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A CFD model for biomass fast pyrolysis in fluidized-bed reactors

QINGLUAN XUE, Department of Chemical and Biological Engineering, Iowa State University, T.J. HEINDEL, Department of Mechanical Engineering, Iowa State University, R.O. FOX, Department of Chemical and Biological Engineering, Iowa State University — A numerical study is conducted to evaluate the performance and optimal operating conditions of fluidized-bed reactors for fast pyrolysis of biomass to bio-oil. A comprehensive CFD model, coupling a pyrolysis kinetic model with a detailed hydrodynamics model, is developed. A lumped kinetic model is applied to describe the pyrolysis of biomass particles. Variable particle porosity is used to account for the evolution of particle physical properties. The kinetic scheme includes primary decomposition and secondary cracking of tar. Biomass is composed of reference components: cellulose, hemicellulose, and lignin. Products are categorized into groups: gaseous, tar vapor, and solid char. The particle kinetic processes and their interaction with the reactive gas phase are modeled with a multi-fluid model derived from the kinetic theory of granular flow. The gas, sand and biomass constitute three continuum phases coupled by the interphase source terms. The model is applied to investigate the effect of operating conditions on the tar yield in a fluidized-bed reactor. The influence of various parameters on tar yield, including operating temperature and others are investigated. Predicted optimal conditions for tar yield and scale-up of the reactor are discussed.

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