Numerical Modeling of Electrostatic Effects in Monodisperse Polyethylene Particles in a Bubbling Fluidized Bed

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Abstract—**Triboelectric charging is a problematic phenomenon in gas solid fluidization. Of interest is the case of polyethylene production, where electrostatic charging leads to reactor wall sheeting which can clog the reactor inlet and disrupt the manufacturing process. It could also lead to more catastrophic issues if high electric potentials are developed, which sometimes result in sparks and fire.**

Numerical modelling to simulate such occurrences has been attempted by previous authors. Of note is the work of Rokkam et al. (2013), who used particles of constant but different charge magnitudes as a function of size, predicting charge-driven preferential segregation in a fluidized bed. Their work was based on the results of Sowinski (2012), Sowinski et al. (2012), who had carried out detailed experiments to test the effect of particle size, fluidizing velocity and wall material on bed electrification. Rokkam's work; however, dealt with charge transport through advection and neglected diffusion and charge generation. These effects have been developed for a monodisperse particle case and the corresponding results are presented in this work. To derive a diffusion model, the wall charging model of Matsusaka et al. (2000) and Matsusaka and Masuda (2003) were used. This allowed derivation of the particle-wall charge flux based on the kinetic theory of the granular flow, similarly to what was done for momentum and granular temperature in Johnson and Jackson (1987). For particle-particle diffusion, a charging model similar to the wall charging model has been derived and implemented. The corresponding expressions for diffusion fluxes were formulated using collision integrals, following Jenkins and Savage (1983) in deriving the rate of change of particle properties of monodisperse granular spheres. The wall boundary condition for charge was then evaluated by equating the charge fluxes due to the particle-wall and particle-particle collisions.

The model developed in this work was then applied to a two-dimensional computational domain, mimicking the laboratory-scale fluidized bed employed by Sowinski (2012), where the effect of different particle sizes was investigated. Thus, three different particle diameters of 362, 462 and 550 µm were used in the simulations. Constant fluidization velocity magnitudes 50% higher than the minimum fluidization velocities were assigned. The simulation was run until steady state values of total bed charge and total electric potential were obtained. Similar

to the experiments, adhesion of particles to the fluid bed wall due to charging was predicted for smaller sized particles (< 350 µm) in preference to larger-sized ones. The average bed charge was shown to increase by over 250% in each case with a sharp boundary layer of about 500 µm thickness at the wall. The electric potential developed was also found to be below the Paschen curve for air, thereby eliminating the possibility of electric breakdown. The bed was subsequently allowed to settle, and the final charge density in the settled bed was found to be nearly the same as the time-averaged value during fluidization. The net bed charge was shown to be negative for all particle sizes tested.

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