A study on the drag, lift and torque coefficients for superquadric particles using an immersed boundary solver

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ABSTRACT

In industrial applications like fluidized beds and pneumatic conveying some aspects of the dynamics of granular material are still not well understood. Coupled CFD-DEM (Computational Fluid Dynamics – Discrete Element Method) has become a promising tool for modelling multiphase flows. Despite that fact that particles in granular materials in industry and nature are mostly non-spherical, the majority of scientists and researches model particulate flows with the hypothesis of perfectly spherical particles. Contact models and drag correlations for such particles are well known and established. However, in real systems, which consist of complexly shaped particles, this assumption can be applied only to a limited degree. An accurate estimation of hydrodynamic torques as well as drag and lift forces for non-spherical particles is a fundamental problem in CFD since these have a strong dependence not only on Reynolds number but also on the aspect ratio and particle orientation. Only few insights have been given on finding an appropriate drag correlation for non-spherical particles [1].

Usually, irregular particles are idealized by some regular shapes like superquadrics. Varying only five shape parameters one can achieve shapes like spheres, ellipsoids, cylinders and rectangular parallelepipeds. To study drag and lift coefficients for a superquadric particle in a uniform flow we employ an Immersed Boundary methodology (IB). Here, an additional forcing term is introduced in the momentum equation that accounts for the presence of a particle. This methodology does not require domain re-meshing and can be fully automated while conducting a series of simulations of a flow past non-spherical particles at different Reynolds numbers, different orientations with respect to the flow direction and particle shapes.

In this work we employ a novel Hybrid Fictitious Domain Immersed Boundary Method (HFDIBM)[2] implemented in Open Source framework CFDEMcoupling®[3]. This method is based on Fictitious Domain and forces imposing of Dirichlet boundary condition performing second order Taylor expansions of Eulerian fields on the immersed surface. Only those CFD cells are forced in the momentum equation that intersect with an immersed surface. We propose a fully automated Immersed Boundary methodology to study drag and lift forces acting on a superquadric particle in a uniform flow with a Reynolds number below 300. The results are compared to existing drag correlations and data available in literature.

REFERENCES

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