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Effect of Al2O3 on structure and viscosity of EAF slag system

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Slag rheology is one of the important parameters in Electric Arc Furnace (EAF) steelmaking, as it significantly impacts process stability, energy efficiency, and the degradation of refractory materials, with its behavior strongly determined by the composition of the slag. The aim of this research is to understand the influence of Al_2O_3 on the structure and properties of EAF slag, thereby facilitating the transition towards hydrogen-based Direct Reduced Iron (DRI) and EAF steelmaking route. A slag system comprising $CaO–SiO_2–MgO–Al_2O_3–FetO$, characterized by a basicity ratio (CaO/SiO_2) of 2 and containing 30 wt% FeO, was formulated based on literature survey and thermodynamic analyses, in that way reflecting typical conditions of EAF steel slag. The content of Al_2O_3 was varied within the range of 5 to 12.5 wt%, while the saturation level of MgO (~5.8 wt%) and the melting temperatures were established through phase diagram analysis and equilibrium calculations. Synthetic slag samples were synthesized from reagent-grade oxides powder. The mixture was melted in a Tammann furnace at temperature ranging from 1517-1600 ℃, which elevated by 100 ℃ above the calculated melting point of each composition, followed by a holding period of 60 minutes to ensure uniformity prior to quenching via water-granulation. The quenched slag samples underwent characterization through X-ray Diffraction (XRD), Raman spectroscopy, Scanning Electron Microscopy with Energy Dispersive Spectroscopy (SEM-EDS), and high temperature rheometer. The XRD analysis indicated that all examined samples displayed semi-amorphous characteristics alongside crystalline phases of MgO, α'-Ca_2SiO_4, and spinel. The Raman spectra evidenced prominent vibrational bands associated with Fe-O band within the slag matrix, with less Si-O band due to high basicity ratio. The combined XRD and Raman analyses provide a structural basis for correlating phase assemblage with high-temperature rheological behavior, which will be evaluated in subsequent viscosity measurements.

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