Extending the Multi-Level Coarse-Grain Model of the DEM to Unresolved CFD-DEM Simulations

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ABSTRACT

In a wide field of applications, the discrete element model (DEM) [1] in combination with computational fluid dynamics (CFD) has proven to be a useful tool to study granular flows. However, a major shortcoming of simulation methods involving the DEM is the high computational cost. The increase of simulation runtime with increasing number of particles hinders the usage of DEM and CFD-DEM simulations for large-scale system.

The coarse-grain (CG) [2] model of the DEM lowers the computational demand by using coarser (pseudo) particles to represent a number of original particles. However, due to the violation of geometric similarity, this approach fails to capture effects that intrinsically depend on particle size. In particular, this becomes a problem in multi-scale processes typically found in industrial facilities.

To overcome this issue, we have introduced a method which concurrently couples multiple coarse-grain levels to adjust the resolution of the simulation as required [3]. Spatially confined sub-domains of finer scale are embedded into coarser representations of the system and are coupled by exchanging volumetric properties of the granular flow. On the one hand, the coarse-grained data allows imposing proper boundary conditions in each sub-region. On the other hand, the fine-scale information can be used to amend the less accurate coarse-grain simulation.

We have extended this multi-level coarse-grain (MLCG) model to unresolved CFD-DEM simulations where the DEM part is typically taking up a large fraction of the computational resources. On the CFD side, each coarse-grain level of the granular model is treated separately using appropriately scaled drag laws and a suitable mesh resolution. The DEM component links up the different levels via the coupling procedure described above.

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