Fundamental and applied magnetohydrodynamics

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Book of Abstracts

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Numerical modelling of thermal decomposition and combustion of microwave pre-treated straw pellets

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In this study thermal decomposition and combustion processes of microwave pre-treated straw pellets are modeled using COMSOL Multiphysics numerical software. 2D axi-symmetric geometry of the combustion reactor is considered and a turbulent, reacting flow is modeled in a steady-state conditions. It is found found that the microwave pre-treatment of biomass significantly influences overall heat output of the device and the temperature distribution in the reactor.

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Numerical modeling of electromagnetic vibrations in a conductive workpiece

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In this research COMSOL multiphysics 5.3 numerical modelling software is used. A mathematical model based on a real induction coil is created. When an induction coil like in the Institute of Physics of the University of Latvia is created, various physics modules are sequentially added: magnetic field, electromagnetic induction, thermal problem, external fields. This is done sequentially such that the results of the mathematical model could be tested.

As result, we get an induction coil model with an aluminium workpiece, which, due to magnetic induction, melts. After external and coil magnetic fields are added, in the workpiece a pressure and volume force distribution is created, which leads to electromagnetic vibrations. Since the model will be created using a real induction coil, it could be further used in experiments with this coil.

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Burbuļu sagraušana ar elektromagnētiski ierosinātu plūsmu. Bubble dispersion in electromagnetically induced flow.

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Most aluminum degassing methods rely on inert gas bubbles to carry and remove excess dissolved hydrogen. In this work, we focus on bubble dispersion by metal flow, more specifically an electromagnetically flow created by rotating permanent magnets. Here the conditions for bubble dispersions are defined and necessary flow characteristics are calculated by numerical modelling. Experimentally bubble size of bubble is measured across different stirring intensities by imaging the surface. Numerically turbulence kinetic energy (TKE) dissipation rate is calculated with a custom OpenFOAM and ELMER solver. Both approaches confirm the dispersion of bubble to target threshold for optimal efficiency. Bubbles are observed and measured across a frequency range of 3 to 60 Hz corresponding to flow in a range of 1 - 4 m/s. Experimentally mean bubble size decreased from 16 to 2.3 mm which reaches the desired threshold. Numerical results predict similar reduction in size from 22 to 1.2 mm.

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Experimental study of MHD flow with SiC flow channel inserts for fusion blanket applications

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In this work there are presented experimental results from magnetohydrodynamic (MHD) flow study in a strong magnetic field up to 5T, performed on the superconducting magnet, in IPUL (Institute of Physics of the University of Latvia). The aim of this experiment is to evaluate the performance of electrical insulation introduced in the PbLi duct by use of SiC flow channel inserts. They are manufactured in several new shapes and made by gel casting method with chemical vapour deposition, that was done in CIEMAT/CEIT (Spain). These inserts act as a barrier for the induced electrical currents, thus not allowing them to penetrate and to close through the stainless steel walls of the PbLi channel. This results in a reduction of total induced electric current density inside the liquid metal. That further leads to a decrease of unwanted MHD pressure drop, that typically occurs in a Dual-coolant Lead-lithium (DCLL) fusion blankets due to inevitable presence of a strong magnetic fields in tokamak reactor.

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Modeļa eksperiments alumīnija kausējuma siltuma izlīdzināšanai ar rotējošiem pastāvīgajiem magnētiem

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Lai iegūtu vienmērīgu kausējuma termisko sadalījumu, piemēram, alumīnija krāsnis, sajaukšanu var nodrošināt ar rotējošiem pastāvīgiem magnētiem. Rotējošais pastāvīgais magnēts ģenerē rotējošu magnētisko lauku, kas inducē tilpuma spēku tuvumā esošajā šķidrajā metālā. Šajā publikācijā ir apkopots eksperimentāls un skaitlisks pētījums par temperatūras izlīdzināšanu ar pastāvīgo magnētu šķidra metāla tilpumam ar vertikālu temperatūras gradientu. Temperatūra tika noteikta ar termopāriem un termokameru. Eksperimentālā ierīce sastāv no plānsienu nerūsējošā tērauda tvertnes, kas piepildīta ar GaInSn eitektisko sakausējumu, un cilindriska NdFeB pastāvīgā magnēta, kas novietots pie sānu sienas. Tika veikts parametriskais aprēķins mainot magnēta slīpuma leņķi, lai atrastu visefektīvāko pozīciju pie kuras termisko līdzsvaru var panākt visātrāk.

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How the magnetohydrodynamics contributes to modern metallurgical production: examples from our experience

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The science of magnetohydrodynamics (MHD) is an invaluable tool in modern industrial development due to the growing usage of electrical energy and environmental concerns. This talk will discuss a few examples from the metallurgical industry. The annual production of primary aluminium is about 64 million tons, nearly all via an electrochemical process consuming 848 TWh of electricity (or 3% of the worldwide total), and it caused 1% of human greenhouse gas emissions. It is estimated that optimization by applying MHD knowledge permits to decrease energy use by at least 34 TWh and to reduce the greenhouse gas emissions by 13M tons each year. The traditional steel production is gradually moving to the electrical arc furnaces, already producing about 25% of steel worldwide, while the MHD mixing and power optimization are largely poorly understood. High-quality metal alloys for aerospace and energy industry applications are produced by the vacuum arc or slag melting techniques where MHD plays a crucial role. Modelling these and multiple other processes requires detailed knowledge of thermophysical material properties of specific alloys at extreme temperatures – a task where contactless electromagnetic levitation plays a crucial role. New applications emerge continuously to drive the growing interest in MHD research.