Dynamic Evolution of the Particle Size Distribution in Gas-Phase Olefin Polymerization Fluidized Bed Reactors

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Abstract

In the present study, a comprehensive mathematical model is developed to predict the evolution of particle size distribution (PSD) in a gas-phase olefin polymerization fluidized bed reactor (FBR). To calculate the particle growth and the spatial monomer and temperature profiles in a particle, the random pore polymeric flow model (RPPFM) is employed. This model is based on the well-known polymeric flow model and on the fundamental Stefan-Maxwell multicomponent diffusion equations. The RPPFM is solved together with a dynamic discretized particle population balance model, accounting for both particle growth and agglomeration, to predict the PSD in the bed. To evaluate the extent of particle agglomeration in the bed, a new agglomeration kernel is developed in terms of the individual particle surface temperatures, the polymer softening temperature and a size dependent function, describing the mechanism of dual particle collisions. The effect of the selected mode of particle collision mechanism on the shape of the PSD is investigated. Under complete mixing conditions of solids in the bed and a uniform size catalyst feed, it is shown that external and internal mass and heat transfer resistances at the particle level can have a strong impact on the PSD or/and the mean residence time of solids in the bed. Furthermore, the effects of bulk polymerization temperature and propylene to ethylene molar ratio on the extent of particle agglomeration in ethylene and ethylene-propylene polymerization in a FBR are thoroughly analyzed.

Keywords: fluidized bed reactor, particle size distribution, olefin polymerization, particle growth model, Stefan-Maxwell equations, particle agglomeration.