Manyele SV, Ph.D., “Dynamics and Flow Non-Uniformity Study in Circulating Fluidized Beds of Different Design Features Using Time Series Analysis”, The University of Western Ontario, August 2001.

Abstract

In this research, a comprehensive study was conducted in various circulating fluidized beds (CFBs) of different design features (gas-solid and liquid-solid, upflow and downflow, high- and low-fluxes), to systematically quantify the flow non-uniformities, by examining the spatial variations (radial and axial profiles of time-averaged data) and temporal variations (time series analysis using statistical, spectral and chaos analyses).

To quantify the extent of radial (spatial) variations, a radial nonuniformity index (RNI) was devised. Using this index, radial distributions of solids concentration and particle velocities in gas-solids and liquid-solids CFBs were examined and compared.

To understand the temporal behavior in a riser (0.076 m i.d. and 10 m high) and a downer (0.1 m i.d. and 10 m high), the microflow structures were studied by analyzing the measured signals of solids concentration and differential pressure fluctuations. In both cases, statistical spectral and chaos parameters varied strongly with location and operating conditions, as well as with the flow direction. In the riser, stronger time-variations were observed near the wall region in the radial direction and in the transition section in the axial direction. In the downer, however, a uniform microflow structure was observed far away below the entrance.

In both reactors the temporal behavior was further examined by evaluating the aggregate properties (frequency, time fraction, existence time, average solids concentration and vertical dimension) using solids concentration signals. Sensitivity analysis was first conducted to establish the settings for the optimum critical solids concentration and the duration of perturbations caused by clusters. A strong dependence of the aggregate properties on operating conditions, local mean solids concentration, radial and axial position was revealed in both reactors.

Furthermore, the temporal variations were examined in a high-flux CFB riser using chaos analysis of differential pressure and solids concentration fluctuations. The complexity and predictability of the gas-solids flow were characterized by correlation dimension and Kolmogorov entropy, respectively. The two chaos parameters varied strongly with the operating conditions (solids flux and gas velocity) and decreased with increasing local mean solids concentration. Meanwhile, the correlation dimension and Kolmogorov entropy decreased exponentially with increasing average absolute deviation and average cycle time of the pressure fluctuations, respectively. The core region and the transition section exhibited higher values of the entropy and dimension.