Transactions of the Korean Nuclear Society Spring Meeting
Gwangju, Korea, May 30-31, 2013

An air bubble velocity measurements in horizontal two-phase bubbly flow

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1. Introduction

The velocity information of bubble and liquid is important for analyzing the flow behavior, momentum, heat and mass transfer characteristics of bubbly two-phase flow. Recently, a review and improvement of the momentum equation have been performed for the computational thermal hydraulic safety analysis code, SPACE [1]. To validate the proposed model, local velocity data for dispersed and continuous phases are required.

The purpose of the present study is to investigate the velocity of an air bubble and water in the horizontal two-phase bubbly flow. The flow visualization has been performed and a velocity of the individual phases is obtained simultaneously.

2. Experiments

2.1 Test Facility

The test facility consists of a test section, a water supply system, instruments, a control system and data acquisition system. Fig. 1 shows a schematic of the test loop.

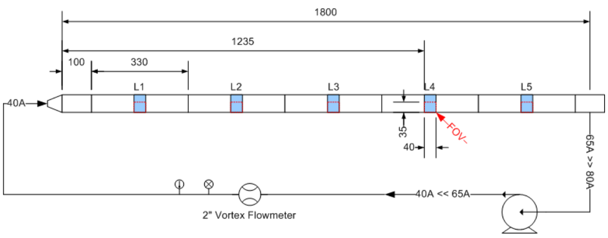

Fig. 1. Schematic of the test loop.

The test section has a rectangular cross-section with the length of 1800mm, width of 80 mm, and height of 60 mm. The test section is made of stainless steel with Pyrex glass windows (width of 40 mm) on 3 sides (front, top, and bottom) at 5 axial locations (245, 575, 905, 1235, 1565 mm from the inlet). The temperature, pressure, and flow rate of the flow are measured by a thermocouple, pressure transmitter, and vortex flow meter, respectively. The air entrainment occurs at the test section outlet, where the suction side of the pump. The entrained air bubble travels through the test section with water.

2.2 PIV/PTV Measurement system

The Particle Image Velocimetry (PIV) and a Particle Tracking Velocimetry (PTV) technique were applied for the measurement of the water velocity and the air bubble velocity. A schematic of the PIV/PTV measurement system is shown in Fig. 2.

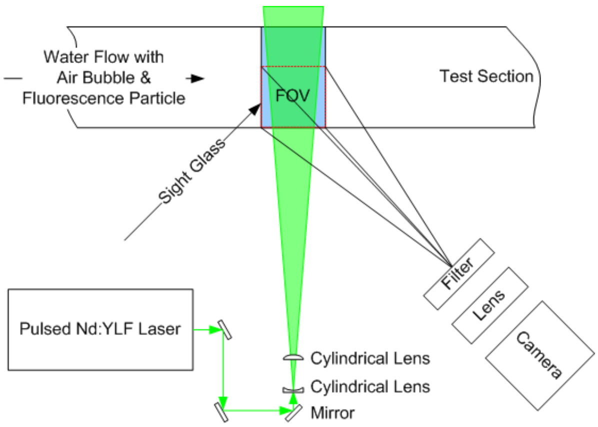

Fig. 2. Schematic of the PIV/PTV measurement system.

A laser beam emitted from a pulsed Nd:YLF laser is expanded by a cylindrical lens to form a planar laser sheet in the test section and the laser pulse was synchronized with the laser using a synchronizer. The PIV/PTV image is measured by the CCD camera with 1280x800 resolutions with a frequency of 1000 Hz.

The fluorescent polymer microsphere particle with an average diameter of 24 μm was premixed with the water. A long pass filter with, 560 nm cut-on wavelength, was used in front of camera to detect only the fluorescence light from the particle.

2.3 Test Parameters and Test Procedure

The test was performed at the atmospheric pressure and room temperature conditions. The superficial velocity of the water was controlled. The flow rate was set at desired values by a speed control of the pump. When the desired flow velocity reached the steady conditions, the PTV/PIV image acquiring started.

The velocity profiles of the water in the absence of air bubble were measured at two different locations: 905 and 1235 mm from the inlet. The results are showed very similar velocity profile that the water flow at the 1235 mm from the inlet is fully developed. Thus, the PTV/PIV images were acquired at this point.

2.4 Methods of analysis

The acquired PIV/PTV images contain mixtures of the reflected light from the air bubble and particle mixed with water. The air bubble image was extracted from the acquired PIV/PTV image using shape and edge detection technique. Then, the extracted air bubble images were analyzed with VisiSize software to acquire the velocity and diameter of air bubble. VisiSize measures velocity using a PTV technique. The PIV analyze to acquire the velocity of water were performed with non-processed PIV/PTV images using a Dantec Dynamic Studio software.

3. Experimental Results

The experiments were performed for 1.00, 1.20 and 1.39 m/s superficial velocity of water.

The average water velocity profiles for 1.39 m/s water velocity are plotted in Fig. 3. The time average of 1,000 instantaneous magnitude of velocity vector at different axial locations in the measured area is overlapped and the standard deviation is also shown.

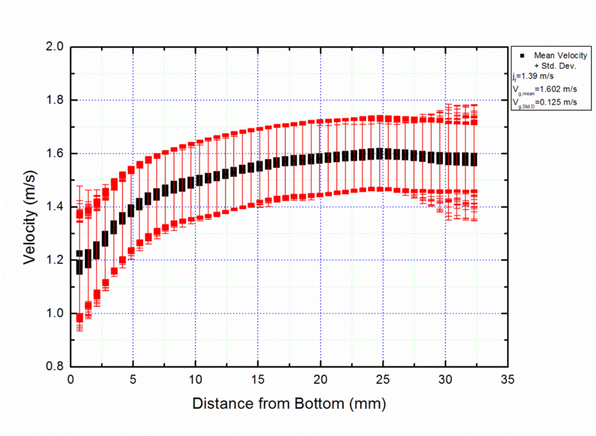

Fig. 3. Average water velocity profiles for 1.39 m/s water velocity with standard deviation.

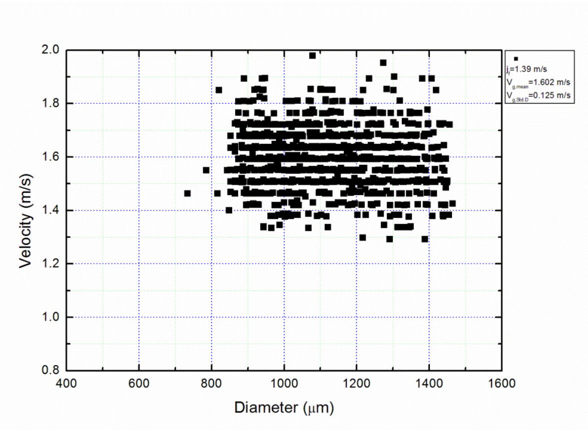

Fig. 4. Air bubble velocity vs. air bubble diameter

Fig. 4 shows the air bubble velocity against air bubble diameter for a water velocity of 1.39 m/s. The instantaneous magnitude of velocity vector is overlapped. The location of air bubble was not obtained. As shown in Fig. 4, an obvious trend does not exist for the diameter dependent air bubble velocity. The wide distribution of velocity seems to be relating to the variation of instantaneous water velocity.

Table I: Comparison of air bubble and water velocity

Distance from Bottom (mm)	AVG. Inlet Water Velocity (m/s)	AVG. Water Velocity (m/s)	AVG. Air Bubble Velocity (m/s)
20~33	1.00	1.17230 (Std.Dev.= 0.09086)	1.18204 (Std.Dev.= 0.11835)
20~33	1.20	1.37312 (Std.Dev.= 0.09086)	1.37963 (Std.Dev.= 0.11835)
20~33	1.39	1.59369 (Std.Dev.= 0.11034)	1.60645 (Std.Dev.= 0.13414)

Table 1 shows the spatially averaged magnitude of velocity vector for water and an air bubble according to a variation of the water injection velocity in the 20~33 mm range of distance from the bottom. The 20~33 mm range of distance from the bottom has a fairly flat velocity profile. At this range, the water and air bubble velocity are very similar.

4. Conclusions

The velocity of an air bubble and water in a horizontal two-phase bubbly flow was experimentally measured using the PIV and PTV techniques.

The measurement results show that the air bubble velocity is very similar with the water velocity in horizontal channel

ACKNOWLEDGMENTS

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MEST) (No. 2012M2A8A4004176)

REFERENCES

[1] B. J. Kim, K. D. Kim, On the Time-Space Averaged Momentum Equation for Dispersed Flow, *Transactions of the Korean Nuclear Society Autumn Meeting*, 2009.

[2] R. Lindken, W. Merzkirch, A novel PIV technique for measurements in multiphase flows and its application to two-phase bubbly flows, *Experiments in Fluids*, Vol.33, p. 814-825, 2002.