Direct numerical simulations of dense granular suspensions in laminar flow under constant and varying shear rates

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Abstract

Using an immersed boundary-lattice Boltzmann method, we investigated the response of dense granular suspensions to time-varying shear rates and flow reversals. The apparent viscosity and the evolution of particle clusters were analysed. The solids fractions and particle Reynolds numbers varied over the ranges 5% [?] φ_v [?] 47% and 0.11 [?] Re_p [?] 0.32. The simulations included sub-grid scale corrections for unresolved lubrication forces. The contribution of the tangential lubrication corrections to the shear stress is dominant when φ_v surpasses 30%. For $\varphi_v > 35\%$, increasing shear-thickening is seen with increasing φ_v. Following a shear reversal, the number of clusters temporarily increases and then decreases to a stable value over the same time scale as the development of the wall shear stress (and apparent viscosity). Simulations with several step changes in the shear rate show the effects of the previous shear history on the viscosity of the suspension.

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