An EMMS Based Solid Stress Model for MP-PIC Method

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Solid stress describes particle-particle interaction, which is a very important parameter in gas-solid fluidization simulations, especially for the dense cases. Gas-solid fluidizations are characterized with meso-scale structures including particle cluster and gas bubble. Meso-scale structures can lead to not only heterogeneous solid distributions of the whole fluidization reactor but also the coexistence of particle dense phase and particle dilute phase locally. Generally the present solid stress models assume homogeneous particle distribution in calculation grid. How to include the effect of sub-grid meso-scale structures in numerical model is the key to improve the accuracy of simulations.

To account for the sub-grid heterogeneity in multi-phase particle-in-cell (MP-PIC) method, a structure-dependent solid stress model is proposed in this work, in which the particle/parcel distribution is taken into account by using the particle/parcel position information within a computational cell. Each parcel is viewed as a cluster of particles which is also dimmed as a dense phase. The cluster is surrounded by dilute phase. Thus the flow field of a cell is divided into several dense phases and a dilute phase. The porosity inside cluster and the diameter of cluster are calculated by using the energy-minimization multi-scale (EMMS) model. Then the solid stress acting on each parcel is calculated with the local information of velocities and porosities within the grid. A bubbling fluidized bed and a circulating fluidized bed riser are simulated to validate this solid stress model with MP-PIC code, and the results show good agreements with experimental data.

Keywords: solid stress, simulation, fluidization, meso-scale, MP-PIC