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In situ observation of metal-slag separation and inclusion motion at the surface of hydrogen-based direct reduction iron melt

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Hydrogen-based direct reduction is emerging as a promising strategy for steel production due to its low CO2 emissions. In this process, the melting of direct reduced iron (DRI) and the separation of steel and slag occur in the electric arc furnace (EAF). However, this process is affected by the thermophysical properties of slag, which are critical and ultimately affect both the yield and the cleanliness of the produced steel.

This study investigated the effect of various thermophysical properties (such as basicity, viscosity, melting point, etc.) of slag on the steel-slag separation process, utilizing different grades of DRI. The in-situ melting behavior of DRI pellets was observed using high temperature confocal laser scanning microscope (HT-CLSM). Multi-scale characterization techniques were employed to analyze the evolution of the steel and slag at different stages of the melting process. The smelting temperatures for low-grade and high-grade DRI should exceed 1530 ℃ and 1580 ℃, respectively, to ensure optimal melting and separation efficiency. Notably, the uniform distribution of alumina within the slag requires higher smelting temperatures to ensure proper iron-slag separation. This is due to the high melting point of alumina, along with its strong viscosity and surface tension, which hinder the effective separation of steel and slag during smelting, eventually impacting steel purity. Furthermore, non-metallic inclusion motion behavior at the surface of DRI melt is observed by HT-CLSM, and the attraction of different particles are analyzed, the obtained understanding can contribute to the gangue removal and the initial slag formation.

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