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A Novel Approach for Measuring the Electrical Conductivity of Molten ESR Slag Systems

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Energy expenditures for slag and metal melting primarily drive production expenses of electro-metallurgical smelting processes. In Electroslag remelting (ESR), the thermal energy is directly generated by resistance heating of the slag system. Therefore, exact knowledge of the electrical conductivity of the molten slag is vital for regulating the process temperature and energy costs during smelting. However, to date, electrical conductivity measurements of ESR slags show substantial deviations due to method- and technique-related errors, such as the neglection of electrical fringe fields and interfacial effects between slag and electrodes, demanding an exact and reliable measurement procedure. In this study, a new high-accuracy approach for measuring the electrical conductivity of molten slag systems is validated in aqueous salt solutions at room temperature. The approach is then tested on a low, medium, and high conductive ESR slag with varying contents in CaF2, Al2O3, and CaO from Wacker Chemie AG within a temperature range of 1,500 to 1,700 ℃. The method uses a calibration-free differential technique with a coaxial electrode geometry to overcome fringe field distortions. Electrochemical Impedance Spectroscopy (EIS) is used to generate an equivalent circuit model for the simulation of the electrochemical cell, allowing the extraction of the electrical slag resistance from interfacial influences. Validation investigations in salt solutions at room temperature correlate well with comparable, highly accurate experimental data. Results with high reproducibility can be achieved for the three tested ESR slags.

Speaker Country

Germany

Primary author: Mr DRUDE, Emanuel-Sebastian (RWTH Aachen University)

Co-authors: Dr BOROWSKI, Nikolaus (SMS group GmbH); MOHSSENI, Javad (Wacker Chemie AG); Prof. FRIEDRICH, Bernd (RWTH Aachen University)

Presenter: Mr DRUDE, Emanuel-Sebastian (RWTH Aachen University)

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