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Mitigation of CO_2 Emissions from Blast Furnaces through Injection of Carbon-Recycled Reducing Agents with High Heat Supply via Partial Combustion

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Mitigation of CO_2 emissions is an urgent challenge for the steel industry, which is one of the most CO_2-intensive sectors. As a promising approach to significantly reduce CO_2 emissions from blast furnace operations, the carbon recycling blast furnace process has been proposed. In this process, carbon recycled reducing agents are synthesized from CO_2 contained in blast furnace gas and injected back into the furnace, thereby reducing the consumption of coal-derived carbon. Since the carbon in these agents originates from internal CO_2, it is not emitted outside the system, contributing to overall CO_2 reduction.

This study investigates the effectiveness of various carbon recycled reducing agents in lowering CO_2 emissions from the carbon recycling blast furnace. First, candidate chemical species that can be synthesized from CO_2 with carbon recycling technology were extracted. Then, the carbon consumption associated with the injection of these agents to the blast furnace was evaluated using a Rist diagram. This theoretical model accounts for heat and mass balance by dividing the blast furnace into upper and lower zones based on the temperature of the thermal reserve zone. Additionally, operational constraints such as the theoretical flame temperature at the tuyere level were considered.

The results indicate that carbon consumption in the carbon recycling blast furnace is primarily influenced by the heat supply from partial combustion of the carbon recycled reducing agents. Carbon consumption decreases as the heat supply from partial combustion increases, due to enhanced thermal input and higher injection rates of the agents. Furthermore, higher blast oxygen concentrations also contribute to reduction of carbon consumption. Based on these findings, it is suggested that carbon consumption and CO_2 emissions can be reduced by up to 40 % compared to conventional blast furnaces by injecting carbon recycled reducing agents with a heat supply from partial combustion exceeding 4000 kJ/kg under high blast oxygen conditions.

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