The present work focuses on the study of space-/time-resolved phase volume fraction distribution of gas-solid flows in a cylindrical fluidized bed. The work particularly deliberates on the characterization of dynamics of phase distribution in unary and binary gas-solids flow and also segregation through measurements using the Electrical Capacitance Tomography (ECT), and through CFD simulations using two-/multi-fluid Eulerian models.

The ability of two-fluid Eulerian model to predict the instantaneous phase distribution was studied. The measured time-averaged phase distributions, bubble chord length distributions and bubbling frequency are compared with the corresponding predictions obtained from two-fluid Eulerian simulations for unary gas-solid flows. The results showed that the predicted time-averaged solid volume fraction distribution differed marginally and were in a satisfactory agreement with the corresponding measurements. However, the bubbling frequency and bubble chord length distribution predicted using different drag models, in particular, the formation of large bubbles/slugs, were considerably different. A modified drag model is proposed that led to a reduction in the regions in the bed in which higher drag force was applied, allowed the formation of larger bubbles/slugs and led to an improvement in the predicted bubbling behavior. It was also found that the use of different drag models, in turn, also affects the total solid viscosity and therefore the bubbling behavior. The posterior analysis showed that among solid-phase kinematic, collisional, and frictional viscosities, the influence of frictional viscosity on the bubbling behavior was found to be more dominant. An increase in the frictional viscosity leads to compaction of the solid phase and increase in the formation of large bubbles/slugs, those were observed experimentally. The predicted bubbling frequency and bubble chord length distribution were in a quantitative agreement with those measured using the ECT for different gas velocities and particle sizes.

Further, the ECT technique was applied to measure the segregation time for binary gas-solids flow in a cylindrical fluidized bed. The measurements of segregation and fluidization of binary mixtures were investigated using the ECT and high-speed imaging. It was established that ECT can be used to detect the regions of complete segregation in a cylindrical fluidized beds. In particular, the binary gas-solids flows in systems with large $D/d_p$ ratio, which are otherwise difficult to characterize using high-speed imaging. Under the fluidization conditions, the bubbling behavior of the mixtures was governed by the smaller-sized particles in spite of
having an equal percentage by weight of the particles in the mixture. For the fluidization of binary mixtures, a relation between the measured variance of solid volume fraction fluctuations and the corresponding flow structures was studied. It was also found that different bubbling behaviors can produce the same time-averaged solid volume fraction profiles. As a consequence, different phase distributions can lead to different heat and mass transport rates depending on the local interfacial area, despite having the same time-averaged phase hold-up distribution.

Further, efforts were made to predict the segregation time using the Eulerian multi-fluid model. It was found that due to higher gas-particle drag force magnitude, the larger particles were carried away from bottom to the top of the bed resulting into less extent of segregation and higher segregation time in comparison to the corresponding experiments. The collisional contribution in the particle-particle drag model led to increase in the segregation time and therefore it was neglected and frictional coefficient was adjusted that improved the agreement with the measured segregation time. In fluidized bed conditions for binary mixtures, the predicted distribution was in a qualitative agreement. The reason for quantitative difference was due to ad-hoc values of different parameters used in particle-particle drag models for collision and friction interactions between the solids.

The present thesis helps to understand the characteristics of instantaneous phase distribution and segregation in gas-solids fluidization. It also helps in accessing the ability of Eulerian multi-fluid CFD models to predict the dynamics of instantaneous phase distribution (in terms of bubble size distribution and bubbling frequency) and segregation in gas-solids fluidization.