Technische Universität Braunschweig

MUSEN

Modeling of Gas-Solid Turbulent Flows with Non-Spherical Particles

Lecture of

Prof. Dr. Berend van Wachem

Lehrstuhl für Mechanische Verfahrenstechnik,
Fakultät für Verfahrens- und Systemtechnik,
Otto-von-Guericke-Universität Magdeburg

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The interaction of solid particles with turbulence has for long been a topic of interest for predicting the behaviour of industrially relevant flows. This talk will investigate the behaviour of solid spheres, elongated axi-symmetric ellipsoidal particles, discs and fibers, and their interaction with turbulence, collisions between the particles, and the effects of the particles on turbulence in DNS of forced turbulence ($Re_\tau \approx 60$), and in two turbulent channel flows, one with low Re number ($Re_\tau = 150$) and one with high Re number ($Re_\tau = 1{,}000$). During the talk, the computational framework as well as the physical findings will be discussed.

Firstly, the drag, torque and lift relations for each particle shape are determined by means of true DNS, where the particle is represented by the mirroring immersed boundary method. 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. All these simulations are coarse-grained into drag, lift and torque correlations.

Secondly, the resulting relations are used in a fully coupled point-particle approach of a horizontal channel flow using a DNS and LES framework. The simulations are carried out with full four-way coupling using the point-source approach: the particles are affected by the fluid, the particles affect the fluid and the particles collide with each other and the wall. The trajectories of the particles are tracked by solving the translational and rotational equations of motion in a Quaternion framework and are closed with hydrodynamic drag and torque laws.

Thirdly, because of the high mass loading, a collision model to deal with the collisions between non-spherical particles and the particles and the wall is constructed based upon a Quaternion approach. Surface roughness of the particles and the wall is also discussed and taken into account. It is shown that the collision between a spherical particle and a wall with roughness is governed by a different mechanism than the collision between a non-spherical particle and a wall with roughness.

An analysis of the turbulent kinetic energy is presented, showing the effect of the particles on the turbulent properties of the flow. It is shown, for instance, that ellipsoids with high Stokes number cause drag reduction, because of momentum transport towards the wall caused by the particles. Finally, the results show there is a big effect of particle shape and particle-orientation, especially for particles with larger Stokes numbers.