Powder Technology
accepted for publication (June 2000)

A Kinetic-theory Analysis of the Scale-up of Circulating Fluidized Beds

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

In response to the challenges associated with the scale-up of high-velocity, gas-solid systems such as circulating fluidized bed (CFB) reactors, numerous sets of scaling parameters have been proposed in the literature. Although the scaling sets are typically derived via a non-dimensionalization of the continuum equations for gas-solid flows, variations between sets arise due to differences in the assumed forms of the constitutive relations. In the current study, an existing kinetic-theory model is used to assess the ability of the various scaling laws. In particular, for unlike systems with identical values of the scaling parameters, the level of similarity between the radial profiles for solids concentration and solids velocity is examined. The model predictions indicate that detailed hydrodynamic similitude is not achieved for "reduced" scaling sets in which the ratio of the particle diameter to tube diameter is omitted. Furthermore, the results also show that the properties characterizing particle collisions (e.g., coefficient of restitution) must also be matched to ensure similarity. Both of these provisions can be traced to the kinetic-theory description of solid-phase stresses, which is not accounted for in the derivation of existing scaling laws, but is included in the mathematical model used in this investigation.