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Mathematical Modeling of Energy Distribution in the Working Volume of Ore - Smelting Electric Furnace

The experience of ore-smelting electric furnaces operation has shown that maintaining an optimal charge, electric and electrode regime of the technological process is the basis for achievement of the technical and economic efficiency of alloy smelting.

The solution of this problem is provided by the choice of optimal geometric parameters of blast furnace bath and the maintenance of the efficient electric mode of melting. From thermodynamic point of view, it distributes the input energy of the blast furnace bath.

The obtained data of active power, current density and temperature are the result of instrumental research of the active ore-smelting electric furnaces [1, 2]. It has given the opportunity to create a structure of the furnace bath working space during different alloys smelting and to solve a number of questions for smelting processes optimization. The results of research gave the possibility to develop a generalized equivalent circuit of an electric chain which provided the efficient control of the electric and technological modes of furnace operation with use of automated process control system [2].

A number of mathematical models of energy distribution in the volume of the bath are known, which make it possible to predict it for the developed and designed electric furnaces.

The main task of the authors was to develop the mathematical model of a current density distribution in the self-burning electrode section and the specific active power in a bath by the method of integral equations of Fredholm, type II. [3].

The decisive advantage of the secondary sources method is the ability to construct effective numerical algorithms for calculating fields that are oriented toward the use of computer technology and suitable for inhomogeneous media and complex interfaces for mediums.

Since the structure of the reaction zone of the working space of the round three-electrode SMR is symmetrical to the axis of each electrode, based on the conditions of axial symmetry, the meridial cross-section of the electrode and the reaction zone was considered with the current supplied through the superconducting contact of the electrode in an inhomogeneous medium and through the superconducting bath of the alloy.

To build the model the following assumptions will be accepted:

1. The bath is round with three symmetrically positioned electrodes.

2. The volume of charge materials consists of a reaction zone with a conductivity of γ_5 and γ_6, and bath volume with conductivity of γ_3 и γ_4

3. The liquid melt (the surface S5) and the surfaces S1, S2, S3, S4 are superconducting ($\gamma = \infty$)

4. The electrodes consist of two zones with the conductivities of γ_1 and γ_2

5. The ARC is not taken into account because technological process of smelting silico-manganese is slag. Liquid conductive slag essentially shunts the arc gap, as a result of which the arc discharge does not account for more than 15% of the energy of the furnace released in the bath.

6. The right-cylindrical coordinate system is started in the center of the bath at the level of the furnace-charge.

7. Because of the slight impact of the surface effect, the magnetic field is not taken into account.

The model is designed for the hemispherical shape of the end face of the electrode and the depth of its immersion in the furnace bath of 1 m.

The simulation results were checked for appropriateness in electrolytic furnace. The potentials of the bath volume points were measured by the double probe method, the active power in each elementary volume of the bath was calculated.

The value of the specific active powers at the selected points, obtained by calculation and experimentally and presented in relative units, coincide with the engineering accuracy.

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