World Academy of Science, Engineering and Technology
International Journal of Chemical and Molecular Engineering
Vol:11, No:02, 2017

CFD-DEM Modelling of Liquid Fluidizations of Ellipsoidal Particles

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Abstract : The applications of liquid fluidizations have been increased in many parts of industries such as particle classification, backwashing of granular filters, crystal growth, leaching and washing, and bioreactors due to high-efficient liquid–solid contact, favorable mass and heat transfer, high operation flexibilities, and reduced back mixing of phases. In most of these multiphase operations the particles properties, i.e. size, density, and shape, may change during the process because of attrition, coalescence or chemical reactions. Previous studies, either experimentally or numerically, mainly have focused on studies of liquid-solid fluidized beds containing spherical particles; however, the role of particle shape on the hydrodynamics of liquid fluidized beds is still not well-known. A three-dimensional Discrete Element Model (DEM) and Computational Fluid Dynamics (CFD) are coupled to study the influence of particles shape on particles and liquid flow patterns in liquid-solid fluidized beds. In the simulations, ellipsoid particles are used to study the shape factor since they can represent a wide range of particles shape from oblate and sphere to prolate shape particles. Different particle shapes from oblate (disk shape) to elongated particles (rod shape) are selected to investigate the effect of aspect ratio on different flow characteristics such as general particles and liquid flow pattern, pressure drop, and particles orientation. First, the model is verified based on experimental observations, then further detail analyses are made. It was found that spherical particles showed a uniform particle distribution in the bed, which resulted in uniform pressure drop along the bed height. However for particles with aspect ratios less than one (disk-shape), some particles were carried into the freeboard region, and the interface between the bed and freeboard was not easy to be determined. A few particle also intended to leave the bed. On the other hand, prolate particles showed different behaviour in the bed. They caused unstable interface and some flow channeling was observed for low liquid velocities. Because of the non-uniform particles flow pattern for particles with aspect ratios lower (oblate) and more (prolate) than one, the pressure drop distribution in the bed was not observed as uniform as what was found for spherical particles.

Keywords : CFD, DEM, ellipsoid, fluidization, multiphase flow, non-spherical, simulation
Conference Title : ICMFIPE 2017 : International Conference on Multiphase Flow in Industrial Plant Engineering
Conference Location : Melbourne, Australia
Conference Dates : February 02-03, 2017