Book of Abstracts

DSMIE 2020

3rd International Conference on

Design, Simulation, Manufacturing: The Innovation Exchange

June 9-12, 2020 | Kharkiv, Ukraine

Sumy State University

Kharkiv Polytechnic Institute 1885 NTU

iATDi International Association for Technological Development and Innovations

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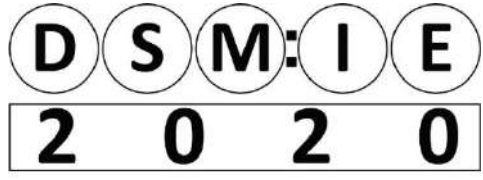

3rd International Conference on Design, Simulation, Manufacturing: The Innovation Exchange (DSMIE-2020)

June 9-12, 2020 | Kharkiv, Ukraine

Book of Abstracts

Sumy
2020

Editors:

Vitalii Ivanov, Oleksandr Gusak, Oleksandr Liaposhchenko, Ivan Pavlenko

Design, Simulation, Manufacturing: The Innovation Exchange: Book of Abstracts of the 3rd International Conference, Kharkiv, Ukraine, June 9-12, 2020 / Vitalii Ivanov, Oleksandr Gusak, Oleksandr Liaposhchenko, Ivan Pavlenko (Eds.). – Sumy: IATDI, 2020. – 164 p.

Recommended by Coordination Board of International Association for Technological Development and Innovations (Protocol No. 11, May 14, 2020) and Academic Council of Sumy State University (Protocol No. 0422-I, May 21, 2020)

The content of this book is based on the 3rd International Conference on Design, Simulation, Manufacturing: The Innovation Exchange (DSMIE-2020), held on June 9-12, 2020, in Kharkiv, Ukraine. This book reports on topics at the interface between manufacturing, materials, mechanical, and chemical engineering, with a special emphasis on design, simulation, and manufacturing issues. Specifically, it covers the development of computer-aided technologies for product design, the implementation of smart manufacturing systems and Industry 4.0 strategies, topics in technological assurance, numerical simulation, and experimental studies of cutting, milling, grinding, pressing, and profiling processes, as well as the development and implementation of advanced materials. It covers recent developments in the mechanics of solids and structures, numerical simulation of coupled problems, including wearing, compression, detonation, and collision, chemical process technology, including ultrasonic technology, capillary rising process, pneumatic classification, membrane electrolysis, and absorption process. Further, it reports on developments in the field of heat and mass transfer, energy-efficient technologies, and industrial ecology. The book provides academics and professionals with extensive information on trends, technologies, challenges, and practice-oriented experience in the areas mentioned above.

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Welcome Message

3rd International Conference on Design, Simulation, Manufacturing: The Innovation Exchange (DSMIE-2020), held in Kharkiv, Ukraine on June 9-12, 2020, was organized by the Sumy State University, National Technical University "Kharkiv Polytechnic Institute", and International Association for Technological Development and Innovations, in partnership with Technical University of Kosice (Slovak Republic), Kielce University of Technology (Poland), University of West Bohemia (Czech Republic), Poznan University of Technology (Poland), and Association for Promoting Innovative Technologies – Innovative FET (Croatia).

DSMIE-2020 received 161 contributions from 28 countries around the world. After a thorough peer-review process, the Program Committee accepted 93 papers written by authors from 23 countries. The acceptance rate of about 58%. Extended versions of selected best papers will be published in scientific journals: Management and Production Engineering Review (published by De Gruyter and indexed by ISI/ESCI, Scopus), Archives of Mechanical Technology and Materials (Poland), Journal of Engineering Sciences (Ukraine), and Advances in Thermal Processes and Energy Transformation (Slovak Republic).

We would 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. Program Committee members and invited external reviewers devoted their time and energy for peer-reviewing manuscripts. Our reviewers come from all over the world and represent 29 countries and affiliated with 63 institutions.

Thank you very much to keynote speakers: Erwin Rauch (Italy), Dagmar Caganova (Slovak Republic), Mateusz Barczewski (Poland), Arun Nagarajah (Germany), Domenico Guida (Italy), Alex Enrich Prast (Sweden) for sharing their knowledge and experience.

We appreciate the partnership with Springer Nature, StrikePlagiarism, EasyChair for their essential support during the preparation of DSMIE-2020. Thank you very much for 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-2020

3rd International Conference on Design, Simulation, Manufacturing: The Innovation Exchange (DSMIE-2020) is the international forum for fundamental and applied research and industrial applications in engineering.

The conference focuses on a broad range of research challenges in the fields of Manufacturing, Materials, Mechanical, and Chemical Engineering, addressing current and future trends in design approaches, simulation techniques, computer-aided systems, software development, ICT tools, and Industry 4.0 strategy implementation for engineering tasks solving.

DSMIE-2020 brings together researchers from academic institutions, leading industrial companies, and government laboratories located around the world for promoting and popularization of the scientific fundamentals of engineering.

The conference schedule includes keynote sessions and technical sessions, expert panels, an exhibition of industry partners, and more.

The official language of the conference is English.

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Conference Topics

Manufacturing Engineering

- CAx Technologies for Product Design and Advanced Manufacturing Processes
- Intelligent Manufacturing Systems, Automation, and Robotics
- Smart Manufacturing and Industry 4.0 Strategy
- Information Management Systems
- ICT for Engineering Education

Materials Engineering

- Methods and Technologies for Additive Manufacturing
- Advanced Materials
- Theoretical Fundamentals and Mathematical Modeling
- Numerical Simulation and Optimization Techniques
- Resource-Saving and Energy Efficient Technologies

Mechanical Engineering

- Mechanics of Solids and Structures
- Dynamics, Acoustics, and Vibrations
- Elasticity and Strength of Materials
- Hydro- and Aeromechanics
- Numerical Simulations of Coupled Problems

Chemical Engineering

- Chemical Process Technology and Plant Design
- Thermodynamics, Heat and Mass Transfer
- Energy-Efficient Technologies, Conversion, and Utilization
- Alternative and Renewable Energy Sources
- Industrial Ecology and Sustainable Engineering

Publishing Opportunities

Full papers of selected contributions of DSMIE-2020 published in two volumes of the book "Advances in Design, Simulation and Manufacturing III" belongs to the Lecture Notes in Mechanical Engineering (ISSN 2195-4356). The books of this series are published by Springer Nature and indexed by Scopus and submitted to Web of Science.

Volume 1 – Manufacturing and Materials Engineering (ISBN 978-3-030-50793-0)

Editors:

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- Justyna Trojanowska, Poznan University of Technology, Poland
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Volume 2 – Mechanical and Chemical Engineering (ISBN 978-3-030-50490-8)

Editors:

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- 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

To read full papers, please visit the official webpage of Publisher via the following link https://www.springer.com/series/11236.

Extended versions of best papers, presented at DSMIE-2020, will be considered for special issues of selected journals, subject to further review:

- Management and Production Engineering Review, Poland (ISSN 2080-8208, e-ISSN 2082-1344), http://mper.org;
- Archives of Mechanical Technology and Materials, Poland (ISSN 2450-9469), https://www.degruyter.com/view/j/amtm;
- Journal of Engineering Sciences, Ukraine (ISSN 2312-2498, e-ISSN 2414-9381), http://jes.sumdu.edu.ua;
- Advances in Thermal Processes and Energy Transformation, Slovak Republic (ISSN 2585-9102), http://atpetjournal.com.

Organizers

Sumy State University

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 14,000 students who are pursuing bachelor and master degrees in 55 majors and 23 fields of knowledge. About 1750 international students represent about 50 countries worldwide.

Sumy State University enters the ranking of THE World University Rankings by Times Higher Education at the position of 1001+. SumDU is included in Global Research University Profiles (GRUP) by Shanghai Ranking. SumDU enters the TOP-group (3%) of leading universities of the world and is classified as a university with high research intensity according to the international ranking of higher education institutions QS World University Rankings. SumDU enters the group of leading Ukrainian universities. SumDU also ranked 101-150 among the fastest-rising young stars of the higher education world by the QS. SumDU ranked 801+ in the recent THE University Rankings in Engineering and Technology. Sumy State University is the first Ukrainian higher education institution, which passed an independent external audit of the QS Company in 2014 and was given the highest points (5 stars) in such categories as Teaching, Engagement, Access, and E-learning. According to the international SCImago Institutions Rankings, Sumy State University takes the 5th place among Ukrainian universities and enters the TOP-200 universities of Central and Eastern Europe. According to international ecological ranking UI GreenMetric, Sumy State University enters TOP-250 the world's universities. SumDU is the 1st Ukrainian university to enter this ecological ranking.

Sumy State University is the 2nd among Ukrainian HEIs according to the results of the evaluation of the quality of universities' scientific activity based on the citation of scientists on Google Scholar by Webometrics. SumDU holds high positions in the consolidated ranking of Ukrainian universities "Osvita.ua".

The University is a signatory of Magna Charta Universitatum and a reliable member of International Association of Universities, European University Association, Euroasian Universities Association, Association of Economic Universities of South and Eastern Europe and the Black Sea Region, IREG Observatory on Academic Ranking and Excellence, IIENetwork and other international organizations.

Sumy State University cooperates with more than 260 partners from 50 world countries, 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. For the last 5 years, the amount of research work in frames of international grant projects has increased in 20 times.

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.

According to the SCOPUS database, Sumy State University holds a leading position among Ukrainian higher education and research institutions for h-index (the index of research impact) and the number of citations by the international academic community.

There are more than 3000 employees in the university, including Corresponding Members of the National Academy of Science of Ukraine, 150 Doctors of Sciences, Professors, and 670 Candidates of Sciences (Ph.D.), Associate Professors represent the academic staff of the University. There are 21 majors in postgraduate and 16 majors in post-doctoral programs, degree awarding academic councils.

According to the number of commercial contracts and grants, and the efficiency of the use of budget funds, Sumy State University is one of the leaders among Ukrainian universities.

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

National Technical University "Kharkiv Polytechnic Institute"

National Technical University "Kharkiv Polytechnic Institute" is one of the oldest and largest higher educational institutions in Ukraine. The University was founded in 1885, and throughout its history, it has significantly influenced the development of world education, science, and technology, and in independent Ukraine, it makes an outstanding contribution to the development of modern domestic higher engineering education. The history of the NTU "KhPI" from the moment of its foundation has become an integral part of the scientific, technical, intellectual, cultural history of Ukraine. Also, NTU "KhPI" is the founder of 8 independent higher educational institutions of Ukraine. Today National Technical University "Kharkiv Polytechnic Institute" includes five educational and research institutes, four faculties, two research institutes, 89 departments, a computer-technological college, an interdisciplinary institute of postgraduate education, a center for distance learning, etc. NTU "KhPI" entered the top three Ukrainian universities of the world ranking QS World University Rankings 2020, ahead of other technical universities in Ukraine.

✉ 2, Kyrpychova str., 61002, Kharkiv, Ukraine
💻 http://www.kpi.kharkov.ua

International Association for Technological Development and Innovations

International Association for Technological Development and Innovations (IATDI) is a non-government organization and a professional community established for fostering and promoting innovations to the science, technology, and education.

IATDI is an organizer of the DSMIE Conference Series and InterPartner Conference Series.

IATDI is aimed at the formation of the integrated relationship between individuals, local authorities and the private sector to improve the quality of human capital, pooling of intellectual potential of members for technological development and innovation, creating a network of partners with domestic and foreign higher education institutions and international organizations, co-organizing strategies in the context of implementing innovative scientific and educational projects, training highly skilled specialists, as well as an exchange of scientific information and academic staff.

✉ Sumy, Ukraine
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The monthly international magazine «Industry in FOCUS» has already attracted the attention of many companies who work in the industrial market. Time of feverish activity made our edition the most popular among the similar journals.

The editorial policy of «Industry in FOCUS» consists of prompting information bridges between developers of technics and technical processes, producers of the industrial output, providers, and consumers. Since our market develops dynamically and our technical specialists should be well-informed, we use the authority and status of our edition to cover the field broadly and give irreversible character to those processes which are taken place in our country now.

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Conference Program

Day 1 – **June 9, 2020** – Tuesday	
10^{00}–12^{00}	Testing Session
Day 2 – **June 10, 2020** – Wednesday	
8^{00}–9^{00}	Registration
9^{00}–9^{30}	Opening Ceremony
9^{30}–11^{00}	Keynote Session 1
11^{00}–11^{20}	Awards Ceremony
11^{20}–11^{30}	Technical Break
11^{30}–13^{00}	Keynote Session 2
13^{00}–14^{00}	Technical Break
14^{00}–15^{00}	Session 1 – Manufacturing Engineering
15^{00}–16^{00}	Session 2 – Mechanical Engineering
16^{00}–16^{15}	Technical Break
16^{15}–16^{45}	Poster Session
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10^{15}–11^{15}	Session 4 – Materials Engineering
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11^{30}–12^{30}	Session 5 – Interdisciplinary Research
12^{30}–13^{00}	Closing & Awards Ceremony
Day 4 – **June 12, 2020** – Friday	
9^{00}–11^{00}	Q&A Session for Organizational Issues

Day 1: June 9, 2020, Tuesday

10^{00}–12^{00} Testing Session

Kharkiv is the second-largest city in Ukraine. It is located in the northeast of the country, the largest city of the Slobozhanshchyna historical region. Kharkiv is the administrative center of the Kharkiv region.

The city was founded in 1654, and after a humble beginning as a small fortress grew to be a major center of the Ukrainian industry, trade, and culture. Kharkiv was the first capital of the Ukrainian Soviet Socialist Republic, from December 1919 to January 1934, after which the capital relocated to Kyiv.

Presently, Kharkiv is a major cultural, scientific, educational, transport, and industrial center of Ukraine, with numerous museums, theatres, and libraries.

Due to its convenient geographical position, Kharkiv has increased its economic power and developed a system of transportation over the centuries.

Kharkiv is a large industrial center of Ukraine. The basis of the production potential is enterprises of high-tech industries, power engineering, electrical industry, transport, and agricultural engineering, tool industry, radionics, aerospace industry. The high-tech products of many Kharkiv enterprises, including modern military tanks, aircraft, and turbines, are well-known worldwide.

Day 2: June 10, 2020, Wednesday

8^{00}–9^{00} Registration

9^{00}–9^{30} Opening Ceremony

Vitalii Ivanov
General Chair of the Conference
Andrii Marchenko
Co-chair of the Conference

9^{30}–11^{00} Keynote Session 1
Chair: Olaf Ciszak
Poznan University of Technology, Poland

Industry 4.0+: The Next Level of Intelligent and Self-Optimizing Factories
Erwin Rauch
University of Bozen-Bolzano, Italy

Industry 4.0 Best Practices and Challenges
Dagmar Caganova
Slovak University of Technology in Bratislava, Slovak Republic

Application of Basalt Powder as a Perspective Low-Cost Waste Filler for Polymeric Composites with Lowered Environmental Impact
Mateusz Barczewski
Poznan University of Technology, Poland

11^{00}–11^{20} Awards Ceremony

Anatoliy Vasylyev
Rector of Sumy State University, Ukraine
Olaf Ciszak
Dean of the Faculty of Mechanical Engineering, Poznan University of Technology, Poland

11^{20}–11^{30} Technical Break

11^{30}–13^{00} **Keynote Session 2**
Chair: Milan Edl
University of West Bohemia, Czech Republic

Digital Twin – A Scientific View
Arun Nagarajah
University of Duisburg-Essen, Germany

HAPS_2020 – A New Altitude Platform Station
Domenico Guida
University of Salerno, Italy

Biogas solutions: dealing with local and global challenges
Alex Enrich Prast
Linkoping University, Sweden

13^{00}–14^{00} **Technical Break**

14^{00}–15^{00} **Session 1 – Manufacturing Engineering**
Chair: Dragan Perakovic
University of Zagreb, Croatia

Comparative Analysis of Platforms for Designing a Digital Twin
Dmytro Adamenko, Steffen Kunnen and Arun Nagarajah
University of Duisburg-Essen, Germany

Production Planning and Setup Times Optimization: An Industrial Case Study
Jose Pedro Vaz, Leonilde Varela, Bruno Goncalves and Jose Machado
University of Minho, Portugal

Workplace Optimization Using a Collaborative Robot
Pavel Kabele and Milan Edl
University of West Bohemia, Czech Republic

Concept Development of a Consistently Traceable Process and System Solution for Ensuring the Requirements of Engineering and Functional Safety
Dominik Ehring, Robin Pluhnau and Arun Nagarajah
University of Duisburg-Essen, Germany

Influence of Milling Parameters on Cutting Forces in High-Speed Milling of Polymer Materials
Alper Uysal[1], Eshreb Dzhemilov[2] and Ruslan Dzhemalyadinov[2]
[1] Yildiz Technical University, Turkey
[2] Crimean Engineering and Pedagogical University, Republic of Crimea

15^{00}–16^{00}	**Session 2 – Mechanical Engineering** *Chair: Justyna Trojanowska* Poznan University of Technology, Poland

Influence of Surface Hardened Nanocrystalline Layers on the Resistance of Contact Fatigue Destruction

Volodymyr Gurey and Ihor Hurey

Lviv Polytechnic National University, Ukraine

Numerical Simulation of Compression and Detonation Strokes in a Pulse Compression Detonation System

Brian Maxwell[1], Konstyantyn Korytchenko[2] and Olga Shypul[3]

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[2] National Technical University «Kharkiv Polytechnical Institute», Ukraine

[3] National Aerospace University «Kharkiv Aviation Institute, Ukraine

Estimation of Random Flow-Rate Characteristics of The Automatic Balancing Device Influence on Centrifugal Pump Efficiency

Yuliia Tarasevych[1], Natalia Sovenko[2] and Ievgen Savchenko[2]

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[2] Sumy State University, Ukraine

Mathematical Modeling of the Operating Process in LS Hydraulic Drive Using MatLab GUI Tools

Oleksandr Petrov, Andrii Slabkyi, Inna Vishtak and Maksym Trofymchuk

Vinnytsia National Technical University, Ukraine

Studies of the Swirling Submerged Flow Through a Confuser

Andrii Rogovyi, Serhii Khovanskyi, Iryna Hrechka and Anatoly Gaydamaka

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[3] National Technical University «Kharkiv Polytechnic Institute», Ukraine

16^{00}–16^{15}	**Technical Break**
16^{15}–16^{45}	**Poster Session** *Chair: Ivan Pavlenko* Sumy State University, Ukraine

Posters List

Section 1 – CAx Technologies for Product Design

No.	Poster Title	Authors
1.1	**Computer-Integrated Design Pistons with the Influence of Casting Defects**	*Oleg Akimov, Vitaliy Alyokhin, Kateryna Kostyk, Leonid Saltykov and Julia Riabets*
1.2	**Improvement of the Effectiveness of General Engineering Courses Using Trainers**	*Mykola Korotun, Yuliia Denysenko, Nina Malovana and Olena Dutchenko*
1.3	**Modeling of Spindle Node Dynamics Using the Spectral Analysis Method**	*Oleg Krol and Volodymyr Sokolov*
1.4	**Method of Design of Interference Fit Based on Complex Mathematical Modeling**	*Vladimir Nechiporenko, Valentin Salo, Petro Litovchenko, Vladislav Yemanov and Stanislav Horielyshev*
1.5	**Design of Conveyor Control Information System Considering Transport Delay**	*Oleh Pihnastyi, Georgii Kozhevnikov and Tetiana Bondarenko*
1.6	**Fundamentals of CAD Design of Rotary Milling Cutters for Multitooth Products**	*Nataliya Ravska, Alexander Klochko, Oleksiy Ivanovskiy, Vyacheslav Vovk and Valeriya Parnenko*
1.7	**Design Calculation of Electrohydraulic Servo Drive for Technological Equipment**	*Volodymyr Sokolov, Olga Porkuian, Oleg Krol and Yevhen Baturin*
1.8	**Parametric Optimization of Technological Layout of Modular Machine Tools**	*Ihor Yakovenko, Alexander Permyakov, Olena Naboka, Olga Prihodko and Yurii Havryliuk*

Section 2 – Smart Manufacturing and Industry 4.0 Strategy

Section 3 – Technological Assurance

No.	Poster Title	Authors

3.1 **Improvement of the Quality of Cutting Tools States Recognition Using Cloud Technologies**
Oleksandr Fomin and Oleksandr Derevianchenko

3.2 **Adaptive Slicing in the Additive Manufacturing Process Using the Statistical Layered Analysis**
Yaroslav Garashchenko and Nina Zubkova

3.3 **Increasing Productivity of Connecting Rods Machining**
Vitalii Ivanov, Ivan Dehtiarov, Viliam Zaloga, Illia Kosov and Volodymyr Savchuk

3.4 **A Probabilistic-Statistical Model of Durability of Parts under Cyclic Loading**
Nataliia Lamnauer, Oleksandr Kupriyanov, Anton Skorkin and Oleg Kondratyuk

3.5 **Theoretical Analysis of Conditions for Improving the Gear Grinding Accuracy and Productivity**
Fedir Novikov, Vladimir Polyansky, Igor Riabenkov, Andrii Hutorov and Oksana Yermolenko

3.6 **Ensuring the Bending Stiffness of Pre-Compressed Cantilever Boring Bars during Fine Boring**
Alexandr Orgiyan, Vladimir Kobelev, Vitalii Ivanov, Anna Balaniuk and Albakush Aymen

3.7 **Improvement of the Accuracy of Grinding by means of Coolant Supply**
Mykhaylo Stepanov, Maryna Ivanova, Petro Litovchenko, Larysa Ivanova and Alexey Kotliar

3.8 **Optimization of Modular Fixtures Setup Time in an Automated Assembly Line**
Hossein Tohidi and Tarek Algeddawy

Section 4 – Numerical Simulation and Experimental Studies

No.	Poster Title	Authors

4.1 **Investigation of Waveforms of Roller Bearing's Working Surfaces on Centerless Grinding Operations**
Vasyl Chalyj, Serhii Moroz, Vitalij Ptachenchuk, Valentin Zablotskyj and Stanislav Prystupa

4.2 **Theoretical and Experimental Studies of Changes in the Workpiece Shape during Narrow Die Indentation**
Vitalii Chukhlib, Evhen Klemeshov, Serhii Gubskyi, Anton Okun and Nikolay Biba

4.3 **A Numerical-Analytical Model of the Temperature Field Distribution During Orthogonal Cutting of Composites**
Gennadii Khavin, Magomedemin Gasanov, Alexander Permyakov and Viktoria Nevludova

4.4 **Investigation of the Grinding Process Considering the Increase of the Active Surface of Abrasive Grains**
Maksym Kurin, Serhii Nyshnyk and Anatolii Dolmatov

4.5 **Processing of Parts under Pulse Loading of a Vibrating Hopper**
Yurii Lapchenko, Volodymyr Symoniuk and Viktor Denysiuk

4.6 **Influence of the Thread Profile Accuracy on Contact Pressure in Oil and Gas Pipes Connectors**
Oleh Onysko, Volodymyr Kopei, Iulia Medvid, Lolita Pituley and Tetiana Lukan

4.7 **Numerical Simulation of Local Plastic Deformations of a Cylindrical Workpiece of a Steel Wheel Rim**
Yuliia Salenko, Ruslan Puzyr, Oleksandr Shevchenko, Viktoriia Kulynych and Oleksandr Pedun

4.8 **Peculiarities of Interaction of Micro-Roughnesses of Contacting Surfaces at FANT**
Ihor Shepelenko, Yakiv Nemyrovskyi, Yuri Tsekhanov, Sergii Mahopets and Oleh Bevz

Section 5 – Advanced Materials

No.	Poster Title	Authors
5.1	**Influence of Modifiers-Ligatures on the Properties of Cast Aluminum Alloy AK5M2 for the Automotive Industry**	*Kristina Berladir, Tetiana Hovorun, Oleksandr Gusak, Yaroslav Reshetniak and Djanibek Khudaybergenov*
5.2	**Numerical Simulation of Elasto-Plastic Behavior of Isotropic Composite Materials**	*Anton Karvatskii, Ihor Mikulionok, Serhii Leleka and Vladyslav Solovei*
5.3	**Simulation of the Process of Obtaining Nanostructures During Laser Radiation on Materials, Cutting Tools and Parts**	*Gennadiy Kostyuk, Viktor Popov, Mykola Nechyporuk, Olecsandr Tymofyeyev and Hanna Yevsieienkova*
5.4	**Strength Properties Control of Mixtures Based on Soluble Glass with Ethereos Solidifiers**	*Olga Ponomarenko, Tatyana Berlizeva, Igor Grimzin, Natalya Yevtushenko and Tatiana Lysenko*
5.5	**Design of New Nanocoatings Based on Hard Alloy**	*Viktor Popov, Gennadiy Kostyuk, Olecsandr Tymofyeyev, Kateryna Kostyk and Olena Naboka*
5.6	**Structure and Corrosion Resistance of Vacuum-Arc Multi-period CrN/Cu Coatings**	*Hanna Postelnyk, Oleg Sobol', Ondrej Chocholaty and Sergey Knyazev*
5.7	**Structural Engineering of Nanocomposite Coatings Based on Tungsten and Titanium Carbides**	*Oleg Sobol' and Osman Dur*
5.8	**Numerical Simulation of the Microstructure of Structural-Inhomogeneous Materials**	*Oleg Zabolotnyi, Viktoriya Pasternak, Igor Andrushchak, Nataliia Ilchuk and Kostiantyn Svirzhevskyi*

Section 6 – Mechanics of Solids and Structures

No.	Poster Title	Authors

6.1 **Liquid Sloshing in Circular Toroidal and Coaxial Cylindrical Shells**
Artem Karaiev and Elena Strelnikova

6.2 **Experimental Identification of a Car Dynamic Model Using the Numerical Algorithms for Subspace State-Space System Identification**
Antonio Lettieri and Carmine Maria Pappalardo

6.3 **Cavitational Wearing of Modified Ceramics**
Alexander Litvinenko, Yuriy Boyko, Bohdan Pashchenko, Yuriy Sukhenko and Evgenii Shtefan

6.4 **Design of Hydraulic Mechatronic Systems with Specified Output Characteristics**
Anatolii Panchenko, Angela Voloshina, Olena Titova, Igor Panchenko and Anatoly Caldare

6.5 **Development of an Energy Recovery Device Based on the Dynamics of a Semi-Trailer**
Massimo Sicilia and Marco Claudio De Simone

6.6 **Gravitational Relief with Spiral Gutters, Formed by the Screw Movement of the Sinusoid**
Sergiy Pylypaka, Tatiana Volina, Mikola Mukvich, Galina Efremova4 and Olena Kozlova

6.7 **Operating Characteristics of Lever-Blade Shock Absorbers with the Extended Mechanical Structure**
Ihor Sydorenko, Vladimir Tonkonogyi, Yuliia Babych, Yuliia Barchanova and Yiheng Zhang

Section 7 – Numerical Simulation of Coupled Problems

No.	Poster Title	Authors

7.1 **Simulation of Wearing Processes with High Sliding Speed**
Aleksandr Dykha, Ruslan Sorokatyi and Volodymyr Dytyniuk

7.2 **Analysis of the Initial Corrosion Stage of a Steel Disk Under the Influence of Stress**
Vladimir Klimenko, Iryna Shuda and Tetyana Zhylenko

7.3 **Research on the Energy State of the Surface of Alloys for Gas-Turbine Engine Blades**
Stephan Loskutov, Dmytro Pavlenko, Dmytro Stepanov, Natalia Honchar and Olena Khavkina

7.4 **Topology Optimization Procedure of Aircraft Mechanical Components Based on Computer-Aided Design, Multibody Dynamics, and Finite Element Analysis**
Adriano Gabriel Manca and Carmine Maria Pappalardo

7.5 **Simulation of Bird Collision with Aircraft Laminated Glazing**
Natalia Smetankina, Igor Kravchenko, Vyacheslav Merculov and Dmitry Ivchenko

Section 8 – Chemical Process Technology

No.	Poster Title	Authors
8.1	**Parameter Identification of the Capillary Rising Process in Nanomaterials for Evaporative Cooling Applications**	*Dmytro Levchenko, Ivan Pavlenko, Anton Shulumei, Marek Ochowiak and Andrii Manzharov*
8.2	**Hydrodynamics of Two-Phase Upflow in a Pneumatic Classifier with the Variable Cross-Section**	*Andrii Lytvynenko, Ivan Pavlenko, Mykola Yukhymenko, Ruslan Ostroha and Jan Pitel*
8.3	**Effect of Hydrodynamic Parameters on Membrane Electrolysis Enhancement**	*Vasyl Serdiuk, Vsevolod Sklabinskyi, Svetlana Bolshanina, Alexey Ableyev and Tetiana Dychenko*
8.4	**Numerical Simulation of the Mass-Transfer Process Between Ammonia and Water in the Absorption Chiller**	*Michal Volf, Maryna Demianenko, Oleksandr Starynskyi, Oleksandr Liaposhchenko and Alireza Mahdavi Nejad*
8.5	**Cooling Process Intensification for Granular Mineral Fertilizers in a Multistage Fluidized Bed Device**	*Mykola Yukhymenko, Ruslan Ostroha, Andrii Lytvynenko, Yakov Mikhajlovskiy and Jozef Bocko*
8.6	**Influence of High-Octane Bioadditives on Physical and Chemical Properties of Low-Octane Gasoline**	*Nina Merezhko, Valentyna Tkachuk, Viktoria Romanchuk, Oksana Rechun and Oksana Zolotariova*

Section 9 – Heat and Mass Transfer

No.	Poster Title	Authors

9.1 **Development of the Typical Design of the High-Pressure Stage of a Steam Turbine**
Olena Avdieieva, Oleksandr Usatyi and Oleksii Vodka

9.2 **Improvement of the Heat Substation Design for District Heating Supply Systems**
Tetiana Babak, Alexey Demirskyy, Gennadii Khavin and Viktoria Nevludova

9.3 **Experimental Research of the Excessive Water Injection Effect on Resistances in the Flow Part of a Low-Flow Aerothermopressor**
Dmytro Konovalov, Halina Kobalava, Roman Radchenko, Vitaliy Maksymov and Mykola Avdeev

9.4 **Characteristics of The Rotary Cup Atomizer Used As Afterburning Installation In Exhaust Gas Boiler Flue**
Victoria Kornienko, Roman Radchenko, Dmytro Konovalov, Andrii Andreev and Maxim Pyrysunko

9.5 **Possibility of Using Liquid-Metals for Gas Turbine Cooling System**
Oksana Lytvynenko, Oleksandr Tarasov, Iryna Mykhailova and Olena Avdieieva

9.6 **Analysis of the Efficiency of Engine inlet air Chilling Unit with Cooling Towers**
Andrii Radchenko, Andrzej Stachel, Serhiy Forduy, Bohdan Portnoi and Oleksandr Rizun

9.7 **Enhancement of the Operation Efficiency of the Transport Air Conditioning System**
Mykola Radchenko, Dariusz Mikielewicz, Veniamin Tkachenko, Serhiy Kantor and Andrii Andreev

9.8 **The Efficiency of Refrigeration Capacity Regulation in Ambient Air Conditioning Systems**
Eugeniy Trushliakov, Andrii Radchenko, Mykola Radchenko, Serhiy Kantor and Oleksii Zielikov

Day 3: June 11, 2020, Thursday

8^{00}–9^{00}	**Registration**
9^{00}–10^{00}	**Session 3 – Chemical Engineering** *Chair: Oleksandr Liaposhchenko* Sumy State University, Ukraine

Improvement of the Model System to Develop Eco-Friendly Bio-Utilization of Phosphogypsum

Yelizaveta Chernysh[1] and Koichi Hasegawa[2]

[1] Sumy State University, Ukraine

[2] Chubu University, Japan

Heat Exchange Characteristics of Trays for Concentrating Solutions in Direct Contact with Hot Gas Emissions

Musii Tseitlin, Valentyna Raiko and Aleksei Shestopalov

National Technical University «Kharkiv Polytechnic Institute», Ukraine

Substantiation of Energy Parameters of a Continuous-Action Vibroextractor for a Solid-Liquid System

Volodymyr Zavialov, Taras Mysiura, Nataliia Popova, Yuliia Zaporozhets and Valentyn Chornyi

National University of Food Technologies of Ukraine, Ukraine

Influence of the Magnetic Field Gradient on the Efficiency of Magnetic Water Treatment

Ihor Roi[1], Iryna Vaskina[1], Krzysztof Jozwiakowski[2], Roman Vaskin[1] and Ivan Kozii[1]

[1] Sumy State University, Ukraine

[2] University of Life Sciences in Lublin, Poland

Improvement of the Production Technology of Liquid Biofuel from Technical Fats and Oils

Mikhailo Mushtruk, Volodymyr Vasyliv, Nataliia Slobodaniuk, Roman Mukoid and Olena Deviatko

National University of Life and Environmental Sciences of Ukraine, Ukraine

10^{00}–10^{15}	**Technical Break**

10^{15}–11^{15} **Session 4 – Materials Engineering**
Chair: Oleg Zabolotnyi
Lutsk National Technical University, Ukraine

Influence of Weak Shock Wave on the Dynamic Stress State of Foam Materials
Olena Mikulich, Lyudmila Samchuk and Yulia Povstiana
Lutsk National Technical University, Ukraine

Optimization of the Technological Process Based on Analysis of Technological Damageability of Castings
Yaroslav Kusyi and Vadym Stupnytskyy
Lviv Polytechnic National University, Ukraine

Effect of Morphological Features on Dielectric Properties of Plasma Electrolytic Oxidation Coatings on D16T Aluminum Alloy
Elena Sevidova[1], Larisa Pupan[1], Yuriy Gutsalenko[1], Aleksandr Rudnev[1] and Oksana Titarenko[2]
[1] National Technical University «Kharkiv Polytechnic Institute», Ukraine
[2] National Academy of the National Guard of Ukraine, Ukraine

Research of Thermomechanical Processes when Processing Cylindrical Surfaces with Wear-Resistant Coatings
Maksym Kunitsyn and Anatoly Usov
Odessa National Polytechnic University

Analysis of Frictional Interaction in a Couple "Billet – Crystallizer"
Oleg Khoroshylov[1], Oleg Podolyak[1], Valentina Kuryliak[2], Andrey Kipensky[3] and Andrey Lomakin[1]
[1] Ukrainian Engineering Pedagogics Academy, Ukraine
[2] Ukrainian Institute of Arts and Science, Ukraine
[3] National Technical University «Kharkiv Polytechnic Institute», Ukraine

11^{15}–11^{30} **Technical Break**

11^{30}–12^{30} **Session 5 – Interdisciplinary Engineering**
Chair: Jose Machado
University of Minho, Portugal

State-of-the-art in Product-Service System Classification
Mariusz Salwin[1] and Andrzej Kraslawski[2,3]
[1] Warsaw University of Technology, Poland
[2] Lappeenranta University of Technology, Finland
[3] Lodz University of Technology, Poland

Ultrasonic Technology of Impregnation and Dosing Application of Liquid Epoxy Binders on Fabric Fiber Fillers

Aleksandr Kolosov, Aleksandr Gondlyakh, Elena Kolosova, Dmytro Sidorov and Iryna Kazak

National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», Ukraine

Combined Thermo-Mechanical Techniques for Post Processing of the SLM-Printed Ni-Cr-Fe Alloy Parts

Dmytro Lesyk[1], Silvia Martinez[2], Oleksii Pedash[3], Vitaliy Dzhemelinskyi[1] and Bohdan Mordyuk[4]

[1] National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», Ukraine

[2] University of the Basque Country, Spain

[3] Motor Sich JSC, Ukraine

[4] G.V. Kurdyumov Institute for Metal Physics of the NAS of Ukraine, Ukraine

Simulation of Thin-Walled Parts End Milling with Fluid Jet Support

Serhii Kononenko, Sergey Dobrotvorskiy, Yevheniia Basova, Ludmila Dobrovolska and Vitalii Yepifanov

National Technical University “Kharkiv Polytechnic Institute”, Ukraine

Finite Element Analysis of Profile Grinding Temperature

Natalya Lishchenko, Vasily Larshin and Sergei Uminsky

[1] Odessa National Academy of Food Technologies, Ukraine

[2] Odessa National Polytechnic University, Ukraine

[3] Odessa State Agrarian University, Ukraine

$12^{30} – 13^{00}$ **Closing & Awards Ceremony**

Chair: Vitalii Ivanov

Sumy State University, Ukraine

Day 4: June 12, 2020, Friday

9^{00}–11^{00}	**Q&A Session for Organizational Issues** *Chair: Vitalii Ivanov* Sumy State University, Ukraine

Presentation Guidelines

The official language of the DSMIE-2020 is English.

Keynote presentations

Each presentation is 30 minutes long. It is recommended to use 25 minutes to present and 5 minutes for open discussion/questions.

Keynote speakers can freely choose the format and style of their presentations.

Also, they can use the official template of the DSMIE-2020, that can be downloaded via link https://dsmie.sumdu.edu.ua/calls/presentation-guidelines.html.

Oral presentations

Individual papers are grouped into thematic sessions, which usually consist of five oral presentations. Each presentation is 10 minutes long. It is recommended to use 7 minutes to present and 3 minutes for open discussion/questions.

The recommended file type to be used for presentations is PowerPoint (*.pptx) or Portable Document Format (*.pdf). The presentation files should be sent to the Organizing Committee (dsmie@teset.sumdu.edu.ua) not later than **June 7, 2020**. All presenters will be introduced to the audience by the Session Chair.

We highly recommend preparing a 16-slides presentation in the structure mentioned below and kindly do not deviate from the format and the maximum number of slides:

- Title Slide [1 slide];
- 1 Introduction and Major Challenges [1 slide];
- 2 Aim and Research Tasks [1 slide];
- 3 Research Methodology [maximum 4 slides];
- 4 Results [maximum 5 slides];
- 5 Conclusions [1 slide];
- References [1 slide];
- Acknowledgment [1 slide];
- Thank you [1 slide].

Remember that you can expand your presentation, giving a speech, and only essential information should be presented in slides. The maximum number of slides in the presentation can be 20.

The following points should be taken into consideration when preparing your oral presentation:

- Ensure that you are available at least 30 minutes before the session starts on the day of the conference.
- Session PC will be equipped with a recent version of the Windows OS, as well as MS PowerPoint and Acrobat Reader software. Presenters are strongly urged to use PDF for their presentations to avoid issues with fonts and other problems. Remember to embed all your fonts into your presentation.
- If you are playing video or animated media, make sure it runs on Windows Media Player.
- When preparing your slides, make sure that they will be legible for the entire audience (i.e., use fonts of sufficient size). JPEG/TIFF images are the preferred file format for inserted images. Images inserted into PowerPoint are embedded in the presentations. Try to avoid overloading the presentation with additional images.
- Suggested fonts are Calibri, Arial, and Times New Roman. If you insist on using different fonts, these must be embedded into the presentation by choosing the right option when saving the presentation (Click on “File”, then “Save As” and Check the “Tools” menu and select “Embed True Type Fonts”).

Recommendations to make an excellent oral presentation:

- Contents of the Presentation should be structured and have the following parts: title, introduction, aim and research tasks, results, conclusions, etc.
- Presentations should not contain full paragraphs of text. Use a bulleted list or outline format and elaborate on the points in your talk.
- Every slide should contain a title that summarizes the information presented on the slide.
- Create a logical flow for your presentation.
- Use large fonts, as big as realistically possible. Small fonts are hard to read.
- Use an ONLY WHITE background with dark text.
- Avoid busy backgrounds that will make the text hard to read. Keep the background simple.
- Limit your graphics to 1-3 per page. Too many graphics can be distracting. Include a good combination of words, pictures, and graphics. Variety keeps the presentation interesting.
- Slides are designed to supplement your presentation, not to be your presentation. Keep it simple, and do not read your presentation word for word from your slides.

- Fill out a storyboard before you begin to put your presentation together. It will help you stay organized, and things will get done faster. Do not read from the slide – vary your choice of words.
- Maintain eye contact with the audience.
- Use a laser pointer to indicate salient features of the slide as you speak (there will be one provided in the session room).
- Speak loudly and articulate.
- The template of the presentation can be downloaded via link https://dsmie.sumdu.edu.ua/calls/presentation-guidelines.html.

Posters

Posters both in PowerPoint (*.pptx) and Portable Document Format (*.pdf) should be sent to Organizing Committee (dsmie@teset.sumdu.edu.ua), not later than **May 31, 2020**. They will be posted on the Conference website for evaluation before the start of the Conference.

Posters should be printed and brought by each author to the conference Registration Desk. The dimensions of the poster should be one page of A1 sized (841 x 594 mm). At the appointed time, at least one of the authors is expected to be at their designated poster board to answer questions and discuss their work with conference participants during the session.

The following points should be taken into consideration when preparing your poster presentation

- Ensure that you are available at least 30 minutes before the Poster Session starts on the day of the conference.
- Authors are required to mount their posters between 15:30 and 16:00 and unmount their posters at 17:30.
- The DSMIE Team is not responsible for mounting/unmounting posters.

Recommendations to make an excellent poster presentation

- Its contents should be structured and have the following parts: title, introduction, research methodology, results, conclusions, etc.
- Presentations should not contain full paragraphs of text. Use a bulleted list or outline format and elaborate on the points in your talk. Create a logical flow for your presentation.
- Include a good combination of words, pictures, and graphics. Variety keeps the presentation interesting.
- Fill out a storyboard before you begin to put your presentation together. It will help you stay organized, and things will get done faster. Do not read from the poster - vary your choice of words.

- Do not talk to the screen; maintain eye contact with the audience.
- The template of the poster can be downloaded via link https://dsmie.sumdu.edu.ua/calls/presentation-guidelines.html.

Awards

One Best Presentation will be selected based on the recommendations of the Session Chairs. One Best Poster will be selected based on the participants' evaluation.

The Certificates for Best Presentation Award and Best Poster Award will be awarded during the Closing & Awards Ceremony (June 11, 2020).

Please note that only presented papers are eligible for the Best Award. Awards will be granted by the International Association for Technological Development and Innovations.

Keynote Speakers

Keynote Speaker

Erwin Rauch,
Ph.D., Assistant Professor
Faculty of Science and Technology,
Free University of Bozen-Bolzano, Italy

Erwin Rauch received his B.Sc. in Logistics and Production Engineering from the Free University in Bolzano (Italy). He also holds an M.Sc. in Mechanical Engineering from the Technical University Munich (TUM) and an M.Sc. in Business Administration from the TUM Business School. Dr. Rauch obtained his Ph.D. degree in Mechanical Engineering from the University of Stuttgart with summa cum laude. Currently, he is an Assistant Professor for Manufacturing Technology and Systems at the Free University of Bolzano. His current research is on Industry 4.0, Smart and Sustainable Production Systems, Digitization, and Assistance Systems in Production and Axiomatic Design. Also, he is the Head of the Smart Mini Factory Laboratory for Industry 4.0 at the Free University of Bolzano. As a project manager, he coordinates the European Union research project “SME 4.0 – Industry 4.0 for SMEs” working with research partners from Europe, the USA, and Asia. He was a Visiting Researcher/Professor at Chiang Mai University (Thailand) and Worcester Polytechnic Institute (USA).

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

Keynote Speech Topic

Industry 4.0+: The Next Level of Intelligent and Self-Optimizing Factories

Digital technologies are increasingly changing society. In the production sector, the term “Industry 4.0” in particular introduced a new era of digitally networked production almost ten years ago. The basic idea of Industry 4.0 was to be able to unfold the advantages through comprehensive connectivity on the shop floor as well, by connecting products, machines, employees with the production system and with all those involved in the value chain, thereby minimizing information disruptions and the resulting inefficiencies by smart factories. To manage interconnected systems between physical assets and computational capabilities, so-called Cyber-Physical Systems, were introduced as transformative technologies leveraging the interconnectivity of machines. Findings from the EU project “SME 4.0 - Industry 4.0 for SMEs” show that many companies do not yet have such a smart and connected manufacturing system, but are on the way to achieving this goal in the medium-term. The next groundbreaking level to be achieved, are Intelligent and Self-Optimizing Manufacturing Systems. While a smart factory can be understood as a manufacturing system, which is capable of applying previously acquired knowledge, an intelligent factory may be seen as a factory which can autonomously acquire new knowledge and to apply it for self-optimization purposes. To achieve this goal, the results from the first phase of the Industry 4.0 era play an important role as connectivity, and modern technologies are a prerequisite for this next level of Industry 4.0+. Several authors are also speaking about Industry 5.0, although it might see more as two phases of Industry 4.0 with a final vision of an intelligent and self-learning/optimizing factory. Based on the results of the first phase, production resources can collect a large amount of high-quality data using sensors, vertical and horizontal data integration guarantees seamless data exchanges, a large amount of big data can be stored and managed via cloud technologies and be processed into more structured data with big data technologies. The next phase of Industry 4.0+ aims to take advantage of this data, creating intelligent and self-optimizing factories, whereby we are already still far away from this vision. It is important to look for new and innovative solutions to how this new level of data quantity and quality can be utilized in companies for self-monitoring and intelligent self-optimization of the manufacturing system. Artificial Intelligence and Bio-Inspired Manufacturing may open up completely new possibilities in this direction. Although Artificial Intelligence and approaches of bionics in manufacturing existed already years ago, now is the right time to take full advantage of these concepts. The presentation shows an outlook on a new level of Industry 4.0 and future trend topics such as Artificial Intelligence and Bio-Inspired Manufacturing.

Keynote Speaker

Dagmar Caganova,
Ph.D., Associate Professor
Ambassador/Representative for Foreign Affairs at the Faculty of Materials Science and Technology in Trnava,
Slovak University of Technology in Bratislava, Slovak Republic

Dagmar Caganova is also the co-founder of the European Alliance for Innovation in the Slovak Republic, management committee member of E-COST (European Collaboration in Science and Technology) TN 1301 Sci Generation, the executive committee member in Danubius Academic Consortium (academic network for Integral Innovation), steering committee member of Danube strategy PA 7 Knowledge society-science, research, innovation and ICT for the Slovak Republic.

Her professional interests, research topics, and international collaborations are mainly focused on Intercultural and Innovation Management, Human Resource Management, Mobility and Smart Cities, International Relationships, and Gender Diversity. She is a member of journal editorial boards, organizer, steering committee member of many national and international summits and conferences. She also acts as a tutor on the Ph.D. study program and has participated in solving national and international scientific and educational projects in various project schemes. At present, she acts as project head for MTF in Horizon 2020 project "Linking Research and Innovation for Gender Equality" with acronym CALIPER. She is a Special Issue journal editor and co-editor of the books published by Springer Nature. She is an author of scientific monographs, papers in current content journals, indexed by Web of Science and Scopus.

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

Keynote speech topic

Industry 4.0 Best Practices and Challenges

Nowadays, this issue is carried out in the Institute of Industrial Engineering and Management at the Faculty of Materials Science and Technology in Trnava, the Slovak University of Technology in Bratislava, the Slovak Republic. This running project, with the title “Working Competencies in the Context of Industry 4.0”, is supported by the National Cultural and Education Grant Agency. The focus is put on identifying specific new job requirements in the form of key work competences and digital skills in the context of the technological development and working environment Industry 4.0. Considering above mentioned, it is needed to contribute to the actual flow of information between labor market actors, reflecting the development of key competencies and digital skills in practice. One of the speech objectives is to specify new job requirements in selected production sectors. So far, it reflects the key challenges in the Industry 4.0 strategy development within the Slovak Republic. Although hard skills should be expected to be developed in the era of Industry 4.0, human resource managers declare that soft skills are more needed to be in the center of attention. That is why the key question is relevant: Which skills and competences development is the most crucial for industrial enterprises in relationship to Industry 4.0? Finally, special attention will be paid to gender diversity and equality as a 5th strategic goal of the Agenda 2030 for Sustainable Development. In the end, there are summarised and highlighted the main trends and challenges within Industry 4.0.

Keynote Speaker

Mateusz Barczewski,
Ph.D., Adjunct
Faculty of Mechanical Engineering and Management,
Poznan University of Technology, Poland

Mateusz Barczewski is a researcher at the Institute of Materials Technology, Faculty of Mechanical Engineering and Management, Poznan University of Technology, Poland.

His research interests are the development of novel polymeric composites and biocomposites, waste management, and rheological measurements. Most of his work was focused on a realization of several projects financed from regional and European Union funds as well as international European projects from the 7th Framework Programme for Research and Technological Development. As a project manager, he coordinates work in project realized underfunding of National Center of Research and development of Poland over the development of novel biocomposites for the automotive industry. He is a journal editor of the special issues in JCR indexed journals and author of more than 70 scientific papers published as monographs, conference proceedings, and papers, including more than 50 peer-reviewed publications in JCR indexed journals.

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

Keynote speech topic

Application of Basalt Powder as a Perspective Low-Cost Waste Filler for Polymeric Composites with Lowered Environmental Impact

Polymeric composites modified with inorganic fillers are widely used due to their good mechanical and thermal properties. The modification efficiency of the filler incorporated into the polymeric matrix depends strongly on its shape, size, and structure. Possibility of composite materials development, characterized by improved thermal stability and reduced price, may be achieved by the application of powder-like low-cost natural fillers such as talc, zeolite, bentonite, or calcium carbonate. Basalt is an inorganic mineral that may be shaped into fibers or finely ground powder. Due to localization of the basalt rock deposit in Europe, also Poland, and Ukraine, finding new ways of its applications, such as a filler for composite materials, seems reasonable. Basalt is mostly used in civil engineering for the production of track ballast and production of high-performance concrete grades. Due to its superior abrasion, chemical and wear resistance, basalt in the form of particles can be used as a filler for thermoset and thermoplastic materials. In our studies, the possibility of use of the basalt powder, which is a waste byproduct generated during the road ballast production as a filler for different polymer types, is discussed. Basalt powder has a fine grain structure and includes very hard phases like diopside and augite; as a result, basalt base materials present superior abrasion, wear, and chemical resistance. The results clearly showed that the use of basalt powder allows enhancing the thermo-mechanical and thermal properties similar to the use of basalt fibers while using a material with a significantly lower price. The possibility of using basalt powder as a filler for thermoplastic as well as thermoset composites was discussed in the course of changes in their mechanical, thermo-mechanical, thermal properties, and fire behavior. For all modified materials, the introduction of the eco-friendly basalt powder filler into the matrix resulted in significantly improved stiffness, hardness, and thermo-mechanical stability. Due to the high thermal stability of basalt, the fire behavior and thermal stability of composites based on different materials were strongly influenced. Presented results are a summary of long-term investigations on the development of novel sustainable composites based on waste filler. The incorporation of the basalt powder as a low-cost inorganic filler allows producing thermoplastic as well thermoset composites with significantly improved thermo-mechanical and thermal stability, increased stiffness and hardness, and modified flammability.

Keynote Speaker

Arun Nagarajah,
Ph.D., Professor
Head of the Department of Product Development Processes and Data Management,
University of Duisburg-Essen, Germany

Prof Nagarajah is a University Professor, Chairman of the Chair of Product Development Processes and Data Management at University Duisburg-Essen, Germany.

He studied mechanical engineering and quality management at University Wuppertal (Germany) and completed a doctorate in the field of product development methods at RWTH Aachen (Germany). He served as a research assistant at Ruhr-University Bochum and RWTH Aachen. He also has several years of industrial experience in the automotive industry.

Prof. Nagarajah is a member of professional societies and involved as an expert for the evaluation of research projects. He is a Head of VDI Working Group “Bergisches Land” for Development and Design and reviewer for “Federal Ministry of Education and Research (BMBF)” and “German Research Foundation (DFG)”.

His research focused on the application of data mining methods for optimization of the product development process; application of artificial intelligence methods for the development of expert systems in product development; use of virtual and augmented reality approaches for early assurance of product development; application of the systems engineering approach for the effective and efficient description of a “digital twin”, product lifecycle management.

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

Keynote Speech Topic

Digital Twin – A Scientific View

Digital Twin is currently a much-discussed topic in business and science. The different parties pursue the goal of working out the benefits of implementation on the one hand, and of modeling a purpose-oriented digital twin on the other hand. A challenge both in science and in the industrial environment is that there is no common understanding or definition of the term digital twin, which makes it difficult in the discussion. If one searches for the commonality from the different definitions, then the term digital twin can overall be understood as a digital representation of a real product or process. As a technology, it seems to open up great opportunities for industry and business, but it also poses great challenges. Digital twins are, therefore, becoming increasingly important in research. The scientific work to date has given too little attention to the question of whether this approach is merely a new name for an existing approach. The aim of the keynote is a critical examination of the digital twin from a scientific perspective. The question should be investigated in which aspects of a digital twin are already covered in the existing PLM approach and which aspects represent a novelty. For this purpose, the core aspects of the technology were identified and compared to PLM. The comparative analysis shows clear similarities. These similarities concern the problem areas, the structure of the data models, and the focus on the whole life cycle phases of a product. From this, it can be argued that the concept of the digital twin, as defined by the industry, is scientifically comparable to the concept of PLM. It means that definitions, methods and IT systems used to implement PLM can be used purposefully for digital twins in an industry context.

Keynote Speaker

Domenico Guida,
Ph.D., Professor
Department of Industrial Engineering,
University of Salerno, Italy

Domenico Guida is a Full Professor at the Department of Industrial Engineering of the University of Salerno, and the Director of the International Master in Engineering and Innovation Management (operational headquarters in Bogota (Columbia)). He is the coordinator of joint academic projects between European and Latin American universities, and since 2019 he is the Director of ITACOL, an International University Center composed of European and Latino American universities. Prof. Guida has been the principal investigator of national research projects (PRIN) and tutor of dozens of Ph.D. students. He is a member of AIMETA, ASME, SEM, IATDI, and he is author of more than one hundred scientific papers (h-index 22) in Applied Mechanics, Rotordynamics, Tribology, Mechatronics, and Control Systems. He has been an expert evaluator of R&D projects co-funded by the EU and the Italian Government. Since 2017 he is the CEO of MEDI4 Ltd., an Academic Spin-Off, whose mission is to cooperate with European SMEs for developing joint R&D projects in manufacturing, transport, and agro-industrial sectors. Since 2010 he is project leader of massive industrial research programs co-funded by EU and national institutions for the development of Unmanned Ground Vehicles, Operating Machines, Aircraft for Special Missions: MILVUS (RPAS - Remotely Piloted Aircraft Systems), DOOR 4.0 (Optimization of Aircraft Cargo Doors), OPUS (Aerospace Robots), MCR – (Robots for Building Maintenance), HAPS_2020 (A new High Altitude Platform Station), GRINTA (Green Intelligence on TomAto Industry) (only those with a budget of more a million euros).

https://www.researchgate.net/profile/Domenico_Guida4

Keynote Speech Topic

HAPS_2020 – A New Altitude Platform Station

HAPS_2020 is the title of a large joint project between the University of Salerno and an Aerospace Italian Company (http://www.aeronet.it/en/), whose goal is the development of a hybrid remotely-piloted-hydrostatic-aircraft for carrying out long-term missions in stratospheric regions. The project has been co-funded in the framework of structural funds of the European commission named: "Strengthening of the Regional Innovative System". The platform is useful for surveillance of large areas, the control of infrastructures, the prevention of fires, the patrolling of the coasts or borderlines, as well as activities related to tourism, the innovative management of archaeological sites, or sites of great cultural interest. In this presentation, the speaker will give an overview of the most critical and challenging tasks that the partnership is facing for the development of the prototype: propulsion system based on photovoltaic and fuel-cell system, the structure of the envelop, materials, critical issues for experimental simulations.

Keynote Speaker

Alex Enrich Prast,
Ph.D., Associate Professor
Department of Thematic Studies,
Linkoping University, Sweden

Biography

Alex Enrich Prast is an associate researcher to the Biogas Research Center (www.biogasresearchcenter.se), a competence center hosted by Linköping University that has the goal to strengthen the implementation of the resource-efficient biogas solutions in the society.

His research in engineered ecosystems focuses on the understanding of the main regulatory factors of the different anaerobic processes with a general aim to increase Biogas reactor's performance. The more we elucidate and understand the mechanisms that drive anaerobic digestion, the more we can increase and methane yield and increase the reuse of elements present in its waste. Biogas reactors also render the opportunity to experimentally understand the factors that regulate anaerobic processes in natural systems. This understanding is essential to consistently increase the biogas production from several organic waste sources and increase the quality of the leftovers, also known as digestate, that can be used as biofertilizer.

https://www.researchgate.net/profile/Alex_Enrich-Prast

Keynote Speech Topic

Biogas solutions: dealing with local and global challenges

Anaerobic digestion is a technology that can generate methane while degrading organic waste in Biogas reactors. The biomethane generated in biogas reactors is one of the existing green technologies with one of the largest societal benefits. During anaerobic digestion not only biogas is produced, but also a biofertilizer that can, in most of the cases, replace mineral fertilizer. However, this technology has a much broader spectrum of societal benefits that are commonly not recognized or acknowledged. Biogas technology provides solutions to many local environmental problems, but its application also contributes to minimizing several global challenges. I will present some examples implemented in Sweden, that made the Biogas production and consumption a successful business model. Sweden has recently decided to increase national biogas production from the current 2 TWh to 7 TWh to contribute to assuring the Swedish internal supply of energy and fertilizer and for the achievement of the Swedish climate polity framework for 2030 and 2045. Some aspects of the “Nordic model” of Biogas production will be shown, and some research challenges and opportunities will be highlighted and discussed. A broader perspective of the benefits from the biogas technology to the implementation of UN Sustainable Development Goals will also be addressed.

Abstracts
Part I
CAx Technologies for Product Design

Comparative Analysis of Platforms for Designing a Digital Twin

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The advancing digitization and related topics such as Industry 4.0 are becoming increasingly important for companies. Digital Twin is one of the most popular terms in the context of Industry 4.0. While not new, this approach has been brought to life with recent technological advances. Digital twins of products should help to analyze their life cycle and optimize development, operation, and service processes. For that, the necessary data must be collected and stored throughout the product life cycle and can also be provided for other tasks. The data is usually available in different formats and at different endpoints. Collection and integration of data into existing information systems are also complicated due to the typically large amount of data and typically manageable only with great effort. The structure and design of the digital twin are currently not standardized. Different are the structures, scope, and design methods. Regardless of building techniques and structure, a digital twin building platform must be defined to bring together models and data from different disciplines and to ensure the benefit of using the digital twin. In the present work, the various platforms that can be used to create a digital twin are examined and compared, since each platform has advantages and disadvantages.

Keywords: Digital Twin, IoT, Platform.

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Computer-Integrated Design Pistons with the Influence of Casting Defects

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In this work, the scientific and practical problem of increase of strength reliability of cast pistons of internal combustion engines taking into account the influence of defects of the casting of gas-shrink character and application of the computer-integrated design is considered. The research aims to create a methodology for determining the locations and sizes of defects in the cast piston with the joint use of computer-integrated modeling and experimental studies in production. For the first time, a method of complex determination of dislocation locations and sizes of gas-shrinkage defects in a cast piston with joint use of computer-integrated modeling and experimental studies in production is proposed and developed. The boundary conditions for calculating the thermal and stress-strain state of the VAZ 21083-1004015 piston in the locations of defects are specified. In this work, the scientific and practical problem of increasing the strength reliability of cast engine pistons is solved, taking into account the influence of casting defects of a gas-shrink nature and using computer-integrated design. Thus, the joint use of the modern computer-integrated design of cast engine pistons with continuous design and technological interaction, which is a powerful tool for the development of new parts and modernization of existing ones, is justified. Also, the paper substantiates the need for the use of systems of engineering modeling of technological processes of production and analysis of the thermal and stress-strain state of cast engine pistons.

Keywords: Computer-Integrated Design, Piston, Engine, 3D Model, Casting Defect.

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Improvement of the Effectiveness of General Engineering Courses Using Trainers

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This article runs about the principles of developing and using trainers to enhance students' educational and learning activities while studying engineering. The authors analyzed modern works of the development, implementation, and improvement of the use of trainers. Based on a generalization of the experience of such developments, a methodological approach was provided, based on the properties and functions of actions when using trainers, principles of visual modeling, sign and symbolic activity. The algorithm for the development of trainers in higher educational establishments is also recommended. At the same time, the requirements for the development of trainers were considered, considering the primary and secondary characteristics of actions, such as the form of the action, the measure of its generality, as well as the awareness and reasonableness of the actions. In addition, the authors provide a scheme to improve the sign and symbolic activity during the development and use of trainers in the study of engineering disciplines. The given methodological approach to the design of trainers is the possibility of a scientifically based solution to the problem of the formation of the most general principles of activity for students and the ability to independently develop the whole system of scientific knowledge based on them.

Keywords: Trainer, Methodological Approach, Simulator, Interchangeability.

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Modeling of Spindle Node Dynamics Using the Spectral Analysis Method

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The article discusses the study of the elastic system dynamics for spindle assembly of drilling-milling-boring machining center type. A three-dimensional model of the spindle assembly on rolling bearings is built. A constructive and design diagram of the spindle assembly and a system of forces acting in the process of milling workpieces are formed. The statement on the polyharmonic nature of the input power effect change during the milling process is substantiated. The phenomenon of modeling disturbing effects by superimposing a “white noise” type random component in the MatLab software environment is investigated. The synthesized input signal and its spectral density using the method of Fast Fourier Transform in a Signal Processing environment are obtained. The concept of the spectral windows for increasing the information content of the obtained dynamic characteristics and reducing the variance of frequency estimates is analyzed. The selection of the best spectral window is carried out, with the help of which the distortion of spectral estimates is minimized.

Keywords: Spindle Node, Frequency Response Data, Spectral Windows.

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Method of Design of Interference Fit Based on Complex Mathematical Modeling

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The work presents the solution of the urgent problem for creating effective means of computer-aided design of rational fits with the interference fit for connecting machine elements during the assembly. As a result of the study, theoretical principles, methods, and software for the automated design of interference fit are developed. The structure of functional relationships between the restrictions on the ranges of values of the initial parameters for calculating fits and the parameters that meet the loading conditions taking into account the operational, strength and technological requirements for them are obtained. Research of tightened bandage joints is carried out, based on which, a model of the fit area in the form of an *n*-parametric geometric image was constructed, which parameters are the interference, specific pressure in the joint, and its geometric dimensions. Based on the analysis of the results of computational experiments, an algorithm is proposed for constructing a geometric interpretation of the model in two-dimensional and three-dimensional coordinate systems. To improve the program for the automated calculation of interference fit, an effective methodology is developed for the analytical description of the area of existence of suitable fits using the mathematical apparatus of the theory of *R*-functions. The research results allow increasing the productivity and quality of the design of interference fits, as well as recommend methodological and software tools for integration into CAE/CAD/CAM.

Keywords: Specific Pressure, Diameter and Length of Fit, Probabilistic Tolerance Interference, Area of Existence, Constraint Factors, Mathematical Apparatus of the Theory of R-Functions.

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Design of Conveyor Control Information System Considering Transport Delay

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In this paper, the design method of optimal control for the conveyor-based transport system, when the quality criterion contains a variable delay in the controls, has been considered. The task of optimal control has been set and the Hamiltonian of the system has been written taking into account the delay in the controls. In the design of optimal control by the flow parameters of the transport system, a control object model containing partial differential equations was used. The mechanism that forms a variable value of the transport delay in the flow parameters of the transport system has been shown. Two characteristic modes of the conveyor system functioning are considered as follows: a transient state, when the value of the linear density at the transport system output is determined by the initial distribution of material along the transport route, and a steady-state state, when the value of the linear density at the transport system output is determined through the values of the movement speed of the conveyor belt and the intensity of the material at the conveyor section input. Equations that make it possible to calculate the controls of the flow parameters of the transport system for which the Hamiltonian of the system satisfies the Hamilton–Jacobi equation have been provided. Controls of the flow parameters are synthesized for the case when the phase coordinate does not reach the limits. It is shown that for the synthesis of controls, it is necessary to predict the magnitude of the output flow from the transport system.

Keywords: Production Line, PDE-model of the Production, Transition Period, Optimal Control, Differential Constraints, Accumulating Bunker, Distributed System.

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Fundamentals of CAD Design of Rotary Milling Cutters for Multitooth Products

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The studies presented in the article are aimed at developing the basics of ensuring the creation of CAD systems for disk run-in milling cutters for machining multitooth products regardless of profile. The development of this tool is based on its design methodology, which is based on the theory of shaping and design of cutting tools. Based on the analysis of the methods of processing multitooth products, the prospects of processing multitooth products with round disc milling cutters are substantiated. In this work, the problem of determining the cutting edges with the perpendicular and inclined axes of the tool and product is solved. The smallest design diameter of a disk run-in mill is determined. The design of the run-in mills, which provides the manufacture of chip grooves between the teeth of the product, is considered. The development of the design of the disk run-in mills included determining the diameter, taking into account regrinding. The geometric parameters of cutters are established. Based on the developed methodology for creating a CAD system for disk rolling mills, an automated system for designing disk rolling mills has been created. The operation study of milling cutters designed using this system confirmed the high accuracy of the products and prospects of their application. It is shown that the development of CAD systems for such mills significantly reduces the design and technological preparation of the production of multitooth products by disk rolling mills.

Keywords: Circular Milling Cutters, Multitooth Products, Cutting Tools, Step Accuracy.

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Design Calculation of Electrohydraulic Servo Drive for Technological Equipment

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The engineering method for design calculation of electrohydraulic servo drive with throttle regulation is proposed. The method is adapted on drives of technological equipment, in particular, equipment for mechanical processing of materials. The engineering method allows determining the main parameters and choosing elements and devices of the drive, to predict its static and dynamic characteristics. As the input data are considered: maximum loading; maximum tracking speed without load; maximum tracking error (or allowable tracking error at maximum speed); piston stroke; reduced mass of moving parts. The method includes the following main stages: construction of the drive settlement scheme, choice of the working fluid and the nominal working pressure; calculation of the constructive parameters and choice of the hydraulic cylinder; choice of the electrohydraulic amplifier; definition of the feedback parameters, determining the drive quality factor and calculation the transfer coefficient of the electronic block; evaluation of the drive static characteristics, calculation of the speed and load characteristics; construction of the drive linear model, stability assessment; research of the drive dynamic characteristics and the control quality, drive correction. The example of the design calculation of the electrohydraulic servo drive for technological equipment is presented. For calculations used the MATLAB application package.

Keywords: Engineering Method, Static Characteristics, Dynamic Characteristics, Transient Process.

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Parametric Optimization of Technological Layout of Modular Machine Tools

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The article describes issues of structural-parametric optimization in the process of synthesis of structures of technological layouts with multi-tool machining on equipment built on the concept of modular design. In the research process, the existing practice of designing this equipment class and statistical studies of previously released machine tools were used. The paper proposes a methodology for calculating the cutting conditions of individual tools during multi-tool machining for various options for replacing the tool during operation and taking into account the probabilistic nature of tool life at a given mean time between failures, what allows providing a specified output cycle of the product with minimal costs associated with the operation of the cutting tool and minimize other components of the technological cost of processing. The proposed methodology is useful both in the design of the new machine tools and in the modernization of previously made machines, built on the concept of modular design.

Keywords: Modular Equipment, Tool Setup, Multi-Tool Machining, Tool Life, Cutting Conditions, Mean Time Between Failures.

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Part II
Smart Manufacturing and Industry 4.0 Strategy

Methods for Modeling Urban Road Traffic Using Timed Automata

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Among the whole range of resources for a good economic and social life of a country, the transport system performs a key role. The efficiency of the country's street network will be central for further developments or will determine its stagnation. With the continuous increase in the number of vehicles and the effect of urbanization, traffic-roads are suffering different solicitations and utilizations for which they were not prepared, sized and projected. Due to the extreme importance of traffic-roads, research must be initialized to reduce the effects of traffic-jams in the streets, size the optimal number of traffic-lanes, and the information about the real-time traffic conditions needs to be implemented in Global Position Systems. The real-time data integration, flexibility, and the extensibility of the models and computational costs were other important aspects considered during the process of developing the models. The proposed TCA- Traffic Cellular Automata- model has appropriate results in the urban traffic theory. The results obtained in different scenarios were simulated and formally verified in the simulation/formal verification environment UPPAAL.

Keywords: Traffic Control, Timed Automata Model, Computer Simulation, Formal Verification.

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Object Recognition Using Neural Networks for Robotics Precision Application

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The fourth industrial revolution is based on the fusion of different technologies and, in particular, between machines and information, and encourages companies to integrate new tools in their production processes to improve working conditions and increase productivity and production quality of companies. The future of production, therefore, depends on increasingly intelligent machinery through the use of digital systems. Intelligent machines and systems are the key elements for future integrated infrastructures based on human-machine interaction and information sharing. This sharing requires the implementation of shared languages that allow different systems to dialogue in a simple way. With this in mind, the ability of machines or systems to learn new operations through the use of algorithms based on neural networks allows us to have increasingly flexible machines capable of replicating the learning processes of human beings. Such self-learning techniques will allow developing a new class of machines capable of revolutionizing our companies.

Keywords: Object Detection, Learning Systems, Unmanned Vehicles, Feed-forward Controllers, Ultrasonic Sensors.

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Big Challenges of Small Manufacturing Enterprises in Industry 4.0

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In the paper, the problems of small manufacturing enterprises, which limit the pace of their development in the face of the current trend in the development of digital technologies were considered. The analysis of information solutions of world leaders involved in the development of Industry 4.0 in the field of open application development is presented. The development trends of Industry 4.0 for small enterprises are described. As a greater homogenization of information technology and software in various small manufacturing enterprises, it is proposed to use the approach developed in JavaMach Cluster, which based on a modular ERP system., A userfriendly interface that allows access to the internal databases of such manufactures is presented to create more homogeneous information technology and software for small machinery manufacturing enterprises. Justified assessment of the effectiveness of the graphical interface connected to the databases of small machinery manufacturing enterprises. The issues related to the formation of unified information flows in the workspace of the modern sector of the economy of small manufacturing enterprises. The basic principles of creating and using non-dissonant databases of such enterprises in the formation of virtual companies are identified. Using the example of an included in the ERP-system module of rolled metal choice, we demonstrated a way to solve the problems of small machinery manufacturing enterprises under the development of Industry 4.0.

Keywords: Virtual Company, Modular ERP-System, Pre-Production Engineering, Interface, Database, JavaMach Cluster.

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Data Analysis of Readiness Programs of Machine-Building Enterprises

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One of the important aspects of providing the high level of the enterprises IT-readiness at machine-building enterprises is using the data science approach. By using data analysis, we mean the ability of the enterprises' experts to increase using data by the most effective appliance of modern data science algorithms. In our research, the analysis has been carried out and the proposed approach can be used in real practice to evaluate the implementation of program projects to boost IT readiness. For example, at the initial stage, when the project is just starting and we do not know the real values of features, we can assign to modifications the average value for each, and then when the project arrives the real value of modification, we can calculate the target and track the dynamics of the assessment, the quality of the program projects to boost IT-readiness of machine-building enterprises. Thus, an important question is the compliance of the enterprise to the necessary level of IT-readiness which is directly connected with data analysis.

Keywords: Data Science, Project Management, IT-readiness, Program Management, Machine Learning.

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Workplace Optimization Using a Collaborative Robot

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The study describes increasing the productivity of the production process using robotization. The application of robots in the manufacturing process and logistics requires a very thorough analysis and knowledge of manufacturing processes. The theoretical part describes the knowledge gained from the scientific literature concerning the robotization and technical standards of the Czech Republic. In the practical part there is an analysis of the current situation – i.e. defining a selected production line and selected workplaces on these lines, especially in terms of activities. The activities performed at these sites and their duration are crucial for determining the suitability of the site for implementing the robot. In the next chapter, the workplaces are evaluated in terms of activities that can be transferred from the operator to the robot to determine which percentage replacement of the operator is feasible. Thus, the selection of suitable activities (processes) for automation will be made at the workplace. The technical solution of the implementation is also proposed for the selected workplace. To achieve a successful application of the collaborative robot into the production process, it was necessary to change the location of the workplace, including electrical and air distribution, investment in a new conveyor and laser gauges. The new layout was based on saving space and saving human influence in the production process. The whole study shows a systematic approach to the introduction of the above-described issue.

Keywords: Operation, Robot, Layout, Production Cycle, Analysis, Rationalization, Process, Improvement.

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Global Trend of Implementation of Industrial Robots Relating to Industry 4.0

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Industry 4.0 is a vision of advanced industrial manufacturing, and one of the foundations it relies on is robotic technology, that is, the implementation of industrial and service robots. Industrial robots have been implemented in all industries in the World in the automation and modernization of production processes. So far, the first generation of industrial robots is still being implemented, which need to be separated from workers for workers' safety. In the last two years, the development of robotic technology has contributed to the implementation of second-generation industrial robots, collaborative robots, into production processes. The paper presents an analysis of the implementation of industrial robots over the last ten years in the World, at the continents of Asia/Australia, Europe, and America, as well as in various industries. The analysis of the implementation of industrial robots in fifteen top countries in the World for 2018 was made, as well as a comparative analysis of the application of traditional industrial robots and collaborative robots in 2017 and 2018 forecasts for the implementation of industrial robots' implementation by 2022 have been made.

Keywords: Production, Robot, Automation, Collaborative robot, Industry 4.0.

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Multi-Agent Model of Energy Consumption at the Metallurgical Enterprise

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An agent-based simulation model has been developed for analyzing the energy management processes of a metallurgical enterprise when implementing a portfolio of energy-saving projects. The overall goal of improving energy efficiency at the enterprise is realized through the management of a portfolio of energy-saving projects that are aimed at performing the following tasks: optimizing the energy balance; minimization of natural gas consumption; optimization of energy efficiency, etc. The features of the informational interaction of agents in a multi-agent system are disclosed, due to mechanisms related to decentralized multi-project planning, including the resolution of resource conflicts when performing tasks, the search for the most optimal resources, which ensure that the work will be carried out on the most favorable conditions. Thus, the article is devoted to solving the complex problem of analyzing the energy management processes of a metallurgical enterprise when implementing a portfolio of energy-saving projects.

Keywords: Portfolio of Energy-Saving Projects, Project Feasibility, Risk, Resource Allocation, Agent Model, Metallurgical Enterprise.

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Development and Implementation Possibilities of 5G in Industry 4.0

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The Industry 4.0 environment combines innovative information and communication technologies with Internet and physical systems, enabling advanced wireless communications and the Internet of Things services. Such digital and wireless transformation has the potential to drive economic growth in manufacturing using 5G technology. A key component of this potential lies in the collaboration between stakeholders in the manufacturing and mobile ecosystems industries who have acted in parallel in the past. In the future, the 5G technology will have a major impact on industry and mobility and will enable manufacturers to complete end-to-end automation with the virtual deployment of new product lines or the entire factory. Directly contributing to the social and economic development, 5G will be the technology that will enable growth and transformation in the Industry 4.0. This paper aims to show the impact that 5G can have on improving manufacturing processes in a smart factory environment and how it can respond to its increasing requirements. It will also outline the technical challenges that the manufacturing industry may meet when implementing this technology. Accordingly, an overview of the state of implementation of the 5G technology and a future development plan of Industry 4.0 in Europe will be given.

Keywords: Information and Communication Technology, Cellular Networks, Industrial Revolution, Smart Manufacturing.

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State-of-the-Art in Product-Service System Classification

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The Product-Service System (PSS) is an integrated combination of products and services. This concept includes a service-based competitive strategy, environmental sustainability and the basis for distinguishing itself from competitors offering cheaper products. The adoption of PSS involves focusing on selling the functionality of the product instead of selling the products. The important element of PSS is classification, i.e. the systematic division of PSS into classes according to a defined principle. The literature on the classification of PSS is very narrow and it does not sufficiently address the possibilities and categories that can be distinguished. The typologies developed have not captured the wealth of classes of PSS so far. The paper presents a comprehensive analysis of the PSS classification. In addition, the paper systematically reviews the literature on the PSS classification published over the last 18 years. Its main objective is to identify the main aspects of the PSS classification, the common features to the various classifications and their limitations. By researching the available classifications, we hope to make it easier for businesses to develop new PSS-based offers and to adapt their business models to specific types of PSS. This publication deals with and analyses 10 classifications of PSS.

Keywords: Product-Service System, Product-Service System Classification, Product-Service System Typology, Product-Service System Continuum, Servitisation Continuum.

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Service Costs in Operational Planning of Transportation with Small Batches of Cargo in City

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The research considers organization peculiarities of cargo transportation by small batches in city routes. At the same time, there is a tendency to reduce shipment sizes, a large number of customers, regularity, and deliveries frequency. A large amount of input information, numerical evaluation of the efficiency criterion, and selection of an intelligent technology from alternatives set are required to decide on the choice of transport service technology for cargo owners according to the development of Industry 4.0 at operational work planning of the transport enterprise. Simulation has been used to determine the effect of process parameters of agricultural cargo distribution in small batches on customer service costs. Simulation experiments were carried out with the help of created software. The total daily cost of shipping small-batch cargo is proposed as a criterion for the service efficiency of cargo owners on delivery routes. It considers the cost of freight transportation and the cost of idle vehicles time under uploads and unloads. A regression model describing the dependence of the total daily expenses for the discharge of small-batch cargoes on the technological parameters: the nominal load capacity of trucks, number of customers, and average sizes of delivery was obtained. It is proposed to use the obtained regression model by carriers when organizing small cargo batches transportation in cities. This will make it possible to choose a rational technology when servicing cargo owners on delivery routes in order to reduce the cost of transporting agricultural goods in small batches.

Keywords: Delivery Routes, Vehicle Load Capacity, Small-Batch Cargoes, Process Parameters, Costs.

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Production Planning and Setup Time Optimization: An Industrial Case Study

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Production activity control approaches, methods, and mechanisms have been widely applied over the last decades, and continue to be of utmost importance nowadays, within the context of the currently fast-growing Industry 4.0 era. In this paper, a Simio-based simulation model is proposed and its application in a printing factory is illustrated. The main aim of this work consists of providing general production planning improvements in the considered factory, with a special focus on the reduction of setup time. The proposed model is based on several distinct production activity control mechanisms, for instance, the CONWIP and the Routing Group mechanisms from Simio, which did enable to reach good improvements regarding a set of performance measures considered, including machines' setup time reduction, along with the maximization of the percentage of products delivered on time. Future work is also planned to be carried out to improve other kinds of performance measures, and by using other types of production activity control mechanisms, to be further applied in other industrial companies and sectors.

Keywords: Production Planning and Control, Optimization, Simulation, Scheduling, Setup.

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Part III
Technological Assurance

Concept Development of a Consistently Traceable Process and System Solution for Ensuring the Requirements of Engineering and Functional Safety

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In times of digital transformation and the growing degree of automation and connectivity of machines, the product complexity increases. Due to the growing risk of misapplication, the early and consistent consideration of Functional Safety is becoming increasingly important with a growing share of electrical-electronical functions. How does the consideration of the reduction of dangers and risks in concept development could be improved by requirements engineering? The aim of this paper is not the expansion of theoretical understanding, instead, it focuses on important aspects of industrial implementation. Unlike theory, Functional Safety is not an integral part of the Requirements Engineering methodology in the evaluated company of the agricultural engineering sector. There are two separate approaches so that continuous traceability in the process is very difficult to ensure. If changes in requirements occur during the development process, which affects safety-relevant functions, the effects on Functional Safety may be ignored. This fact isn't limited to the evaluated agricultural company, instead of this, it represents a cross-company and cross-industry problem. The project objective is the development of a concept for the integration of Functional Safety in the methodology of Requirements Engineering. To examine the research question if Model-Based Systems Engineering is a suitable approach for combining Requirements Engineering and Functional Safety, the RFLP structure is built on the example of a tire pressure control system. As a result, determined requirements, such as "bidirectional traceability", "cross-disciplinary, function-oriented approach", "possibility of linking requirements and architectures", "reusability" and "possibility of clustering" are validated.

Keywords: Model-Based Systems Engineering, Bidirectional Traceability, RFLP.

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Improvement of the Quality of Cutting Tools States Recognition Using Cloud Technologies

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The work considers improving the quality of constructing large-scale diagnostic models in technical diagnostics systems by developing a software architecture for high-performance computing in the form of a web service using cloud-based machine learning technologies. The obtained results are brought to practical realization in the form of tools of the automated system of technical diagnostics of cutting tools with the diagnostic parameters of large dimensions. A method has been developed for building information models of cutting tool states based on indirect measurements using test pulse effects on a cutting system in the form of loads with impacts and recording system responses, based on which information models are built in the form of multidimensional transition functions. The methods of forming test pulse loads of the cutting system by successive insertion of the cutting tool into the workpiece with different cutting depths, with variable feed, and with variable cutting duration are considered. The computational experiment demonstrates the advantages of information models in the form of multidimensional transition functions for modeling nonlinear dynamic systems in problems of diagnosing the states of cutting tools. It has been established that multiclass cutting tools state recognition can be used as an effective technology of automated technical diagnostics systems.

Keywords: Tool Laboratory, States Recognition, Cloud ML.

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Adaptive Slicing in the Additive Manufacturing Process Using the Statistical Layered Analysis

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The results of the study on the capabilities of adaptive slicing the original 3D model at layered product shaping are presented. The proposed method of adaptive slicing the 3D model allows increasing the process effectiveness and regulates the accuracy of manufacturing products by setting the building step for each lowering of the working platform of additive technologies installation. The building step is selected, taking into account the density of distribution of angles between the building direction vector and the product surface normals that are in the current layer. The developed algorithm for adaptive slicing the 3D model provides for balanced truncation of the distribution, which further reduces the building time compared to existing slicing strategies with variable steps. Evaluation of the effectiveness of adaptive slicing was carried out based on the comparative analysis of the number of layers and the predicted deviations from the regular surface shape as applied to 3D models of industrial products. Improve the effectiveness of the proposed adaptive slicing with an increase in the geometric complexity of the product is revealed.

Keywords: Technological Preparation, Variable Step, Building Time, Accuracy of Shaping.

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Increasing Productivity of Connecting Rods Machining

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The paper is dedicated to the increase of the efficiency of multiproduct manufacturing. The experience in designing the manufacturing processes of manufacturing machining parts, such as connecting rods, is analyzed. A progressive manufacturing process based on the concept of intensification of machining and application of multiaxis equipment is proposed. This approach made it possible to reduce the complexity of the manufacturing process in drilling, milling, and boring operations. Research has been conducted on the design, optimization, modeling, and production of fixtures for multiproduct manufacturing. The design of a flexible fixture for machining non-detachable connecting rods is provided, which allows adjustment of locating and clamping elements in a certain size range. Studies have shown an increase in machining productivity of the proposed manufacturing process from 1.7 to 3.9 times depends on batch size.

Keywords: complex part, manufacturing process, fixture design, locating, multiaxis machining, setup time.

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Optimization of the Technological Process Based on Analysis of Technological Damageability of Castings

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Reasons for machine failures are analyzed in the article. The primary role of the machining and assembly process structure for the formation of the product's damages is noted. Improvement of the operating properties and reliability indicators are considered as a result of the pre-production technological system optimization as a part of the product's Life Cycle Support. The relationship between the technological damageability and the workpiece's material structure is presented in a formalized form. Methods for assessing the degree of the material's damage based on the results of direct and indirect measurements of the material's mechanical properties without destroying are analyzed. The method of experimental studies is described. The advantages of the method of LM-hardness analysis and evaluation of the heterogeneity of the workpiece's physical structure are submitted. The impact of the technological route structure on forming the process of product damage was studied based on experimental researches. Technological damageability is proposed to be used as a criterion for the analysis of the technological process of workpiece machining. This method is an energy approach to the research of the product's damage accumulation.

Keywords: Casting, Technological Damageability, LM-hardness Analyses Method, Weibull Homogeneity Coefficient.

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A Probabilistic-Statistical Model of Durability of Parts under Cyclic Loading

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The article suggests the use of a probabilistic-statistical model for calculating the strength of parts under cyclic fatigue loads. Statistical analysis of the samples was carried out according to the results of a mass experiment on the strength of samples during fatigue tests. The numerical characteristics of the statistical sample are found: the average value, the corrected variance, the squared asymmetry coefficient, and the excess coefficient. As a result of the research, two models of the distribution of random variables were used: a three-parameter logarithmic-normal and a four-parameter model with upper and lower thresholds - the number of loading cycles. Estimates of the parameters of these two models were found using the moment method. The graphs of the distribution density functions of the two models were built based on the experimental results. To verify the adequacy of the models, sensitive functional characteristics were used, such as the average residual life and failure rate. The theoretical and empirical values of the functions are compared for the two models. It is shown statistically that the proposed four-parameter model is more adequate than the previously proposed three-parameter model (log-normal distribution). It is also shown that the four-parameter model proposed for assessing the strength of parts under cyclic loads is more physically adequate.

Keywords: Probabilistic-Statistical Model, Strength, Reliability, Cyclic Load.

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Combined Thermo-Mechanical Techniques for Post-processing of the SLM-Printed Ni-Cr-Fe Alloy Parts

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The selective laser melting (SLM) is an additive manufacturing process applied to fabricate the metal parts owing to the melting of the metal powder in a layer by layer approach. The combined thermo-mechanical techniques for the post-processing of Ni-Cr-Fe alloy parts fabricated by the SLM process are proposed. In this study, the flat parts were fabricated using a nickel-based pre-alloyed Inconel 718 powder. The hot isostatic pressing (HIP) followed by homogenization (H) and/or aging (A) was carried out to modify the structure of the material and reduce the porosity. The shot peening (SP) and ultrasonic impact treatment (UIT) using a seven-pin impact head were applied to improve the surface texture parameters and stress state. The surface texture and hardness of the SLM-built and thermo-mechanical post-processed Inconel 718 specimens are studied and compared. Results indicated that the used mechanical surface treatments after heat treatments led to a further increase in the surface hardness and formation of a new surface microrelief. The UIT process forms regular microrelief with smoother surface roughness and lower height profile parameters while the SP-induced surface hardness is higher than that of the UIT-processed specimen.

Keywords: Inconel 718, Selective Laser Melting, Post-processing, Hot Isostatic Pressing, Homogenization, Aging, Shot Peening, Ultrasonic ImpactTreatment.

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Theoretical Analysis of Conditions for Improving Gear Grinding Accuracy and Productivity

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The aim of this study is a theoretical substantiation of the possibilities for increasing accuracy and productivity in gear grinding and determining the optimal machining conditions based on the reduction of elastic displacements arising in the technological system. The expediency of gear grinding using the profile copy method is shown based on a theoretical analysis of the conditions for increasing the accuracy and productivity of gear grinding operations. Compared to the traditional milling, this method has more significant technological capabilities in terms of improving the accuracy and productivity of machining. This machining effect appears while implementing the dead-stop grinding, which provides a significant reduction in elastic displacements that occur in the technological system due to the uneven removed stock. In this case, the main part of stock removal is carried out in terms of high-performance deep grinding. For the implementation of gear grinding using the profile copy method, an analytical ratio has been obtained to determine the lateral feed elastic displacement that occurs after each wheel pass. Using this ratio allows achieving high machining productivity with the required accuracy. It has also been found out that it is possible to increase the machining accuracy and productivity during milling by increasing the refinement of the wheel pass by reducing the conditional cutting stress. This can be achieved by using high porosity grinding wheels, providing a decrease in the friction intensity in the cutting zone due to their high cutting ability.

Keywords: Abrasive Wheel, Dead-stop Grinding Scheme, Elastic Displacement.

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Ensuring the Bending Stiffness of Pre-Compressed Cantilever Boring Bars during Fine Boring

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The research discovers ensuring technological and dynamic capabilities of fine boring due to the use of cantilever boring bars with increased bending stiffness. Experimental design of the cantilever boring bar and a method for increasing its bending stiffness for fine boring of long holes of small diameter (d = 10–20 mm) with a ratio of l/d> 4 is proposed. Bending stiffness increases due to preliminary compression of the outer layers of the boring bar hollow housing with a unique lock pin-drawbar. The experiments were carried out first on pipes of different lengths, in which the effect of the drawbar increased bending stiffness significantly, and then the experiments were carried out on small diameter boring bars. The results of all experiments show a significant increase in bending stiffness and vibration resistance of unique small diameter boring bars for boring long holes. To study the bending vibrations, a testing bench was assembled based on a finishing boring machine. The measurements were carried out using strain-gauge transducers power on via the differential circuit. It has been established that the effect of boring bar drawbar leads to an increase in bending stiffness by about 1.3–1.4 times, and the vibration amplitudes during cutting decrease by about 2-3 times.

Keywords: Lock Pin-drawbar, Cutting Tool Holder Nut, Bending Oscillations.

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Improvement of the Accuracy of Grinding by means of Coolant Supply

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This article considers the issues related to various methods of supplying cutting fluid to the cutting zone during grinding. It is established that the improvement of the technique for supplying cutting fluids to the cutting zone is one of the promising directions for increasing the processing efficiency. In this regard, a method for supplying cutting fluid was proposed. To increase the accuracy of processing parts, grinding is performed without the contact of the heated liquid coolant with the surfaces of the grinding wheel head, headstock, and tailstock, bed, and table of the machine tool, as well as grinding waste. For the practical implementation of this method, a device was developed for supplying a liquid coolant during machining by external round grinding. This device contains a nozzle for grinding waste, a distributing nozzle, which covers the workpiece, and the receiver with air channels and radial nozzles made with different diameters. The research to determine the rational parameters (diameters and numbers of air nozzles) of this device is carried out.

Keywords: External Round Grinding, Coolant Supply Device, Cutting Force, Nozzle, Air Curtain.

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Optimization of Modular Fixture Setup Time in an Automated Assembly Line

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Designing and fabricating different fixtures are among the main barriers for manufacturing systems to produce a variety of products with different geometries. To overcome the time and costs associated with the frequent changes in fixture design, modular fixtures have been developed. The changeability plan of these fixtures is vital for changeable manufacturing systems, especially in automated systems in which robots are in charge of placing and securing parts in their respective places. In this paper, we are extending the model presented in the literature in two directions to further reduce the fixture setup time in a mid-volume mid-variety automated production system. First, we consider both vertical and horizontal movement of the robot to find the optimal changeability plan. Then, a new fixture design is introduced that improves the fixture modularity to hold more products with different geometries. The results prove that the newly proposed models can significantly reduce fixture setup time.

Keywords: Changeability, Robot Travel Path, TSP, Fixture Design, MILP.

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Part IV
Numerical Simulation and Experimental Studies

Investigation of Waveforms of Roller Bearing's Working Surfaces on Centerless Grinding Operations

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The article investigated the formation of waviness on working surfaces rings of roller bearings, which causes the appearance of noise and vibration in the bearing units of machines and mechanisms. To establish patterns of appearance of waviness some principles of systems theory and mathematic simulation were used; in particular, the establishments of transfer functions, finding the equation of dynamics, usage of Laplace transformations to solve differential equations, building locus diagrams and others. For analysis, a centerless grinding system with some simplifications was considered as a linear, continuous, closed dynamic system. Based on this a flow-chart of plunge centerless grinding model on rigid shoes was compiled and the transfer function was found. The solution of the system's characteristic equation revealed the influence of waviness on the ground surface and the regeneration process of this waviness on the locus diagram of the displacement vector of the workpiece's center.

Keywords: Undulation, Dynamic Stability, Centerless Grindin, Rigid Support.

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Theoretical and Experimental Studies of Changes in the Workpiece Shape during Narrow Die Indentation

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The study performs the analysis of existing technological schemes of manufacturing crankshaft forgings. Advanced technology of the manufacturing is proposed based on this analysis. The influence of sizes of a tool and its indentation depth on the forming process of a workpiece is examined. As a result of the carried-out theoretical and experimental studies, dependency diagrams of the influence of the upper die thickness and its indentation depth on the change in sizes of the workpiece, namely the maximal widening, the lengths of the contact areas of the workpiece with the upper and lower dies and the value of the maximal workpiece diameter reduction is received. These diagrams can be used to determine optimal parameters of the process of the narrow die indentation into a workpiece to receive the optimal form of the workpiece, used for the subsequent forging. The comparison of the results of the experimental studies and computer simulation in the QForm V8 program showed appropriate convergence of the results.

Keywords: Narrow Die, Indentation, Forging.

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A Numerical-Analytical Model of the Temperature Field DistributionDuring Orthogonal Cutting of Composites

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The process of machining composite materials, as the phenomenon of targeted destruction of the surface layer, is accompanied by the release of a large amount of heat. That heat largely determines defines the picture of the stress-strain state in the tool-composite contact. The intensity and distribution of the temperature field mainly define the choice of the tool type and processing parameters which provide a given surface quality and productivity. A numerical-analytical model for determining the temperature field for orthogonal cutting of fiberglass with bundles reinforced is presented. The two-dimensional stationary problem of heat conduction of piecewise homogeneous bodies is solved by the boundary element method. An empirical relationship for average temperature and the heat source arising at the contact of the tool flank surface with the material being processed is used for as the boundary conditions in the model. The dependences of the maximum temperature on the feed, speed, and depth of cut are given. It is shown that to prevent the possible occurrence of thermal destruction and burns in each case, there is a limit combination of technological parameters – feed, speed and depth of cut.

Keywords: Reinforced Polymers, Machining, Modeling, Thermal Effects.

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Simulation of Thin-Walled Parts End Milling with Fluid Jet Support

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One of the biggest barriers in the formation of surfaces of the thin-walled parts is the difficulties of prediction and prevention of deflections. The research is focused on the use of fluid jet support in processing as the technique to increase material cutting stability. The analysis of existing methods of deviations prevention is made. A preliminary number of simulations are proposed to define dynamic cutting parameters, apply it to the fluid jet simulation, and investigate the influence on the frequency part structure characteristics. The simulation results are allowed to trace the change in the natural frequency of the part and part with jet support. The potential fluid flow speed is established. The degree of the stress caused by directional fluid jet force is calculated. The technique is novel and useful in the sense that it is supported by fluid flow jet that can theoretically be organized on the existing equipment basis. The solution does not significantly affect the characteristics of the equipment structure while saving dimensional parameters. Matching between nozzle diameters and efficiency of fluid jet support is presented. Considerable oscillation amplitude reduction of the thin-walled part was observed using the proposed solution.

Keywords: Thin-walled Parts, Fluid Jet Support, High-Speed Milling, SPH-particles, Undesirable Deflections, Oscillation Amplitude.

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Research of Thermomechanical Processes when Processing Cylindrical Surfaces with Wear-resistant Coatings

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The possibilities of technical support of the quality of finishing processing of the cylinder working surfaces using coatings of wear-resistant materials are considered. For this, a design scheme is proposed for determining the stress-strain state of the cylinder-coating system. The influence of the processing regimes of a cylindrical group with a wear-resistant coating on its physical and mechanical characteristics is determined. The dependence of SIF on the delamination angle α and the roughness of the working area of the cylindrical surface Ra is presented. A design scheme is proposed for studying the mutual influence of exfoliation sections on stress intensity in a wear-resistant coating. The effect of particles on the wear resistance of the coating deposited by the electrochemical method is determined. A study of composite materials based on Ni/Ni-TiO_2 in a scanning electron microscope. The calculated and experimental values of the ultimate dimensions of crack-like defects during grinding of wear-resistant coatings are considered. The dependence of crack formation on the surface of the surface processed by grinding under the cutting depth and tool characteristics is determined.

Keywords: Durability, Reliability, Wear Resistance, Delamination, Thermomechanical Processes, Diamond Abrasive Processing, Tribocorrosion.

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Investigation of the Grinding Process Considering the Increase of the Active Surface of Abrasive Grains

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The problems of the grinding process of difficult-to-process materials are analyzed. The main factors influencing the efficiency of preserving the parameters of the quality of the surface and the surface layer are the cutting modes, characteristics of the abrasive wheel and lubricating and cooling technological environments are defined. At the same time, all these factors indirectly affect the efficiency of processing due to wear, blunting and salinization of the grinding wheel. The study of the kinematics of the microcutting process with round external and internal grinding of surfaces was conducted. It has been determined that the work of plastic deformation is the main source of heat formation during grinding. The method of calculation of processes of plastic deformation, based on the closed system of equations of mechanics of continuous media is considered. In the experimental part of the work, the research of the influence of technological regimes and the characteristics of the abrasive tool on the energy indices of the process of round external grinding of hard-working materials has been carried out.

Keywords: Microcutting, Kinematics of the Process, Heat Stress, Energy-Intensive Processes, Plastic Deformation, Dissipation Energy, Deformation Power.

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Processing of Parts under Pulse Loading of a Vibrating Hopper

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In the article, the critical analysis of the current state of processing of vibrating methods of grinding, the advantages of their existing methods of processing machine parts and devices with traditional grinding are indicated. The inspection of the developed vibration installation, the influence of the regime of vibrating on the movement of the working environment in a vibration bunker are analyzed, the process of conducting a scientific experiment is planned. The results of experimental researches on the process of vibroabrasive processing of details, the reproducibility of the experiment, and the reliability of the obtained results were considered. It has been determined that the results of mathematical modelling coincide with the results of the experiment. To determine the patterns vortex circulation movement of the working environment, a specially introduced coordinate system was used and a single shooting was performed, which made it possible to determine the movements of parts and abrasive granules. In addition, from the analysis of demonstration shooting, the trajectory of parts movement in the volume of the working environment was predicted. The analysis of technological possibilities of vibroprocessing in a wide range of frequency and oscillation scope is carried out. The reasons for the problem selection of optimum modes of vibration processing and possible directions for overcoming them are presented. different modes of vibration machine operation are modeled. The results of the analysis made it possible to determine the principles of optimal selection of vibration treatment modes. The method of operation of a vibrating machine with the most effective use of mechanical energy of vibrations is established.

Keywords: Vibroprocessing, Vibrosetting, Circulation movement, Electromagnetic, Abrasive material, Vibrohopper.

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Finite Element Analysis of Profile Grinding Temperature

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The analysis of equations for determining the grinding temperature taking into account the curvature of the grinding profile, is performed. Mathematical models of the temperature field were proposed, which makes it possible to identify the influence of the curvature radius of the surface to be ground on the grinding temperature in the range from a semicircular profile to a linear one as the radius of the semicircular profile tends to infinity. The variation range of the curvature radius is established, in which the curvature of the profile being ground can be neglected when calculating the grinding temperature. The influence of the profile curvature radius on the maximum grinding temperature was established using both direct calculating and computer simulating of the temperature field by the analytical model and the finite element method (FEM), respectively. Grinding temperature FEM simulation results differ by no more than 0.5 % compared to the analytical model under otherwise similar conditions. It is established that the FEM simulation is more suitable due to its greater sophistication, which makes it possible considering the individual geometric features of the surface to be ground as well as any instantaneous distribution of the heat flux in the grinding zone. At the same time, an analytical model for direct calculating of the grinding temperature takes much less time to get a result and can be used in computer monitoring and grinding diagnosing of subsystems on CNC machines.

Keywords: Curvature Radius, Temperature Field, Heat Flux, Analytical Model, Finite Element Method, FEM Simulation.

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Influence of the Thread Profile Accuracy on Contact Pressure in Oil and Gas Pipes Connectors

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Pipeline connectors of the oil and gas assortment must ensure good screwing and durability during it. These operating requirements depend to a large extent on the contact pressure between the thread surfaces of the pin and the box at the start of screwing and in the fully screwed state. The paper presents the study of the dependence of the contact pressure between the threads of the box and the pin, depending on the accuracy of the profile of the threads. The contact pressures at the time of insertion of the pin into the box are investigated based on theoretical assumptions about the effect of the weight of the drill pipe stand on the example of the tool joint 2 7/8 Reg. Based on the finite element method for the 114 mm diameter tubing connector, the contact pressure inside the connector, depending on the accuracy of the thread profile is investigated. Studies show that at the time of insertion of the pin into the drill pipe box, the pressure changes by almost 10 % depending on the upper and lower limit of the thread profile deviations. In a finally screwed state, the contact pressure increases twice if the pin thread profile is made on upper limit deviation, and at the box, the thread profile is made as nominal.

Keywords: Threading Tool-joint, Tapered Thread, Finite Element Model, Process of Screwing, Pin and Box.

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Numerical Simulation of Local Plastic Deformations of a Cylindrical Workpiece of a Steel Wheel Rim

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The presented studies of the process of radial-rotational profiling of the rims of the wheels of vehicles are aimed at studying the field of stress-strain. An attempt is made to simulate this dynamic process by a static finite element model. This statement of the problem justifies itself from the viewpoint of the physical nature of the method in a finite minimum time. The von Mises stress intensity during plastic deformation of a cylindrical workpiece by a pair of solid-state profile rollers is determined, and the distribution pattern of meridional stresses and displacements of the workpiece sections is shown. The results are compared with existing analytical models for profiling the wheel rim. Numerical modeling of the process of deformation of a cylindrical workpiece by a pair of rollers showed that opposite stresses act both in the tangential and in the meridional direction in the deformation zone. The magnitude and direction of the tangential stresses coincide with both modeling techniques. The distribution pattern of the meridional stresses acting in the deformation zone is contradictory. It is shown that the workpiece changes shape during loading. If some zones are stretched, then other zones are necessarily compressed, i.e. the shell is deformed along the entire peripheral surface. This circumstance allows us to assume the possibility of a directed influence on the deformation zone by applying additional forces to the free sections of the workpiece.

Keywords: Finite-Element Model, Shell, Meridional Stresses.

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Peculiarities of Interaction of Micro-Roughnesses of Contacting Surfaces at FANT

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Based on the theory of cutting mechanics, using a model experiment, the basic laws of the interaction of surface microroughness with a tool have been established, which allow developing a theoretical model for the first stage of finish anti-friction non-abrasive processing (FANT), which will ensure the efficient course of the micro-cutting process and the filling of microcavities with anti-friction material. It is noted that during the interaction of cast-iron microroughness with a brass tool, the top of the microroughness dulls with the formation of a rounding radius. The mechanism of forming the radius of rounding of micro-roughness is shown, a significant interdependence between it and the front cutting angle is established. The phenomena occurring on the back surface of micro-roughness are revealed. The ways to improve the efficiency of the micro-cutting process by ensuring the established values of the rake cutting angle are proven. It is proposed to consider the application of FANT anti-friction coatings from the perspective of a systematic approach and the principles of self-organization, which will make it possible to predict the achievement of optimal quality parameters of the surface layer: equilibrium roughness, favorable microrelief, required hardening, and residual stresses.

Keywords: Finish Anti-friction Non-abrasive Treatment, Anti-friction Coating, Micro-cutting, Contact Interaction, Cutting Angle, Rounding Radius.

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The Influence of Milling Parameters on Cutting Forces in High-Speed Milling of Polymer Materials

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This article presents the results of experimental studies during high-speed end milling of pure and carbon black reinforced polyamide materials depending on the cutting conditions used. The physicomechanical properties of such materials largely depend on the technological requirements of their manufacture. The high elastic properties of the polymer materials and their composites contribute to an increase in the contact area of the tool with the workpiece, especially on the back surface, thereby leading to an increase in the cutting forces. The result of this phenomenon causes a decrease in the critical wear threshold of the tool compared to metal processing. Based on this experimental study, it was found that milling of pure polyamide couldn't be performed at the cutting speeds beyond 500 m/min due to the occurring high temperature at the contact area. The cutting forces for both polymer materials increased as the feed and cutting speed increased. Furthermore, when comparing carbon black reinforced and pure polyamide materials, it was observed that more cutting force is needed for milling of pure polyamide material.

Keywords: High-Speed Milling, Carbon Black Reinforced Polyamide, Cutting Forces.

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Part V
Advanced Materials

Influence of Modifiers-Ligatures on the Properties of Cast Aluminum Alloy AK5M2 for the Automotive Industry

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The paper analyzes the effectiveness of modifying aluminum alloys with active additives of microcrystalline alloys of different types. Production technologies have been developed, and the optimum amount of the most effective modifiers and active reinforcing additives for silumin made from recyclable materials has been determined; the connection of changes of structure with the parameters of mechanical properties of secondary silumin was established. It was found that the optimum amount of modifier-ligature Al-Ti5 was 0,1% by weight of liquid metal. Using more modifiers is not rational from the standpoint of materials science, economics, and ecology. The addition of such additive provided in the cast and heat-treated material an increase in the hardness by (20-30)% and tensile strength by (15-25)% due to the change in shape and dispersion of the formed intermetallic phases, reduction of porosity and increase in density. The use of non-deficient, cheap and environmentally friendly active additives in combination with traditional refining-modifying treatment can provide a significant increase in the properties of cast aluminum alloy products and are recommended for use in industry.

Keywords: Aluminium Alloy, Silumin, AK5M2, Modifiers, Ligature, Structure, Hardness, Tensile Strength.

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Influence of Surface Hardened Nanocrystalline Layers on the Resistance of Contact Fatigue Destruction

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The conducted research has shown that in the process of frictional treatment of test-pieces made of Steel 40NiCr6 and Steel CT80 after hardening and low-temperature tempering, a hardened nanocrystalline layer is formed on the surface layer. The grain size of the hardened surface layer was 20-60 nm near the treated surface. The value of a hardened layer's TEF that allows us to estimate the thermodynamic state of the metal was determined. After friction treatment, the residual compression stresses are formed in the hardened layer. Experiments have shown that in the case of frictional treatment, the shape of the working surface of the tool significantly affects the nature of the redistribution of residual stresses of the first kind. Thus, when hardening the Steel 40NiCr6 test-pieces, residual compression macrostresses occur in the hardened and low-temperature tempered state. The conducted research has shown that frictional treatment increases the resistance to fatigue destruction during contact loading. Thus, the increase in the durability of Steel CT80 after frictional treatment reaches 1.6...1.8 times compared to unhardened test-pieces. The crack is formed in the area of tensile loads and passes through the base metal.

Keywords: Nanocrystalline Layer, Friction Hardening, Residual Stress, Contact Fatigue.

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Numerical Simulation of Elasto-Plastic Behavior of Isotropic Composite Materials

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Tools in the form of methodology and software for the numerical study of the thermal-elastoplastic state of coke-pitch composites using the example of isostatic graphite production technology have been developed. A closed mathematical formulation and a method for numerically solving an elastoplastic problem with isotropic hardening based on an implicit inverse mapping algorithm are considered. Using the finite element method, the corresponding program code was developed and verified. A comparison of the results with the data of numerical analysis obtained using the ANSYS Mechanical APDL software product shows that, with isotropic hardening, the maximum discrepancy does not exceed 1.13 %, and for ideal plasticity, it is no more than 3.58 %. The calculations of the thermal-elastoplastic behavior of the coke-pitch composite in the technological stage of the production of isostatic graphite blanks are performed. It is shown that in the case of non-compliance with the temperature regimes at the initial stages of roasting, plastic deformations occur in the isostatic graphite blanks, which lead to cracking and deterioration of the uniformity of the physical properties of the finished products.

Keywords: Composite Material, Elastoplasticity, Numerical Analysis, Implicit Algorithm, Isostatic Graphite.

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Simulation of the Process of Obtaining Nanostructures During Laser Radiation on Materials, Cutting Tools and Parts

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The likelihood of obtaining nanostructures on solid alloys (K20) and VK 8 (MC 347) was compared under the action of laser radiation with a heat flux density of 10^{-12}-10^{16} (W/m^2) with a duration of 10^{12}-10^{-16} (s) and spot size contact $5 \cdot 10^{-7}$ and 10^6 m. The zone where the formation of nanostructures was considered the region where the temperature is in the range of 500-1500 K, its growth rate exceeds 10^7 (K/s). The technological parameters of laser radiation are obtained at which these conditions are met. The zones of formation of nanostructures depending on the heat flux density on the time of action of the ionizing radiation are determined. It is shown that it is necessary to take into account the rate of temperature rise and the probability of thermoelastic destruction due to the action of temperature stresses. In low-speed temperature rise formed micro and submicrostructure that has been confirmed experimentally. For the first time, the influence of grain formation energy on temperature development, its rate of change, temperature stresses and the possibility of nanostructures formation is taken into account. The comparison shows that the zone of technological parameters at which nanostructures are realized for the (MC347) hard alloy with the laser contact size R = 10^{-6} m differs little (MC347) is more likely, and for R = 5-10^{-6} m it is significantly more for carbide HA (MC347).

Keywords: Nanostructure, Submicrostructure, Technological Parameters, Steel, Hard Alloy, Pulse Laser Radiation.

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Strength Properties Control of Mixtures Based on Soluble Glass with Ethereos Solidifiers

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The paper presents the mechanism of solidifying mixtures on a soluble glass base with complex ethereos solidifiers, such as ethylene glycol acetates, triacetate with furfuryl alcohol and furfuryl oxypropyl cyclocarbonates. The castings comparative manufacturing technology based on cold-solidifying mixtures on soluble glass with these solidifiers is given. To experimentally determine and establish the regularities of increasing of the compressive strength of the mixture using ether hardeners and technological additives: ethylene glycol monoacetate (EGMA), ethylene glycol diacetate (EGDA), ethyl silicate (ES-40), ethylene glycol (EG), tetraethoxysilane (TEOS), triacetate with furfuryl alcohol (TAC with FA) and furfuryl oxypropyl cyclocarbonates are established. The basic physical and mechanical properties of mixtures with these additives, such as compressive strength, survivability, friability, gas permeability, and knocking-out ability were determined by standard methods according to the state standards (GOST). The most effective ethereos solidifiers, which allow obtaining high-quality mixtures on soluble glass with the highest strength properties, were determined.

Keywords: Cold-Solidifying Mixture, Soluble Glass, Ethylene Glycol Acetates, Furfuryl Oxypropyl Cyclocarbonates, Triacetate with Furfuryl Alcohol.

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Design of New Nanocoatings Based on Hard Alloy

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The paper investigates the possibility of creating high-entropy nitride, carbide, boride, sulfide, phosphide and oxide nanocoatings on hard alloy T12A based on hafnium, zirconium, molybdenum, tungsten, yttrium, and nickel. The study of obtaining coatings and nitrides, carbides, borides, sulfides, phosphides and oxides directly in the body of the material at ion energies in the range from 200 to $2 \cdot 10^4$ eV with charge numbers from 1 to 3. Characteristics such as the grain volume for all these ions and nitrogen ions and the depth of their occurrence are obtained, which allows us to estimate the layers of nanostructures from compounds and elements or submicrostructures that can be formed by these high-entropy coatings. It is shown that it is possible to avoid the production of intermetallic compounds due to the high mobility of nitrogen, carbon, boron, sulfur, phosphorus and oxygen ions. It is shown that to obtain effective high-entropy coatings, it is necessary to provide an appropriate space-time distribution law of the ion supply to the CT material by controlling the installation.

Keywords: Highly Entropic Coatings, Submicrostructures, Nanostructures, Solid Solutions, Intermetallide.

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Structure and Corrosion Resistance of Vacuum-Arc Multi-period CrN/Cu Coatings

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The influence of deposition conditions (pressure, bias potential, layer thickness) on the structure and corrosion resistance of vacuum-arc multi-period CrN/Cu coatings is studied. For research, we used the methods of precision XRD, scanning electron microscopy with energy dispersive microanalysis, impedance spectroscopy, and potentiodynamic polarization tests to detect corrosion resistance in a solution of 0.9% NaCl. According to structural studies, phases with an fcc crystal lattice are formed in the layers: Cu and CrN mononitride. In CrN layers obtained at the highest bias potential of –200 V, a change in the lattice period associated with the action of compression stresses was revealed. Tests for corrosion resistance showed that for all the samples studied, the corrosion process has a predominantly anodic reaction. The most corrosion-resistant coatings are those obtained at a pressure of $5 \cdot 10^{-4}$ Torr and the greatest bias potential of -200V in constant rotation mode. The feature of such coatings is the smallest thickness of copper and CrN layers (about 8 nm), the presence of compression stresses (which enhances adhesion between the layers), and the absence of a pronounced texture (the paths of easy diffusion are minimized).

Keywords: Composite Coatings, Bias Potential, Phase Composition, Corrosion Rate, Polarization Curves, Electrochemical Impedance Spectroscopy.

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Effect of Morphological Features on Dielectric Properties of Plasma Electrolytic Oxidation Coatings on D16T Aluminum Alloy

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The article focuses on the results of the surface morphology and dielectric properties research of the plasma electrolytic oxidation (PEO) coatings produced in the alkaline-silicate electrolytes in galvanostatic (GS) mode using rectified anode current. PEO coatings were formed on the samples of wrought aluminum alloy D16Tused normally for the manufacturing of the diamond grinding wheels bodies. The influence of PEO factors on the porosity (quantity, shape, size, structure and its distribution on the surface) and dielectric properties (volume resistivity, electrolytic strength) was studied. It was established that through porosity increases in the series of solutions: 12 g/L LG ("liquid glass" (LG), a technical-grade sodium silicate solution) < 1 g/L KOH + 6 g/L LG (alkaline-silicate solution) < 2 g/L KOH + 12 g/L LG. The accordingly sizes of pores are 10…15 μm, up to 1 μm and 2…10 μm. The through porosity increases in each electrolyte with increasing of anode current density from 5 to 15 A/dm^2. The smallest relative increase in porosity is observed in the samples oxidated in sodium liquid glass solution 12 g/L LG. It was demonstrated that the dielectric properties research results qualitatively correlate with the micro geometric and morphology characteristics. The electrolyte composition is a major factor affecting the volume resistivity and electrolytic strength. The coatings produced in 12 g/l LG technical-grade sodium solution have the best dielectric properties, corresponding to the smallest through the porosity of these samples.

Keywords: Morphology, Through Porosity, Surface, Galvanostatic Mode.

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Structural Engineering of Nanocomposite Coatings Based on Tungsten and Titanium Carbides

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The elemental and phase compositions, structure, substructure, and mechanical properties of nanocomposite coatings based on a quasibinary system of tungsten and titanium carbides are studied. It was found that as a result of selective sputtering during coating formation, it is enriched with heavy tungsten atoms in comparison with the sputtered target. The content of carbon atoms varies in proportion to the change in the content of titanium atoms in the coating, which is determined by the higher binding energy in the Ti-C system compared to W-C. With a low content of titanium atoms in the coating (up to 7 at%), a two-phase state is formed in the coating from (Ti, W)C (with an fcc crystal lattice (structural type NaCl) and W_2C (with a hexagonal close-packed lattice) phases. Characteristic concentration regions with a certain growth rate of crystallites and the formation of a microstrain state. It has been established that in areas with low concentrations of impurity elements, hardness maxima are detected which are associated with the formation of a two-phase state and the appearance of a predominant orientation of crystallites with the [111] axis perpendicular to the growth plane. The hardness of nanocomposite coatings is significantly higher than the hardness of basic WC and TiC coatings and corresponds to a superhard state with the maximum value (39.1 GPa).

Keywords: Quasibinary System, Nanocomposite, Phase Composition, Crystallites, Texture, Microstrain, Hardness.

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Numerical Simulation of the Microstructure of Structural-Inhomogeneous Materials

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The algorithm of the process of filling the powders of structurally inhomogeneous materials (SIM). Based on the developed computer program for modeling the process of random packaging of various particles of the charge (powder), the structural characteristics of the source material were predicted (aluminum, copper, saponite). Classification of structurally inhomogeneous materials by size and particle shape is presented. The research of separate areas of the microstructure of particles of structurally inhomogeneous materials by the application program is substantiated Smart-eye. The microstructure of in-homogeneous materials obtained as a result of the entanglement of particles was investigated. The functional dependencies of porosity on the computer-simulation modeling of densities of various shapes and sizes of particles in the mold are investigated. Thus, there are grounds for asserting that the developed software for the process of formation of structurally inhomogeneous materials with the help of mathematical and computer modeling can be used to predict existing or create new composites with specified properties for operation under certain conditions, as well as the dynamic calculation of composite media taking into account the size of structural elements, establishing a correlation between components, structure, and properties.

Keywords: Porosity, Microstructure, Algorithm, Modelling, Forecasting, Inhomogeneous Materials, Particle Formation, Structural Characteristics.

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Part VI
Mechanics of Solids and Structures

Liquid Sloshing in Circular Toroidal and Coaxial Cylindrical Shells

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Free liquid vibrations in circular toroidal and coaxial cylindrical shells are considered. The liquid is supposed to be an ideal and incompressible one, and its flow inside the reservoirs is irrotational. In these assumptions, there exists a velocity potential that satisfies the Laplace equation. The mixed boundary value problem to determine this potential and liquid pressure are formulated for the Laplace equation and further reduced to solving the system of one-dimensional singular integral equations. For its numerical implementation, the boundary element method is used taking into account the ring shape of the free surface. The effective numerical procedures are proposed to accurate calculations of singular integrals containing elliptical integrals in their kernels. Numerical simulations are provided for both circular toroidal and coaxial cylindrical shells for different filling levels and various widths of gaps. The analytical solution is received for coaxial cylindrical shells, including a limit case of the infinitesimal gap. This solution can be considered as a benchmark test and allows us to validate the proposed numerical method.

Keywords: Free Liquid Vibrations, Circular Toroidal and Coaxial Cylindrical Shells, Boundary Element Method.

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Experimental Identification of a Car Dynamic Model Using the Numerical Algorithms for Subspace State-Space System Identification

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In this paper, a system identification numerical procedure is used to perform an experimental work based on the System Identification Toolbox available in MATLAB. This work aims to show the possibility of identifying a mathematical model of a car using low-cost sensors. The instrumentation used to reach this goal is composed of an Arduino Mega2560, a GPS receiver module, and an inertial measurement unit. The Arduino is used to handle the sensors and to save the measured data. The inertial platform is used to get the linear acceleration and angular rates of the system, while the GPS is used to get the trajectory of the car. By employing the N4SID algorithm, a discrete state-space model of the system can be identified and used to predict the behavior of the car system. It is also possible to obtain a continuous model from the discrete one and to identify the natural frequencies and the system damping factors. The results show the possibility to easily identify a mathematical model of a complex system using a limited set of experimental data.

Keywords: Applied System Identification, Car Dynamics, State-space Representation, Numerical Algorithms for Subspace State-Space System Identification (N4SID).

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Cavitational Wearing of Modified Ceramics

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The results of studies of cavitation resistance of modified ceramics are presented. ZrO_2 was inserted into the matrix based on Al_2O_3 in the amount of 2% by weight. The experiments were carried out under the action of ultrasound, which was generated by oscillations of a magnetostrictive vibrator. The frequency of cavitation effect 22 and 44 kHz was used. The intensity of wear of the specimens was evaluated by the losses of their mass. It was shown that the insertion of ZrO_2 into the Al_2O_3 ceramic matrix increases the resistance of ceramics. The nature of dependencies shows a similar pattern of wear of the specimens. The increase in the content of Al_2O_3 in the structure of the material and the addition of the small dispersed ZrO_2 increases the viscosity of ceramics. The shock waves after the collapse of cavitation bubbles are quenched in ceramics and increased its durability. The process of wearing of ceramics is cyclical. It is accompanied by the separation of the micro-particles. The destruction of the material occurs along the grain boundaries of Al_2O_3, internal defects, and glass-visible phase. The wear rates are similar for the tested specimens. The cyclical nature of ceramic wear is identical to metal wearing. This allows the use of known approaches for the analysis of results. The study of the rate of mass losses of ceramic specimens demonstrated the similarity with the hydro abrasive wearing of metals.

Keywords: Modified Ceramics, Vibration, Cavitation Wearing.

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Influence of Weak Shock Wave on the Dynamic Stress State of Foam Materials

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This paper proposes the technique for the analysis of weak shock wave influence on the dynamic stress state of foam materials with negative and positive Poisson's ratio. The investigation of the dynamic behavior of foam materials under the action of weak shock waves is performed in the framework of couple stress elasticity, where one can account for the influence of shear rotation deformation in structurally inhomogeneous media. For the solution of the non-stationary problem, Fourier transforms are used. The calculation of transforms of dynamic stresses in the foam medium is performed by using the boundary integral equation method and the theory of complex variable functions in the framework of couple stress elasticity. The numerical implementation of the developed algorithm is based on the method of mechanical quadrature and collocation technique. For calculation of originals of dynamic stresses discrete, Fourier transform is used. The distribution of dynamic hoop stresses in a positive and negative Poisson's ratio foam medium with tunnel cavities under the action of a weak shock wave is investigated. The algorithm is effective in the analysis of the dynamic behavior of the foam media with tunnel defects of various cross-sections.

Keywords: Auxetic, Couple Stress Elasticity, Time Domain Problem.

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Design of Hydraulic Mechatronic Systems with Specified Output Characteristics

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Current trends in expanding the scope of mechatronic systems with a hydraulic drive of active working bodies of self-propelled vehicles require the development of new approaches to solve the problem of improving the output characteristics of hydraulic drives of mechatronic systems with rotary hydraulic machines. When designing mechatronic systems, much attention is paid to ensuring the specified output characteristics of the actuators of the designed system. A methodology for designing hydraulic mechatronic systems with the elements of multi-criteria optimization has been developed, which allows designing a mechatronic system with specified output characteristics. The optimization parameters of the controls of the mechatronic system with a hydraulic drive of the active working bodies of self-propelled vehicles have been substantiated. This technique involves five stages: the choice of the mechatronic system parameters; substantiation of optimized control parameters; development of a mechatronic system model; optimization of selected parameters of the mechatronic system; analysis of optimization results. The parameters of optimization of controls of a mechatronic system with a hydraulic drive for active working bodies and running systems of self-propelled vehicles have been substantiated. As a result of the studies, the optimal settings of the safety valve of the mechatronic system have been established, providing deviations of the pressure and angular velocity of the actuators from the set ones with an error of 0.17% and 0.67%, respectively.

Keywords: Mechatronic System, Planetary Hydraulic Motor, Optimization Criterion, Integral Quadratic Estimate.

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Mathematical Modeling of the Operating Process in LS Hydraulic Drive Using MatLab GUI Tools

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The main objective of this research is to describe the LS hydraulic drive based on a multimode directional control valve, for the most important operation of the hydraulic drive, to develop a mathematical model, to describe the developed mathematical model in the MATLAB system, to develop a software module in the MATLAB system for conducting theoretical studies of the mathematical model of the hydraulic drive. The subject of research is working processes in the LS hydraulic drive, a mathematical model of the LS hydraulic drive. Methods of mathematical modelling of differential equations of a nonlinear mathematical model, development of software module analytical methods were used in the research. The result of the research is the mathematical model of the LS hydraulic drive in the form of a system of differential equations and the scheme in the MATLAB Simulink system, which provided the solution of mathematical model equations and obtaining graphs of transients in a hydraulic drive. The algorithm for data exchange in the MATLAB Simulink system and the GUI graphical interface program, which implements data exchange, allows us to investigate the influence of the parameters of a load-sensitive hydraulic drive on the amount of overregulation by the pressure of the hydraulic pump in the hydraulic drive.

Keywords: Matlab Simulink, Mathematical Model, Load-sensing, Hydraulic Drive, Modeling of Working Process.

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Gravitational Relief with Spiral Gutters, Formed by the Screw Movement of the Sinusoid

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The differential equations of the particle movement along a rough screw surface formed by the screw motion of a sinusoid under the action of the force of its weight are composed in the article. The sinusoid is located on a vertical plane and is an axial cross-section of the helical surface. The equations are solved by numerical methods and trajectories of a particle movement along a helical surface are constructed. Graphs of changing particle velocity and its distance from the surface axis were also received. The conditions of the stabilization of the particle movement are found. It is shown that in the general case, as a result of acceleration, the particle moves away from the surface axis and stops in one of its gutters. The changing of constant coefficients can control the depths and density of the gutters. In the particular case at zero depth of the gutter, a sinusoid becomes a straight line and the particle moves along the surface of the screw conoid.

Keywords: Axial Cross-Sectional Curve, Friction Coefficient, Particle, Movement Trajectory, Differential Equations.

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Development of an Energy Recovery Device Based on the Dynamics of a Semi-Trailer

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A semi-trailer is a vehicle without a power unit, whose purpose is to carry goods and materials; semi-trailers differ one from another based on the type and weight of the transported goods. In this work, we analyzed the motion dynamics of a generic articulated vehicle and developed a rigid multibody model. First, we analyzed mathematical models from literature to understand the vehicle's dynamic; secondly, we created a 3D model, based on theoretical background and typical constructive solutions; finally, we launched multibody simulations in a multi-domain environment SimScape. The results were used to evaluate the obtainable electric energy harvesting part of semi-trailer wheels' rotational kinetic energy; finally, the electric power would be stored into a battery. Having an energy recovery system mounted directly on the semi-trailer would result in great benefits both for the costs and for the environmental impact: since every utility needs the engine to be always active, with an electric source we could power every utility of the semi-trailer without using the engine so that we could avoid the unnecessarily introduction of pollutants into the atmosphere.

Keywords: Heavy vehicle, Dynamics, Vehicle, Multibody, Fuel Economy.

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Studies of the Swirling Submerged Flow Through a Confuser

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In vortex devices, it is often required to conserve part of the energy of the swirl flow to be dispersed. One of the most rational ways to save energy is to use a confuser. The characteristic of the confuser on a swirling flow has been little studied. It was performed a numerical simulation of the operating characteristics of the confuser. To validate the mathematical model, a comparison is made with the experimental data on the expiration of a swirling jet. Validation of the results was made by comparing with the experimental results not only qualitatively, but also quantitatively in terms of velocities at characteristic points of the flow. A comparison of the flow patterns shows a fairly accurate description of the flow pattern, the attenuation of rotation, and the velocity values in different sections by a mathematical model. A comparison of the use of the SST turbulence model to the effects of streamline curvature and system rotation is presented. The application of the RANS approach using the adjusted SST turbulence model allows quickly determining all the main characteristics of the swirl flow using medium-power computers. An analysis of the operation mode of confusers of different angles on a swirling flow shows that an increase in the average speed and pressure at the outlet from the confuser with a large angle leads to the possibility of saving most of the swirling flow energy and using it in the future.

Keywords: Swirling Flows, Confuser, Numerical Simulation, Turbulence, Submerged Flow.

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Operating Characteristics of Lever-Blade Shock Absorbers with the Extended Mechanical Structure

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The torsion suspension is a widespread structure in today's transport machine engineering. Since the torsion bar represents just an elastic element, the problem of energy dissipation in suspensions is highly relevant for its application. Hydraulic absorbers with the movable element's reciprocating translational motion respectively to the housing or lever-type hydraulic shock absorbers of piston and vane types, with the movable element's rotational movement respectively to the housing, are currently used as a dissipation device in torsion suspension. These absorbers only implement throttle-valve type working characteristics, associated with these devices' functional capacities and depending on design constraints. The paper presents a synthesis of an innovative lever-blade absorber, whose performance is not related to the value of the working chamber's inner pressure. Their essential peculiarity relates to the presence of a mechanical control loop in the structure, that determines a close relationship between the performance and the value of the shock absorber movable element displacement relative to the body. In the process of synthesis, the appropriate methods, built based on technical systems' modeling with modified kinematic graphs, are tested. The synthesis results are shown in the form of structurally implemented samples. A comparative analysis of the samples with their basic performance determination is performed.

Keywords: Lever-Blade Shock Absorbers, Mechanical Control Loop, Shock Absorber Performance.

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Estimation of Random Flow-Rate Characteristics of The Automatic Balancing Device Influence on Centrifugal Pump Efficiency

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The main function of an automatic balancing device is to balance the axial force in multi-stage centrifugal pumps. The advantage of this method of axial force balancing is the self-regulation of the device parameters. This allows balancing the axial force at different pump operating modes. In classic designs, the static characteristic (dependence of the hydrodynamic axial force of the device on the face gap), as well as the flow rate characteristic of the balancing device, are substantially determined by the cylindrical gap geometry. A middle gap of the cylindrical throttle, as well as its conductivity, is a random function due to manufacturing tolerances and possible erosive wear of sealing surfaces under pump operation. The paper presents the method of calculating the flow rate characteristics of the device with the random changes in the middle gap during operation of the pump, as well as the influence of random changes in local hydraulic resistances and parameter taper of face gap. The analysis of the influence of each of the considered random factors is made. Probabilistic characteristics of the pump efficiency are determined.

Keywords: Cylindrical Throttle, Face Throttle, Flow-rate, Axial Force, Probabilistic Characteristics, Pump Efficiency.

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Part VII
Numerical Simulation of Coupled Problems

Simulation of Wearing Processes with High Sliding Speed

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A calculation model of the wearing process under conditions of high-speed friction has been offered. The model is based on the thermokinetic theory of fracture. The determination of model parameters is based on a probabilistic-physical approach. The model is presented in discrete form and adapted for use by computer simulation methods using the Spatio-temporal discretization of the calculation algorithm. The analysis of the results showed that the prevailing factor that affects the stress-strain state of the tribosystem and the wearing processes is the rate of decrease of the friction coefficient from static to dynamic. It is proposed to use the rate of change of the friction coefficient to assess the effectiveness of using methods to increase the wear resistance of tribosystems under conditions of high-speed friction. As a result of the presented studies, an experimental analysis of the effect of changes in the coefficient of friction on the sliding velocity on wearing processes under conditions of high sliding velocities has been carried out. Experimental data confirm that the coefficient of change of the coefficient of friction is sensitive to the technology of the formation of the surface layer.

Keywords: Surface of Friction, Markov Chain, Tribological Damage, Computer Simulation, Laboratory Test.

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Analysis of Frictional Interaction in a Couple "Billet – Crystallizer"

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The design of an experimental device (cold billet head) for determining the forces of extraction from the mold of a continuous casting machine of copper alloy billets is proposed. The expediency of monitoring the temperature of the measuring element on which the base with strain gauges is made is shown. The temperature of the measuring element is controlled by a thermocouple mounted on the axis of the cold billet head, which is the place for averaging the temperature over the cross-section of the temperature compensator and the measuring element. It is shown that at current levels of overcoming the frictional force of rest and the sliding friction force (graphite - bronze pair), the cross-sectional area of the base should be 5.33 10^{-4} m^2. It is shown that the effort to overcome the static friction force exceeds the efforts to overcome the sliding friction force by 2.1–2.3 times.

Keywords: Continuous Casting, Mold, Billet Extraction Force, Experimental Cold Billet Head, Measuring Element.

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Analysis of the Initial Corrosion Stage of a Steel Disk Under the Influence of Stress

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As known, there are many types of metals corrosion, which in turn leads to the appearance of cracks, which bring the details of mechanical engineering out of operation. The work investigates the corrosion of an isotropic stress disk. To analyze the effect of corrosion on the disk operation, the method of singular integral equations is used. We conducted a literature review of this topic. We showed the solution of singular integral equations. The asymptotic stress values of an isotropic medium with a corrosion crack in the field of centrifugal forces are obtained. The analysis of the stress state of an isotropic steel disk was carried out depending on the shape, size, and location of the damage. The problem of a fixed disk with a crack, which shores are loaded with normal pressure, is considered. We built graphical illustrations that confirm the dependence of cracks appearing on the load, and also prove the compensation of load by increasing the number of cracks.

Keywords: Corrosion, Steel, Stress Intensity.

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Research on the Energy State of the Surface of Alloys for Gas-Turbine Engine Blades

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The work concerns the research on patterns of the electron work function (EWF) distribution over the sample surface, depending on the fatigue tests. When studying samples made of high-temperature alloy EP866 used for highly loaded parts of gas turbine engine (GTE) compressors, we determined a stage of reversible structural rearrangements when the EWF value for a given surface point decreases and increases periodically fluctuating around a particular average amount. At the initial stages of testing, the EWF oscillates near a specific value, which indicates the reversibility of the process of accumulation of fatigue damage and the change in the hardening processes – relaxation at these stages. Then a stage of irreversible structural changes in the material of the surface layer is observed when the EWF decreases monotonously until the sample is destructed. It was found that in the process of cyclic deformation, the material areas experiencing the same mechanical stresses correspond to the surface areas with the similar EWF values. The deformation processes preparing the formation of a fatigue crack to cause the creation of a "deformation" dip on all the EWF distribution curves, and, accordingly, the contact potential difference (CPD). It can be assumed that the maximum change in EWF in the dip corresponds to the most intensive flow of deformation processes. The EWF distribution over the sample surface makes it possible to predict the place of fatigue cracks initiation at the early testing stages.

Keywords: Electron Work Function, Compressor Blades, Fatigue Testing, Deformation Processes.

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Topology Optimization Procedure of Aircraft Mechanical Components Based on Computer-Aided Design, Multibody Dynamics, and Finite Element Analysis

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In mechanical engineering, the optimization process is time-consuming because of the lack of communication between design, simulation, and analysis software. In the case of single productions or small quantities, this possibility is not taken into account. In the case of serial productions, on the other hand, the optimization of the design time is of paramount importance due to the large amount of money that can be saved. To address these challenges, this investigation proposes a topological optimization procedure for mechanical parts that have complex geometric shapes using the integration of CAD, MBD and FEA software. The theory of linear elastodynamics is the basic approach used for the integration process carried out in this paper. In particular, the components analyzed in this work belong to the closing system of the ATR 42/72 cargo door. To explain the software integration procedure devised in the paper using SOLIDWORKS, MSC ADAMS, and ANSYS, a slider-crank mechanism is employed first as a demonstrative example. Subsequently, this computational procedure is applied to a flexible component of the latching system of the door whose loading conditions were previously obtained considering the entire opening mechanism modeled as a rigid multibody system. Finally, the topological optimization of the mechanical part is carried out and a consequential reduction in the amount of material to use is performed. The results obtained are considered significant since they led to considerable advantages in the door opening and closing system as well as a reduction of the total weight of the entire airplane.

Keywords: Topology optimization, Computer-Aided Design (CAD), Multi-Body Dynamics (MBD), Finite Element Analysis (FEA), Aircraft components, ATR 42/72 cargo door, Integration of Computer-Aided Design and Analysis (I-CAD-A).

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Numerical Simulation of Compression and Detonation Strokes in a Pulse Compression Detonation System

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At the National Technical University "Kharkiv Polytechnical Institute", an experimental pulse compression detonation (PCD) system was developed to operate on propane-air mixtures while addressing potential issues with regards to efficiency, ignitability of the gas, and the critical tube diameter for detonation. In this PCD system, the reactive gas was pre-compressed within the detonation tube, before ignition. The resulting mixture was found easier to ignite, and the transition to detonation within the tube was much more reliable and consistent. To gain further insight, and to investigate the effect of pressure gradient on the strength/velocity of outflow products and the overall thermodynamic cycle, a two-stage modelling procedure was adopted. First, a 3D inert simulation of the compression process of the PCD system was conducted using ANSYS. The resulting pressure and density profiles within the detonation tube were then prescribed as initial conditions for a 2D detonation stroke and outflow simulation. For this stage, the Compressible Linear Eddy Model for Large Eddy Simulation (CLEM-LES) framework adopted. For the PCD system, it was found that higher peak pressures were obtained at the outflow location of the tube when compared to a detonation tube filled initially at constant pressure equal to the ambient condition. As a result, the higher thermal efficiency of the detonation cycle may be achieved. However, it was found that the outflow products were under expanded, which may adversely affect the generated impulse. Therefore, the use of nozzles should be investigated in future work as part of the PCD system proposed here.

Keywords: Gas Compression, Detonation Initiation, Pressure and Density Profiles.

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Simulation of Bird Collision with Aircraft Laminated Glazing

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Aircraft collisions with birds are a severe safety problem. The purpose of this paper is to create a closed-form mathematical collision model that estimates the response of a laminated airplane glazing to bird impact and provides a risk score that can be utilized to underpin decisions made by engineers and designers. The collision model includes a bird impulse model, and a method for analyzing the stress-strained state of laminated airplane glazing at different operational factors is presented. The technique consists of a method for strength analysis of the laminated airplane glazing at bird impact and a method for analyzing superfluous pressure. The laminated glazing model is based on the refined theory accounting for transverse shear strains, thickness reduction, and normal element rotation inertia of each layer. The mathematical model of pressure impulse authentically reproducing bird impact is based on experimental research. Theoretical results are in good agreement with experimental data, allowing recommending the method for developing new airplane glazing elements.

Keywords: Bird Strike, Laminated Windshield, Safety.

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Part VIII
Chemical Process Technology

Ultrasonic Technology of Impregnation and Dosing Application of Liquid Epoxy Binders on Fabric Fiber Fillers

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The developed US technology of impregnation and dosed application of liquid epoxy binders on fabric fibrous fillers using rectangular radiating plates is described. According to the developed technology, US vibrations propagate uniformly along the width of the emitting plates, and according to the command of applying a voltage to the excitation windings along the length of the emitting plates. In this case, an analogy of the physical effect is achieved in the form of the peristaltic movement of liquid and pasty media relative to the fabric filler. Also, air inclusions are squeezed out of the interfiber space and uniformity of saturation of the impregnated material is achieved. Varying the content of the polymer binder, the uniformity of its distribution in the fabric material and the removal of the excess binder are controlled by the tilt angles and dosage of the pressing force of the pairs of emitting plates to the surface of the processed material, as well as by a change in the power supplied to the transducers of the emitting plates. It is also possible to use highly viscous and highly concentrated impregnating polymeric compositions, as well as compositions with short-fiber filler.

Keywords: Ultrasound, Process, Device, Impregnation, Dosing, Application, Woven, Epoxy, Polymer.

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Parameter Identification of the Capillary Rising Process in Nanomaterials for Evaporative Cooling Applications

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The article is devoted to the study of fluid lift dynamics due to the capillary effect, as well as the development of the reliable mathematical model of capillary rising process based on parameter identification considering the experimental results data. The results of the research are applicable in evaporative cooling technologies, inertial-filtering separation, and filtration processes. The practical significance of the obtained data is in relatively high performance (absorbency, thermal resistance, and liquid transportation capacity) of studied material samples for use in heat and mass transfer equipment. The experimental research consists of four stages for five samples of paper-like porous nanomaterial. According to the results of analytical and experimental studies, the mathematical model was developed for the aim of estimating the parameters of the liquid's movement. Particularly, the proposed approaches based on both quasi- and nonlinear, single- and multiparameter regression analyses, the rising-rate parameter and the maximum height of the liquid's rise along the capillary plate were identified. Carrying out the validation of the proposed mathematical models with experimental results allows concluding that the two-parameter estimation of the operating parameters with the relatively high value of the r-Pearson correlation coefficient allows clarifying the proposed reliable mathematical model of liquid's lifting process in capillary-porous media with enough accuracy.

Keywords: Evaporative Cooling, Maisotsenko Cycle, Porous Materials, Capillary Effect, Regression Approach.

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Hydrodynamics of Two-Phase Upflow in a Pneumatic Classifier with the Variable Cross-Section

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This paper is aimed at the investigation of the two-phase upflow hydrodynamics in prismatic-shape apparatuses with the variable cross-section. To reach this aim, the mathematical model of the gas flow was developed based on the averaged in time and space velocities of the turbulent flow. This model is supplemented by the research of the solid particle movement in this flow. The research novelty of the proposed research is in the obtained dependencies for determining the velocity field of solid particles in a pneumatic classifier, as well as for estimating the friction coefficient. Additionally, equations for determining the velocity field of a gas phase were developed by velocity components of the two-dimensional gas flow. As a result, related graphical characteristics of the gas flow in the pneumatic classifier were built, and trajectories of solid particles were defined with respect to the apparatus width and height. The approach for evaluating empirical parameters was proposed based on the quasi-linear regression analysis. Moreover, the conducted regression analysis allows identifying the parameters of the mathematical model by the results of numerical simulations. The proposed approach will allow optimizing the technological and operating parameters of the pneumatic classification process and design of the related separation equipment.

Keywords: Separation Process, Gas-dispersed Flow, Turbulent Mode, Velocity Field, Regression Analysis.

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Effect of Hydrodynamic Parameters on Membrane Electrolysis Enhancement

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The work studies the process of Cd^{2+} and Zn^{2+} cations transfer from an electrolyte to a near-membrane zone and through a cation-exchange membrane RALEX®CM-PES 11-66 at a two-chamber electrolyzer and the cations reduction as metals. The electrolyte of an anode chamber imitated possible composition of the industrial passivating baths for cadmium and zinc electroplating and contained 50 g/l sodium dichromate, 10 g/l sulfuric acid and 3 g/l Cd^{2+} or 1.755 g/l Zn^{2+}. A catholyte was presented by 1% aqueous sulfuric acid. A titanium plate (VT0 standard) was taken as a cathode, and lead (C2 grade) was taken as an anode. Various hydrodynamic conditions were studied as to their effect on the regularity of mass-transfer of impurity ions at the near-membrane zone with and without forced mixing of anolytes. Transfer of the impurity ions of Cd^{2+}, Zn^{2+} through the cation-exchange membrane with cadmium and zinc reduction at the cathode was studied at various current densities and various hydrodynamic conditions. Enhancement patterns of metallic cadmium and zinc are studied as a function of the current density increased and the forced mixing applied.

Keywords: Cation-exchange Membrane, Current Density, Similarity Parameters, Forced Mixing.

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Numerical Simulation of the Mass-Transfer Process Between Ammonia and Water in the Absorption Chiller

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This paper describes the absorption process of gaseous ammonia into liquid water in the plate heat exchanger, which is considered to be the crucial part of an absorption cooling system. Two approaches are utilized to numerically simulate this absorption process. In the first approach, the dissolution of gaseous ammonia into liquid water, as well as the following chemical reaction between the dissolved liquid ammonia and liquid water, are modeled. In the second approach, only the dissolution of ammonia into water is considered. The Henry's Law with Van't Hoff correlation is used for the simulation of the ammonia absorption process, namely the calculation of the concentration of ammonia in gas and in liquid. The Henry's law is utilized since its line has the best correlation with the ammonia-water equilibrium line for the concentrations, which is taken into account in the numerical simulations. The ammonia mass flux from gas to liquid phase and its concentration at the outlet of the computational domain is determined as a result of the simulations.

Keywords: Refrigerators Machines, Chillers, Ammonia Absorption, CFD, Eulerian Model, Henry's Law, Van't Hoff Correlation.

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Cooling Process Intensification for Granular Mineral Fertilizers in a Multistage Fluidized Bed Device

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The design of a multistage cooler with several inclined perforated shelves for cooling granular fertilizers is presented and explained in the article. It is proved that such device has certain technical and energy advantages compared with typical designs of coolers. For this purpose, physical modeling of the hydrodynamic structure of the fluidized bed in the shelf apparatus was carried out. The formation of hydrodynamic regimes that differ in their hydrodynamic structure depending on the design parameters of the shelf contact elements is justified. A mathematical model of the kinetics of cooling granules in a fluidized bed is developed, which makes it possible to determine the cooling time of granules and calculate the temperature profile in a suspended layer. The optimal design parameters of the shelf cooler were experimentally determined, at which the granules are intensively cooled to the technologically required temperature. The results of experimental studies are presented, which confirm the efficiency of granular fertilizers cooling in multistage shelf apparatus with less energy consumption.

Keywords: Shelf Cooler, Inclined Perforated Shelves, Active Hydrodynamic Mode, Coefficient, Time, Temperature Profile.

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Substantiation of Energy Parameters of a Continuous-Action Vibroextractor for a Solid-Liquid System

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The results of studies on energy consumption for the process of extracting target components with continuous vibration extraction in a solid-liquid system with a small difference in phase densities are presented. The influence of low-frequency mechanical oscillations on energy consumption is substantiated and regularities of their change from the mode parameters of the process are established. It is established that the power required to perform vibration mixing is determined by the fictitious force in the oscillatory motion and the resistance created by the viscous friction of the mixing device in the working environment. Taking into account the fictitious component of the vibrating mixing system, the equation of total energy consumption for the continuous vibration extraction process is obtained. For the interpretation of the obtained experimental dependencies, the energy consumption by the vibration mixing devices was calculated. It has been shown that vibration mixing allows for the efficient use of the energy invested in a unit of work volume, evenly distributing it in the cross-section of the apparatus.

Keywords: Vibroextraction, Mathematical Model, Hydrodynamics, Mass Transfer, Diffusion, Pulsating Flow.

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Part IX
Heat and Mass Transfer

Development of the Typical Design of the High-Pressure Stage of a Steam Turbine

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The article describes the creation of a methodology for the optimal high-efficiency flowing parts of the first compartments of powerful steam turbines, which consists of typical stages. The use of typical stages when creating the flow part of a high-pressure cylinder can significantly reduce the cost of manufacturing a steam turbine cylinder. A method for the formulation of the optimization problem is proposed. It ensures the finding of profiles for the nozzle and, accordingly, rotor blades of the same shape with minimal losses on the example of a 310MW turbine. As a result of the optimization of the first compartment of the high-pressure cylinder, the optimal flow part of the compartment was obtained. Based on which the plan of the numerical experiment was constructed with 6 variable profile parameters. The calculations were carried out using 3D modeling of the working medium flow. Based on the calculation results, the optimal profile was obtained, the profile loss of which is 2.35% less than that of the base one.

Keywords: Steam Turbine, High-Pressure Cylinder, Optimization, CFD, AxStream, Plan of the Numerical Experiment.

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Improvement of the Heat Substation Design for District Heating Supply Systems

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New requirements and trends for the design and retrofit of heat substations of the central heating system are formulated. The main differences in the design of the central and individual heat substations are considered. The classification of heat substations for heating and hot water supply depending on the equipment included is given. The strategy of computer-aided design of the central heat substations under conditions of a new tariff policy is presented. The basis of the design is the simulation of the equipment selection that has not only technical compliance but also ensures the economic efficiency of implementation, which guarantees the reliability and operability of the substation during its operation. A model of operation of the substation in various conditions (time of year, the day of the week, day time) is presented. Mathematical models are implemented as a computer-aided design system, which allows us to calculate new heat substations and to make a high-efficiency retrofit, and does not require special training of personnel.

Keywords: Heat Substation, CAD System, Retrofit of Heating System, Modeling Software.

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Experimental Research of the Excessive Water Injection Effect on Resistances in the Flow Part of a Low-Flow Aerothermopressor

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Water injection to the compressor channel is one of the effective ways to increase the power and efficiency of gas turbine plants. A promising method of water spraying is to use a jet apparatus – an aerothermopressor. Experimental studies of the excessive water injection effect on resistances in the flow part of a low-flow aerothermopressor are presented in this paper. To conduct an experimental study, an experimental setup was developed. An analysis of the obtained experimental data was carried out. A decrease in pressure losses by 15-20 % relative to pressure losses in a “dry” aerothermopressor is stated. Checking the calculated equation for adequacy with experimental data is shown in a discrepancy in a range from 40 % to –20 %. An empirical equation is obtained to determine the pressure losses for the low-flow aerothermopressor (checking the calculated empirical equation for adequacy with experimental data is shown a discrepancy in a range from +15 % to –15 %). It was found that the pressure loss becomes equal to or exceeds the losses for the dry aerothermopressor when the flow rate water amounts more than 0.2 (20 %).

Keywords: Thermogasdynamic Compression, Injection, Relative Pressure Losses.

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Characteristics of The Rotary Cup Atomizer Used as Afterburning Installation in Exhaust Gas Boiler Flue

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The requirements concerning the development of the high-performance fuel combustion equipment with a low environmental impact and high flexibility have significantly increased. Therefore, a sophisticated analysis is needed for obtaining the data for designing the afterburning installation. The research is aimed at investigating of atomization characteristics of rotary cup atomizer. Experimental studies of atomization characteristics were carried out on the experimental setup with atomized liquid of fuel oil, water, and water-fuel emulsions. For determining the droplet diameter of atomized liquid, the method of collecting droplets on glass slides coated with a layer of viscous liquid, in which the droplets of atomized liquid do not dissolve, was used. The uneven distribution of atomized liquid around the axis of atomizer was measured using a sector collector. The dependence of the effect of over the cross-section of atomizer cup on the average droplet diameter of atomized fuel, the coefficient of uneven distribution of atomized liquid around the axis of the atomizer, the atomizer root angle on air pressure and atomizer speed have been investigated by using the experimental data. Based on the experimental and theoretical data, a nozzle with atomizer diameter d_p = 25 mm was selected, which satisfactorily atomizes the fuel at a flow rate of 1–3 kg/h and provides the required diameter of emulsion droplets.

Keywords: Water-Fuel Emulsion, Exhaust Gas, Rotary Cup Atomizer, Droplet Diameter, Atomization Characteristic.

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Possibility of Using Liquid-Metals for Gas Turbine Cooling System

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The possibility of using heat pipes to cool elements of a gas turbine is considered. The temperature of the parts gas turbine should be approximately equal to 850–950 °C to ensure its safe operation. This temperature range is suitable for a special type of heat pipes with a liquid metal coolant. It is proposed to reduce the temperature gradients on the turbine blade by mounting porous reservoirs with a liquid metal coolant on the inner surface of the blade body. In a closed porous reservoir, a two-phase state of the coolant is maintained, and heat is transferred by the mutually opposite movement of steam and liquid due to diffusion. The solution to the problem of modeling the processes of motion and phase transition in a porous medium filled with coolant is presented. The problem of thermal conductivity of a multilayer system consisting of a heated shell of a blade and a porous reservoir filled with a liquid metal coolant is formulated, and a numerical solution is proposed. As a practical example of the use of high-temperature heat pipes, a new type of aircraft engine nozzle cooling system has been developed. The example consists of two parts. The first part showed a decreasing temperature gradient in the leading edge of the gas turbine nozzle. The second part concerns the development of the cooling system of the nozzle as the whole.

Keywords: Gas Turbine, Cooling System, Two-Phase Model, Porous Reservoir, Liquid-Metal Heat Carrier, Nozzle Vane, Gas Turbine Blade.

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Analysis of the Efficiency of Engine Inlet Air Chilling Unit with Cooling Towers

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The processes of cooling air at the inlet of energy installations by exhaust heat conversion chillers with heat removal from them by cooling towers of the circulating cooling system are studied on the example of a gas turbine. Two-stage air cooling is considered using combined type exhaust heat conversion chillers, which utilizes the exhaust gas heat of a gas turbine and which includes absorption lithium-bromide and refrigerant ejector chillers as stages to convert waste heat into cold. The data on current heat loads on exhaust heat conversion chillers and cooling towers in accordance with climatic conditions of operation with the different distribution of heat loads on the cooling towers according to their number was obtained on the base of the results of modeling the operation of the gas turbine cooling complex. It was shown the possibility to increase the fuel saving due to turbine inlet air cooling through decreasing the number of cooling towers and electricity consumption for driving the fans of cooling towers.

Keywords: Turbine, Climate, Thermal Load, Chiller, Cooling Tower, Fan.

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Enhancement of the Operation Efficiency of the Transport Air Conditioning System

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On analyzing the operation of air coolers of railway air conditioning (AC) systems, characterized by considerable variations in current heat loads according to actual climatic conditions on the route lines, the reserves to increase its efficiency by the intensification of refrigerant evaporation in air coils and to enlarge the range of deviation of refrigerant flows from their optimum values without noticeable decreasing heat flux were revealed. It has been proved that overfilling the air cooler coils by liquid refrigerant injector recirculation enables excluding the final dry-out stage of refrigerant evaporation with extremely low intensity of heat transfer and as result provides increasing the heat efficiency of air coolers (overall heat flux) by 20–30 % compared with conventional air coolers with complete refrigerant evaporation and superheated vapor at the exit. Moreover, a larger deviation of current heat load on railway route lines is permitted without considerable falling air cooler heat efficiency due to refrigerant injector recirculation at available many circulations. The method to determine the rational design heat load on air coolers of railway AC systems, providing closed to maximum refrigeration output generation over the considered period, was developed.

Keywords: Railway Air Conditioner, Changeable Heat Load, Liquid Refrigerant Recirculation.

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The Efficiency of Refrigeration Capacity Regulation in the Ambient Air Conditioning Systems

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The operation of the ambient air conditioning systems (ACS) is characterized by considerable fluctuations of the heat load in response to the current climatic conditions. It needs the analyses of the efficiency of the application of compressors with frequency converters for refrigeration capacity regulation in actual climatic conditions. A new method and approach to analyzing the effectiveness of ACS cooling capacity adjusting by using the compressor with changing the rotational speed of the motor as an example have been developed, according to which the overall range of changeable heat loads is divided into two zones: the zone of ambient air processing with considerable fluctuations of the current heat load, that requires effective refrigeration capacity regulation by the compressor with frequency converters (from 100 % rated refrigeration capacity down to about 50 %) and not an adjustable zone of reduced refrigeration capacity below 50 % rated refrigeration capacity of the compressor. The magnitudes of threshold refrigeration capacity between both zones are chosen according to the rational value of installed (design) refrigeration capacity on the ACS, required for cooling the ambient air to a target temperature that ensures the maximum annual refrigeration capacity production in actual current climatic conditions. The proposed method and approach to the analysis of the efficiency of the refrigeration capacity regulation of the ACS compressor by distributing the overall range of changes in current heat loads allows increasing the efficiency of utilizing the installed refrigeration capacity in prevailing climatic conditions.

Keywords: Ambient Air Processing, Stable Heat Load, Changeable Heat Load, Threshold Refrigeration Capacity, Refrigeration Capacity Distribution.

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Part X
Energy Efficient Technologies and Industrial Ecology

Improvement of the Model System to Develop Eco-Friendly Bio-Utilization of Phosphogypsum

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This paper focused on the modeling of the possibility of bacteria growth under medium that different content phosphogypsum (PG) doses for environmental protection purposes with special attention to the analysis of the effect of PG features underestimation of E.coli growth. The culture of E. coli is diluted with Lysogeny broth (LB) initially without adding PG to obtain an optical density at 600 nm (OD600) of 0.05. Study is carried out by adding different doses of PG (250 mg/200ml LB; 500 mg/200ml LB; 1000 mg/200ml LB). The OD600 is measured with the use of an absorption spectrophotometer. Under modeling PG feature effluence, several factors are identified that impact on bacteria growth and the general methodological approach to assessing the biochemical activity of PG is formed. The important direction for feature study the effect of PG use as a component of the medium for E. coli is the assessment of mutations and adaptive biochemical mechanisms, in particular, the possibility of biofilm formation. Microorganisms in biofilms are better adapted and much more resistant to high concentrations of various groups of xenobiotics. In some cases, the matrix itself is involved in bioremediation, sorbing and retaining toxic substances from the aqueous phase.

Keywords: Environmental Protection, Phosphogypsum, Modeling Influence, E.coli, Bioremediation

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Influence of High-Octane Bioadditives on Physical and Chemical Properties of Low-Octane Gasoline

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The problem of environmental safety of road transport has become an integral part of the security of Ukraine. The annual increase in vehicle emissions into the atmosphere requires the strengthening of environmental requirements for commercial fuels and exhaust gases of internal combustion engines. Modern cars require high-octane fuel with anti-knock properties, which are characterized by an experimental octane number of 92.95 and 98. For cars with gasoline engines with a compression ratio of up to 8, which are present in the fleet of Ukraine, as well as for trucks of the previous generation, there is a need for gasoline with a lower octane number. The presence of imported cars requires the production of gasoline, which would meet environmental requirements and would have a low cost. In this regard, increasing interest in the use of bioadditives, that would improve the environmental and operational properties of the fuel. World experience shows that the use of 10-15% bioadditives in the gasoline mixture does not have a negative impact on the technical and operational performance of the internal combustion engine. Therefore, the study of the influence on the physical and chemical properties of low octane gasoline is relevant.

Keywords: Gasoline, Operational Properties, Quality, Ecological Purity, Bioadditives.

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Improvement of the Production Technology of Liquid Biofuel from Technical Fats and Oils

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Because of petrol energy saving, emission standards of diesel exhaust gases hazardous substances requirement toughening, as well as carbonic oxide exhaust emission control, many countries need to find how to reduce the negative influence of heat engine over the environment. The most important operation of biodiesel technical processing from fat and oil waste were studied. The importance of keeping within the mass ratio of fat, oil, and alcohol was shown. The influence of fat and oil quality stock raw materials on the composition of biodiesel were estimated. Requirements for input raw materials were developed. A determining influence of raw material moisture on the mechanism of triglycerides transesterification in fatty acids methyl ester was shown, that, according to its operational characteristics, is close to petro-diesel fuel. The raw material free fatty acids (FFA) in conjunction with water make the process ineffective. As a result of scientific research, the technology of biodiesel production from vegetable oils and animal fats has been substantiated and its equipment support is offered. Experimental - industrial tests of mobile plants showed its possible to produce a good quality product that meets the modern operational requirements for biodiesel that could be used in engines without significant redesign. As a result of scientific research, the technology of biodiesel production from vegetable oils and animal fats has been substantiated and its equipment support was offered. A hardware-processing configuration and a layout equipment plant of mobile plant for the production of biodiesel from fats and oils were developed.

Keywords: Waste, Animal Fat, Vegetable Oil, Alcohols, Free Fatty Acids, Transesterification, Bio-Fuel, Plant.

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Influence of the Magnetic Field Gradient on the Efficiency of Magnetic Water Treatment

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This paper focuses on the study of the influence of a magnetic field gradient on the efficiency of the magnetic water treatment process (MWT). For this purpose, the changes in the kinetics of oxidation of organic matter with ozone were used. The methods of theoretical analysis of the geometry of the magnetic field in the equipment of water purification technologies were applied for experimental study of the influence of the inhomogeneous magnetic field on the kinetics of the oxidation reaction of organic pollution. Statistical processing of experimental results allowed approximation of the regression equation of MWT efficiency on the rate of magnetic induction change and duration of processing. The efficiency of MWT does not increase monotonically with increasing duration of the MWT process both increasing the value of magnetic induction change. The speed of the aqueous solution and the geometry of the inhomogeneous magnetic field are closely related and have been one of the main parameters that determine the MWT efficiency. These parameters can be expressed by the magnitude of the magnetic induction change. Experimentally established dependencies can find application in the development of scientific and methodological bases for the implementation of the process of magnetic treatment of polluted waters for the purification intensification in environmental protection systems.

Keywords: Magnetic Water Treatment, Aqueous Solution, Inhomogeneous Magnetic Field, Magnetic Induction Change, Magnitude.

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Heat Exchange Characteristics of Trays for Concentrating Solutions in Direct Contact with Hot Gas Emissions

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The paper presents the comparative study results of the thermal characteristics of trays applicable for concentrating technological and waste liquids in direct contact with hot gas emissions. The dual-flow tray with large perforation, a baffle tray, similar to that of the mixing condensers, and a paset, i.e. a tray, consisting of a funnel and a cone with a smaller outer diameter, mounted above it, were tested. The enthalpy exchange coefficient was chosen as a comparison parameter since it takes into account both “dry” (due to the temperature difference) and “wet” (due to evaporation) types of heat exchange. Using this coefficient, the degree of influence of liquid temperature and hydrodynamic factors (gas velocity and irrigation density) to the kinetics of enthalpy exchange during the interaction between air and 15 % sodium chloride solution was evaluated. It was found out, that according to the degree of influence on the heat exchange intensity, factors arranged in the following sequence: air velocity, related to the entire apparatus cross-section; spray density and temperature. Moreover, the impact of temperature appeared to be, although noticeable, but negligible. Processing the experimental results mathematically, formulas are obtained to calculate the enthalpy exchange coefficients for all contact trays researched. Recommendations are also provided for their use.

Keywords: Thermal Characteristics, Dual-flow Tray, Baffle Tray, Paset, Direct contact heat exchanger, Enthalpy Exchange Coefficient.

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Conference Notes

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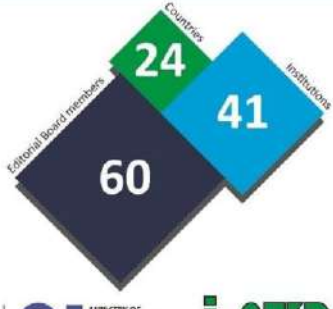

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