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From Concept to Reality: Exploring the Potentials of Hydrogen Plasma Smelting Reduction

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The iron and steel industry is undergoing significant changes due to global efforts to combat climate change, like the Paris Agreement and the European Green Deal. These initiatives aim for the European Union to become carbon neutral by 2050 and significantly reduce greenhouse gas emissions by 2030. This is a big challenge for the industry, which produced 1.95 billion tons of crude steel in 2021, mostly using the energy-intensive blast furnace and basic oxygen furnace (BF-BOF) process.
The paper introduces Carbon Direct Avoidance (CDA) as a promising pathway for reducing emissions, focusing on the Hydrogen Plasma Smelting Reduction (HPSR) approach. This technique, which uses electrical energy and hydrogen for reduction, is being developed at the Montanuniversitaet Leoben at laboratory scale and at a demonstration plant operated by K1-MET GmbH. Due to the generation of exited hydrogen species (atomic and ionized) and high temperatures in the arc's focal spot, the reduction process is favoured both thermodynamically and kinetically.
The study delves into laboratory-scale experiments demonstrating the significant influence of cathode geometry, plasma gas composition, and iron ore feed rate on arc stability and reduction rate in the HPSR process. It also examines how iron ores of varying degrees of pre-reduction affect hydrogen utilization and overall process time while maintaining consistent product microstructure. The research aims to identify optimal combinations of pre-reduction states and plasma gas composition to maximize hydrogen utilization. The results contribute to the iron and steel industry's efforts to reduce greenhouse gas emissions and achieve international sustainability goals.

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