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# Development of a Solar Rotary-Kiln Reactor for the Reduction of Metal Oxide Particles

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A solar rotary-kiln reactor has been fabricated for the reduction of metal oxide particles at ~1650 K as part of a solar thermal decoupled water electrolysis process for the production of hydrogen. Particle motion is controlled through the reactor's angular speed of rotation. At rotational speeds greater than 65 rpm, the internal walls of the reactor are fully covered with particles. Simultaneously, mixing elements generate a particle cloud in the reactor in order to increase the absorption of incident solar radiation. A model of the reactor that solves the energy conservation equation and includes the kinetics of the metal oxide reduction suggests that peak thermal efficiencies of 47 percent are possible for the reduction of hematite to magnetite. In parallel, the solid state kinetics for the reduction of cobalt oxide (a promising alternative to iron oxide) in a low oxygen partial pressure atmosphere has been determined. Reduction follows the shrinking core model and is initially limited by the rate of oxygen diffusion in the gas phase and later limited by the chemical kinetics at the shrinking reactive interface. Regression of the model to isothermal and non-isothermal thermogravimetric analyzer data yielded the temperature-dependent reaction rate parameters.

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