Multiphysics Simulation of a DRP Shaft Furnace

NOGARE Daniela Dalle

Danieli Research & Development,
Danieli & C Officine meccaniche S.p.A., Buttrio (UD),
Italy

A 2D axialsymmetric model of a DRP (direct reduction plant) shaft furnace that includes momentum, species and enthalpy balances for the solid and the gas phases was solved. The process consists in the reduction of iron ore pellets with H_2 and CO mixtures at high temperature. The process gas can contain natural gas, which is catalytically converted on metallic iron by steam reforming and cracking reactions into syngas and carbon. The model describes the moving iron ore and DRI pellets bed as a non Newtonian continuum fluid, whose viscosity is a function of the flow field itself and of the solids attrition properties. The motion of the gas through the porous bed is described by a Brinkman equation and by a continuity equation with a positive production term, due to the flux of mass from the solid to the gas phase because of the oxides reduction. Gas and solids composition and temperatures come from transport equations of species and enthalpy. The kinetics of the reduction reactions are implemented with a two interfaces shrinking core model, corresponding to the hematite/wüstite and wüstite/iron interfaces. The catalytic reactions involving the species in the gas phase include steam reforming, water gas shift and methane cracking. The model is able to reproduce the behavior of an industrial DRP reactor operated at high pressure, in terms of final metallization and total carbon content of the DRI (direct reduction iron) product. Moreover, it gives insight into the behaviour of the reactor, in terms of flow patterns, local compositions, temperature profile and spatial distribution of the reactions. This is a powerful tool for designing novel configurations, to address the special requirements of new processes and for understanding how to face contingent changes in operations, e.g. feedstock, composition of flow rate, promptly suggesting optimal measures.

Co-authors: **Alberto Zugliano, Alessandra Primavera, Tommaso Melchiori, Paolo Canu**