Resolved numerical simulations of gas flow through static particle arrangements with a channel

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ABSTRACT

Experimental and numerical studies found that fractures of particle assemblies occur often in dense gas-solid flows systems, leading to considerable heterogeneity in the configuration. We have studied the influence of such heterogeneities on the hydrodynamic drag by detailed investigation of an idealized case consisting of random configurations of spheres with a channel-like void region. Highly resolved lattice Boltzmann simulations were carried out to solve fluid flow through static homogeneous and heterogeneous particle arrangements respectively. We consider the overall pressure drop dependence on the characteristic width of the channel, the superficial Reynolds number (30 ≤ Re ≤ 300) and the solid volume fraction in the dense region (0.4 ≤ φ_p ≤ 0.55).

The numerical results are in good agreement with previously reported works [1-3]. However, the overall momentum exchange obtained for configurations containing a heterogeneity is significantly lower. A significant reduction is shown in overall pressure drop even for a channel width of only one particle diameter. In addition to the numerical simulations, we have further supplemented our numerical findings with a semi-analytical approach combining the correlations for pressure drop in homogeneous particle beds and in channels. We estimate the channel pressure drop with the appropriate correlations selected according to the superficial Reynolds number.

This work underlines the significance of channel/crack formation on fluid-solid momentum exchange and overall pressure drop in dense particle arrangements. In a large-scale granular system, the channel formation can develop on a scale smaller than the grid resolution of unresolved simulations. Consequently, such sub-grid heterogeneities are often overlooked in unresolved CFD-DEM simulations. Our proposed analytical description of overall fluid-solid momentum exchange might open the path towards the development of specific sub-grid models for unresolved CFD-DEM simulations.

REFERENCES