Reuse Opportunities for Bauxite Residue

Abstract

Bayer processing of bauxite employed for production of alumina yield a residue red-mud. The worldwide annual-rate of red-mud generation is approximately 120 million tons, and most of this is stockpiled. Red mud is rich in elements like aluminum, titanium and rare-earth elements, in addition to the major iron-bearing constituents. The objective of this research is to explore such a strategy to extract iron as magnetite. Pyrometallurgical reduction experiments using carbon mixtures and a novel hydrometallurgical route are experimented.

Reduction experiments performed with petroleum coke as a reductant resulted in incomplete reduction. Gaseous reductants CO (g) and CO$_2$ (g) are also used for reduction. Four temperatures: 475oC, 500oC, 550oC and 600oC, time-of-reaction 10, 20 or 30 min, CO (g):CO$_2$ (g) 1:1.5 or 1:1 or 1.5:1 are varied to study the conversion. The ‘optimal conditions’ for the reduction are determined to be: a processing temperature of 540oC ± 10oC, partial pressures CO (g) and CO$_2$ (g) each of 0.070atm (bar) ± 0.001atm (bar)/ inert diluent-gas: N$_2$ (g), for a conversion-time of 30min. A mathematical-model was developed on the basis of unidirectional-diffusion of CO$_2$ (g) within the CO$_2$ (g)–CO (g)–N$_2$ (g) gas-phase of the porous product-layer.

Magnetic classification was performed, by employing (a Frantz) dry magnetic-separator as well as (a Davis-Tube) wet magnetic-separator, on samples produced under optimal conditions by CO$_2$ (g)–CO (g)–N$_2$ (g) gas-phase reduction. Magnetic separation in: obtaining a magnetic portion with high iron and non-magnetic portion containing nonferrous (Al, Ti) is not successful. This finding was subsequently attributed to the nanometer length-scales crystallites of the predominant iron-containing phase, hydrated ferric-oxide(s) as determined by STEM micrographs. In addition, the presence of substitution for Fe$^{3+}$ by Al$^{3+}$ and Ti$^{3+}$/4+ are determined with the help of Mössbauer spectrograms.

A hydrometallurgical route involving selective leaching and precipitation of iron in red-mud is tried. Red-mud is leached in oxalic acid at: 95°C, 15 % Pulp density, 2.5 h leaching time, 1.5 pH. Kinetic studies yielded the leaching mechanism to be predominantly fluid film control. Ferric oxalate in the leach liquor is reduced to insoluble ferrous oxalate selectively using iron powder. The ferrous oxalate formed is ~98 % pure. TGA and DSC data of the ferrous oxalate are shown in Nitrogen and air atmosphere. Precipitation of ferrous oxalate and reduction of ferrous oxalate to magnetite will be optimized.