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DEM-CFD numerical simulation and experimental validation of heat transfer and two-component flow in fluidized bed

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ABSTRACT

Based on the improved computational fluid dynamics and discrete element method (DEM–CFD), heat transfer and two-component flow in fluidized bed have been studied from two respects of experiment and numerical simulation in this paper. During experiments, the particle temperature and moving images are, respectively, recorded by infrared thermal imager and high speed camera. With the increase of the gas velocity, the mixing index in fluidized bed and the cooling rate of the particles are also increasing. Due to the large heat capacity and weight, the temperature of biomass particles drops slower than that of quartz sand. The fictitious element method is employed to solve the incompatibility of the traditional DEM–CFD model, where the larger biomass particles are considered as an aggregation of numerous fictitious sphere particles arranged in certain sequence. The distribution of dense spherical elements inside biomass plays an important part in gas flow, which makes the internal gas velocity lower, and the gas temperature is close to the particle temperature. By the comparison of data collected by infrared thermal imager and the simulated results, it can be concluded that experimental data are basically agreement with numerical simulation results within the first 9 s. Affected by low temperature air, the average temperature of the particles in the lower bed height area (h < 30 mm) is about 3° lower than that of the other heights. When the superficial gas velocity is increasing, the average temperature difference of the particles in each height region of the bed also becomes larger. At this time, the fluidized bed is in good condition, and the gas temperature distribution is more uniform in the whole area. On the contrary, bubbles are not easy to produce, and the fluidization is restricted at lower superficial gas velocity. The gas–solid heat transfer mainly exists under the bed height of 10 mm and decreases rapidly on fluidized bed height, while the value of contact heat transfer on the X axis is U-shaped distribution, which gradually increases from the middle to both sides. The mixing index (MI) is employed to quantitatively discuss the horizontal and vertical mixing effectiveness. The vertical mixing process is faster than horizontal mixing process, both of which go through an increasing and stabilizing stage during the whole process.