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Institute of Fluid Flow Machinery of the Polish Academy of Sciences in Gdańsk

The Institute of Fundamental Technological Research of the Polish Academy of Sciences in Warsaw

University of Warmia and Mazury in Olsztyn

Ministry of Science and Higher Education
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Polish Academy of Sciences

Book of abstrakt

14th WDZYDZEANUM

CONFERENCE ON FLUID-SOLID INTERACTION

WDZYDZE LANDSCAPE PARK, POLAND

30.08 – 3.09.2026



Edited by:
Tomasz Ochrymiuk

WYDAWNICTWO IMP PAN

INSTITUTE OF FLUID–FLOW MACHINERY

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Conference profile:

The conference brings together researchers, engineers, and industry representatives working on the modelling, experimental investigation, and practical application of phenomena occurring at fluid–solid interfaces. Its interdisciplinary character reflects the fact that many important engineering and scientific problems cannot be understood by analysing fluids and solids separately. Instead, they must be treated as interacting continua whose behaviour is coupled across a common interface. This perspective is especially important in industrial practice, where fluid–solid interaction influences the design, operation, optimisation, and modernisation of machines, energy systems, civil engineering structures, and technological processes. For this reason, the conference combines fundamental research with validated numerical models, experimental studies, technological concepts, and solutions intended for practical implementation. Particular attention is given to work that can improve efficiency, reliability, safety, and environmental performance.

The conference covers a broad range of topics, including combustion and catalytic combustion, renewable energy technologies, flow through porous media, filtration processes, fuel cells, turbine cooling, and energy storage. These subjects are considered together with questions of technical feasibility, economic performance, profitability, and operational durability, so that scientific results can be linked more directly with real engineering needs. The scope of the meeting also extends beyond classical energy and mechanical engineering. FSI problems in civil engineering include wind–structure interaction, fluid loading of buildings and other structures, and transport processes in porous construction materials.

In biology and medicine, similar ideas appear in the interaction between blood flow and deformable vessels, as well as in the coupling of biological fluids with living tissues. These examples show that the same general principles can connect very different fields. More broadly, the conference is interested in phenomena occurring at the interface between two continua, where the response of one medium affects the behaviour of the other. These interactions may involve momentum, heat, mass, electrical charge, or biological transport, and they may occur in large industrial installations as well as at micro- and nanoscales.

By bringing these perspectives together, the conference creates a platform for cooperation between academic institutions, research organisations, and industrial partners, while encouraging the development of solutions that are scientifically sound, technologically relevant, and ready to address practical challenges.

Foreword

Dear Participants,

it is my great pleasure to present the Book of Abstracts of the 14th Wdzydzeanum Conference on "Fluid–Solid Interaction", held from 30 August to 3 September 2026 in Wdzydze Landscape Park, Poland. For many years, the Wdzydzeanum Conference has provided a forum for scientists, engineers, doctoral students, industry representatives, and all those interested in phenomena occurring at the interface between fluids and solids. Its interdisciplinary character promotes the exchange of knowledge among specialists representing various fields of science and engineering, while also fostering new research initiatives and opportunities for cooperation between academia and industry.

The abstracts collected in this volume reflect the broad range of topics addressed by the conference participants. They cover, among others, numerical and experimental modelling, fluid-flow and heat-transfer processes, combustion, renewable energy sources, flows in porous materials, fuel cells, energy storage systems, the cooling of machinery components, structural analyses, and issues related to the efficiency and reliability of modern energy systems. The diversity of the contributions presented confirms the important role of fluid–solid interaction research in the development of modern energy engineering, mechanics, materials engineering, and environmental protection. Such research is particularly relevant in view of the challenges associated with the energy transition, the responsible use of resources, the reduction of human impact on the environment, and the implementation of solutions that support sustainable development.

This Book of Abstracts is more than a collection of summaries of conference presentations. It also provides an overview of current research, emerging methods, and the challenges faced by contemporary science and industry. I hope that the contributions presented here will inspire valuable discussions, facilitate new professional connections, and lead to further joint scientific and technological projects. The unique surroundings of the Wdzydze Landscape Park have long created an atmosphere conducive to both scholarly discussion and the informal exchange of ideas and experience. I believe that this year's meeting will once again provide an excellent opportunity to broaden our knowledge, present innovative achievements, and build lasting relationships between representatives of academia and industry.

I would like to express my sincere gratitude to all authors for preparing and submitting their abstracts, to the members of the Scientific Committee for their commitment and academic support, and to all individuals and institutions involved in organising the conference for their contribution to the preparation of this event.

Tomasz Ochrymiuk

Head of Organising Committee
14th Wdzydzeanum Conference on Fluid–Solid Interaction

Preface

Fluid–Solid Interaction: Where Different Worlds Meet

Many of the most interesting phenomena in nature and engineering occur not inside a fluid or inside a solid, but at the interface where the two meet. Air flows around an aircraft wing and causes it to bend and vibrate. Steam heats the casing and rotor of a turbine, while the resulting thermal expansion changes the clearances through which the steam flows. Blood pressure deforms an artery, and the deformation of the arterial wall in turn influences the blood flow. Boiling water heats a glass so rapidly that thermal stresses may cause it to crack. Hydrogen transported from the surrounding environment enters a metal and may gradually weaken it. In each of these examples, the behaviour of the fluid cannot be fully understood without considering the solid, and the response of the solid cannot be predicted without accounting for the fluid. This mutual dependence is the subject of fluid–solid interaction, commonly abbreviated as FSI. At first glance, fluids and solids appear to belong to two separate worlds. Fluids flow, mix and form vortices, while solids generally retain their shape, carry loads and deform under stress. For many years, these two worlds were also treated separately in engineering analysis. Fluid mechanics was used to determine velocity, pressure and temperature fields, while solid mechanics was used to calculate deformation, stress and structural strength. Such separation is convenient, but nature does not respect the boundaries between academic disciplines. In a real machine, biological system or technological process, fluid flow and structural response usually take place at the same time. Pressure causes deformation, deformation modifies the flow, heat changes material dimensions, and those dimensional changes alter the conditions of heat transfer. In many cases, these processes form a continuous feedback loop, and FSI provides a framework for describing it.
The central idea of FSI is surprisingly intuitive: a fluid and a solid exchange physical quantities through their common interface. This interface may be the wall of a pipe, the surface of a turbine blade, the inner wall of an artery, the outer surface of a heated component or the microscopic boundary between two different materials. It may remain almost stationary, or it may move, bend, vibrate and change its shape. Regardless of its form, the interface is where the two domains communicate. A fluid exerts pressure and frictional forces on a solid, and the solid reacts by deforming or moving. Its motion changes the boundary of the fluid domain and therefore modifies the flow. At the same time, energy may pass from the fluid to the solid or in the opposite direction, while chemical species, electrical charge or ions may also cross or move along the interface. For this reason, the interface should not be regarded merely as a geometrical boundary. It is an active physical region in which momentum, energy, mass and other quantities are transferred. In many modern applications, especially at micro- and nanoscales, the interface may even possess properties of its own. It can resist motion, store or transport energy, support surface stresses, or create a jump in temperature or velocity. The quality of an FSI model therefore depends not only on how accurately the fluid and solid are described separately, but also on how faithfully their interaction is represented at the common surface.
The development of numerical methods has transformed the way engineers study complex systems. Computational fluid dynamics, or CFD, makes it possible to simulate flows that would be difficult or expensive to investigate experimentally, while computational solid dynamics allows engineers to predict deformation, vibration, fatigue and failure in complicated structures. FSI brings these capabilities together. In the simplest approach, information is transferred in only one direction. The fluid may be calculated first, and the resulting pressure or temperature may then be applied as a load to the solid. This one-way coupling can be sufficient when the deformation of the solid is so small that it has no meaningful effect on the flow. More demanding

problems require two-way coupling: the fluid acts on the solid, the solid changes shape, and the new shape affects the fluid. Information must therefore be exchanged repeatedly. An even more integrated approach solves the fluid–solid problem as a single coupled system. There is no universal strategy suitable for every application. The appropriate level of coupling depends on the physics of the problem, the scale of the expected deformation, the speed of the process and the accuracy required. A useful model should be sufficiently detailed to capture the essential interaction, but not unnecessarily complex.

FSI is often associated with the mechanical interaction between a moving fluid and an elastic structure, but this is only one of several possible forms of coupling. Momentum-FSI concerns the exchange of forces and motion. Wind acting on a flexible plate, steam exciting turbine blades or blood deforming an artery are typical examples. These interactions can lead to vibration, resonance or instability. Under certain conditions, the fluid may continuously supply energy to a structural vibration, producing flutter in aircraft structures, turbomachinery blades and other flexible components exposed to high-speed flows. Momentum interaction is also relevant at small scales, where the traditional assumption that a fluid has exactly the same velocity as a solid wall may no longer be accurate. A certain degree of slip may occur, and surface effects can become comparable with the behaviour of the fluid as a whole.

Thermal-FSI concerns the exchange of energy between a fluid and a solid and is among the most common forms of coupled analysis in power engineering. When hot steam enters a cold turbine component, the component does not heat uniformly. Its surface responds first, while the interior remains colder. Different regions expand at different rates, creating thermal stresses. Rapid heating may shorten the time needed to start a machine, but it can also increase the risk of material damage. The reverse process occurs during cooling, when a turbine rotor and its casing may contract at different rates. The resulting differences in displacement can reduce internal clearances, produce rubbing and cause vibration. A familiar everyday example is a cold glass into which boiling water is poured. The thin bottom may heat and expand much faster than the thicker walls, subjecting the glass to a complex transient stress state that may cause it to crack vertically. Although this example appears simple, it illustrates the same physical principles that govern the operation of large industrial installations. Thermal interaction becomes even more complex when the contact surface itself influences heat transfer. At very small scales, the temperature may not change smoothly across the interface, and surface layers, thermal resistance and microscopic transport mechanisms may need to be considered.

Fluids and solids may also interact through the transport of matter. Moisture leaving wet wood, oxygen entering a material, hydrogen penetrating a metal or chemical species moving through a porous structure are examples of mass-FSI. The transported substance may change the properties of the solid, while the stress state of the solid may influence the rate of transport or reaction. Stress-corrosion cracking provides a particularly important example. A corrosive substance may enter a highly stressed region of a component and gradually weaken the material. The damage develops through a combination of mechanical loading, diffusion and chemical reactions, and none of these processes alone fully explains the failure. In turbine components, hydrogen-related embrittlement can begin at an exposed surface and advance into the metal. Stresses may accelerate surface reactions and promote crack initiation. The same general philosophy can be extended to electrical current and ion transport. In fuel cells, batteries and electrochemical devices, electrical charge, heat, chemical species and mechanical stresses may all interact across interfaces between different materials. Biological systems offer another example, since the flow of blood is accompanied not only by mechanical deformation of vessel walls, but also by the transport of ions, nutrients and other substances.

Power plants and turbomachinery provide some of the clearest demonstrations of why FSI is needed. A steam turbine operates under high pressure, high temperature and significant rotatio-

nal speed. During steady operation, its components may reach a relatively stable thermal state, but the most demanding conditions often occur during start-up, shutdown or an unexpected event. During a rapid start-up, steam transfers heat to valves, casings and rotors. Temperature gradients produce thermal stresses, while thermal expansion changes the dimensions of the components and the clearances between rotating and stationary elements. Operators would like to start a turbine as quickly as possible, especially in an energy system that must respond to rapidly changing demand and variable renewable generation. Yet an excessively fast start-up may use up a significant part of the machine's fatigue life. Thermal-FSI can therefore support the design of start-up procedures that are both fast and safe. Unexpected cooling can be equally dangerous. If cold water enters a hot turbine, the fluid flow determines how the water reaches different parts of the machine, while the structure responds through rapid and non-uniform contraction. FSI also helps to analyse blade vibration, which is not simply a fluid problem or a structural problem, but a phenomenon created by their interaction.

The human cardiovascular system is a natural FSI system. Blood is a moving fluid, while arteries are flexible structures. Each heartbeat produces a pressure wave that travels through the vessels, expands the arterial wall and changes the velocity and distribution of blood flow. A rigid-wall model may provide useful information in some cases, but it cannot reproduce the full dynamics of a compliant artery. In hypertension, atherosclerosis or other diseases, the stiffness and geometry of the vessel wall may change, influencing the stresses exerted by the blood. FSI models can therefore contribute to the interpretation of diagnostic measurements, the assessment of disease progression and the design of medical devices such as stents, artificial valves and vascular grafts. This example also demonstrates that the solid need not be made of steel, glass or another conventional engineering material. It may be living tissue whose properties vary between patients and change over time.

At the scale of a power turbine, bulk fluid behaviour and the properties of the solid often dominate. At micro- and nanoscales, however, the relative importance of the interface increases. As a system becomes smaller, its surface area becomes large in relation to its volume. Effects that are negligible in a large pipe may become decisive in a microchannel. Slip at the wall, temperature jumps, surface tension, adhesion and surface transport can strongly influence performance. This is why advanced FSI is particularly promising for microfluidics, nanotechnology, compact heat exchangers, fuel cells and emerging energy-conversion devices. The interface can no longer be treated as an ideal mathematical line with no physical properties; it becomes a region that may require its own description. New technologies continuously reveal interactions that traditional models were not designed to capture. The challenge is therefore not only to improve numerical algorithms, but also to identify the correct physical mechanisms and represent them in a consistent way.

FSI problems are rarely simple. Real industrial geometries are complicated, material properties depend on temperature, flows may be turbulent, and operating conditions can change rapidly. Numerical simulation has therefore become an essential tool, but it should not be treated as a substitute for physical understanding. A detailed computational model can produce impressive images and large volumes of data, yet its predictions are useful only when the assumptions, boundary conditions and material models are appropriate. Experimental validation of numerical models remains crucial. Measurements of temperature, pressure, displacement, vibration or stress help determine whether the model captures the real behaviour of the system. The greatest value of simulation is not merely that it reproduces a known result, but that it allows researchers and engineers to explore situations that are difficult to measure directly, compare alternative designs, identify dangerous operating conditions and better understand the mechanisms responsible for observed behaviour.

Fluid–solid interaction is interdisciplinary by its very nature. It connects fluid mechanics, solid

mechanics, thermodynamics, materials science, numerical mathematics, computer science and experimental engineering. In biological applications, it also involves medicine and physiology, while in electrochemical systems it reaches into chemistry and electrical engineering. This breadth is one of the field's greatest strengths, but also one of its challenges. Productive FSI research requires not only advanced software and computational resources, but also communication between disciplines and cooperation between academia and industry. Industrial problems reveal the limitations of existing models and create a demand for new methods, while academic research provides the theoretical foundations and numerical tools needed to address them. When these communities work together, FSI becomes more than an abstract scientific concept: it becomes a practical means of improving safety, efficiency and reliability.

FSI is sometimes described as a relatively young branch of continuum physics. Its foundations, however, are connected with questions that scientists have studied for centuries: how fluids exert forces on surfaces, how heat crosses material boundaries, how surface tension acts and how matter is transported between different media. What is new is the possibility of combining these phenomena within comprehensive computational models and applying them to complex real-world systems. The future of FSI is likely to involve increasingly integrated multiphysical simulations in which mechanical, thermal, chemical, electrical and biological processes are considered together whenever their mutual influence is important. Models will extend from the scale of entire machines to microscopic interface layers and will be supported by growing computational power, new experimental techniques and data-driven methods. Yet the central idea will remain simple: the fluid and the solid must be understood as parts of one interacting system. The contributions collected in this Book of Abstracts reflect the many directions in which this idea is being developed. They show that FSI is not limited to one class of machines, one computational method or one branch of engineering. It is a broad way of looking at physical systems—a way that places interaction, feedback and the common interface at the centre of analysis. It is my hope that the studies presented during the conference will encourage discussion not only about increasingly sophisticated numerical methods, but also about the physical meaning of coupling itself. The continuing development of FSI depends on our ability to connect disciplines, scales and perspectives, just as the fluid and the solid are connected at their common surface.

Tomasz Ochrymiuk

Head of the Energy Conversion Department
Institute of Fluid-Flow Machinery Polish Academy of Sciences

Invited Lecturers



Anna Sandak

Inno Renew, IAM,
University of Primorska, Slovenia

Anna Sandak is an associate professor at the University of Primorska, where she leads the Materials Group at the InnoRenew CoE Department. Her academic background bridges biology and wood science. In 2022, Dr Sandak was awarded the ERC consolidator grant for the project ARCHI-SKIN, which develops a living coatings system based on fungal biofilm. Her study on probiotic architecture continues within the REMEDY project, awarded under the European Innovation Council Pathfinder call, which she coordinates. Dr Sandak represents research and academia on the European Commission's Technology Council for Advanced Materials and chairs the steering committee of the EIC's Engineered Living Materials portfolio. Her research focuses on the intersection of biotech and advanced materials, concentrating on exploiting renewable materials and engineered living systems to revolutionize the construction industry. By integrating biotechnology with traditional building practices, she aims to create resilient, eco-friendly structures that adapt and evolve with their environments, setting new standards for sustainability in the built environment.



Jan Vogt
Duale Hochschule,
Baden-Württemberg Mannheim, Germany

Prof. Jan Vogt is a professor of Mechanical Engineering with a specialization in Process Engineering at the Baden-Wuerttemberg Cooperative State University Mannheim (DHBW Mannheim), where he has been teaching since 2020. His teaching activities primarily focus on thermodynamics, heat and mass transfer, and process engineering.
He studied Mechanical Engineering at the Technical University of Darmstadt, where he also completed his doctoral degree at the Institute of Technical Thermodynamics. His PhD research focused on the development of a laser-based optical measurement technique for the simultaneous acquisition of temperature and velocity fields.
Following his doctorate, he worked in industry from 2012 to 2020 at Alstom Power AG and later General Electric, where he was involved in the development of computational models for lifetime assesments of steam turbines, with a strong emphasis on finite element analysis and heat transfer applications.
His current research interests include thermodynamics, thermal and fluid transport phenomena, and applied process engineering, with a particular focus on heat transfer in complex technical systems.



Yevhen Kharchenko

Department of Strength of Materials
and Structural Mechanics
Lviv Polytechnic University, Ukraine

Prof. Dr. Hab. Eng. Yevhen Kharchenko works at the Department of Strength of Materials and Structural Mechanics of the Lviv Polytechnic University in Ukraine. He has been the Head of this Department since 2002. From 1998 to 2024, he also worked at the University of Warmia and Mazury.

He studied Dynamics and Strength of Machines at the Faculty of Mechanics and Mechanical Engineering of the Lviv Polytechnic University, where he earned a PhD in Machine Design and Operation in 1983. In 1997, he obtained his habilitation in the field of dynamics in drive systems and support structures of drilling machines. He obtained the title of Professor (awarded by the Ministry of Education and Science of Ukraine) in 2001 in the field of technical sciences.

He conducted research on the theory of linear vibrations and nonlinear mechanical systems of the concrete-continuous type. His research interests include the dynamics, strength, and technical diagnostics of machines and engineering structures, as well as mathematical modeling and computer simulations in mechanics and mechanical engineering.

His current interests include the start-up processes of shaft elevator drive systems, taking into account the interaction of electromagnetic phenomena occurring in asynchronous motors and wave processes in hoisting cables under non-stationary operating conditions.



Jakub Sandak

InnoRenew Centre of Excellence,
Andrej Marusic Institute, University of Primorska, Slovenia

Jakub Sandak ("Kuba") is a leader of the Advanced Manufacturing Department at the InnoRenew Centre of Excellence and Associate Professor at the Andrej Marusic Institute, University of Primorska, Slovenia. He holds a PhD in Agricultural Sciences from Tottori University (Japan), an MSc in Natural Resources Process Engineering from Shimane University (Japan), and an engineering degree in Wood Science and Technology from the Poznań University of Life Sciences (Poland). As a third-generation carpenter, he combines a deep appreciation for traditional craftsmanship with cutting-edge research and technological innovation.

His research focuses on the characterization and processing of wood and other bio-based materials, with particular interests in multi-sensor assessment of material properties, spectroscopy, chemometrics, hyperspectral imaging, computer vision systems, wood machining processes, wood mechanics and fracture, numerical modelling across multiple scales, mechatronics, and intelligent manufacturing systems. He has extensive experience in developing expert systems for process monitoring and control, as well as optimizing manufacturing processes in the furniture and wood industries.

Kuba is particularly passionate about designing, assembling, testing, and implementing innovative scientific instrumentation. His work bridges fundamental material science with advanced sensing, digitalization, and sustainable manufacturing technologies, contributing to the development of healthier and more sustainable built environments.



David Šimurda
Laboratory of Internal Flows
at the Institute of Thermomechanics
Czech Academy of Sciences, Czech Republic

Dr. David Šimurda has been actively involved in experimental research on turbomachinery aerodynamics since his studies at the Czech Technical University in Prague. He received his Ph.D. in 2011 with a thesis focused on transonic and supersonic flow in turbine blade cascades.
He is currently the Head of the Laboratory of Internal Flows at the Institute of Thermomechanics of the Czech Academy of Sciences and has been a lecturer in Fluid Mechanics at the Technical University of Liberec since 2019. His research focuses on experimental aerodynamics of turbomachinery, with particular emphasis on high-speed compressible flows and blade cascade aerodynamics, and more recently on aeroelasticity and blade vibrations. A significant part of his work is carried out in close collaboration with industrial partners, combining fundamental research with aerodynamic testing and development of turbomachinery components.
He is actively involved in the international turbomachinery community through the organization of scientific conferences and collaborative research activities.



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Contents

Richard Acquah, Jakub Sandak
Wind-Driven Rain Modelling and Fluid–Structure Interaction for Service Life Prediction and Aesthetic Colour Change of Timber Façades **21**

Janusz Badur, Tomasz Ochrymiuk, Waldemar Dudda, Piotr Józef Ziółkowski
A Statement of The Cosserats Materials within The Framework of The Port-Hamiltonian Thermodynamics **22**

Mariusz Banaszkiewicz, Tomasz Ochrymiuk
Possibilities of converting 200 MW turbo-sets for operation as synchronous condensers **23**

Tomasz Borzyszkowski, Ryszard Szwaba
Performance analysis of a Darrieus wind turbine in the low Reynolds number regime **24**

Łukasz Breńkacz, Bartosz Puchalski, Paweł Bagiński, Małgorzata Bogulicz
Structural Dynamics of an Active Gas Foil Bearing as an Experimental Basis for Fluid-Structure Interaction Modeling **25**

Mateusz Bryk, Tomasz Ochrymiuk, Adam Cenian, Ksawery Kuligowski
CFD Modelling of Heavy Fuel Oil Dispersion and Sediment Penetration from the s/s Stuttgart Wreck in the Baltic Sea **26**

Sebastian Bykuć, Weronika Radziszewska, Katarzyna Bogucka-Bykuć, Jörg Verstraete
Analysis of the effect of V2X on energy market in Poland **28**

Grzegorz Bzymek, Tomasz Ochrymiuk
A comprehensive assessment of the wear and tear on the rotor blades of the final stages of the NP section of STF 100 DKY5-6N45 turbines, and the potential for predicting their technical condition in terms of long-term operation across a wide range of loads **29**

Adam Cenian, Benedykt Hac, Tomasz Ochrymiuk
Project Baltwreck – how to avoid and remediate environmental pollution resulting from wrecks in the Baltic Sea **30**

Oktawia Dolna
A Simplified Mathematical Model for Analysing Fluid Flow Through a Converging Channel **31**

Ved Prakash Dubey, Mateusz Kopeć, Zbigniew L. Kowalewski
Yield Surface Evolution of Ti-Cu Bimetal under Complex Loading for Multifunctional Engineering Components **32**

Piotr Duda, Tomasz Płusa, Rafał Sala, Sebastian Jarosiński
CFD Modeling and Experimental Evaluation of an Automotive Diesel SCR Aftertreatment System **33**

Waldemar Dudda, Piotr Józef Ziółkowski, Janusz Badur
An investigation of behaviour of 26H2MF and St12T steels during torsional test at elevated temperatures using Finite Element Method **34**

Łukasz Dziubiński, Wojciech Sobieski
Experimental determination of the power characteristics of a Rushton turbine in a baffled tank **35**

Dariusz Gołębiewski, Tomasz Kodlewicz, Sylwia Kruk-Gotzman, Tomasz Ochrymiuk
Predictive Maintenance Under Data Scarcity: Regime Classification and Self-Referential Degradation Detection from Scalar Vibration **36**

Benedykt Hac, Adam Cenian
An assessment of the impact of the "Triple Barrier" system and active reactive minerals on the biodegradation kinetics of polycyclic aromatic hydrocarbons in Baltic Sea bottom sediments under psychrotolerant conditions **38**

Cherif Hamrani, Natalia Frankowska, Agnieszka Ozga
The problem of identifying random impulse distributions with identical lower-order stochastic moments **39**

Agnieszka Haryńska, Satish Bykkam, Dominika Filipek, Łukasz Haryński, Katarzyna Cudo, Beata Bochentyn, Emerson Coy, Dominika Kwidzińska, Katarzyna Grochowska, Katarzyna Siuzdak, Damian Głowienka
Mechanical Stress and Morphological Control in Triple-Cation Perovskite Thin Films: A Systematic Analysis of Macroscopic Deformations **40**

Jarosław Karwacki, Krzysztof Mik, Michał Gliński, Marcin Bugaj, Patryk Chaja
Heat Demand Coverage Analysis for a District Heating Network in Central Poland Supplied by a Hybrid PVT–Heat Pump System with Thermal and Electrical Energy Storage **41**

Saiful Islam Khan, Katarzyna Siuzdak, Katarzyna Grochowska
Anodization of magnetron-sputtered titanium films on ITO coated glass substrates: Phenomena governing the formation of aligned and separated titania nanotubes at the fluid-solid interface **42**

Yevhen Kharchenko

Modeling transverse vibrations of drilling masts with a step change in cross-section **43**

Hanna Koshlak
Energy Efficiency Enhancement of PV Integrated Smart Windows through Optimal Localization of Self Adhesive Heating Elements **45**

Michał Kowalczyk, Tomasz Kowalczyk
Dynamic Modelling of a High-Temperature Thermal Energy Storage System with Direct Steam Generation: Optimisation of the Charging Process with Consideration of Thermal Constraints **46**

Tomasz Kowalczyk, Kacper Krupa, Sylwia Kruk-Gotzman
Application of Digital Twin Technology for Production Scheduling Optimization under Limited Availability of Generating Units **47**

Zbigniew L. Kowalewski
Effect of fatigue loading scenarios on the behaviour of power engineering steels **48**

Sylwia Kruk-Gotzman, Tomasz Kowalczyk, Michał Kowalczyk, Mateusz Bryk, Tomasz Ochrymiuk
Horizon-Dependent Crossover Between SARIMAX and Gradient Boosting for Day-Ahead District Heating Demand Forecasting: A Multi-Network Study Under Honest Rolling-Origin Evaluation **49**

Sebastian Krupa, Tomasz Kowalczyk
Exergy-Based Analysis of Distributed Polygeneration Systems with Synthetic Fuel-Based Energy Storage for Microgrids under Islanded Operation **50**

Ksawery Kuligowski, Tomasz Ochrymiuk, Adam Cenian, Benedykt Hac
Modelling the mobility of PAH through the Baltic Sea bed, from the leaked fuel accumulated around the WWII wreck *Stuttgart* **51**

Paweł Madejski, Michał Karch, Atta Heydarpour Tabrizi
Experimental Visualization and Analysis of Water Jet Breakup and Droplet Formation Using High-Speed Camera Imaging **52**

Łukasz Miazio
Analysis of the Temperature Profile of the Deposited Layer during 3D Printing **54**

Bartosz Moczulak
Numerical analysis of the influence of Savonius turbine blade settings on the control characteristics over the ridge of a gable roof **55**

Bartosz Moczulak, Waldemar Dudda
Influence of the working medium on the operation of foil bearings in the start-stop cycle. **56**

Zdzisław Nowak, Michał Giersig
Nanocomposite materials mechanical properties determination based on indentation test and finite element simulation and energy equivalence **57**

Agnieszka Ozga
Mechanistically-informed machine learning in stochastic mechanical systems modeling **58**

Anatoliy Pavlenko
Improving the efficiency of building energy systems in urban areas **59**

Sebastian Piątkowski, Wojciech Sobieski
Representative Length for Tortuosity Estimation in Granular Beds Using the Path Tracking Method **60**

Janusz Podliński, Mateusz Tański, Robert Miotk, Mirosław Dors, Tomasz Półrolnik
Small electrostatic precipitator for local space heaters **61**

Tomasz Przybyliński, Paulina Rolka
Phase Change Materials (PCMs) Doped with Nanoparticles: Their Effects and CFD Modeling Methods **62**

Weronika Radziszewska, Sebastian Bykuć, Jörg Verstraete, Katarzyna Bogucka-Bykuć
Predictive Maintenance Under Data Scarcity: Regime Classification and Self-Referential Degradation Detection from Scalar Vibration **63**

Anna Sandak
Living Interfaces: Fluid–Solid Interactions in Engineered Living Materials **64**

Jakub Sandak
Wetting of wood surface **65**

Wojciech Sobieski, Łukasz Miazio
Discrete Modeling and Thermal Analysis of FDM/FFF Additive Manufacturing Processes **67**

Maria Staszczak, Elżbieta Pieczyska, Andres Diaz Lantada
Smart microactuators based on shape memory polymers **68**

Bartłomiej Szałowski, Paweł Madejski
Numerical Modeling of Turbulent Multiphase Flows Using the Euler–VoF Method **69**

Piotr Szmytkiewicz, Jan Schönhofer, Rui Aleixo, Grzegorz Cerkowniak, Magdalena Stella
Remarks on thermal discharge modelling of waste heat in the sea – a case study of the planned nuclear power plant in Lubiatowo, Poland **71**

David Šimurda, Petr Šidlof, Jan Lepičovský, Jiří Fürst, Jindřich Hála
Unsteady Aerodynamics in Vibrating Transonic Blade Cascades: Experimental and Numerical Investigations **72**

Jan Vogt
Experimental Study of Hybrid Heat Pipe–Water Cooling Concepts for High-Heat-Flux Applications **73**

Jörg Verstraete, Sebastian Bykuć, Weronika Radziszewska
The prospects of V2X development in Poland **74**

Krzysztof Wojno, Jakub Szarmach, Bartosz Hrycak, Dariusz Czylkowski, Katarzyna Grochowska, Katarzyna Siuzdak, Jacek Ryl
Anodization of magnetron-sputtered titanium films on ITO coated glass substrates: Phenomena governing the formation of aligned and separated titania nanotubes at the fluid-solid interface **75**

Ireneusz Zagrodzki, Mateusz Bryk, Tomasz Kowalczyk
Hybrid Decarbonization of District Heating Systems – Why Cost Optimization is Not Enough? The Case Study of Ustka **76**

Piotr Józef Ziółkowski, Ryszard Szwaba, Patryk Chaja, Tomasz Ochrymiuk
An example of effective cooling technique for CPV system **77**

Piotr Józef Ziółkowski, Mateusz Bryk, Tomasz Ochrymiuk, Janusz Badur
Parametric analysis CFD of the wind loads on the industrial steel chimney depending on the distance from a nearby building **78**

Wind-Driven Rain Modelling and Fluid–Structure Interaction for Service Life Prediction and Aesthetic Colour Change of Timber Façades

Modelowanie trajektorii kropli deszczu w warunkach wietrznych oraz interakcji wilgoci z konstrukcją w celu przewidywania trwałości budynku i zmian estetycznych elewacji drewnianych

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Abstract
Timber façades are increasingly used in sustainable construction, but their long-term performance and visual appearance are strongly influenced by environmental exposure. Wind-driven rain (WDR) is a major factor governing moisture accumulation, biological degradation, and weather-induced colour changes. The interaction between climatic loading and façade geometry further creates complex exposure patterns that can significantly affect timber performance.
This study presents a simplified approach for accessing WDR exposure and its influence on the service life and aesthetic colour change of timber façades. The approach combines three-dimensional building geometry, local climatic data, and ray-tracing-based exposure analysis to quantify the spatial distribution of rain loads across façade surfaces. Particular attention is given to the influence of architectural features such as recessed openings, overhangs, and façade details, which alter local fluid flow and rain deposition patterns.
Figure 1 illustrates a timber-clad façade exhibiting non-uniform weathering and colour variation associated with differences in environmental exposure. The proposed framework enables the identification of highly exposed regions susceptible to increased moisture loads, accelerated deterioration, and uneven aesthetic ageing. The results contribute to the understanding of fluid–structure interaction processes affecting timber building envelopes and support the development of more durable and resilient façade designs.



Fig. 1. Timber façade exhibiting non-uniform weathering and color change resulting from varying environmental exposure conditions

A Statement of The Cosserats Materials within The Framework of The Port-Hamiltonian Thermodynamics

Ujęcie Materiałów Cosseratów w ramach Termodynamiki Port-Hamiltonowskiej

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Abstract
Modern, additively manufactured materials require complex mathematical models. Therefore, the Cosserats continuum model provides the necessary structural complexity for both solids and fluids. However, constructing the surface contact conditions for these two Cosserats continua remains an open question.
In this paper, we attempt to construct a complete Fluid-Solid Interaction (FSI) model for the Cosserats continuum using the tools and capabilities provided by port-Hamiltonian thermodynamics. For this purpose, we utilize the Arbitrary Lagrangean-Eulerian (ALE) description, presenting a complete set of evolution equations and contact conditions for FSI. The novelty of this formulation lies in redefining the differential surface contact conditions as energy ports in pH thermodynamics.
We focus on the details of ports called: "momentum-FSI" and "angular momentum FSI." The presented model applies to the mathematical description of nanomaterials and the control theory of nanotechnologies.

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Possibilities of converting 200 MW turbo-sets for operation as synchronous condensers

Możliwości konwersji turbozespołów klasy 200 MW do pracy w charakterze kompensatora synchronicznego

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Abstract

Electric power generation in Polish energy system is realized in 50 Hz alternating current. Total inertia of all turbogenerators in the system is extremely important for maintaining grid frequency in permissible limits in order to prevent damage to electrical equipment or in extreme cases to avoid blackout. The loss of one large power plant may result in a temporary unbalance between power generation and consumption on the order of gigawatts. The first line of defense in such circumstances is system inertia: the more rotating masses in the system the smaller the frequency deviation, i.e. the system is more stable.

Synchronous generators operating in coal-fired units play, besides the main function of electric power generation, also many system functions. They include: assurance of inertia, assurance of immediate response to disturbances or reactive power compensation. Most of these functions are not assured by renewables (wind, photovoltaics) or are assured in limited scope.

In Polish electric power system the power generated by renewable energy sources is constantly increasing and old coal-fired units are being de-commissioned. In order to balance the reactive power in the system it is necessary to produce additional inductive reactive power. One of the ways of reactive power generation is to convert generators from decommissioned coal-fired units to operation as synchronous condensers. It is a cost-attractive, fast in execution method enabling further use of the existing infrastructure of power plants to generate income.

The coal-fired 200 MW units being so far the main part of the Polish Energy system, in spite of deep modernizations conducted in the recent years, are more and more frequently decommissioned and partly replaced by gas or combined cycle units.

This paper presents an analysis of possibilities of converting the 200 MW class steam turbo-set to a synchronous condenser. A detailed analysis of new operating conditions of steam turbine was carried out and their influence on dynamic and thermal state of turbine rotors was investigated. Natural frequency calculations of the shaft line were performed by means of finite element method. Windage heating was estimated using the available correlations for steam turbines.

Performance analysis of a Darrieus wind turbine in the low Reynolds number regime

Analiza pracy turbiny wiatrowej typu Darrieus w zakresie niskich liczb Reynoldsa

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Abstract
Wind energy is a key component of the present and future energy mix. Darrieus-type vertical axis wind turbines (VAWTs) offer several advantages over conventional horizontal axis turbines, particularly in urban environments, making them a promising solution for distributed energy systems. Due to their geometry, VAWTs operate with a continuously varying angle of attack over a full 360° rotation, leading to dynamic stall effects. The low Reynolds number regime is especially relevant during startup and for small-scale turbines with short blade chord lengths, where aerodynamic performance is limited. Rotor motion is initially driven by drag forces. As the tip speed ratio (TSR) increases, the turbine may pass through a region of negative net torque (deadband). Beyond this range, typically for TSR > 1, the turbine transitions to a lift-driven regime with improved efficiency. Overall performance is strongly influenced by geometric parameters such as solidity and aspect ratio, which determine optimal operating conditions and power output.



Fig. 1. Darrieus Turbine type H

Structural Dynamics of an Active Gas Foil Bearing as an Experimental Basis for Fluid-Structure Interaction Modeling

Dynamika strukturalna aktywnego gazowego łożyska foliowego jako eksperymentalna podstawa modelowania interakcji płyn-konstrukcja

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Abstract
Gas foil bearings rely on strong interactions between the compressible gas film and a compliant, friction–damped foil support. Reliable coupled modeling therefore requires an experimentally validated description of the solid subsystem, particularly for active bearings in which geometric changes alter clearance, preload, and, ultimately, the fluid-structure response. This study identifies the directional effective dynamic properties of the structure of a novel gas foil bearing equipped with a three-segment sleeve actuated by stepper motors. The prototype includes a continuous top foil and three bump-foil strips that form the elastic and dissipative support. Tests were performed with a stationary journal ($\Omega = 0$); consequently, no aerodynamic gas film was generated, and the measured response intentionally represents only the preloaded foil-sleeve-housing structure. The bearing housing was excited with an instrumented modal hammer on a rigid, vibration-isolated rig, while non-contact laser sensors recorded displacement. Repeated force-displacement records were used to identify a second-order single-degree-of-freedom model with a time delay. The selected reduced-order model yielded an effective modal mass of 1.51 kg, stiffness of $6.99x10^5 N/m$, damping of $7.52x10^2 N \cdot s/m$, a natural frequency of $108.3Hz$, and a damping ratio of 0.37. The reconstructed responses reproduced the first displacement peak, reversal, and rapid decay observed experimentally. Differences among models identified for individual impacts also revealed amplitude-dependent shifts in static gain and resonance, indicating nonlinearity associated with foil contact and friction. The identified coefficients are not complete gas-bearing dynamic coefficients; rather, they provide an experimentally anchored solid-domain baseline for future fluid-structure interaction and rotordynamic models that combine structural compliance with speed-dependent gas-film forces.
Acknowledgements: The authors gratefully acknowledge the support provided through the ACTIVERING project, entitled "Aktywne łożyska foliowe ze zmiennymi właściwościami dynamicznymi" (Active Foil Bearings with Variable Dynamic Properties), agreement no. LIDER/51/0200/L9/17/ NCBR/2018, carried out within the LIDER research and development programme and funded by the National Centre for Research and Development (NCBR). The authors also acknowledge that part of the numerical calculations was performed at the Academic Computer Centre in Gdansk.

CFD Modelling of Heavy Fuel Oil Dispersion and Sediment Penetration from the s/s Stuttgart Wreck in the Baltic Sea

Modelowanie CFD rozprzestrzeniania się mazutu z wraku statku "Stuttgart" oraz jego migracji w osadach dennych morza bałtyckiego

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Abstract
The wreck of the s/s "Stuttgart", resting on the seabed of the Baltic Sea, represents a potential long-term source of marine pollution by petroleum-derived substances. One of the major environmental risks is the leakage of heavy fuel oil, which, due to its rheological properties, high viscosity, and potential interaction with bottom sediments, may spread in a manner different from lighter petroleum fractions. The aim of this study is to numerically reproduce the process of heavy fuel oil leakage from the wreck, its transport within the near-bottom layer, and its penetration into the seabed structure using computational fluid dynamics (CFD) methods.
The model accounts for the multiphase nature of the flow, as well as the effects of gravity, viscosity, buoyancy, near-bottom currents, and sediment properties such as porosity and permeability. Particular attention is given to the coupling between heavy fuel oil flow above the seabed surface and its migration within the porous medium. This approach enables the analysis of both the spatial extent of contamination and the potential accumulation of petroleum-derived substances in bottom sediments. Simulations were carried out for different leakage intensity scenarios and hydrodynamic conditions representative of the Baltic Sea environment.
The obtained results allow for the assessment of the direction and rate of heavy fuel oil spreading in the vicinity of the wreck, the identification of areas particularly vulnerable to contamination, and the estimation of contaminant penetration depth into the seabed. The proposed approach may serve as a tool supporting environmental risk assessment related to historical shipwrecks, as well as the planning of monitoring and remediation activities in areas affected by potential petroleum-derived substance leakage.

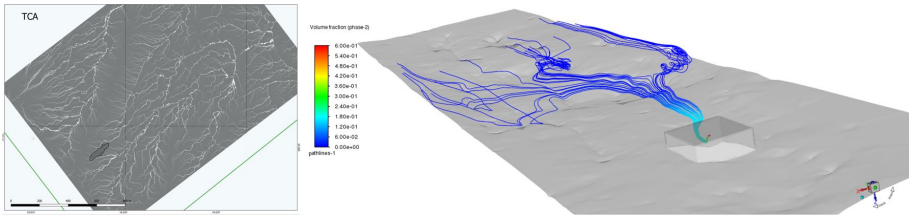


Fig. 1. Seabed topography and spatial distribution of mazut dispersion obtained from numerical simulation.

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Analysis of the effect of V2X on energy market in Poland

Analiza wpływu V2X na rynek energii w Polsce

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Abstract
Poland is characterized by a rapidly growing electric vehicle market and increasing deployment of renewable energy sources, particularly photovoltaic installations. While the national power system remains dominated by conventional generation, this process results in an increasing pressure on low-voltage distribution networks. The number of electric vehicles (EVs) is growing in Poland and it is expected to reach over 600 000 of electric cars by 2030. It is clear their energy needs will become a burden for the grid and a danger in case of insufficient regulations. However, V2X technology implemented in EV chargers can be a game changer. V2X chargers allow for bidirectional energy flow between a car and the charger. Thanks to that, an EV becomes something of a battery in the energy system, but not quite. The car can act as a battery, but only when it is parked by the charger for a longer period and if the user allows it to be discharged to some level, as the primary function of the EV is to drive.
In this article we will focus on the prospects of growing potential of the EVs as a part of elasticity service on the energy market in Poland in 2030 and 2040. Considering the forecasted growth of number of EVs of different types (private cars, trucks, specialized vehicles, etc.), the potential in capacity and power of EV fleet will be significant in the market. With proper incentives, aggregators and pricing schemes, the potential of V2X can be used to support the grid locally, diminishing the problems caused by the uncontrolled renewable energy sources. The article will outline possible scenarios of the development of V2X and their impact on the grid and changes in price.
In conclusion we will outline the barriers for the best case scenario and present the human factor of the EV usage and their impact on the future of the industry.

Acknowledgements: The work results were obtained in studies co-financed by the Interreg Central Europe, project V4Grid.

A comprehensive assessment of the wear and tear on the rotor blades of the final stages of the NP section of STF 100 DKY5-6N45 turbines, and the potential for predicting their technical condition in terms of long-term operation across a wide range of loads

Kompleksowa ocena zużycia eksploatacyjnego łopatek wirnikowych ostatnich stopni części NP turbin STF 100 DKY5-6N45 oraz możliwości predykcji stanu technicznego w aspekcie długotrwałej eksploatacji w szerokim paśmie obciążeń

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Abstract
This study analyses the physical and thermodynamic conditions leading to the formation of a two-phase steam flow. The aim was to identify the parameters conducive to non-equilibrium condensation and to develop models and diagnostic criteria for interpreting operational data. The research combined thermodynamic-hydraulic modelling and CFD calculations with experimental measurements and machine learning methods. The subject of the research was a 900 MW DKY5-6N45 turbine.
The results confirmed that large load variations significantly increase steam moisture content and blade erosion, which reduces turbine efficiency. CFD simulations showed that the dryness fraction decreases on average from 1.0 (blade with reference geometry) to 0.9 (after edge erosion), indicating the impact of geometric degradation on condensation. Diagnostic patterns were developed for the analysis of turbine measurement signals, and a concept for an intelligent diagnostic system was proposed. The conclusions emphasise the need to take into account non-equilibrium condensation and blade erosion processes when assessing turbine performance. This work constitutes a multidisciplinary analysis of non-equilibrium condensation in a steam turbine, combining thermodynamic-hydraulic modelling, CFD simulations and experiments with machine learning methods.
Acknowledgements
The research was carried out within the Program of the Polish Ministry of Science and Higher Education entitled “Doktorat wdrożeniowy” DWD/6/0443/2022.

Project Baltwreck – how to avoid and remediate environmental pollution resulting from wrecks in the Baltic Sea

Projekt Baltwreck – jak uniknąć i przeciwdziałać zanieczyszczeniu środowiska przez wraki zalegające na dnie morza bałtyckiego

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Abstract
The project Baltwreck addresses issues related to combating risks related to wrecks and various hazardous substances in the aquatic environment in order to increase safety and improve water quality. There are around 20 000 known military and civilian shipwrecks on the bottom of the Baltic Sea, ca 10(1) developing efficient wrecks diagnostics methods;
(2) developing risk management & decision-making tool related to wrecks hazards;
(3) in-situ and ex-situ studies of remediation technologies for hazardous fuels from wrecks as well as munition/weapons and explosives;
(4) examining the toxicological risk for marine ecosystems caused by dumped munitions and hydrocarbon deposits.
The developed risk management tool will help policy makers, marine and cities administration to prioritise action plan and take proper actions. Besides, valuable documentation will be prepared for cultural heritage institutions and could contribute to touristic attractiveness of municipalities. This includes production of video material for virtual wrecks tours.

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A Simplified Mathematical Model for Analysing Fluid Flow Through a Converging Channel

Matematyczne modelowanie przepływu płynu przez kanał o malejącym przekroju poprzecznym

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Abstract
This paper presents a new analytical method for the design and optimisation of the flow and geometric parameters of a confusor. The method is applicable to Newtonian fluids and is based on an incompressible-flow formulation. In the proposed approach, quasi-single-phase flows of gas – water droplet and gas–dust particle mixtures are treated as real gases with appropriately determined thermophysical properties. These properties are subsequently used to derive both flow and thermodynamic characteristics, capturing variations in mixture velocity, the linear head-loss coefficient, wall shear stress, overall pressure drop, local pressure drop, frictional pressure drop, accelerational pressure drop, and absolute pressure along the confusor length, among other quantities. The continuity equation is solved in conjunction with a momentum equation. At this stage, the thermal energy balance equation is omitted from the mathematical model.
Most theoretical models further assume flow through a pipe of constant geometry. This paper addresses this limitation by introducing a new computational method capable of modelling flow through a confusor.
The mathematical model is formulated using a lumped-capacitance approach, thereby providing coaxial-flow characteristics along the channel. It is intended for use at both the design and optimisation stages in the development of the flow-through confusor and the converging channel itself.
Using the proposed procedure, the relevant flow parameters for a prescribed confusor geometry can be determined rapidly and accurately. In addition, the method can be employed for reverse analysis.
A novel equation describing the coaxial, linear variation of wall shear stress along the converging channel is incorporated into the mathematical model; to the authors' knowledge, it has not previously been reported in the literature in this field. Several empirical correlations adopted from the literature are correspondingly modified to yield a set tailored to flow through a converging channel. The mechanical energy balance equation is also formulated for this flow, and the resulting equations are used to provide the flow characteristics.
The analytical model has undergone both theoretical and experimental validation, and the resulting data exhibit a satisfactory level of concordance.
In the absence of any comparable analytical method reported in the accessible scientific literature, the proposed approach effectively addresses a recognised gap in this research area.

Yield Surface Evolution of Ti-Cu Bimetal under Complex Loading for Multifunctional Engineering Components

Ewolucja powierzchni plastyczności bimetalu Ti-Cu pod złożonym obciążeniem dla wielofunkcyjnych komponentów inżynierskich

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Abstract
Bimetallic materials have attracted considerable attention for thermostructural and energy-related applications due to their ability to combine complementary material properties within a single structure. Ti-Cu bimetal combines the high mechanical strength and corrosion resistance of titanium with the excellent thermal and electrical conductivity of copper. However, the mismatch in the mechanical response of both constituents may generate complex multiaxial stress states during service. In this work, the initial yield surface and its evolution in a Ti-Cu bimetal were experimentally investigated under proportional axial-shear loading. The yield surfaces were determined in the axial stress-shear stress space from experimental yield points at 0.01% plastic offset strain using sequential biaxial probing paths and fitted with the Szczepiński anisotropic yield criterion.

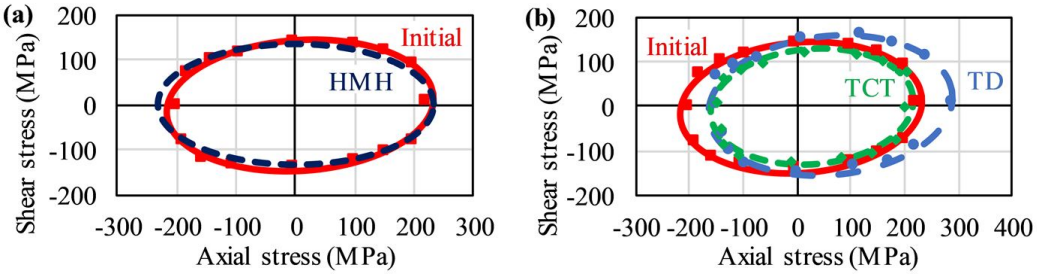


Fig. 1. Initial yield surface (a) of Ti-Cu bimetal and its evolution reflecting pre-deformation (b).

The initial yield locus was found to be close to the Huber-von Mises-Hencky (HMH) isotropic yield surface, although noticeable tension-compression asymmetry and initial anisotropy were observed. Monotonic tensile pre-deformation (TD) resulted in kinematic hardening, whereas combined tension-cyclic torsion (TCT) pre-deformation produced pronounced anisotropic softening and reduction of the yield surface dimensions, particularly in the compressive and shear directions. EBSD and microstructural analyses revealed that the yield surface evolution strongly depended on the deformation mode and interface-driven texture evolution.

Acknowledgement: This work was funded by the National Science Centre, Poland through the grant no. 2023/51/B/ST8/01751.

CFD Modeling and Experimental Evaluation of an Automotive Diesel SCR Aftertreatment System

Modelowanie i weryfikacja eksperymentalna układu oczyszczania spalin SCR samochodowego silnika o zapłonie samoczynnym

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Abstract
One of the most effective technologies for reducing NOx emissions from diesel engines is urea-based Selective Catalytic Reduction (SCR). By utilizing this method, new diesel passenger cars in the European Union comply with the Euro 6e standard, which restricts NOx emissions to 80 mg/km. Currently, the automotive industry is preparing for the implementation of the upcoming Euro 7 regulations. Although Euro 7 does not drastically lower absolute tailpipe emission limits for light-duty vehicles, it introduces significantly more stringent compliance controls by evaluating emissions across a broader range of ambient temperatures and real-world driving conditions. A primary challenge under these new guidelines is ensuring efficient system operation immediately after an engine cold-start, when low exhaust gas temperatures severely restrict urea injection and hinder chemical reduction. Furthermore, operation under these thermal conditions promotes the formation of solid deposits, which can block flow channels and impair system performance. To mitigate the high costs associated with physical prototyping and experimental testing, numerical simulations are heavily utilized. This paper presents the experimental evaluation of a passenger car diesel exhaust aftertreatment system incorporating an SCR catalyst. The development and experimental validation of a corresponding numerical model are detailed. Finally, the validated model is deployed to simulate and analyze system behavior under challenging, low-temperature transient conditions.
Acknowledgements: We gratefully acknowledge the Polish high-performance computing infrastructure PLGrid (HPC Center: ACK Cyfronet AGH) for providing computer facilities and support within computational grant PLG/2025/018690

An investigation of behaviour of 26H2MF and St12T steels during torsional test at elevated temperatures using Finite Element Method

Badanie zachowania stali 26H2MF i St12T podczas próby skręcania w podwyższonych temperaturach z wykorzystaniem metody elementów skończonych

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Abstract
At a time when renewable energy sources are flourishing, and in the absence of sufficient energy storage facilities to stabilise the power grid, it is essential to speed up the start-up and shutdown of conventional power stations and combined heat and power plants, thereby making their operation more flexible.
Consequently, it is necessary to continually expand our understanding of how structural components and parts, as well as the materials from which they are made, behave when the number of start-ups and shutdowns increases, particularly where these processes are accelerated.
It was precisely with a view to gaining a deeper understanding of the behaviour of St12T and 26H2MF steels, from which certain turbine components are made, that a series of more extensive tests were carried out at elevated temperatures, and these tests were subsequently simulated using the finite element method.
This study focuses primarily on the behaviour of St12T and 26H2MF steels during torsion testing at elevated temperatures of $550 - 600°C$.

Experimental determination of the power characteristics of a Rushton turbine in a baffled tank

Eksperymentalne wyznaczanie charakterystyki mocy turbiny Rushtona w zbiorniku z przegrodami

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Abstract
The study concerns the experimental determination of the power characteristics of a six-blade Rushton turbine operating in a cylindrical baffled vessel – a system widely used in the chemical and biotechnological industries. The main objectives of the study are to determine the empirical relationship between the power number and the Reynolds number, to evaluate the reliability of the measurement methods used, and to provide reference data for numerical simulations.

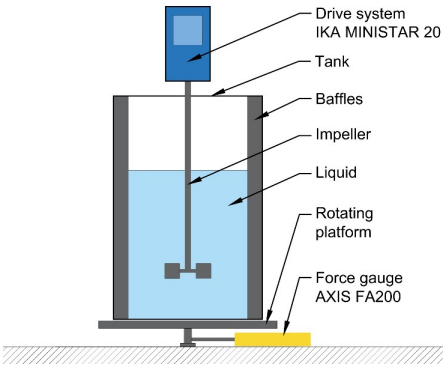


Fig. 1. Schematic diagram of the experimental setup.

Two independent methods of measuring the mixing torque were used in the study (Fig. 1). In the first method, the vessel was mounted on a bearing-supported rotating plate, and the reaction torque was determined as the product of the force measured by an Axis FA200 force gauge with a measurement range of 0 to 200 N, a resolution of 0.1 N and an accuracy of ±0.4 %, and the measured arm length. In the second method, readings from the IKA MINISTAR 20 laboratory drive were used, with a range of up to 20 N·m and an accuracy of ±3 N·m, whose internal method of torque determination has not been documented in detail by the manufacturer. The working fluid was water. Measurements were carried out over a rotational speed range of 150 to 800 rpm in steps of 50 rpm. Each measurement point was repeated ten times.

Predictive Maintenance Under Data Scarcity: Regime Classification and Self-Referential Degradation Detection from Scalar Vibration

Predykcyjne utrzymanie ruchu w warunkach ograniczonej dostępności danych: klasyfikacja reżimów pracy oraz samoodniesieniowa detekcja degradacji na podstawie skalarnej miary drgań

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Abstract

Unplanned failures of rotating machinery are among the key sources of operational risk in industrial plants, generating production downtime, repair costs, and threats to process continuity. From an insurer's perspective, this risk is a direct financial exposure, which motivates continuous condition monitoring across large populations of insured assets. At that scale, instrumentation is necessarily economical: the only signal available for each machine is typically a scalar vibration-severity indicator, without raw waveforms or spectra. This constraint – rather than a limitation to be engineered around – defines the practical problem addressed here.

The aim of the proposed research is to develop a reproducible methodology for condition monitoring based solely on scalar velocity RMS (v_{RMS}, mm/s per ISO 10816/20816), sampled hourly along three axes (X/Y/Z) by continuous monitoring system (CMS) sensors installed on approximately 90 machines. Because raw spectra are unavailable, the approach deliberately excludes bearing-fault frequency diagnosis (BPFO/BPFI/BSF/FTF) and instead targets what scalar three-axis v_{RMS} can support: separating operating from standstill hours, characterizing the on/off regimes of fixed-speed machinery, deriving directional features from the axial/radial ratio, and detecting sustained increases in a machine's working vibration level over time.

Each machine is analysed strictly against its own history; no cross-machine baseline or common signal is assumed. The methodology comprises three stages. First, unsupervised regime classification separates work from standstill hours (Gaussian mixture models with BIC-based model selection and robust threshold placement), so that all subsequent analysis operates only on genuine operating hours. Second, outliers within the operating regime are removed using a modified z-score based on the median and MAD, yielding a clean working-level signal. Third, a self-referential degradation detector tracks the machine's working vibration level – computed as the median v_{RMS}, over a rolling window measured in working hours rather than calendar time, so that idle periods and data gaps do not distort the timeline – and raises graded warnings (watch / alarm) when the current level persistently exceeds the machine's own recent baseline by a set margin and a positive trend confirms the rise, rather than a single transient spike. The intent is early detection during the rising phase of degradation, before a failure occurs.

The methodology is validated against real failure events present in the historical data: several of the monitored machines experienced documented faults, and these episodes

serve as ground truth for assessing whether the detector flags the associated rise in v_{RMS}, with useful lead time. The detector is designed for online operation – evaluating each new measurement against the machine's established working baseline as it accrues — so that the same logic validated offline can run continuously in deployment. The full pipeline, together with anonymized data, is intended for open release, addressing the reproducibility gap in condition monitoring on limited instrumentation. The expected outcome is a validated, openly available methodology for regime classification and early degradation warning on scalar vibration data – a realistic basis for condition monitoring where instrumentation is limited to severity indicators, and a decision-support foundation for prioritising inspection and loss-prevention effort.

An assessment of the impact of the "Triple Barrier" system and active reactive minerals on the biodegradation kinetics of polycyclic aromatic hydrocarbons in Baltic Sea bottom sediments under psychrotolerant conditions

Ocena wpływu systemu "Triple Barrier" oraz aktywnych minerałów reaktywnych na kinetykę biodegradacji wielopierścieniowych węglowodorów aromatycznych w osadach dennych Bałtyku w warunkach psychrotolerantnych

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Abstract
This research analyses how the combination of a multi-layered protective barrier with the use of specially selected minerals affects the rate of natural degradation of toxic petroleum-derived pollutants (PAHs) under specific marine conditions. The study clarifies whether such an integrated technology enables the effective and faster neutralisation of contamination in an environment with a persistently low temperature, where biological processes naturally occur much more slowly.
The wreck of the German hospital ship S/S Stuttgart, lying on the seabed of Gdańsk Bay at a depth of 22–24 m, constitutes a critical, point source of chronic emissions of heavy petroleum hydrocarbons (HFOs) and gas tar into the protected Natura 2000 ecosystem. This technical analysis describes the complex contamination conditions in an area of approximately 45 ha, where concentrations of polycyclic aromatic hydrocarbons (PAHs) have been recorded at levels exceeding toxicity thresholds (TELs) by more than 70 times. The transport mechanisms of pollutants within the porous seabed medium are determined by the high density of the medium, leading to the gravitational accumulation of fuel in morphological depressions ('stagnant pools') and vertical penetration of sediments to a depth of 1.3 m. Advanced remote-sensing techniques, including multibeam bathymetry (MBES) and seismoacoustic profiling (SBP), were used to delineate the contamination zones (A, B, C). In the SBP record, the presence of high concentrations of hydrocarbons manifests as amplitude anomalies and acoustic blanking, which enabled the spatial reconstruction of the volume of contaminated excavated material.
This paper presents the framework of an integrated hazard mitigation model based on the 'Triple Barrier System' strategy. This model involves the sequential implementation of the following measures: (i) extraction of free-phase fuel from reservoirs, (ii) multi-layer hybrid isolation of the wreck using HDPE geomembranes, and (iii) active capping of sediments using reactive minerals (clinoptilolite, expanded clay) with a sorption capacity for WWA. The synergy between physical isolation and assisted in-situ bioremediation allows the half-life of contaminants to be reduced from approximately 25 years to 6.2 years, which represents an acceleration of the degradation kinetics compared with natural attenuation processes. The engineering methodology presented here provides tools for cost-effective optimisation (ALARP) of remediation processes under the low-temperature conditions of the Baltic Sea seabed, with a view to achieving the environmental objectives of the Water Framework Directive.

The problem of identifying random impulse distributions with identical lower-order stochastic moments

Problem identyfikacji rozkładów losowych impulsów o identycznych momentach stochastycznych niskich rzędów

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Abstract
This paper presents fundamental research on the stochastic vibrations of a one-dimensional dynamical system subjected to impulsive excitation, with a focus on moment-based monitoring ambiguity (**moment degeneracy**) and its consequences for energy forecasting, structural fatigue, and low-cost diagnostics. A mathematical model is used to derive a moment-based representation of the system response, where raw stochastic moments are estimated from simulated realisations of the vibration process. The excitation randomness is described by two variables: inter-arrival times τ_i, assumed to be **independent and identically distributed random variables**, and impulse amplitudes η_i , represented as a discrete random variable with prescribed moments.
We demonstrate that vibration responses generated by different random impulse sequences may exhibit nearly identical first- and second-order moments, leading to significant ambiguity in system identification. **To address this, we investigate the use of higher-order moments and distribution reconstruction methods to uncover hidden excitation characteristics**. A comprehensive simulation study is carried out for multiple scenarios sharing similar lower-order statistics. The analysis incorporates machine-learning methods based on recurrent neural networks, including **LSTM, BiLSTM, and GRU, to compare data-driven classification against traditional moment-based methods. These findings are discussed** in the context of energy-harvesting sidewalk systems and coal-dust filtration processes, where correct identification of excitation influences energy prediction, material fatigue, filtration efficiency, and operational safety
Acknowledgements: This research was partly funded by the Polish Ministry of Education and Science, grant number SAP:10000501.00 130000. This research was also partly supported by the "Excellence Initiative – Research University" program at AGH University of Krakow.

Mechanical Stress and Morphological Control in Triple-Cation Perovskite Thin Films: A Systematic Analysis of Macroscopic Deformations

Naprężenia mechaniczne i kontrola morfologiczna w trójkationowych cienkich warstwach perowskitowych: Systematyczna analiza makroskopowych deformacji

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Abstract
Metal halide perovskites have emerged as a high-performance material for next-generation photovoltaics. A major challenge in perovskite engineering is the evolution of residual stress during solution processing, which often manifests as surface deformations and are frequently misclassified as catastrophic so called film cracking. Such premature diagnosis, often based solely on visual evaluations, neglects the underlying structural integrity of the material and obscures the true relationship between film morphology and device performance.
In this work, we present a systematic analysis of these large-scale deformations in triple-cation mixed-halide perovskite films ($Cs_{0.15}FA_{0.774}MA_{0.076}Pb(I_{0.95}Br_{0.05})_3$). We demonstrate that the crystallization pathway of this system is governed by the hydrodynamic intensity of antisolvent delivery rather than conventional dipping time. By modulating the volumetric dispensing rate, we induce or suppress distinct buckling regimes. Recognizing their true physical origin, we propose describing these features as film ridges rather than structural fractures or cracks. Electron scanning microscopy was used to verify film continuity and integrity at the ridge sites, while structural strain evolution has been systematically quantified via GIXRD and Williamson-Hall (WH) analysis. Furthermore, the nanomechanical response of these structures is probed through nanoindentation, bridging the gap between morphological appearance and mechanical properties of the active layer. By correlating these structural metrics with photovoltaic performance (J-V characteristics, Suns-JV, short-term stability), we investigate whether ridges-dominated architectures act as performance-limiting defects or functional strain-relaxation pathways. Ultimately, this study shifts the focus from the cracking paradigm toward a deeper understanding of film mechanics in high-performance perovskite solar cells.

Heat Demand Coverage Analysis for a District Heating Network in Central Poland Supplied by a Hybrid PVT–Heat Pump System with Thermal and Electrical Energy Storage

Analiza pokrycia zapotrzebowania na ciepło w sieci ciepłowniczej zlokalizowanej w centralnej Polsce, zasilanej przez hybrydowy system typu PVT–pompa ciepła wraz z magazynowaniem ciepła i energii elektrycznej

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Abstract
This study investigates the application of a hybrid renewable energy system based on photovoltaic thermal (PVT) collectors, a large-scale heat pump (HP), thermal energy storage (TES), and electrical energy storage (EES) for a district heating network located in central Poland. The analyzed network represents a small- to medium-scale district heating system with an annual heat demand of approximately 55 GWh and significant seasonal variability.
A dynamic lumped-parameter model was developed to simulate the thermal and electrical performance of the integrated system using hourly operational and weather data. The model accounts for low-temperature operation of unglazed PVT collectors, including the effects of wind, precipitation, long-wave radiation, and condensation related heat gains. The heat pump performance was evaluated under variable source- and sink-side temperatures representative of actual district heating operating conditions.
The results indicate that the proposed configuration can cover approximately 90-100 % of district-heating demand during extended summer periods. The heat pump achieved daily average coefficients of performance between 2.0 and 3.1, while the combination of electricity generation by the PVT collectors and electrical energy storage reduced grid electricity imports. Monthly electricity self-sufficiency reached nearly 50% during the most favorable operating periods.
The findings demonstrate that PVT-assisted heat pump systems can provide an effective seasonal renewable heat supply for district-heating networks under the climatic conditions of central Poland, particularly during summer and shoulder seasons. The study also highlights the importance of supervisory control and appropriate selection and control of operating temperatures for improving overall system performance.

Anodization of magnetron-sputtered titanium films on ITO coated glass substrates: Phenomena governing the formation of aligned and separated titania nanotubes at the fluid-solid interface

Anodowanie magnetronowo rozpylanych warstw tytanu na szklanych podłożach powlekanych ITO: modele powstawania przylegających i rozstawionych nanorurek ditlenku tytanu na granicy ciecz-ciało stałe

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Abstract
The fabrication of semitransparent titania nanotube-based electrode materials is of high interest for photoelectrochemical energy conversion and optoelectrochemical sensing applications. In this work, we discuss the interfacial electrochemical phenomena responsible for the growth and formation of vertically aligned and laterally spaced nanotubes formed by anodization of Ti films sputtered onto transparent conductive layer coated glass substrates. Optimized magnetron sputtering parameters ensure the deposition of uniform, dense and mechanically robust Ti films, essential for uniform oxide growth and eventually crack-free oxide tubular layer formation.
Typically, anodization is carried out in fluoride-containing organic electrolytes. In an ethylene glycol-based electrolyte, the classic field-assisted dissolution mechanism dominates in explaining the formation of aligned titania nanotubes through anodization. Titanium is oxidized at the metal-oxide interface ($Ti \rightarrow Ti^{4+} + 4e^-$; $Ti^{4+} + 2O^{2-} \rightarrow TiO_2$), while the formed oxide is simultaneously dissolved at the oxide-electrolyte interface ($TiO_2 + 6F^- + 4H^+ \rightarrow {TiF_6}^{2-} + 2H_2O$). This process under the voltage control results in highly ordered, vertically aligned closely-packed nanotubes. In contrast, when the electrolyte is switched to a diethylene glycol-based solution to obtain laterally spaced nanotubes, the oxygen bubble model dominates in explaining the growth phenomena. Oxygen ions trapped in the growing oxide layer give rise to O_2 bubbles that create high local pressure, which drives oxide flow, pushes the developing pores apart, and promotes the separation of neighboring nanotubes. As a result, well-defined gaps appear between the tubes, producing laterally spaced nanotubes, while they remain vertically oriented maintaining a high aspect ratio.
The developed protocols enable reproducible, scalable fabrication of semitransparent aligned and separated nanotube morphologies, advancing the fundamental understanding of self-organization phenomena at electrochemical fluid-solid interfaces.

Modeling transverse vibrations of drilling masts with a step change in cross-section

Modelowanie drgań poprzecznych masztów wiertniczych ze skokową zmianą przekroju poprzecznego

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Abstract

Nowadays, much attention is paid to the study of the dynamics of machines and engineering structures, since scientific developments in this field constitute the theoretical basis for optimal design. These studies mainly aim to reduce dynamic loads in drive mechanisms and load-bearing structures, reduce the vibration activity of machines and their elements, predict the service life of critical parts and assemblies, ensure the stability of operating modes, and improve control systems for machine units.

Well drilling plays a key role in various branches of world industry, including mining, oil and gas exploration, geothermal energy, water supply and geological research. These processes provide valuable information about the internal structure of the Earth, give an idea of geological formations, and also allow for the successful development and use of huge accumulated energy resources. The problem of intensifying technological processes for drilling wells, while simultaneously increasing the technical level of drilling rigs to improve their productivity, reliability, and durability, is relevant and requires additional scientific research.

Modern drilling rigs are complex electromechanical systems consisting of supporting structures, machines, mechanisms, and actuators, which differ significantly in both design and technical characteristics. Elements of the drilling complex often operate in extreme conditions, characterized by significant static loads and intense mechanical vibrations. In-depth study of the static and dynamic strength of drilling equipment is a necessary condition for its rational design and effective operation.

This work is devoted to mathematical modeling of transverse vibrations of long-length high-altitude structures with a step change in cross-section using the direct discretization method. The method is illustrated by examples of calculating free and forced vibrations of drilling masts. Cases of fixing the mast on an absolutely rigid and flexible base are considered. In addition to conducting a modal analysis of high-rise structures, the amplitude-frequency characteristics of a mast with a flexible base are determined for the case when vibration excitation occurs due to the interaction of a curved drill pipe column with the base platform.

For a mast rigidly fixed to the base, calculation models with four, eight, and twelve degrees of freedom were used, and for a mast with a flexible base - models with five, nine, and thirteen degrees of freedom. The results of the dynamic analysis of mechanical systems illustrate the good convergence of the method. The errors in determining the three lowest natural frequencies using calculation models with a smaller number of degrees of freedom in relation to the values obtained on the most accurate models do not exceed 5%.

Unsteady vibrations of the drill mast that occur during the start-up of the drilling rig's lifting system are also considered. The mathematical model of dynamic processes includes

the equations of motion of drive elements, the equations of longitudinal wave processes in the drill pipe string, the equations of transverse vibrations of high-altitude metal structures, and the equations of electromagnetic phenomena in an asynchronous motor. The influence of non-stationary operating modes of the lifting system on internal forces and on the strength of the elements of the drilling rig has been studied.
The results obtained can be used both in design bureaus for optimal design of drilling rigs and in manufacturing enterprises for the rational selection of operating modes of drilling equipment.

Energy Efficiency Enhancement of PV Integrated Smart Windows through Optimal Localization of Self Adhesive Heating Elements

Zwiększenie efektywności energetycznej inteligentnych okien zintegrowanych z panelami fotowoltaicznymi poprzez optymalną lokalizację samoprzylepnych elementów grzejnych

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Abstract This study evaluates the optimal placement of self-adhesive heating elements within a PV-powered triple-pane smart window. By comparing configurations on Surface 5 (internal argon-filled gap) and Surface 6 (interior glass surface), the research identifies the most efficient localization to minimize heat loss and enhance thermal comfort. The experimental methodology utilizes high-precision thermocouples and heat flux sensors to rigorously evaluate heat transfer mechanisms and spatial temperature distributions across distinct smart window configurations. The findings establish a robust empirical foundation for optimizing the energy efficiency of active glazing systems integrated with renewable energy sources.

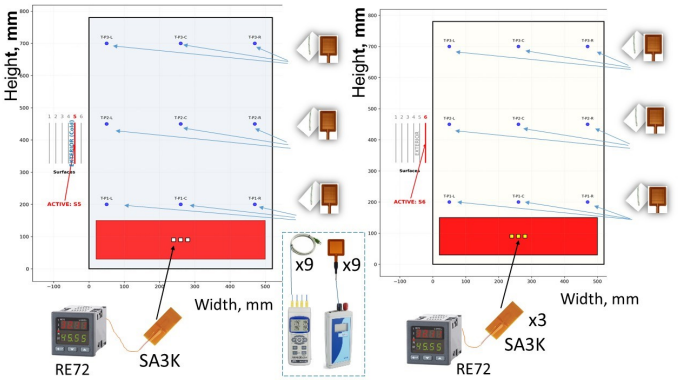


Fig. 1. Schematic layout of the smart window prototype featuring alternative heating layer locations: (a) integrated on surface 5 (internal cavity side); (b) mounted on Surface 6 (interior room side).

Acknowledgements: This research was funded in whole or in part by the National Science Centre, Poland, DEC-2025/09/X/ST8/00339, "Integracja fotowoltaiki z oknami ogrzewanymi elektrycznie: pilotażowe badanie w celu zwiększenia efektywności energetycznej budynków". For the purpose of Open Access, the author has applied a CC-BY public copyright licence to any Author Accepted Manuscript AAM version arising from this submission.

Dynamic Modelling of a High-Temperature Thermal Energy Storage System with Direct Steam Generation: Optimisation of the Charging Process with Consideration of Thermal Constraints

Dynamiczne modelowanie wysokotemperaturowego magazynu ciepła z bezpośrednią generacją pary - optymalizacja procesu ładowania z uwzględnieniem ograniczeń termicznych

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Abstract
High-temperature thermal energy storage systems represent a promising solution for integrating variable energy sources with industrial processes requiring a continuous heat supply. A particularly relevant application is the use of thermal storage for direct process steam generation, where effective operation of the charging process requires an accurate representation of the transient thermal phenomena occurring within the system.
The presentation will introduce a methodology for the dynamic modelling of a high-temperature thermal energy storage system and analyse how the level of model complexity affects its suitability for optimisation and control purposes. Dynamic models of different levels of detail will be discussed, ranging from a simplified lumped-parameter 0D model, through a one-dimensional model capable of representing the temporal and spatial temperature distribution, to the concept of three-dimensional models enabling a detailed analysis of local thermal phenomena.
Particular attention will be given to the 1D model implemented in the OpenModelica environment. This model provides a compromise between the accurate representation of the underlying physical processes and the computational requirements associated with its future use in control systems. The model will also be validated using experimental temperature data obtained during the charging process.
A further aspect of the work concerns the development of a charging control strategy aimed at achieving a prescribed final temperature distribution within the storage system. Experimental investigations have demonstrated that the temperature gradient inside the storage medium has a significant influence on the subsequent discharging process and direct steam generation. This finding confirms the hypothesis that the operational performance of the storage system depends not only on the total amount of stored energy, but also on its spatial distribution.
The proposed modelling and control framework is intended to determine the required heat input profile leading to a specified final temperature gradient, for example from 20 °C to 500°C or from 100°C to 600°C. The 0D model will be used to analyse the overall energy balance and to compare the simulated stored-energy profile with experimental results, whereas the 1D model will enable the analysis and control of the spatial temperature distribution within the storage system.

Application of Digital Twin Technology for Production Scheduling Optimization under Limited Availability of Generating Units

Wykorzystanie technologii Digital Twin do optymalizacji grafików pracy źródeł wytwórczych w warunkach ograniczonej dyspozycyjności infrastruktury

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Abstract

Modern production systems increasingly operate under conditions of reduced equipment availability, resulting from progressive wear, degradation of operating parameters, or deviations from nominal conditions. A particular challenge arises in decision-making under borderline operating conditions, where continued machine operation carries a risk of failure, while immediate shutdown leads to significant financial losses.

This paper presents the concept of using Digital Twin technology as a tool to support maintenance planning and dynamic optimization of production schedules under such conditions. The Digital Twin, fed with real-time measurement data, enables forecasting of further degradation of the technical condition of equipment and estimation of the remaining safe operating time until the scheduled maintenance outage.

A case study of a steam turbine within a combined heat and power (CHP) plant consisting of multiple generation units is presented. A decision-making model is developed that integrates production constraints, heat demand forecasts, and market conditions. The model enables the determination of an optimal load profile for the machines, minimizing the rate of degradation while maintaining the required heat production and maximizing operational profit. As a result, continuous operation of the equipment until the planned maintenance outage becomes feasible.

A comparative analysis demonstrates that the application of the Digital Twin approach reduces the number of unplanned outages and associated emergency repair costs, which include not only service expenses but also lost revenues and penalties for failure to deliver contracted energy. In the analyzed scenario, significant economic savings were achieved compared to the emergency shutdown case, along with improved predictability of system operation.

The results indicate that the integration of diagnostic, predictive, and optimization models within a Digital Twin framework constitutes an effective tool for supporting operation and maintenance management in modern energy systems.

Effect of fatigue loading scenarios on the behaviour of power engineering steels

Wpływ scenariuszy obciążenia przy zmęczeniu na zachowanie się wybranych stali stosowanych w energetyce

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Abstract
This research work proposes an alternative methodology that allows assessing the effectiveness of non-destructive testing in the form of optical measurement systems (DIC) in monitoring the development of damage in power engineering steel subjected to cyclic loading. The tests were carried out on power engineering steel 10CrMo9-10 (10H2M) used in pipelines and steam distribution systems in the supercritical state. Experiments were conducted on the steel in the as-received state and after its long-term service for 280 000 hours at an elevated temperature of 540 °C and an internal pressure of 2.9 MPa. A series of strength and microstructural studies were conducted, including tensile tests as well as high- and low-cycle fatigue tests within a stress amplitude range from 250 MPa to 450 MPa, in order to characterize the damage mechanisms depending on the degree of material exploitation. In Fig.1 an example of the dynamics of material damage development is presented based on fatigue damage strain indicator φ reflecting the mechanisms of the degradation process, supported by DIC images. Similar program of tests was carried out for X10CrMoVNb9-1 steel (P91).

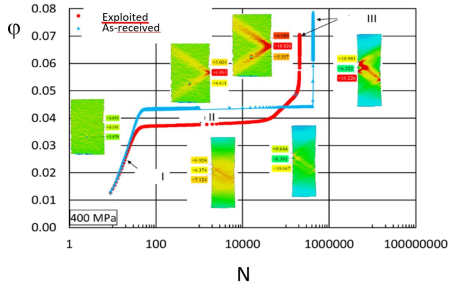


Fig. 1. Variation of the fatigue damage strain indicator φ as a function of the number of cycles for the as-received and exploited 10H2M steel; tests were carried out for stress range equal to 400 MPa.

Acknowledgements: The work was funded partly by the National Science Centre in Poland through the grant no. 2023/51/B/ST8/01751.

Horizon-Dependent Crossover Between SARIMAX and Gradient Boosting for Day-Ahead District Heating Demand Forecasting: A Multi-Network Study Under Honest Rolling-Origin Evaluation

Zależna od horyzontu prognozy zmiana przewagi modeli SARIMAX i gradient boosting w prognozowaniu dobowego zapotrzebowania na ciepło sieciowe: analiza wielu sieci z zastosowaniem rzetelnej walidacji kroczącej typu rolling-origin

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Abstract
Day-ahead heat demand forecasting in district heating networks, at horizons up to 40 hours, is critical for source dispatch and operational optimization. Yet the applied literature (*Energy and Buildings, Energy*) is dominated by decomposition-based hybrids benchmarked against weak baselines and evaluated under regimes that inflate apparent accuracy. In this work we compare two model families — dynamic harmonic regression SARIMAX (Fourier terms for daily and weekly seasonality, exogenous weather variables, Kalman-filter state re-anchoring) and gradient boosting (XGBoost) with a rich set of autoregressive, rolling, and calendar features — on hourly SCADA data from **three independent district heating networks** differing in scale and load structure. Evaluation is conducted under a single honest rolling-origin regime with a 40-hour forecast window applied identically to both families, avoiding the common conflation of one-step-ahead metrics with multi-hour forecasting. Our central finding is a reproducible **crossover of error curves as a function of horizon**: SARIMAX dominates at short horizons (1 to a few hours), where fresh lags and residual AR structure are available, whereas XGBoost takes over at the day-ahead horizon, once recent lags become inaccessible and nonlinear interactions among exogenous variables carry the predictive load. The crossover holds across all three networks, indicating a mechanistic rather than artifactual origin. We provide a mechanistic explanation grounded in the availability of autoregressive information as a function of horizon, together with a residual analysis (an AR(2) signature plus a residual diurnal hump at lags 20–24 in XGBoost). The results yield a practical, horizon-dependent model-selection rule and demonstrate that a methodologically clean, honestly validated pair of simple models outperforms the complex hybrids prevalent in the literature.

Exergy-Based Analysis of Distributed Polygeneration Systems with Synthetic Fuel-Based Energy Storage for Microgrids under Islanded Operation

Analiza egzergetyczna rozproszonych systemów poligeneracyjnych z magazynowaniem energii w postaci paliw syntetycznych w aspekcie pracy wyspowej mikrosieci energetycznej

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Abstract
The ongoing energy transition, the development of distributed generation and the increasing share of intermittent renewable energy sources create a growing need for local energy systems capable of flexible, efficient and secure operation. Polygeneration systems integrating the production of electricity, heat, cooling, process steam and synthetic fuels are particularly important. However, assessment based solely on energy balances does not fully reflect the quality of energy conversion processes or identify the actual sources of thermodynamic losses.
The objective of this doctoral research is to develop a model, simulation and optimisation of distributed polygeneration systems with energy storage in the form of synthetic fuels, with particular emphasis on islanded microgrid operation. Exergy analysis will constitute the main system assessment method, enabling the identification of exergy destruction, evaluation of the quality of energy-carrier utilisation and determination of the impact of individual devices and control strategies on the overall system efficiency.
The investigated system will include renewable energy sources, cogeneration units, boilers, heat pumps, electrolysers, fuel cells or reversible solid oxide cell systems, electrical and thermal energy storage, and hydrogen or other synthetic fuel storage. Both grid-connected operation and the transition to islanded mode will be analysed, including the ability of the separated microgrid to maintain autonomous and self-balanced operation.
The models will be developed in the Modelica/OpenModelica environment, which enables physical, multidomain and dynamic representation of complex energy systems. Modelica models will be integrated with Python-based tools through the Functional Mock-up Interface standard to automate simulations, scenario analyses and optimisation of system parameters and control strategies.
The initial outcome of the research is a modular architecture of the energy system model and a component library representing energy sources, consumers, storage units and energy conversion technologies. Mechanisms for data exchange, energy-flow balancing, operational constraint representation and Functional Mock-up Unit export have been developed. The initial results confirm the feasibility of performing dynamic simulations of a complex multi-energy system and provide a basis for extending the model with comprehensive exergy balances, optimisation algorithms and microgrid resilience analysis under islanded operating conditions.
The expected result of the research is a methodology supporting the design and operation of local polygeneration systems, enabling simultaneous reduction of exergy losses, operating costs and emissions, while improving flexibility and security of energy supply.

Modelling the mobility of PAH through the Baltic Sea bed, from the leaked fuel accumulated around the WWII wreck *Stuttgart*

Modelowanie mobilności WWA poprzez dno Morza Bałtyckiego, wyciekających z paliwa zgromadzonego naokoło wraku Stuttgart z II Wojny Światowej

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Abstract
The wreck of the German hospital ship "Stuttgart", sunk during World War II in the Baltic Sea, remains a potential source of long-term hydrocarbon contamination due to the leakage of residual fuel from its deteriorating structure. This study presents a numerical risk-assessment model designed to evaluate the migration of selected polycyclic aromatic hydrocarbons (PAHs) and monoaromatic petroleum hydrocarbons originating from the accumulated fuel deposits surrounding the wreck. The seabed was represented as a fully water-saturated porous medium, analogous to saturated soil, with hydrostatic pressure corresponding to water depths of 18–22 m incorporated into the transport calculations. Contaminant migration was simulated using a modified advection–dispersion framework in which spreading is governed by local gravimetric gradients, Darcy's seepage velocity, sediment adsorption properties, and compound-specific retardation processes. The model further incorporates first-order biodegradation mechanisms to account for the partial decomposition of hydrocarbons during transport. Four representative compounds exhibiting different physicochemical characteristics were selected for analysis: benzene, toluene, naphthalene, and xylene. For each compound, transport parameters were used to calculate (i) travel times to specified distances within the seabed together with the corresponding residual concentrations, and (ii) the probability of detecting a given contaminant at a defined location, time horizon, and concentration threshold. The probabilistic component of the model enables the quantification of uncertainty associated with contaminant persistence and migration pathways under varying environmental conditions. The proposed methodology provides a practical decision-support tool for evaluating the long-term environmental consequences of fuel leakage from historical shipwrecks. By estimating both contaminant arrival times and occurrence probabilities, the model supports national authorities and marine environmental agencies in prioritizing monitoring activities, assessing ecological risks, and planning mitigation measures aimed at limiting further pollution spread within the Baltic Sea ecosystem.

Experimental Visualization and Analysis of Water Jet Breakup and Droplet Formation Using High-Speed Camera Imaging

Eksperymentalna wizualizacja i analiza rozpadu strugi wody oraz powstawania kropli z wykorzystaniem obrazowania kamerą szybkoklatkową

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Abstract
Liquid jets are widely used in numerous industrial applications, particularly in systems involving heat and mass transfer, spray cooling, combustion, and direct contact condensation (DCC). The breakup of a liquid jet and the subsequent formation of ligaments and droplets are fundamental processes that determine the interfacial area between the liquid and the surrounding gas phase. Understanding these mechanisms has been the subject of extensive research in fluid mechanics due to their significant influence on transport phenomena and process efficiency [1,2].
The aim of this study is to experimentally investigate the breakup mechanisms of a liquid jet discharged from a subcritical nozzle and to characterize the formation of ligaments and droplets that increase the contact surface area between the liquid and the surrounding gaseous medium. Parameters such as droplet size distribution, droplet velocity, spray angle, and condensate concentration significantly affect the performance of heat and mass transfer processes. A better understanding of these relationships may help optimize nozzle geometry and operating conditions in liquid atomization systems. The experiments were conducted in a specially designed test facility (Fig. 1a) that allows investigations of interchangeable nozzles with different geometric parameters under a wide range of operating conditions [3]. Flow visualization was performed using non-invasive optical measurement techniques, including high-speed camera imaging, which enabled detailed observation of the water jet development and breakup process (Fig. 1b).
The investigated water jet was generated using a nozzle with an internal diameter of 4 mm and an outlet channel length of 8 mm. The pressure and flow rate of the working fluid were continuously monitored using pressure transducers and a flow meter, while a standard water pump controlled the operating conditions. Image analysis along the jet axis allowed the identification of changes in jet structure, the observation of ligament and droplet formation, and the determination of the distance from the nozzle exit at which jet breakup begins. The results obtained contribute to a better understanding of the physics of liquid-jet atomization and provide valuable information for the design and optimization of advanced heat and mass transfer systems based on direct contact condensation.

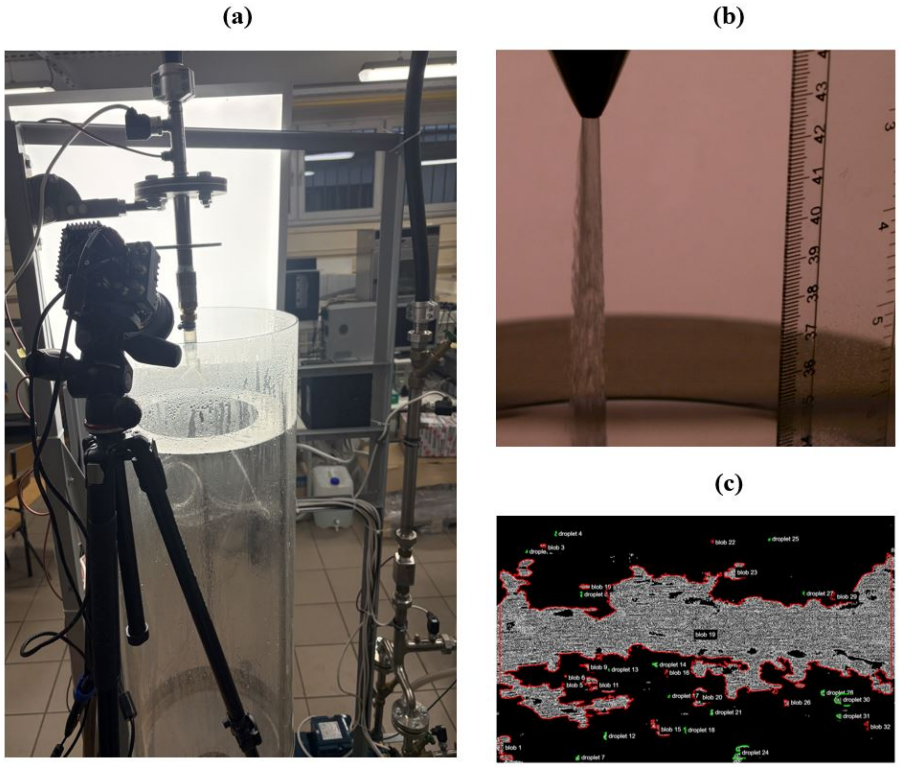


Fig. 1. Experimental setup for investigating liquid jets and sprays (a) and jet flow visualization using High-Speed Camera Imaging (b) with results of droplet detection algorithm application (c)

Acknowledgements: Funded by the National Science Centre, Poland under the OPUS call in the Weave programme (Grant number: 2023/51/I/ST8/02700).

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Analysis of the Temperature Profile of the Deposited Layer during 3D Printing

Analiza przebiegu temperatury warstwy zdeponowanej podczas druku 3D

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Abstract
This paper presents a method for measuring the temperature of a deposited layer during the 3D printing process using a K-type thermocouple. The sensor was placed in a previously prepared cavity located in the central part of the base layer, between adjacent material paths. The adopted location of the measurement point minimized the influence of the measuring system on the process and ensured temperature recording in an area representative of the local heat transfer occurring during printing.
Measurements were taken with a time step of 0.5 s, and data recording began after the sensor readings stabilized prior to the start of extrusion. During the process, the thermocouple was successively covered by subsequent material layers. This enabled the analysis of temperature changes over time, encompassing the phases of rapid heating, heat conduction into the structure, and the subsequent cooling of the material.
To evaluate repeatability, a series of experiments was conducted under initial and boundary conditions that were kept as similar as possible. The obtained temperature profiles demonstrated qualitative agreement, including a characteristic rapid temperature increase in the initial phase of the process and the system's gradual transition into a quasi-steady state. At the same time, the results exhibited high sensitivity to minor variations in ambient temperature, build plate temperature, and the sensor's position relative to the print paths.
The developed measurement method enables the recording of local temperature changes during the additive manufacturing process and serves as a basis for validating numerical thermal models of 3D printing.

Numerical analysis of the influence of Savonius turbine blade settings on the control characteristics over the ridge of a gable roof

Numeryczna analiza wpływu ułożenia łopat turbiny Savoniusa na charakterystyki przepływu nad kalenicą dachu dwuspadowego

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Abstract
Integration of small wind turbines into large building components for wind power applications in built environments. The study results indicate that a Savonius turbine mounted on a gable roof ridge switch is accessible from the electrical power supply, with a 30-degree tip angle providing torque control. The influence of blade number - including blade overlap, overlap ratio, and angular offset – on the aerodynamic interaction between the rotor and the accelerated flow over the ridge was not adjusted.

This paper presents a numerical study of the fluid-solid interaction between concentrated wind flow over the ridge of a gable roof and a Savonius rotor with multiple blades. The analysis was performed using SolidWorks Flow Simulation software. For each configuration, quasi-static torque characteristics are calculated as a function of rotor angular orientation at a reference wind speed of 10 m/s and various elevation angles. The study examines the velocity and speed distributions in rotor spread, rotor size, rotational speed, and height for various blade arrangements that are actuated by the ridge. Preliminary results indicate that the blade arrangement affects both the mean torque and the amplitude of its cyclic variations. This research aims to support the formulation of design networks for ridge-mounted Savonius turbines at right-angle and lateral wind speeds typical of the Polish built environment.

Influence of the working medium on the operation of foil bearings in the start-stop cycle.

Wpływ medium roboczego na pracę łożysk foliowych w cyklu start-stop

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Abstract
Foil bearings are gaining increasing attention as a bearing technology for high-speed rotating machinery, including vapour microturbines operating in organic Rankine cycle (ORC) systems. Unlike conventional bearings, foil bearings use the viscosity of the surrounding fluid to generate a hydrodynamic lubricating film, eliminating the need for external oil-based lubrication systems. However, their tribological performance is strongly dependent on the properties of the working medium, particularly during start-up and run-down phases when direct contact occurs between the journal and the top foil.
This paper presents experimental results on the influence of the working medium on foil bearing performance during start-stop cycles. The tests were conducted on a dedicated test rig enabling foil bearing operation in various media, including ambient air and the low-boiling liquid HFE-7100 (a non-flammable dielectric fluid with a boiling point of 61 °C and a dynamic viscosity of 0.57 MPa·s at 25°C). Selected material pairs of top and bump foils (brass 2.0321/CuAl7, CuAl7/Inconel) were tested under repeatable start-stop conditions at rotational speeds up to 8000 rpm. The test cycle comprised four phases: ramp-up, steady-state operation, coast-down, and standstill, performed automatically for up to 1000 consecutive cycles.
The measured parameters included friction torque, chamber temperature, and mass wear of the top and bump foils. Friction torque profiles were analysed to identify peaks associated with lubricating film formation and loss during start-up and coast-down. Foil mass loss was determined using a precision analytical balance with a resolution of 0.01 mg.
The results indicate that the choice of working medium significantly affects friction torque characteristics and resulting foil wear. HFE-7100 demonstrated favourable lubricating properties compared to air, leading to reduced mass wear of the top foil. The thermal behaviour of the bearing was also sensitive to the medium type, with notable differences in temperature stabilization between variants.
The findings contribute to understanding fluid-solid interaction phenomena governing foil bearing operation in non-standard lubricating environments and support the design of more durable bearing systems for ORC microturbines.

Nanocomposite materials mechanical properties determination based on indentation test and finite element simulation and energy equivalence

Metoda numeryczna wyznaczenie właściwości mechanicznych materiałów kompozytowych z testu indentacji oraz hipotezy równoważności energii

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Abstract
The model of indentation test with Berkovich tip was initiated by the additionally generated plastic energy that is assumed to be equally distributed during deformation process. An explicit equation for estimating the total strain energy which, together with the principle of energy balance in deformation domain, allows us to assess the stress distribution within the contact area between the indenter and material. The representative volume element (RVE) of a real, heterogeneous (with inclusions, voids, chemical crystallites) material is mapped into a point of fictitious homogeneous continuum in which all the micro-rearrangements are smeared out without resolving the details of contributing components. We assume the total strain energy equivalence hypothesis: during material deformation, each RVE in its real configuration, described by the set of state variable pairs, it is associate a safe unchanged (homogenized) equivalent created theoretically configuration, the state (isotropic) of which is described by the effective state variables, so that the total internal energy defined over the two (real and theoretical) configurations is the same. The proposed method can uniformly describe the distribution of equivalent stress σ_{eq} and all principal component stresses σ_{kk} in the material deformation region under the indenter tip. Overall, the presented finite elements methods estimation of mechanical properties of multi-phase nanocomposite provides an efficient way to assess the stress-strain characteristics and fracture properties of a material in multi scale of metals or cement-based, polymer-based and many other nanocomposites.

Mechanistically-informed machine learning in stochastic mechanical systems modeling

Uczenie maszynowe oparte na modelowaniu stochastycznych układów mechanicznych

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Abstract
This study addresses the integration of random physical models with machine learning algorithms within the framework of stochastic mechanical systems analysis. Given the increasing complexity of engineering systems, the mechanistically-informed machine learning paradigm represents a critical extension of classical numerical methods, while ensuring the physical consistency of the results. This work provides a critical analysis of contemporary neural network architectures integrated and collaborating with stochastic mechanical systems.. The examination of selected research cases demonstrates that the hybridization of domain knowledge with data-driven methods allows for a significant reduction in generalization error, particularly under conditions of sparse experimental data and in the presence of stochastic noise. The presented findings highlight the high efficiency of surrogate models in predicting dynamic responses and assessing the structural reliability of complex non-linear systems, establishing new standards for the design of mechanical systems robust to random parameter variability.
Acknowledgements: Acknowledgements: This research was t partly funded by Polish Ministry of Education and Science grant number SAP no.: 10000 501.00 130000.
Research project partly supported by program „Excellence initiative – research university" for the AGH University of Krakow.

Improving the efficiency of building energy systems in urban areas

Poprawa efektywności systemów energetycznych budynków na obszarach miejskich

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Abstract
The optimization of hybrid building energy systems is commonly addressed using two main approaches: model-based and rule-based energy management strategies that ensure operational stability, and heuristic or algorithmic methods designed to optimize multiple objectives such as operational cost, CO_2 emissions, and system reliability. However, these approaches are often insufficiently validated with respect to energy demand sensitivity, limiting their robustness under dynamic and uncertain operating conditions. This study proposes an integrated energy forecasting and management framework that combines real-time energy management with intelligent load control based on dynamic building energy modeling. Despite significant progress in hybrid renewable energy system control, existing solutions frequently lack unified and computationally efficient algorithmic architectures capable of simultaneously addressing multiple renewable energy sources, energy storage systems, and demand response. Moreover, many approaches exhibit limited effectiveness in handling complex multi-objective optimization problems in real-time applications. To overcome these limitations, the proposed framework integrates machine learning–based energy demand forecasting with a two-level optimization strategy supported by adaptive parameter control and parallel evaluation. The framework enables real-time decision-making while maintaining computational efficiency. By coordinating hybrid renewable energy systems with conventional power supply infrastructure, the proposed approach reduces carbon emissions and energy consumption while ensuring occupant comfort, thereby demonstrating strong potential for practical deployment in smart and energy-efficient buildings.

Acknowledgements: This work was carried out with the support of the grant project "Improving the efficiency of building energy systems in existing urban areas" Nr DEC - 2025/57/B/ST8/01347

Representative Length for Tortuosity Estimation in Granular Beds Using the Path Tracking Method

Reprezentatywna długość próbki dla estymacji krętości w złożach granularnych z wykorzystaniem metody śledzenia ścieżki

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Abstract
The study investigates the minimum representative sample length required for stable estimation of geometrical tortuosity in granular porous media using the Path Tracking Method (PTM) algorithm. The analysis was performed for virtual granular beds generated using the Discrete Element Method (DEM). Tortuosity was defined as the ratio of the cumulative path length to the cumulative projection onto the flow direction. The stability of the estimator was analyzed using repeated random shuffling of the sequence of elementary segments and applying the coefficient of variation criterion $CV(n) = \frac{SD(\tau(n))}{\tau(n)}$.

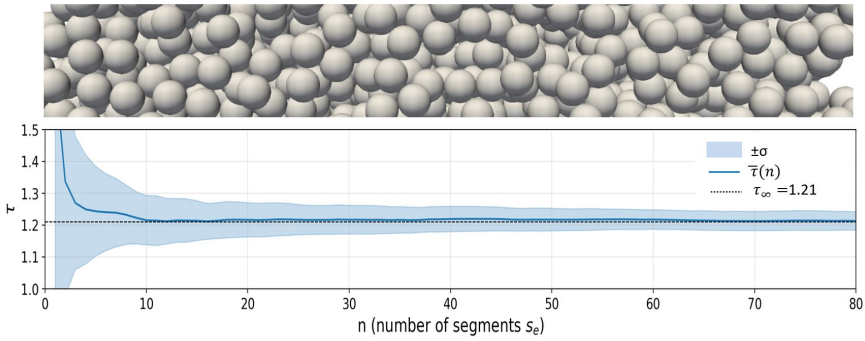


Fig. 1. Tortuosity convergence $\tau(n)$.

The results showed (Fig. 1) convergence of tortuosity to a stable asymptotic value with an increasing number of elementary segments. For the analyzed beds, the representative sample length corresponding to a precision level of $CV < 2\%$ was approximately 29 particle diameters. The obtained results remain consistent with REV ranges reported in the literature for other properties of granular porous media. The proposed approach provides a statistical interpretation of the representative sample length in the analysis of tortuosity in granular porous media and links the minimum sample size to the required level of estimation precision.

Small electrostatic precipitator for local space heaters

Mały elektrofiltr do miejscowych ogrzewaczy pomieszczeń

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Abstract
Local space heaters and residential solid fuel combustion remain significant contributors to particulate matter (PM) emissions in urban and suburban areas. To address this environmental challenge, a compact electrostatic precipitator (ESP) dedicated specifically for residential chimneys has been developed. This presentation outlines the comprehensive research and development process of this device, tracing its evolution from the initial conceptual phase to a fully market-ready product.
One of the topics of this presentation will be aerodynamic optimization of electrostatic precipitators. Experimental measurements using Particle Image Velocimetry (PIV) will be discussed, which were used to analyze the gas flow dynamics and particle behavior in the ESP. Example measurement results will be presented, demonstrating how velocity fields and flow distribution were modified to increase particulate capture efficiency in a confined physical space.
Additionally, the presentation will discuss the engineering and design phases that transformed the optimized prototype into a practical, scalable solution. Overcoming a number of technical hurdles, the development process resulted in a robust, production-ready electrostatic precipitator designed for seamless installation on domestic chimneys. This final device offers an effective, ready-to-deploy solution for reducing emissions from local space heaters, potentially contributing to improved local air quality.

Acknowledgements: The work results were obtained in studies co-financed by the European Union from the European Regional Development Fund, program of the Polish National Center for Research and Development (NCBiR) under the project entitled "Small electrostatic precipitator for local space heaters", agreement no. POIR.01.01.01-00-1316/19.

Phase Change Materials (PCMs) Doped with Nanoparticles: Their Effects and CFD Modeling Methods

Materiały zmiennofazowe PCM domieszkowane nanocząsteczkami: wpływ ich działania i sposoby modelowania CFD

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Abstract
Phase change materials (PCMs) are finding an increasing number of industrial applications, although their primary use is as heat or cold storage. Their main advantage is their ability to be used over a wide temperature range, allowing them to utilize not only sensible but also latent heat within a specific temperature range, which contributes to their relatively high heat capacity. Unfortunately, they also have disadvantages, including high purchase price and low thermal conductivity, which slows the charging and discharging process of the heat storage. To improve their thermal conductivity, complex heat exchanger geometries and various nanoscale dopants are used, which unfortunately increase costs and do not fully solve all the problems related to heat and cold storage in heat storage systems. This paper will discuss the advantages and disadvantages of phase change materials, methods for improving thermal conductivity, and present test results for the selected PCM material. Additionally, CFD modeling methods for PCM materials with nanoparticles will be presented based on a literature review.

Predictive Maintenance Under Data Scarcity: Regime Classification and Self-Referential Degradation Detection from Scalar Vibration

Predykcyjne utrzymanie ruchu w warunkach ograniczonej dostępności danych: klasyfikacja reżimów pracy oraz samoodniesieniowa detekcja degradacji na podstawie skalarnej miary drgań

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Abstract
The fear of the electric cars burning down with whole garage was for years the most often raised argument when mentioning the safety and security of Electric Vehicles (EV). While there were some cases of EV catching fire, the car companies have considered the matter deeply and now the EVs (especially cars) are statistically safer than their fuel equivalent. However, it does not mean that the safety and security of the electric vehicles is in any way neglected. On the contrary, the fire and user safety of EVs are very well covered in the regulation and there are many safety measures implemented around EV chargers.
The upcoming technology of bidirectional EV chargers - V2X - introduces a new level of safety issues that have to be considered. First, the ability of discharging a car has a potentially much bigger and more damaging impact on the grid – it might enhance the negative effects of the renewable energy sources and cause problems with e.g. voltage. Secondly, for the bidirectional operation to make sense, a more advanced management system that would be actively connected to the data sources as e.g. market prices or weather forecast would be needed. More advanced and connected systems are generally more prone to cybersecurity issues and their stronger and more complex computational units became more vulnerable to wider range of attacks (e.g. DDOS).
In this article we would like to present the real data regarding the safety and security of the V2G technology. The V2G is the environment consisting of many elements: grid, EV, charger, aggregators, payment services energy market and users. The safety and cybersecurity should be considered for all those elements and also for the interaction between them. We present, first, the aspects of ensuring physical safety of the charging infrastructure, the legal requirements for installation and inspection of the chargers. In the second part we present the chosen aspects of cybersecurity: those that apply to most of such system and the ones more specific to the charging infrastructure.

Acknowledgements: The work results were obtained in studies co-financed by the Interreg Central Europe, project V4Grid.

Living Interfaces: Fluid–Solid Interactions in Engineered Living Materials

Żywe interfejsy: oddziaływania cieczy i ciał stałych w inżynieryjnych materiałach ożywionych

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Abstract
Engineered living materials (ELMs) represent a new class of biohybrid systems in which living cells are embedded within structured matrices to deliver adaptive and long-lasting functionality. Unlike conventional materials, these systems actively exchange matter and energy with their surroundings, evolve, and respond to environmental stimuli. As a result, they behave less like passive solids and more like dynamic interfaces between biological activity, material structure, and surrounding fluids. This keynote will explore how bioinspiration from natural living interfaces can guide the design of next-generation functional materials. In nature, systems such as microbial biofilms, plant surfaces, and biological tissues operate as integrated fluid–solid environments in which transport, structure, and biological function are tightly coupled. These systems achieve remarkable capabilities, including self-regulation, self-repair, and adaptive transport of nutrients and metabolites. Translating such principles into engineered materials opens opportunities to design surfaces and porous structures that maintain functionality over long timescales while adapting to changing conditions. Examples from living coatings and biohybrid functional surfaces in architecture will illustrate how embedding living microorganisms within designed matrices enables materials to sense, respond, and regenerate. By outlining ELMs as bioinspired, adaptive interfaces, this contribution aims to highlight how lessons from natural systems can inform the development of sustainable materials with built-in functionality, resilience, and long-term performance.

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Wetting of wood surface

Zwilżanie powierzchni drewna

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Abstract
Wood is a hygroscopic, porous, and chemically heterogeneous material of biological origin. Its complex structure poses significant challenges for the characterization of surface properties, which play a critical role in the performance, durability, and processing of wood products. Surface wettability and surface free energy strongly influence key industrial processes, including adhesive bonding, coating application, and the development of water-repellent treatments for protection against moisture and weather exposure.
The conventional determination of surface free energy using the sessile drop method, when applied without appropriate consideration of wood-specific characteristics, can lead to inaccurate or misleading results. Wood wettability is governed not only by its chemical composition but also by the spatial distribution of chemical constituents, which varies across anatomical features such as earlywood and latewood, as well as heartwood and sapwood. Consequently, reliable surface characterization requires the integration of information on surface topography (roughness and micro-roughness) together with the mapping of chemical heterogeneity. Advanced approaches for three-dimensional surface topography assessment and two-dimensional chemical mapping provide valuable insights into the factors governing wetting behaviour. However, these techniques introduce additional challenges related to data processing, interpretation, and correction of wettability measurements.
This presentation provides an overview of the key challenges associated with the assessment of wood surface wettability and surface free energy. Special attention is given to recommended measurement techniques, sensor technologies, laboratory procedures, and customized solutions for the automated characterization of wood surfaces. The presented methodologies aim to improve the reliability and reproducibility of wettability measurements, supporting both fundamental research and industrial applications in wood science and technology.

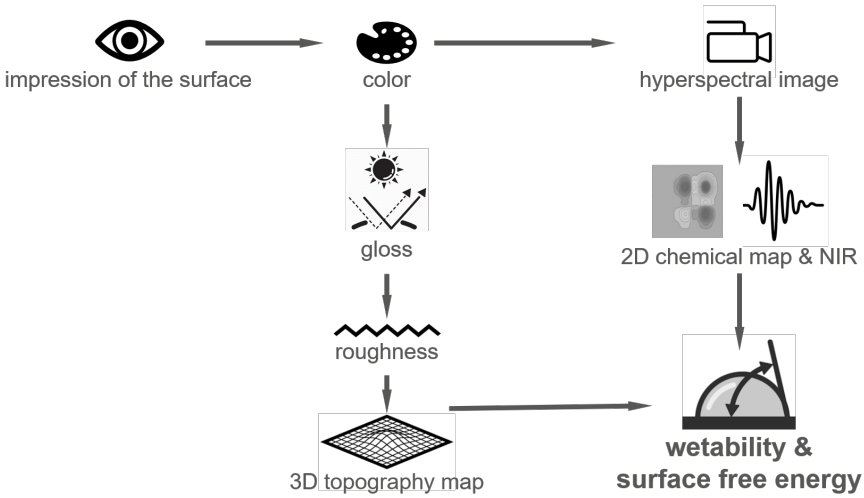


Fig. 1. Surface characterization of biological origin materials from wettability perspective.

Discrete Modeling and Thermal Analysis of FDM/FFF Additive Manufacturing Processes

Dyskretne modelowanie i analiza termiczna procesów wytwarzania addytywnego FDM/FFF

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Abstract
The study presents a discrete model of the 3D FDM/FFF printing process, combining the reconstruction of material deposition trajectories with a dynamic thermal analysis within the DEM framework. The approach enables the reproduction of real printing paths, assignment of mass to discrete elements, and identification of thermal contacts between elements and the substrate. Geometric consistency was verified by comparing geometry, mass, and printing time with reference data, while the thermal component was validated using a virtual temperature sensor model that accounts for spatial averaging and dynamic system response.

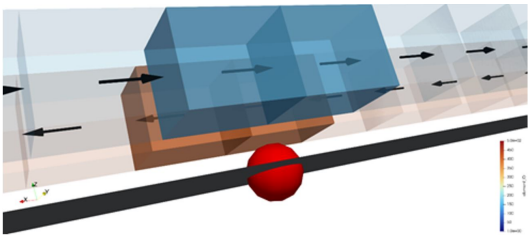


Fig. 1. Reconstruction of the first two printing paths and discrete elements used for virtual temperature sensor modelling.

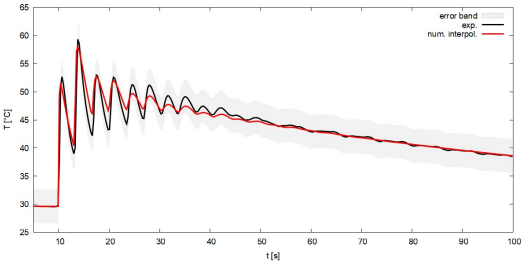


Fig. 2. Comparison of virtual sensor temperature with experimentally measured temperature.

Good agreement with experimental data was achieved in terms of temperature dynamics. Sensitivity analysis revealed a dominant influence of heat conduction in the direction normal to the layers, heat transfer with the substrate, and convection. The use of effective parameters allowed compensation for model simplifications and improved agreement with measurements. The model provides a flexible geometric representation of elements (including spherical and cuboidal ones) and integration with existing DEM frameworks, enabling realistic simulations of additive manufacturing processes. It constitutes a coherent framework for modelling coupled geometric and thermal phenomena in FDM, suitable for analysis and optimization of more complex structures.

Smart microactuators based on shape memory polymers

Inteligentne mikro-siłowniki na bazie polimerów z pamięcią kształtu

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Abstract

Key shape memory parameters for the innovative material - Shape Memory Polymer (SMP) - Shape fixity R_f and Shape recovery R_r - were determined with high accuracy in a thermomechanical loading program conducted in a modified thermal chamber of the Instron testing machine. Figure 1 presents the procedure scheme and the results obtained for an Anycubic resin specimen with an exposure time of 2 s per layer. The results indicate a shape fixity of ≈ 86% and a shape recovery of ≈ 79%, confirming the good shape memory performance of the investigated polymer.

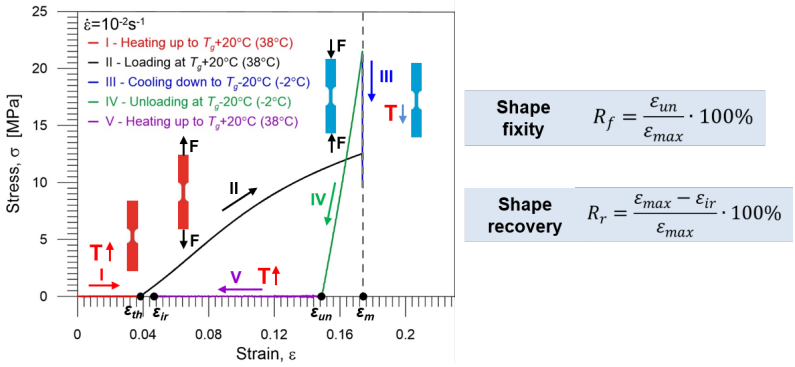


Fig. 1. Stress-strain curves obtained for shape memory photopolymer during the thermomechanical loading program.

Micro-actuators were designed and fabricated using additive manufacturing technologies. Different exposure times were applied during the printing process to obtain devices with varying material responses. This approach allows the production of components with different degrees of polymerization by applying different exposure times to selected regions of the photopolymer. As a result, programmed shape changes can be triggered by stepwise heating to various temperatures. The enhanced functionality of SMP-based actuators enables their miniaturization, which is essential for applications in robotics and biomedical engineering.

Acknowledgements: The research has been supported by the NCN - Grant UMO-2024/53/B/ST8/03931 and the KMM-VIN Research Fellowship Programme (16th Call).

Numerical Modeling of Turbulent Multiphase Flows Using the Euler–VoF Method

Modelowanie numeryczne turbulentnych przepływów wielofazowych z wykorzystaniem metody Euler–VoF

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Abstract
Multiphase turbulent flows are encountered in numerous industrial applications, including spray systems, atomization processes, heat and mass transfer equipment, combustion technologies, and direct contact condensation (DCC). Accurate prediction of interfacial dynamics, phase distribution, and turbulence effects remains one of the major challenges in computational fluid dynamics. The Euler–Volume of Fluid (Euler–VoF) approach is widely applied to simulate gas–liquid flows with deformable interfaces; however, the accuracy of the predictions strongly depends on the selected turbulence model. Therefore, assessing the capabilities and limitations of turbulence models in reproducing complex multiphase flow phenomena is essential for the reliable simulation and design of industrial systems [1,2].
The structure and stability of the liquid jet strongly depend on the geometric parameters of the nozzle, including the outlet diameter, outlet channel length, and outlet angle. Computational Fluid Dynamics (CFD) has become a widely used tool for analyzing fluid flow and heat transfer processes and can be effectively applied to study the influence of nozzle geometry on spray development and liquid jet breakup [3]. In the present study, a nozzle with an internal diameter of $d = 4mm$, an outlet channel length of L = 8 mm, and an outlet angle of $\beta = 20°$ was investigated (Fig. 1a). Numerical simulations were performed using a coupled Eulerian–Lagrangian approach with the Volume of Fluid (VoF) method for interface reconstruction and transition modeling between the continuous liquid phase and dispersed droplets. The continuous phases, namely water and air, were modeled within the Eulerian framework, whereas detached droplets were tracked using a Lagrangian approach (Fig. 1b). To reduce computational cost while maintaining sufficient accuracy in interface representation, Adaptive Mesh Refinement (AMR) was applied in regions characterized by large gradients of volume fraction and flow variables. The obtained results provide insight into the influence of turbulence modeling on the prediction of jet evolution, interface deformation, and droplet formation, contributing to the development of more reliable numerical tools for multiphase flow simulations.

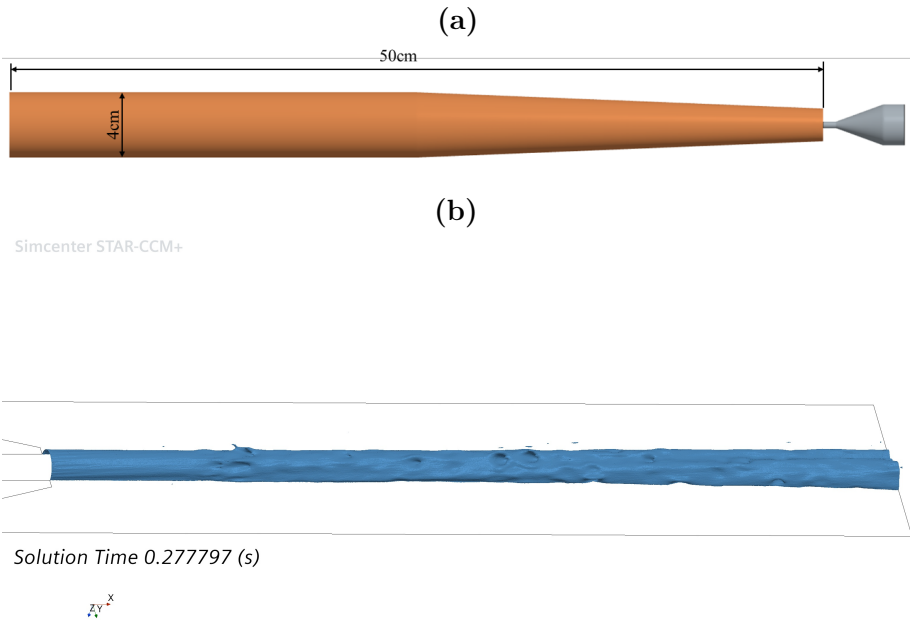


Fig. 1. View of the simulation domain (a), and iso-surface of volume fraction function $\alpha = 0.5$ representing interface between water and air (b).

Acknowledgements: Funded by the National Science Centre, Poland under the OPUS call in the Weave programme (Grant number: 2023/51/I/ST8/02700).

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Remarks on thermal discharge modelling of waste heat in the sea – a case study of the planned nuclear power plant in Lubiatowo, Poland

Uwagi na temat modelowania rozprzestrzeniania się ciepła odpadowego w morzu na przykładzie projektowanej elektrowni jądrowej w Lubiatowie, Polska.

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Abstract
Since the 1950s, global electricity production has been steadily increasing, with a growing share coming from nuclear power plants. Nuclear power plants typically operate at a thermal efficiency of approximately 33%. This means that for every 1 kWh of electricity generated, roughly 2 kWh of waste heat must be dissipated. One of the most common methods of discharging this waste heat is through cooling water systems that release heated water into a receiving water body, such as a river, lake, or the sea (open cooling system). For such systems to operate safely, the receiving water body must have sufficient assimilative capacity to prevent recirculation of heated water back to the intake and to avoid significant negative environmental impacts.
Under current Polish and European regulations, assessing the environmental impact of such discharges is mandatory and requires a multi-stage analysis, including field measurements, numerical modeling, and environmental studies. The need to manage waste heat in an environmentally responsible manner has made the accurate prediction of thermal plume behavior an important area of research in fluid mechanics and hydraulic engineering.
The first studies describing methods for calculating the mixing of heated water with ambient water and determining the extent of thermal anomalies date back to the 1950s. Today, the mathematical models and procedures used for such calculations are well-established within the technical sciences. In Poland, scientific and applied research on the dispersion of heated water in rivers, lakes, and the sea has been conducted since the 1960s by the Institute of Hydro-Engineering of the Polish Academy of Sciences (IBW PAN) in Gdańsk.
This paper presents the initial methodological assumptions for thermal discharge modelling with a flow rate of $Q = 150 m^3/s$ and $\Delta T = 10°\mathrm{C}$ above ambient. Particular attention is given to near-field and far-field modelling, model calibration, and heat exchange with the atmosphere. The calculations indicate that the isotherm corresponding to a temperature increase of Δ T $= 2°\mathrm{C}$ remains within approximately 300–400 meters on average from the discharge point.

Unsteady Aerodynamics in Vibrating Transonic Blade Cascades: Experimental and Numerical Investigations

Niestacjonarna aerodynamika drgających transonicznych kaskad łopatkowych: badania eksperymentalne i numeryczne

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Abstract
The prediction and control of unsteady aerodynamic forces remain among the key challenges in the design of modern high-speed turbomachinery. Reliable assessment of dynamic blade loading, aerodynamic damping, and flutter susceptibility requires a detailed understanding of the complex interaction between blade motion, shock-wave dynamics, and transonic flow structures. This lecture summarizes recent experimental and numerical investigations conducted by the authors aimed at improving the understanding of unsteady aerodynamic phenomena in transonic blade cascades. Particular attention is devoted to forced blade oscillations and the influence of vibration patterns on the resulting aerodynamic loading. To support these studies, a dedicated transonic test facility has been developed, enabling controlled multi-blade excitation under well-defined flow conditions. The presented research combines several advanced diagnostic techniques, including unsteady surface pressure measurements, optical blade-motion tracking, strain-gauge force measurements, and high-speed schlieren visualization of shock-wave dynamics. These experimental investigations are complemented by unsteady CFD simulations, allowing detailed analysis of blade–flow interaction mechanisms and assessment of the capabilities of current numerical methods. Selected results from recent studies will be presented to illustrate the effects of blade vibration parameters on the unsteady flow field and aerodynamic forces. The combined experimental–numerical approach provides valuable insight into the physical mechanisms governing dynamic loading in transonic cascades and contributes to the validation and development of prediction methodologies for aeroelastic phenomena in modern turbomachinery.
Acknowledgements: This research was supported by the Ministry of Education Youth and Sports of the Czech Republic under the grant LUAUS23231.

Experimental Study of Hybrid Heat Pipe–Water Cooling Concepts for High-Heat-Flux Applications

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Abstract

The global electricity consumption of data centers was estimated at 415 TWh in 2024 and has increased by approximately 12% per year over the last five years. Cooling accounts for around 30% of total energy demand, particularly in older infrastructures, making thermal management a key factor for reducing both operating costs and CO_2 emissions. Conventional air-based cooling systems, such as CRAC (Computer Room Air Conditioning), cool the air in server rooms and are therefore relatively inefficient compared to modern liquid cooling approaches, which directly remove heat from CPUs and GPUs via a highly turbulent liquid flow.

In compact electronic systems such as notebooks, smartphones, and air coolers, heat pipes (HPs) and vapor chambers (VCs) are widely used to distribute heat from localized sources over larger surfaces for dissipation to ambient air. However, their condenser sections are typically still cooled by forced air convection, which requires fans and large fin structures.

This work investigates hybrid cooling concepts that combine heat pipes or vapor chambers with direct water cooling. Instead of dissipating heat via air, the condenser side is thermally coupled to circulating water in order to enhance heat transfer and reduce reliance on air flow. Three different experimental configurations were developed: (i) heat pipes integrated with water-circulating silicone tubes replacing conventional fins, (ii) an air cooler fully enclosed in a water-filled container with forced circulation, and (iii) a vapor chamber with a directly mounted water-conducting enclosure on the condenser side to enable direct heat extraction.

Experiments were conducted using a heated copper block (60 x 60 x 15 mm) as a CPU surrogate, with heat inputs of up to 250 W. Thermal performance was evaluated via temperature differences between heat source and coolant, allowing calculation of thermal resistances under different operating conditions.

The investigated systems achieved thermal resistances between 0.05 and 0.09 K/W. These results demonstrate performance comparable to state-of-the-art direct liquid cooling solutions while offering additional advantages, including reduced liquid flow velocities, improved tolerance to pump failures, and increased flexibility in coolant selection.

The prospects of V2X development in Poland

Perspektywy rozwoju technologii V2X w Polsce

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Abstract
V2X technology is a general term for all of the uses of bidirectional chargers of electric vehicles (EV) including: V2H – vehicle to home, V2B – vehicle to building and V2G – vehicle to grid. In this approach, an EV is considered an energy storage that can supply the flexibility services for households, building or even a grid, for some part of the day. While the concept is known and considered for more than 10 years, the development of this technology is very slow and even now based mainly on pilots.
Considering the rapid development of EV fleet in Poland, the team made a deeper analysis, including the organization of brainstorming workshops with key stakeholders (representatives of DSO, TSO, energy trader, EV club, local administration and V2H users) to: first, establish the barriers for development of V2X technology, second, evaluate the benefits and possible scope of the technology in the near future and, last but not least, to draw the path for the V2X technologies in Poland.
The research showed that the biggest barriers are the technical ones: lack of standardization of communication protocols for cooperation of cars and chargers is limiting the market. At the moment, most of the available V2G chargers only cooperate with a limited numbers of brands and cars. The other barriers affect different use cases in different scales, e.g. V2H is technology that can be easily implemented at the prosumers, while V2G requires much more legislation change and establishment of business models to make it attractive to aggregators. Regarding the development prospects, it is expected that V2H will be developing steadily, but slowly, especially as presents a limited return on investments; V2B will be used and considered by companies when the availability of the chargers increase and the price of the chargers will drop more or less by half. The potential of V2G is limited and it is unlikely the V2G scheme will be present before 2035, outside of pilot projects.

Acknowledgements: The work results were obtained in studies co-financed by the Interreg Central Europe, project V4Grid.

Anodization of magnetron-sputtered titanium films on ITO coated glass substrates: Phenomena governing the formation of aligned and separated titania nanotubes at the fluid-solid interface

Anodowanie magnetronowo rozpylanych warstw tytanu na szklanych podłożach powlekanych ITO: modele powstawania przylegających i rozstawionych nanorurek ditlenku tytanu na granicy ciecz-ciało stałe

Krzysztof Wojno[1,2,*], **Jakub Szarmach**[1,2], **Bartosz Hrycak**[1], **Dariusz Czylkowski**[1], **Katarzyna Grochowska**[1], **Katarzyna Siuzdak**[1], **Jacek Ryl**[2]

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Abstract
The development of reliable and accessible platforms for controlled surface modification remains a key challenge in modern materials engineering. Techniques such as plasma treatment, laser and thermal processing are widely used to tailor the physico-chemical properties of materials in catalysis, sensing, and energy technologies. Examples include modification of conductive polymers, activation of composite electrodes, or even calcination and structurization of anodized titanium oxide layers. In many cases, however, achieving precise and reproducible exposure of the material surface to the treatment source remains a significant limitation.
In this work, we present a low-cost automated modification platform based on a repurposed 3D printer. By replacing the printing head with a plasma torch, the printer's motion system is used to guide the plasma source across the sample surface in a controlled and repeatable manner. The system enables programmable control of parameters such as plasma-sample distance, scanning speed, spacing between successive passes, and the number of scans applied to a given region. This approach allows automated and reproducible treatment of entire surfaces while maintaining the flexibility associated with additive manufacturing platforms.
As a proof of concept, the system was used for plasma modification of 3D-printed conductive electrodes composed of PLA with carbon nanostructure additives. The treatment etched the polymer matrix, increasing the exposure of conductive carbon domains on the electrode surface. The obtained results demonstrate that the proposed platform can serve as a versatile tool for controlled surface modification and development of low-cost functional materials.
Moreover, we present the laser-assisted modification of semitransparent oxide nanotubes as surface modification and patterning strategy. The electrochemical studies show that laser-treated semitransparent oxide materials can be considered as potential electrodes for photoelectrochemical devices due to their enhanced photo-responsive behavior.
Acknowledgements: Research was realized within project no SKN/SP/658313/2026 financially supported by MNiSW. The work was also supported by the National Science Centre (Republic of Poland) under Project no 2021/41/B/ST8/01849.

Hybrid Decarbonization of District Heating Systems – Why Cost Optimization is Not Enough? The Case Study of Ustka

Hybrydowa dekarbonizacja systemów ciepłowniczych – dlaczego optymalizacja kosztowa to za mało? Studium przypadku Ustki

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Abstract
The transition of district heating systems in Poland, where coal still accounts for more than 57% of the fuel input, requires a shift toward low-emission hybrid systems. This paper presents a case study of the municipal network modernization in Ustka, focusing on the confrontation of mathematical operational optimization results with the physical constraints of the low-temperature heat source.
The research methodology was based on two complementary pillars: an optimization model (Solver) that minimizes operating costs (OPEX) based on real market signals from the Polish Power Exchange (TGE), and an advanced 3D numerical model (ANSYS) of a field of 122 vertical boreholes of a ground heat exchanger. The optimization results indicated that the most economically advantageous solution (OPEX approx. 38.5 PLN/GJ) is a CHP-led configuration working with ground-source and air-source heat pumps, with an optimal capacity split of 1.2 MWel (CHP) and 3.0 MWth (heat pumps).
However, a rigorous thermodynamic analysis of the reservoir showed that pure cost optimization is insufficient for making a secure investment decision. Transient simulations of the borehole field demonstrated that at a 1.0 MW power extraction, the ground does not reach thermal equilibrium. The temperature deficit in the active geological layers exceeds 2 K even after 6 months of regeneration, leading to a permanent, cumulative cooling of the low-temperature source in subsequent years of operation.
The study proves that the decarbonization of municipal systems must consider ground regeneration dynamics as a critical parameter, superior to economic indicators. Final recommendations indicate the necessity of using hybrid systems where air-source heat pumps (ASHP) relieve the ground heat exchanger, ensuring long-term durability and the physical stability of the entire system.
Keywords: decarbonization, hybrid optimization, ground heat exchanger (GHE), municipal district heating, 3D ANSYS simulations.

An example of effective cooling technique for CPV system

Przykład efektywnej techniki chłodzenia w systemie CPV

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Abstract
The growing worldwide demand for energy, together with the urgent need to develop sustainable energy solutions, has driven significant advancements in photovoltaic (PV) technologies. Among these innovations, concentrated photovoltaic (CPV) systems have emerged as a promising alternative to conventional PV installations. By employing optical devices that concentrate solar radiation onto high-efficiency photovoltaic cells, CPV technology offers the potential for enhanced energy conversion efficiency.
To increase the amount of generated energy, concentrated photovoltaic (CPV) technology utilizes optical concentrators that focus solar radiation onto small, highly efficient photovoltaic cells. Due to their superior electrical performance, both CPV and concentrated solar power (CSP) technologies have attracted considerable research interest when compared with conventional photovoltaic systems. CPV installations employ optical concentration methods to direct and intensify sunlight onto advanced multi-junction solar cells, enabling more effective utilization of incoming solar energy. Furthermore, CPV modules are typically equipped with solar tracking mechanisms that continuously adjust their position to follow the sun's movement, thereby maximizing solar irradiance capture throughout the day [2].
In our study, we proposed active liquid cooling, specifically using glycol. Initially, three geometries were analysed for optimal heat transfer, and the one with the best parameters was selected. The solution was then compared with those described in the literature.
Acknowledgements: The work results were obtained in the project: Opracowanie produkcji I linii produkcyjnej EleWall - modułowej fasady fotowoltaicznej o wysokiej sprawności w technologii Concentrated Photovoltaics
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Parametric analysis CFD of the wind loads on the industrial steel chimney depending on the distance from a nearby building

Analiza parametryczna CFD obciążeń wiatrowych działających na przemysłowy komin stalowy w zależności od odległości od pobliskiego budynku

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Abstract
Slender industrial structures often have a low mass-to-stiffness ratio, which makes them highly susceptible to strongly unsteady and chaotic wind actions. The close proximity of neighboring buildings can change the wind dynamics acting on a slender structure by creating zones of turbulence and increasing wind pressure on the structure. Furthermore, climate change, which is causing an increase in the number of violent storms and gales, keeps the issues of structural safety and the proper selection of wind loads in the design process constantly relevant. This paper presents a parametric CFD analysis, which examined the impact of wind speed, height, and distance of surrounding structure on wind loads on a 100-meter steel industrial chimney. CFD analysis was performed for several cases of wind speed, wind direction, height, and distance of surrounding structure. The results obtained were compared with the results of the standard procedure for wind load assessment (EN 1991-1-4:2005 Eurocode 1) and a comparative analysis was performed.

Index of authors.

A
Acquah, R. – 22,
Aleixo, R. – 72,
B
Badur, J. – 23, 35, 79,
Bagiński, P. – 26,
Banaszkiewicz, M. – 24,
Bochentyn, B. – 41,
Bogucka-Bykuć, K. – 29, 64,
Bogulicz, M. – 26,
Borzyszkowski, T. – 25,
Breńkacz, Ł. – 26,
Bryk, M. – 27, 50, 77, 79,
Bugaj, M. – 42,
Bykkam, S. – 41,
Bykuć, S. – 29, 64, 75,
Bzymek, G. – 30,
C
Cenian, A. – 27, 31, 39, 52,
Cerkowniak, G. – 72,
Chaja, P. – 78,
Coy, E. – 41,
Cudo, K. – 41,
Czylkowski, D. – 75,
D
Diaz Lantada, A. – 69,
Dolna, O. – 32,
Dors, M. – 62,
Dubey, V.P. – 33,
Duda, P. – 34,
Dudda, W. – 23, 35, 57,
Dziubiński, Ł. – 36,
E
F
Filipek, D. – 41,
Frankowska, N. – 40,
Fürst, J. – 73,
G
Giersig, M. – 58,
Gliński, M. – 42,
Głowienka, D. – 41,
Gołębiewski, D. – 37,
Grochowska, K. – 41, 43, 75,
H
Hac, B. – 31, 39, 52,
Hamrani, C. – 40,
Haryńska, A. – 41,
Haryński, Ł. – 41,
Hála, J. – 73,
Hrycak, B. – 75,
I
J
Jarosiński, S. –34,
K
Karch, M. – 53,
Karwacki, J. – 42,
Khan, S.I. – 43,
Kharchenko, Y. – 44,
Kodlewicz, T. – 37,
Kopeć, M. – 33,
Koshlak, H. – 46,
Kowalczyk, M. – 47, 50,
Kowalczyk, T. – 47, 48, 50, 51, 77,
Kowalewski, Z.L. – 33, 49,
Kruk-Gotzman, S. – 37, 48, 50,
Krupa, K. – 48,
Krupa, S. – 51,
Kuligowski, K. – 27, 52,
Kwidzińska, D. – 41,
L
Lepičovský, J. – 73,
M
Madejski, P. – 53, 70,
Miazio, Ł. – 55, 68,
Mik, K. – 42,
Miotk, R. – 62,
Moczulak, B. – 56, 57,
N
Nowak, Z. – 58,
O
Ochrymiuk, T. – 23, 24, 27, 30, 31, 37, 50, 52, 78, 79,
Ozga, A. – 40, 59,
P
Pavlenko, A. – 60,
Piątkowski, S. – 61,
Pieczyska, E. – 69,
Płusa, T. – 34,
Podliński, J. – 62,
Półrolnik, T. – 62,
Przybyliński, T. – 63,
Puchalski, B. – 26
R
Radziszewska, W. – 29, 64, 75,
Rolka, P. – 63,
Ryl, J. – 75,
S
Sandak, A. – 65,
Sandak, J. – 22, 66,
Sala, R. – 34,
Schönhofer, J. – 72,
Siuzdak, K. – 41, 43, 75,
Sobieski, W. – 36, 61, 68,
Staszczak, M. – 69,
Stella, M. – 72,
Szałowski, B. – 70,
Szarmach, J. – 75,
Szmytkiewicz, P. – 72,
Szwaba, R. –25, 78,
Š
Šidlof, P. – 73,
Šimurda, D. – 73,
T
Tabrizi, A.H. – 53,
Tański, M. – 62,
V
Verstraete, J. – 29, 64, 75,
Vogt, J. – 74,
W
Wojno, K. – 76,
Z
Zagrodzki, I. 77,
Ziółkowski, P.J. – 23, 35, 78, 79