NUMERICAL INVESTIGATION OF THE ELECTROMAGNETIC STIRRING SYSTEM OF LIQUID METAL IN SKULL CRUSIBLE WITH ELECTRON-BEAM MELTING

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Abstract

The brief information on the history and peculiarities of electron-beam skull melting technology

of refractory metals and alloys is given. Its advantages and disadvantages are formulated. One of the main directions of further development is the maximum amount of melt in the skull crucible increasing. The necessity of mathematical modeling of multifunctional processes for the rational choice of the design of a skull crucible with electromagnetic stirring system, which provides obtaining up to 150 kg of titanium melt in one melting process, is substantiated. In particular, the question of choosing the design and operating modes of the electromagnetic stirring system with an emphasis on the peculiarities of its work at the initial stage of the accumulation of the melt are considered. The methodology of numerical three-dimensional modeling of the electromagnetic field and hydrodynamics in the system "inductor – scull crucible" is given. An electromagnetic problem is formulated relative to the vector magnetic and scalar electric potentials, hydrodynamic – in the form of Navier-Stokes equations using the Low Reynolds k-ε turbulence model. Among the factors that determine the effectiveness of an electromagnetic stirrer we considered: the number of coils of the inductor, the angle of phase shift between the currents of the coils, the direction of the travelling magnetic field, the frequency of the power supply. The electromagnetic and hydrodynamic problems were calculated for the five positions of the interface between melt and skull which correspond to the sequential stages of the melting process with the gradually increased melt volume in the crucible. The inductors with two, three, and six coils were considered. When comparing variants, the average speed of motion in the melt volume was taken as the criterion for the stirring efficiency. The results of computational research are presented, the algorithm of electromagnetic stirring system operation is proposed. References 9, figures 8.

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