Numerical study on highly viscous slurry under shear flow

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Abstract

Highly viscous slurry is used for various industrial processes. The rheological evaluation of such the slurry is of great importance in the processes. It is considered that the apparent viscosity of slurry depends on various factors such as shear rates, particle rotation, liquid phase temperature, and solid volume fraction. In this study, we perform a numerical simulation by DEM-DNS method in order to analyze the rheological characteristics of highly viscous slurry. The DEM-DNS method is a coupled method of discrete element method (DEM) and computational fluid dynamics, where hydrodynamics force acting on a solid particle is simulated by the immersed boundary method. This method can calculate the flow around the particles with high accuracy. As initial particle location, we prepared a sedimentation state and a dispersed state in the computational domain. In the numerical simulations, we investigated the influences of shear rate, liquid phase temperature, and particle rotation. We first evaluated the apparent viscosity in sedimentation systems. The results show that the apparent viscosity became shear-thinning. This is probably because as shear rate increases, the liquid trapped within the particle clusters is released. As a result, the apparent viscosity decreases gradually as increasing the shear rate. The results also indicate that the particle rotation influenced shear stress, namely, apparent viscosity. As far as the dispersed system is concerned, the calculated viscosity agreed with theoretical formula derived by Krieger and Dougherty.

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Keywords: DEM-DNS; shear-thinning; high viscosity; volume fraction, Brownian motion, Krieger and Dougherty, rheology