Numerical simulation on structure formation of magnetic particles under magnetic fields

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This study gives an attention to structure formation of magnetic particles by dipole-dipole interaction under magnetic fields in materials processing. When magnetic field is applied to medium containing magnetic particles, the direction of magnetic moment of magnetic particles align in the same direction as the magnetic field, and magnetic particles make chain clusters by the dipole interaction among particles[1]. So, the magnetic field is useful tool on development of anisotropic materials.

In this time, we performed numerical simulations of the structure formation of magnetic particles whose size is on the order of micrometers in material processing, and studied the unsteady process of the formation and its feature. Figure 1 shows the schematic model of numerical simulation. The cube of simulation region is a part of the inside of the container and the periodic boundary condition for a 3D system is used. Magnetic particles are randomly dispersed in the container at the initial condition. The translational motion and the rotational motion of particles are governed by Newton and Euler equation, respectively. Here, we used DEM including the magnetic effect. About the simulation research of magnetic particles, A. Satoh has already published many studies[2]. He deals with magnetic particles in magnetic fluids, and particle size is on the order of tens of nanometers. Therefore, he calculates using Brownian dynamics method in which particles do not collide directly with each other. He also discusses mainly the rheology of magnetic fluid due to the structure of magnetic particle, and not structure formation in unsteady process.

One example of numerical simulation results is shown in Fig. 2. Particles aligned in the direction of the magnetic field and made the structure formation of chain cluster. We discuss the structure formed by the magnetic particles and the formation process when the concentration and particle size of the particles in dispersion medium are changed.

Reference
1) M. Yamato, *et al*., Polymer, **55** (2014) 6546-6551.
2) A. Satoh, Introduction to Molecular-Microsimulation of Colloidal Dispersions, Elsevier, (2003).

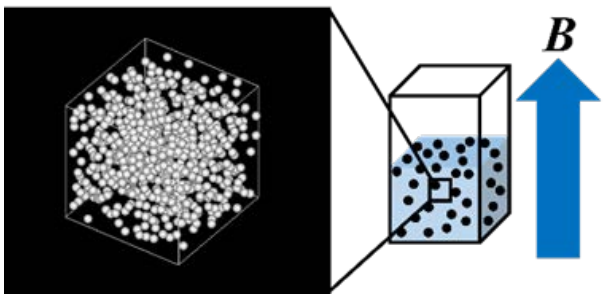
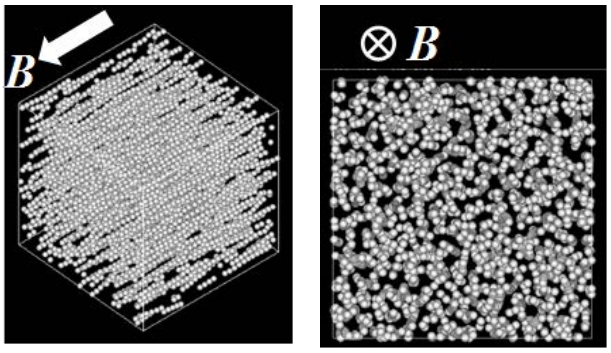


Fig. 1 Model of numerical simulation



(*a*) Isometric view

(*b*) Perpendicular section to the direction of magnetic field

Fig. 2 Result of numerical simulation