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Сборник трудов аспирантов и магистрантов вузов России представляет работы, обсуждавшиеся на научно-практической конференции, посвященной различным проблемам в области техники, информационных технологий и экономики.

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As a result, this will enable more flexible and reliable operation of RES sources integrated into a traditional centralized network.

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1. Burmeister, M. V. Virtual inertia systems: a new approach to the integration of renewable energy sources into electric power systems / M. V. Burmeister, I. I. Berdyshev, R. V. Bulatov, R. R. Nasyrov // Electricity. Transmission and Distribution, Moscow. – 2023. – No. 5 (80). – pp. 27-39.
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MECHATRONICS AND AUTOMATION

The research of electromagnetic and hydrodynamic processes during levitational melting of aluminum products

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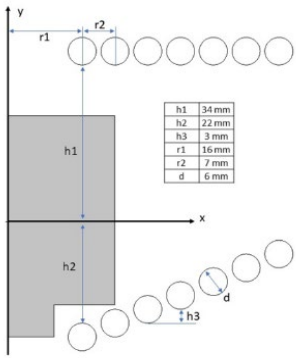
Abstract: *This paper deals with the research of electromagnetic and hydrodynamic processes occurring in an induction unit for levitation melting of an aluminum billet weighing 18.6 g. The distributions of current density in the melt, magnetic induction, Lorentz force, and velocities in the melt were obtained.*

Keywords*: alternating electromagnetic field, magnetic hydrodynamics, levitation melting, control volume method, multiphysics.*

There are different methods of aluminum melting: melting in induction crucible and duct furnaces, in resistance furnaces, in gas furnaces. All these types of melting have one significant disadvantage - contamination of the molten metal during interaction with the crucible. This problem can be solved by melting in suspension. It eliminates contact with the crucible, reduces waste and increases production efficiency.

Suspended melting allows to melt metals and alloys in a vacuum or in an atmosphere of purified inert gas, preserving the purity of the starting materials with the mass content of introduction impurities not exceeding thousandths of a percent. Castings, which are obtained by this method of melting, have high homogeneity and have minimal deviation from the specified alloy composition [1], [2].

Magnetohydrodynamic problems are multiphysics problems. Their peculiarity lies in modeling the interaction of different areas of physics, because of which such problems are often limited by software modeling tools due to the rather narrow focus and complexity of such problems. Magnetohydrodynamic processes are the processes occurring in a conducting fluid or gas when interacting with a magnetic field. The study of these processes requires synthesis and conjugation of methods of electromagnetism and hydrodynamics. The connecting elements are the inverse effect of fluid motion on its own magnetic field, as well as the force and temperature effects of the electromagnetic field [1], [2].



To investigate the electromagnetic and hydrodynamic processes occurring in the induction system for levitation melting of an aluminum billet weighing 18.6 grams, a numerical model was developed in the Ansys software package, which allows us to calculate the electromagnetic and hydrodynamic parameters of the installation [1], [2].

In this paper, an induction system for levitating melting was considered with the inductor divided into a lower part providing the main levitating force and an upper winding stabilizing the melting in suspension The calculation scheme is presented in Fig. 1.

In the considered induction system, the effective value of current I = 650 A with frequency f = 9650 Hz is given. The electromagnetic problem is solved by the finite element method.

The hydrodynamic problem is solved in a transient, axisymmetric formulation. An explicit VOF model was chosen taking into account mass forces. The problem involves two Euler phases: air and liquid aluminum.

When solving this MHD problem with feedback, an algorithm was formed:

1. Solving an electromagnetic problem;
2. The volumetric forces F (x, y) acting on the melt, which were obtained when solving the electromagnetic problem, are unloaded;

Fig. 1 – Calculation scheme of the induction system for levitation melting.

3. The unloaded volumetric forces F (x, y) are interpolated onto the mesh of the hydrodynamic part;
4. Interpolated body forces F (x, y) are applied on the CFD side of the solver;
5. The hydrodynamic problem is being solved;
6. We unload the volume fraction β (x, y) of the melt obtained by solving the hydrodynamic problem;
7. We interpolate the unloaded volume fraction β (x, y) onto the grid of the electromagnetic part;
8. We apply the interpolated volume fraction β (x, y) on the Emag side of the solver;
9. Repeat the cycle from solving the electromagnetic problem until we reach the required time for solving the problem.

As a result of solving the conjugate MHD problem, the distributions of current density, magnetic induction, Lorentz force and velocity were obtained.

Fig. 2 shows the change in the shape of the free surface over time.

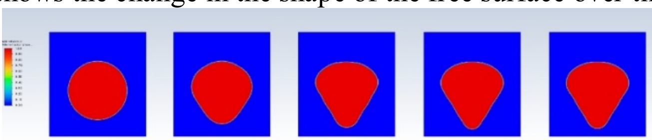


Fig. 2 – Change in the shape of the free surface over time.

Figure 3 shows the results of a similar study by a team of scientists consisting of S. Spitans, E. Baake, B. Nacke and A. Jakovich.

Having analyzed the distributions which were obtained by solving the MHD problem, it can be noted that the shape of the free surface, the velocity field in the melt, the Lorentz force supporting the melt in the air correlate well with the data obtained in the article by S. Spitans [1]-[2], depicted on Fig. 3.

References

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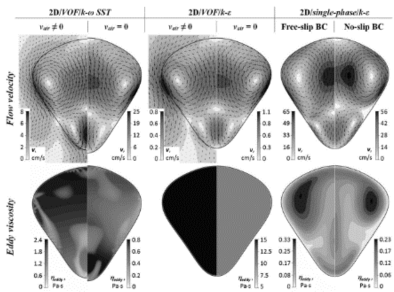
Fig. 3 – Results of the study by the team of Spitanes, Baake, Nacke and Jakovich [1]-[2].



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Development of a shuttle accelerator based on a linear electric motor

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Abstract: *the study examines the method of accelerating the weft thread plotter of a loom based on a linear electric motor with elastic elements, including power calculations, evaluation of the mass and dimensional parameters of the electric motor, as well as calculation of springs and torsion bars. Special attention is paid to accelerator modeling and assessment of its transients. The results allow us to*