Application of coupled DEM and SPH to complex industrial and biophysical particle suspension problems

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ABSTRACT

Complex particle suspensions are very common in many industrial processes and in biophysical systems such as digestion of food and blood flow. These multiphase systems typically involve particulate solids (usually able to be regarded as rigid but sometimes deformable) embedded in a fluid. For higher solids fractions the particle interactions can dominate with fluid flow being secondary so that the flow can be considered more as a porous media flow through the deforming body of particles. For lower and intermediate solid fractions, the particles are commonly suspended in the carrier fluid with transport behaviour governed by momentum transfer through both the particulate solids and fluid phases. The particle interactions often give the resulting pseudo-fluid Non-Newtonian rheological behaviour even when the interstitial fluid is Newtonian. These behaviours become more complex still in complex geometries (as is common in industrial applications) and with the presence of free surfaces for the fluid component.

A natural particle method combination for modelling these systems involves a coupling of the DEM (Discrete Element Method) and SPH (Smoothed Particle Hydrodynamics) methods. This combines the advantages of DEM to resolve the particle interactions with the ability to predict fluid flow in geometrically challenging systems with complex free surface behaviour.

In this talk, a coupled DEM+SPH method will be described which uses both a Darcy porous media representation of the solids in the SPH model and empirical drag laws to give the drag on the particulates based on the local fluid velocity and volume fraction. Examples of application will be given for

1. Industrial flows: discharge from an overflow ball mill, media and slurry flow in a SAG and tower mill and separation behaviour in a wet vibrating screen
2. Biophysical flows: classification of particulates by size in discharge flow through the pyloric sphincter of the stomach, multiphase flow of digesta in the small intestine and red and white blood cell transport in capillaries.

Issues relating to the choice of the sub-models used to create the phase coupling, momentum conservation, fully resolved fluid flow vs. unresolved fluid flow and approaches to particle deformability will be discussed.