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Microstructural effect of Al2O3 on the H2-based direct reduction of iron ore

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The supply of green H2 as a reducing agent, as well as electricity from renewable energy sources, is essential for transforming the steel industry towards greener production, making the efficient use of H2 and electricity crucial. The impact of gangue on the H2-based direct reduction (DR) process of iron ore remains less well-understood, yet it is important for optimizing the efficiency of the process. To understand the effect of gangue on the H2-based DR of iron ore pellets, powder compacts with defined concentrations of gangue were produced, serving as model systems for DR pellets. The effects of concentration, particle size, and pore distribution on the H2-based DR of hematite at 700°C were systematically studied by microstructural investigations in combination with thermogravimetric analysis. Using Al2O3 as an example of a common iron ore gangue, it was shown that a concentration of 5 wt.% Al2O3 decreased the final reduction degree by ˜4% compared to pure Fe2O3. Additionally, by decreasing the particle size from 90 to 1 µm of the added Al2O3 powder, the reduction kinetics were significantly decelerated, and the final reduction degree was further decreased, specifically by ˜9% compared to pure Fe2O3. This shows that not only the gangue concentration is relevant for the H2-based DR, but also its microstructural distribution. EDX spot analysis reveals the presence of an interface region between Al2O3 particles and the iron matrix after reduction, consisting of Fe, Al, and O, which indicates the formation of the hercynite phase (FeAl2O4), leading to a lower final reduction degree. This study allows for a better understanding of the mechanisms behind the H2-based DR using gangue-containing iron ore pellets as well as providing recommendations for the iron and steel industry regarding the optimal design of DR pellets.

Speaker Country

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