Zhu Haiyan, Ph.D., “Turbulent Fluidized Bed vs. High Density Riser — Regimes and Flow Characterizations”, The University of Western Ontario, November 2006.

Abstract

In this research, a comprehensive study is conducted in high-density fluidization systems of different design features (bubbling, turbulent, high density circulating fluidized bed, and a newly designed circulating-turbulent fluidized bed) to further investigate the flow regime transition and local flow structures. Experimental results are examined including the spatial variations (radial and axial profiles of time-averaged data) and temporal variations (time series analysis using statistical analyses).

The global and local regime transition velocity from bubbling to turbulent fluidization for FCC particles is investigated and compared. Extensive experiments are carried out using a new developed optical fiber probe system, which can measure the solids concentration and velocity at multi-points. Results show different transition manners for the global and local flow regime transition reflected by the measurements of differential pressure fluctuations and local solids concentration fluctuations. The effects of static bed height and pressure tube spacing on the transition velocity are also studied. The effects of operating condition on local flow structures in the bubbling and turbulent fluidization regimes are studied in detail.

The hydrodynamic characteristics in the bottom region of CFB risers with FCC particles are studied over a wide range of operating conditions. The results include radial solids concentration and corresponding radial profiles of standard deviation, particle velocity profiles, and probability density distributions. Comparisons are made between the flow structures in the riser bottom region and that in bubbling and turbulent fluidized bed to clarify flow regimes applicable to the bottom region of CFB risers.

A novel circulating-turbulent fluidized bed (C-TFB) featuring high solids concentration and no solids back mixing is introduced and tested in a cold-model set-up. The purpose of the new design is to integrate circulating and turbulent fluidized beds into a unique fluidization system for more efficient gas-solid contact and uniform flow structure. The hydrodynamic characteristics of the C-TFB are analyzed in terms of differential pressure, solids concentration, particle velocity, and local solids flux distributions. Experimental results reveal that an axial homogeneous flow structure is easily obtained with cross-sectional average solids volume concentrations higher than 0.25 throughout the entire C-TFB. For all locations, there is no net downflow of solids and a good gas-solid mixing can be observed.