Abstract

Conical fluidized beds are used for various applications in many industries. Despite their wide applications, the detailed understanding of conical fluidized bed is still missing. A detailed data on the local hydrodynamic of these systems can be useful for their design, operation, and scale-up. Most of the literature on conical fluidized beds only reveal about their overall performance in terms of overall pressure drop, minimum fluidization velocity prediction, global mixing and segregation characteristics. However, the local interaction between the fluid-solid and solid-solid are more critical. Further, the effect of particle size, particle size distribution and column dimensions on mixing and segregation of the conical bed are not well understood. To the best no scale-up studies are reported in literature on conical fluidized bed. Such studies are largely missing due to lack of experimental data as most of the technique work in optical range and is not applicable in dense conical fluidized bed. Further, very few measurement techniques are available which can provide the data with the same accuracy at both scales.

In current thesis, radioactive particle tracking (RPT) technique was used to study the flow behavior in conical fluidized bed. Experiments were performed for both gas-solid and liquid-solid conical fluidized beds for different fluid inlet velocities and particle sizes. Binary bed of same density and different particle size was used to study the effect of bed composition and fluid inlet velocity on performance of gas-solid and liquid-solid conical fluidized beds. Effect of operating conditions on axial and radial mean velocities, axial and radial RMS velocities, and granular temperature were studied. Further, time series analysis was performed to quantify Hurst's exponent, axial and radial autocorrelation functions. Chaos analysis was performed to estimate Kolmogorov entropy and correlation dimensions. Further, segregation index was calculated to quantify the mixing and segregation behavior of the gas-solid and liquid-solid conical fluidized beds for different fluid inlet velocities and bed compositions. It was found that both gas-solid and liquid-solid fluidized beds provide better mixing compared to their cylindrical fluidized bed. Particle-particle interactions were found to be critical in determining the flow physics at the top section of the mono and binary dispersed conical fluidized beds. While, fluid-particle interactions were more critical at the bottom of the conical bed, which was relatively dilute compared to top section. Regime transition was observed for both gas-solid and liquid-solid conical fluidized beds at higher velocity. It was observed that regime transition only depends on fluid velocity and not on bed composition. Liquid-solid conical bed was found to be calm and homogeneously distributed compared to gas-solid conical bed.

Finally, scale-up studies are performed for gas-solid mono and binary dispersed conical fluidized beds using the inertia set of Glicksman law. Effect of fluid velocity on performance of scaled-up setup is also investigated. It was found that the behavior of the bed changes significantly with changing the column dimensions. Inertia set of Glickman law was able to predict the mean velocities of solids in mono dispersed bed. However, predictions were not good for local/fluctuation quantities like RMS velocity, granular temperature and autocorrelation function. For binary bed inertia set of Glickman law was not able to predict even mean velocities. Hence, used set of scale-up rule was not applicable for conical bed and a dedicated scale-up rule for conical fluidized bed is required. Further, a dedicated scale-up rule for binary bed will also be required which will be different from the mono dispersed bed.