Hydrodynamics and heat transfer around a horizontal tube immersed in a Geldart B bubbling fluidized bed

Abstract:

In dense gas–solid fluidized beds the heat transfer to immersed objects is strongly coupled to the hydrodynamic behavior. The objective of this study is to experimentally and numerically assess the heat transfer coefficient around a horizontal tube in a Geldart B bubbling fluidized bed and derive a numerical-correlative approach for predicting the angular dependent heat transfer coefficient. The considered system consists of corundum as the solid bed material and air as the fluidization gas, entering the cylindrical geometry through a Tuyere nozzle distributor. Experimental data are obtained from a pilot scale test-rig with different tubular heat transfer probes and evaluated in a comprehensive uncertainty analysis. The resulting magnitude and angle dependent variations of the heat transfer coefficient at different superficial gas velocities are compared to three dimensional numerical simulations. The applied CFD model of the fluidized bed treats both gas and powder as Eulerian phases. The size distribution of the particles is described by two granular phases with corresponding mean diameters and a sphericity factor to account for their non-spherical shape. The fluid–solid interactions in this Multi Fluid Model are considered by incorporating the Kinetic Theory of Granular Flow and a sphericity-adapted drag model. The hydrodynamics at the tube surface, e.g. solid volume fraction, gas and
particle velocities, are used for a novel numerical-correlative calculation of the angle dependent heat transfer coefficient between the bed material and the immersed tube. Special focus is set on depicting the particle contact time at the tube surface appropriately. The numerical results show the correct tendency of an increasing heat transfer coefficient with rising gas velocity and are partially in good agreement with the experimental observations.

Stichworte: Eulerian approach; experimental investigation; fluidized bed; heat transfer coefficient; hydrodynamics; numerical simulation

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