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Scale-Up of High-Velocity Gas-Solid Systems: A Comparison between Kinetic-Theory Modeling and Existing Scaling Laws

M. Detamore, K. Frender, M. Swanson, and C. Hrenya
Department of Chemical Engineering
University of Colorado

Experience in fluid catalytic cracking (FCC) and other gas-solid processes has indicated that the scale-up of high-velocity fluidized beds is a complex and poorly understood process. In response to the practical difficulties associated with these systems, numerous sets of dimensionless scaling parameters have been proposed in the literature. Typically, the ability of such scaling laws has been assessed via a comparison between the measured (dimensionless) pressure gradients of fluidized beds of different sizes. In the current effort, a kinetic-theory model for dense, high-velocity gas-solid systems is used to compare the radial profiles of unlike systems for which the scaling parameters are kept constant. Several sets of existing scaling laws are examined, and comparisons are made between the model predictions for radial solids concentration and velocity of the "small" and "large" beds. The results indicate that the "full" set of scaling parameters is necessary to provide an exact match between hydrodynamic profiles, whereas simplified versions of the full set do not result in similitude. Furthermore, this work also indicates the importance of matching particle and wall properties (e.g., elasticity of collisions, wall roughness) between scaled systems in order to achieve hydrodynamic similarity.