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Comparison of direct reduction by CO gas and carbonaceous materials

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Today, commercial direct reduction (DR) processes predominantly use natural gas for the reduction of iron ores and emits large amounts of CO2. One way to decrease the CO2 emissions is by using carbon-neutral reducing agents such as biocarbon. This study compares the direct reduction behavior of a magnetite ore concentrate by different reducing agents: pure CO gas, anthracite (a low-volatile coal), a combination of pure CO gas and anthracite, and hydrochar (a type of biocarbon). Ore concentrate was briquetted with or without carbon material addition. The briquettes were reduced in a thermogravimetric analysis (TGA) furnace non-isothermally up to 1000 ℃ under argon or CO atmosphere.

It was found that the reduction of ore concentrate briquette in pure CO (without carbon addition) initiated at the lowest temperature (~625 ℃), followed by ore concentrate briquetted with pristine hydrochar (~730 ℃). In contrast, the reduction of ore concentrate briquetted with anthracite did not initiate until 825 ℃, regardless of the atmosphere used. Furthermore, it was found that the reduction rate of the ore was the most rapid when it was briquetted with hydrochar, followed by when it was reduced in pure CO atmosphere without carbon addition, and lastly when the ore was briquetted with anthracite. The utilization of CO gas in the case when the ore was briquetted with anthracite enhanced the later part of reduction process. Ore concentrate reduced completely to metallic iron after sufficiently long holding time (1-3 hours) except when it was mixed with anthracite and reduced in argon atmosphere. The result shows that choice of reducing agent significantly influenced the porosity and thus the diffusion rate of CO within the briquettes. Furthermore, it can be concluded that the addition of biocarbon to iron ore agglomerate facilitates a more efficient reduction process while reducing the fossil-CO2 emissions.

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