411f Fluidization of Nanoparticles in a Rotating Fluidized Bed

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The rotating fluidizing bed (RFB) system has advantages in terms of handling of fine powders over a conventional fluidized bed due to the additional forces generated by the rotation of the distributor that allows for an increased throughput of gas without entrainment of the solid phase. The RFB system can be applied to several processes based on fluidization such as granulation, particle coating, combustion and various gas-particle chemical reactions. In this work, agglomerates of nanoparticles such as fumed silica Aerosil® R974, Aerosil® R972 and Aeroxide® TiO2 P25 were fluidized in a rotating fluidized bed. Their fluidization behavior is represented by the bed pressure drop, expansion and minimum fluidization velocity measured under different rotating speeds that generated force fields of 10, 20, 30 and 40 times the force of gravity (9.8 m/s2). In addition, the effect of bed expansion and the tangential velocity component of the fluid on the pressure drop across the fluidized bed were modeled theoretically. It was observed that the fluidized bed pressure drop that corresponds to APF type powders, i.e., Aerosil® R974 & R972, was higher than theoretically calculated by current models. This discrepancy is explained in that the additional pressure drop has its origins on tangential momentum effects since these powders have a reduced effective viscosity due to their large void fraction when compared against micron size powders. Thus the tangential velocity component from the region above the fluidized bed, which behaves vortex-like, penetrates into the expanded bed generating additional forces, i.e., a Coriolis force which increases the pressure drop across the measured region. A non-dimensional analysis was done on the system by using the Navier-Stokes equation for non-linear flow through a packed bed; it was found that due to the high porosity of the APF powders, the Darcy's term is around two orders of magnitude less than for micron size powders. Therefore, under these conditions, the Coriolis term, which was neglected for fluidization of micron size powders, can contribute to the pressure drop of the fluidized bed. Subsequently, a new equation is proposed that accounts for the tangential effects.