THE EFFECTS OF VIRTUAL MASS FORCE AND PARTICLE ASPECT RATIO ON ORIENTATION OF SLENDER PARTICLES IN A STIRRED TANK

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Fundamental knowledge on particle orientation is important for processing and utilizing irregular shape particles. The orientation of slender particles influences the application of slender particles in many fluidization processes, such as pulp and paper, catalytic reaction, air pollution control.

In this paper, the effects of virtual mass force and aspect ratio on the orientation of a slender particle in a particle cloud are studied. Virtual mass force, also called added mass force, apparent mass force, is a force due to the relative acceleration of the phases. The definition of virtual mass force is defined by Kuo and Wallis (1):

$$F_v = C_v \rho_l \left[\frac{\partial}{\partial t}\left(u_g - u_l\right) + u' \frac{\partial}{\partial z}\left(u_g - u_l\right) \right]$$

It accounts for the kinetic energy change associated with the liquid motion induced by the bubble.
Aspect ratio is the length to diameter ratio of a slender particle. It is usually used to describe the shape of non-spherical particles. For slender particles, the influences of virtual mass force and aspect ratio haven't been investigated in detail.

Two-fluid model proposed by Ishii (2) is employed to simulate the turbulent solid-liquid two-phase flow with slender particles in a stirred tank. The simulation is performed in the baffled tank stirred by six-blade Rushton turbine impeller. It is proposed that the fluid is incompressible and the interactions between slender particles are negligible.

The orientation and velocities under different conditions are compared to show the effects of virtual mass force. It is found that virtual mass force shows little impact on slender particles velocities, while exerts obviously influence on particles orientation, as shown in Figure 1. In addition, slender particles with three different aspect ratios are simulated. Similar to virtual mass force, the influence of aspect ratio on particles velocities can nearly be ignored, but the aspect ratios present definite influence on the orientation of the slender particles, as shown in Figure 2.

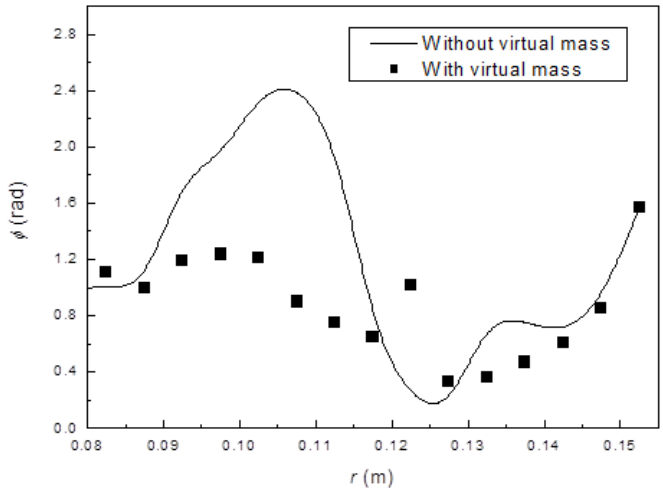

Figure 1. Influence of virtual mass force on orientation
(r, radial coordinate; ϕ, the angle between the particle and the plane normal to velocity)

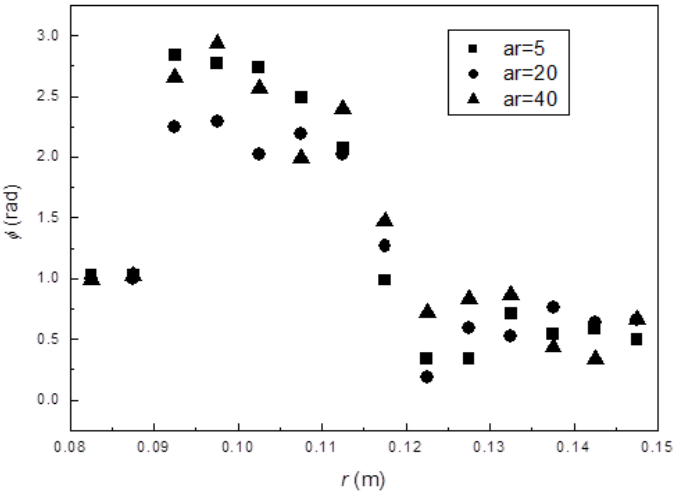

Figure 2. Influence of aspect ratio on orientation
(r, radial coordinate; ϕ, the angle between the particle and the plane normal to velocity; ar, aspect ratio)

REFERENCES

1. J. T. Kuo and G. B. Wallis. Flow of bubbles through nozzles. Int. J. Multiphase Flow, 14(5):547~564, 1988.
2. M. Ishii. Thermo-fluid dynamic theory of two phase flows. Paris, Eyrolles, 1975.