ABSTRACT

The objective of the present study was to investigate the hydrodynamics of three-phase fluidized beds, their rheology, and experimentally verify a predictive three fluid hydrodynamic model developed at the Illinois Institute of Technology, Chicago. The recent thorough reviews by L.S. Fan , B.L. Tarmy and C.A. Coulaloglou (1990) show that there exist no such models in the literature.

The IIT hydrodynamic model computes the phase velocities and the volume fractions of gas, liquid, and particulate phases. Model verification involves a comparison of these computed velocities and volume fractions to experimental values.

In this thesis, a three fluid model is presented. The input into the model can be particulate viscosities either measured with a Brookfield viscometer or derived using the mathematical techniques of kinetic theory of granular flows pioneered by Savage and others. The computer simulation of a three-phase fluidized bed in an asymmetric mode qualitatively predicts the gas, liquid and solid hold-ups (volume fractions) and flow patterns in the industrially important churn-turbulent (bubbly coalesced) regimes. The computations in a fluidized bed with a symmetric distributor incorrectly showed no bubble coalescence.

A combination of X-ray and γ-ray densitometers was used to measure the solids and the liquid volume fractions in a two dimensional bed in the bubble coalesced regime. There is a good agreement between the theory for an asymmetric distributor and the experiments.

The porosity fluctuation signals inside two phase and three phase fluidized beds were detected by using a γ-ray absorption technique and analyzed by means of the fast Fourier transform (FFT) power spectrum method. The measurements indicated that the bubble coalescence and break-up could be detected by using such techniques. The experimental and simulation porosity fluctuations and bubble frequencies show a fair comparison.

A high resolution micro-imaging / measuring system apparatus was used to measure instantaneous and time averaged particle velocities. The fluctuations of particle velocities around their average values were found to be approximately Maxwellian. The measured time averaged velocities compare well with the predicted velocities for an asymmetric distributor used in this study.

A Brookfiled viscometer was used to measure the "apparent" bed viscosity in two three-phase fluidized beds. The viscosities were also calculated from measurements of particle oscillations (granular temperatures) using a high resolution micro-imaging /measuring system. To obtain these viscosities a dense phase kinetic theory formula derived in D. Gidaspow's book (1994) was used. There is an excellent agreement between the macroscopically measured viscosities using a Brookfiled viscometer and those computed from particle fluctuations and collisions using kinetic theory.