Fundamental and applied magnetohydrodynamics

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LU ”Zinātņu māja”

Book of Abstracts

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Force density in 2D centrifugal system using travelling magnetic field

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Purification of liquid metal from small, unwanted solid particles that are the by-product of industrial processes is a common problem in metallurgy. In practice purification is achieved using various filtration methods such as sedimentation, mechanical filters, etc.

Another used method is centrifugation that uses the rotation of the fluid and inertial forces to separate particles with a density different from that of the fluid itself. Rotation of the liquid metal can be achieved by using a travelling magnetic field, thus inducing separation of the particles. Such a magnetic field can be created by externally rotating magnets, meaning that the system is completely contactless – no moving parts are in contact with the liquid metal at any time, thus also improving overall safety, especially for alkali metals.

The aim of the presented work is to describe and analyse the developed EM force density in a 2D, simplified centrifugal version of such a system using an analytical and numerical approach. The analysis of forces in the system is the first step in calculating the velocity distribution of a centrifugal filter which would, in theory, be able to perform a separation of solid particles from liquid metal.

2

Paņēmiens šķidra metāla brīvās virsmas elektromagnētiskai stabilizācijai

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Piedāvāta jauna metode šķidra metāla brīvās virsmas stabilizācijai elektromagnētiskā ceļā. Paņēmiens var tikt pielietots maiņstrāvas un maiņvirziena šķidruma plūsmas MHD ģeneratoru darbības uzlabošanai ar pielietojumiem tālās kosmosa misijās un citviet.

Izveidots demonstrācijas stends, kas sastāv no diviem pretēji novietotiem un pretfāzēs saslēgtiem skaļruņiem, kas imitē termoakustiskā dzinēja darbību, analoģiski LU Fizikas Institūtā veiktā FP-7 Eiropas projekta "SpaceTrips" iekārtai. Starp skaļruņiem ir iestrādāta caurspīdīga U-veida caurule, kas ir piepildīta ar InGaSn eitektisko sakausējumu, ievietotu pastāvīgo magnētu radītajā magnētiskajā laukā.

Demonstrēts, ka, izmantojot piedāvāto metodi, iespējams iegūt vizuāli novērojamu stabilizējošu efektu pat ar relatīvi vāju magnetohidrodinamisko mijiedarbību.

3

Heat density in a 2D centrifugal system using travelling magnetic field

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In metallurgy, during the manufacturing process, liquid metals often have impurities such as solid oxide particles. Often, they can be removed from molten metals using mechanical filters (sieves). In praxis, due to the filter clogging and greater metal loss higher efficiency of this process is desired.

Another approach is to use centrifugal (inertial) force and the fact that liquid metals are good electrical conductors – by applying traveling magnetic field which causes the molten metal to move. This, together with the fact that the metal and impurities have different densities, can be used to create a centrifugal filter.

In real-world applications, the estimation of power required for centrifugal filter to work is of most importance. This work generated the heat power density in the liquid metal due to the induced currents is explored both analytically and numerically.

The goal of this presentation is to show the analytical approach used for power estimation in simplified 2D case and to compare obtained results with numeric model.

4

Continuous Directional Solidification of Aluminium Alloys Under Combined Electromagnetic Interaction

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Direct chill directional solidification is a method how to cast metal alloys with great control of solidification parameters like solidification velocity and temperature gradient at the solidification interface. This paper describes results and methods of our experiments with electromagnetic interaction (EM) in direct chill casting of silicon rich aluminium alloys like A356 and A360. Studies about EM influence on metal solidification shows that various combinations of magnetic fields have significant influence on grain structure in directionally solidified ingot. We directionally solidified aluminium rods with diameter of 10 to 20 mm under various EM interactions. In this study there are applied static electromagnetic field of 0.4T and current flow through solidification interface. Static field is created by an array of permanent magnets in ring formation where highest field value is in the center and pointed axially. The direct current is introduced with immersed electrode into molten aluminium through solidification interface to seed rod. Interaction between current and magnetic field creates tiny molten metal flows directly in mushy zone which than influences heat transfer and affects grain structure and properties of alloy. By studying microstructure we observed that EM interference can influence grain size and shape, and properties of alloy, like strength, ductility, isotropy. Columnar structure of dendrites disappears when magnetic field and current are introduced. We combined static magnetic field with induced short but strong current pulses in mushy zone with 100 to 500A. This creates pressure waves which also enhances the small scale flows in mushy zone

5

Modeļeksperiments termoelektromagnētisko efektu pētīšanai metināšanas punktā.

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Metālu additīvā ražošana ir lētāka un vieglāka metode, ar kuru var straujāk prototipēt, salīdzinot ar parasti pielietoto liešanu. Analizējot ekstrūzijas vai lāzeru additīvo ražošanu ir svarīgi aplūkot metināšanas punktu, jo tas ietekmē objekta kvalitāti. Lai uzlabotu kvalitāti, apsver izmantot termoelektriskus materiālus ar magnētiem, kam ir empīrisku pētījumu rezultāti, bet ne par darbības mehānismu vai optimāliem apstākļiem. Šajā darbā mēs izpētām kušanas punkta dinamiku un svarīgākos aspektus, izmantojot mērogotu eksperimentu ar šķidru gallinstanu, kam ir atbilstošs COMSOL modelis. Izmantojot eksperimentu, verificējam COMSOL modeli, tad mainot modeli un izmantojot bezdimensionālus skaitļus mēs mērogojam rezultātus atbilstoši metālu additīvās ražošanas apstākļiem. Ar piedāvāto pieeju ir vieglāk izpētīt kušanas punktu, tad tālāk varēs pārbaudīt gūtos uzlabojumus in situ sinhrotrona eksperimentā.