REDUCTION OF HEMATITE (Fe_2O_3) TO METALLIC IRON (Fe) BY CO IN A MICRO FLUIDIZED BED REACTION ANALYZER: A MULTISTEP KINETICS STUDY

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A better understanding of the reduction kinetics of iron oxides in a fluidized bed promotes the development of relevant industrial processes, e.g. chemical looping combustion and non-blast furnace iron making. The reduction of iron oxides into iron is complex because the process is heterogeneous and several elementary reactions take place simultaneously. It is hard to figure out the reduction kinetics under fluidization in a fixed bed reactor such as in a thermogravimetry analyzer (TGA) which suffers from the limitations of heating rate, external diffusion, thermal pretreatment before reaction occurs. In this study, the reduction kinetics of hematite to metallic iron at different temperatures and carbon monoxide concentrations are experimentally investigated in a micro fluidized bed reaction analyzer (MFBRA), developed by the Institute of Process Engineering (IPE), Chinese Academy of Sciences (CAS) to develop the kinetics of fast gas-solid reactions. Results indicate that the reduction process has to be described by multistep kinetics and separated into several elementary reactions (i.e. hematite-magnetite, magnetite-wüsitite and wüsitite-iron), which proceed in parallel with different controlling mechanisms as well as with different time dependences. A multistep kinetics model based on Johnson-Mehl-Avrami (JMA) model is developed for the isothermal reduction process of hematite to metallic iron by taking into account the influences of reduction temperature and reducing gas concentration, using statistical analysis tools in the Statistical Product and Service Solutions (SPSS). The kinetics parameters, i.e. activation energy and pre-exponential factor, are determined for each elementary reaction. The contribution of each individual reaction to the whole reduction process is further discussed. The results also suggest that the reduction of hematite to wüsitite takes place fast and dominates the initial part of the entire reduction while the reduction of wüsitite to iron plays a less important role in the initial stage but controls the whole reduction in the late stage. The conclusions obtained in this study are comparable with that in the literature and indicate that the multistep kinetics model is able to capture the properties of both elementary reactions and the integrated process, providing an analysis strategy for revealing detail characteristics of the complex