SUB-GRID DRAG MODEL FOR IMMERSED VERTICAL CYLINDERS IN FLUIDIZED BEDS

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Immersed vertical cylinders are often used as heat exchangers in gas-solid fluidized beds. CFD simulations are computationally expensive for large scale systems with bundles of cylinders. Therefore sub-grid models are required to facilitate simulations on a coarser grid, where internal cylinders are treated as a porous medium. The influences of cylinders on the gas-solid flow tend to enhance segregation and affect the gas-solid drag. A correction of gas-solid drag must be modeled via suitable sub-grid constitutive relationship. In the past, Sarkar et al. 2013 (1) have developed a sub-grid drag model for horizontal cylinder arrays based on 2D simulations. However, the effect of vertical cylinder arrangement was not considered due to computational complexities. In this work, highly resolved 3D simulations with vertical cylinders were performed in a periodic domain with imposed pressure drop. These simulations were filtered to construct a sub-grid drag model, which can be implemented in coarse-grid simulations. Gas-solid drag was filtered for different average solids fractions; instantaneous snap shots for various average solid fractions are shown in Fig. 1. A reduction in drag was identified as shown in Fig. 2 (a), when compared with simulation without cylinders, and with horizontal cylinders. Fig 2 (b) shows that slip velocities significantly increases when vertical cylinders are present. Vertical suspension drag due to vertical cylinders is insignificant, but substantial horizontal suspension drag is observed.

REFERENCE

1.A. Sarkar, X. Sun and S. Sundaresan. Sub-grid drag models for horizontal cylinder arrays immersed in gas-particle multiphase flows. Chem. Eng. Sci.104399–412, 2013.

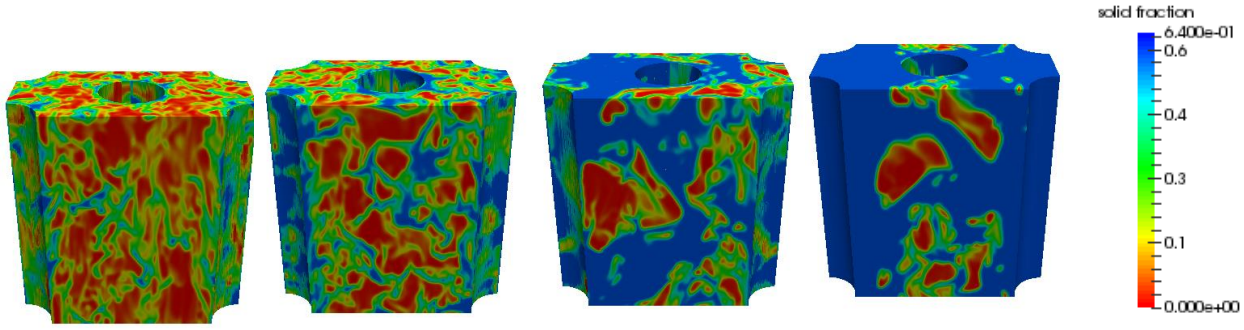
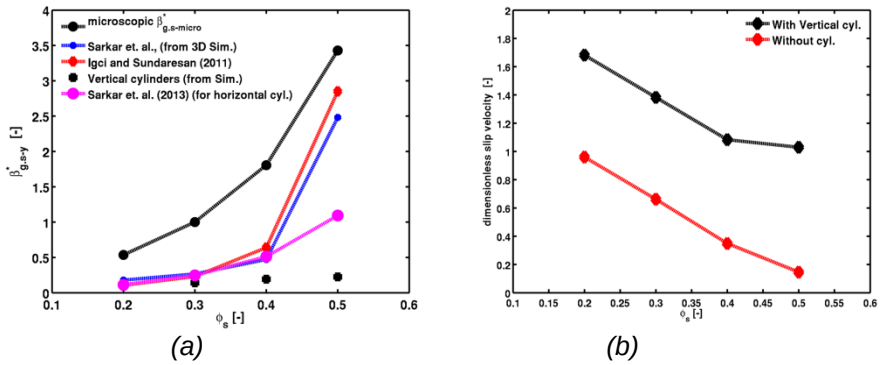


Fig. 1: Randomly selected instantaneous snap shots for solid fraction of (left to right) 0.2, 0.3, 0.4 and 0.5.



(a) *(b)*

Fig. 2 (a) The dimensionless filtered gas-solid drag coefficient as a function of solid fraction, (b) the dimensionless filtered slip velocity as a function of solid fraction.