Abstract

Indian hematite iron ore is associated with goethite, kaolinite and gibbsite mineral phases, which contribute to high loss on ignition (LOI) due to presence of water molecule in its matrix. The presence of high LOI in final concentrate deteriorates quality of pellets. Due to the presence of chemically bound water in the matrix of hydrated minerals, high-pressure steam is released at high temperature during induration of pelletization process resulting in formation of multiple cracks in pellets thereby reducing strength and quality of pellets. This necessitates the removal of LOI from fine iron ore feed for pelletization and a thorough investigation into the kinetics of LOI removal. A comprehensive literature review reveals that although fundamental studies have been done to understand the mechanism of LOI removal, no direct and comprehensive study have been made to understand the kinetics of LOI removal from goethetic hematite iron ore in fluidized bed reactor. Therefore the present dissertation aims at the study of kinetics of thermal decomposition of hydrated minerals associated in natural hematite iron ores in fixed and fluidized bed systems using isothermal methods of kinetic analysis.

Experiments in fixed bed demonstrated that mass of the fixed bed influences the LOI removal much more than the initial LOI in the sample. While majority of LOI (more than 80%) could be removed only in 5 minutes in the temperature range 900 to 1100°C in low mass system (max. 15 gm); around 75 minutes are required for the same in the high mass system (max. 1 kg). It was further observed that in static bed 100% removal of LOI is not possible beyond a certain critical bed depth (16 mm) irrespective of residence time and temperature. Kinetic analysis also indicated that the decomposition of hydrated mineral in hematite in fixed bed mostly follows the chemical reaction kinetics and at higher temperature nucleation and growth kinetics also starts influencing the decomposition. The estimated activation energy values in all the experimental situations are found to be 60-70 kJ/mol.

Experiments in high temperature batch fluidized bed reactor (FBR) demonstrated that the LOI content could be reduced by more than 90% in FBR within one minute of residence time at the temperature of 1100°C. Three kinetic models namely chemical reaction kinetics, diffusion and nucleation/growth kinetics are found to best fit to the experimental data at different temperature regimes for iron ore samples having different LOI. In case of low LOI sample, two separate kinetics are found to follow in the two different temperature regimes.

Up to 700°C, chemical kinetics dominates, which is followed by nucleation and growth which become active at high temperature. In case of high LOI (more than 6%), diffusion kinetics dominates till 400°C, then chemical kinetics dominates in the range of 400-650°C and finally nucleation and growth kinetics also become active beyond 650°C.

Key words: LOI removal, Thermal decomposition, Fluidized bed, Kinetic analysis, Hydrated iron ore