

MODELING SUPERQUADRIC PARTICLES IN CFD-DEM USING A HYBRID FICTITIOUS DOMAIN - IMMERSED BOUNDARY METHOD

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In many industrial applications like fluidized beds and pneumatic conveying motion of granular material is still not well understood. Better understanding of underlying fundamentals is essential for design and optimization of such processes. With rapid advancements of hardware and computational resources, coupled CFD-DEM (Computational Fluid Dynamics – Discrete Element Method) becomes more and more popular among scientists and researchers. This approach takes into account physics of both the particles and the fluid. Despite that fact that particles in granular materials in nature and industry are present mostly in non-spherical shapes, many DEM and CFD-DEM codes still employ discs (in 2D) and spheres (in 3D) to represent particle shapes due to their implementation simplicity and well established drag and lift force correlations. However, spherical particles behave differently than complex shaped particles not only on the single grain level but also as an assembly. Hence, more sophisticated models must be introduced in DEM and CFD-DEM, like superquadric[1] particles that are extension of ellipsoidal particles in 3D. Varying only five shape parameters one can achieve different shapes like spheres, ellipsoids, cylinders and rectangular parallelepipeds.

In this work we present fully parallel Open Source implementation of superquadric particles in CFD-DEM for the cases when particle size is relatively big compared to the cells of fluid mesh. The method is based on Fictitious Domain approach and forces imposing of Dirichlet boundary condition on the immersed surface by adding a force term to the momentum equation. Only those fluid mesh cells are forced in the momentum equation that intersect with an immersed particle.

A Hybrid Fictitious Domain Immersed Boundary solver (HFDIBM) is implemented within the Open Source framework CFDEMcoupling@[2], a coupled solver joining two software packages LIGGGHTS@[3] and OpenFOAM®. It is compatible with local mesh refinement and can be applied to more general geometries. We show that the implemented method blocks up to 99.5% of incoming flow and is more than for the standard Immersed Boundary solver in CFDEMcoupling@[4]. We present the detailed description of the algorithm along with a number of validation and application examples. Results are compared with the standard Immersed Boundary solver in CFDEMcoupling® and Hölzer-Sommerfeld drag correlation[5].

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