Effect of the unsteady flow on a particle orientation process in a rotating container under high magnetic fields

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Because of recent development of superconducting magnetic technology, attention has been given to magnetic alignment. This technique aims at improvement of physical properties by controlling the direction of particles and crystals. When a particle with magnetic anisotropy is applied a rotating magnetic field, the smallest axis of magnetic susceptibility is aligned to the axis of rotation. In current studies, a container with particles which are dispersed in solvent is rotated in a static magnetic field in order to apply a rotating magnetic field. When a container with liquid is started to rotate or stopped, convection occurs in the suspension. Therefore, we have examined the effect of the convection on the magnetic orientation process through numerical simulation [1].

This study considered the flow of fluid in a cylindrical container filled with liquid without particles and assumed axisymmetric flow. The size of the container is $r_0 = h = 20$ mm, the angular velocity of the container is $\Omega = 2\pi$ rad/s and the solvent is water. Figure 1 shows the streamline in a rotating container at $t = 1$ s from the start of rotation. This result indicates that the flow occurs in vertical section of a rotating container. Next, we investigated the effect of the flow on an oriented rod-like particle under rotating magnetic field $\boldsymbol{B} = 5$ T. We assumed polyethylene fiber [2] with the diameter of $d = 20$ μm and the length of $l = 200$ μm. Figure 2 shows the relationship between time and the angle (Θ) between the rotation axis (z) and the particle axis. Theoretical curve is drawn for the case without considering the effect of the flow. Behaviors of particles in three different positions A, B and C where location of their center (r, z) is indicated in the figure are examined. This figure shows that the particle near the wall is more susceptible to the convection. That is to say, degree of the effect of the flow on the alignment process of particle varies by position of the particle. In case of continuous rotating magnetic field, the particle is finally aligned parallel to the axis of rotation because the convection disappears as time goes by. However, in case of modulated rotation magnetic field, the convection occurs each time the angular velocity is modulated. As a result of this, oriented particles will always be affected by the convection.

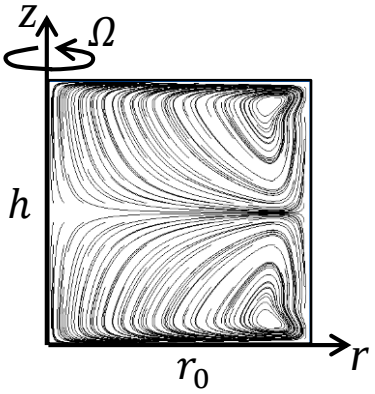

Fig. 1 The streamline in a rotating container at $t = 1$ s.

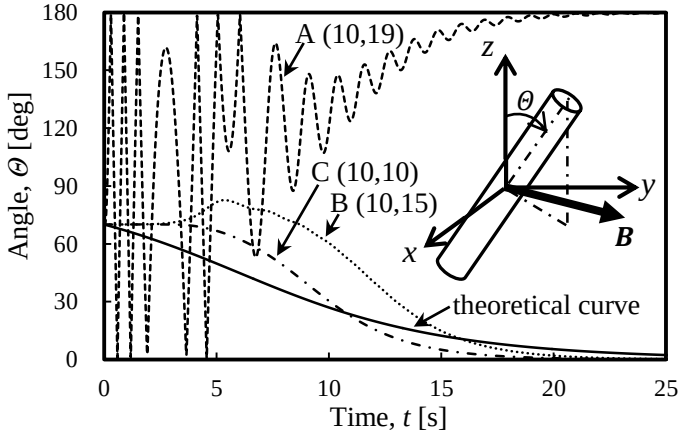

Fig. 2 Time dependence of the angle between the rotation axis of the container and the particle axis.

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