DRAG MODEL FOR COUPLED CFD-DEM SIMULATIONS OF NON-SPHERICAL PARTICLES

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Abstract

Particle-laden multiphase flows are relevant in several areas of process technology. Typical examples are fluidized or spouted beds, pneumatic conveying of granular media or mixing and separation processes. The accurate prediction of the physical behavior of the particles and the continuous fluid phase is important for the three-dimensional modeling of these processes.

At higher particle volume concentrations the interactions between the particles and also between fluid and dispersed phase becomes more decisive. The shape of the particles has also an essential influence on the particle behavior. For this reason, the simulation with a coupling of the Discrete Element Method (DEM) and CFD methods is the preferred option if the computational expense is justified.

In common DEM software (EDEM [1], PFC-3D [2]) a multi-sphere approach is used to model non-spherical particles for bulk mechanics, wherein an arbitrarily shaped particle is approximated by a clump of different spheres. In the presented work this multi-sphere approach is also used in CFD-DEM simulations to calculate the drag forces of the particles resulting from the fluid flow. Thus for every sphere within the clump a partial drag force is calculated. The sum of these values over all spheres within a clump gives the drag force of the non-spherical particle, which depends on the orientation of the particle to the fluid flow and the Reynolds number. For the calculation of the drag coefficient a large number of parameters are used, characterizing the position of the spheres inside the clumps. So the degree of overlap, the shading area, the distance from each other and the sphere diameter are incorporated in the calculation of the drag values.

The new drag model is implemented within the CFDEMcoupling [3] environment which couples the DEM code LIGGGTHS [4] with the CFD code OpenFOAM [5]. It is validated against CFD simulations of the flow around single particles, literature data and experimental data from wind tunnel tests. The drag model shows a good fit of the CFD calculation for a wide range of particle shapes, Reynolds numbers and particle orientations. It gives in some cases better results than the widely used model of Hölzer and Sommerfeld [6] (see Fig. 1 left).

The drag model is used for simulation of the sedimentation of large single particles and for the physical behavior in sprouted beds (see Fig. 1 right). The results are compared to experimental investigations of these processes and will be discussed relating to the validity of the drag model.

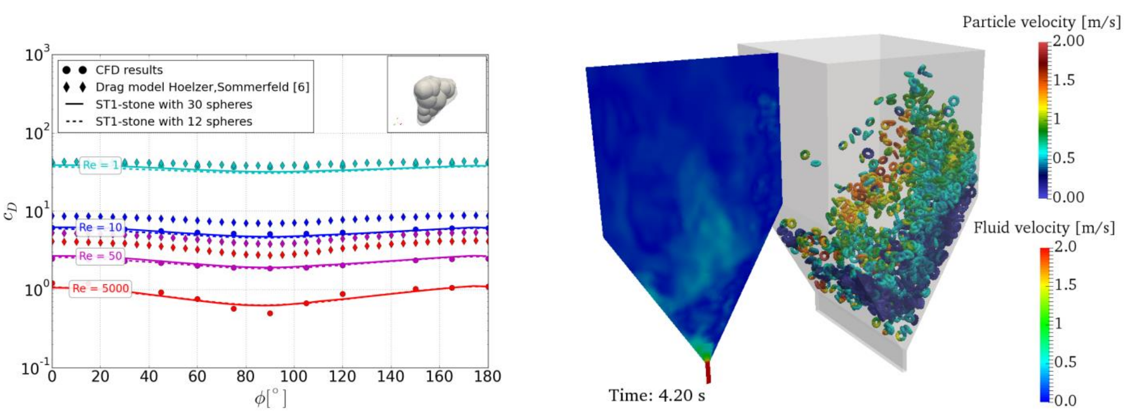

Figure 1: Drag coefficient for the new model depending on Reynolds number and particle orientation in comparison to CFD data and the drag model of Hölzer and Sommerfeld [6] (left) and coupled CFD-DEM simulation of a sprouted bed with non-spherical (torus-shaped) particles (right)

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