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Faculty of Mechanical Engineering

Brno University of Technology

43rd MEETING OF THE DEPARTMENTS OF FLUID MECHANICS AND TERMOMECHANICS

Collection of abstracts

ČEŠKOVICE 2026

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Program konference

Středa 24. 6. 2026

	10:00 – 11:45	*Registrace*	
	12:00 – 13:00	***Oběd***	
	13:00 – 13:20	*Zahájení konference*	
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	13:40 – 14:00	**prof. Ing. Václav Uruba, CSc.** *Spanwise Coherence in a Circular-Cylinder Wake*	ZČU
	14:00 – 14:20	**doc. Ing. Marek Mlkvik, PhD.,** *Water Micro-Drop Deposition after Oblique Impact on Solid Surface*	STU
	14:20 – 14:40	**Ing. Marian Ledvoň, Ph.D.** *Hydraulic Resistance of Cenosphere Filtration Beds*	VŠB
	14:40 – 15:00	**Ing. Kryštof Lebeda** *Centrifugal Pump Operating in Pump, Energy-Dissipation and Turbine Regimes*	VUT
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Numerical Analysis of Cavitation Development in a Single-Blade Slurry Pump

Dávid Vranský[*], *Marek* Mlkvik, Róbert Olšiak *and Branislav* Knížat

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Abstract. The Cavitation is a harmful phenomenon in pumps, as it can cause performance degradation, pressure pulsations, vibration and erosion damage. Single-blade slurry pumps are commonly used for transporting wastewater, slurry and liquids containing solid or fibrous particles due to their high passage capability and reduced risk of clogging. In this study, cavitation development in a single-blade slurry pump was investigated using CFD. The numerical model was created in ANSYS CFX and included the complete hydraulic domain of the pump. Cavitation was modelled using the Zwart-Gerber-Belamri model and turbulence was described by the *SST k-ω* model. The simulations were performed at a fixed flow rate and decreasing inlet absolute pressure. The results were analysed for three inlet absolute pressures: 70 kPa, 35 kPa and 19,5 kPa. Vapour-dominated regions were identified using the criterion of water vapour volume fraction $\alpha_v > 0{,}5$. The results showed that decreasing inlet pressure led to a substantial increase in cavitation extent. The mean volume of the vapour-dominated region increased from $2{,}83\times10^{-6}\,\mathrm{m}^3$ at 70 kPa to $1{,}33\times10^{-4}\,\mathrm{m}^3$ at 19,5 kPa. The pressure fields confirmed that vapour formation occurred in regions of reduced absolute pressure.

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Downstream evolution of spanwise coherence in a circular-cylinder wake

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Abstract. The spanwise coherence of velocity fluctuations in the wake of a circular cylinder is investigated experimentally at a Reynolds number of $Re \approx 5000$ using time-resolved stereoscopic particle image velocimetry. Three-component velocity fields are measured in a set of cross-stream planes downstream of the cylinder, allowing access to both spatial and temporal dynamics of the wake. The analysis is focused on the wake centerline, where two-point correlations of the streamwise and cross-stream velocity fluctuations are evaluated along the spanwise direction. The corresponding integral correlation length scales are determined as functions of the downstream position to quantify the persistence of coherent motion. In addition, the power spectral densities of the velocity components are examined at a representative centerline location to relate spanwise coherence to the flow's dominant unsteady dynamics. The results show a progressive loss of spanwise coherence with increasing downstream distance, with the cross-stream velocity component exhibiting stronger correlation associated with vortex shedding, while the streamwise component reflects broader wake organization. The integral length scales decrease downstream, indicating the breakdown of organized structures and the onset of turbulence-dominated dynamics. The present study provides a compact experimental characterization of spanwise coherence in a transitional cylinder wake and establishes a basis for further investigation of three-dimensional wake dynamics using time-resolved measurements.

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Numerical study on water micro-drop deposition after oblique impact on solid surface

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Abstract. The interaction of micro-drops with solid substrates is a key physical process in a wide range of technological applications, such as the fabrication of functional nano-coatings. Although some previous works simplify the problem by assuming normal (perpendicular) impact, industrial processes—such as the coating of geometrically complex medical implants—are characterised by substantial deviations in drop incidence trajectories. This study utilises numerical simulations based on the Volume of Fluid (VOF) method, accelerated by a GPU-based solver, to investigate the effect of the impact angle on the interaction regimes of micro-drops (diameter < 10 μm) dry surfaces. The results are generalised using the dimensionless criterion *K*, which accounts for inertial, viscous, and surface tension forces. The simulations reveal that the impact angle shifts the transition threshold between deposition and splashing. For $\alpha < 30^\circ$, the onset of splashing occurs at a lower value of $K = 45$, compared to the threshold of $K = 57.7$ reported for strictly perpendicular impacts ($\alpha = 0^\circ$). In contrast, for larger impact angles ($\alpha > 40^\circ$), the drops exhibit increased resistance to splashing, with stable deposition that persists even at $K = 65$. These findings provide qualitative insight into the impact phenomena of oblique drops impact and provide quantitative guidelines for the optimisation of spray-coating process efficiency in industrial applications.

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Experimental Determination of Hydraulic Resistance Coefficients of Cenosphere Filtration Beds

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Abstract. This paper presents an experimental investigation of hydraulic resistance coefficients of a filtration bed composed of cenospheres of different size fractions. The experiments were carried out in a cylindrical column with an inner diameter of 40 mm, using bed heights ranging from 5 to 25 mm and flow rates between 0.2 and 4 $dm^3 \cdot min^{-1}$. The pressure drop was measured immediately upstream and downstream of the filtration bed. The experimental data were evaluated using the Darcy–Forchheimer model. This approach enabled the determination of the permeability and the inertial resistance coefficient. The results demonstrate a significant dependence of these coefficients on particle size. Furthermore, the observed influence of bed height on the calculated parameters suggests possible compaction effects or wall friction. These empirical parameters serve as essential inputs for CFD modeling of cenosphere-based porous media and provide a basis for the hydraulic design and scale-up of industrial filtration units.

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Numerical Investigation of the Pump, Energy-Dissipation and Turbine Regimes of a Radial Centrifugal Pump Converted into a PaT

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Abstract. The use of centrifugal pumps operating as turbines (PaTs) has become an attractive solution for energy recovery in water distribution networks and small-scale hydropower, owing to their low cost and wide availability. While the pump and turbine operating modes of such machines are relatively well documented through characteristic curves, the transition between these regimes and in particular the energy-dissipation regime that separates them remains comparatively unexplored, despite its importance for understanding off-design operation and operational stability.

This paper presents a computational fluid dynamics (CFD) investigation of a radial centrifugal pump operating across three consecutive regimes: normal pumping, the energy-dissipation regime, and turbine operation. The study is deliberately confined to this continuous part of the complete characteristic, covering the path from operation close to the shut-off point, through the energy-dissipation zone, and into stable turbine operation. The remaining branches of the full four-quadrant characteristic are outside the present scope. A three-dimensional model of the machine is developed and a systematic mesh-independence study is carried out to ensure that the predicted integral quantities and flow structures are not influenced by spatial discretization. The numerical results are validated against experimental measurements, showing good agreement for the global performance characteristics in both pump and turbine modes.

Beyond the reproduction of the characteristic curves and the identification of the best-efficiency points (BEP) in pump and turbine modes, particular attention is given to the internal flow behavior in the regions close to the transitions between the three regimes. The analysis reveals the development of complex flow features including recirculation, flow separation, and strongly unsteady structures. These results provide physical insight into the mechanisms governing the regime transitions and highlight flow phenomena that are not captured by performance curves alone, with implications for the reliable design and operation of PaT installations.

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Experimental imaging of supercritical discharge of bubbles in a liquid jet

Pavel Novosad[*], *Jiri* Hajek, *Milan* Maly, *and Jan* Jedelsky

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Abstract. Primary breakup in twin-fluid internal mixing atomisers is governed by the intermittent passage of gas-liquid structures through the discharge orifice; yet, the instability mechanisms at the orifice remain insufficiently characterised at the relevant temporal and spatial scales. This study presents a high-speed imaging investigation of orifice flow instability in a transparent nozzle with a refractive-index-matched working fluid, enabling direct imaging of bubble transit events at 120 000~fps across a range of discharge pressures and bubble sizes. Vena-contracta separation was found to limit optical access, restricting observations to bubbles large enough to cause wall attachment. In the wall-attached regime, the dominant jet oscillation frequency scales near-linearly with the discharge Weber number, implicating surface tension as the governing parameter. During bubble transit, periodic gas-jet pinch-off consistent with Kelvin-Helmholtz instability is observed; the measured instability wavelength is systematically underestimated by analytical predictions for both Rayleigh and Rayleigh-Taylor instability modes.

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Numerical Mesh Sensitivity Study of Flow-induced Acoustic Resonance in Closed Side-Branches

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Abstract. Flow-induced acoustic resonance in closed side branches represents an important aeroacoustic phenomenon occurring in many industrial piping systems. Since the prediction of such coupled hydrodynamic–acoustic behavior is highly sensitive to numerical discretization, the present study investigates the influence of mesh resolution, near-wall treatment, and inlet velocity profile generation on the accuracy of CFD simulations of closed side-branch resonance. A precursor-pipe approach was used to generate a sufficiently developed inlet velocity profile prior to the main simulations, while several precursor meshes with progressively refined cell sizes and near-wall resolution were evaluated to assess profile convergence. The main simulations were performed on four computational meshes with increasing refinement, including a locally adapted mesh in the shear-layer region, for inlet velocities of 10 m/s, 14 m/s, and 18 m/s. Pressure signals were monitored at the closed end of the branch and at multiple locations within the shear layer to identify dominant oscillation modes and evaluate the coupled resonance behavior. The results highlight the importance of consistent inlet profile generation, adequate near-wall resolution, and local shear-layer refinement for accurate prediction of flow-induced resonance phenomena in closed side-branch configurations.

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Research on Capture Efficiency of a Reinforced Slot Exhaust Hood for Lighter-than-Air Contaminants

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Abstract. The reinforced slot exhaust hood (Aaberg exhaust hood) extends the capture distance of contaminants by combining suction with supply air through one or two supply slots, overcoming the limitations of traditional local exhaust ventilation. When assessing capture efficiency using the tracer gas method with CO_2, a systematic bias occurs: CO_2 has a higher density than air (Archimedes number $Ar = -0.0012$), sinks towards the partition (workbench) beneath the exhaust hood, accumulates on it and is captured all at once, causing an overestimation of efficiency and occasional measured values exceeding 100 %. As a solution, positioning the partition above the exhaust slot – an "upside-down" configuration – was proposed. This configuration eliminates CO_2 accumulation on the partition and simultaneously models the capture of lighter-than-air contaminants (welding fumes, soldering vapours) with an equivalent density of 0.62 $kg \cdot m^{-3}$ ($Ar = +0.0012$). Comparison of capture efficiency maps with previously published results for the partition in the normal position clearly demonstrates the effect of tracer gas density: the measured capture distance decreased from $x/b \approx 78$ to $x/b \approx 30$ after elimination of the systematic error.

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Influence of wheel rotation on tire wear particles sampling under roller test bench conditions

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Abstract. Tire abrasion at the tire–road contact interface generates microscopic rubber particles on the order of micrometers, which are subsequently dispersed into the atmosphere and can be transported to aquatic systems and soil. The associated environmental impact represents a potential hazard to living organisms due to particle inhalation and ingestion. This study investigates the dispersion behavior of tire wear particles (TWPs) in the vicinity of their generation on a real passenger vehicle. The primary objective is to identify the dominant parameters governing particle transport trajectories, thereby supporting the development, refinement, and correction of laboratory measurement methodologies. The parameters were evaluated using numerical simulations conducted in Ansys Fluent, with particular attention to wheel rotational speed and tire tread pattern. In addition, the study examines the influence of sampling device positioning and the effect of the imposed volumetric flow rate.

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Spray deposition of antibacterial coatings

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Abstract. This study investigates the antibacterial properties of functional coatings prepared by a spray deposition technique utilizing an in-house developed mesh nebulizer-based coating device. The thin layers were deposited onto silicon wafers with varying deposition intensities, specifically 5, 10, and 20 passes of the coating device at constant speed of 50 mm/s. The surface morphology and coverage were characterized using scanning electron microscopy, while the antibacterial efficacy was quantitatively evaluated via flow cytometry with fluorescent probe propidium iodide against *Staphylococcus epidermidis* CCM 4418 and *Escherichia coli* CCM 3954. The results demonstrate that the coating prepared with 20 nozzle passes exhibited the highest antibacterial activity. For *S. epidermidis*, the proportion of PI-positive cells indicating membrane-compromised bacteria reached 66.0% (± 0.7%), significantly higher than the control measurement of 8.5% (± 5.5%) in a solution that has not been exposed to the coated wafers. In the case of *E. coli*, the coatings achieved 33.8% (± 1.0%) bacterial mortality, compared to 3.6% (± 1.1%) for the control. The lower mortality rate observed in *E. coli* is attributed to the more complex and protective structure of its cell wall compared to Gram-positive bacteria. These findings confirm that mesh nebulizer spray deposition is an effective method for fabricating bioactive surfaces with significant potential for reducing bacterial colonization.

The data that support the findings of this study are openly available at https://zenodo.org under DOI 10.5281/zenodo.20374182.

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Experimental Analysis of Non-Spherical Particle Dynamics and Airflow Interaction in a Rotor Spinning Trash Ejector

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Abstract. This study investigates the aerodynamic behaviour of non-spherical impurity particles within the trash removal system of a Rieter R36 rotor spinning machine. Utilizing high-speed visualization and Particle Image Velocimetry (PIV), the research compares the velocity fields of the airflow (umean=4 m/s) against the trajectories of discrete impurities. Morphological analysis of 1,500 particles established a median circularity of 0.74 and a D50 of 50 µm, parameters which were integrated into a Lagrangian framework using drag correlation. Results reveal a significant velocity slip and decoupling from fluid streamlines near the opening roller exit, where centrifugal forces dominate over aerodynamic drag. The measured mean particle velocity of 2.17 m/s shows excellent agreement with the theoretical prediction of 2.2 m/s. This inertial lag causes particles to follow ballistic-like trajectories, necessitating the optimization of the ejector wall geometry to ensure effective separation and prevent fibres re-contamination.

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Development of gaskets for high-temperature applications in the energy sector

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Abstract. The increasing need for thermal energy storage from renewable sources represents a key challenge for the development of efficient and resilient energy infrastructure. High-temperature thermal energy storage systems commonly employ heat-transfer or storage media such as molten metals or molten salts. Their application, however, imposes demanding requirements on sealing technologies, particularly with respect to chemical compatibility, thermal stability, and operational reliability. Therefore, the development of dedicated sealing systems is essential to prevent leakage of these media into the environment under all operating conditions, including repeated charging and discharging cycles.

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Regulation of surplus electricity in an off-grid photovoltaic system

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Abstract. This paper evaluates the use of electricity from an off-grid photovoltaic system with battery storage and surplus power regulation in a model single-family house. The analysed system consists of a photovoltaic array with an installed capacity of 4.725 kWp, a 5 kW inverter, and a $LiFePO_4$ battery storage system rated at 48 V / 314 Ah and 16.0 kWh. Household consumption represents the typical daily electricity demand of a four-person household, with a daily value of 10.8 kWh. The controlled load represents additional demand used to utilise surplus energy that cannot be directly consumed in the household or stored in the battery storage system. Three operating models are compared: Model A, direct household use; Model B, battery-storage use; and Model C, controlled-load use after the battery has reached its operating limit. Within the 20–80% SOC operating range, the usable battery capacity is 9.6 kWh. After household consumption and battery charging, 1.04 kWh was available for the controlled load on a partly cloudy day and 18.23 kWh on a clear-sky day. The results show that battery storage increases daily photovoltaic energy utilisation, while an additional controlled load is required during periods of higher production.

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Effect of Supplementary Combustion Air Supply on Emission Formation in a Wood Stove

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Abstract. Residential wood stoves represent an important source of local heat production. This study investigates the effect of supplementary combustion air supply on emission formation in a manually operated wood stove. Two operating configurations were compared: fully open combustion air supply and operation with the tertiary air inlet sealed. The concentrations of CO and NOx were measured continuously, and particulate matter concentration was determined by an optical and a gravimetric method. The results showed that sealing the tertiary air inlet had the strongest effect on PM emissions. Under fully open-air supply conditions, PM concentrations were 35.6 $mg \cdot m^{-3}$ by the optical method and 32.9 $mg \cdot m^{-3}$ by the gravimetric method. After sealing the tertiary air inlet, these values increased to 218.7 $mg \cdot m^{-3}$ and 126.1 $mg \cdot m^{-3}$, respectively. In contrast, CO concentration at 13% O_2 changed only slightly, from 1386.5 to 1368.1 $mg \cdot m^{-3}$, while Nox at 13% O_2 increased moderately from 57.4 to 67.1 $mg \cdot m^{-3}$. These results indicate that supplementary air supplied to the upper part of the combustion chamber mainly influenced the burnout of particle-forming species. Further research will focus on repeated measurements and the development of a control strategy for combustion air supply.

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A Comparative Study between a Laboratory and a Pilot-Plant Flue Gas Condenser behind a Biomass Boiler

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Abstract. Flue gas condensation heat recovery represents a significant opportunity to increase the thermal efficiency of biomass energy plants. However, the accurate prediction of the heat transfer coefficient during water vapor condensation in a gas mixture remains a challenging task. This is primarily due to the simultaneous presence of non-condensable gases, progressive fouling of heat transfer surfaces, and unresolved scale-up effects from laboratory to industrial scale, which challenge the reliability of existing design correlations. This paper presents an experimental study of water vapor condensation inside vertical tubes conducted across two scales: a laboratory apparatus (units of kW) operating in the transition flow regime ($5\,050 < Re_{in} < 6\,320$), and a pilot-plant facility (hundreds of kW) in a fully turbulent regime ($12\,224 < Re_{in} < 19\,614$). The effects of cooling medium temperature, flue gas velocity, and inlet flue gas quenching intensity on the inner heat transfer coefficient (α_{in}) were systematically quantified. On the laboratory scale, α_{in} exhibited a strong dependence on the wall temperature, with values ranging from $79\,W/(m^2 \cdot K)$ to $601\,W/(m^2 \cdot K)$ On the pilot-plant scale, the effect of flue gas quenching prior to the heat exchanger inlet was isolated: under otherwise identical hydrodynamic conditions ($Re \approx 14\,800$), flue gas quenching increased the α_{in} value by approximately $104\,\%$ — from $73{,}8\,W/(m^2 \cdot K)$ to $150{,}7\,W/(m^2 \cdot K)$ as a result of the immediate onset of film condensation across the entire heat transfer area.

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Ejector cooling system powered by solar heat for air-conditioning of buildings

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Abstract. The paper deals with the operating conditions and requirements for the control of a small transcritical heat pump with CO_2 as the working medium, designed for the use of low-temperature waste heat. The evaluated system consists of a variable frequency compressor, a gas cooler, an evaporator, an expansion element and a controllable ejector. At the nominal calculation point at an evaporation temperature of −10 °C and a compressor frequency of 50 Hz, the gas cooler output reached 6.0 kW, the evaporator output reached 3.8 kW, the compressor input reached 2.12 kW and the COP reached 2.81. In the evaluated set of operating states, the average COP value was 2.85, with the minimum value being 1.67 and the maximum 3.65. The evaporation temperature had the most significant impact on the COP. Increasing the evaporation temperature from −12 °C to −5 °C increased the COP from approximately 2.40 to 3.30, i.e. by 37.5%. However, this positive effect is limited by the pressure load on the high-pressure side, since at the nominal point the discharge pressure was 92.46 bar and the safety limit of the device was 110 bar. Based on the results, a priority control structure is proposed that takes into account the protection of the high-pressure side, the protection of the heat source from subcooling, and the compressor power control.

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Utilization of the Invasive Plant Reynoutria Japonica for Energy Purposes

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Abstract. The use of renewable energy sources remains a critical focus for promoting sustainable development and environmental protection. This study investigates the use of an unconventional biofuel derived from the biomass of invasive plant species, namely Japanese knotweed (Reynoutria japonica), evaluates its energy potential and impact on air pollution by its combustion in a small heat source. The primary objective of this research is to determine the performance and emission parameters when burning this type of fuel in the form of wood chips in a heat source and evaluate the production of particulate matter (PM) emissions. The research includes a comprehensive physicochemical characterization of selected biomass samples along with empirical measurements of their combustion properties. It quantifies and compares performance and emission parameters in different operational configurations of the combustion process. The added value of this article is also the research on technologies for reducing particulate matter using an electrostatic precipitator implemented as a secondary emission reduction technology. Experimental results show that through an optimal combination of fuel pretreatment and adapted technical configurations of the combustion process, it is possible to significantly minimize the harmful environmental impacts of alternative biomass fuels on ambient air quality. This research brings valuable insights to the current discussion on sustainable biomass use and provides practical recommendations for increasing the ecological safety of localized, decentralized household heating systems. Integrating invasive plant management with bioenergy production represents a viable strategy with a double benefit for ecological restoration and sustainable thermal energy production.

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Physical principles of passive condensate return in pump-less ejector refrigeration systems

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Abstract. Ejector refrigeration systems are a promising alternative to conventional vapour-compression refrigeration, as they can use low-grade heat such as solar or waste heat. In a conventional ejector cycle, however, a mechanical pump returns liquid refrigerant from the condenser to the generator, reducing system simplicity and requiring active pow er input. This paper evaluates physical principles that can replace the pump or eliminate active condensate pumping and provides a preliminary comparison of selected working fluids for passive condensate return. The analysed mechanisms include hydrostatic pressure of a liquid column, pressure generated by heating and phase change, momentum transfer in a gas-liquid ejector, and capillary pressure in a porous structure. A computational comparison of working fluids available in CoolProp is also performed for gravitational and capillary return under selected operating conditions. The principles are assessed in terms of operating conditions, performance indicators, technological maturity, design limitations and working-fluid suitability. The results show that condensate return can be achieved by several physical mechanisms. The final selection depends on the working fluid, available pressure potential, safety and environmental requirements, system layout and the available heat source.

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CFD Modeling of Flow and Heat Transfer Processes in a Cooler for Sampling from an Airlift Fermenter

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Abstract. The article deals with CFD modeling of fluid flow in a cooler designed for sampling from an airlift fermenter. The authors focused on the hydraulic and thermal analysis of a tube-in-tube cooler. Boundary conditions and fluid parameters were determined based on experimental measurements provided by the client and the availability of cooling water.The aim of the study is to obtain a comprehensive understanding of the cooler operation for the proposed geometry derived from balance calculations and client requirements. The CFD modeling includes the analysis of different cooling water inlet configurations and the influence of obstacles (swirl generators) placed in the annular cooling-water region to intensify heat transfer during cooling of the sampled medium. Due to the low velocity of the cooling medium, special attention was paid to the modification of the laminar boundary layer in the heat-transfer area.

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Heat Transfer Research in Industrial Applications

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Abstract. The Heat Transfer and Fluid Flow Laboratory at Brno University of Technology develops experimental methodologies and advanced thermal-fluid solutions for a broad range of industrial applications. In metallurgical processes, the research is focused on the development of methodologies for the characterization and optimization of spray cooling, hydraulic descaling, work roll cooling and controlled heat treatment, combining laboratory measurements, inverse heat conduction methods and numerical simulations. These approaches enable accurate determination of heat transfer boundary conditions and support the design of efficient, robust and energy-saving cooling technologies. An equally important research direction is the development of polymeric hollow fiber heat exchangers for automotive and other industrial applications, where low weight, corrosion resistance, compactness and reduced environmental impact are required. In this area, the laboratory focuses not only on thermal performance, but also on the specific limitations of polymer-based devices, including low material thermal conductivity and the need for reliable fiber fixation and sealing. Current work therefore includes the design of compact and manufacturable hollow fiber modules suitable for automated assembly. The activities also extend toward membrane and separation processes, including gas separation and potential CO2 capture applications, where transport phenomena, heat and mass transfer, and material design are closely interconnected. By linking methodology development, experimental research and industrial implementation, the laboratory contributes to innovation in heavy industry as well as in polymer-based thermal and separation technologies.

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Operating conditions and requirements for control of a transcritical CO_2 heat pump

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Abstract. The paper deals with the operating conditions and requirements for the control of a small transcritical heat pump with CO_2 as the working medium, designed for the use of low-temperature waste heat. The evaluated system consists of a variable frequency compressor, a gas cooler, an evaporator, an expansion element and a controllable ejector. At the nominal calculation point at an evaporation temperature of −10 °C and a compressor frequency of 50 Hz, the gas cooler output reached 6.0 kW, the evaporator output reached 3.8 kW, the compressor input reached 2.12 kW and the COP reached 2.81. In the evaluated set of operating states, the average COP value was 2.85, with the minimum value being 1.67 and the maximum 3.65. The evaporation temperature had the most significant impact on the COP. Increasing the evaporation temperature from −12 °C to −5 °C increased the COP from approximately 2.40 to 3.30, i.e. by 37.5%. However, this positive effect is limited by the pressure load on the high-pressure side, since at the nominal point the discharge pressure was 92.46 bar and the safety limit of the device was 110 bar. Based on the results, a priority control structure is proposed that takes into account the protection of the high-pressure side, the protection of the heat source from subcooling, and the compressor power control.

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Increasing the Efficiency of Heat Sources Using a Heat Pipe

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Abstract. This study investigates the use of heat pipe technology for waste heat recovery in small heat sources, from which a significant amount of thermal energy is dissipated through the chimney to the external environment. This research addresses the inherent thermal inefficiency of standard heat sources, which lose a significant portion of the heat generated by fuel combustion through flue gas emissions transported through the flue gas duct. The paper presents a solution to mitigate these thermodynamic losses by innovatively designing a closed-loop heat exchanger assembly configuration with phase change heat transport. The system design integrates an evaporator section located in the upper zone of the fireplace insert to capture high-temperature waste heat directly from the combustion gases. This captured thermal energy is then transported by a phase change working fluid mechanism through the steam duct to a strategically located condenser section. The condenser, integrated directly into the primary air intake path, enhances the transfer of thermal energy to the incoming combustion air stream. By preheating the ambient intake air before it is introduced into the combustion chamber, the heat source achieves a measurable improvement in overall thermodynamic efficiency. This method of utilizing previously wasted energy recovery reduces the primary fuel requirement needed to deliver the required thermal output. Experimental results show that this configuration results in reduced fuel consumption, lowers local operating costs and minimises environmental impact through reduced greenhouse gas emissions. Such a looped system of exchangers based on the heat pipe principle for waste heat recovery ultimately offers a highly efficient and economical solution for small heat sources, enabling efficiency increases in the range of 5 to 15%.

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Real-Drive Data Acquisition from Electric Vehicles for Thermal Management and Euro 7 Non-Exhaust Particle Assessment

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Abstract. The paper presents an efficient real-drive data acquisition chain for electric vehicles, developed as a scalable basis for thermal management, digital-twin validation and future Euro 7-oriented assessment of non-exhaust particle-related events. The system combines compact CAN/LIN logging, GNSS/IMU data, LTE communication, S3 object storage, automated decoding and dashboard-based visualization. Compared with conventional measurement systems, the proposed solution reduces installation volume, acquisition cost and operational complexity, while enabling long-term measurements during normal vehicle operation. The experimental platform is based on Škoda Enyaq electric vehicles equipped with CAN data acquisition systems. The collected signals include electric-drive quantities, torque and regenerative braking information, longitudinal and lateral acceleration, steering angle, accelerator position, ambient and cabin temperature and battery thermal behaviour. These data support the analysis of real-world energy flows, battery temperature evolution, cabin thermal load, cooling and heating demands, and the interaction between driver behaviour, traffic conditions and vehicle thermal response. They also provide input for the calibration and validation of GT-SUITE and IPG CarMaker models, including battery, drivetrain, vehicle dynamics and thermal subsystems. The proposed workflow is also relevant for Euro 7-related research on non-exhaust emissions. Although direct particle measurement requires dedicated instrumentation, the acquired vehicle data provide the operational context needed to interpret brake- and tyre-related particle formation. Speed, acceleration, braking intensity, recuperation level, road profile, ambient conditions and component temperatures can be used to identify events with increased particle-generation potential. The system can therefore serve as a trigger and contextual backbone for targeted particle sampling, brake-wear analysis and future virtual homologation workflows.

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Experimental Investigation into the Thermal Performance of Li-ion Battery Cells

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Abstract. This work presents an experimental investigation into the thermal dynamics of Li-ion battery cells, bridging the gap between standard operational heating and destructive failure via thermal runaway. The study is divided into two primary phases to address both continuous battery operation and critical failure. The first phase focuses on the heat generation mechanisms during charge and discharge processes across different cell chemistries, notably comparing NMC and LFP technologies. By analyzing the temperature distribution on the cell surface and evaluating the impact of internal resistance and applied current loads, the research quantifies the irreversible Joule heating during charging and the critical thermal peaks at the end of deep discharge cycles. The evaluation of temperature gradients highlights the varying thermal homogenization capabilities of energy-optimized versus power-optimized cells. The second phase transitions to the destructive regime, utilizing a specialized TR apparatus to induce and analyze thermal runaway. This segment examines the temperature escalation during extreme external heating and targets the dynamics of cell failure by quantifying the emission of solid particulate matter and gases expelled during the venting process. This comprehensive analysis provides critical insights for the advancement of battery thermal management systems. The findings offer valuable data for both the optimization of cell cooling strategies and the modeling of aerosol dispersion during critical battery failures.

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Application of hydrogen technologies in the transport sector

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Abstract. The presented article deals with the potential use of low-pressure hydrogen storage technology based on metal hydride materials in urban public transport vehicles. This concept represents an alternative to traditional high-pressure storage tanks, offering increased safety, compactness, and the potential for long-term system durability. The paper provides a detailed analysis of the principles of hydrogen absorption and release in metal hydride storage systems, as well as their integration into the vehicle's energy chain. Special attention is given to the development of the energy balance between the fuel cell, storage batteries, and the traction electric engine, focusing on the energy flow dynamics under various operational modes of the vehicle. The analysis enables the identification of key factors influencing the efficiency and stability of the propulsion system, particularly in terms of optimizing the cooperation of individual energy components. The results suggest that a well-designed integration of metal hydride storage systems can contribute to increased energy efficiency, reduced operational risks, and broader adoption of hydrogen technologies in the field of sustainable urban mobility.

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Analysis of the use of charging infrastructure in the BUT campus

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Abstract. This paper focuses on an analysis of charging electric vehicles at the Brno University of Technology campus in Brno – Kralovo Pole. The goal of this work is to evaluate the operational characteristics of charging, such as energy consumption, charging time, and how frequently users access charging stations during normal operation. The analysis is based on data collected in 2023 and 2024, when the charging infrastructure was in pilot operation. Individual charging cycles, energy consumption, and time to charge were evaluated. Preliminary results indicate that the charging time and method can affect daily demand peaks and the load of the electrical network in the area, and these data can be used to optimize the operation of the charging infrastructure and to manage energy consumption and peaks during the day.

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Energy storage system management and integration challenges

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Abstract. The integration of energy storage systems within energy communities represents an important pathway for improving the utilization of locally produced energy in urban areas. In the context of the European Union's efforts to reduce dependence on imported fossil fuels, Slovakia is increasingly focusing on solutions that combine local energy generation, shared energy use, and coordinated energy management. Energy communities provide a suitable framework for such integration, as they enable residential buildings, public infrastructure, and other consumers to participate collectively in the production, storage, and consumption of energy. In urban districts, the role of energy storage becomes particularly relevant when local electricity generation from photovoltaic systems is combined with centralized heating infrastructure. Battery storage systems can increase the local use of electricity generated within the community, reduce grid interactions during peak periods, and support the operation of auxiliary technologies connected to the district heating system, such as heat pumps, circulation pumps, control systems, or power-to-heat units. In this way, electricity storage can contribute not only to higher self-consumption within the energy community but also to improved operational flexibility of the centralized heating system.

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Influence of MH Alloy Grain Fragmentation on Void Formation in an MNTZV-159 Pressure Vessel

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Abstract. The presented article deals with degradation processes occurring in the metal hydride bed of an MNTZV-159 storage tank, with emphasis on MH alloy grain fragmentation, redistribution of the active material, and void formation in the vicinity of the internal heat transfer intensifier. Particle fragmentation, induced by repeated hydriding–dehydriding cycles and mechanical loading, alters the granulometry of the bed, promotes vibrational compaction, and leads to the development of a locally non-homogeneous structure. These changes negatively affect permeability, flow path tortuosity, heat transfer, and hydrogen distribution within the porous medium. To evaluate material redistribution, a transient CFD model was developed in the ANSYS CFX environment. The MH alloy was modeled as a highly viscous continuous phase, while the dominant settling mechanism was assumed to be gravity acting under long-term vibrational loading typical for mobile applications. The model enabled the identification of regions of compaction, void formation, and non-uniform material distribution within the storage tank under real operating conditions.

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Analysis of stopping of the Continuous Casting Machine (CCM) application of the Theory Physical Similarity

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Abstract. The so called secondary cooling zone is an important part of the continuous casting machine (CCM). In this zone a breakout may occur due to an increase of the local and temperature heterogeneity of steel, due to an increase of the stress caused by bending of the slab and by high local concentration of non-metallic slag inclusions. Changes of the chemical composition of the steel during continuous casting are particularly dangerous. In the event that two melts are cast one right after another, i.e. if the melt of the steel with chemical composition A ends and it is immediately followed by the steel B, it may automatically stop the CCM and an atypical breakout may take place. It happened during continuous casting of the slab 250x1530 mm in the area of straightening 20 minutes after flying change of tundish. With use of dimensional analysis altogether 8 criteria of similarity were derived according to the π-theorem. Important data in temperature field of the slab were calculated by the original model. Numerical values of eight criteria were determined for the steels A and B. This application of the theory of physical similarity clearly proved markedly increased tendency of the steel B to breakouts in comparison with the steel A. In order to prevent repetition of this accident of caster for another pair of steels cast immediately one after another, it is necessary to assess the derived individual criteria of similarity for both steels and other operations with these criteria. The way to reduce the risk of breakouts may be found mainly in the change of thermo-physical properties of both steels, consisting primarily of reduction of differences of their chemical composition.

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Particles from Tires Emitted During Roller Dynamometer Testing

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Abstract. This study examines tire wear particle emissions generated during short term vehicle tests on a roller dynamometer, with emphasis on how mechanical and thermal loading influence the release of particles. Non exhaust emissions, particularly those from tire abrasion, have become amajor environmental concern and a dominant source of primary microplastics. Their relevance increases with the rise of electromobility, as electric vehicles typically generate higher tire wear rates due to greater vehicle mass. Submicron and nanoscale particles are of particular interest because of their high specific surface area and associated toxicological risks.

The objective of this work is to develop a dedicated measurement methodology for quantifying tire wear emissions on a standard roller dynamometer and to assess the influence of prior tire usage. The experimental setup uses a Škoda Enyaq positioned on a dynamometer with two 300 mm steel rollers. The tire tread undergoes enhanced deformation—twice per wheel revolution—while the braked roller induces combined tensile, compressive, and shear stresses that promote crack initiation and particle release.

A sampling hood (200 L/min) positioned behind the wheel collected aerosol particles using an isokinetic probe connected to a TSI OPS optical counter, complemented by PM_{10} filter sampling and background monitoring. Tests alternated between 50 and 90 km/h with braking loads from 4 to 25 kW per wheel. Two tire sets were evaluated: naturally worn tires and cleaned winter tires.

Results show that emission intensity strongly correlates with dynamic loading, tread temperature, and surface condition. Operational wear and thermally induced degradation significantly increase particle release, especially in the ultrafine fraction. The study demonstrates that roller dynamometers, when paired with appropriate sampling methods, provide a reliable platform for controlled laboratory assessment of tire wear emissions.

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