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Numerical Simulation of Rheology and Texture Formation of Plate-like Particle Suspensions

Daisuke Nishiura[1*], Hiroshi Kawabata[1], Hide Sakaguchi[1]

[1]JAMSTEC

The separation process of melt from crystal-particles bed in magma of shear flow is one example of geological phenomena induced by particle-fluid interaction. In the process, microstructures in magma, formed during shear flowing of magma before solidification, influence on not only igneous rock texture but also magma rheology. This means it is important to clarify the mechanism of microstructure formation in a sheared magma in order to estimate the magma rheology from the igneous rock texture. However, the formation mechanism of microstructure in magma has not been clarified because the experimental observation of the microscopic behaviors of melt and crystal-particles is difficult in high temperature or high pressure. Therefore, using the numerical simulation coupled particle motion with fluid flow should be useful for the investigation of the microscopic phenomenon on severe environment to do experiment.

In this research, the microstructure formation mechanism of particles in suspensions is investigated by using the 3-D numerical simulation that modeled the motion of plate-like particle and fluid flow in shear field. The simulation method for the behavior of fluid and particles is developed by coupling a discrete element method with computational fluid dynamics. Individual plate-like particle is created by bonding spherical particles. Moreover the hydrodynamic interaction force between fluid and particles and viscoelastic contact force of interparticle are considered. Particles with major axis of 70 micron, minor axis of 30 micron and thickness of 10 micron are regularly located in fluid by a certain interval. Then, a shear stress applies the system and the processes of the orientation and cluster formation of plate-like particles are investigated in detail.

As a result, particles began to move by shear flow, and then the viscosity of suspensions was decreased to a certain value due to the formation of a particles cluster. This kind of cluster formation was significantly observed at high particle concentration. In additionally, the orientational degree to shear direction of particle inner the cluster became large as increasing particle concentration. On the other hand, the orientaional degree of particle out of cluster was almost orthogonal to the one of particle inner the cluster. The details of these mechanisms of orientation and cluster formation induced by shear flow will be discussed in the presentation.

Keywords: Discrete element method, Computational fluid dynamics, Simulation, Rock texture, Shear