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Assessment of SiO_2 and Al_2O_3 interchangeability in the DR-EAF Steelmaking Route

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The acid gangue components in agglomerates used in the Direct Reduction–Electric Arc Furnace (DR-EAF) steelmaking route, particularly SiO_2 and Al_2O_3, have a significant impact on EAF performance. These oxides influence slag characteristics such as volume, foaming capacity, and viscosity and affect key operational parameters: metallic yield, electric energy and oxygen consumption, refractory and electrode wear, dephosphorization efficiency and tap-to-tap time.

Considering the growing interest in the DR-EAF route, driven by the steel industry's decarbonization efforts, and the limited availability of high-grade iron ores suitable for this process, it is essential to understand the acceptable limits of SiO_2 and Al_2O_3 in DR-grade agglomerates, assessing how each acid gangue component affects EAF performance. More specifically, it is fundamental to evaluate whether, and to what extent, SiO_2 and Al_2O_3 can be interchanged in the chemical composition of DR-grade agglomerate, considering technical and operational constraints of the EAF process. A clear understanding of the impacts of SiO_2 and Al_2O_3 enables iron ore mining companies to design agglomerates with optimized levels of these oxides, aligned with the operational and economic targets of steel producers.

This study investigates the effects of varying the individual levels of SiO_2 and Al_2O_3 while keeping their combined content (SiO_2 + Al_2O_3) constant, and how these variations influence EAF performance. The analysis was conducted using numerical simulation models for direct reduction and electric arc furnace processes. Isothermal solubility diagrams (ISDs) were used to estimate the MgO saturation levels under specific conditions of FeO content, temperature and ternary basicity in the slag.

The results indicate that varying the individual levels of SiO_2 and Al_2O_3—while maintaining their combined content (SiO_2 + Al_2O_3) constant—has only a marginal impact on slag properties and key operational parameters. Therefore, within defined limits, SiO_2 and Al_2O_3 can be considered interchangeable in the DR-EAF process.

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