Evaluation of Particle Motion in Solid-Liquid Two-Phase Pipe Flow with Downward/Upward Flow Directions

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Keywords: Solid-liquid two-phase flow, Pipe flow, Gravity, PTV

Particle laden two-phase flow still has unknown points due to the complicated interaction between particle and fluid. Basic understandings of the particle motion and turbulence modulation are required to clarify the interaction between particle and fluid (Tsuji et al. 1982). One of the important factors of changing particle motion is the effect of gravity acceleration acting on the particle. The aim of this research is to clarify a difference of solid particle motion by changing the flow direction in a pipe flow. To evaluate the effect of gravity force on the particle motion, the flow measurement of downward and upward flows under the condition of both single and two-phase flow is performed by using PTV (Particle Tracking Velocimetry).

Experimental setup

Figure 1 shows a schematic diagram of flow system. The inner diameter of the pipe is 26 mm and the length is 1500 mm is used as test section of flow. The carrier fluid is water, and the mean fluid velocity in the pipe is set to 0.75 m/s. The Reynolds number is 19500. Downward and upward flows are formed by using two pipes connected a U-tube. The spherical glass beads, whose mean diameter is 625 μm and its density is 2590 kg/m³, is released into the flow from the upper of the channel. Particle volume fraction is set to 0.6 %. A high-speed video camera (HSVC: Dantec Dynamics, Phantom v710) detects an image in two-phase pipe flow. A continuous laser (Dantec Dynamics, RayPower 2000) with 532 nm in wavelength is illuminated to the flow by a sheet of 2 mm in thickness. The fluorescent paint including the Rhodamine B is used as the tracer particle for detecting the fluid motion. Glass particles are also painted it. HSVC can recognize only fluorescence from the paint through a sharp-cut filter. The frame rate and image size of HSVC are 3000 FPS and 512 × 512 pixels, respectively. The instantaneous velocities of both phases are respectively calculated by PTV algorithm developed by Ishikawa et al. (2000). The measurement point is set to 910 mm from the flow inlet both downward and upward flows. The origin of coordinate system is defined at the center of the pipe and the x and y axes are set the longitudinal and the radial directions, respectively. The mean velocity in longitudinal direction and RMS velocities in the longitudinal and radial directions of both particle and fluid are obtained. The particle number density is also obtained by using PTV.

Results and conclusion

Figure 2(a) and (b) show the distribution of particle number density and RMS velocity of fluid in the longitudinal direction respectively. Vertical axes indicate the particle number density and the longitudinal RMS velocity of the fluid u’/Re, respectively. In both figures, horizontal axes indicate the dimensionless distance from the pipe center divided by the pipe radius R. The distribution of the particle at near the wall is completely different by changing the flow direction because the external force direction to the particle differs in this region. At the pipe center, the particle number density has no significant difference between downward and upward flows. However, at the pipe center, the fluid RMS velocity in the upward flow is larger than that in the downward flow. At the pipe center in the upward flow, the turbulence of water is enhanced by the particles motion. The difference of the RMS velocity at the pipe center is caused by the motion of the particle cluster around this region.

Fig.1 Schematic diagram of flow system

Reference
