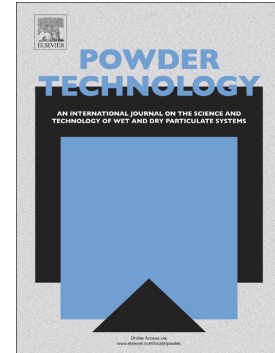


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Reduction kinetics of hematite ore fines with H₂ in a rotary drum reactor

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Abstract: Porous hematite ore was prepared by the dehydration of low-grade limonite ore with high moisture content. In this study, the mechanisms and kinetics of the isothermal reduction of hematite ore fines by hydrogen–nitrogen gas mixtures were investigated using a rotary drum reactor in the temperature range of 700–900 °C. The reduction rate and degree of reduction initially increased with H₂ content and temperature, and subsequently, the reduction rate decreased with the increasing reduction reactions of iron oxide. Our results indicate that the dehydration significantly increases the specific surface area of the original limonite ore, creating nanopores. We found that the reduction of hematite (Fe₂O₃) to metallic iron (Fe) was controlled by a first-order reaction model (one-dimensional formation and growth of nuclei) below 850 °C. However, at 900 °C, the reaction initially followed the above model and then shifted to follow a diffusion-controlled reaction model in the final stages of reduction owing to the low diffusion rate of oxygen in the formed dense iron layer. The value of the apparent activation energy for the overall reduction process of hematite to metallic iron was ~51 kJ/mol.

Keywords: hematite; kinetics; hydrogen reduction; mechanism; limonite ore

1. Introduction

Iron ores are the raw materials of the iron and steel industry, and they are in increasing demand for the production of steel, which is widely used in many industries across the world [1]. However, high-grade iron ore has been exploited for several decades. Thus, its reserves are being rapidly depleted. This has led to an increase in the production costs of iron and steel, particularly in China, where more than 953 billion tons of iron ore in 2015 were imported, mainly from Australia and Brazil [2]. Therefore, in recent years, greater attention has been paid to exploiting low-grade iron ores, such as complex refractory limonite ore.

Limonite ore deposits are formed by the chemical weathering of magnesium silicate (olivine) under wet sub-tropical and tropical climate conditions and have a very high moisture content [3]. The predominant mineral in

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