Meshfree particle methods for continuum-based modelling of multiphase granular flows: challenges and opportunities

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ABSTRACT

Mesh-free particle methods for granular continuum provide the opportunity to overcome the limitation of Eulerian mesh-based models, (in dealing with large deformation) without the scalability issue of the mesh-free discrete models. Here we develop and evaluate the continuum-based mesh-free particle methods for the simulation of multiphase granular flows in various regimes (i.e. quasi-static, dense flow, and kinetic regimes). The models of this study are based on two commonly used particle methods of Smoothed particle hydrodynamics (SPH) and Moving Particle Semi-implicit (MPS). A regularized viscoplastic rheological model (i.e. μ(I)) with a pressure-dependent yield criterion predicts the viscous behaviour of granular materials. Models are validated and compared for the gravity driven granular flow in sub-aerial and submerged granular collapse. The challenges of particle methods related to the implementation of the rheological model, calculation of mechanical and pore pressures, approximation of the shear divergence are investigated and addressed. Role of common SPH/MPS enhancement techniques, such are particle redistribution techniques, higher order integrations, and adding numerical diffusion are also studied.

The results demonstrate the ability of the particle models in dealing with the large deformations in granular flows. SPH and MPS techniques produce similar results. A high sensitivity of results to the tensile instability (in high-shear regions) and the unphysical pressure fluctuations are observed. The enhancement techniques have proven to be effective in improving the failure and post-failure behaviours of granular materials.