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Numerical Simulation on Two Components Particles Flow in Fluidized Bed

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Abstract : Flow of gas and particles in fluidized beds is complex and chaotic, which is difficult to measure and analyze by experiments. Some bed materials with bad fluidized performance always fluidize with fluidized medium. The material and the fluidized medium are different in many properties such as density, size and shape. These factors make the dynamic process more complex and the experiment research more limited. Numerical simulation is an efficient way to describe the process of gas-solid flow in fluidized bed. One of the most popular numerical simulation methods is CFD-DEM, i.e., computational fluid dynamics-discrete element method. The shapes of particles are always simplified as sphere in most researches. Although sphere-shaped particles make the calculation of particle uncomplicated, the effects of different shapes are disregarded. However, in practical applications, the two-component systems in fluidized bed also contain sphere particles and non-sphere particles. Therefore, it is needed to study the two component flow of sphere particles and non-sphere particles. In this paper, the flows of mixing were simulated as the flow of molding biomass particles and quartz in fluidized bad. The integrated model was built on an Eulerian–Lagrangian approach which was improved to suit the non-sphere particles. The constructed methods of cylinder-shaped particles were different when it came to different numerical methods. Each cylinder-shaped particle was constructed as an agglomerate of fictitious small particles in CFD part, which means the small fictitious particles gathered but not combined with each other. The diameter of a fictitious particle d_fic and its solid volume fraction inside a cylinder-shaped particle α_fic, which is called the fictitious volume fraction, are introduced to modify the drag coefficient β by introducing the volume fraction of the cylinder-shaped particles α_cld and sphere-shaped particles α_sph. In a computational cell, the void ε, can be expressed as ε=1-α_cld α_fic-α_sph. The Ergun equation and the Wen and Yu equation were used to calculate β. While in DEM method, cylinder-shaped particles were built by multi-sphere method, in which small sphere element merged with each other. Soft sphere model was using to get the connect force between particles. The total connect force of cylinder-shaped particle was calculated as the sum of the small sphere particles' forces. The model (size=1×0.15×0.032 mm3) contained 420000 sphere-shaped particles (diameter=0.8 mm, density=1350 kg/m3) and 60 cylinder-shaped particles (diameter=10 mm, length=10 mm, density=2650 kg/m3). Each cylinder-shaped particle was constructed by 2072 small sphere-shaped particles (d=0.8 mm) in CFD mesh and 768 sphere-shaped particles (d=3 mm) in DEM mesh. The length of CFD and DEM cells are 1 mm and 2 mm. Superficial gas velocity was changed in different models as 1.0 m/s, 1.5 m/s, 2.0m/s. The results of simulation were compared with the experimental results. The movements of particles were regularly as fountain. The effect of superficial gas velocity on cylinder-shaped particles was stronger than that of sphere-shaped particles. The result proved this present work provided a effective approach to simulation the flow of two component particles.

Keywords : computational fluid dynamics, discrete element method, fluidized bed, multiphase flow
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