THE NUMERICAL STUDY DYNAMICS OF THE ANODE EFFECT IN THE INDUSTRIAL ALUMINIUM ELECTROLYSIS

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The developed mathematical model for the industrial electrolysis of aluminum makes it possible to determine the development of the anode effect with various changes in technology and to predict the development of MHD instability of the metal electrolysis process, which is important for minimizing losses in the current yield of metal and reducing gas emissions. It is found that the anode effect is divided into three stages.

The initial stage is MHD-stable, where the configuration of the liquid phases and the initial distribution of velocities in the mixture are considered known. The initial mirror of the metal has a slight perturbation in the form of a wave, which affects the nature of the mixture motion, in addition to the Lorentz forces.

At the next stage, MHD instability may develop. Basically, a chemical reaction occurs at the soles of the anodes with the formation of gas. The gas spreads unevenly in the electrolyte and in the area between the anodes, while forming domains directly under the anodes. The Lorentz force is unevenly distributed with the formation of regions with greater intensity. A vertical vortex motion of the liquid electrolyte appears, which promotes downward transport of the gas phase and increases the risk of reverse oxidation. With an increase in the density of bubbles under the anodes, the electric current is redistributed, and its greatest value is located in the region of the greatest rise in the metal, which corresponds to the space between the anodes. There is a rise in aluminum, which can continue until the Lorentz force is compensated by the force of gravity, or until the release of gases reduces the current density and thus the Lorentz force.

At the final stage of MHD instability, the electrolysis process is terminated when the soles of the anodes and the internanode space are completely covered with gas domains. At this stage, the electrolysis reaction rates are reduced to zero. The magnetic field also decreases by several orders of magnitude.

Thus, it is at the second stage of the dynamics of the anode effect that a sharp increase in voltage occurs as a result of the formation of a gas insulating layer around the anodes, which can be prevented by the timely supply of alumina to the cryolite melt.

References

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