Modeling of gas-solid turbulent flows with non-spherical particles

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In this contribution, we have developed a computational model to simulate the behaviour of turbulent flows laden with non-spherical particles. The computational model comprises different novel elements. Firstly, the drag, torque and lift relations of each particle shape is determined by means of DNS, where the particle is represented by the mirroring immersed boundary method (1). A large number of simulations is performed for each particle, to gather data on the drag, torque, and lift on the particle under various Re numbers and angles of attack.

Secondly, the resulting relations are then used in a fully coupled point-particle approach of a horizontal channel flow using the Large Eddy Simulation (LES) framework. The horizontal channel flow properties are based on the experimental and modeling work of (2). The Re number of the flow through the channel is around $Re \approx 22,500$, the particle equivalent diameter is $d_p = 200\,\mu m$ and the mass loading of the particles is $m = 1.0$. Three types of particles were studied: two types of ellipsoids and disk-shaped particles.

Thirdly, because of the high mass loading, a novel collision model to deal with the collisions between non-spherical particles and the particles and the wall is constructed based upon a Quaternion approach (3).

Simulations were performed of these 3 shapes of particles and compared to simulations with spherical particles and the available experimental data. Figure 1 shows some preliminary results. The results show there is a big effect of particle shape and particle-orientation. The effect of the walls on the particle orientation is shown in the figure below on the right. Also, the concentration profiles differ significantly, due to the variation in upward effect of the turbulence. Finally, the effect of wall roughness one the particle flow and orietation is researched.

References

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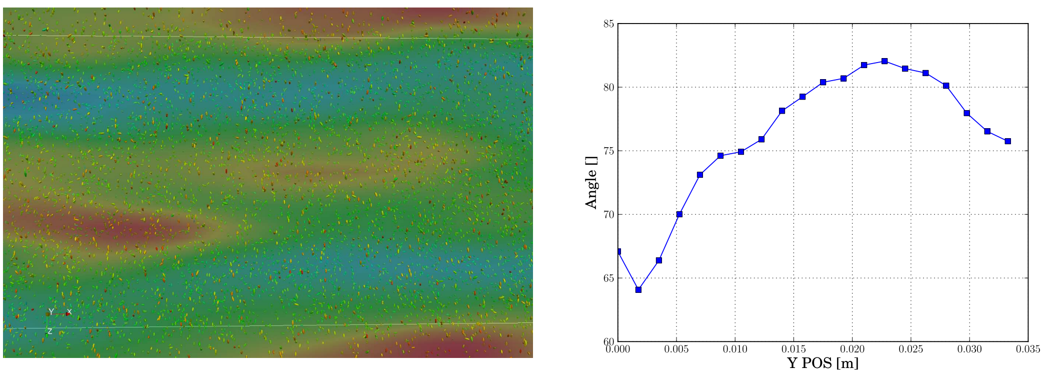

Figure 1: Left: Snapshot of the flow and the ellipsoids in the channel. Right: The angle of orientation of an ellipsoid in the flow; the wall has a large effect due to collisions.