
Chair: Vitalii Ivanov
Sumy State University, Ukraine

Metrology 4.0: The Role of Digital and Information Technologies
Michał Wieczorowski
Poznan University of Technology, Poland

10^{30}–11^{00} **COFFEE BREAK**

11^{00}–13^{00} **BUSINESS TO SCIENCE SESSION**
Chair: Michał Wieczorowski
Poznan University of Technology, Poland

Industry Meets Research: Collaboration as a Key for Sustainable Development
Dmytro Adamenko
WAGO GmbH & Co. KG, Germany

Business Needs Science – Interdisciplinary Cooperation Between Scientists and Manufacturers Based on MIRIA Project
Dominik Czerwinski
ALVO Medical Sp. z o.o., Poland

Research and Development Cooperation of the Kielce University of Technology with the Business Environment
Slawomir Luscinski[1,2]
[1] *Kielce University of Technology, Poland;*
[2] *Centre for Research and Innovation CENWIS, Poland*

People Potential and New Technologies: A Catalyst for Regional Development
Milan Edl[1,2]
[1] *University of West Bohemia, Czech Republic;*
[2] *Research and Innovation Strategies for Smart Specialization, Czech Republic*

13^{00}–14^{00} **LUNCH**

14^{00}–15^{30} **SESSION 4 – MECHANICAL AND MATERIALS ENGINEERING**

Chair: Ivan Pavlenko
Sumy State University, Ukraine

Numerical Study of Hydrodynamic Characteristics of the Automatic Balancing Device Elements of the Centrifugal Pump
Yuliia Tarasevych[1] and Ievgen Savchenko[2]
[1] *AGH University of Science and Technology, Poland*
[2] *Sumy State University, Ukraine*

Formation of Liquid Droplets at the Prilling Bucket Outlet under Free Oscillations of the Liquid Jet
Oleksandr Yurchenko[1], Ruslan Ostroha[1], Vsevolod Sklabinskyi[1], Oleksandr Gusak[1] and Jozef Bocko[2]
[1] *Sumy State University, Ukraine*
[2] *Technical University of Košice, Slovak Republic*

Damage Mechanisms of Multilayer Axisymmetric Shells Obtained by the FDM Method
Oleksandr Salenko[1], Dmytro Dzhulii[1], Volodymyr Drahobetskyi[2], Anastasiia Symonova[2] and Dmytro Moloshtan[2]
[1] *National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Ukraine*
[2] *Kremenchuk Mykhailo Ostrohradskyi National University, Ukraine*

Strengthening of Mechanical Engineering Parts Using Chemical-Thermocycling Treatment
Khrystyna Berladir[1,2], Tetiana Hovorun[1], Ivan Pavlenko[1,2] and Justyna Trojanowska[3]
[1] *Sumy State University, Ukraine*
[2] *Technical University of Košice, Slovak Republic*
[3] *Poznan University of Technology, Poland*

Mechanical Properties of Hybrid Composites Based on Polypropylene Modified with Natural Fillers
Mykola Melnychuk, Igor Shevchuk, Vitalii Kashytskyi, Yurii Feshcuk and Nina Polivoda
Lutsk National Technical University, Ukraine

An Increase in the Technological Properties of Mixtures in the Foundry Industry: A Novel Approach
Olga Ponomarenko, Nataliia Yevtushenko, Tatyana Berlizeva, Stepan Yevtushenko and Mikhailo Vorobyov
National Technical University "Kharkiv Polytechnic Institute", Ukraine

15^{30}–18^{00} **CULTURAL PROGRAM –** Rocky Mountain Lake (Skalnaté Pleso)

19^{30}–20^{00} **AWARDS CEREMONY**

20^{00}–22^{00} **SOCIAL PROGRAM – GET TOGETHER PARTY**

Day 4 | June 9, 2023

09^{00}–11^{30} **SESSION 5 – IDEAS EXCHANGE & DISCUSSION**

11^{30}–12^{00} **CLOSING CEREMONY**

Posters List

1 **A CANVAS Based Assessment Model to Evaluate SMEs Readiness for Digital Business Models**
Manuel Holzner, Erwin Rauch, Guido Orzes and Dominik T. Matt

2 **Digital and Information Technologies in Metrology 4.0**
Michał Wieczorowski, Justyna Trojanowska and Oleksandr Sokolov

3 **Impact of Standardized Reusable Packaging on a Supply Chain Design and Environmental Efficiency**
Damian Dubisz, Paulina Golinska-Dawson and Adam Koliński

4 **Implementation of Intelligent Transport Systems in an Urban Agglomeration: A Case Study**
Joanna Sęk, Piotr Trojanowski, Łukasz Gilewicz, Bartosz Gapinski and Artem Evtuhov

5 **Analysis of Microcutting of VT8 Titanium Alloy and 12Cr2Ni4A Steel During Grinding with Cubic Boron Nitride**
Tatiana Chumachenko, Oleksandr Derevianchenko, Taiana Nikolaieva, Yevhen Omelchenko and Alla Bespalova

6 **An Impact of the Cutting Fluid Supply on Contact Processes During Drilling**
Eshreb Dzhemilov, Eskender Bekirov, Alper Uysal and Ruslan Dzhemalyadinov

7 **Substantiation of Chip Removal Models During Milling of Closed Grooves**
Oleksandr Gnytko and Anna Kuznetsova

8 **Surface Roughness Assessment after Milling of Pure and Carbon Black Reinforced Polypropylene Materials**
Ahmet Hakan Akin, Yusuf Furkan Yapan, Jaroslav Kusyj, Vitalii Ivanov and Alper Uysal

9 **Improvement of Two-Stage Drive for Multioperational Milling Machine**
Oleg Krol, Volodymyr Sokolov and Petko Tsankov

10 **Information Technologies of the Analysis for Models to Ensure Quality Characteristics of the Working Surfaces During Mechanical Processing**
Maksym Kunitsyn, Anatoly Usov and Yuriy Zaychyk

11 **Just in Time Gear Grinding Wheel Dressing**
Natalia Lishchenko, Garret O'Donnell, Vasily Larshin, Artem Mochuliak and Sergey Uminsky

Keynote Speakers

Keynote Speaker

Fazel Ansari,
Priv.-Doz. Dr.-Ing., Professor,
Vienna University of Technology, Austria;
Fraunhofer Austria Research GmbH, Austria

DSMIE Conference Series

Fazel Ansari is the Head of the Research Group "Production & Maintenance Management" (former "Smart and Knowledge-Based Maintenance") at the Vienna University of Technology (TU Wien, Austria) since 2018. He also leads Fraunhofer Austria's Strategic Projects in the Center for Sustainable Production and Logistics. Fazel obtained his Habilitation degree in Industrial Engineering at the TU Wien and his summa cum laude Ph.D. in computer science from the University of Siegen, Germany, specializing in knowledge-based systems and knowledge management. He holds an MSc. degree in Mechatronics from the University of Siegen and a BSc. in Mechanical Engineering from the University of Tehran. Fazel Ansari is an interdisciplinary researcher conducting fundamental- and applied-oriented research at the intersection of artificial intelligence (AI), industrial engineering, and production management. His research focuses on Human-centered Cyber-Physical Production Systems, operations and maintenance management, knowledge management 4.0, and Industrial AI. Fazel Ansari is engaged in several international scientific associations, namely as an IEEE Senior Member, a member of IFAC's Technical Committee 5.2 "Management and Control in Manufacturing and Logistics", and a member of the Scientific Committee at the International Association of Learning Factories (IALF).

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Keynote Speech Topic

Cognitive Digital Twins in Sustainability-Driven Maintenance Planning

AI enables coupling physical artifacts with their paired digital objects; thus, a digital twin emerges in conjunction with a cyber-physical system. A cognitive digital twin intends to substitute the physical prototype of an artifact (product or system) by simulating, predicting, and prescribing its physical expectations and behaviors. Over the past years, digital twins in real-world manufacturing are mostly understood as a data hub, which facilitates precisely matching digital data to the supervised physical objects (e.g., production plant, machine) to represent its physical capabilities. Yet, industrial digital twins do not feature cognitive capabilities for planning and optimization purposes while contributing to the automation and intelligentization of manufacturing systems and processes. Besides, the twin (digital and green) transformation of manufacturing industries undergoes a fundamental change to scope planning objectives considering not only productivity but also sustainability goals. From an ecological and environmental point of view, existing machines on the shop floor are available resources and valuable assets that can live longer through optimal maintenance and retrofit management, i.e., extended remaining useful life time and efficient operation can be achieved. This talk examines how cognitive digital twins may contribute to twin transformation in manufacturing, focusing on maintenance management. Further, it addresses the benefit of data-driven approaches for extending the scope of OEE towards OSEE (Overall Sustainable Equipment Effectiveness) as a new benchmark and baseline KPI for assessing production efficiency and sustainability.

Keynote Speaker

Alexander Hošovský,
Ph.D., Associate Professor,
Technical University of Košice,
Slovak Republic

DSMIE Conference Series

Alexander Hošovský received his MSc. in avionics from M.R. Štefánik Air Force Academy in Košice in 2004. He started his Ph.D. study at the Faculty of Manufacturing Technologies with a seat in Prešov, Technical University of Košice in 2005 and received his degree in mechanical engineering in 2008. The title of the habilitation thesis is "Computational Intelligence Methods in Modeling and Control of Manipulators with Artificial Muscles", in 2014. He works as an Associate Professor in Industrial Engineering at the Technical University of Košice. His research interests include soft actuators and soft robotics, computational intelligence, bio-inspired control, and system identification. He is the recipient of the Young Research Prize for Science and Technology and Rector's Prize for Young Researchers in 2016 and currently serves as an academic editor for two journals (Computational Intelligence and Neuroscience, International Journal of Intelligent Systems) and co-edited several soft robotics-related research topics in several other journals.

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Keynote speech topic

Current Trends in Soft Robotics for Smart Machines Development

Typical robots that dominate the industry are rigid machines capable of highly accurate and fast repetitive motions needed to meet stringent specifications (as in manufacturing, for instance). However, these machines lack structural adaptability, which improves functionality in unstructured environments, and can be dangerous to humans. While collaborative robotics with still rigid machines is constantly improving, the use of soft materials in the construction of robots opens much broader capabilities for such devices in view of future applications in various areas. Soft robotics has become a highly active and research-intensive field, where many scientific disciplines meet to design smart soft machines with capabilities that better match the characteristics of living entities and improve their performance in challenging conditions of future automation applications. On the other, their structural compliance comes with the cost of much more difficult modeling and control in the form of time-varying properties, hysteresis, creep effects, and many others, which require advanced computational techniques to be applied. In addition, tighter coupling between the computing capabilities and body of the robot might be desirable to achieve what is known as embodied intelligence.

Keynote Speaker

Michał Wieczorowski,
Ph.D., Professor, Vice-Rector for Development and Cooperation with Business and Industry,
Poznan University of Technology, Poland

DSMIE Conference Series

Prof. Wieczorowski is the Head of the Division of Metrology and Measurement Systems, Institute of Mechanical Technology, Faculty of Mechanical Engineering and Management of Poznan University of Technology. Also, he is a Vice-Rector for Development and Cooperation with Business and Industry. Prof. Wieczorowski has been a full professor since 2015. Among his achievements are the Fulbright scholarship at Northwestern University (USA) and Visiting Professor at Polytechnic University of Hauts-de-France (France). Prof. Wieczorowski is the author of 6 books and over 25 chapters, 3 books as editor, over 150 papers in journals, over 100 articles at congresses and conferences, over 50 implemented research works, and 2 patents. The scientific interests of Prof. Wieczorowski are topography analysis, nanometrology, coordinate measurement technique, optical scanning, photogrammetry, reverse engineering, and computed tomography. He is a member of the Engineering Academy in Poland, the Metrology Council at President of the Central Office of Measures, the Board of Committee on Machine Building of the Polish Academy of Sciences, the Advisory Board for the Minister of Science and Higher Education for implementation doctorate procedure, Board of Regional Council of Industry of the Future. He serves as an Associate Editor of Measurement, Measurement: Sensors, Measurement: Food and Metrology and Measurement Systems. Also, he is a Guest editor of 5 Special Issues of MDPI Materials.

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Keynote speech topic

Metrology 4.0: The Role of Digital and Information Technologies

Industry 4.0, on which many different studies have already been written, brings with it a completely different outlook, especially in IT. Cyber-physical systems, the Internet of Things, networks and cloud-based big data, artificial intelligence, and robotics are essential elements that have also found their way into Metrology 4.0, sometimes called Metrology of the Future. In the paper, measurement technologies for Metrology 4.0 were presented. They belong to coordinate measurement techniques in macro, micro, and meso scales. Optical scanning and computed tomography were discussed, focusing on achievable big data. From an IT point of view, the use of artificial intelligence was shown. The possibility of using augmented and virtual reality was also depicted with a short note on cybersecurity. Finally, some ideas regarding Metrology for the Future were briefly presented. It will probably be more oriented to man and use the planet's natural resources more efficiently. Systems will be based on objects working together, with the definition of connections using the idea of blockchain. And as the data overgrows, data management systems and applications will appear, allowing the user to select the most relevant data.

Invited Speakers

Invited Speakers

Dmytro Adamenko,
WAGO GmbH & Co. KG, Germany

Dominik Czerwinski
ALVO Medical Sp. z o.o., Poland

Slawomir Luscinski, Ph.D.,
Kielce University of Technology, Poland;
Centre for Research and Innovation CENWIS, Poland

Milan Edl, Ph.D.,
University of West Bohemia, Czech Republic;
Research and Innovation Strategies for Smart Specialization, Czech Republic

Abstracts
Part I
Smart Manufacturing

Sensor Selection for Smart Retrofitting of Existing Plants

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The chemical, process, and energy generation industries are essential production industries worldwide. However, these traditionally powerful industrial sectors have been under ever-increasing cost pressure in recent years, so the companies are continuously trying to improve wage- and energy-intensive products as well as services through the use of digitalization of production processes, e.g., to use operational data to optimize processes by tailoring them to customer needs and, at the same time, cutting operation and production costs. The machines and equipment in these industries are typically operated for several decades and cannot be directly integrated into the newly developed digitized processes. One of the possibilities to perform a so-called smartification of the machines and equipment is to retrofit them with sensors and data processing hardware. The present paper presents a methodology for the systematic selection of sensors for retrofitting existing and operating plants. For this purpose, the requirements for the selection process have been established. The advantages and disadvantages of existing methods for sensor selection are presented and analyzed. Subsequently, a new methodology for sensor selection is presented and successfully validated in the retrofit process of an existing and still operating for 20 years 900 kW wind turbine.

Keywords: Sensors, Plant Retrofit, Predictive Maintenance, Digitalization, Industrial Growth.

DOI: https://doi.org/10.1007/978-3-031-32767-4_1

Machine Vision Systems for Collaborative Assembly Applications

Vladyslav Andrusyshyn[1,2][0000-0001-7223-6520], Vitalii Ivanov[1,2][0000-0003-0595-2660], Ján Pitel'[1][0000-0003-1942-0438], Kamil Zidek[1][0000-0003-0176-7433] and Peter Lazorik[1][0000-0002-6837-1508]

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The collaboration of robots with workers in production is one of the most discussed topics within the framework of the Industry 4.0 concept. Collaborative production cells have increased flexibility and adaptability to production conditions because of combining the advantages of a human and a robot and expand the list of tasks that can be automated. However, the widespread adoption of collaborative robots in manufacturing is hampered by open questions about the safety of workers and ease of use. Machine vision systems allow collaborative robots to work more closely with the environment and endow them with basic cognitive functions. That is why this article is devoted to analyzing the use of machine vision systems in modern collaborative assembly cells. The authors analyzed scientific works in machine vision systems, described practical examples of their application, and catalogs of popular manufacturers to evaluate current propositions in machine vision systems. As a result, the main areas of application of machine vision systems were formed, their classification was presented, and recommendations for choosing an optimal machine vision system were proposed. In addition, the obtained recommendations were used in the practical case when analyzing the equipment of the collaborative assembly line of the SmartTechLab laboratory of the Faculty of Manufacturing Technologies of the Technical University in Kosice.

Keywords: Industry 4.0, Smart Assembly Line, Human-Robot Collaboration, Collaboration Safety, Visual Inspection System, Process Innovation, Sustainable Manufacturing.

DOI: https://doi.org/10.1007/978-3-031-32767-4_2

Digital Twins for Industrial Robotics: A Comparative Study

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The paper aims to compare NX Mechatronic Concept Designer (MCD) and Tecnomatix Process Simulate (TPS) and their suitability for simulating mechatronic machines in digital twinning. A Digital Twin (DT) is a virtual model that serves as a real-time digital counterpart of a physical object or process. Compared to a conventional simulation, it differs in its ability to model the behavior of the actual counterpart from many points of view and with much greater complexity. Digital Twins have a crucial role in the Fourth Industrial Revolution but are also used in different areas like meteorology, traffic simulation in smart cities, and civil engineering. Digital Twins in industrial engineering help maintain the optimal pace of assembly lines, flexibly adapt production, increase manufacturing process efficiency, and generate cost-effective products. Increasing usage of IoT solutions drives the Digital Twin market, which is growing exponentially. The paper discusses the two software packages' possibilities, advantages, and disadvantages and proposes the methodology and philosophy of making DT. The contribution of this work is to compare the possibilities of making mechatronic de-vices for educational and research purposes from scratch through to their final implementation.

Keywords: Digital Twin, Mechatronic Concept Designer, Process Simulate, Virtual Commissioning, Process Innovation.

DOI: https://doi.org/10.1007/978-3-031-32767-4_3

A CANVAS Based Assessment Model to Evaluate SMEs Readiness for Digital Business Models

Manuel Holzner[1], Erwin Rauch[1[0000-0002-2033-4265]], Guido Orzes[1[0000-0001-7740-3885]] and Dominik T. Matt[1,2[0000-0002-2365-7529]]

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This work focuses on developing and implementing an assessment model to evaluate the readiness of small and medium-sized enterprises for digital business models. By virtue of an underlying systematic literature re-view, a total of 90 publications regarding existing assessment models to evaluate the digital readiness of business models were examined. However, none of these publications presents a suitable and holistic assessment model. This work presents an assessment tool to close this gap in the scientific literature. The assessment model includes the evaluation based on two parameters the representatives need to evaluate: the current score and the need for action. The user is guided through 45 assessment criteria organized according to the business model CANVAS in 9 categories or blocks during the assessment. Besides the numerical representation of the assessment results, the model reveals a visual representation of the results and a list of business model aspects that should be prioritized in reorganizing the currently existing business model. The assessment tool has been tested and validated in an SME machine-producing company. Based on the positive result and feed-back, the tool is included in a web-based Industry 4.0 Toolbox to support SMEs and family business in introducing digital business models.

Keywords: Assessment, Digital Transformation, Business Model, Industry 4.0, SME, Sustainable Manufacturing.

DOI: https://doi.org/10.1007/978-3-031-32767-4_4

PLC Control of a 2-Axis Robotic Arm in a Virtual Simulation Environment

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The trend of automation can be observed in all areas of industrial production. Automation is an increasingly topical subject in today's continuous production process optimization era. The article aims to bring closer the field of computer-aided programming and simulation of the movement of the selected 2-axis robotic arm using PLC automation in a specific work environment. The article describes programming procedures for robotic arms used in industry, PLC automation technology programming, and simulation programs commonly used to verify the functionality of proposed robotic workplace solutions in practice. The article deals with the specific design of the PLC automatic control application in a selected Factory I/O simulation program controlling robotic arms and production equipment in a simulated workplace. The conclusion of the contribution is a reference to experimental validation of the application proposal by simulation and an assessment of its suitability for future use in practice.

Keywords: PLC Control, Virtual Simulation, Factory I/O, Robot Programming, Manufacturing Innovation.

DOI: https://doi.org/10.1007/978-3-031-32767-4_5

Evolution of Competence Management in Manufacturing Industries

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Manufacturing enterprises can identify organizational and human resource competence fields and individual competencies, which are documented. They mostly rely on technology management approaches to predict and supply future demanding competencies. Technology trends are examined and evaluated, and relevant competencies are derived. Others use data-driven trend analysis gaining benefits from internal and/or external data sources and expert opinions. However, a few manufacturing industries consider systematic selection and extensive use of competence-relevant sources and tools. Therefore, the planning and prognosis of future competencies re-main inaccurate and incomplete. Although data-driven approaches majorly contribute to this area, the correct selection of data sources, objective assessment of causalities, and, thus, correct interpretation of findings are mostly unresolved challenges. A structured analysis of competence sources is carried out to contribute to the body of knowledge in competence management and provide a practice-oriented solution. External and internal competence sources are identified and combined in a targeted manner to compensate for the weaknesses of state-of-the-art approaches. In this paper, the initial results of the framework model are presented. A systematic literature analysis is conducted to identify possible competence sources. Target competence sources are described, and an initial classification is provided. As the main result, the classification of competence sources is transferred into a decision-support framework model for identifying future competence sources of workers in manufacturing companies. The developed framework model enables manufacturing enterprises to plan additional competence sources and relate them to job profiles on the shop floor level.

Keywords: Competence Management, Competence Profiling, Competence-Sources, Future Competencies, Framework Model, Manufacturing Investment.

DOI: https://doi.org/10.1007/978-3-031-32767-4_6

Designing a Workplace in Virtual and Mixed Reality Using the Meta Quest VR Headset

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The research examined the possibility of using the Meta Quest VR headset and the advanced Passthrough Sky 1:1 Mode in virtual reality VR and mixed reality MR to design the workspace. The development of Passthrough Sky technology enables the implementation of MR in the industrial environment to an extent greater than has been possible before. The article focuses on the research gap in this field. A room setup workspace was created in the GUI of the Meta Quest device, defining laboratory and references to objects in the real world. Later a Guardian Boundary was created, approximating the walls of the room. Subsequently, outline walls, desks, and a door were defined. The Passthrough Sky 1:1 Mode was selected with the alignment of the Room setup. Interactions were made possible between the virtual and real world in the mixed reality of MR. As part of the laboratory design, equipment models were designed and put in place. These objects were used to check the ergonomics and collisions and to verify the overall impression of the workplace designed based on the intuition of an experienced worker. The aim of the research is considered to be accomplished. The workplace design in this work focused on the description of the technology. The Meta Quest technology and the ShapesXR application are suggested for designing a specific workplace in the selected production plant within the proposed future work.

Keywords: Virtual Reality, Augmented Reality, Mixed Reality, Extended Reality, Oculus Quest, Meta Quest, Passthrough Sky, Shapesxr, Workplace Design, Manufacturing Investment, Process Innovation.

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Digital and Information Technologies in Metrology 4.0

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Industry 4.0, on which many different studies have already been written, brings with it a completely different outlook, especially in IT. Cyber-physical systems, the Internet of Things, networks and cloud-based big data, artificial intelligence, and robotics are essential elements that have also found their way into Metrology 4.0, sometimes called Metrology of the Future. In the paper, measurement technologies for Metrology 4.0 were presented. They belong to coordinate measurement techniques in different scales: macro, micro, and meso. Optical scanning and computed tomography were discussed, focusing on achievable big data. From an IT point of view, the use of artificial intelligence was shown. The possibility of using augmented and virtual reality was also depicted with a short note on cybersecurity. Finally, some ideas regarding Metrology for the Future were briefly presented. It will probably be more oriented to man and use the planet's natural resources more efficiently. Systems will be based on objects working together, with the definition of connections using the idea of blockchain. And as the data overgrows, data management systems and applications will appear, allowing the user to select the most relevant data.

Keywords: Metrology, Dimensional Measurements, Artificial Intelligence, Augmented Reality, Scale, Sustainable Manufacturing.

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Part II
Information Management Systems

Quality Management at the Manufacturing Enterprise: Repair Processes Case Study

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Finding optimal mechanisms for effective management of production preparation processes is the focus when improving management systems. Emergency repairs accelerate the planning stages, and a significant part of the costs of the repair process is probabilistic. Therefore, to predict the occurrence of random factors in the repair process, a mathematical model is proposed based on forecasting the costs of the tool repair process and equipping and using a decision tree. The cost model includes fixed process costs, total salary costs, and machine tool depreciation; costs in the event of additional factors; probability of occurrence of factors. The tool repair costs for 6 months were taken as incoming data of the analyzed manufacturing enterprise. The predicted value of the costs for the tool and technological equipment repair process is equal to 60,219.94 UAH. Applying the proposed algorithm makes it possible to protect the repair management of the ma-chine-building enterprise from inefficient costs or investments under limited resources.

Keywords: Prediction, Repair, Process Innovation, Quality, Sustainable Manufacturing.

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Impact of Standardized Reusable Packaging on a Supply Chain Design and Environmental Efficiency

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Reusable packaging is more and more commonly used in business practice. Numerous researchers attempt to identify the correlation between the parameters of a supply chain based on the standard logistic units. This paper aims to analyze the carbon dioxide equivalent emissions of transport processes in a supply chain, considering various reusable packaging variants. The novelty of the approach is based on the use of environmental assessment when evaluating the efficiency of the modeled solution. Based on the conducted literature and exploratory research, it can be stated that the implementation of standardized reusable packaging affects the design of the supply chain and its parameters. The presented case study outlines the direct impact of changes on environmental efficiency within the sustainable supply chain based on the application of standardized logistics units. The proposed changes influence is focused on reducing the carbon footprint of the entire supply chain.

Keywords: Standardized Packaging, Sustainable Development, Environmental Performance, Sustainable Supply Chain.

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Agile Framework as a Key to Information Management Systems Delivery

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The article examines the nature of the agile framework, and explores the peculiarities of its management. Project oversight and controls are key for delivering expected project and service outcomes. Building consistency and learning from each other helps to improve every project. The objective of our research, based on the agile framework, is to provide a set of practices for project teams to deliver success and promote information management systems. It leads to reliable delivery based on project management competencies, agile working methods, scaled agile framework techniques, and project-based service provision. The proposed framework defines what work needs to be done and how it can be accomplished at the engagement. The framework is comprehensive, covering critical areas that impact solution delivery, including strategy, planning, mobilization, management, development, and operations which is essential to consider information management systems specific. The research is based on the following engagements: to promote consistency across engagements worldwide with a common language and standard approach; to support the industrialization approach with a disciplined process for delivering high-quality solutions across multiple lo-cations, multiple workforces, and multiple cultures; to enhance reliable, high quality and on-time delivery of engagements by providing a field-tested approach gleaned from current subject matter experts' experiences.

Keywords: Agile Framework, Delivery Management, Increasing Efficiency, Sustainable Manufacturing.

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Perspectives of Lean Management Using the Poka Yoke Method

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The paper provides a theoretical perspective on Lean management, which is very often mentioned in connection with manufacturing companies. In the article, we present and offer an overview of Lean management used in the industry. Through this paper, we want to present the potential and advantages of the Poka-Yoke method for continuous improvement and modernization of pre-established and often outdated procedures in production processes. As an example, we describe the lean methodology and its elements. In conclusion, we focus on one method: the Poka-Yoke. It has advantages and disadvantages, but this paper points to selected parameters and possibilities for implementing this method in production as quickly and efficiently as possible. In conclusion, the advantages of implementing this method are highlighted. The research shows it is obvious how it is possible to contribute to increasing product quality, reducing costs associated with repairs and complaints, increasing productivity, and reducing loss of time caused by errors. By implementing lean management, we can also contribute to increasing the safety of the production process and reducing the risk of equipment failures. The research shows how lean production tools and the Poka-Yoke method can effectively develop intelligent manufacturing enterprises.

Keywords: Lean Management, Poka-Yoke, Process Innovation, Sustainable Manufacturing.

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Agile in the Context of Manufacturing SMEs

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Flexible production management, as well as lean production, are the trend of our time. Small and medium-sized enterprises are under pressure from large enterprises since the latter has a well-established system and the resources to carry out experimental and pilot projects without harming the enterprise. Smaller enterprises are forced to respond flexibly to changes in the technology market and demand in cramped conditions. The study included an analysis of modern methods for assessing the effectiveness of Industry 4.0 technologies implementation and an analysis and comparison of the principle of lean production and Agile. Experts of a typical SME evaluated modern agile methods according to the selected methods, and the factors with the highest risk for the enterprise were also selected. During the study, the Agile and Lean methods were compared to select the appropriate method of assessing the attractiveness of Agile methodologies for MSP production management. Selected assessing methods could help introduce not only Agile or Lean components but other modern trends in management and manufacturing processes.

Keywords: Sustainable Manufacturing, Lean, Management, Industry 4.0, Industry 5.0, DEMATEL.

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Efficiency of the Production Process in the New Production Facility

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The paper's main objective is to optimize a specific product's production process in an unnamed company. We used PLM software Tecnomatix Plant Simulation from Siemens to optimize the production process. While solving the optimization, it was found that it could not be done in the cur-rent production hall, and it would be necessary to build a new production hall. For this reason, two simulations were created. The first simulation deals with the current production process of a particular product. The second simulation deals with the predictive production process in the new production hall. To better visualize the new plant's production process and appearance, the walls and production equipment are created in the 3D model and arranged according to the layout. As last, the results of both simulations will be compared. Based on the comparison, we will get approximate results by how much we will be able to optimize the production process in the new production hall.

Keywords: Simulation Effectiveness, Predictive Manufacturing, Lean Production, Sustainable Manufacturing.

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Implementation of Intelligent Transport Systems in an Urban Agglomeration: A Case Study

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The development of road transport requires cities to have a multi-faceted traffic management system. It is particularly true in city centers, where public transport modes (buses and trams) are also being added in addition to individual vehicles. The article is based on field research carried out, for which the case study was the city center of Szczecin. The article proposes a three-stage research methodology, consisting of an inventory of the current state of the selected infrastructure section, surveys of traffic density and travel time, and analysis of the data obtained (field research), which are the key to selecting locally appropriate ITS-class devices. The actions taken resulted in selecting ITS systems according to criteria such as improvement of traffic safety and fluidity, improvement of the overall traffic management and information system, and improvement in the functioning of public transport. As part of the work, many devices and systems were identified that can significantly improve the collective and individual mobility of the studied street section. These include intersection monitoring, accommodating signaling, a tram priority system, and passenger and parking information boards. This article aims to present the possibilities of implementing ITS systems in city centers, considering the specific individual road conditions and the need to improve vehicle flow management, using the example of a ready-made proposal for the city of Szczecin, using the minimum necessary equipment.

Keywords: ITS, Traffic Studies, Cities Mobility, Public Transport, Sustainable Transportation.

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Tracking of Trucks Using the GPS System for the Purpose of Logistics Analysis

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This article deals with and describes the issue of truck logistics analysis using GPS localization technology. Nowadays, it is still a progressive technology that works on the principle of data collection in real-time, so its results are up to date. The Mapon program is used for the evaluation and analysis of this issue. It analyzes selected monitored parameters such as route planning, fuel consumption, driver behavior, breaks, breakdowns, etc. Based on this program, it is possible to optimize parameters and preferentially reduce the costs associated with the transportation of cargo or avoid the movement of freight vehicles empty, which results in inefficient transport and underutilization of resources, and economic loss. Creating a report is the main task of this program, which will be described in the article. The article will discuss a GPS tracking system's other uses and benefits: operational planning, anti-theft, assistance services, and real-time truck location. Thanks to this option, the ability to guide the driver according to the requirements and also faster assistance in an emergency.

Keywords: Technology, Data, Vehicle, Reporting, Sustainable Transportation.

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Part III
Manufacturing Technology

Preliminary Study of Mass Material Removal for Aluminum Alloy by Low Pressure Abrasive Water Jet

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Nowadays, great demands are placed on the improvement of technological processes from the perspective of quality and also from the environmental point of view. Most of the recent studies of control depth machining are realized with pressures above 100 MPa. The presented article focuses on preliminary testing of control depth cut machining by abrasive water jet technology with low pressure 50 MPa and low abrasive mass flow. The study shows promising results for the high-strength aluminum alloy AW7075. Experiments were realized using 5 levels of traverse speed (from 100–500 mm.min^{-1}) and 4 levels of abrasives mass flow (20–50 g.min^{-1}). The maximal mass material removal observed was 0,12 g pre one pass, and the maximal depth observed was 843 µm, both with traverse speed 100 mm.min^{-1} but with different abrasive mass flow. According to the obtained results can be designed more complex experiments to determine possibilities of control depth machining using an abrasive water jet with 50 MPa pressure.

Keywords: AWJ Machining, Control Depth Machining, Traverse Speed, Abrasive Mass Flow, Groove, Sustainable Manufacturing.

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Analysis of Microcutting of VT8 Titanium Alloy and 12Cr2Ni4A Steel During Grinding with Cubic Boron Nitride

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The article is devoted to the analytical and experimental study of cutting with a single grain when grinding titanium alloy VT8 and carbon case-hardened steel 12Cr2Ni4A. Titanium has high strength, good corrosion resistance, and, at the same time, has a relatively small mass, which makes its use indispensable in areas where, along with their mass, good mechanical properties of products are essential. The machining of titanium is hampered by its very high chemical activity at elevated temperatures. A weld may form in the contact area. It changes the geometry of the cutting edge by the formed build-up. The object of the study is the unit cutting forces that occur during the grinding of titanium alloy and carbon case-hardened steel, as well as the associated values that affect the quality of the machined surface. The research used samples of titanium alloy VT8 and steel 12Cr2Ni4A. Grinding was carried out with cubic boron nitride (CBN) wheels. The results of this study will further allow the prediction of the parameters of the part processing mode to obtain the necessary indicators of the quality of the surface layer and the geometric dimensions of the part while increasing the productivity of the grinding wheel and minimizing energy costs. The study aims to establish the dependences of the change in unit cutting forces and the values emerging from them during the grinding of samples from VT8 and 12Cr2Ni4A.

Keywords: Cutting Forces, Titanium Alloys, Grain Cutting, Grain Size, Heat Flow, Hardened Steel, Temperature, Industrial Innovation.

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An Impact of the Cutting Fluid Supply on Contact Processes During Drilling

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The article discusses machining blind holes with twist drills, which is one of the most common machining operations. Typical problems for this process are difficulty to chip removal and coolant supply to the machining zone. Also, when chips are removed along the spiral grooves, they rub against the hole's surface, deform, and, as a result, the surface quality deteriorates. For a comprehensive assessment of the drilling process and the influence of various cutting fluids, it is necessary to control all parameters directly in the material removal process. The paper proposes a method for controlling contact loads and cutting temperature along the generatrix of the workpiece when using various compositions of cutting fluids and assessing their effect on the roughness of the resulting surface. The influence of the supply method of the studied cutting fluids is also shown. So the supply of liquids to the cutting zone through the internal channels of the tool contributes to a significant decrease in the cutting temperature and, by reducing the friction coefficient, helps to reduce the surface roughness compared to the most used method of supply-irrigation.

Keywords: Process Innovation, Drilling, Contact Pressures, Cutting Temperatures, Surface Roughness, Cutting Fluids.

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Modeling and Surface Modification of AISI 321 Stainless Steel by Nanosecond Laser Radiation

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Increasing the hydrophobicity of technological surfaces in terms of sustained economic growth is a priority for developing mechanical engineering quality, including green energy. The use of methods of laser action on the surfaces of metals makes it possible to increase the efficiency of such surfaces, providing the conditions for reducing the coefficient of friction and the hydrodynamic resistance during the flow of processing fluid to modernize hydraulic turbines and other things effectively. The paper considers is-sues related to forming the AISI 321 steel surface structure after exposure to nanosecond laser radiation. It describes the main features of the energy impact on the sample to obtain a hydrophilic and superhydrophobic surface. Based on the proposed methodology, an experimental study was carried out, and definitions were made of the primary indicators that determine the efficiency of the energy impact on the working environment and the formation of sandwich structures. A reasonable estimation of the laser radiation efficiency is given while forming the sample's surface structure. It allows correcting rational modes for creating a surface with desired properties to provide the highest hydrophobicity and hydrophilicity. A new mechanism for the formation of surface superhydrophobicity is proposed and discussed. The practical value of the study is in the study of ways to improve the efficiency of surfaces by possibly intensifying their hydrophilic and superhydrophobic characteristics after energy exposure to a nanosecond laser.

Keywords: Nanolaser, LIPSS, AFM, Electrostatic Effect, Hydrophobicity, Energy Efficiency, Industrial Growth.

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Improvement of the Quality of Wear Zones for Cutting Tools Textures Classes Recognition based on Convolutional Models

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For modern metalworking machine tool systems, which operate with limited operator participation, there is a need to develop methods for automatic control and recognition of the states of cutting tools. It provides the possibility of predicting their residual resource and timely replacement. In recognizing the cutting tools (CT) states, data mining methods are increasingly used: decision trees, genetic algorithms, fuzzy logic, and neural networks. Therefore, the task of improving the quality of CT wear zones textures classes' recognition (based on convolutional models' application) is relevant. The article aims to create a new fuzzy neural net classifier to improve the quality of cutting tool wear zones recognition texture classes. The scientific novelty consists in creating convolutional models and a new fuzzy neural net classifier of CT wear zone textures – for recognizing wear mechanisms on the flanks of cutters in finishing turning conditions. Practical usefulness consists in improving the quality of textures classes of CT wear zones recognition to the level of almost 100%. An example of a corrective influence on the turning process is a change in the feed rate S – in the case of concentrated wear traces recognition on the near-vertex section of the cutter's flank surface.

Keywords: Finishing Turning Conditions, CT States Classifier, Convolutional Model, Industrial Growth, Manufacturing Innovation.

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Conductivity Measurement Verification of Additively Manufactured and Bulk Metals

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Eddy current testing method has the predisposition to be a sufficient tool for the evaluation of surface and subsurface layers in additively manufactured metal components. Electrical conductivity is the most significant material parameter influencing the penetration depth of eddy currents. Its value is missing in AM powder materials data sheets and differs from conventional ones. The described experiment checks the eddy current testing device's ability for material conductivity measurement. The main purpose is to compare measured conductivity in AM stainless steel material with measured conductivity within recent research on the same material and check measurement deviation on various materials. The eddy current testing de-vice's ability to distinguish various materials was checked during the preliminary experiment. During the main experiment, a device was calibrated for conductivity measurement, and various materials were inspected using its special conductivity regime. Parameters important for deviation expression were calculated and analyzed. Some similarities and differences were found with other research in the field. Based on the derived conclusions, the method used can determine conductivity. Higher deviations were obtained in the case of high-conductivity materials. However, exceptions can be special alloys. Furthermore, the calculation of standard penetration depth seems essential for verifying the influence of deviation, which also concerns the mentioned comparison of AM stainless steel conductivity measurements.

Keywords: Eddy Current Testing, Conductivity, Selective Laser Melting, Standard Penetration Depth, Manufacturing Innovation.

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Substantiation of Chip Removal Models During Milling of Closed Grooves

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The timely chip evacuation from the cutting zone is of the utmost importance due to the possibility of repeated chip cutting, which is actually abrasive. The authors proposed three main schemes for forced chip removal from closed T-shaped slots: due to the forced removal of chips from the space between the teeth of the cutter (supply of a lubricating-cooling technological medium through the channels in the tool body); due to the forced removal of chips from the space outside the cutting tool (cooling agent supply through the channels of the external nozzle); a combination of the two previous methods. The theoretical foundations of the proposed chip removal devices have been developed to determine the rational parameters of their functioning based on five mathematical models. Confirmation of the reliability of the developed theoretical provisions and the adequacy of the created mathematical models requires appropriate experimental studies. When conducting experimental studies, mechanical processing of T-shaped grooves 12 in steel and cast-iron blanks was performed. For this, milling cutters with a diameter of 21mm were used for processing cast iron and with a diameter of 21mm for processing steel 45. Verifying the hypothesis about the adequacy of the developed mathematical models is carried out using the Fisher F-criterion. The simulation error is estimated by calculating the absolute and relative errors of the mismatch between the theoretical curve and the curve approximating the experimentally obtained data.

Keywords: T-Shaped, Tool Body, Teeth, Mathematical, Adequacy, Fisher, Sustainable Manufacturing.

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Surface Roughness Assessment after Milling of Pure and Carbon Black Reinforced Polypropylene Materials

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Polypropylene (PP) material and its composites are preferred for many applications due to their advanced properties. Although PP material products are produced in a near-net shape, milling, which is a secondary machining process, is required to obtain dimensional tolerances, appropriate geometric shapes, and quality surfaces. For this reason, the chip removal process gains importance so that PP can be used in structural parts and assembled with different parts. In this study, milling of pure polypropylene (Pure PP) and carbon black reinforced polypropylene (CB-PP) composite investigated the effect of cutting speed (70, 100, and 130 m/min) and feed (0.4, 0.5, and 0.6 mm/rev) on the average surface roughness (Ra), chip morphology, and exit burr formation. In addition, the Ra value was predicted by mathematical modeling of the Ra. A relationship was established between the Ra and cutting parameters such as cutting speed, feed, and radial depth of cut. The experimental results showed that the Ra value decreased as the cutting speed increased and the exit burr area increased. Also, as the feed increased, the Ra value and the exit burr size increased. It was seen that the deviation of mathematical modeling from experimental results was 11% on average, and it was usable. It was observed that CB-PP gave better Ra than pure PP under the same cutting parameters.

Keywords: Sustainable Manufacturing, Process Innovation, Milling, Carbon Black, Polypropylene, Surface Roughness, Burr Formation.

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Improvement of a Two-stage Drive for Multioperational Milling Machine

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The issues of creating drive mechanisms for drilling-milling-boring machine tools with a vertical spindle axis of rotation are considered. 3D modeling of the spindle assembly structures with a power bevel gear and the rotary table with a power worm gear, as the main forming elements in processing housing parts, has been carried out. The toolkit of the integrated computer-aided design system and specialized 3D operations in the express mode of multivariate modeling were used. A new approach is proposed to improve the kinematic parameters of the shaping unit drive devices for the machine tool in a two-criteria formulation. A variant of partitioning the gear ratio of a two-stage worm-bevel drive into stages from the condition of their equal strength is considered, under which favorable conditions for lubricating the wheels of both stages are simultaneously realized. An analytical form is presented for determining the energy parameters at various drive stages on the base. The main indicator of the performance of worm and bevel gears, respectively, is the contact endurance of the wheel's teeth of these gears, provided that the contact stresses are equal. A numerical analysis was carried out for several combinations of worm wheel materials and bevel wheel tooth hardness.

Keywords: 3D Modeling, Stage, Gear Ratio, Uniform Strength, Product Innovation, Manufacturing Investment.

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Information Technologies of the Analysis for Models to Ensure Quality Characteristics of the Working Surfaces During Mechanical Processing

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In this work, information technology was developed to analyze and synthesize models to ensure the quality characteristics of the working surfaces of products during mechanical processing. For this, the problem of thermoelasticity for bodies weakened by inhomogeneities is solved. The work aims to create information technologies about the state of the working surfaces of products during their mechanical processing. It considers the in-fluence of inhomogeneities in the materials of structural elements on their functional gradient properties to ensure high efficiency in designing the ap-propriate type of technological systems. Mathematical models of the dynamics for thermomechanical processes accompanying the mechanical processing of products from materials of the heterogeneous structure were im-proved. A spatially non-stationary formulation of the problem was used based on systems of differential equations of thermoelasticity in partial derivatives and discontinuity conditions on defects of the elastic-deformation characteristics of the processed material. This allows for improving the accuracy of the identification of mathematical models generally. The developed mathematical models of the system for evaluating the effectiveness of the functioning of technological complexes of mechanical processing make it possible to determine the relationship between the parameters of the state of the processed surfaces and the main controlling technological characteristics that provide the necessary properties of functionally gradient materials.

Keywords: Structural, Integral, Thermal, Problem Crack, Layer, Surface, Defects, Stress State, Process Innovation.

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CAD, Laser Powder Bed Fusion Fabrication and Post-Processing of Customized Metal Dental Products

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Laser-based additive manufacturing has a significant impact on the dental industry. Metal 3D printing and post-processing of customized dental products are very relevant due to the growing demand of patients for fast and high-quality treatment. This work is focused on a CAD design and laser powder bed fusion (L-PBF) fabrication of a prosthetic bridge according to the patient's data. Metal-ceramic crowns are often used to place the prosthetic bridge. Using the high-purity cobalt chromium metal powder, an industrial laser printer was applied to fabricate the specimens and dental prosthetic components. The L-PBF-manufactured dental components were post-processed by thermomechanical technique to provide the material properties and surface integrity. Results indicate that the post-processing induced the porosity reduction in the subsurface layer and a new surface texture formation. The thermomechanical technique improved the surface roughness parameters. Applying mechanical surface treatment resulted in completely removing defects on the heat-treated surface.

Keywords: 3D Printing, Selective Laser Melting Technology, Cobalt-Chromium Powder, Prosthetic Bridge, Post-Processing, Sustainable Manufacturing, Manufacturing Investment.

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Just in Time Gear Grinding Wheel Dressing

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Due to the high cost of modern high-performance grinding wheels, it is necessary to use them rationally, i.e., with the minimum required number of dressings. It implies optimal gear grinding wheel dressing cycles. The method proposed in the paper makes it possible to establish a connection between the grinding wheel dressing interval and the number of active working strokes during which this gear grinding wheel performed useful work to remove the grinding stock allowance (the paper's novelty). Work strokes during which the grinding wheel performs "air grinding" should not be counted as active (useful) ones. It is proposed to identify such "idle strokes" based on information about the actual location of the gear grinding stock allowance on the left and right sides of each gear tooth gap. The gear grinding stock allowance actual location is defined by the Renishaw contact probe or by acoustic emission method in advance of gear grinding. So, the dressing interval has to depend on the actual load on the gear grinding wheel. This load will depend on the number of active working strokes. In turn, the latter depends on the actual gear stock allowance location before gear grinding. The number of "idle strokes" need not be considered when determining the grinding wheel dressing interval. It allows for reducing the number of dressings (about 10-30%) of the expensive gear grinding wheel at the gear grinding rough stage, thereby increasing the grinding wheel life (up to its complete wear).

Keywords: Stock Allowance, Adaptive Dressing, Dressing Interval, Wheel Load Factor, Grinding Strokes, Effective Strokes, Idle Strokes, Process Innovation.

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Generalized Method for Rational Selection of Parameters for Interference Fits Using Computer-Aided Joint Design Systems

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The next stage of modernization of the generalized method proposed by the authors for selecting rational parameters of interference fits based on mathematical modeling using computer-aided design software is completed in work. Numerical calculations of the desired values of the parameters and analysis of their mutual influence on the qualitative selection of joints with an interference fit on a smooth surface are performed using this method. The developed multiparametric complex of mathematical models of suitable standard interference fits is described in detail in the authors' previous publications. The object of this research is a set of spatial images, which are geometric objects of the specified complex in three-dimensional space. The paper formulates practical recommendations for the effective selection and adoption of rational values for the parameters of the designed fits. At the same time, the geometric images of the studied models are analytically described using the mathematical apparatus of the theory of R-functions based on the author's computer programs. The numerical-analytical results obtained in this work can be used in the automated design of interference fits.

Keywords: Mathematical Modeling, Heating Temperature, Contact Pressure, Secant Plane, Product Innovation.

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Surface Relief Formation in Peripheral End Milling

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Theoretical studies of peripheral milling and the results of simulating the construction of a 3D relief of the machined surface have been presented. A digital model of the surface relief formation during peripheral milling with an end mill has been developed. The related simulating algorithm has been created. The milling process model is compiled taking into account the dynamic phenomena occurring in a closed technological machining system (TMS) and machining along the trace, represented by a function of a de-lay argument. The dynamic system is represented by a single-mass model with two degrees of freedom. The created application program for simulating peripheral milling with an end mill makes it possible to predict the power parameters of the cutting process and the geometric and machining parameters, depending on the geometric parameters of the cutter and workpiece, cutting mode, and dynamic characteristics of TMS. A 3D relief of the ma-chined surface has been constructed. Its geometric component consists of the shape of micro-roughness, formed from the geometric engagement of the cutting edge of the helical mill with the workpiece and the elastic movement of the TMS. Simultaneously, it corresponds to the interaction of the next cutter tooth along the helix. The created application program makes it possible to predict the microrelief of the machined surface depending on the main TMS parameters.

Keywords: End Milling, Simulation Machining, Machined Surface Relief, Process Innovation.

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Improvement of the Automatic Workpiece Clamping Mechanism of Lathes to Expand Technological Capabilities

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The force characteristics of actuators of automatic clamping mechanisms determine the forces of clamping workpieces in the spindle assemblies of lathes. It determines the opportunities for clamping the workpieces with a wide range of material characteristics and construction rigidity. The conducted work aims to develop a new method of measurement of the force characteristics of the drive of automatic clamping mechanisms. The measurement issue is solved by implementing the contactless method, which meets the requirements for ensuring the efficient operation of a high-speed spindle assembly. The developed structure provides new opportunities for creating a control system with better possibilities for interactive estimation of the clamping forces. The use of the developed design helps to increase the quality of clamping and, consequently, the productivity of machining workpieces with an expanded range of characteristics. The proposed design of the clamp drive does not contain radially movable parts and implements a contactless power supply. It is proposed to control the clamping mechanism by non-contact measurement of the torque at the input link of the mechanical drive in the range of 0–50 N·m.

Keywords: Clamping Forces, Clamp Drive, Spindle, Contactless Measurement, Product Innovation.

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An impact of Solid lubrication on the Diamond Grinding Characteristics of Difficult-to-Machine Materials

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The article focuses on the study of the influence of solid lubrication on the characteristic of the process of final diamond grinding (DG) and diamond spark grinding (DSG) of difficult-to-machine materials – hard alloy VK6, titanium alloy VT22, and heat-resistant stainless steel 10Cr11Ni23Ti3MoB. The evaluation was carried out based on the surface roughness parameter Ra and the post-contact temperature T_{pc}. A comparative analysis was performed for DG and DSG processes using an SL and un-der dry conditions. It has been established that the use of a solid lubricant (SL) based on stearic acid (65%) and molybdenum disulfide (35%) reduces the post-contact temperature by 1.4...2.1 times and the roughness by 1.3...1.6 times with diamond grinding of VT22 alloy and steel 10Cr11Ni23Ti3MoB. SL has a varying effect on the grinding performance of VK6, depending on the parameters of the processing mode. In DSG, the nature of the influence of SL on Ra and T_{pc} doesn't change, but their absolute values increase by 1.1…1.5 times. The best results with solid lubrication were achieved on the surface of stainless steel 10Cr11Ni23Ti3MoB – Ra = 0.22…0.39 μm and Ra = 0.38…0.49 μm with DG and DSG, respectively. The results indicated that solid lubrication with a new type of composition has a noticeable positive influence on the surface roughness of difficult-to-machine materials during diamond grinding and diamond spark grinding at the final stage.

Keywords: Process Innovation, Solid Lubricant, Diamond Grinding, Diamond Spark Grinding, Roughness, Difficult-to-Machine Materials, Post-Contact Temperature.

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The Stress-Deformed State of the Cylinder Liner's Working Surface

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Studies of changes in the stress-deformed state of its working sur-face were carried out to improve the surface layer quality and the operational properties of the internal combustion engine's cylinder liners. A technique for modeling the operation of the "liner–ring" conjugation using the finite element method is proposed. A calculation scheme has been developed that considers the liner's main design features and the conditions for its loading by contact loads from the rings and gas pressure. The selected calculation scheme of the part and the boundary conditions of the connection operation made it possible to simulate and calculate the stress-deformed state of the surface layer of the liner's working surface. The research results are obtained through graphs and stress diagrams of the surface layer of the cast-iron liner working surface along the entire contact zone with piston rings. The presence of stress concentration at the boundaries of the liner contact area with the ring has been established. It was proved that there is a peak of compressive stresses in front of the ring in the contact zone and tensile stresses be-hind the ring. Applying antifriction coatings to the working surface of the part was proposed to reduce the negative effect of tensile stresses. The obtained research results can be used to improve the technology of processing cylinder liners during their manufacture and restoration to improve the product's operational properties.

Keywords: Cylinder Liner, Stress-Deformed State, Simulation, Finite Element Method, Calculation Scheme, Stress Concentration, Industrial Growth.

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Turning of NC10 Threads for Drill Pipes: Theoretical Study of the Designed Profile

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Drilling wells to produce drinking water and hydrocarbon raw materials requires more efficient means and methods. Couplings and nipples of drilling connections are made by turning. This process depends on the geometrical parameters of the turning tools. Almost all modern manufacturers of cutters use tools with an inclination angle of the cutting edge to ensure the stability of the cutter. The value of this angle is equal to the helical lead angle and therefore depends on the pitch and diameter of the thread. For small-sized drill connections, the helical lead angle can exceed 3.5°, which leads to a change in the thread profile since the threaded screw becomes in shape not the usual Archimedean screw but a convoluted helicoid. So, from this point of view, the study of the accuracy of the thread profile is theoretically justified because it is based on a correct calculation. The smallest NC10 drill pipes connector is chosen for this work because its helical angle reaches 3.75°. The application of the calculation algorithm developed by the authors showed that the deviation from the nominal half-profile angle of 30° ±0.75° reaches 0.24°, which is 30% of the tolerance and indicates the importance of taking into account this technological component of the turning process to ensure the accuracy of the NC10 drill bit.

Keywords: Pin, Box, Threading Profile, Drilling Tool-Joint, Convolute Screw, Cutting Edge, Product Innovation.

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Part IV
Engineering Education

Dual Educational System of Professional Training of Future Skilled Workers

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The article reveals the main ways of designing professional training for future skilled workers in dual education. This form is a methodological characteristic of vocational education; it involves the coordinated interaction of the educational and industrial spheres of training qualified personnel with a certain profile within the framework of different organizational forms of education. The main objectives of introducing elements of the dual form of training are to eliminate the main shortcomings of traditional forms and methods of training future skilled workers, to bridge the gap between theory and practice, education and production, and to improve the quality training qualified personnel, taking into account the requirements of employers with-in framework new organizational-different forms of training. Justified structural components of the dual form of education are revealed: organization of cooperation between politicians, business, and social partners; development of a legislative framework for the recognition of national standards for the quality of vocational education; in-service training for students; involvement of qualified production personnel in pedagogical activity (instructors, teachers); implementation of institutional research and consulting (monitoring the quality of the provision of educational services in the field of vocational education, updating educational standards).

Keywords: Dual Education, Employer, Technology, Training, Sustainable Development Education, Methods, Educational Policies.

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A Digital Twin for Remote Learning: A Case Study

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In recent years, industrial production has gone through intensive processes of increasing productivity and quality. However, the previous optimization approaches have already exhausted their potential and possibilities for further improving production, and the 4th industrial revolution has arrived. Digitalization plays the most critical role in the optimization of production today. One of the essential technologies for digitizing production is the digital twin technology. A digital twin is an exact virtual model of a product or production line. It consists of several elements, such as manufacturing simulations, 3D CAD models, and real-time data feeds from sensors embedded in the physical operating environment. The article presents the concept of a digital twin at the Faculty of Manufacturing Technologies of the Technical University of Košice. It describes 3 phases of model creation: CAD software, Unreal Engine, and real-time 3D software (Twinmotion). The research presents a systematic approach to solving the problem of creating a digital twin for education purposes. A prototyped digital twin of the faculty building and facilities can be used for educational and presentation purposes regarding remote learning, enabling students and educators to move around the building remotely. The digital twin, created by using multimedia and immersive technologies, will expand opportunities and increase learning efficiency in various ways, but it will also provide the basis for industrial production to increase productivity and quality.

Keywords: Digital Twin, Remote Learning, Computer Modelling, Sustainable Manufacturing.

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A Model of Formation of Professional and Creative Competences for Engineers Based on Information and Digital Technologies

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The article aims to design a model for forming professional and creative competencies of agricultural engineers based on information and digital technologies. Modern methodological approaches and theoretical and empirical methods (a generalization of scientific literature, observation, modeling, testing, pedagogical experiment, statistical analysis, and reference comparison) are used in this scientific paper. The model for forming a prospective agricultural engineer's professional and creative competencies is proposed. The component structure of an agricultural engineer's professional and creative competencies in their professional preparation is analyzed. The didactic means of information and digital technologies and the components of the educational SMART environment in the professional training of an agricultural engineer are studied. The technological stages of managing the process of forming an agricultural engineer's professional and creative competencies in a digital educational space are substantiated. The model's effectiveness for forming professional and creative competencies of a prospective agricultural engineer utilizing information and digital technologies is proved compared to the traditional education system.

Keywords: Agricultural Engineers, Professional Competencies, Creative Competencies, Model, Information Digital Technologies, SMART-Environment, Educational Policies, Sustainable Development Education.

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Entrepreneurial Mindset Development in Engineering Students through a Business Canvas Approach

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Nowadays, engineering education focuses on developing students' entrepreneurial mindset alongside analytical, design thinking, and creativity, which are the base for socially valuable innovations. Introducing a customer-centric approach to engineering learning projects allowed engineering students to realize the latest business trends, the users of their technical solutions, and the needs of customers to whom their ideas were oriented. Such a context requires the search for new methods and practices to develop engineering students' entrepreneurial mindset. The current research aimed to substantiate the effective entrepreneurship teaching method that could be embedded in an engineering course and foster the development of engineering students' entrepreneurial competence. As a result, an experimental method, which combined the typical 7 steps Engineering Design Process and Business Model Canvas approach, was proposed. The developed assessment instrument was used to monitor any changes in the student's entrepreneurial competence. The method application positively affected such aspects as engineering students' analytical skills, design thinking and decision-making, business-oriented thinking, communication, and leadership.

Keywords: Educational Policies, Engineering Education, Entrepreneurial Competence, Entrepreneurial Intention, Project Learning, Design Process, Business Modeling.

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Part V
Design Engineering

Transient Processes Quality Indicators of the Rotation Lever Hydraulic Drive for the Dust-Cart Manipulator

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The paper defines the analytical dependences of the transient processes quality indicators of the rotation lever hydraulic drive of the dust-cart manipulator. This is necessary to determine the drive parameters, which makes it possible to improve the quality of the transient processes to increase the service life of the dust-cart on the whole. Among the primary quality indicators of the transient processes, the following indices were considered: relative overregulation, amount of overregulation, and duration of the regulation. The value of the power fluid pressure in the hydraulic drive of the dust-cart manipulator rotation lever was considered as the transient function. The pipeline's volume on the section hydraulic pump–rod cavity of the hydro-cylinder was determined as 1.7·10–3 m^3. It provides the acceptable quality of transient processes with the following values of the quality indicators: relative overregulation of 30%, amount of overregulation – 1, and duration of regulation – 72.5 ms. Response surfaces of indices and quality domain of the transient processes of the rotation lever drive of the dust-cart manipulator were constructed in the plane of the basic impact parameters: area of the rod cavity of the hydraulic cylinder, the volume of the pipelines between the hydraulic pump and rod cavity of the hydraulic cylinder. It is suggested to supplement the corresponding technique of the design calculation with the obtained analytical dependences of the indices and quality domain of the transient processes of the hydraulic drive of the rotation lever of the dust-cart manipulator.

Keywords: Quality Indicators, Transient Processes, Quality Domain, Hydraulic Drive, Dust-Cart Manipulator, Municipal Waste, Industrial Growth, Process Innovation.

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Vibration Damping of Lifting Mechanisms for Elevators Using Control Systems

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The possibility of increasing lifting mechanisms' productivity through damping elastic mechanical vibrations that negatively affect the control quality, increase the dynamic winch loads, contribute to the accumulation of fatigue stresses in kinematic circuits, lead to the equipment premature failures and unplanned downtime, as well as an increase in the cost of repairs and operation, is considered. Previous studies demonstrated that establishing mechanical characteristics with the required stiffness decreases the passenger elevators' lifting mechanism's vibrations. However, due to the mass ratio, small values such as stiffness formed do not eliminate the vibrations. Recommendations are proposed to improve the winches' dynamic modes quality at the expense of damping the passenger elevators' lifting mechanisms vibrations. A generalized block diagram of an elevator system with corrective feedback is given, and the damping coefficient's maximum possible value and an expression for optimal feedback coefficient value are found. The dependence obtained using a physical model and confirming the derived mathematical regularity is shown. The elevator lifting mechanism start-up oscillograms are given, where significant fluctuations of values in two sections of the mechanical characteristic are registered in the dynamic mode. The oscillograms of the elevator lifting mechanism start with corrective feedback in the control system are also considered, illustrating the significant damping of vertical vibrations. It is found that the damping coefficients' values can reach and even exceed one, which corresponds to the elevator lifting mechanisms' aperiodicity.

Keywords: Lifting Mechanism, Optimal Control, Vibration Damping, Mechanical Stiffness, Corrective Feedback, Mass Ratio, Process Innovation.

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Comparative Analysis of Design Methods for Pneumatic Control Systems

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In many technological processes, improving the reliability of technical systems is now a topical issue. The design of pneumatic control systems is based on three main approaches: elemental, aggregate, and mixed. But the choice of approach to control system design is determined by many factors, e.g., the structure's complexity, the scheme's speed, etc. Since minimization is important for constructing a rational pneumatic control system, a comparative analysis of pneumatic control system design methods was carried out in this paper: the design method using a standard positional structure and the design method using the minimization of a system of logical equations. A comparative analysis of the two methods has been carried out using the specific example of designing a control system rotary feeder for panels. Still, their application is not limited to a specific pneumatic drive control system. It can be used in the design of new pneumatic drive systems as well as the modernization of existing systems. The analysis of the con-structed schemes of the pneumatic control system allows estimating ad-vantages of application of the method of minimization of systems of logical equations at a design stage, namely: minimum, in comparison with the standard positional structure, quantity of elements of the pneumatic scheme that positively influences the reliability of operation of the scheme, reduce expenses at project realization, raises the speed of operation of the system, and also facilitates installation, adjustment and system operation.

Keywords: Position Structure, Minimisation, Logical Equations, Correspondence Matrix, Discrete Distributor, Energy Efficiency.

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Runner Control System of Kaplan Turbine

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The paper analyzes the existing control systems for hydraulic turbines and provides frequency control schemes from leading hydroturbine equipment manufacturers. The design features of the construction of circuits with discrete and discrete-analog control methods with an embedded computer system for controlling the speed of a hydraulic turbine, which guarantees trouble-free operation in case of load deviations and power failures, are considered. A fully automatic method for controlling a hydraulic unit is proposed, in which the computer system independently controls the turbine based on the parameters of the operation of the hydraulic unit recorded by devices by the computer control program. The analysis of the operation of the schemes is carried out, taking into account the specifics of the functioning of the control system. A nonlinear mathematical model of the hydromechanical part of the regulator is considered to assess the quality indicators of transient processes occurring during a hydraulic turbine's start-up, shutdown, and reverse operation modes. Using this mathematical model and control algorithms improves the positioning accuracy and reliability of hydropneumatic systems with the possible simplification of circuit solutions is an effective solution to control problems. A gradual study of the dynamics of the runner hydraulic drive was carried out. The obtained results prove that using a positional hydropneumatic drive to build a system for controlling the speed of a hydraulic turbine with discrete and discrete-analog control makes it possible to synthesize a hydropneumatic drive with high positioning accuracy.

Keywords: Energy Efficiency, Control System, Runner, Kaplan Hydro Turbine, Regulator, Mathematical Model, Positional Hydro Pneumatic Drive, Synthesis.

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Dynamic Behavior of Vibratory Screening Conveyor Equipped with Crank-Type Exciter

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The paper is focused on the computer simulation and experimental testing of the improved vibratory screening conveyor equipped with the controllable crank-type exciter characterized by the changeable forced frequency and eccentricity. The main scientific novelty of this research is implementing the three-mass discrete-continuous oscillatory system, whose disturbing body is designed in the form of a flat spring characterized by both inertial and stiffness parameters. The proposed excitation method and the novel spring system design can be effectively used while developing new vibratory technological equipment in various industries, e.g., chemical, mining, pharmaceutical, agricultural, etc. The 3D-model of the vibratory screening conveyor is designed in the SolidWorks software; the strength analysis of the conveyor's springs is performed using the finite-element method integrated into the SolidWorks Simulation application; the control system of the experimental prototype is developed using Arduino software and hardware; the experimental data is processed with the help of the Serial Port Plotter soft-ware. The main results of the theoretical research present the specific geo-metrical parameters of the conveyor's flat springs ensuring its operation under energy-efficient near-resonance conditions and time dependencies. The results of experimental investigations allow for determining the dynamic response of the conveyor's oscillatory system at different forced frequencies, which correspond to the eigenfrequencies of the disturbing spring and the intermediate springs. The obtained results allow for substantiating the optimal operating conditions of the vibratory screening conveyor.

Keywords: Sieving, Conveying, Vibration Exciter, Flat Spring, Inertial Parameters, Stiffness Parameters, Three-mass Oscillatory System, Near-resonance Operation Regime, Power Consumption, Vibration Amplitude, Process Innovation.

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A Curvilinear Blades Profile of Accelerating Devices

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With the help of the variation method based on the Euler-Lagrange equation have been determined the shapes of the guiding blades of centrifugal accelerating devices in which solids move between two specified points of the centrifugal field within minimal time limits. Detailed mathematical conversions have been done while solving the initial differential equation. Three forms of final brachistochrone equations have been received. The properties of this curve have been determined depending on the constant in the Euler-Lagrange condition. The conditions for real solutions and the integration constants have also been considered. Brachistochrone curves corresponding to three ranges of constant values requiring a minimum of initial integral while determining the minimum time for the body moving from one point of the centrifugal field to another have been constructed. The curves have been constructed both in absolute and relative coordinates. Simplified brachistochrone equations for the most abundant case in practice when the initial relative velocity of a moving particle can be neglected have been obtained. The parameter boundaries of the investigated curves under which their curvature can cause considerable frictional forces and even jamming of the material in the guiding blades have been determined. In this regard, the conclusion has been made that the blade shape should be as close to the rectilinear as possible for the acceleration of solid particles. The curvilinear blade profile can be justified in case of liquid or gaseous material acceleration.

Keywords: Product Innovation, Centrifugal Field, Brachistochrone, Differential Equation, Legendre Condition.

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Mechatronic Hydraulic System with Adaptive Regulator for a Manipulator of the Mobile Working Machine

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The paper presents a mechatronic hydraulic system with an adaptive regulator designed for a manipulator drive of mobile working machines. Manipulator has the following basic characteristics: a carrying capacity of up to 500 kg, a maximum boom length of 2.5 m, a lifting height of up to 2.8 m, a pump capacity of 16 kW, and rated pressure in the hydraulic system of 16 MPa. The mechatronic hydraulic system is built on a controlled pump, proportional hydraulic valves with electrohydraulic control, and a controller. The controller acts as an adaptive regulator and allows adjusting the feed-back signal of the hydraulic system when changing its operating modes to improve its dynamic characteristics. A nonlinear model of the hydraulic system has been developed. Simulation studies of dynamic processes have been conducted. The possibility of reducing overregulation and oscillation in the hydraulic system has been found. An increase in operating speed has also been considered by introducing the corrective component of the feedback signal and its delay. A fuzzy inference system has been applied to model the dependence of the coefficient of the corrective component of the feedback signal.

Keywords: Adaptive Regulator, Dynamic Characteristics, Fuzzy Inference System, Industrial Growth, Product Innovation.

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Vibration Modeling of the Steam Turbine Housing Considering the Impact of Linear Parameters

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The simulation of natural and forced oscillations of a low-pressure cylinder with a change in its linear parameters is considered. The thicknesses of the structure's internal walls are taken as linear parameters. This approach allows the creation of several models with different material consumption. As a comparative criterion (objective function), the maximum frequency ranges near the operating frequency are taken. The study was carried out on three models of the low-pressure cylinder body: the original and two options for reducing the material consumption of the structure. The foundation was modeled using a system of rods. The low-pressure rotor was taken into account through an external load. Clips and other equipment were considered through the masses. The subject of the study is the permissible frequency range near the operating frequency. The object of study is the most flexible medium-power steam turbine casing. The oscillation theory and the finite element method were used to solve the problem. A comparison with experimental data on natural frequencies is made. Based on the study, the most optimal model for reducing material consumption is proposed.

Keywords: Turbine, Material Consumption, Frequency Range, Eigenvalue, Vibration, Energy Efficiency.

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Experimental Evaluation of the Impact of the Diametral Clearance on Output Characteristics of a Planetary Hydraulic Motor

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During the operation of the planetary hydraulic motor, the diametrical clearance between the rotors increases. Determination of the influence of the diametrical gap between the rotors of a planetary hydraulic motor on the change in its output characteristics over the entire range of changes in loads and supply of the working fluid to diagnose its technical condition un-der operating conditions is an urgent task. An analysis of literary sources shows the lack of information on experimental studies of changes in the technical condition of planetary (orbital) hydraulic motors. The conducted experimental studies substantiate the effect of wear (diametric clearance) on the change in the output parameters of a planetary-type hydraulic motor. It has been established that the change in the diametrical clearance within 0.02 ... 0.16 mm has practically no effect on the change in pressure drop and the overall efficiency of the hydraulic motor at changes in load 120…1500 N·m and flow rate 50…110 l/min. At the same time, the rotational speed of the shaft of the planetary hydraulic motor is very "sensitive" to changes in the diametrical gap between its rotors. An increase in the diametrical clearance up to 0.23 mm causes a sharp drop in the rotation and overall frequencies of the hydraulic motor shaft. Thus, for diagnosing the technical condition of the planetary hydraulic motor, a diagnostic parameter (rotation frequency) has been established to evaluate its technical condition under operating conditions.

Keywords: Clearance Between Rotors, Fluid Flow, Load, Rotation Frequency, Efficiency, Test Bench, Energy Efficiency, Industrial Growth.

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Stabilization of the Transient Dynamic Characteristics for a Hydraulic Drive with a Planetary Hydraulic Motor

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An important direction in designing hydraulic drives of mechatronic systems of self-propelled machines is research related to ensuring the stability of the characteristics of their output links (hydraulic motors) during transients. An analysis of literary sources shows that there are practically no studies of the influence of the design features of the structural elements of planetary hydraulic motors on the change in dynamic processes occurring in hydraulic drives. The paper solves the problem of ensuring the stability of a hydraulic drive's dynamic characteristics during transient processes using passive pulsation dampers. As a result of the work done, a mathematical model has been improved, making it possible to investigate the effect of a passive pulsation damper on stabilizing the output characteristics of a hydraulic drive. It has been established that during the acceleration of the hydraulic drive, the amplitude of pressure and torque surges are determined by the safety valve's opening time. Using a passive pulsation damper increases the opening time of the safety valve by 7 times, making it possible to reduce pressure and torque surges by 2.2 times. In steady-state operation, the pulsation damper stabilizes (smoothes) the pulsations caused by fluctuations in the disturbing external load and uneven pump delivery. Using a passive pulsation damper operating as a damping device makes it possible to stabilize the dynamic characteristics of the hydraulic drive during transients.

Keywords: Transient Processes, Pulsation Damper, Pressure Pulsation, Fluid Flow Rate, Rotation Frequency, Energy Efficiency.

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Numerical Study of Hydrodynamic Characteristics of The Automatic Balancing Device Elements of The Centrifugal Pump

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In many centrifugal pump designs, the axial force is balanced by special balancing devices. Long cylindrical and short-face throttles are the main constructive elements of such devices. The hydrodynamic characteristics of the cylindrical and face throttles depend on their geometry and operating parameters of the pump. The pressure distribution in the cylindrical throttle determines the pressure in the chamber of the automatic balancing device, the value of which affects the pressure distribution in the face throttle and the value of the resulting axial force. Since an automatic balancing device can be one of the most failure-prone components of centrifugal pumps, improving computational methods and designing such hydraulic units is still a significant problem. The Computational Fluid Dynamics method (Ansys CFX) is used to calculate the hydrodynamic characteristics of the traditional construction of the automatic balancing device. The pressure and velocity distributions are obtained. The value of axial force is calculated in a traditional balancing device. Some recommendations are given.

Keywords: CFD, Cylindrical Throttle, Annular Seal, Face Throttle, Pressure Distribution, Flow-Rate, Energy Efficiency.

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Design of the Curvilinear Axis of the Silage Pipeline

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After chopping the green mass with a cutting drum in forage harvesters, it must be loaded into a vehicle. A silo pipeline is used for this. It directs the movement of the crushed mass in the appropriate direction. The trajectory of particle movement is determined by the shape of a flat curve – the axis of the silo pipeline. The importance of the regularity of changes in the curvature of the axis of the silo pipeline or the trajectory of particle movement is shown analytically in the article. A differential equation of the movement of a single particle on the surface of the silo pipeline has been formulated. It is shown that the differential equation has an analytical solution for an axis in the form of a circle. For other cases, numerical methods should be used. A comparative analysis of the transportation process of crushed mass in silo pipelines with different axis shapes was made. Solutions of differential equations are accompanied by corresponding graphical illustrations.

Keywords: Product Innovation, Trajectory, Curvilinear Axis, Velocity, Particle Movement, Differential Equation, Arc Length.

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Part VI
Process Engineering

Baromembrane Separation Efficiency of Amber Solubilized Extract and Prospects for its Industrial Application

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Human interest in amber has been known since ancient times. The use of the amber extract, with its complex of biologically active sub-stances, is relevant and promising in modern conditions of development of technology and industry. To obtain a clear aqueous extract of amber for food, cosmetic and pharmaceutical needs, the process of baromembrane separation of the solubilized amber extract from the formed micelles as a result of replacing the selective low polar solvent with water was investigated. The research used the baromembrane method of extract separation using different filter membranes. The obtained products were subjected to the instrumental methods of chemical analysis ICP-MS to determine the total content of microelements, HPLC to determine the total content of volatile components, and the analytical chemical method of determining antioxidant activity. The solubilized amber extract can be clarified by filtering the solution using membranes with a pore size ≤ 220 nm, while the chemical composition of the obtained products is observed.

Keywords: Amber, Extract, Filtration, Membrane, Solubilized Solution, Industrial Growth.

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Numerical Simulation and Optimization of Separation Equipment for Gas Preparation Unit

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As a result of the analysis, it was determined that the urgent task is the development of methods for regime-technological and hardware-constructive optimization of the separation equipment of gas processing plants. Simultaneously, attention should be paid to empirical dependencies and numerical simulations. The existing installations are not always highly efficient. They require improvement since, over time, the amount of target components in the raw materials extracted from the well decreases, and the content of water, paraffin, and other harmful impurities increases. This forces to increase in the intensity of separation and mass exchange processes. The proposed technique for optimizing technological and structural calculations of separation equipment (separators of the first and second stages) of the gas preparation plant allows for determining the rational structural dimensions and optimal operational parameters to ensure a high degree of separation of the gas mixture components. For the numerical study and optimization of chemical-technological processes of gas preparation plants intended to produce hydrocarbon products, the static and dynamic optimization simulations of chemical-technological processes were chosen using tools of CAE-systems of thermodynamic modeling. The simulated operation of the atmospheric hydrocarbon processing unit and the hydrocarbon gas preparation unit for which the optimal operating modes of the separators of the first and second stages of the hydrocarbon gas preparation unit are determined.

Keywords: Process Engineering, Process Design, Process Intensification, Numerical Simulation, Mathematical Modeling, Natural Gas, Liquid Fuels, Crude Oil Processing, Separator, Process Innovation.

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Hydrodynamic Characteristics of Pumping Bulk Materials Using Vortex Chamber Ejectors

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Compressors of various types are used as blowers for pneumatic transport, and all of them, except jet-type devices, have low reliability and durability. Jet pneumatic conveying installations cannot be completely used due to the very low efficiency of jet ejectors and the low efficiency of energy transfer to solid particles. On the other hand, vortex chamber superchargers have better characteristics of the granular medium in comparison with direct-flow jet ejectors. When implementing the working process without a drainage channel, the pressure at the device outlet decreases with an increase in the mixed flow rate. The characteristics of the vortex chamber ejector for pumping granular medium without a drainage channel have been deter-mined. The mathematical model adequacy was carried out based on a comparison of the flow integral characteristics: mass flow rates and pressures in all channels for gas and mass flow rates of bulk material in the inlet and out-let channels. The ejector characteristics were studied based on solving the Reynolds-averaged Navier-Stokes equations using the SST turbulence model. The flow rate of solid particles at the device outlet correlates with the diameter of the solid particles. The rational size of solid particles has been determined to ensure the maximum flow rate of the granular medium, which is ensured by the minimum residence time of the solid particle in the vortex chamber.

Keywords: Vortex Ejector, Numerical Simulation, Material Losses, Characteristics, Residence Time, Process Innovation, Energy Efficiency.

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Energy Performance Indicators of the Mobile Branch Trimmer

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The energy performance of material shredders varies and depends on many factors. Concerning the use of single-stage mobile shredders of fruit tree branches of a compacted garden, there are none at all. Therefore, the purpose of these studies was to determine the energy performance indicators of the branch chopper based on a generalized assessment. The obtained data analysis showed that an increase in the rotation frequency from 12 to 21 s^{-1} led to a rise in the specific work for the technological process execution from 3–5 to 11–15 kJ/kg. During an increase in the rotation frequency within a range from 12 to 19 s^{-1} with the supply of branches from 1.58 to 2.18 kg/s, the energy intensity of the process decreases from 0.632–0.727 to 0.536–0.721 kJ/kg. It is due to achieving the operating speed of the hammers necessary for the effective grinding of branches, reducing the time the material stays in the chamber, and increasing the degree of grinding. The energy capacity reaches its minimum value at the rotor rotation frequency range from 14 to 19 s^{-1} (depending on the material feed). In contrast, the sieving capacity of the recutters will coincide with the productivity of the flow of crushed particles. Labor costs for obtaining 1 kg of chopped wood at the upper limit of throughput capacity of 1.58 kg/s are 10.6 kJ, and the energy intensity of the process is 0.539 kJ/kg.

Keywords: Branch Chopper, Energy Indicators, Grinding Process, Work, Energy Consumption, Energy Efficiency.

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Theoretical Study of Powder Particle Parameters in a Modified Cold Spray Nozzle

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The article aims to understand the influence of the nozzle channel geometry on the temperature and velocity parameters of the sprayed particles and the possibility of controlling the process parameters to improve the physical and mechanical characteristics of the resulting coatings. The paper presents the results of calculations of the temperature and velocity of aluminum and nickel particles in the channel of a supersonic nozzle for cold spraying. The study was conducted for two nozzles – the standard one used in DYMET low-pressure units and its modification. The calculations were performed using a well-known one-dimensional gas-dynamic model. The study was conducted in two stages. First, the flow characteristics in the nozzle were calculated based on the known values of the temperature and air pressure at the nozzle inlet and the known values of the cross-sectional area at each point along the nozzle. The next step was to calculate the particle velocity and temperature. The scientific novelty is the following: the effect of modified nozzle geometry on aluminum and nickel particles velocity and temperature at the nozzle exit is shown compared to the results for standard low-pressure cold spray nozzle. The practical value is that obtained results can be used to develop recommendations for aluminum and nickel powders' cold spray deposition of restorative and protective coatings with improved characteristics using the modified nozzle.

Keywords: Gas Flow, Nozzle Channel, Particle Velocity, Isentropic Model, Energy Efficiency.

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Formation of Liquid Droplets at the Prilling Bucket Outlet under Free Oscillations of the Liquid Jet

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The equipment requires the appropriate level of control and quality to produce the proper level of products. To ensure the necessary product quality, one uses various substances abundant in the chemical industry, which can affect the quality and structure of new substances and change their aggregate state. Mineral fertilizers today are pretty widespread and, play an important role in agricultural and industrial production, are obtained by granulation. This paper presents theoretical studies on using rotating vibrating granulators accumulated during their commercialization. The shown equations of fluid motion in a static mode in a cylindrical coordinate system are used to solve the equations of the so-called jet theory. They form the basis of the theoretical description of fluid motion near the jet. The calculations are relevant for analyzing the operation of rotating vibrating granulators in industrial conditions to assess the granulation composition of the product, which, in turn, increases the reliability and stability of the entire industrial plant for the production of mineral fertilizers.

Keywords: Granulator, Frequency, Speed, Pressure, Process Innovation, Industrial Growth.

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Part VII
Advanced Materials

Plasma Deposition of Noble Metals as Control Factors in Synthesis of Copper Oxide Nanostructures

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Application of plasma and use of deposition of noble metals ap-plied at a certain stage of synthesis of copper oxide nanostructures can result in a significant change in the growth dynamics, as is confirmed by the simulation of the growth process reported in the paper. Interaction of plasma ions with the side surfaces of the growing nanowires creates defects on the surfaces, thus increasing the energy of oxygen adsorption from the gas phase. As a result, the concentration of oxygen on the side surface of a nanowire increase, which enhances the rate of losses of copper flux supplied from the nanowire root to the tip, thus shortening the possible length of the nanowire and increasing its diameter; the nanowires become bulkier at that. In turn, the deposition of noble metals engaged after the nanowire reaches the saturation on the dependence of its length on time, when the growth stops, al-lows covering the active sites of the oxygen adsorption and preventing the increase of oxygen concentration on the side surface. As a result, the rate of copper loss during the copper diffusion towards the nanowire tip along the nanowire length is decreased, thus leading to further elongation of the nanowires.

Keywords: Metal Oxide, Nanowires, Ion Bombardment, Gold Nanoparticles, Process Innovation.

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Strengthening of Mechanical Engineering Parts Using Chemical-Thermocycling Treatment

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This work is devoted to studying the process of thermocycling cementation for the thermal strengthening of machine-building parts. The effect of diffusion saturation under conditions of thermocycling influence on the structure and properties of AISI 5120 steel was studied. A comparative analysis of the structure and properties was conducted after various thermal, chemical-thermal, and chemical-thermocycling treatments. The technology of chemical-thermocycling processing with different cycles has been developed. The thickness of the diffusion layer, its microhardness, and the distribution of carbon over the thickness of the saturated layer were determined. The study of the structure of products that underwent thermocycling cementation showed that carbide inclusions throughout the thickness of the layer had a rounded shape and small sizes. In the cemented layer obtained by the traditional (isothermal) processing method, carbides were located mainly along the grain boundaries as a grid. The method of thermocycling as a method of thermal treatment is based on the constant accumulation from cycle to cycle of positive changes in the structure of metals. It was shown that thermocycling directly in cementation processes allows the necessary diffusion enrichment of the surface layers with metals or non-metals from the external active medium in a shorter time than during isothermal exposure. It has been experimentally proven that the final thermocycling of cemented steels reduces the duration of the process by 1.3–1.8 times.

Keywords: AISI 5120, Diffusion Saturation, Cementation, Process Innovation, Thermocycling Cementation, Microhardness, Working Capacity, Industrial Growth.

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Research of Biologically Active Polymeric Hydrogel Transdermal Materials

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A paper deals with biologically active polymeric hydrogel trans-dermal materials. It was proved that using humic acids is a perspective for the functional effect on the properties of hydrogel biopolymer materials. Structuring processes and strength characteristics improving are the most changeable while using humic acids. Biologically active polymer hydrogel transdermal materials were designed and produced based on gelatin, hydroxypropyl cellulose, and sodium alginate, modified with lignite humic acids. The peculiarities impact of the received humic substances conditions from lignite on their qualitative and quantitative composition were determined. By carrying out rheological, conductometric, and microscopic studies, it was found that modifying gelatin-sodium alginate and hydroxypropyl cellulose-sodium alginate systems with humic acids allows for receiving polymer hydrogels with a high structuring degree. It has been found that effective processes for receiving biologically active polymer hydrogel transdermal materials based on gelatin, hydroxypropyl cellulose, and sodium alginate can be carried out in different humic acids concentration values while achieving an increase in hydrogel polymer structuring processes. The humic substances' optimal content in gelatin-sodium alginate systems was found to be no more than 5% by weight.

Keywords: Hydrogel, Polymer, Gelatin, Hydroxypropyl Methylcellulose, Sodium Alginate, Humic Acid, Transdermal Materials, Industrial Growth.

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Mechanical Properties of Hybrid Composites based on Polypropylene Modified with Natural Fillers

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Hybrid composites based on a polymer matrix and a natural (renewable) filler can be one of the alternatives to widely used polymers. It is well known that natural fillers have poor adhesion to hydrophobic polymer matrices. To improve the interaction between hydrophilic fillers and hydrophobic matrix, fillers are usually pretreated with activators. Composites made by injection molding based on polypropylene and Kraft-lignin, micro-cellulose from hemp waste with filling from 9 to 27 wt % were investigated in work. To enhance the adhesion between the filler and the polymer, a special chemical treatment of the components was used with the addition of talc as a compatibilizing agent. Tensile and bending tests of the composites were carried out, as well as studies on the determination of microstructure features and evaluation of the influence of reinforcement and homogenization of mixtures using SEM. It was established that, compared to primary polypropylene, the flexural strength of composites with microcellulose practically did not change, Young's modulus (E) increased to 12% de-pending on the degree of filling, and the flexural strength of composites with lignin increased to 42.3 MPa (32%), E up to 1570 MPa (22%). The tensile strength is practically unchanged for the cellulose filler and slightly increased to 10% for lignin, and Young's modulus, depending on the type of filler and degree of filling, increased from 10 to 32%. Structure studies indicate a good interphase interaction of components in composites.

Keywords: Hybrid Composites, Kraft-Lignin, Microcellulose, Polypropylene, Flexural Strength, Tensile Strength, Manufacturing Innovation.

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Dispersion Properties of Waves in Polyurethane Foam

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The article is devoted to analyzing the dispersion properties of waves in structurally inhomogeneous materials such as foam. In analyzing the change of the wave propagation speeds in foam materials, the apparatus of the Cosserat was used. This approach allows us to account for the influence of shear-rotation deformations and analyze the dispersion properties of waves. Numerical calculations have been performed in the case of closed-cells polymer foam. The article shows that the dispersion properties characteristic of shear and rotation waves can be involved in defining the parameters of the Cosserat continuum, which are not easy to decide on in experimental studies. Analytical studies allow not only to obtain the values of the corresponding speeds of shear-rotation waves but also to clarify the directions of empirical studies. Also, the obtained results make it possible to determine the optimal characteristics of foamed materials by studying the effect of changing each of the mechanical characteristics on the change in the shear-rotation rates of the material. The proposed analytical approach can also be used to clarify the methods and parameters of experimental studies of determining shear-rotational wave speeds.

Keywords: Polyurethane Foam, Cosserat Elasticity, Dispersion Properties, Manufacturing Innovation.

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Numerical Investigation of Materials Porosity Based on the 3D Computer Simulation Particle Packaging Model

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This article presents the main components of Monte Carlo methods. An alternative to the basic processes of computer simulation of spherical elements in a stochastic medium is described. A 3D computer simulation model for packaging spherical cylinders (spherical elements) has been developed. The motion pattern of spherical elements was modeled, particularly the position of the lobes before movement and the position of spherical elements after movement. The authors presented 3D modeling of round cylinders with a spherical base and described the process of modeling spherical cylinders in a specific direction and point. The results obtained allowed us to study the close relationship between spherical components and to find out how much the shape of non-spherical elements differs from spherical ones. Based on the developed 3D computer model for modeling spherical cylinders, materials' physical and mechanical properties, particularly porosity, were studied. It was found that the experimental results of porosity increase with increasing diameter of spherical elements (i.e., particles). As a result, it made it possible to predict the porosity of the package. The paper's authors have also investigated the influence of container parameters (width and height) on materials' properties (porosity). In this study, the phenomenon of edge effects was observed, which were caused mainly within the bunker width of 600–800 mm.

Keywords: Polydisperse Simulation, Monte Carlo Methods, Spherical Elements, Packaging, Software, No Intersection Condition, Center Coordinates, Bunker Parameters, Particle Size, Particle Shape, Product Innovation.

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An Increase in the Technological Properties of Mixtures in the Foundry Industry: A Novel Approach

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The formation of the quality of castings is mainly influenced by the properties of the molding sand, the casting mold, and the cast metal. The instability of the technological and physical-mechanical properties of molding sands is the main reason for the occurrence of up to 50% of casting defects. Therefore, improving the quality of mixtures' technological properties based on modern adaptation and stabilization methods is an urgent problem in foundry production. For that purpose, the analysis of the causes of the main defects of castings in the production conditions of foundries was carried out, the actual characteristics of the dispersion of the technological properties of the mixture were determined, active industrial experiments were carried out, mathematical models of its properties were developed, and nomograms were proposed for solving the problem of adaptive control of the properties of molding sands. Research has been carried out to improve the technological properties of molding sands based on the joint use of mathematical modeling methods and industrial experiments in a foundry workshop. A method for controlling their properties has been developed and implemented, which made it possible to improve the quality of castings and reduce their casting defects. Recommendations have been developed to improve the parametric reliability of mixers that significantly impact the properties of molding mixtures.

Keywords: Molding Sand, Modeling, Optimization, Mathematical Model, Casting, Automated Production, Mixer, Quality, Product Innovation.

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The State of Electrolytic Plasma in Synthesis of Oxide Ceramic Coatings on the Magnesium Basis

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The basis for determining the density of electrons in plasma is the study of the broadening of spectral lines, which is caused by the linear Shtark-effect. This article demonstrates the applicability of the classical theory of scattering, with the help of which, analyzing the spectral characteristics of spark plasma discharges in the electrochemical system of magnesium-electrolyte, determined that during the synthesis of oxide-ceramic coatings on a magnesium basis in discharge channels for electron density $(3.2…3.4)\cdot10^{22}$ m^{-3} and their temperatures $(1…1.1)\cdot10^{4}$ K equilibrium, not degenerate, quasi-ideal plasma is formed with an ionicity (0.02...0.10). This temperature makes conditions for dissociation and ionization of electrolyte components and also ensures high chemical reactivity. At the same time, the speed of the reaction is much higher compared to classical electrochemical methods. The performed calculations provide the possibility of further correct thermodynamic calculation of the concentrations of the reaction products of the synthesis of oxide ceramic coatings in the electrolytic plasma of the magnesium alloy–electrolyte system.

Keywords: Product Innovation, Plasma-Electrolyte Treatment, Oxide Ceramic Coatings, Magnesium Alloys, Electron Density, Electron Temperature, Industrial Growth.

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Damage Mechanisms of Multilayer Axisymmetric Shells Obtained by the FDM Method

Olexandr Salenko[1][0000-0002-5685-6225], Dmytro Dzhulii[1][0000-0002-8863-626X], Volodymyr Drahobetskyi[2][0000-0001-9637-3079], Anastasiia Symonova[2][0000-0003-1411-6656] and Dmytro Moloshtan[2][0000-0001-8881-8541]

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The emergence and development of additive technologies (in particular, fused deposition modeling, FDM) determine the intensification of re-search in this area, given that there is currently a transition from applied and artistic applications to the use of FDM in solving engineering problems. The paper analyzes the behavior of thin-walled shells obtained by FDM (tanks of various technological purposes) under internal thermobaric loading. The damage and destruction of the tanks were simulated. The mechanism of damage development was checked experimentally. It was concluded that an essential physical and mechanical characteristic is the product's crack resistance, characterized by the stress intensity factor (SIF) and differs between the initial filament and the finished product. The SIF value depends on the existing defects and leaks in the formed body of the product. It is also determined by both the material used and the printing modes. It is shown that applying thin sealing films and various printing techniques can improve the mechanical characteristics of the product as a whole.

Keywords: 3D Printing, Strength, Crack Resistance, Fracture, Serviceability Prediction, Product Innovation.

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An Increase in the Performance of Parts Made of Heat-Resistant Steels and Alloys

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Increasing gas turbine engine parts' heat strength and heat resistance is considered. Heat-resistant steels and alloys are most often used in highly loaded units and units of modern aerospace engineering, turbines, and power plants of the generator type. They work under high contact loads and temperatures and must simultaneously have sufficient heat strength and resistance. For this, metallographic studies of these materials were performed, and structures and the influence of alloying elements were analyzed. Special attention was paid to studying the microtopography of the working surfaces formed during the finishing operations of the part's production. It is because their efficiency largely depends on the microtopography of the surfaces. Finishing operations of polishing the cylindrical surfaces of parts such as bolts and studs improve their disassembly during the overhaul of aircraft engine assemblies. While poor-quality polishing deteriorates the fatigue strength, such surfaces' resistance to thermal fatigue does not allow them to achieve regulated performance. The study reveals the possibilities of increasing mate-rials' heat strength and resistance using appropriate heat treatment, particularly repeated heat treatment.

Keywords: Heat-Resistant Materials, Heat Resistance, Working Temperatures, Contact Loads, Alloying Elements, Product Innovation.

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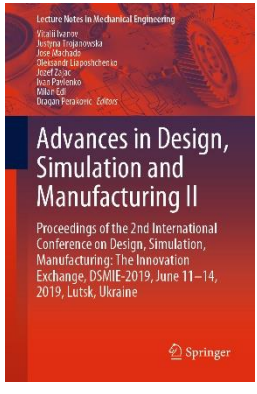

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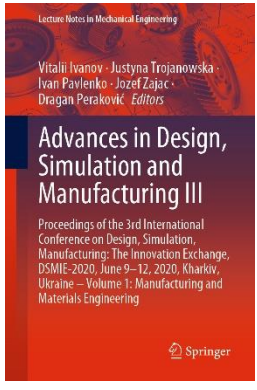

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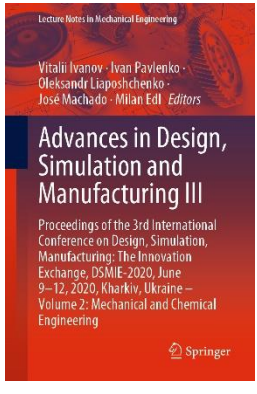

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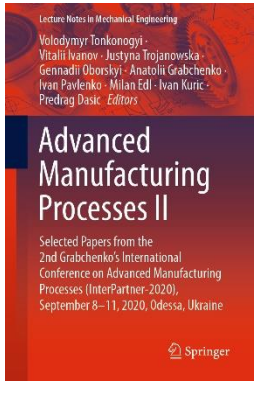

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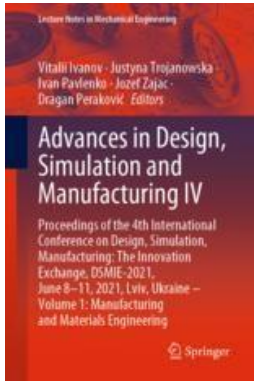

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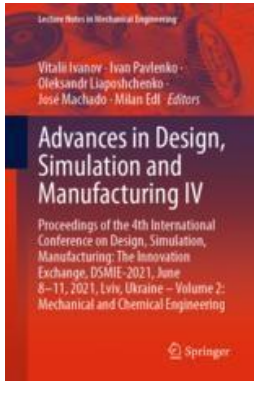

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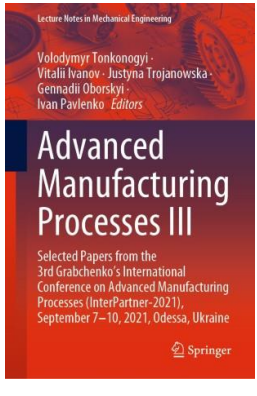

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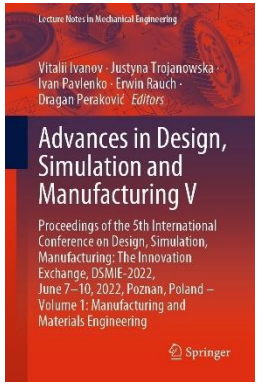

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Editors: Ivanov, V., Trojanowska, J., Pavlenko, I., Rauch, E., Perakovic, D. (Eds.)

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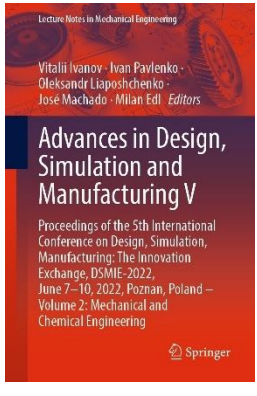

Advances in Design, Simulation and Manufacturing V

Proceedings of the 5th International Conference on Design, Simulation, Manufacturing: The Innovation Exchange, DSMIE-2022, June 7-10, 2022, Poznan, Poland – Volume 2: Mechanical and Chemical Engineering

Editors: Ivanov, V., Pavlenko, I., Liaposhchenko, O., Machado, J., Edl, M. (Eds.)

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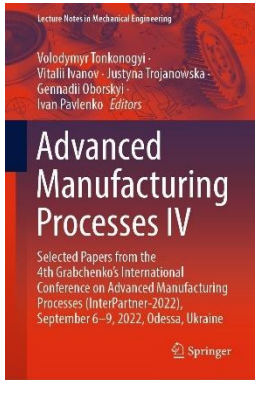

Advanced Manufacturing Processes IV

Selected Papers from the 4th Grabchenko's International Conference on Advanced Manufacturing Processes (InterPartner-2022), September 6-9, 2022, Odessa, Ukraine

Editors: Tonkonogyi, V., Ivanov, V., Trojanowska, J., Oborskyi, G., Pavlenko, I. (Eds.)

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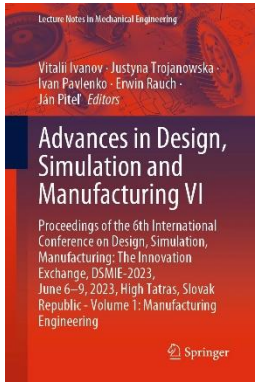
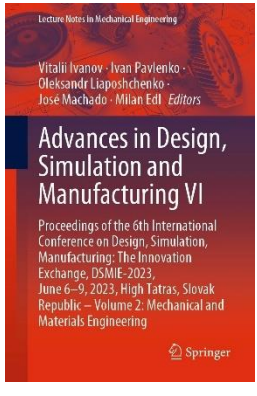


Advances in Design, Simulation and Manufacturing VI

Proceedings of the 6th International Conference on Design, Simulation, Manufacturing: The Innovation Exchange, DSMIE-2023, June 6-9, 2023, High Tatras, Slovak Republic – Volume 1: Manufacturing Engineering

Editors: Ivanov, V., Trojanowska, J., Pavlenko, I., Rauch, E., Piteľ, J. (Eds.)

https://link.springer.com/book/10.1007/978-3-031-32767-4



Advances in Design, Simulation and Manufacturing VI

Proceedings of the 6th International Conference on Design, Simulation, Manufacturing: The Innovation Exchange, DSMIE-2023, June 6-9, 2023, High Tatras, Slovak Republic – Volume 2: Mechanical and Materials Engineering

Editors: Ivanov, V., Pavlenko, I., Liaposhchenko, O., Machado, J., Edl, M. (Eds.)

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Full-text papers were published in the Lecture Notes in Mechanical Engineering book series (ISSN 2195-4356).

The book **"Advances in Design, Simulation and Manufacturing VI"** was organized in two volumes according to the main conference topics: Volume 1 — Manufacturing Engineering and Volume 2 — Mechanical and Materials Engineering. Each volume is devoted to research in design, simulation, and manufacturing in the main conference areas.

Volume 1 - Manufacturing Engineering

Volume 2 - Mechanical and Materials Engineering