Yan, Aijie, Ph.D., “Hydrodynamics and Scale-up of Circulating Fluidized Beds”, The University of Western Ontario, April 2004.

Abstract

The scale-up effect on the hydrodynamics of gas-solids circulating fluidized bed riser reactors of different riser diameters was systematically studied in two 10 m long, 76 mm and 203 mm internal diameter risers by measuring the pressure drops, solids holdup, and particle velocity with pressure transducers, a reflective-type fibre optic concentration-probe and a five-fibre optic velocity probe. A large number of measurements from the two risers with special design features of solids inlet valve make it possible to obtain information over a wide range of riser operating conditions. The similarities and differences in the flow behaviours of the two risers are clearly observed. Solids concentration increases with the increase of riser diameter, while the cross-sectional average particle velocity decreases somewhat for the larger riser. Meanwhile, a larger riser has steeper radial profiles for both solids concentration and particle velocity at each axial level. Asymmetry of the radial profiles of solids concentration and particle velocity at both entrance and exit regions are also observed. Such asymmetry is much stronger with higher flux. For both risers, the flow development in the riser centre is nearly instant at the riser bottom under all operating conditions and there is no significant difference for the two risers in the center region throughout the riser. On the other hand, in the wall region, the flow development slows down for both risers, and such a slow down is much more significant for the larger riser. In the wall region, the solids holdup of the 8 inch riser is higher than that of the 3 inch riser, but the particle velocity is lower. The solids inventory and riser diameter appears to have little influence on the shape of the profile, but the average solids holdup is higher with higher solids inventory and decreases with the increase of riser diameter. Increasing solids flux also slows down the flow development, but increasing superficial gas velocity makes the flow development faster. Based upon the theoretical analysis and the systematically experimental data obtained in this study, a series of correlations is proposed to predict the radial profiles of particle velocity and solids holdup for the CFB riser reactors. In all locations measured, there was a clear dependence between the local particle velocity and solids concentration of both risers. Gas distribution and particle aggregation are considered the key factors that affect the local hydrodynamics in the twin-riser system. The information obtained from this study could be beneficial, especially for FCC industrial design and operation.