Book of Abstracts

DSMIE 2021

4th International Conference on

Design, Simulation, Manufacturing: The Innovation Exchange

June 8-11, 2021 | Lviv, Ukraine

Sumy State University

National University Lviv Polytechnic

IATDI International Association for Technological Development and Innovations

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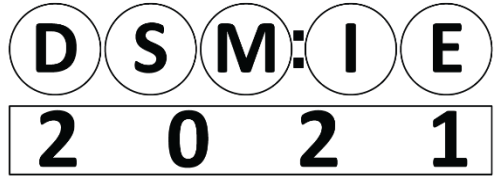
International Association for Technological Development and Innovations



4th International Conference on Design, Simulation, Manufacturing: The Innovation Exchange (DSMIE-2021)

June 8-11, 2021 | Lviv, Ukraine

Book of Abstracts

Sumy
2021

Editors:

Vitalii Ivanov, Ivan Pavlenko, Oleksandr Liaposhchenko, Oleksandr Gusak

Design, Simulation, Manufacturing: The Innovation Exchange: Book of Abstracts of the 4th International Conference, Lviv, Ukraine, June 8-11, 2021 / Vitalii Ivanov, Ivan Pavlenko, Oleksandr Liaposhchenko, Oleksandr Gusak (Eds.). – Sumy: IATDI, 2021. – 168 p.

Recommended by Coordination Board of International Association for Technological Development and Innovations (Protocol No. 2, February 25, 2021).

The content of this book is based on the 4th International Conference on Design, Simulation, Manufacturing: The Innovation Exchange (DSMIE-2021), held on June 8-11, 2021, in Lviv, Ukraine. This book reports on topics at the interface between manufacturing and materials engineering, with a special emphasis on product design and advanced manufacturing processes, intelligent solutions for Industry 4.0, covers topics in ICT for engineering education, describes the numerical simulation and experimental studies of milling, honing, burnishing, grinding, boring, and turning, 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 fatigue, fluid behavior, particle movement, pressure distribution. Further, it reports on developments in chemical process technology, 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

4th International Conference on Design, Simulation, Manufacturing: The Innovation Exchange (DSMIE-2021), held in Lviv, Ukraine on June 8-11, 2021, was organized by the Sumy State University, Lviv Polytechnic National University, 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), Association for Promoting Innovative Technologies – Innovative FET (Croatia), and Society for Robotics of Bosnia and Herzegovina (Bosnia and Herzegovina).

DSMIE-2021 received 175 contributions from 27 countries around the world. After a thorough peer-review process, the Program Committee accepted 100 papers written by authors from 20 countries. Thank you very much to the authors for their contribution. These papers are published in the present book, achieving an acceptance rate of about 57%. Extended versions of selected best papers will be published in scientific journals: Management and Production Engineering Review (Poland), Archives of Mechanical Technology and Materials (Poland), Journal of Engineering Sciences (Ukraine), Advances in Thermal Processes and Energy Transformation (Slovak Republic), and Assembly Techniques and Technologies (Poland).

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 to peer-reviewing manuscripts. Our reviewers come from worldwide and represent 18 countries, and are affiliated with more than 70 institutions.

Thank you very much to keynote speakers: Vitalii Pasichnyk (Ukraine), Katarzyna Antosz (Poland), and Alper Uysal (Turkey) for sharing their knowledge.

We appreciate the partnership with Springer Nature, StrikePlagiarism, EasyChair for their essential support during the preparation of DSMIE-2021. 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-2021

4th International Conference on Design, Simulation, Manufacturing: The Innovation Exchange (DSMIE-2021) 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 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-2021 brings together researchers from academic institutions, leading industrial companies, and government laboratories located worldwide to promote and popularize 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.

Sumy State University

National University Lviv Polytechnic

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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-2021 published in two volumes in the book **"Advances in Design, Simulation and Manufacturing IV"**. It belongs to the Lecture Notes in Mechanical Engineering (ISSN 2195-4356) series. The books of this series are published by Springer Nature and indexed by Scopus and submitted to Web of Science Core Collection.

Volume 1 – Manufacturing and Materials Engineering (ISBN 978-3-030-77719-7; DOI 10.1007/978-3-030-77719-7)

Editors:

- Vitalii Ivanov, Sumy State University, Ukraine
- Justyna Trojanowska, Poznan University of Technology, Poland
- Ivan Pavlenko, Sumy State University, Ukraine
- Jozef Zajac, Technical University of Kosice, Slovak Republic
- Dragan Perakovic, University of Zagreb, Croatia

Vol. 1

Volume 2 – Mechanical and Chemical Engineering (ISBN 978-3-030-77823-1; DOI 978-3-030-77823-1)

Editors:

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

Vol. 2

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

Extended versions of the best papers, presented at DSMIE-2021, 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;
- Assembly Techniques and Technologies, Poland (e-ISSN 2450-8217), http://tiam.com.pl/.

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 12,000 students pursuing bachelor's and master's degrees in 55 majors and 23 fields of knowledge. About 1900 international students represent about 50 countries worldwide.

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Sumy State University cooperates with more than 280 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.

The University actively develops academic mobility programs, including long-term and short-term studies, internships and placement programs for undergraduate and postgraduate students, professional development, teaching, and research mobility for staff with substantial scholarship and grant support using technologies of credit transfer and recognition of academic results.

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

Lviv Polytechnic National University

Lviv Polytechnic National University is the oldest technical higher educational institution in Ukraine and East Europe. It was founded in 1816.

Over the past decade, Lviv Polytechnic National University has become a true leader among universities and academies of Western Ukraine in providing high-quality higher education under European standards. The training of bachelor, specialist, and master students is carried out by 16 Institutes, where Ukrainian and international students study 66 bachelor's degree programs and 135 specialties, 130 of which are for master's degrees. The educational process at the higher education institution is provided by 2200 academic staff members, among which there are almost 400 – Doctors of Sciences, Professors and more than 1200 – Candidates of Sciences and Associate Professors;

the University Institutes train scientific and pedagogical staff at the Department of Doctoral and Post-graduate studies in 100 and 53 specialties.

Lviv Polytechnic University has 22 Specialized Academic Councils for thesis defense in 52 specialties, 17 of which – for getting the Doctor of Science degree in 45 specialties. The Specialized Academic Councils consist of leading Doctors of Sciences, University Professors, who head well-known scientific schools, and scholars from other higher national education institutions, institutes of the National Academy of Sciences of Ukraine, etc.

Lviv Polytechnic implements Knowledge Transfer Schemes. This approach enables the full implementation of new study programs for training specialists and leading technical universities in Europe, presenting two documents on higher education (Ukrainian and European).

✉ 12, Bandera St., Lviv, 79013, Ukraine
💻 https://lpnu.ua/en

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 for 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.

✉ 5/30, M. Lushpy Ave., Office 29, Sumy, 40035, Ukraine
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The monthly international magazine «Industry in FOCUS» has already attracted many companies who work in the industrial market. Time of feverish activity made our edition the most popular among similar journals.

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Agenda

Day 1 – **June 8, 2021** – Tuesday	
10^{00}–12^{00}	Testing Session
Day 2 – **June 9, 2021** – Wednesday	
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9^{00}–9^{30}	Opening Ceremony
9^{30}–11^{00}	Keynote Session
11^{00}–11^{20}	Coffee Break
11^{20}–12^{30}	Session 1 – Solutions for Industry 4.0
12^{30}–13^{30}	Time for Lunch
13^{30}–14^{30}	Session 2 – Manufacturing Engineering I
14^{30}–15^{30}	Session 3 – Manufacturing Engineering II
15^{30}–15^{50}	Coffee Break
15^{50}–17^{00}	Session 4 – Materials Engineering
18^{00}–22^{00}	Gala Dinner
Day 3 – **June 10, 2021** – Thursday	
8^{00}–9^{00}	Registration
9^{00}–10^{00}	Session 5 – Mechanical Engineering I
10^{00}–11^{00}	Session 6 – Mechanical Engineering II
11^{00}–11^{20}	Coffee Break
11^{20}–12^{30}	Session 7 – Chemical Engineering I
12^{30}–13^{30}	Time for Lunch
13^{30}–14^{30}	Session 8 – Chemical Engineering II
14^{30}–15^{00}	Closing & Awards Ceremony
15^{00}–18^{00}	Industry Tour
Day 4 – **June 11, 2021** – Friday	
10^{00}–12^{00}	City Tour
12^{00}–14^{00}	Ideas Exchange
14^{00}–16^{00}	Q&A Session for Organizational Issues

UA time (GMT+3) is used for all sessions.

Poster Session is open online via the following link https://dsmie.sumdu.edu.ua/schedule/posters.html.

Venue

Lviv (Lwow, Lemberg, Leopolis, Lvov) – all those names were given to Lviv – the city of "sleeping lions", which has changed them throughout its long history. Nowadays, Lviv remains one of the most beautiful, charming, and mysterious cities of Eastern Europe. It was included in the UNESCO World Heritage List for its monuments to the past and architecture. Lviv or «Lion's city», was named by its founder – the Galycian-Volynian King Danylo Galytsky, in honor of his son Lev. The city was first mentioned in the Galycian-Volynian Chronicle in 1256.

Lviv, the capital of Western Ukraine, is a large industrial and commercial center of Ukraine. Its narrow old streets and its historic center make it one of the best places in the country. The center of ancient Lviv was in the place of today's Rynok Square (Market Square). Situated on the crossroads of trade routes, Lviv grew fast and soon became an important center of commerce and crafts.

Lviv is a city of legends; many of them are romantic. Sometimes Lviv seems like a city full of legends, gothic novels, and fairy-tales, with its cobbled streets, ancient facades, and shady courtyards. Lviv is also famous for its churches and monasteries, including the Roman Catholic Cathedral, Uspensky Church, St George's Cathedral, Church of St John the Baptist, Jesuit Church, and many others. Lviv is also famous for its Museum of Historic Religions. Inside the Town Arsenal, the Museum of Old Arms displays various arms taken from over 30 countries.

We invite you to discover the pleasure! Welcome to Lviv!

Day 1: June 8, 2021, Tuesday

10^{00}–12^{00}	**Testing Session**

Testing Session for speakers will be organized during the specified time. Skype™ software was selected for online presentations. Guidelines will be sent to all speakers before the testing session. Direct links for downloading are presented below

https://www.skype.com/ru/get-skype/skype-for-mobile/

https://www.skype.com/ru/get-skype/

https://www.skype.com/ru/features/tablet-skype/

DSMIE-2021 will be broadcasted via the YouTube channel of the International Association for technological Development and Innovations. Please visit the following link **https://www.youtube.com/c/IATDIngo**.

Day 2: June 9, 2021, Wednesday

8^{00}–9^{00}	**Registration**
9^{00}–9^{30}	**Opening Ceremony**

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Ihor Hrytsay
Co-chair of the Conference
Oleh Matviikiv
First Vice-Rector of the Lviv Polytechnic National University
Oleksandr Gusak,
Dean of the Faculty of Technical Systems and Energy Efficient Technologies, Sumy State University
Vadym Stupnytskyy
Head of the Department of Robotics and Integrated Mechanical Engineering Technologies, Lviv Polytechnic National University

9^{30}–11^{00}	**Keynote Session 1** *Chair: Vitalii Ivanov* Sumy State University, Ukraine

Design and Engineering Assurance for the Customized Implants Production Using Additive Technologies
Vitalii Pasichnyk
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Ukraine

Machine Learning in Machining Process Data Analysis
Katarzyna Antosz
Rzeszow University of Technology, Poland

Sustainable Machining: Improving MQL Performance in Milling of Stainless Steel Using Nanofluid
Alper Uysal
Yildiz Technical University, Turkey

11^{00}–11^{20}	**Coffee Break**

11^{20}–12^{30} **Session 1 – Solutions for Industry 4.0**

Chair: Vadym Stupnytskyy

Lviv Polytechnic National University, Ukraine

Autonomous Data-Driven Integration into ERP Systems

Janis Peksa

Riga Technical University, Latvia

An Intelligent Scheduling System Architecture for Manufacturing Systems Based on I4.0 Requirements

Leonilde Varela, Vaibhav Shah, Aurelio Lucamba, Adriana Araujo And Jose Machado

University Of Minho, Portugal

Optimization Work with a Digital Human Model

Pavel Kabele and Milan Edl

University of West Bohemia, Czech Republic

Applicability of Traditional Project Closeout Approaches in Agile Developed IT Projects

Philipp Rosenberger[1] and Jozsef Tick[2]

[1] University of Applied Science FH Campus Wien, Austria

[2] Obuda University, Hungary

A New Approach for the Evaluation of Internal Logistics Processes and their Readiness for the Industry 4.0 Concept

Michal Zoubek, Michaela Koubovska and Michal Simon

University of West Bohemia, Czech Republic

Three Dimensional Technology Radar Model to Evaluate Emerging Industry 4.0 Technologies

Erwin Rauch and Eugenio Vinante

Free University of Bolzano, Italy

12^{30}–13^{30} **Time for Lunch**

13^{30}–14^{30} Session 2 – Manufacturing Engineering I

Chair: Oleg Zabolotnyi
Lutsk National Technical University, Ukraine

Wear Characteristics of Carbon and Tool Steels Hardened by Combined Laser-Ultrasonic Surface Treatment

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

[1] National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Ukraine
[2] University of the Basque Country, Bizkaia Science and Technology Park, Spain
[3] G.V. Kurdyumov Institute for Metal Physics of the NAS of Ukraine, Ukraine
[4] University of the Basque Country, Spain

Ensuring the Technological Parameters of Cast Block Crankcase of Automobile's Diesel Engine

Oleg Akimov[1], Kateryna Kostyk[1], Stepan Klymenko[2], Pavel Penzev[1] and Leonid Saltykov[1]

[1] National Technical University "Kharkiv Polytechnic Institute", Ukraine
[2] Physico-technological Institute of Metals and Alloys of the National Academy of Sciences of Ukraine, Ukraine

The Contact Pressure in Drawing Parts without Clamping the Workpiece Flange

Roman Arhat[1], Ruslan Puzyr[2], Viktor Shchetynin[1], Viacheslav Puzyr[1] and Tetiana Haikova[1]

[1] Kremenchuk Mykhailo Ostrohradskyi National University, Ukraine
[2] Kremenchuk Mykhailo Ostrohradskyi National University College, Ukraine

The Dynamic Model of the Automatic Clamping Mechanism with a Rotating Input Link

Borys Prydalnyi
Lutsk National Technical University, Ukraine

Diamond Spark Grinding of Hard Alloys Using Solid Lubricants

Aleksandr Rudnev[1], Yuriy Gutsalenko[1], Elena Sevidova[1], Larisa Pupan[1] and Oksana Titarenko[2]

[1] National Technical University «Kharkiv Polytechnic Institute», Ukraine
[2] National Academy of the National Guard of Ukraine, Ukraine

14^{30}–15^{30} Session 3 – Manufacturing Engineering II

Chair: Volodymyr Tonkonogyi
Odessa National Polytechnic University, Ukraine

Development of Optimum Thin-Walled Parts Milling Parameters Calculation Technique

Sergey Dobrotvorskiy[1], Serhii Kononenko[1], Yevheniia Basova[1], Ludmila Dobrovolska[1] and Milan Edl[2]

[1] National Technical University «Kharkiv Polytechnic Institute», Ukraine
[2] University of West Bohemia, Czech Republic

Simulation Research of Machining-Induced Surface Layer Operational Characteristics

Vadym Stupnytskyy, Ihor Hrytsay and She Xianning
Lviv Polytechnic National University, Ukraine

Geometric Modeling of Lathe Cutters for Turning High-Precision Stainless Steel Tapered Threads

Oleh Onysko[1], Iulia Medvid[1], Vitalii Panchuk[1], Vesna Rodic[2] and Cristian Barz[3]

[1] Ivano-Frankivsk National Technical University of Oil and Gas, Ukraine
[2] Independent University of Banja Luka, Bosnia and Herzegovina
[3] Technical University of Cluj-Napoca, North University Center of Baia Mare, Romania

Optimal Milling Conditions for Complex Shaped Thin-Walled Components

Anton Germashev, Yuri Vnukov, Mark Kuchuhurov, Viktor Logominov and Bert Lauwers

[1] National University «Zaporizhzhia Polytechnic», Ukraine
[2] KU Leuven, Belgium

Justification of Technological Possibilities for Reducing Surface Roughness during Abrasive Processing

Fedir Novikov[1], Dmytro Novikov[1], Andrii Hutorov[2], Yevhen Ponomarenko[3] and Oleksii Yermolenko[1]

[1] Simon Kuznets Kharkiv National University of Economics, Ukraine
[2] NSC "Institute of Agrarian Economics", Ukraine
[3] LTD "Business Center "INGEK", Ukraine

15^{30}–15^{50} Coffee Break

15^{50}–17^{00} Session 4 – Materials Engineering
Chair: Mykola Melnychuk
Lutsk National Technical University, Ukraine

The Ion Bombardment Modeling as a Component of the Structural Engineering of Nanoperiodic Composite Structures
Oleg Sobol', Nataliia Pinchuk, Andriy Meilekhov and Mariia Zhadko
National Technical University «Kharkiv Polytechnic Institute», Ukraine

Optimal Design of Composite Shelled Sandwich Structures with a Honeycomb Filler
Andrii Kondratiev[1], Olexander Potapov[2], Anton Tsaritsynskyi[3] and Tetyana Nabokina[3]
[1] O.M. Beketov National University of Urban Economy in Kharkiv, Ukraine
[2] Yuzhnoye Design Office, Ukraine
[3] National Aerospace University "Kharkiv Aviation Institute", Ukraine

The Influence of Synthesis Modes on Operational Properties of Oxide Ceramic Coatings on Aluminum Alloys
Nataliya Imbirovych[1], Oleksandr Povstyanoy[1], Olha Zaleta[1], Sergey Shymchuk[1] and Olga Priadko[2]
[1] Lutsk National Technical University, Ukraine
[2] National University of Life and Environmental Sciences of Ukraine, Ukraine

Rational Choice of a Material for Orthopedic Insoles Based on the Mechanical Characteristics and Practical Application Purposes
Ruslan Zaloha[1], Kostiantyn Dyadyura[1], Viliam Zaloga[1] and Michal Hatala[2]
[1] Sumy State University, Ukraine
[2] Technical University of Kosice, Slovak Republic

Structure and Properties of Surface Bandage Shelves for the Gas Turbine Engine's Blades
Natalia Zaichuk[1], Sergii Shymchuk[1], Anatolii Tkachuk[1], Yurii Feshchuk[1] and Jacek Szczot[2]
[1] Lutsk National Technical University, Ukraine
[2] Airport Lublin SA, Poland

Preparation and Characterization of a Biocomposite based on Casein and Cellulose
Mykola Melnychuk[1], Victoria Malets[1], Marcin Sosnowski[2], Ivanna Mykhaylyuk[1] and Inna Boyarska[1]
[1] Lutsk National Technical University, Ukraine
[2] Jan Dlugosz University in Czestochowa, Poland

18^{00}–22^{00} Gala Dinner

Day 3: June 10, 2021, Thursday

8^{00}–9^{00}	**Registration**
9^{00}–10^{00}	**Session 5 – Mechanical Engineering I** *Chair: Vitalii Pasichnyk* National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», Ukraine

Mathematical Model of the Thermoelasticity of the Surface Layer of Parts during Discontinuous Friction Treatment

Volodymyr Gurey[1], Heorhiy Shynkarenko[2] and Ihor Kuzio[1]

[1] Lviv Polytechnic National University, Ukraine

[2] Opole University of Technology, Poland

Wear Simulation for Internal Cylinder Contact in Rolling-Slip Mode

Aleksandr Dykha, Serhii Matiukh and Oleg Makovkin

Khmelnitsky National University, Ukraine

The Optimal Thickness of the Surface Plasma Hardening Layer of Functional-Gradient Parts with Symmetrical Stress Concentrators

Zinoviy Stotsko[1], Oleg Kuzin[2] and Mykola Kuzin[1,2,3]

[1] Lviv Polytechnic National University, Ukraine

[2] Lviv Branch of Dnipro National University of Railway Transport named after academician V. Lazaryan, Ukraine

[3] Lviv Research Institute for Forensic Expertise, Ukraine

Controllable Crank Mechanism for Exciting Oscillations of Vibratory Equipment

Oleksii Lanets, Oleksandr Kachur, Vitaliy Korendiy and Vasyl Lozynskyy

Lviv Polytechnic National University, Ukraine

An Increase in Wear Resistance Frictional Contact of Functional Surfaces for Plunger Pairs

Kostiantyn Svirzhevskyi[1], Oleg Zabolotnyi[1], Anatolii Tkachuk[1], José Machado[2] and Andriy Kononenko[1]

[1] Lutsk National Technical University, Ukraine

[2] University of Minho, Portugal

Mathematical Modeling of Physical and Mechanical Properties for Polymeric Materials Reinforced with Carbon Nanotubes

Anton Karvatskii, Taras Lazarev, Ihor Mikulionok, Victor Vytvytskyi and Vladyslav Solovei

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

[2] State Enterprise "Design Office "South" named after M.K. Yangel, Ukraine

10^{00}–11^{00} **Session 6 – Mechanical Engineering II**

Chair: Oleh Onysko

Ivano-Frankivsk National Technical University of Oil and Gas, Ukraine

Pressure Distribution in the Face Throttle of the Centrifugal Pump's Automatic Balancing Device

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

[1] AGH University of Science and Technology, Poland

[2] Sumy State University, Ukraine

The Influence of the Gas Content in the Working Fluid on Parameters of the Hydraulic Motor's Axial Piston

Pavel Andrenko[1], Andrii Rogovyi[2], Iryna Hrechka[1], Serhii Khovanskyi[3] and Maksim Svynarenko[4]

[1] National Technical University Kharkiv Polytechnic Institute, Ukraine

[2] Kharkiv National Automobile and Highway University, Ukraine

[3] Sumy State University, 2, Rymskogo-Korsakova St., Sumy, 40007, Ukraine

[4] Kharkiv National University of Construction and Architecture, Ukraine

Detuning of a Supercharger Rotor from Critical Rotational Velocities

Andrii Marchenko, Andrey Grabovskiy, Mykola Tkachuk, Oleksandr Shut and Mykola Tkachuk

National Technical University "Kharkiv Polytechnic Institute"

Particle Movement in a Centrifugal Device with Vertical Blades

Serhii Pylypaka[1], Tatiana Volina[2], Andrii Nesvidomin[3], Irina Zakharova[2] and Alla Rebrii[3]

[1] National University of Life and Environmental Sciences of Ukraine, Ukraine

[2] Sumy Regional Institute of Postgraduate Pedagogical Education, Ukraine

[3] Sumy National Agrarian University, Ukraine

Institutional Aspects of Integrated Quality Assurance of Engineering Study Programs at HEI Using ICT

Vitaliy Kobets[1], Vira Liubchenko[2], Ihor Popovych[1] and Svitlana Koval[3]
[1] Kherson State University, Ukraine
[2] Odessa National Polytechnic University, Ukraine
[3] Kherson State Agrarian University

In-Campus Way of the Insight Transfer Technology

Lesya Shkitsa, Volodymyr Kornuta, Olena Kornuta, Vasyl Bui and Iryna Bekish
Ivano-Frankivsk National Technical University of Oil and Gas, Ukraine

11^{00}–11^{20} **Coffee Break**

11^{20}–12^{30} **Session 7 – Chemical Engineering I**
Chair: Oleksandr Liaposhchenko
Sumy State University, Ukraine

Hydrodynamic Parameters of a Combined Contact Device

Viktor Moiseev, Oleksandr Liaposhchenko, Eugenia Manoilo, Maryna Demianenko and Oleg Khukhryanskiy
[1] National Technical University «Kharkiv Polytechnic Institute», Ukraine
[2] Sumy State University, Ukraine
[3] LLC "UZLITI Engineering", Republic of Uzbekistan

Optimization of Diesel Fuel Composition with Bio-Component and Functional Additives

Nina Merezhko, Valentyna Tkachuk, Volodymyr Komakha, Oksana Rechun and Liubov Kovalska
[1] Kyiv National University of Trade and Economics, 19, Kioto St., Kyiv 02156, Ukraine;
[2] Lutsk National Technical University

Numerical Simulation as a Tool for Design Optimization of Two-Phase Swirl Flow Atomizers

Andzelika Krupinska[1], Marek Ochowiak[1], Daniel Janecki[2], Sylwia Wlodarczak[1] and Magdalena Matuszak[1]
[1] Poznan University of Technology, Poland
[2] University of Opole, Poland

Simulation of the Bulk and Granular Materials Separation Process in the Scissor Type Gravity Separator

Igor Dudarev, Vasyl Olkhovskyi, Svitlana Panasyuk and Serhii Khomych
Lutsk National Technical University, Ukraine

Justification of Local Expenditure Characteristics of Vibrotransporting Devices in Design Modeling of Continuous Vibroextractors

Volodymyr Zavialov, Taras Mysiura, Nataliia Popova, Yuliia Zaporozhets and Valentyn Chornyi
National University of Food Technologies, Ukraine

Particle Image Velocimetry Based on Matlab and PIVlab for Testing Flow Disturbing Elements

Marek Ochowiak, Sylwia Wlodarczak, Andzelika Krupinska and Magdalena Matuszak
Poznan University of Technology, Poland

12^{30}–13^{30} **Time for Lunch**

13^{30}–14^{30} **Session 8 – Chemical Engineering II**
Chair: Ivan Pavlenko
Sumy State University, Ukraine

Equipment for Oilfield Wastewater Treatment Using Swirling Flows

Oleksandr Liaposhchenko[1], Viktor Moiseev[2], Oleksandr Starynskyi[1], Eugenia Manoilo[2] and Houssein Seif[1,3]
[1] Sumy State University, Ukraine
[2] National Technical University «Kharkiv Polytechnic Institute», Ukraine
[3] AlKhorayef Company For Sale, Maintenance & Repair of Oil Production Equipment LLC, Kuwait

Thermal Characteristics of the Wet Pollution Layer on Condensing Heating Surfaces of Exhaust Gas Boilers

Victoria Kornienko[1], Roman Radchenko[2], Tadeusz Bohdal[3], Mykola Radchenko[2] and Andrii Andreev[1]
[1] Kherson branch of Admiral Makarov National University of Shipbuilding, Ukraine
[2] Admiral Makarov National University of Shipbuilding, Ukraine
[3] Koszalin Technical University, Poland

Stimulation of Anaerobic Fermentation of Wastewater and Sewage Sludge

Yelizaveta Chernysh, Igor Roy, Viktoriia Chubur, Manabu Fukui and Ivan Koziy
[1] Sumy State University, Ukraine
[2] Hokkaido University, Japan

Efficiency of Thermopressor Application in an Ejector Refrigeration Machine

Dmytro Konovalov, Halina Kobalava, Andrii Radchenko, Oleksii Zielikov and Viktor Khaldobin

Admiral Makarov National University of Shipbuilding, Ukraine

Obtaining of the Novel Organo-Mineral Fertilizers in Pan Granulators: Technological Fundamentals

Artem Artyukhov[1], Serhii Vakal[2], Viktoriia Shkola[1], Viktoriia Vakal[2] and Anna Yanovska[1]

[1] Sumy State University, Ukraine

[2] Scientific Research Institute of Mineral Fertilizers and Pigments, Ukraine

14^{30} – 15^{00}	**Closing & Awards Ceremony** *Chair: Vitalii Ivanov* Sumy State University, Ukraine
15^{00} – 18^{00}	**Industry Tour**

Day 4: June 11, 2021, Friday

10^{00}–12^{00}	**City Tour**
12^{00}–14^{00}	**Ideas Exchange** *Chair: Ihor Hrytsay* Lviv Polytechnic National University
14^{00}–16^{00}	**Q&A Session for Organizational Issues** *Chair: Vitalii Ivanov* Sumy State University, Ukraine

Posters List

No.	Poster Title & Authors
1	**Investments in Blockchain Information Management Systems based on Business Angels' Criteria** *Andrei Davydovitch, Tatjana Vasiljeva, Julija Novinkina and Bohdan Haidabrus*
2	**Agile Project Management Based on Data Analysis for Information Management Systems** *Bohdan Haidabrus, Janis Grabis and Serhiy Protsenko*
3	**The Implementation of Industry 4.0 Supported by Service Robots in Production Processes** *Isak Karabegovic, Edina Karabegovic, Mehmed Mahmic, Ermin Husak and Predrag Dasic*
4	**Intelligent Numerical Control of Profile Grinding** *Vasily Larshin, Natalia Lishchenko, Oleksandr Lysyi and Sergey Uminsky*
5	**Choice of Carrier Behavior Strategy According to Industry 4.0** *Dmitriy Muzylyov, Natalya Shramenko and Mykola Karnaukh*
6	**Reliability of Road Transport Means as a Factor Affecting the Risk of Failure - The Transport Problem Case Study** *Piotr Trojanowski and Justyna Trojanowska*
7	**Complex Recognition Approach for Cutting Part of Cutters in Finishing Turning** *Oleksandr Derevianchenko and Oleksandr Fomin*
8	**Fractal Analysis of Structural and Phase Changes in the Metal of Welded Steam Pipe Joints** *Yaroslav Garashchenko Alyona Glushko, Olena Kobets and Olena Harashchenko*
9	**Research of the Spindle Units for Multioperational Lathes in the APM WinMachine Environment** *Oleg Krol and Volodymyr Sokolov*

No.	Poster Title & Authors
10	**Technological Inheritability of Product Material Using the Criterion of Technological Damageability** *Yaroslav Kusyi*
11	**Rational Design Solution Based on Mathematical Modeling of an Interference Fit** *Vladimir Nechiporenko, Valentin Salo, Petro Litovchenko, Valeriya Rakivnenko and Andriy Horbunov*
12	**Design and Engineering Assurance for the Customized Implants Production Using Additive Technologies** *Vitalii Pasichnyk, Maksym Kryvenko, Svitlana Burburska and Oleksandr Haluzynskyi*
13	**The Optimal Conditions for Adding Strain to the Deformation Zone during the Expansion of Automobile Pipe Adapters** *Ruslan Puzyr, Eduard Klimov, Andrii Chernish, Serhii Chernenko and Yuliia Sira*
14	**Technological Parameters of Hole Shaping in the Cones Rolling-Cutter Row of Roller Cone Bits** *Andrii Slipchuk and Roman Jakym*
15	**Design Calculation of Automatic Rotary Motion Electrohydraulic Drive for Technological Equipment** *Volodymyr Sokolov, Olga Porkuian, Oleg Krol and Oksana Stepanova*
16	**Optimization of the Interelectrode Gap in Electrical Discharge Grinding with Changing Electrode Polarity** *Roman Strelchuk and Oleksandr Shelkovyi*
17	**Determination of Radial Displacement Coefficient for Designing of Thread Joint of Thin-Walled Shells** *Tetiana Tutko, Olha Dubei, Liubomyr Ropyak and Vasyl Vytvytskyi*
18	**Mobile Application for Test Control of Knowledge among Mechanical Engineering Students** *Alexander Alexeyev, Tetiana Malandii and Alina Moshna*
19	**An Android Application for Explaining Form Deviations Using 3D Models** *Grigore Marian Pop, Radu Comes and Liviu Adrian Crisan*

No.	Poster Title & Authors
20	**Information and Communication Technology Tools for Enhancing Engineering Students' Creativity** *Olena Titova, Petro Luzan, Natalia Sosnytska, Serhii Kulieshov and Olena Suprun*
21	**Measurement of Contact Pressure for Conical Honing** *Eshreb Dzhemilov and Ruslan Dzhemalyadinov*
22	**Simulation Methodology of Diamond Burnishing** *Vladimir Fedorovich, Ivan Pyzhov, Janos Kundrak, Larisa Pupan and Irina Voloshkina*
23	**Study of Dynamic and Power Parameters of the Screw Workpieces with a Curved Profile Turning** *Ivan Hevko, Andrii Diachun, Oleg Lyashuk, Yuriy Vovk and Andriy Hupka*
24	**Effect of Abrasive Finishing on the Electrical Parameters of S-band Rectangular Waveguides** *Natalia Honchar, Pavlo Tryshyn, Dmytro Stepanov and Olena Khavkina*
25	**Prediction the Durability of Hobs Based on Contact and Friction Analysis on the Faces for Cutting Teeth and Edges during Hobbing** *Ihor Hrytsay and Vadym Stupnytskyy*
26	**Analytical Model of Crack Formation Potential during Thermomechanical Processing of Materials** *Maksym Kunitsyn, Anatoly Usov and Yulia Sikirash*
27	**The Influence of Grinding Modes on the Quality of the Surface Layer** *Maksym Kurin, Serhii Nyshnyk and Anatolii Dolmatov*
28	**Improvement of the Gear Shaping Effectiveness for Bimetal Gears of Internal Gearing with a Friction Coating** *Mykola Korotun, Yuliia Denysenko, Olaf Ciszak and Oleksandr Ivchenko*
29	**Penetration Depth of the Critical Temperature into the Workpiece Material During Grinding** *Vladimir Lebedev, Tatiana Chumachenko, Nataliya Klymenko, Olga Frolenkova and Serhii Yevtifieiev*

No.	Poster Title & Authors
30	**Interaction of Flexural and Torsional Vibration Shapes in Fine Boring with Cantilever Boring Bars** *Alexandr Orgiyan, Gennadiy Oborskyi, Vitalii Ivanov, Anna Balaniuk and Ruslan Matzey*
31	**Heat Flows Affected on the Wheelhead of a Cylindrical Grinding Machine** *Mykhaylo Stepanov, Petro Litovchenko, Larysa Ivanova, Maryna Ivanova and Magomediemin Gasanov*
32	**An Experimental and Statistical Investigation on Cutting Forces in Turning of AISI 304 Stainless Steel under Dry, MQL and Nanofluid MQL Conditions** *Youssef Touggui, Alper Uysal, Ugur Emiroglu and Eshreb Dzhemilov*
33	**Strengthening of the NKV Type Centrifugal Pump's Shaft by Chemical-Thermocycling Treatment** *Kristina Berladir, Tetiana Hovorun and Oleksandr Gusak*
34	**Advanced Technologies of Manufacturing Readily Removable Cores for Obtaining High-Quality Castings** *Olga Ponomarenko[1], Igor Grimzin[2], Nataliia Yevtushenko[1], Tatiana Lysenko[3] and Dmytro Marynenko[1]*
35	**Powder Technology and Software Tools for Microstructure Control of $AlCu_2$ Samples** *Oleg Zabolotnyi, Viktoriya Pasternak, Nataliia Ilchuk, Nataliia Huliieva and Dagmar Cagáňová*
36	**The Durability of the Nanocrystalline Hardened Layer during the Fretting Wear** *Ihor Hurey, Tetyana Hurey, Olena Lanets and Petro Dmyterko*
37	**Compression Mechanics of Cylindrical Samples with Radial Deformation Limitation** *Ihor Shepelenko, Yuri Tsekhanov, Yakiv Nemyrovskyi, Vasiliy Gutsul and Sergii Mahopets*
38	**Methods and Algorithms for Calculating Nonlinear Oscillations of Rotor Systems** *Vitalii Simonovskiy, Ivan Pavlenko, Jan Pitel', Denys Stremoukhov, Vitalii Ivanov*

No.	Poster Title & Authors
39	**Optimizable Mathematical Model of Curve Steel Parts' Fatigue** *Svetlana Bershak, Victor Kurgan, Ihor Sydorenko, Oleksii Lopakov and Volodymir Kosmachevskiy*
40	**Fluid Behavior in an Auto-Balancing Unit without External Dampin** *Ilona Drach and Andrii Goroshko*
41	**Improvement of Operating Processes of High-Head Tubular Horizontal Hydraulic Turbines** *Oleksandr Gusak, Mikhail Cherkashenko, Oleg Potetenko, Alexander Hasiuk and Kseniya Rezvaya*
42	**Influence of the Shape of Windows on the Throughput of the Planetary Hydraulic Motor's Distribution System** *Anatolii Panchenko, Angela Voloshina, Igor Panchenko, Viktor Pashchenko and Andrii Zasiadko*
43	**Evaluating the Wall Thickness of a Blow Molding Billet** *Dmitro Sidorov, Aleksandr Kolosov, Elena Kolosova, Julia Nosachova and Mykola Glushchenko*
44	**Synthesis of Target Reducing Performance Using a Reducing Valve with Mechanical Control System** *Ihor Sydorenko, Vladimir Tonkonogyi, Vladimir Semenyuk, Valeriy Lingur and Liubov Bovnegra*
45	**Contact Interaction of a Ball Piston and a RunningTrack in a Hydrovolumetric Transmission** *Mykola Tkachuk, Andrey Grabovskiy, Mykola Tkachuk, Iryna Hrechka and Volodymyr Sierykov*
46	**Hydrodynamic Characteristics Features of Trays Used in Heat and Mass Transfer Processes with Waste Liquids** *Andrii Masikevych, Musii Tseitlin, Valentina Raiko and Oleksii Shestopalov*
47	**Hydrolysis of Vegetable Raw Pectin-Containing Materials under Vibration and Centrifugal Mixing of Liquid Environment** *Igor Palamarchuk, Vladyslav Palamarchuk, Maxim Gudzenko, Viktor Sarana and Roman Mukoid*
48	**Comprehensive Model of a Catalytic Converter** *Valery Ved and Olena Ved*

No.	Poster Title & Authors
49	**Modelling of the Effect of Slide Burnishing on the Surface Roughness of 42CrMo4 Steel Shafts** *Rafal Kluz, Tomasz Trzepiecinski, Magdalena Bucior and Katarzyna Antosz*
50	**The Main Parameters of the Physalis Convection Drying Process** *Marija Zheplinska, Mikhailo Mushtruk, Volodymyr Vasyliv, Natalia Slobodyanyuk and Yuriy Boyko*
51	**An Agro-Industrial Complex Fat-Containing Wastes Synthesis Technology in Ecological Biofuel** *Mikhailo Mushtruk, Olena Deviatko, Sergii Ulianko, Nataliia Kanivets and Nataliia Mushtruk*
52	**Energy Saving Load-Sensing Hydraulic Drive based on Multimode Directional Control Valve** *Oleksandr Petrov, Andrii Slabkyi, Leonid Kozlov and Nataliia Rybko*
53	**Rational Refrigeration Loading of Ambient Air Conditioning System** *Mykola Radchenko, Eugeniy Trushliakov, Veniamin Tkachenko, Oleksandr Rizun and Oleksiy Moskovko*
54	**Enhancing Energy Efficiency of Ship Diesel Engine with Gas Ecological Recirculation** *Roman Radchenko, Maxim Pyrysunko, Victoria Kornienko, Dmytro Konovalov and Olena Girzheva*
55	**Improvement of Engine Indicators during their Operation on Gas Fuels** *Victor Zaharchuk, Oleh Zaharchuk, Mykola Skalyha, Larisa Pylypiuk and Ihor Shlonchak*

Presentation Guidelines

The official language of the DSMIE-2021 is English.

Keynote presentations

Each presentation is 30 minutes long. It is recommended to use 25 minutes to present the main content 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-2021, which can be downloaded via the link https://dsmie.sumdu.edu.ua/calls/presentation-guidelines.html.

Oral presentations

Individual papers are grouped into thematic sessions, which usually consist of 5-6 oral presentations. Each presentation is 10 minutes long. It is recommended to use 8 minutes to present and 2 minutes for open discussion/questions.

The recommended file type 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 4, 2021**. 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 conference day.
- Session PC will be equipped with a recent version of the Windows OS and MS PowerPoint software. 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 light 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 slide. Too many illustrations 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.
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- The template of the presentation can be downloaded via the 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 **June 4, 2021**. They will be posted on the Conference website for evaluation before the start of the Conference.

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- The poster's content should be structured and have the following parts: title, introduction, research methodology, results, conclusions, etc.
- Posters 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 poster interesting.
- Fill out a storyboard before you begin to put your poster together. It will help you stay organized, and things will get done faster. Do not read from the poster - vary your choice of words.
- Maintain eye contact with the audience.
- The template of the poster can be downloaded via the 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 10, 2021).

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

Vitalii Pasichnyk,
DSc., Professor, Vice-Rector for Scientific Work,
National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», Ukraine

Prof. Pasichnyk is a Full Professor at the Department of Machine Design of National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute». His research interests are related to computer-integrated manufacturing engineering, computer-aided processes planning, and advanced manufacturing engineering. The main research focus is the application of additive technologies for custom orthopedics implant design and manufacturing. Prof. Pasichnyk is a scientific adviser of the research group working with advanced technologies of digital manufacturing. He is a member of the Administrative Committee of the National Council of Ukraine for Science and Technologies Development.

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Keynote Speech Topic

Design and Engineering Assurance for the Customized Implants Production Using Additive Technologies

Development and dissemination of practical additive technologies applications have become a significant trend in technology development in various applied fields. Medical engineering is one of the industry branches where using such technologies already has a tangible effect and will become even greater in the future, especially in the manufacture of customized implants. In many cases, customized implants provide the patient with a quality of life that other solutions cannot offer. At the same time, the correct application of medical engineering solutions in this area requires enhanced engineering support. The point here is not as much about the optimal modes of implant formation but the engineering support system for decisions at each step from the initial condition analysis to surgery. Considerable practical experience of authors in the field of possibilities for additive technologies application in creating customized implants and their entire engineering support system is presented. These results are based on the authors' own practical experience, implemented in the Laboratory of Biomedical Engineering of the Institute of Orthopedics and Traumatology of the National Academy of Medical Sciences of Ukraine.

Keynote Speaker

Katarzyna Antosz,
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Katarzyna Antosz is a Professor of mechanical engineering at the Department of Manufacturing Processes and Production Engineering, Faculty of Mechanical Engineering and Aeronautics, Rzeszow University of Technology, Poland. She is a member of Lean Learning Academy Polska, the Polish Production Management Association, International "Association of Engineering, Project, and Production Management (EPPM)", and International Association for Technological Development and Innovations.

Her professional interests, research topics, and international collaborations mainly focus on production engineering, systems reliability, predictive maintenance, lean maintenance, and intelligent decision support systems in production and maintenance. Her research skills and experience are in machine learning methods and fuzzy logic for modeling, assessing, and improving processes and implementing expert systems in a maintenance strategy using methods for assessing criticality, prioritizing production and maintenance, and implementing the Lean Six Sigma concept.

She is the Editor-in-Chief of the quarterly "Technologia i Automatyzacja Montażu" (Assembly Techniques and Technologies). She is also a journal editor of special issues in JCR indexed journals, a reviewer of international journals, and a member of organizational and program committees of international conferences.

Prof. Antosz is an author of more than 80 scientific papers published as monographs, conference proceedings, and articles. She is a contractor in national and international EU projects and projects implemented in companies. She participates in domestic and foreign study visits at universities and enterprises, including Norway, Japan, Portugal, Germany, and Belgium.

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Keynote speech topic

Machine Learning in Machining Process Data Analysis

One of the assumptions of Industry 4.0. is the most advanced digitization and comprehensive use of the realized processes data, most often obtained with the use of dedicated sensors. Such actions help to optimize the enterprise's work on many levels because the obtained information can be used in various contexts, depending on the demand. In the assumptions of Industry 4.0, data processing is expected to bring about general changes in production, and the spread of cutting-edge technologies will enable a gradual increase in productivity in manufacturing companies. Therefore, it is important to obtain relevant data and develop a concept for their analysis to use appropriate methods to extract knowledge from them. The keynote speech will present the possibility of using data mining methods in the data analysis of a machining process. The data were obtained from the developed system for monitoring the condition of cutting tools during the machining process. It was a real-time system based on such types of sensors as: accelerometers, an acoustic emission sensor, a force and torque sensor, and the signals generated during machining. The data were processed using computational intelligence algorithms. Machine learning methods were used primarily for developing the prediction models. The developed predictive models explain the changes in the condition of a cutter blade depending on the values of the measured parameters. Based on the data analysis, problems in the machining process were also detected. The developed models were evaluated with the use of indicators to assess the quality of classifications. The obtained results confirm the high quality of predictive models. The proposed models can be used to support a decision-making process in determining the RUL of a cutting tool. It will reduce the consumption of raw materials and production waste and reduce the company's environmental impact, which is consistent with sustainable development assumptions.

Keynote Speaker

Alper Uysal,
Ph.D., Associate Professor
Department of Mechanical Engineering,
Yildiz Technical University, Turkey

DSMIE Conference Series

Alper Uysal is an Associate Professor at the Department of Mechanical Engineering of the Yildiz Technical University and the Coordinator of the Incoming Erasmus Students at the department. He received his B.Sc. in Mechanical Engineering from the Uludag University in Bursa (Turkey). He obtained his M.Sc. and Ph.D. degrees in Mechanical Engineering from the Yildiz Technical University in Istanbul (Turkey).

His professional interests, research topics, and international collaborations mainly focus on machining technologies, cutting metal and composite materials, sustainable machining, and slip-line modeling of machining operations. He has been director and researcher for scientific projects. He has also served as associate editor and editorial board member for a scientific journal and committee member of national and international conferences.

He was a Visiting Professor at Institute for Sustainable Manufacturing, University of Kentucky (USA).

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

Keynote speech topic

Sustainable Machining: Improving MQL Performance in Milling of Stainless Steel by Using Nanofluid

Sustainability meets the needs of the present generation without compromising the future generation's ability to meet those needs. It plays a key role in improving efficiency and encouraging environmental consciousness. The core of mainstream sustainability thinking has become the idea of three dimensions; environmental, social, and economic sustainability. And the goal of sustainability is to satisfy basic social and economic needs, both present and future, and the responsible use of natural resources, all while maintaining or improving the well-being of the environment and ecology on which life depends. As a sustainable manufacturing concept, the creation of manufactured products that use non-polluting processes, conserve energy and natural resources and are economically sound and safe for employees, communities, and consumers. Sustainable machining leads to improved environmental friendliness, reduced cost, reduced power consumption, reduced wastes, enhanced operational safety, and improved personnel health. In machining operations, a major environmental issue is the abundant and often indiscriminate use of metalworking fluids. The main problems associated with metalworking fluid applications are operator health, machining cost, energy consumption, and chip recyclability. Therefore, alternative methods have been seeking to meet sustainability indices. Among them, dry machining appears to be the most sustainable alternative to conventional flood-cooling. However, minimum quantity lubrication (MQL) shows a good promise when dry machining is not feasible as it helps to reduce the use of cutting fluids significantly, while the tool-life and performance requirements are maintained uncompromised. Stainless steel materials have been used in many fields such as automotive, food, medical, chemistry, etc., after performing machining operations despite being faced with problems due to high strength, low thermal conductivity, and work hardening tendency during machining. However, these materials can be machined by using various cutting fluids, but these cutting fluids are harmful to the environment and health and increase the machining cost due to using copiously as stated above. It is possible to improve MQL performance by adding nano particles to the cutting fluids. Within this framework, the case study results are discussed in the milling of stainless steel by using the nanofluid MQL method.

Abstracts
Part I
Product Design and Manufacturing Processes

Ensuring the Technological Parameters of Cast Block Crankcase of Automobile's Diesel Engine

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The relevance of computer-integrated technologies for manufacturing parts is significant in the world. The purpose of this work is to analyze the quality of cast block crankcase using a universal technology of complex computer-integrated design of cast parts of internal combustion engines using engineering modeling of thermal and hydrodynamic parameters of casting. The results of computer-engineering modeling of thermal and hydrodynamic processes of block crankcase casting have shown that gas-shrinkage defects can be stress concentrators in the part's structural elements. Therefore, they can affect the strength characteristics during operation. The developed 3D model of block crankcase casting with a technological gating-feeding system allowed creating a finite-difference model of casting and tooling and performing engineering modeling of casting processes in the ICS NovaFlow. The analysis of physical features of the processes of filling and cooling the castings in the mold was performed for the cast block crankcase of 4DTNA1 automobile diesel, the locations and sizes of gas-shrinkable defects were determined according to the Niyama criterion. The research results allowed us to form boundary and initial conditions for modeling the stress-strain state of the block crankcase in the places of gas-shrink porosity formation. Further development of the above studies will be carried out for castings of new types, configurations, other casting technologies, newly synthesized alloys.

Keywords: Solidworks, Novaflow, Block Crankcase, Engines, 3D Model, Casting Defects.

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The Contact Pressure in Drawing Parts without Clamping the Workpiece Flange

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In the paper, dependence has been obtained to calculate the contact pressures when drawing down the axisymmetric workpiece without a blank flange collet. The solution is based on the assumptions of the momentless theory of shells. The adequacy of the mathematical model is confirmed by experimental data for a narrow interval of forging blanks. The experiments have been carried out on a specially designed tooling to measure load cell deformation using a strain gauge. All the equipment used has passed metrological control. To calculate the meridional and tangential stresses on the torus-shaped portion of the matrix, dependencies were obtained that contain a term connecting the thickness of the workpiece with the value of the stresses arising during drawing, which more accurately describes their distribution on the drawing edge of the matrix. The expression for calculating the surface contact pressure during the drawing of a cylindrical part makes it possible to consider the friction stresses at the radius of the matrix rounding and calculate the drawing force. The obtained dependence differs from the conventional ones in its simplicity and clarity and can be used at the preliminary stage of choosing equipment for stamping. It is shown that the friction stresses between the contacting surfaces can be controlled over a wide range while achieving a significant change in the stress state and the distribution of deformations in the volume of the workpiece.

Keywords: Metal Drawing, Plastic Deformation, Die Body Radius, Drawing Punch, Contact Pressure.

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Complex Recognition Approach for Cutting Part of Cutters in Finishing Turning

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In the conditions of finishing and precision turning, the traditional approach to laboratory assessment of the condition of cutters by periodically recording the parameters of the wear zone along the flank surface and subsequent recognition is, in the authors' opinion, insufficiently effective. It does not consider significant changes (due to wear) in the geometry of the cutting edges and, in particular, in the forming of their sections, the state of which directly affects the quality of the processed surface. Therefore, there is a need for complex control and complex recognition of cutting part states. The article aims to develop an approach to complex recognition of cutters cutting part in finishing turning. The scientific novelty consists of creating classifiers for complex recognizing the states of cutters for finishing turning, using the most informative features of the shape of all wear zones, and analyzing their effectiveness. The research was carried out under conditions of processing hardened steel 115CrV3 on a lathe model TPC - 125 BH1P. On a special laboratory stand, equipped with a vision system, comprehensive periodical monitoring of the condition of the cutting part of the cutters for finishing was carried out. Practical usefulness consists of developing a method for predicting the residual life of cutters for finishing turning, using a set of features characterizing the shape and size of defects and microdefects of all wear surfaces of the cutting part. Timely replacement of a failed tool with a new one provides a significant economic effect.

Keywords: Tools Failures, States of Cutters, Complex of Classifiers.

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Fractal Analysis of Structural and Phase Changes in the Metal of Welded Steam Pipe Joints

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The research results of the ability to assess the boundaries of structural components' geometric complexity, which are visible in a metallographic analysis of the metal samples of Welded Steam Pipe Joints, considering the operating time, are presented. The estimation of the complexity of grain boundaries was made based on a statistical analysis of fractal dimensions obtained by the cellular method for measuring the grain boundary length. The fractal analysis of microsection images is carried out using a developed program. The computer system was tested for several samples cut from sections of steam pipelines with different operating times, operated under conditions of creep and low-cycle fatigue. A comparative analysis of fractal dimensions of structural components' boundaries in the microsections images of various metal sections with different operating times is carried out. The research and comparative analysis are carried out for the heat-affected zone, base metal, weld, and substrate areas. As a result, the possibility of assessing the complexity of the boundaries of structural components in the steam pipelines metal and their welded joints was confirmed based on the analysis of statistical characteristics of the distribution of their fractal dimension.

Keywords: Metallographic Analysis, Boundaries of Structural Components, Geometrical Complexity, Fractal Dimension.

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Research of the Spindle Units for Multioperational Lathes in the APM WinMachine Environment

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The problem of modeling the spindle unit's design for multi-operational lathes equipped with a set of modular tooling according to the rigidity criterion is considered. Structural and calculation schemes of a two-support structure in the form of a constant cross-section beam on duplexed angular contact ball bearings considering linear and angular stiffness are proposed. The procedure for constructing an analytical static formula of a spindle as an analytical dependence of its general compliance on the cantilever's dimensions is used, which adequately reflects the conditionally constant (spindle on two supports) and replaceable (modular tooling) parts of the object under consideration. With the help of this formula, it is possible to express procedure probing the machine's working space according to the compliance indicator. Analytical dependencies for finding a rational ratio of the spindle main design parameters from the standpoint of maximum rigidity are proposed. This approach is most effective for typical double-support spindles equipped with a variety of tooling. The efficiency of the APM Structure3D module in solving problems of assessing the stress-strain state, considering the complex mechanism of deformations in supports, is shown. The stress fields, which predetermine the picture of the researched object's deformation state, are presented. For a comprehensive study of the spindle unit, the capabilities of APM Structure3D to determine the set of natural frequencies and the corresponding vibration modes are used.

Keywords: Machine Tools, Spindle-Cantilever Stiffness, Optimal Size Ratio, Static Formular, Stress Field.

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Technological Inheritability of Product Material Using the Criterion of Technological Damageability

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Product Life Cycle Support (PLS) becomes a priority direction in mechanical manufacturing. That realize by providing the rational operational parameters and reliability indicators for manufactured machines and their products. The PLS - concepts are an effective tool for the development of functionally-oriented technological processes. The prediction of the product behavior during exploitation using technological inheritability of its properties is an important problem for modern mechanical manufacturing. The technological damageability is proposed to estimate the technological inheritability of material properties during manufacturing products from castings. Analyzing of material degradation of manufactured products using the LM-hardness method is suggested. LM-hardness method, used for control of the dissipation of the material's mechanical properties, received by means of special devices in fixed conditions. In general, the degree of the material degradation of manufactured products is described using the Weibull coefficient (m). For the first time, it was proposed technological damageability D for analyzing of degradation of the products material structure for castings in sand molds. The influence of the design parameters of the "Sandvik" tool during end milling on the technological inheritability of material properties using the distribution of Weibull coefficient (m) is analyzed.

Keywords: Technological Inheritability, Homogeneity, Technological Damageability, Weibull Coefficient.

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Wear Characteristics of Carbon and Tool Steels Hardened by Combined Laser-Ultrasonic Surface Treatment

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For increasing the subsurface layer's wear resistance, AISI 1045 carbon steel and AISI D2 tool steel samples were hardened by a laser heat treatment (LHT) followed by ultrasonic impact treatment (UIT). This paper focuses on studying the effects of the separately applied LHT, UIT, and combined LHT+UIT processes on the wear behavior of the hardened surface of carbon and tool steel. The comparison of the surface roughness and hardness after surface treatments are also addressed. The hardened samples were examined after the short-term (15 min), and long-term (45 min) wear tests under oil-lubricated conditions in the quasi-static and dynamic loading conditions. An optical 3D profilometer evaluated the wear tracks. The results demonstrated that the formed fine-grained martensitic structure coupled with high surface hardness and low surface roughness after combined treatment lead to a significant reduction of the wear loss regardless of the steel type.

Keywords: Laser Hardening, Ultrasonic Peening, AISI 1045 Steel, AISI D2 Steel, Roughness, Hardness, Wear.

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Rational Design Solution Based on Mathematical Modeling of an Interference Fit

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The paper proposes a significant improvement in the integrated methodology for automated calculation and selection of interference fits. The study's main task was to find a rational combination of the values of the variable parameters of the complex mathematical model of the area of existence of the fit. The specified search was carried out in the range of a finite set of permissible parameter values that correspond to the conditions for calculating the fit. As an effective tool for performing a large volume of numerical and analytical calculations, the author's computer program for the automated design of interference fit was used. The research object was the geometric image of the model of the area of existence of the fit parameters in the form of a three-dimensional body as part of the complex of a multiparametric mathematical model. For solving this problem, one of the projections of the model of the area of existence of fit parameters is described analytically based on the theory of R-functions. In the research process, the influence of the fit diameter's value (the main geometric characteristic of the fit) on the quality and reliability of the shroud joint during its thermal assembly and during the operation was determined. The research results are recommended for improving the mathematical and software tools for computer-aided design of interference fits when choosing the most rational design solution for the given operating conditions and assembly of the joint.

Keywords: Multiparametric Model, Area of Existence, Fit Parameters, Fit Diameter, Working Fit Length, Computer-Aided Design, Theory of R-Functions.

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Design and Engineering Assurance for the Customized Implants Production Using Additive Technologies

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The development and dissemination of practical additive technologies applications have become a significant trend in technology development in various activity fields. Medical engineering is one of the industries where such technologies already have a tangible effect and will become even greater in the future, especially in the manufacture of customized implants. In many cases, customized implants provide the patient with a quality of life that other solutions cannot offer. Simultaneously, the correct application of medical engineering solutions in this area requires enhanced engineering support. The point here is not about the optimal modes of implant formation but the engineering support system for decisions at every step from the initial condition analysis to surgery. So far, considerable practical experience has been gained, and many publications have appeared describing individual case implementation. Simultaneously, there is a lack of publications that would give an idea of the wide range of possibilities for using additive technologies in creating customized implants and their entire system of engineering support. This paper's results are based on the authors' own practical experience, implemented based on the Laboratory of Biomedical Engineering at the Institute of Orthopedics and Traumatology of the National Academy of Medical Sciences of Ukraine.

Keywords: Additive Technologies, 3D Printing, Endoprosthesis, Customized Implants.

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The Dynamic Model of the Automatic Clamping Mechanism with a Rotating Input Link

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Some features of a new design of clamping mechanism drive for automatic fixing of cylindrical objects in metalworking machines are considered. One of the proposed design features is a rotating input link, which receives input energy in the form of rotational motion. The presented drive's operation is considered a part of the clamping mechanism with a collet chuck. Furthermore, the clamping mechanism's interaction with a drive of the main movement of a lathe is described. The dynamic model is presented as a system with lumped parameters, consisting of rigid bodies connected by inertialess elastic-dissipative links. The stages of the backlash elimination and conversion of the mechanism elements' kinetic energy into the system's stressed state's potential energy are considered separately. The obtained results can contribute to the development of methods for calculating this type's structures' parameters. They can be helpful in the determination of more optimal geometric-mass parameters of the elements of these structures.

Keywords: Clamp Drive, Spindle Assembly, Lathe.

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The Optimal Conditions for Adding Strain to the Deformation Zone during the Expansion of Automobile Pipe Adapters

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It is shown that pipe parts with an increased diameter of the edge portion are widely used in the automobile industry as connecting adapters for fuel and exhaust systems. Moreover, one of the requirements for the manufacture and further operation of adapters consists of the same wall thickness of the part in each of its sections. This requirement is almost impossible to meet if the diameter of the end of the tubular billet is increased using a traditional expansion process. To increase the thickness of the part at the end after the expansion, various methods of adding strain to the deformation zone in the form of retaining rings, bandages, and spring elements are used. This increases the cost of technology. The paper presents the results of a numerical experiment to determine the optimal conditions for additional loading of the deformation zone using conical protrusions on the punch generatrix. It is shown that this method of increasing the thickness of the finished part wall is efficient and does not require special costs. The thickness of the finished product at the end of the billet will depend on the location of the conical protrusion on the punch, its length, and the geometric characteristics of the tubular billet. A punch with a protrusion at the end of the conical surface's generatrix has better results compared to a tool with a straight generatrix.

Keywords: Tubular Billet, Plastic Deformation, Increase of the Billet Thickness.

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Diamond Spark Grinding of Hard Alloys Using Solid Lubricants

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The article focuses on the results and comparative analysis of diamond spark grinding of titanium-tungsten hard alloy T15K6 using various lubricating media - cooling technological mean with irrigation (3% soda solution of water) and solid lubricants (technical stearin, sebacic acid, mixture (1:1) of stearin with sebacic acid. Specific energy intensity BM estimated the efficiency of the process, detailed work As, productivity Q, relative consumption of diamonds in wheel q, and prime cost Cg. The best combination of the indicated characteristics ensures using a solid lubricant based on a mixture (1:1) of stearin with sebacic acid: the increase in productivity Q is 13.8%, the decrease in the indices q is 33.3%, and Cg is 14.5%. The grinding speed exerts the biggest influence on BM and As. The intensity of these growths during grinding with the introduction of a solid lubricant mixture (1:1) of stearin with sebacic acid into the cutting zone is much less (by 12%) compared to the technological cooling mean with irrigation, which makes it possible to increase the range of grinding speeds, the processing efficiency and makes the diamond spark grinding of hard alloys less wasteful and more environmentally friendly.

Keywords: Cooling Technological Means, Hart-to-Machine Materials, Irrigation, Stearin, Sebacic Acid, Specific Energy Intensity, Specific Grinding Work, Productivity, Consumption of Diamonds, Surface Roughness, Diamond Wheel.

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Technological Parameters of Hole Shaping in the Cones Rolling-Cutter Row of Roller Cone Bits

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In this paper, the examination will be focused only on roller cone bits with three cones. The results show that most problems with deviation from the profile are fixed on the holes. The purpose of this is to increase the accuracy of the holes in the rolling-cutter row of the cone for the tungsten carbide insert cutters. For this purpose, from the batch of tungsten carbide insert cutters a statistically controlled group of tungsten carbide insert cutters was selected. The geometric parameters of the shank for the detection of deviations in the surface profile were studied. The obtained data make it possible to state that the cutting speed within the studied limits does not significantly affect the magnitude of the holes breakdown when fine reaming the holes in the rolling-cutter row of the cone body for the tungsten carbide insert cutters fit. Such results indicate significant reserves in improving the accuracy of molding by monolithic carbide reamers. The effect of technological parameters on the statistical relationship between the magnitude of the hole deployment and the roughness of the processing surfaces was also studied. For the sake of clarity of the advantages of solid carbide reamers and reamers compared with those with soldered hard-alloyed plates, the comparative data for two types of reamers are presented.

Keywords: Tungsten Carbide Insert Cutter, Accuracy, Drilling, Breakdown, Hardness, Reamering, Fretting Fracture, Roughness.

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Design Calculation of Automatic Rotary Motion Electrohydraulic Drive for Technological Equipment

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The article is devoted to the development of electrohydraulic drives for technological equipment. The engineering method for the design calculation of automatic electrohydraulic rotary motion drive with volume regulation was presented. This method allows evaluating the main parameters and choice drive elements and devices using the maximum load moment and hydraulic motor rotation velocity, predicting its static and dynamic characteristics. The electrohydraulic drive's automatic control system was proposed considering the control object's observation noise and stochastic perturbation. The example of design calculation for the automatic electrohydraulic drive parameters for technological equipment for the following input data was performed: maximum load moment M_{max}=120 N·m; maximum rotation frequency n_{max}=2100 rpm; reduced inertia moment of the rotating parts J = 0,8 kg·m^2. The possibility of using a serially produced axial piston-regulated pump with an inclined disk and an unregulated hydraulic motor with an inclined washer was shown. The drive's mathematical model parameters as an object of automatic control were determined based on hydraulic machines' passport data. The research of the system's dynamic characteristics was carried out.

Keywords: Engineering Method, Volume Regulation, Automatic Control System, Dynamic Characteristics.

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Optimization of the Interelectrode Gap in Electrical Discharge Grinding with Changing Electrode Polarity

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The paper investigates the process of electrical discharge diamond grinding with changing the polarity of electrodes in time in the cutting zone for processing various materials, and the value of the interelectrode gap is determined. The study aims to determine the optimal value of the interelectrode gap during electrical discharge grinding using the mathematical method of planning experiments. The mathematical method of planning experiments was used, which allows solving the optimization problem under conditions of incomplete knowledge of physical processes' mechanism. The experiment's planning gave the result with small errors and made it possible to minimize the number of experiments. As a result of experimental studies, a mathematical model of the limiting interelectrode gap from the electrical modes of electrical discharge diamond grinding was built. The functional dependence of the interelectrode gap was obtained, with the help of which it is possible to determine the value of the optimal interelectrode gap for various electrical parameters of electrical discharge grinding. It was established that the most significant factors that affect the interelectrode gap are the voltage of the ignition pulse and the amplitude of the discharge current.

Keywords: Diamond Grinding, Interelectrode Gap, Voltage, Current Amplitude, Frequency, Duty Cycle, Electrode Polarity.

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Determination of Radial Displacement Coefficient for Designing of Thread Joint of Thin-Walled Shells

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The oil and gas industry uses drilling, casing, and compressor pipes connected by threaded couplings. Variable tensile forces load a drill string during its operation in a well. Experience shows that pipes are destructed on the body of the pipe or in the thread's roots. It indicates the importance of studying the contact stresses in the elements of threaded joints. To theoretically determine the distribution of contact stresses in a "pipe - coupling – pipe" thread joint, an integral equation is drawn up with the thread joint's contact pressure as an unknown variable. To develop this equation, it is necessary to determine the radial displacements and angles of rotation of the normal in the coupling and pipes caused by a single annular force or a single annular moment applied in any normal cross-section. Based on the theory of thin shells of finite length, a method for determining the radial displacements of shell middle surface points (coupling), due to the annular force applied in its arbitrary cross-section, as well as the angles of rotation of the normal to its middle surface caused by these force factors. The fact that the annular moments in the right and left parts of the coupling are opposite has been considered.

Keywords: Pipe, Coupling, Thread Joint, Shell, Force Loads, Contact Pressure.

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Part II
Solutions for Industry 4.0

Investments in Blockchain Information Management Systems Based on Business Angels' Criteria

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Blockchain technology bears an enormous potential to revolutionize markets and economies. Previous research studies on investments in blockchain technology were carried out as part of the paradigm of investing in speculative assets without focusing on the launch of the blockchain at the company level. Currently, there is no scientific basis for properly evaluating the investments in blockchain information management systems that help managers and investors in the decision-making process. Authors assume that the evaluation/scoring model for investment in blockchain information systems, based on business angels' investment criteria, is the solution for this market. The study's research problem is that the vast majority of the stakeholders do not look at blockchain investments through the paradigm of investing in blockchain information management systems from the company perspective. The research aims to identify the main groups of investment criteria for blockchain investments and create a theoretical framework based on the literature overview for further analysis.

Keywords: Blockchain Technology, Initial Coin Offering, Distributed Ledger, Theoretical Framework.

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Agile Project Management Based on Data Analysis for Information Management Systems

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Nowadays, many projects and product managers, industry, and portfolio leads understand that data from the project or portfolio can be valuable for increasing their activities. There are many different types of project and portfolio lifecycle processes of managers daily duties: pre-sales and sales, mobilization, delivery, and closure phases. Definitely, in research, we focus on the processes, staffing, governance, and reporting activities. The day-by-day tasks are quite regulated and clearly described using templates and techniques as a company standard. Our literature review shows that Data Science methods can increase the level of project management and project success in several business problems. This study gives new opportunities to improve project management evaluation and results for managers, industry, and delivery leads. The proposed approach allows doing a project, portfolio management, and agile development more accurately, considering best practices and project performance data. Moreover, our results can provide more efficient benefits for different internal and external stakeholders.

Keywords: Agile Development, Lean, Scrum, SAFe, Project Management, Data Science, Data Analysis, Machine Learning.

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Optimization Work with a Digital Human Model

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Ergonomics is a scientific discipline that today brings together several major scientific disciplines that deal with the rationalization of workspace design. It tries to unite these fields into one comprehensive one: to adapt the environment, especially the working environment, to humans so that it consumes as few biological reserves as possible when using it. This environment should therefore be pleasant for people, not negatively affect their physical and mental strength. In the past, the ergonomics of workplaces were not much addressed. First, a machine, tool, or workplace was created, and only then has an operator sought them. One had to adapt to the machine in order to use its help. The relationship between a person and his workplace began to be resolved only with the emergence of the first ergonomic companies. This work describes the Rula analysis and the relationship between ergonomic analysis and REFA time analysis. The application of individual methods is followed by evaluating results and determining individual problems at workplaces. Based on the identified shortcomings, proposals are made that partially or entirely eliminate these shortcomings. The effectiveness of the designs is retrospectively tested by ergonomic methods and subsequently evaluated.

Keywords: Ergonomics, Tecnomatix Jack, Rula, Analysis, REFA, Time Analysis, Workplace Introduce.

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The Implementation of Industry 4.0 Supported by Service Robots in Production Processes

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The ongoing implementation of Industry 4.0 in all segments of society will improve many aspects of human life and initiate many changes in business, production processes, and supply chains from raw materials to finished products. In other words, it enables the introduction of self-automation, self-configuration, self-diagnosis and solution, knowledge, and intelligent decision-making, owing to the innovations and their implementation in robotics, smart sensors, 3D printers, Internet of Things (IoT), and Big Data technology. The essential quality shift in the implementation of Industry 4.0 in production processes is the implementation of AGV service robots (automatically guided vehicles) in the automation of transport operations in the production process itself (such as transport of raw materials, semi-products, and finished products), on assembly lines, storage of finished products and supply of finished products. The implementation of service robots in the production process is amortized very quickly if they are in operation for 24 hours, while the investments can pay off in 2-3 years, and the system operates for about 15 years. The availability of work itself is about 98.5%. The implementation of service robots optimizes production time and costs, thus providing high productivity. The paper presents the annual application of service robots in logistics and the application of AGV service robots with different structures in production processes.

Keywords: Industry 4.0, Smart Factory, Service Robots, Automatic Guided Vehicles, Transportation, Logistic, Production Process.

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Intelligent Numerical Control of Profile Grinding

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The use of a single computer-aided control to automate production and its preparation creates a common technical base when the adjustable online model of the profile gear grinding operation allows compensating for the lack of online sensors built into the gear grinding system. In this case, the automation of design and production within a single integrated CAD/CAM/CAE system appears to be a single technological process in which not only general but also phased results are defined. This becomes possible by optimizing the entire (and not only partial) sequence of work performed. The introduction of negative feedback from the built-in online sensors of technological information (when such sensors are available) allows, based on monitoring the grinding system state and output parameters, to correct the setting of the CAE-system which is used not only offline but also in the online mode of CNC machine work. When the adjustment of the CAE system is regulated by deviation, this approach to control makes it possible to increase the efficiency of automated grinding systems. The paper provides a fundamental solution to the problem of making adjustments to the control program of a CNC machine based on the results of measuring the state and output parameters of the grinding system. Given as an example, a step-by-step sequence of actions to determine the parameters of grinding of complex-shaped machine parts (for example, gear wheels) makes it possible to understand the algorithm of operation of an intelligent self-training grinding system.

Keywords: CAD/CAM/CAE, Product Life Cycle, Product Design, Process Design, Self-Training Grinding System.

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Choice of Carrier Behavior Strategy According to Industry 4.0

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The research aims to choose a strategy for transport companies' behavior in the context of the development of Industry 4.0. It is proposed to use a mini-maximum model as an optimization function. This model proposes to make a management decision based on the accounting of primary capital investments for trucks purchase and costs associated with rolling stock operations. The article presents an initial algorithm for accelerating decision-making by creating your software product for specific transportation conditions. This approach allows managers to search faster for the optimal transport option of any production, which is necessary for the concept of industry 4.0. The article provides an example of calculating the creation of a rolling stock fleet for goods transportation into the retail chain of supermarkets in Kharkiv. This approach is universal and can be used to choose the best option for delivering goods between enterprises when transporting raw materials, agricultural goods, mail, etc. The approach is universal for making a correct management decision for different types of routes and allows managers to form the necessary fleet of vehicles with minimal investment and the highest productivity.

Keywords: Route, Costs, Model, Transportation, Risk.

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Autonomous Data-Driven Integration into ERP Systems

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The following article makes a case study with an SAP ERP system, which integrates with an external Web Service using API access. Algorithm implementation is demonstrated with all transactions used in SAP ERP. However, it should be noted that a limited version of SAP ERP S/4HANA version release 2.00.044. It was pointing to the capabilities test between the external system and the ERP system. During the experiment, the ABAP programming language and the built-in SAP ERP background job are used and configured as needed. The received data is stored in the SAP ERP data warehouse, modified to save the new data. The main result is to provide integration capabilities. Utility to use the Web Service and the ERP system's integration technique to enable the capability's regular use. The experiment shows that the SAP ERP system can be integrated from an external source and store data to improve future business processes and increase its business values. The approach allows for the development of future frameworks and the expansion of ERP systems between external systems.

Keywords: Enterprise Resource Planning Systems, Algorithm Implementation.

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Three Dimensional Technology Radar Model to Evaluate Emerging Industry 4.0 Technologies

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Emerging Industry 4.0 technologies are changing very fast, and in few years, technologies reach a new level of maturity, or new technologies are introduced. This makes it difficult for manufacturing companies to keep track of the fast development and evaluate a future introduction of new technologies related to the Fourth Industrial Revolution. Therefore this work aims to realize an Industry 4.0 technology radar for industrial organizations based on the Gartner Hype Cycle Curve. This tool aims to analyze new emerging technologies that could affect manufacturing firms, enabling selecting the most suitable ones. The technology evaluation considers three parameters: a technology maturity level, enterprise value, and deployment risk of technologies. The application of such a tool highlights which technologies to include in the company's future technology strategy. The developed technology radar was applied in a real industrial case study to prove its applicability and limitations.

Keywords: Industry 4.0, Technology Radar, Evaluation Model, Maturity model, Gartner Hype Cycle; Emerging Technologies.

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Applicability of Traditional Project Closeout Approaches in Agile Developed IT Projects

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This article investigates the applicability and compatibility of project closeout processes defined in traditional project management frameworks in cases of agile-developed IT projects. Based on a literature review analysis of three project management frameworks, the hypothesis is formed that traditional project closeout processes are critical in agile developed IT projects. The developed hypothesis suggests an unclear indication of how to trigger a project closeout, the inapplicability of scope fulfillment for closeout trigger, and critical transitions between closed projects and ongoing agile software improvement and maintenance. All three parts of the hypothesis are then individually evaluated by an online survey with 85 participants. As a result of this survey, all three hypotheses are falsified. For most project management practitioners in agile projects, closeout processes are not critical, scope fulfillment is still the most relevant closeout trigger, and the transition to a continues-improvement and maintenance process is seen as principally uncritical.

Keywords: Agile Project Management, Tailoring, Project Closeout; SCRUM, IT Project Management.

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Reliability of Road Transport Means as a Factor Affecting the Risk of Failure – The Transport Problem Case Study

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The article's objective was to develop a method for analyzing the operational reliability of means of transport, emphasizing destructive factors affecting the disruptions in the continuity of supply. The introduction contains a diagram of the occurrence of adverse events in the transport system. The concept of reliability analysis of rolling stock based on two conditions (its fitness and unfitness) was presented. We describe the proposed method in three stages. The first one is related to activities aimed at extending the fitness condition of the rolling stock. As part of this stage, destructive factors were classified, depending on the rolling stock life cycle phase, with degradation parameters identified and characterized. The second stage concerns diagnostic activities. An approach to assessing damage based on the diagnostic indicator, which resulted in the so-called diagnostic matrix's suggestion, was developed. The last stage of the presented method includes repair activities, based on which the concept of applying risk measures, including the risk measure of rolling stock unavailability, was introduced. The results acquired based on the presented method are designed to provide data enriching the decision-making process in transport activities, aimed at reducing the risk of failure to perform the transport task. The method of analyzing the reliability of means of transport presented in our work forms part of the author's work on developing a comprehensive analysis of the operational reliability of transport systems.

Keywords: Transport Engineering, Car Stock, Transport Systems, Mechanical Engineering.

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An Intelligent Scheduling System Architecture for Manufacturing Systems Based on I4.0 Requirements

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In this paper, an Industry 4.0 oriented architecture of a manufacturing scheduling decision support system is provided. This proposal is based on an analysis performed about some other decision support systems architectures found in the literature and based on another analysis that was carried out regarding the results obtained through a questionnaire distributed through a wide set of enterprises in the Iberian Peninsula. This analysis did enable us to realize that the main characteristics considered fundamental to be integrated into the prosed manufacturing scheduling decision support system were, in fact, of upmost importance, within the current Industry 4.0 requirements. Moreover, the main characteristics proposed for integrating the manufacturing scheduling decision support system's architecture presented were also used to establish a comparative analysis between the proposed system's architecture and the ones analyzed from the literature. Besides, through this analysis, it was possible to realize that none of the architectures analyzed from the literature covered the whole set of important I4.0 oriented characteristics proposed.

Keywords: Intelligent Manufacturing Scheduling, Decision Support System Architectures, Industry 4.0.

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A New Approach for the Evaluation of Internal Logistics Processes and their Readiness for the Industry 4.0 Concept

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The concept of Industry 4.0 is inflected in many areas with the introduction of automation, robotics, or modern storage systems with a key element of digitization. An important area for implementing the elements of Industry 4.0 is internal logistics because the supply of production lines and material storage are among the company's key processes. The complexity and irregularity of processes can be automated and changed into an autonomous form based on the concept. The article deals with internal logistics and describes new approaches to the evaluation of logistics processes based on the developed methodology. The methodology design is based on theoretical foundations, and therefore the main part of the article describes the main areas entering the new methodology. Internal logistics is structured into five main dimensions, which completely cover it. According to the company maturity, dimensions are divided into six levels, where the highest level corresponds to Industry 4.0 principles. The evaluation is based on maximizing the criterion function and point evaluation from structured interviews with company members. After partial results from each dimension, it is possible to evaluate the current company level in internal logistics, which is the primary goal. The methodology is therefore mainly of a diagnostic nature.

Keywords: Industry 4.0, Internal Logistics, Logistics Audit, Readiness Model, Manipulation.

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Part III
ICT for Engineering Education

Mobile Application for Test Control of Knowledge among Mechanical Engineering Students

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The article analyzes mobile technologies that are the most widely used in a modern technical university's educational process. It is noted that under certain conditions for test control on mobile devices, technologies that are limited to the use of students' mobile devices will be preferred. It is emphasized that for the successful mobile devices use in the knowledge test control of students. It is necessary to consider the features of practical classes on professional and practical training of future engineers. Such features include the widespread use of graphic materials at all training stages and holding a part of the practical training in specialized classrooms without access to mobile Internet. The mobile application SSUquestionnaire-m is described, which allows one to consider the features of engineering training listed in the article and ensure participation of all students in the classroom in control activities at the same time.

Keywords: Engineering Education, Mobile Technologies, Fuzzy Logic, Mobile Learning.

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Institutional Aspects of Integrated Quality Assurance of Engineering Study Programs at HEI Using ICT

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Informatization of Ukrainian higher education institutions is a key priority of the state education policy, one of the directions to improve HEI's IT infrastructure. The paper aims to develop an integrated quality assurance information system to enhance institutional aspects of higher education institutions' study programs. Therefore, there is an urgent need for all stakeholders to develop, at the university level, a service-oriented architecture to assure the quality of higher education with mandatory elements, for example, student survey results, student ratings, university teachers' rating, educational programs, results of uniqueness verification for scientific research and qualifying papers, review of educational programs for higher education applicants etc. It will allow to unify the approaches to electronic resource management and accelerate the integration of multi-level HEI quality assurance resources into a single portal. The paper presents a quality assurance information system, which allows processing students' feedback to provide HEI's authorities' decision making.

Keywords: Quality Assurance Management in HEI, Students' Feedback, Engineering Study Programs.

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An Android Application for Explaining Form Deviations Using 3D Models

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The research aims to develop a mobile learning engineering application, presenting the form deviations according to ISO 1101. This application aims to improve the quality of tolerances and dimensional control and 3D Modelling courses for engineering students, covering the following lines of studies: design, robotics, industrial and mechanical engineering. The previous studies focused on mobile learning's impact on student achievement show that the method could be one of the promising educational technologies. The educational applications used on mobile devices develop a friendly environment and generate a positive effect on learning. The authors conducted a detailed analysis of the educational applications presenting geometrical tolerances available in Google Play. This paper also presents the advantages and disadvantages of the published applications. In 2018 we published the educational android application ISO Checker. They are using this mobile application integrated into the engineering courses students transmitted positive feedback. Students are hi-tech learners, and they are in trend with current technological innovations in education.

Keywords: Mobile Learning, Geometrical Tolerancing (GD&T), From Deviations, Geometrical Product Specification (GPS), Educational Application.

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In-Campus Way of the Insight Transfer Technology

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The version of solving the relevant problem of increasing the innovative activity of engineering specialties students by organizing the academic environment is proposed. The purpose of the activity is to update future engineers and working citizens' professional competencies and ensure transparent conditions for evaluating instructional designing results. The ways of implementing the project-oriented training principles in the technical university are presented, which will allow to actively involve students in scientific and innovative activities within the educational process and the performance of qualification work. The authors have proposed a model of the information system based on the use of electronic document flow, implemented, at this stage, for the organization of the activity process. The proposed approaches to engineering education will allow to use of student youth's potential for the development of innovations by scientific-educational project teams and minimize the costs of ensuring the functioning of single information space of innovation-project activity.

Keywords: Citizens Innovation Development, Innovation Infrastructure, Information System.

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Information and Communication Technology Tools for Enhancing Engineering Students' Creativity

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Nowadays, students naturally prefer using information and communication technologies in various situations. That led to their different attitude to information and the way they perceive and process information. On the other hand, engineers' widespread use of information and communication technologies in their job has changed the goals, learning content, methods, forms, teaching aids, methods, and teachers and students' interaction. The article's purpose was to analyze a range of tools in terms of didactic tasks that could be successfully solved. The paper deals with the review of resources enabled revealing some learning areas which the information technologies can support: activation of various external senses through the use of multimedia, automation of calculations, improve graphic part of the design, organization of a creative educational environment, optimization of the time-consuming processes of learning outcomes control. The ideas for the organization of students' cognitive activities of higher levels and learning software for implementing the ideas are presented in the article. Being oriented on the development of the creative potential of engineering students, the information and communication technologies influence goals, learning content, teaching forms and methods as well as cooperation of teachers and students providing development of students' information literacy, skills of processing information, creation and joining ideas into new combinations and transferring them to different situations to provide engineering students' preparedness for the innovative engineering activity.

Keywords: Engineering Education, Engineering Students' Creativity, Software.

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Part IV
Numerical Simulation and Experimental Studies

Development of Optimum Thin-Walled Parts Milling Parameters Calculation Technique

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In machining thin-walled parts, determining the optimum machining strategy and the criterion selection of milling parameters is highly relevant. This study addresses the gap in the variety of computer-aided machining parameters calculation solutions. Thin-walled parts are broadly used in many industries due to their efficiency and lightweight. But there are many barriers to surface formation processes. Therefore, the features of thin-walled parts in modern manufacturing preparation have to be taken into account. Furthermore, to provide machining parameters information in a wide range, an intelligent selection method of parameters is essential for a robust basis in the progressive Industry 4.0 concept. The research is laid down in the context of production digitalization in Industry 4.,0 thus represents linkage of data, analytics, and interface interaction. The software solution interface is a calculation application consisting of modules of thin-walled part geometrical and material properties, machine, tool, removal, cut parameters, and the area of computed results. The solution database is based on the resultant values collected from mechanical engineering literature, static and dynamic finite element modeling of thin-walled part response under applied loads.

Keywords: Thin-Walled Parts, Milling Parameters, Variable Stiffness, Part Deflection, High-speed Milling.

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Measurement of Contact Pressure for Conical Honing

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One of the promising directions for increasing the efficiency of parts processing with diamond tools is studying the mechanics of contact interaction based on the theory of elastic-plastic contact interaction of rough surfaces. The contact interaction theory allows you to establish the optimal requirements for diamond tools, processing modes, and the workpiece's initial parameters. This study discusses a method for determining the contact pressures directly in the honing process of conical holes. The existing methods are based on theoretical calculations or require significant equipment modernization with subsequent analysis of the obtained data. The proposed method is simple and considers the distribution of the linear contact load of the honing bar along the generatrix of the conical hole in the workpiece. The method is based on the usage of strain gauges which are characterized by small dimensions, low cost, and high measurement accuracy at any stage of the technological operation. The results of static and machine experiments showed the qualitative characteristics of the tool-workpiece contact.

Keywords: Honing, Contact Pressure, Method of Measurement.

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Simulation Methodology of Diamond Burnishing

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The paper presents computer simulation results of the equivalent stress distribution in the surface layer of the diamond burnishing and ultrasonic burnishing products. Finite element analysis was carried out using Third Wave AdvantEdge (TWA) and Solid Works CAE systems. The simulation considered the physical and mechanical properties of both processed and tool mate-rials. The elastic modulus of the processed material Epm was found to have the most significant influence on equivalent stresses in the surface layer of the processed materials, which predetermines the operational properties of products. The Epm values served as a basis in simulation experiments to study the effect of the technological parameters (burnishing force P, burnishing speed V, burnishing depth t, and the burnisher radius r) on equivalent stresses σeq in the surface layer of the burnished material. The primary influencing technological factors in the analysis of the equivalent stress distribution during diamond ultrasonic burnishing were the vibration frequency of the tool f, the radius of its working surface, and the elastic modulus of the solder Esol. As a result of the simulation, rational values of the technological parameters of the diamond burnishing and ultrasonic burnishing were determined. The study showed that the optimal choice of the technological parameters should consider both the equivalent stress distribution in the surface layer of the products and the factors influencing the tool wear observed under a particular processing mode.

Keywords: Burnished Products, Surface Quality, Finite Element Method, Equi-Valent Stress.

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Optimal Milling Conditions for Complex Shaped Thin-Walled Components

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This paper investigates the dynamic behavior of the milling of complex shaped thin-walled components. As an interrupted cutting characterizes the milling process, a detailed study of the tool entrance point in relation to the vibration of the part is performed. Milling tests were performed on two thin-walled workpieces with different static and dynamic characteristics. The rigidity of the milling tool was much higher than the rigidity of the workpiece. End milling of thin-walled components deals with short cutting lengths, contributing to a decrease in the number of regenerative waves on the cutting surface. As a result, there is less than one regenerative wave beginning from relatively low spindle speed. Therefore, vibrations in high-speed milling of thin-walled structures are rather caused by resonance phenomenon than by self-excited oscillation. These findings have been supported by experimental validation where two thin-walled structures have been machined. The worst processing conditions occur when the tool impacts the workpiece when its amplitude of vibration is high.

Keywords: Thin-walled Structures, Chatter, Surface Quality, Vibrations.

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Study of Dynamic and Power Parameters of the Screw Workpieces with a Curved Profile Turning

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A dynamic model of the external turning of the screw workpiece outer edge is worked out. The differential equations of the system motion to determine the torsional and linear vibrations of a screw workpiece, a mandrel, and a cutter are deduced. Based on research analyses, the analytical dependences for determining the dynamic loads on the system are developed. The graphic dependences of variation value of cutting force in time are developed, as well as the angle change of screw workpiece deformation in time, and the linear deformation while turning the screw workpiece outer edge. The cutting conditions for turning the screw workpiece outer edge are experimentally specified. According to the results of the experimental study of turning L-shaped auger spirals, outer edges made of 30 Steel (eq. C 30), 20 Steel (eq. C 22), and Steel 08kp (eq. St14), the increase in cutting speed reduces the cutting force. The increase of cutting depth and feed leads to increased cutting force.

Keywords: Curved Profile, Turning, Cutting, L-shaped, Screw.

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Effect of Abrasive Finishing on the Electrical Parameters of S-band Rectangular Waveguides

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Most S-band waveguides are manufactured from a calibrated rectangular tube supplied with the required channel surface accuracy and quality. However, for the compactness of the transmission line, waveguides are made with corner bends and variable cross-sections, which are made by welding or soldering. During manufacturing, defects and deformations occur in the weld zone, which are eliminated by finishing. The main problem here is the assurance of required characteristics of current-carrying surface in weld zones. Several methods for machining waveguide channels provide the necessary roughness, although not all of them apply to rectangular cross-sections and, for machining, corner bends. Previously, the influence of the microroughness height on the waveguide electrical characteristics was studied, but different finishing methods create their characteristic micro-relief, the direction of microroughness, a certain degree of work hardening; all these factors also affect the electrical characteristics of working surfaces and require further research. In this work, comprehensive studies have been carried out to study various methods and tools for finishing, making it possible to machine hard-to-reach places of waveguide corner bends, including ensuring the waveguide electrical parameters. Based on the work results, rotating polymer abrasive tools are recommended to finish the weld-affected zones of waveguide corner bends, which provide a favorable surface micro-relief and improved electrical parameters. A model is proposed that makes it possible to predict the attenuation coefficient taking into account the presence of areas with inhomogeneous roughness.

Keywords: Rectangular Waveguide, Attenuation Coefficient, Conductivity, Finishing, Roughness, Texture Direction, Work Hardening, Tube Brush, Polymer-abrasive Filament.

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Prediction the Durability of Hobs Based on Contact and Friction Analysis on the Faces for Cutting Teeth and Edges during Hobbing

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A method for determining the most dangerous zones of the hob cutter to develop the fastest wear of teeth and edges by the criterion of maximum friction on the contact surfaces has been developed. The geometric model of 3D undeformed chips, which is the basis for determining the force and tribological load, considers the actual shape of the transition surface in each gap, considering the shape and size of the inner surface of the chips, which is formed during the previous axial position of the hob. The cutting force was investigated as a function of the cross-sectional area and the chip compression ratio. This value is set depending on the variable thickness of the cross-sections and is determined using the Deform 2D software. The effect of changing the actual geometry of the cutting wedge of the hob's teeth on friction and contact conditions on the flank face of the trailing edges ultimately determines the maximum wear of the hob cutter.

Keywords: Hobbing, Cutting Forces, Dynamic Process, Gear Wheel, Cutting Simulation, Friction Process.

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Modelling of the Effect of Slide Burnishing on the Surface Roughness of 42CrMo4 Steel Shafts

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Slide burnishing is one of the methods of metal processing that use the phenomenon of surface plastic cold deformation. This article presents the results of a study investigating the effect of slide burnishing on the surface roughness of 42CrMo4 steel shafts. The burnishing process was performed with the use of a polycrystalline diamond tip tool. Before burnishing, the samples were subjected to turning on the toolmaker's lathe. Investigations were conducted based on PS/DS-P:Ha3 Hartley's plan, which makes it possible to define the regression equation in the form of a second-degree polynomial. Moreover, the artificial neural network (ANN) models have been used to predict the surface roughness of shafts in the burnishing process. The input process parameters considered include the applied pressure, burnishing rate, and feed rate. In all analyzed burnishing cases, the value of the mean surface roughness was reduced. The differences between the experimental data and Hartley's model do not exceed 24%. The best representation of Hartley's model was obtained for the burnishing parameters: feed rate f = 0.32 mm/rev, applied pressure P = 130 N, and burnishing speed v = 180 rpm. ANN models were the best predictors of roller surface roughness of the shafts. With the Pearson's correlation R_2 coefficient = 0.99974, the values of prediction errors did not exceed 0.0016249.

Keywords: Artificial Neural Networks, Hartley's Plan, Multilayer Perceptron, Surface Topography.

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Analytical Modelling of Crack Formation Potential in Thermomechanical Processing of Materials

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Thermomechanical processes that accompany the processing of products made of structurally inhomogeneous materials are considered. The presence of stress concentrators in the surface layer of processed products in various types of heterogeneities of hereditary origin introduced in obtaining the workpiece and subsequent mechanical processing types are the leading indicators of working surfaces' bearing capacity. The lack of research on the influence of inhomogeneities formed in the surface layer of products during mechanical processing on their functional properties and, in particular, on the bearing capacity or wear resistance, their optimization determines the relevance of constructing a mathematical model of defect formation in the physical and technical processing of structural elements using optimal criteria of fracture mechanics. A numerical and analytical model is developed to determine the thermomechanical state of structurally inhomogeneous materials containing inhomogeneities such as interfacial cracks and inclusions during mechanical processing. Based on this model, the crack resistance criterion's functional relationships with the technological control parameters are determined to ensure products' processed surfaces' quality characteristics.

Keywords: Temperature, Heat, Defect Formation, Cracks, Surface Layer, Stress State.

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The Influence of Grinding Modes on the Quality of the Surface Layer

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The analysis shows that one of the most rational ways to increase the efficiency of the grinding process is the choice of rational processing modes because, in this case, occur a comprehensive solution to the problem: first, the need to use expensive lubricant-cooling agent reduced, and second, the need for special grinding wheels and their frequent trueing was reduced. The structure of comprehensive theoretical and experimental studies of energy-power parameters for the technological processes was considered. A system of equations developed based on the hyperbola method was presented, which describes spatial fields of the velocities of particle displacements around the abrasive grain. The order of mathematical operations is expounded, which allows finding important physical quantities characterizing the chip material's deformed state. The deformed state of the cut layer is analyzed – the flow around abrasive grain during plunge grinding. The velocities and dislocation density fields were constructed for a specific example of processing. In the experimental part of the work, the research of the influence of technological regimes and the abrasive tool's characteristics on the quality of the hard-working materials' grinded surface was carried out.

Keywords: Grinding Process, Velocity Fields, Dislocations Density, Quality of Grinded Surface, Surface Roughness, Abrasive Grain, Recommendations for Technological Modes.

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Improvement of the Gear Shaping Effectiveness for Bimetal Gears of Internal Gearing with a Friction Coating

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This paper presents an experimental study of the gear shaping process of the internal gearing with a friction coating. It is known that this process is characterized by the occurrence of significant vibrations, the decrease in the stability of the cutting tool, and the ambiguity of the technological parameters. These factors limit the ability to process bimetallic discs with friction coatings on gear-shaping machines. Therefore, the dependence of the amplitude of oscillations of the ram and the table with the fixture for clamping the package of parts on different machining modes are investigated in the paper. The experiment was performed on a gear-shaping machine model TOS OHO 50 and using an accelerometer 7290A-2. To register the vibration acceleration, the Information Collection System "National instruments mod. NI-9234" was used. Also, during the experiment, the analysis of the period of stability of the cutting tool depending on the number of double runs of the shaper-type cutter and circular feed. The tool's stability was analyzed by the chamfer wear on the rear surface, which was checked by a microscope. According to the experiment results, the optimal processing mode, according to the tool's maximum productivity and stability, is proposed in the paper. The application of the proposed processing mode reduces the self-excited vibrations of the technological system, increases the cutting tool's stability, stabilizes the surface roughness parameters, and increases the gear-shaping process's efficiency of the package of friction discs.

Keywords: Bimetal Gears, Gear Shaping, Friction Discs, Vibrations.

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Penetration Depth of the Critical Temperature into the Workpiece Material During Grinding

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The grinding process successfully ensures high accuracy of the part, microgeometry, and geometry, then very often grinding reduces such quality indicators as the phase-structure and stress composition of the processed surface. When grinding, high contact temperatures arise, some of which, called critical, have a negative effect on the part's material and can lead to a change in the phase-structural composition and the stress state. The grinding process must be carried out so that these temperatures do not penetrate to a greater depth than the value of the remaining machining allowance. In this case, negative phase-structural changes occur in the layer of material that is removed. The article describes a technique that calculates the depth of penetration of critical temperatures and adjusts the processing modes so that each subsequent pass does not exceed the metal layer that will be removed.

Keywords: Contact Temperature, Critical Temperature, Allowance for Processing, Phase Transformations, Structural Transformations, Stress State, Surface Layer.

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Justification of Technological Possibilities for Reducing Surface Roughness during Abrasive Processing

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This work aims to determine the parameters of surface roughness during abrasive processing analytically and to substantiate the technological possibilities of its reduction in the conditions of transition from the micro-cutting process to the process of elastic-plastic deformation of the processed material. On this basis, the minimum possible values of surface roughness parameters during free abrasive treatment are analytically determined. It is shown that the main way to reduce the surface roughness is to reduce the grain size of the abrasive powder and increase the surface concentration of abrasive grains in the cutting zone. Based on the analysis of the graph of the relative supporting length of the micro-profile of the treated surface experimentally established during abrasive polishing, the significant effect of individual deep scratches on the surface roughness is shown. It is established that they occur as a result of the work of larger grains included in the considered grain fraction with a grain size of 1/0 and the different heights of the grains in the cutting zone. Therefore, it is recommended to use abrasive grains with a small range of their size spread during abrasive polishing and use ovalized abrasive grains, which prevent the formation of deep scratches. The obtained results can be effectively used for abrasive polishing of reflective surfaces of space products that operate under light conditions and require high surface roughness.

Keywords: Abrasive Polishing, Micro-Cutting Process, Ovalized Grains.

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Geometric Modeling of Lathe Cutters for Turning High-Precision Stainless Steel Tapered Threads

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The profiling of high-precision tool-joint tapered threads is performed according to an algorithm based on a convoluted screw model, which is functionally dependent on the cutter's geometric parameters and the size of the thread itself. It is proved based on visualization of algorithm that effective production of exact tapered thread from stainless steel is possible only using cutters with a specially calculated profile based on interpolation of a hyperbolic curve. There is created an acceptable geometric model for the cutting part of the thread cutter, the profile of which is a function of the back rake angle. Based on the visualization, it is confirmed that the axial profile of the sides of the tool-joint thread made by the cutter with a non-zero back rake angle is actually curved. On the example of algorithmic calculation of shaping by turning the tool-joint tapered thread size 2 7/8 Reg, it is determined that the use of the cutter model with a back rake angle of 12° and with a usual profile of the cutting edge causes the exceeding of the nominal thread profile side half profile angle by 3-10%, which gives grounds for the use of cutters without correction of their edge profile.

Keywords: Threading Lathe Tool, Rake Angle, Drilling Tool Joint, Geometric Modeling, Convolute Screw.

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Interaction of Flexural and Torsional Shapes Vibrations in Fine Boring with Cantilever Boring Bars

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In the process of fine boring of small-diameter holes (d = 10 - 20 mm), coupled flexural-and-torsional vibrations of boring cantilever bars are excited. It is of practical interest to study such vibrations during fine boring of long (or deeply located) holes with a ratio l/d>3 (l – the length of a boring cantilever bar). In such cases, a coordinate relationship arises between the flexural and torsional forms. A number of experimental studies have been carried out to assess this relationship and the effect on the emergence of an increasing vibration level. The work studies the features of joint flexural-and-torsional vibrations, the relationship between amplitudes and frequencies, and vibration modes' effect on the loss of vibration resistance. The experiments were carried out on a test bench assembled based on a finishing-boring machine. Measurements were made by strain and piezometric sensors. Samples of steel and cast iron were bored. The criterion for the cutter resharpening was the relative radial wear and the machined surface roughness.

Keywords: Cantilever Boring Bar, Flexural-and-Torsional Vibrations, Vibration Resistance, Dynamic Model, Flexural rigidity.

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Heat Flows Affected on the Wheelhead of a Cylindrical Grinding Machine

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The paper focused on analyzing the scheme of the effect of heat (cooling) flows on the grinding wheelhead of a cylindrical grinding machine tool with an estimate of the power of heat sources to determine the influence of the temperature factor on the accuracy of machining. The most important sources of heat, which act on the wheelhead body, and were studied in the paper are heat released in the spindle bearings; heat released in guideways; heat released in the cutting zone; heat received by the grinding wheelhead body as a result of the action of heated liquid coolant on its front wall; heat from the airflow, removed by the ventilation system of the grinding wheel drive electric motor; heat (cooling flow) from the airflow arising from the rotation of the pulley and the movement of the drive belts of the grinding wheel drive; heat from the ventilation effect that occurs under the encasing of the grinding wheel as a result of its rotation at high peripheral speed; heat (cooling) supplied to the belt drive pulley of the grinding wheel drive, installed at the output end of the spindle. The mathematical models for determining the quantity of heat for each of the mentioned heat sources are given.

Keywords: Grinding Wheelhead, Heat Flow, Roller Guideways, Coolant Liquid, Cutting Zone, Heat Transfer.

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Simulation Research of Machining-Induced Surface Layer Operational Characteristics

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The analysis of the rheological model, which formalizes the influence of the main technological factors on the formation of residual stresses and strains in the cutting process, is described in the article. An explanation of the physical phenomena of deformation processes during cutting and comparing theoretical conclusions with simulation studies results are given. The main task, the solution of which is proposed, is the generalization and system analysis of methodological studies of the influence of the technological factors and the cutting tool's geometry on the formation of the stress-strain and thermodynamic state of the surfaces of the workpieces during the cutting. Such problem-oriented modeling results are the basis for predicting the impact of technological process parameters on the formation of product's operational properties. An original scheme for determining the residual strains on top and in the machined surface depth is proposed. The analysis of the influence of technological operation data on residual strain formation was carried out using DEFORM 3D simulation.

Keywords: Functional-Oriented Process, Residual Strain, Simulation Study, Finite Element Analysis, Cutting Parameters.

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An Experimental and Statistical Investigation on Cutting Forces in Turning of AISI 304 Stainless Steel under Dry, MQL and Nanofluid MQL Conditions

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Machining AISI 304 austenitic stainless steel is well-known as it is very challenging due to its low thermal conductivity and hardening tendency. High-cutting forces are one of the common problems encountered during the machining of this kind of hard-to-cut materials. An attempt to improve its machinability while ensuring environmentally friendly conditions has been made. This experimental study was conducted from the perspective of performance assessment of machining parameters in turning AISI 304 under dry, minimum quantity lubrication (MQL), and nanofluid MQL conditions with consideration of the cutting forces. Additionally, as a methodology, the response surface methodology (RSM) and quantitative evaluation based on the primary effects plot were used. The study revealed that nanofluid MQL offered encouraging results compared to the MQL and dry conditions. Ultimately, the desirability function optimization method (DF) has been successfully executed to determine the best optimal machining responses under different cutting cooling conditions.

Keywords: Cutting Forces, MQL, Nanofluid, Nano Graphene, AISI 304, Response Surface Methodology, ANOVA.

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Part V
Advanced Materials

Strengthening of the NKV Type Centrifugal Pump's Shaft by Chemical-Thermocycling Treatment

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The paper is devoted to studying the process of nitrocementation with cycling heating compared to nitrocementation with isothermal heating. The purpose of thermocycling nitrocementation is to grind the base'sbase's structure and the surface layer of steel type AISI 5140, which produces the centrifugal pump'spump's shaft. The metallographic analysis showed that the grain score after isothermal and after thermocycling nitrocementation varies from № 5-6 to № 9 in the core and № 5-6 to № 10 in the diffusion layer (respectively). The thickness of the protective layer after thermocycling nitrocementation is 1.50 more than isothermal nitrocementation, which indicates a positive effect of thermal cycling on the saturation rate of the steel matrix. The depth of the protective layer obtained during nitrocementation and surface hardness are the criteria for assessing the shaft'sshaft's serviceability. It is established that thermocycling nitrocementation in comparison with isothermal leads to increase cavitation resistance by 0.6-1.5 times. The use of chemical-thermocycling treatment leads to reduced time, grinding of grain, and improved mechanical properties of constructional steel.

Keywords: Pump, Shaft, Nitrocementation, Thermocycling Treatment, Cavitation Wear, Cavitation Resistance.

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The Influence of Synthesis Modes on Operational Properties of Oxide Ceramic Coatings on Aluminum Alloys

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Electrophysical parameters of the process synthesis of oxide ceramic coatings in the plasma of spark discharge for electrolytes 1 g/l KOH (S1); 3 g/l KOH +1 g/l of liquid glass and 5 g/l KOH + 6 g/l liquid glass, and distances between electrodes from 0.05 m to 4.5 m have been investigated in this work. The influence of synthesis regimes on the physic and mechanical properties of coatings has been researched too. Experiments helped us understand that the *reduction* in *coating thickness* at a critical distance between electrodes is dependent on the depletion of the electrolyte, and the maximum microhardness is dependent on the growing of the power in separate spark discharges and (or) the growing of the content of Al2O3 in this coating. The influence of the distance between electrodes on its meaning was found with the help of the study on wear resistance. It is experimentally set that the value of the synthesis voltage is influenced by the composition, electrolyte concentration, and the distance between the electrodes: an increase in the distance between the electrodes leads to an increase in the synthesis voltage.

Keywords: Oxide Ceramic Coating, Plasma and Electrolyte Synthesis, Forming, Microhardness, Thickness, Wear Resistance.

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Optimal Design of Composite Shelled Sandwich Structures with a Honeycomb Filler

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The multi-parameter problem of the optimal design of composite sandwich structures with the honeycomb filler has been solved. For this purpose, the optimization process was divided into several stages according to the reasonable levels of significance of the objective function's parameters, i.e., minimal weight. At the first stage, preliminary analysis of thermal protection coatings of sandwich structures with the honeycomb filler is carried out, the most rational types thereof are found, the values of physical and mechanical characteristics, as well as the optimal ranges of variation and the initial value of the thickness of thermal protection coatings for different sections of the structure, are determined. At the second stage, the task of choosing the optimal relationship of the thickness of the thermal protection coating, height of the honeycomb filler, size of its cell, and thicknesses of bearing skins is solved, with simultaneous securing of the acceptable temperature ranges for the outer and inner surfaces of sandwich shells and bearing capacity of the rational variant in all critical areas. To further reduce the weight, the honeycomb filler structure is optimized at the third stage by varying the angle of opening of the cell of irregular hexagonal shape and coefficient of its shape in each section of the structure. Implementation of the suggested approach in weight optimization of a real object's structural parameters showed its efficiency, expressed in a significant reduction of the optimal structure's weight compared to its initial variant.

Keywords: Optimization, Minimum weight, Bearing Skins, Composite Materials, Thermal Protection Coating.

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Preparation and Characterization of a Biocomposite Based on Casein and Cellulose

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The problems caused by synthetic waste have led to the need to develop new materials that can be environmentally safe for living organisms and biocompatible with the environment, replacing widely used synthetic polymers. IF spectroscopy was used to study the chemical composition of the composite and to detect harmful substances. The nature of the relationships of structural components in the compositions was studied using scanning electron microscopy. The impact strength was determined by the Charpy method. The nature of the interaction of system components at the microstructural level is investigated. In particular, the anisotropy of properties, which is ensured by the uniform distribution of cavities in the volume of the composite and good adhesion of microcellulose with casein binder, was investigated. It is established that the composite does not contain harmful, toxic substances and can be positioned as a biocomposite. This material has been shown to have sufficient impact characteristics, in particular, impact strength a = 47 KJ/m^2 and can be used in the manufacture of food packaging, such as an alternative to polystyrene

Keywords: Cellulose, Plant Fibers, Biodegradable Material, Casein, Food Packaging, Chemical Composition, Impact Strength.

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Advanced Technologies of Manufacturing Readily Removable Cores for Obtaining High-Quality Castings

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The work investigates the physical, mechanical, and technological properties of mixtures to manufacture cores in a foundry. The filler is technical salt, the binder is an aqueous solution of sodium silicate, and the hardener is a solution based on propylene carbonate on a silicate basis. These rods are used to make internal surfaces in thin-walled castings. The work proposes a new method of manufacturing cores based on cold-hardening mixtures (CHM), which harden at room temperature. The planned experiment was chosen as the basis for modeling the properties of the mixture. The following parameters were chosen as optimization parameters: compressive strength, friability, and durability. According to the developed mathematical models, the mixture composition was optimized. The optimum binder content is 4.0 to 6.0 %, and the hardener content is 0.3 to 0.4 %. A technological process of preparing CHM for readily removable salt cores has been developed. As a result, the surface quality of the internal surfaces of castings improved. The cycle of core production was reduced, and the casting cleaning costs were reduced due to the elimination of the decoring process; environmental safety of the technological process was provided to the use of non-toxic materials.

Keywords: Cold-Hardening Mixture, Binder, Hardener, Salt, Core, Mathematical Model, Casting, Quality.

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The Use of Ion Bombardment Modeling as a Component of the Structural Engineering of Nanoperiodic Composite Structures

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The influence of bias potential on the phase-structural state and hardness of nanolayer multi-period vacuum-arc coatings has been studied using modeling radiation damage during ion bombardment, phase-structural studies, and measurement of microhardness. A significant expansion of the defect formation area was revealed when using layers of multi-element (high-entropy) alloys. For the composition (TiZrAlVNbCr), the depth of defect formation reaches 30 % of the total layer thickness (around 14 nm). It was found that for monometallic layers of the TiN/MoN system, the use of a constant potential of -230 V leads to the formation of the phase composition of TiN and γ-Mo2N. The hardness of such a coating is 44 GPa. The use of a high-voltage potential (-1000 V) in a pulsed form allows the formation of TiN and an equilibrium MoN phase, reduces the micro deformation of crystallites, and increases the hardness to 47 GPa. The introduction of layers of high-entropy (TiZrAlVNbCr) alloy nitride into the nanocomposite instead of TiN layers, and thus obtaining a composite (TiZrAlVNbCr)N/MoN, even in a high-voltage pulse mode, leads to stabilization of the nonequilibrium (γ-Mo2N) phase in molybdenum nitride layers. However, the feature of high-entropy alloys associated with low diffusion mobility and high distortion of the crystal lattice makes it possible to achieve the highest hardness of 54 GPa in such a nanocomposite.

Keywords: Computer Simulation, Radiation Damage, Nanoscale Layers, High-Entropy Alloy, Crystallite Size, Microdeformation, Hardness.

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Powder Technology and Software Tools for Microstructure Control of $AlCu_2$ Samples

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Abstract. The powder technology of structurally inhomogeneous materials of $AlCu_2$ sample formation is developed. The algorithm for image recognition of separate particles' microstructure of structurally inhomogeneous materials is formed and implemented in the Smart-eye software, which provides tools for analysis of surface and internal properties of structurally inhomogeneous materials. The developed powder technology is applied in obtaining the samples of $AlCu_2$, which are further analysed by the Smart-eye software. The structural characteristics of the starting material ($AlCu_2$), in particular porosity, were predicted. The analysis of the average results of the study of the microstructure of $AlCu_2$ particles is held, which shows that the developed models allow accurate control of the microstructure and properties of structurally inhomogeneous materials obtained based on powder technologies. Improvement of granulometric composition of structurally inhomogeneous materials is proved. Based on the obtained materials developed powder technology, it is possible to predict the structural characte ristics of AlCu2 raw materials at a qualitative level. Thus, it is possible to exercise to carry out practical realization of the received results on manufacture.

Keywords: Technology, Inhomogeneous Materials, Metallographic Analysis, Particles', Smart-Eye.

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Rational Choice of a Material for Orthopedic Insoles Based on the Mechanical Characteristics and Practical Application Purposes

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The general principles for the usage of polymer materials for the manufacturing of orthopedic products are discussed. The current choice of polymeric materials for orthopedic insoles and footwear is based on empirical evidence. In many cases, this choice is made subjectively because there is no information regarding each material's mechanical properties and their in vitro interaction. The insole functionality will depend on the mechanical properties of the used materials, the target functions of which are: amortization, energy absorption, stiffness, adaptation to the sole of the foot, filling of the cavities inside the shoe, and relieving pressure when walking. Accommodative insoles are suitable for patients with diabetes, early Charcot's disease, or any form of neuropathy, while functional insoles are best used for treating pronation, plantar fasciitis, and heel spur syndrome. This study aimed to provide objective criteria for selecting materials for orthopedic insoles based on their mechanical characteristics. The mechanical properties of the materials were quantified using standardized methods.

Keywords: Standardization, Foot Insoles, Performance Polymers, Polymer Composite, Friction and Wear, Additive Manufacturing Technology.

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Structure and Properties of Surface Bandage Shelves for the Gas Turbine Engine's Blades

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Analysis of the properties of the materials from which the parts of a gas turbine engine are made showed that they must have a high melting point, high strength, high creep resistance, and be machined. Therefore, the best option for strengthening the blades of titanium alloy VT3-1 is the formation in the wear zone of a thermodynamically compatible, heat-resistant, and wear-resistant layer, which is different from the main material of the blade. Samples for research were cut from the bandage shelves of the compressor blade in the shank area: the first - with high-quality soldering relite, the second – the shelf is worn, and there is a defect in the form of a drop. It was found that the main titanium alloy has a homogeneous structure, and the surface of the defective coating has a lower roughness, microcracks. Its local areas differ in elemental composition. Clusters of pores explain the clear and wide grain boundaries of titanium alloy under defective soldering at the boundaries. Such clusters of defects are etched more strongly than the base metal, so the base alloy has a needle-like martensite hardened structure formed by rapid cooling in the air after soldering. It is proved that such defects are formed due to the violation of soldering technology. It is proposed to create a protective layer of composite material VTN-1 with tungsten particles, which contains solid parts of tungsten carbide and titanium-based solder VPr16, to strengthen the working blades in the wearing zone.

Keywords: Heat Resistance, Soldering, Relit, Bandage Shelf, Titanium Alloy, Spectral Analysis, Mechanical Properties.

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Part VI
Mechanics of Solids and Structures

Wear Simulation for Internal Cylinder Contact in Rolling-Slip Mode

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The work's goal is to develop computational and experimental approaches to determine friction units' wear resistance with internal contact of cylinders with slip. The scientific novelty consists of considering the slip for calculating the friction path and wearing the cylinders with internal contact and the proposed method for identifying the wear law parameters based on the test results. Practical value is the proposed methods to account for load, slip, and lubrication conditions on the resource for the design of friction units. The dependences for determining the friction path for the internal rolling of cylinders have been considered. The design of an experimental setup for studying friction and wear of cylinders with slip has been proposed. Experimental studies have been carried out: paths of friction; wear of surfaces both with a key and without a key; lubricants' effect on wear has been studied. The form of the wear model is proposed to determine the effectiveness of methods for increasing wear resistance. The method for determining the parameters of the wear law has been implemented based on the test results. The results show the efficiency of copper powder as an additive to a lubricant. It has been established that the wear of cylinders with a key is greater than the wear of cylinders without a key due to different friction paths. A practical example of determining the wear of a car hub shaft using the wear patterns is presented.

Keywords: Friction Pair, Bearing, Wear Parameters, Lubrication, Additive, Suspension Hub, Laboratory Test.

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Mathematical Model of the Thermoelasticity of the Surface Layer of Parts during Discontinuous Friction Treatment

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The developed mathematical model of thermoelasticity and the depth of the surface layer during the frictional treatment of the working surfaces of machine parts with a tool with a discontinuous working part are presented. Friction treatment refers to surface hardening methods using highly concentrated energy sources. A highly concentrated energy source occurs in the tool-contact area during a high-speed metal disk on the treated surface. It is represented by the initial-boundary problem of thermoelasticity formulated in terms of elastic displacements and temperature change. Afterward, the appropriate variational problem is formulated, and the numerical scheme for its solution is constructed. This numerical scheme uses finite element semi-discretization in space and a one-step recurrent time integration scheme. We present numerical results for one-dimensional modeling of dynamical interaction of the heat and mechanical fields in steel workpieces, generated by a periodic sequence of pressure and heat flux impulses.

Keywords: White Layer, Surface Strengthening, Friction Treatment, Temperature, Stress, Finite Element Method.

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The Durability of the Nanocrystalline Hardened Layer during the Fretting Wear

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The results of the study of the influence of the modified strengthened surface layer after friction treatment on the wear resistance during fretting-wear of Steel C45 (EU) – Bronze CuAl10Ni5Fe4 (EU) and Steel C45 (EU) – Steel 1.7220 (EU) friction pairs are presented. Friction treatment refers to surface strengthening methods using highly concentrated energy sources. After friction treatment, a nanocrystalline reinforced (white) layer is formed in the surface layers of the metal. The thickness and microhardness of the reinforced layer depend on the process medium used in the processing. Thus, on samples of Steel C45 (EU) (quench hardening and low-temperature tempering) after friction treatment using as a process medium mineral oil, the thickness of the hardened layer was 150-160 μm, and microhardness – 7.2 GPa with a hardness of the original structure of 4.2 GPa, after treatment with using its technological medium the saturated aqueous solution of mineral salts based on magnesium and calcium chlorides layer thickness was 200-220 μm and hardness – 8.4 GPa. It is shown that the strengthened nanocrystalline white layer significantly increases the durability of friction pair during fretting wear. Thus, in the study without oil lubrication of Steel C45 (EU) – Bronze CuAl10Ni5Fe4 (EU) wear resistance increased 1.6 times. The samples were strengthened use as a process medium the saturated aqueous solution of mineral salts based on magnesium and calcium chlorides. The established coefficient of friction pair decreases. But only the sample (Steel C45) was strengthened (after friction treatment), the counter-sample was ground (without friction treatment).

Keywords: Fretting Wear, Friction Treatment, White layer, Nanocrystalline Structure.

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Mathematical Modeling of Physical and Mechanical Properties of Polymeric Materials Reinforced with Carbon Nanotubes

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Techniques for determining the elasticity modulus of single-wall nanotubes (SWNTs) of different types using the relationship between the parameters of molecular and structural mechanics have been analyzed and developed. The formulations of linear and nonlinear relations for determining the parameters of structural mechanics based on the energy potentials and force coefficients of molecular mechanics are considered. Using the finite element method, numerical models have been developed to study the elasticity modulus of nanotubes of various types and sizes, macros in the APDL ANSYS Mechanical APDL programming language. Comparison of the results obtained with theoretical and experimental data showed satisfactory agreement. The discrepancy with the known theoretical estimates lies in the range of 0.08–5.1 %. Using numerical modeling, an assessment was made of the possibility of using functionalized polymers (nanocomposites) as structural materials for the manufacture of cartridges for the storage and distribution of compressed gas. Based on calculations of the stress-strain state of a cartridge for storage and distribution of compressed carbon dioxide, it was found that the use of a functionalized polymer for the manufacture of containers operating under pressure can significantly reduce its weight and even increase its capacity while ensuring the required strength.

Keywords: Nanocomposite, Functionalized Polymer, Elastic Modulus, Tensile Strength, Finite Element Method.

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Controllable Crank Mechanism for Exciting Oscillations of Vibratory Equipment

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This paper aims to improve the eccentric drive of vibratory equipment using a controllable crank mechanism. Unlike the existent vibration exciters widely used in industry, the proposed design of the crank mechanism allows smooth variation of the excitation frequency and the amplitude. These advantages simplify the process of adjusting the operation modes of vibratory equipment under changeable technological or manufacturing conditions. The scientific novelty of the presented research results consists in substantiating the design and operational parameters of the proposed controllable crank mechanism to provide the resonance operation mode of vibratory equipment. To describe the kinematics of the mechanism, the corresponding motion equations are derived using the method of closed vector loops. The numerical modeling of the mechanism motion is carried out using PTC Mathcad software. To analyze the correctness of the derived equations and numerical modeling results, the simulation of the mechanism motion is performed in SolidWorks software. The analytical expressions describing the dependency of the amplitude of forced vibrations excited by the crank mechanism on the displacement of the controllable slider are derived based on the obtained results. Using these expressions, it is possible to adjust the excitation amplitude following the changeable technological or manufacturing conditions by means of changing the position of the slider with the help of a stepper motor and a screw gear.

Keywords: Resonance operation mode, Amplitude, Frequency, Kinematic analysis, Numerical modeling, Simulation.

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Compression Mechanics of Cylindrical Samples with Radial Deformation Limitation

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The presented work aims to construct a plasticity diagram for graphite-containing cast iron SCH20, which is necessary to predict this material's ultimate deformation values for deformation conditions with significant negative values of the stress state's coefficient. It has been established that low-plasticity cast iron can be plastically deformed only at negative values of the stress state's stiffness coefficient. For the first time, the cast iron SCH20 deformation data with significant negative values of the stress state's stiffness coefficient has been calculated. A technique has been developed to construct a plasticity diagram for low-plastic materials with negative values of the stress state's stiffness coefficient. A compression model of a cast-iron tubular sample is obtained, which ensures the creation of large plastic deformations and the calculation of stress-deformed state parameters. Calculations performed using the developed model made it possible to establish the studied material's ultimate deformation, accumulated before fracture, at significant negative values of the stress state's stiffness coefficient. Modeling performed according to the proposed methodology using the DEFORM software package showed good overlapping between the calculated data and model experiments results.

Keywords: Stress-Deformed State, Plasticity, Compression, Deforming Broaching, Finite Element Method, Cast Iron, Stiffness Coefficient, Stress State.

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Methods and Algorithms for Calculating Nonlinear Oscillations of Rotor Systems

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In the article, linear and nonlinear parameter identification methods were described relating to mathematical models of rotor oscillations for centrifugal pumps and turbochargers. For solving a nonlinear estimation problem, the combined use of several methods at each iteration step was proposed. In this regard, the determination of initial values for the estimated parameters was based on both the finite element and the discrete models. For studying the nonlinear rotor oscillations, a method for designing the discrete mathematical models was proposed based on the linear identification of equivalent masses using data obtained by the calculation of eigenfrequencies and mode shapes as a result of the finite element analysis. Using the artificial neural network, the methodology for estimating the inertia coefficients of rotor systems based on measurements of oscillation amplitudes at the frequency close to the critical one was developed. Finally, the proposed techniques were developed by implementing both quasilinear regression analysis and the artificial intelligence system. The corresponding program techniques were proved by the experimental research data of rotor oscillations using the accelerating and balancing stand with the vacuum camera. The developed methods and related program applications help evaluate the dynamic characteristics of pumps and turbochargers.

Keywords: Finite Element Model, Discrete Model, Eigenfrequency, Amplitude, Regression Analysis, Artificial Neural Network, Inertia Coefficients, Nonlinear Component.

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The Optimal Thickness of the Surface Plasma Hardening Layer of Functional-Gradient Parts with Symmetrical Stress Concentrators

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Based on the approaches of continuous mathematical modeling, a computational methodology is proposed for establishing one of the most important operational parameters of surface engineering technologies, which determines the life of parts - the thickness of the hardened layer. For the first time, using non-local models of mechanics and the Fenics finite element analysis package, a scheme for finding the optimal hardening depth of parts depending on the load parameters and characteristics of stress concentrators has been built. Using the example of wheel rims of locomotives, it is shown that in the presence of stress concentrators, the increase in the life cycle of parts is achieved by plasma strengthening to a depth of 2.5 … 3.5 times larger than the radius of the concentrators. The methodology proposed in the work is necessary for describing the behavior of the material of parts under the action of force loads in the presence of stress concentrators for selecting the optimal technological modes of hardening the surface layers. The established relationship between the change of properties of local volumes of wheels of locomotives at operational loadings and characteristics of concentrators of tension is used to obtain products with the defined life cycle, computer designing of the technological process of plasma strengthening of surfaces of contact interaction of details.

Keywords: Mathematical Modeling, Finite Element Analysis, Stress Concentrator, Surface Engineering Technology, Contact Strength, Plasma Hardening, Weakened Zone.

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An Increase in Wear Resistance Frictional Contact of Functional Surfaces for Plunger Pairs

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A comprehensive approach to the technological wear resistance of parts is based, on the one hand, on the assessment of quality indicators of parts that characterize their geometric shape, surface layer quality, and volumetric properties, depending on technological factors, and, on the other hand, on performance characteristics: contact stiffness, corrosion resistance of parts depending on their quality indicators. In order to do this, considering the mutual influence of quality indicators, changes in one indicator depending on another and changes in the second indicator depending on the first, which are manifested in the same technological transition, such effects significantly affect the values of quality indicators, especially in the manufacture of precision details. A method for estimating the contact interaction of friction plunger pairs is proposed, which considers microgeometric parameters and physical and mechanical properties of the surface layer of conjugate parts based on the theory of the elliptical shape of the microprojections of the surface layer. Modeling the process of contact interaction of coaxial sliding contact of two surfaces, in the form of contact of a cylindrical plunger and a sleeve with equivalent values of parameters of roughness, undulation, and macrodeviations is given. As a result of the comparison of calculated and actual values of wear resistance parameters, the suitability of this approach for modeling of processes of contact interaction of friction surfaces is confirmed. The results confirming the adequacy of the offered model are presented.

Keywords: Wear Resistance, Roughness, Waviness, Modeling, Tangential Surfaces, Plunger Pair, Contour Area.

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Part VII
Numerical Simulation of Coupled Problems

The Influence of the Gas Content in the Working Fluid on Parameters of the Hydraulic Motor's Axial Piston

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Abstract. There is a powerful influence of undissolved air on the axial piston hydraulic machines parameters, which requires research to detect this effect and reduce it. Considering the working fluid's variable parameters and the load at the hydraulic motor output make it possible to increase the accuracy of mathematical modeling and improve the motor output characteristics. An energy-efficient device for mixing liquid with air is developed. Its use provides a fine gas-liquid mixture. The efficiency of the device was confirmed experimentally and by CFD calculations. The experimental research results of the working liquid gas content influence of and load on the hydraulic motor's shaft on rotational speed have resulted. The model of the axial piston hydraulic motor rotational speed depending on the specified factors is received. The adequacy of the obtained mathematical models is checked. It is established that with increasing gas content in the working liquid, there is an increase in the amplitude of pressure fluctuations upstream the axial piston motor, and the oscillation frequency remains virtually unchanged. The hydraulic motor's speed and the torque on the shaft are practically not affected by the gas content of the working liquid.

Keywords: Axial Piston Motor, Gas Content, Working Liquid, Experiment, Numerical Simulation.

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Optimizable Mathematical Model of Curve Steel Parts' Fatigue

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The article discusses models of fatigue curves that have found application in determining machine parts' endurance limit. It is shown that the fatigue curve can be represented in the form of a composite one, consisting of two sections: the left one, subject to the power equation, and the right one - the Weibull equation. It was found that the use of such a fatigue curve of a new shape allows one to describe the characteristics of fatigue resistance in the entire region of high-cycle loading of real parts with a high correlation coefficient, especially large parts. Also, determine the physical endurance limit, if any. Varying the position of the first section of the two-link fatigue curve made it possible to establish that the point of intersection of the sections in some cases was "floating", tied to the maximum stress of the operational stress spectrum. In most other cases, the intercept's abscissa was fixed, close to or equal to the abscissa of the breakpoint of the traditional fatigue curve. In these cases, the benefits of the new fatigue curve are most apparent. Dependencies between the main parameters of the new shape fatigue curve are obtained. Based on the proposed fatigue curve of a new shape, a method was developed for assessing the endurance limits of parts under irregular loading, depending on various options for the action of the maximum breaking stress.

Keywords: Aggressive Environment, Cyclic Life, Endurance Limit, Fatigue Curve, Agreement Criterion.

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Fluid Behavior in an Auto-Balancing Unit without External Damping

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This article describes mathematical models of stationary motion in rigid supports of a rigid rotor with a cylindrical chamber partially filled with fluid. It is considered limited from the above chamber, which is located eccentrically and symmetrically on the shaft. In each case, based on integrating the liquid equilibrium differential equations, the pressure distribution laws in the fluid and specific shapes of equal pressure surfaces are defined. Considered cases simulate fluid behavior in an auto-balancer without considering external damping. It is investigated that the fluid is symmetrical about the axis of rotation of the system. Simultaneously, its bulk is concentrated by eccentricity (with the eccentric arrangement of the chamber). The constructed models' analysis shows the impracticability of automatically balancing the rigid rotor with fluid in the rigid supports. The experimental results confirm the assertion. These results are obtained using dynamic photography, which is realized on an up-to-date computer and video equipment.

Keywords: Rotor, Unbalanced Rotor, Rigid Rotor, Oscillations, Automatic Balancing, the Auto-Balancing Unit (ABU).

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Improvement of Operating Processes of High-Head Tubular Horizontal Hydraulic Turbines

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The article deals with new promising directions for the hydropower industry, which enables the hydraulic turbine operating range to be expanded in terms of heads and flow rates, the reliability of the equipment to be increased during peak loads of daily regulation and especially at start-up and shut-down modes, the capacity to be raised by 1.5 times, i.e., to increase the power of the hydraulic unit with the runner of the same size and significantly increase the average operating efficiency. New designs protected by many patents of Ukraine gave advantages of tubular horizontal bulb hydraulic units over Kaplan and Francis turbines for medium and high heads up to 230-250 m. The paper presents the directions and procedure of calculation that sharply reduces energy losses in hydraulic turbine inlet due to the formation of laminar flow in the near-wall boundary layers of the nozzle vanes that form the angular momentum required for optimum operation, a more uniform inlet conditions upstream the runner, allowing to reduce shock losses at the inlet to the runner and providing conditions for a laminar boundary layer at the inlet elements of the blades for operating modes close to best efficiency point. As a result, new design concepts and more advanced solutions in the system for control and computation of the flow enable the reliability and the basic operating parameters of new types of hydraulic turbines to be increased.

Keywords: Hydropower Industry, Hydraulic Turbine, Flow Computation, Laminar Boundary Layer.

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Detuning of a Supercharger Rotor from Critical Rotational Velocities

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The paper delivers an analysis of the dynamic characteristics of a rotor system of the turbocharger of a two-stroke internal combustion engine. A cantilever installed impeller is considered. The shaft rests on two bearing supports. The stiffness of the bearing supports and the shaft bending stiffness are varied in the analysis. Natural eigenfrequencies are first determined for the initial design. To separate them reliably from the operational domain of rotational velocities, certain criteria are established. Those criteria can be met by selecting certain stiffness parameters of the rotor system. The objective is to alter the first and second eigenfrequencies so that the operating range of the rotor system is fully enclosed between them. The relations of the eigenfrequencies upon the varied stiffness parameters are obtained from a finite element model. These data are used to determine the area of admissible design variables in the parametric space. When the parameters are chosen from this set, the design safety concerning oscillation moderation can be achieved.

Keywords: Turbocharger, Turbocharging Systems, Critical Velocities, Natural Oscillation Frequencies, Rotor System, Detuning.

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Influence of the Shape of Windows on the Throughput of the Planetary Hydraulic Motor's Distribution System

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Modern trends in the use of hydraulic drives of active working bodies of self-propelled equipment require new rotary hydraulic machines, particularly planetary. The processes occurring in hydraulic machines are associated with the movement of the working fluid through the channels of their distribution systems. Proposed the choice of a rational form of working windows of distributors in the design of systems for distributing the working fluid of planetary hydraulic machines, depending on their technical characteristics, purpose, production conditions, etc. A structural and functional diagram has been developed for determining the flow area of a distribution system with different shapes of distribution windows, which allows modeling the process of changing the flow area. The analysis of the output characteristics of the distribution systems has been carried out, making it possible to make a rational design decision on the choice of the shape of the windows of the projected distribution system of the planetary hydraulic motor. It has been established that distribution windows made in the form of a segment are the most functional while being very complex in manufacturing technology. Distribution windows, made in the form of a hole, are the most technologically advanced but have a flow area three times less than segment ones.

Keywords: Design of Hydraulic Machines, Movable and Fixed Distributors, Rational Choice.

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Particle Movement in a Centrifugal Device with Vertical Blades

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The particle movement parameters in a centrifugal scattering device (conical disk with vertical rectilinear blades) are determined in the article using a movable coordinate system, which rotates with the disk. The disk rotates with a given angular velocity around a vertical axis. Since a moving system's vertex describes a circle, such a system can be taken as the accompanying Frenet trihedron of this circle known in differential geometry. It allows finding the components of the particle's absolute acceleration in the projections on the trihedron's orts. A system of differential equations of particle motion is compiled and solved by numerical methods. Kinematic characteristics and the regularities of the relative movement of a particle on the conical surface were found. Analytical description of the particle movement allows investigating the particle's acceleration and finding the relative and absolute velocities at the moment of the particle's descent from the disk. As a result, determining the influence of technological and structural parameters on the particle's acceleration process is possible using obtained analytical dependencies.

Keywords: Differential Equations, Frenet Trihedron, Angular Velocity, Radius Vector, Acceleration.

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Evaluating the Wall Thickness of a Blow Molding Billet

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An engineering approach to estimating the necessary billet's wall thickness to produce a thermoplastic article in a blow molding process was proposed. The obtained analytical dependences establish the relationship between the diameters, wall thicknesses, and the forming zone's length for the polymer blank and final blow product. Examples of manufactured bottles for 0.5 l and 1.5 l carbonated beverages show that the accuracy of forecasting the thickness of the wall thickness of a billet is in the range of 12.9 %. An example of determining a billet's wall thickness for obtaining a barrel with a diameter of 0.4 m was given produced by the technology of extrusion blow molding from high-density polyethylene. The analysis of the change in the required wall thickness for the polymer billet was performed depending on its diameter and the wall thickness of the final product. It was shown that the most acceptable size of the diameter for the polymer billet should be selected within 30 % of the diameter of the finished product. In this case, with a barrel wall thickness of 2.8 mm, it is necessary to extrudate the billet with a wall thickness of 9 mm. The proposed approach does not require complicated calculations or special software and is convenient for design engineers and production technologists.

Keywords: Thickness, Barrel Wall, Extrusion, Simple Calculations, Process, Melt, Thermoplastic.

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Synthesis of Target Reducing Performance Using a Reducing Valve with Mechanical Control System

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Pressure reducing valves are widely used in the industry. The growing demand for precise pressure control in industrial hydraulic or pneumatic systems and automatic pressure control with maximum energy independence and autonomy of these operations requires the introduction of new design solutions. The article presents design implementation, synthesized based on graph theory, a fundamentally new passive pressure reducing valve with a mechanical control system. Theoretical and experimental studies of this device have been carried out when solving the problem of autonomous stabilization of the pressure at the valve outlet when the pressure at its inlet changes. It has been established that the presence of a mechanical control system in a synthesized pressure reducing valve makes it possible to achieve the required target characteristic of the reduction in high performance according to the criteria of compliance and multiplicity. The results obtained can be used to create a design technique for this type of pressure-reducing valves.

Keywords: Adjustable Throttle, Pressure Valve, Control System, Target Characteristic, Reduction Efficiency.

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Pressure Distribution in the Face Throttle of the Centrifugal Pump's Automatic Balancing Device

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Face throttles are widely used as a functional element of seals or automatic balancing devices in pumps of different constructions. Hydrodynamic characteristics of such throttles are greatly influenced on rotor dynamics and the efficiency of the pump. It is necessary to know the pressure distribution in the face throttle gap with considering all possible effects that determine the fluid flow to calculate their hydrodynamic characteristics. The problem of viscous incompressible fluid flow through the face throttle of centrifugal pump automatic balancing device considering the throttle surfaces' axial and angular displacements is considered. Equations of unsteady flow are solved. The inertia of the fluid is included. As a result, an analytical expression for the pressure distribution in the face gap is obtained. The influence of the local losses and the relative motion of the face throttle surfaces is analyzed. Hydrodynamic characteristics and coefficients of inertia, stiffness, and damping are calculated.

Keywords: Hydrodynamic Losses, Pressure Drop, Inertia Components, Axial Oscillations, Flow-rate.

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Contact Interaction of a Ball Piston and a Running Track in a Hydrovolumetric Transmission

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Modern hydrovolumetric transmissions with ball pistons work under high loads. In the field of their contact interaction with the running track, there are significant efforts. For analyzing the contact interaction of ball pistons with running tracks, the pliability of their surface layers is considered. They are modeled with materials with nonlinear properties. The analysis of changes in the contact area and contact pressure distributions depending on the properties of the material of the intermediate layer is carried out. In particular, a material with a bilinear elastic characteristic was investigated. It was found that the properties of the material strongly affect both the shape and size of the contact area. This changes the distribution of contact pressure. At low pressing force, the contact area has an oval shape. The contact pressure has a maximum in the center of the contact area. With increasing pressing force, the contact area takes the form of a dumbbell. The maximum contact pressure is shifted to the periphery of the contact area. Thus, it is possible to control the distribution of contact pressure by changing the properties of the material of the intermediate layer. Accordingly, it is possible to influence the stress-strain state of contacting bodies.

Keywords: Hydrovolumetric Transmission, Contact Interaction, Contact Pressure, Von Mises Stress.

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Part VIII
Chemical Process Technology and Heat and Mass Transfer

Obtaining of the Novel Organo-Mineral Fertilizers in Pan Granulators: Technological Fundamentals

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In this article, the efficiency of a new way of obtaining organo-mineral fertilizers in disk (pan) granulators is discussed. Based on the literature review, the granule shell's formulation is proposed, which increases the efficiency of assimilation of soil fertilizer and increases soil fertility. A method of encapsulating nitrogen fertilizer in a shell with an organic binder is described. The application of the pan granulator as the main equipment of the granulation unit is substantiated. The algorithm of calculation of the granulation unit and theoretical bases of constructive calculation of the granulator is given. This algorithm includes the technological calculation of the capsulation process, the constructive calculation of the pan granulator, the optimization calculation of the granulation unit, and the granulation unit's design stage. The crystal structure of the granule and the shell were studied, and their elemental composition was determined. The research results allow estimating the effectiveness of a new method of organo-mineral fertilizers obtaining.

Keywords: Fertilizers, Granulation, Pan Granulators, Encapsulation.

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Simulation of the Bulk and Granular Materials Separation Process in the Scissor Type Gravity Separator

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In different industries, separation (classification) is a typical process in processing bulk and granular materials. The mathematical model of the separation process based on theoretical mechanics and Markov chains' theory was proposed. The model allows us to consider the sieve parameters, such as the tilt angle, the pitch and size of sieve orifices, and the material particles' parameters such as size, friction coefficient, and initial velocity. Modeling the separation process allows us to justify the sieve parameters when the sieve is used effectively. The research methodology involved a comparison between model predictions and experimental data. The bulk material separation process's intensity index on the sieve was calculated based on the experimental study results. Comparison between model data and experimental data indicates the adequacy of the proposed mathematical model of the separation process. The separator's design elements are also offered, which will ensure the separation process's high efficiency.

Keywords: Theory of Markov Chains, Separation Model, Sieve Parameters, Separator Parameters.

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Numerical Simulation as a Tool for Design Optimization of Two-Phase Swirl Flow Atomizers

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This study aims to analyze the hydrodynamics in two-phase swirl flow conical atomizers. The Euler-Euler model was used for the calculations. Numerical simulations were performed to provide information about the fluid velocity distribution and the atomizer's internal flow. The numerical calculations confirmed the experimental data. This data was found based on the consistency of the spray angles obtained by both methods. Assuming the correctness of the numerical simulations performed, they can be treated as a tool for further analysis of mass and energy exchange along with the atomizer and optimizing the atomizer's design depending on the requirements. The influence of the swirl chamber geometry on the obtained spraying effect was demonstrated. Increasing the swirl chamber's height (increasing the HS/DS ratio) causes a decrease in the spray angle value. Moreover, the swirl chamber's geometry influences the flow inside the atomizer, which determines the atomization effect.

Keywords: Conical Two-Phase Atomizers, Swirl Chamber, Eulerian Model.

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Equipment for Oilfield Wastewater Treatment Using Swirling Flows

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Installations for the treatment of oilfield wastewater have been developed. The article presents a solution to hydrocyclone installations for the treatment of oilfield wastewater based on the use of swirling flows. Due to the centrifugal forces in the hydrocyclone and the turbulent water movement, the armor shells of oil droplets are destroyed, enlarged, and the monodispersity increases. The forces acting in the hydrocyclone are considered, and the efficiency of centrifugal forces in separating solid particles is estimated. The main parameters and requirements for the quality of oilfield wastewater are given, recommended for calculation in developing new and improving existing oilfield wastewater treatment plants for oil reservoir flooding, which allows increasing oil recovery by 1,5-2 times. Improving the systems of field preparation of products includes developing new effective technical means, including hydrocyclones and the improvement of traditionally used equipment. Hydrocyclone can be used as the main element in the wastewater treatment system. The regime is observed, in which there is no over-dispersion of the remaining oil in the water (water in oil). Thus, the device implements a mechanism for separating light (oil, gas) and heavier fractions (sediment, water, oil).

Keywords: Oilfield Wastewater, Hydrocyclone, Separation, Swirling Stream, Hydrodynamic Treatment, Filter.

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Hydrodynamic Characteristics Features of Trays Used in Heat and Mass Transfer Processes with Waste Liquids

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The paper presents the results of a study to obtain information on hydrodynamic features of trays that are suitable for use in heat and mass transfer processes with waste liquids and gases. Two types of so-called pasets – varieties of baffle tray – were considered. The first of them was a structure consisting of a funnel and a smaller diameter cone installed above it. The second type was distinguished by an element located above the funnel, which consisted of two cones joined by their bases. Descriptions of the fluid flow over these contact elements under irrigation conditions without and with a gas supply are given. The data on the pressure drop on dry and irrigated trays are obtained, which are summarized in the form of appropriate equations. A comparison of the hydrodynamic characteristics between the two types of pasets, as well as with the dual-flow tray, showed that there are no significant differences between the pasets. At the same time, the first of them has a simpler design and requires less metal. The pressure drop on both types of pasets is 1.6-1.9 times greater than on a dual-flow tray. However, since the pasets contain two stages of contact, it can be assumed that they offer less resistance to the passage of gas. Their advantage over the dual-flow tray is also a more stable hydrodynamic regime. The cause for the instability of the dual-flow tray regime was shown to be the hysteresis of the pressure drop dependence on the gas velocity.

Keywords: Hydrodynamics, Pressure Drop, Contact Elements, Baffle Tray, Paset, Dual-flow Tray, Dry Tray, Irrigated Tray, Fluid Flow.

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Hydrodynamic Parameters of a Combined Contact Device

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The foaming device can be used to carry out mass transfer and heat exchange processes between gas and liquid and for cleaning gases in the chemical, petrochemical, food, and related industries. A paper presented a combined contact device, which increases the efficiency of mass transfer, avoid clogging by creating a high-intensity, turbulized gas-liquid layer, which does not allow dispersed particles to accumulate on the sheets of the tray and stabilizer, provides a better dip of the liquid on the tray, with a significant decrease in the hydraulic resistance of the separation and mass transfer equipment. The article is considered a theoretical approach to defining the hydrodynamic performances of a combined contact device, determine critical gas mass value, at which the dynamic foam layer becomes unstable. The realization of the stabilization method of the gas-liquid layer greatly extends the scope of foaming devices and opens new possibilities for intensifying varied technological processes.

Keywords: Hydrodynamics, Stabilization, Foam Layer, Plate, Turbulization.

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Particle Image Velocimetry Based on Matlab and PIVlab for Testing Flow Disturbing Elements

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The article presents the basics of the Particle Image Velocimetry (PIV) measurement method, a non-invasive technique for determining fluid velocity fields, and the designed and constructed universal PIV digital imaging anemometry stand and its possible applications. It can be widely used, both in industry and in scientific laboratory research. The PIV method is used in many areas, e.g., in gas and fluid flows, combustion studies, and machining processes. The PIV measuring installation with the elements designed in AutoCad 2019 by AutoDesk is showed. The stand consists of a tank, LED lamps, pumps, a special nozzle, a camera, and a PC with PIVlab software. Both pumps are equipped with controllers. The obtained results allow for identifying zones where there is no fluid movement or places where particles move at low speeds. The preliminary conditions for research and analysis have been defined. The designed and constructed stand is undoubtedly suitable for research work related to the flow on a laboratory scale. PIV can be successfully used to describe the process of liquid spraying, spray drying, granulation and grinding, mixing and separation, heat and mass transfer.

Keywords: PIV, Fluid Flow, Measurements, Measuring Stand.

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Hydrolysis of Vegetable Raw Pectin-Containing Materials under Vibration and Centrifugal Mixing of Liquid Environment

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The problem of removing solid particles of inhomogeneous liquid systems outside the zone of intensive mass transfer in the industry is solved by various means, among which we can note the use of ultrasound, centrifugal forces, low-frequency oscillations. Among the multifaceted mechanical action methods on various dispersed systems in heat and mass transfer processes, vibration plays an important role. It is one of the most effective means for forming and correcting the desired state of inhomogeneous media. Creating a field with vibration action on various technological environments significantly activates and streamlines heat and mass transfer processes, improves the quality of various processes of mixing materials with properties that do not match each other, and reduces the duration of operating cycles and energy consumption. When creating a combined force and moment imbalance, both the dynamic loads on the support nodes increase, and there is a more intense oscillating movement of the blade shaft along its axis. At momentary imbalance, the loads on the support nodes are reduced while providing the desired linear oscillating motion, which is quite effective for the system under study. With the help of software and methods of mathematical and statistical analysis, graph-analytical power ratios, kinetic-energy parameters of the designed symmetry were built, which allowed substantiating energy-efficient modes of operation of the developed device.

Keywords: Unbalance Elements, Oscillating System, Vibrational Mixing, Energy.

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Comprehensive Model of a Catalytic Converter

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The paper's scope is devoted to atmospheric air protection based on developing mathematical models of catalytic processes to purify environmentally hazardous substances at gas mixtures in the proposed design converter. The existing mathematical models of catalytic processes on a solid surface have been analyzed, and the relevance of further research on the complex rendering of a description of catalytic reactions taking into account the interaction features «gas flow − solid surface − heat and mass transfer along the surface − transformation processes in the internal volume and on outlet surface is an eco-safe gas mixture». Based on the conversion's theoretical description, a three-level model describing the constructed catalytic converter processes is proposed. The connection of theoretically grounded models with known phenomenological models of carbon monoxide oxidation is shown. The advantages of the three-level model of catalytic conversion as the basis for making decisions on improving the catalytic device structure are determined. Algorithms and software for modeling the catalytic purification processes of gas mixtures from technogenic dangerous objects have been developed. The advantage of the proposed mathematical models and algorithms is their high speed, the ability to automate environmental safety monitoring based on the developed information and software products, the qualitative and quantitative agreement of the obtained numerical results with the results of experimental studies.

Keywords: Environmental Danger, Protection of Atmospheric Air, Hazardous Gas Mixtures, Catalytic Conversion, Mathematical Modelling, Catalyst, Environmental Assessment.

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Justification of Local Expenditure Characteristics of Vibrotransporting Devices in Design Modeling of Continuous Vibroextractors

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Extensive industrial implementation and practical provision of conditions for optimal vibroextraction process, which is based on a new method of countercurrent phase separation and creation of a regime of intensive alternating turbulence of the workflow by pulsating jets, is constrained by the complexity and insufficient study of expenditure characteristics of vibrotransporting devices required for modeling and design of this type apparatuses. For this purpose, the article describes the regularity of pulsating jets propagation generated by transport elements, the dependence of the vibroextractor productivity on the solid phase, and the level of longitudinal mixing by the longitudinal mixing coefficient from determining relative geometric parameters. The mathematical description can be taken as a basis for optimizing problems for the definition of rational operating modes of the vibroextractors having the combined structure of hydrodynamic flows and providing necessary productivity with the minimum effect of longitudinal mixing.

Keywords: Vibroextraction, Intensification, Hyrodynamics, Pulsating Flow, Mass Transfer, Longitudinal Mixing, Velocity of Flows, Mathematical Model.

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The Main Parameters of the Physalis Convection Drying Process

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The experimental research results of the intensified convective process of drying of physalis at a constant temperature using the laboratory installation providing the set temperature modes of conducting the process in the set time interval on all working zones of drying had resulted. The process of convective drying was improved. The rehydration process's rational parameters were substantiated for the use of dried products in the food industry to preserve vitamin composition and nutrients in the maximum amount. It was proved that the drying process's temperature regimes significantly impact energy savings and the cost of the final product. It was established that the dried finished product (physalis) is better stored if drying is carried out at low temperatures. Rational parameters of the drying process of physalis fruits were experimentally established, at which the optimum regenerative capacity of drying temperature (for particles) is 90 °C, (for circles) is 70 °C. As a result of research, it was proved that with increasing temperature of drying physalis (circles), cells decrease in volume due to moisture release. The higher the temperature, the more steam is released, and the cells coagulate into a small ball. The corresponding regression equations approximate the experimental studies' results. These equations allow setting the final product's moisture content, which will depend on the temperature and duration of the process.

Keywords: Physalis, Convection Drying, Regenerative Capacity, Temperature, Drying Period, Moisture Content.

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Part IX
Energy Efficient Technologies and Industrial Ecology

Stimulation of Anaerobic Fermentation of Wastewater and Sewage Sludge

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This paper focused on determining the regularities of modern trends in the field of stimulation of wastewater and sewage sludge (SS) components transformation in anaerobic conditions with particular attention to the theoretical substantiation of the magnetic fields' mechanisms field influence on these bioprocesses. The network system's visualization and clustering of research areas of stimulation of anaerobic fermentation of wastewater and SS were carried out. The clusters were formed through a network: the red cluster conducted with the area of enzyme activity and use of various biostimulants for microorganism growth under anaerobic digestion and ecosystem bioremediation; the green cluster associated with general fermentation processes at the junction of aerobic and anaerobic conditions using different co-substrates; the blue cluster has generalized the use of methods of genetic modification of microorganisms used in anaerobic processes, including the digestion of SS, as well as the influence of minerals on the stimulation of fermentation. The analysis of visualization clusters was also devoted to studies on biostimulation of bacterial activity processes using a magnetic field. The generalized model of the magnetic field's stimulating effect on bioprocesses was formed, which can be used in anaerobic digestion of SS and wastewater bio-treatment to produce useful bio-based products.

Keywords: Anaerobic Digestion, Stimulating Effect, Cluster Visualization, Magnetic Field, Generalized Model.

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Efficiency of Thermopressor Application in an Ejector Refrigeration Machine

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This paper investigates the influence of using thermopressor devices in the heat using ejector refrigeration machine cycles. The thermopressor is a multifunctional apparatus in which refrigerant vapor is cooled, and a simultaneous pressure is increased. A calculation method was used to determine the thermodynamic and energy efficiency of a thermopressor as part of an ejector refrigeration machine. It is proposed to use the apparatus for cooling the vapor in front of the condenser. The calculation considered the pressure loss in the nozzle (confuser), the working chamber, the diffuser, and the frontal resistance of the injected liquid droplets. The thermopressor application in the ejector refrigeration machine cycle allows increasing the ejection coefficient and the ejector refrigeration machine thermal coefficient due to increasing the pressure. The expected increase in the thermal coefficient is 1.5–2.0%. The results obtained are an important contribution to the development of thermopressor technologies and can be used to design jet devices.

Keywords: Thermogasdynamic Compression, Thermal Coefficient, Overheating.

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Thermal Characteristics of the Wet Pollution Layer on Condensing Heating Surfaces of Exhaust Gas Boilers

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Analysis of the literary sources showed a lack of data on the pollution, heat transfer, and thermal efficiency coefficients for condensing surfaces with water-fuel emulsions combustion. The study aims to obtain the dependences of heat transfer coefficients, pollution, and thermal efficiency from the wall temperature for condensing low-temperature heating surfaces. Experimental studies on pollution intensity were held on the experimental installation with fuel oils and water-fuel emulsions combustion. In the wet capillary-porous body, together with energy transfer in the form of heat, energy is transferred due to mass transfer. It is necessary to consider the presence of internal sources of heat because, in the layer, there is an additional amount of heat due to the passage of absorption processes and the passage of chemical reactions. The dependences of heat transfer coefficients, pollution, and thermal efficiency from wall temperature have been developed based on the experimental-theoretical data. Analysis of the results has shown that water-fuel emulsions combustion with a water content of 30 % increase heat transfer and the cleaning periodicity of heating surfaces. It is recommended to reduce the periodicity between cleaning to 8 hours to obtain high values of heat transfer and thermal efficiency for condensing heating surfaces. The obtained dependences of the pollution coefficients for condensing heating surfaces are recommended for use in the standard method for the design calculation of convective heating surfaces of exhaust gas boiler.

Keywords: Water-Fuel Emulsion, Exhaust Gases, Low-Temperature Heating.

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Optimization of Diesel Fuel Composition with Bio-Component and Functional Additives

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Environmental friendliness of fuels used in automobile internal combustion engines is a global problem of humanity, which is given considerable attention by leading scientists and practitioners of the oil refining industry and international environmental organizations. Today, the share of oil that meets the transport industry's needs is 97–99 %, and the share of transport as the final consumer of energy carriers is constantly growing. Therefore, the production of fuels of petroleum origin, which would meet the increased environmental properties requirements, will grow. The article aims to optimize the composition of the composition to produce diesel fuel for spark-ignition engines using bio-additives. The physical and chemical properties of diesel fuel obtained by modifying fuel of Petroleum Origin of the L Brand, which is produced at PJSC "Ukrtatnafta" with a bio-component – rapeseed oil isobutyl Ester (IBERO) using a cetane-boosting and depressant additive, are studied.

Keywords: Diesel Fuel, Operational Properties, Quality, Ecological Purity, Bioadditives.

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An Agro-Industrial Complex Fat-Containing Wastes Synthesis Technology in Ecological Biofuel

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The energy crisis has affected almost all countries globally, and it did not bypass Ukraine either. That is why alternative energy resources have started to be actively introduced. Rational modes of synthesis of ecological biofuel from raw materials of animal origin are substantiated. The necessity of preserving the mass ratio of all components of the reactive medium was proved. A laboratory evaluation of the influence of the properties of fat-containing raw materials on the composition of liquid biofuels was performed. Original laboratory installations have been developed and manufactured to solve the set tasks and determine the influence of various technological factors on fuel yield and quality. Laboratory studies on the physicochemical properties and fatty acid composition of a wide range of animal fats and fatty waste as a potential raw material for biodiesel were conducted. The technology of diesel biofuel production from the fat-containing wastes of the agro-industrial complex, which have a significant free fatty acid content, was studied and justified. The reaction mixture's optimal temperature during esterification and transesterification with different alcohols and the process's speed depending on the main factors is determined. The use of potassium hydroxide is advantageous because the potassium salts formed during the production of diesel biofuels can be used as mineral fertilizers. The possibility of obtaining and using the methyl esters of fatty acids and fatty wastes from processing and food productions of the agro-industrial complex as an alternative liquid fuel was proved.

Keywords: Biofuels, Methyl Esther, Transesterification, Fat.

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Energy Saving Load-Sensing Hydraulic Drive Based on Multimode Directional Control Valve

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During the operation of the load-sensing hydraulic drive in the mode of controlling the hydraulic engine consumption, an important parameter is a value of counterbalancing pressure differential Δp, which determines the amount of power loss. To reduce power losses and the value of counterbalancing pressure differential Δp in the mode of controlling the hydraulic engine consumption, a new scheme of load-sensing drive based on the multimode directional control valve, which includes a safety-overflow section, in which the introduction of a special plunger changes the control system parameters, which allowed to reduce the value of pressure Δp to values (0,7-0,8) MPa. Minimization of the pressure value Δp is supported by the combination of construction parameters of the overflow valve of the safety-overflow section. As a result of additional theoretical studies, it was determined that the obtained combinations of design parameters do not increase the time of the transient process and the amount of overregulation of the pressure during the operation of the hydraulic drive in the mode of controlling the hydraulic engine consumption.

Keywords: Energy Efficiency, Mathematical Model, Hydraulic Drive Schema, Overflow valve, Working Process.

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Rational Refrigeration Loading of Ambient Air Conditioning System

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The efficiency of ambient air conditioning (AC) systems operation depends on utilizing their installed (design) refrigeration capacity for covering varying thermal loads according to actual changeable climatic conditions. Proceeding from this, the annual refrigeration energy generation in response to its consumption is used as a primary criterion for assessing the efficiency of AC systems yearly operation. The traditional AC system design issues from a design refrigeration capacity value covering the maximum current thermal loads and annual refrigeration energy consumption lead to inevitable refrigeration capacity overestimation and oversizing installed refrigeration machines. The method to determine the appropriate design refrigeration capacity to cover current thermal duties and provide closed to annual refrigeration energy generation simultaneously is developed. The novel approach to further enhancing modern variable refrigerant flow (VRF) system energy efficiency due to functioning the refrigerant receivers already installed as thermal storage to accumulate refrigeration to cover peak thermal loads has been proposed. The developed method's application enables defining minimum design refrigeration capacities providing a maximum rate of annual refrigeration energy generation increment that leads to reduced sizes of variable-speed or traditional refrigerant compressors.

Keywords: Air Conditioning, Thermal Load, Design Refrigeration Capacity.

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Enhancing Energy Efficiency of Ship Diesel Engine with Gas Ecological Recirculation

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During the operation of ships, millions of tons of nitrogen oxides NOx, sulfur oxides SOx, soot, heavy metal compounds, and water vapor are emitted into the atmosphere every year. The exhaust gas recirculation (EGR) technology reuses engine exhaust gases during combustion to reduce the amount of oxygen at the engine cylinder's inlet and reduce the amount of NOx rejected. The exhaust gas recirculation temperature is an important factor in allowing a higher percentage of the exhaust gas recirculation. Caused by higher loads, higher exhaust gas temperatures limit the higher exhaust gas recirculation coefficients. The application of the EGR system of the ship's diesel engine using the heat of the gases by the ejector and absorption chillers for cooling the engine inlet air is proposed to cool the air entering the 6G50ME-C9.6 marine engine. A circuit design solution was proposed using the heat of recirculation gas (RG) by an ejector chiller (ECh) and absorption chiller (ACh) in the EGR system. The analysis has been made of using the heat of RG to cool the air entering the engine. The effect has been analyzed, considering changes in climatic conditions on the Odessa-Shanghai route for a dry cargo vessel. It has been found that the use of an exhaust gas recirculation system using heat RG for cooling engine intake air by ECh and ACh reduces the temperature of the air entering the engine. The temperature drops by 5-15 °C, which in turn reduces the specific fuel consumption (SFC) by 0.6-1.8 g/(kW·h). Also, the amount of harmful substances formed during engine operation decreases SOx by 10-14%; NOx by 25-35%.

Keywords: Ecology, Ejector Chiller, Exhaust Gas Recirculation, Harmful Emissions.

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Improvement of Engine Indicators during their Operation on Gas Fuels

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The purpose of the study is to improve engine indicators during its work on gas fuels. Research methods are experimental and theoretical. Engine indicators were determined experimentally when working on natural gas. High energy indicators of a gas engine with spark ignition converted from diesel engine obtained through the correct choice of design and adjustment parameters, including the degree of compression of the engine and the installation angle of ignition timing. Gas engine performance when using biogas with different methane content was determined by calculations using a mathematical model of the engine operating process. An adequacy check of the mathematical model was performed by comparing the calculated and experimental data. It was found that engine power decreases, and fuel consumption increases when using gas, which simulates the composition of biogas. The energy indicators of the engine are unsatisfactory while operating on biogas. This is due to the content in biogas of a significant amount of inert impurities, first of all, carbon dioxide. Calculations using a mathematical model of a gas engine found that using biogas purification from impurities, its composition can be approximated to the composition of natural gas.

Keywords: Biogas, Gas Engine, Mathematical Model, Energy Indicators.

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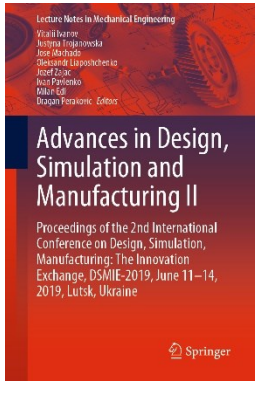

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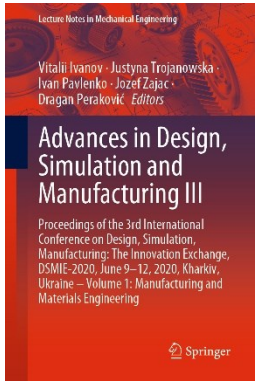

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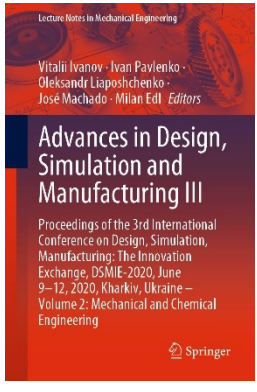

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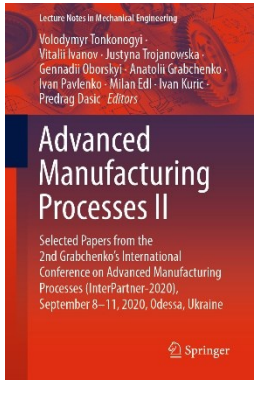

Advanced Manufacturing Processes II

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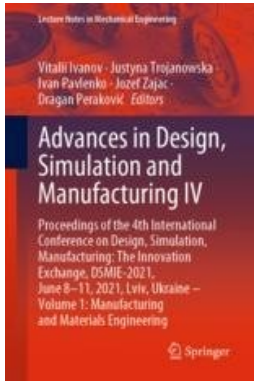

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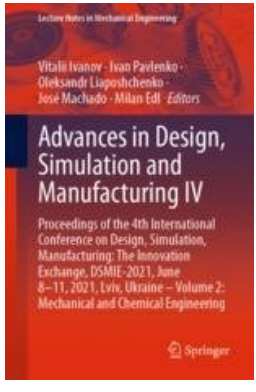

Advances in Design, Simulation and Manufacturing IV

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