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Transport of Local Two-Phase Parameters in Vertical Air/Water Flow for Bubbly and Slug Flow Regime

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1. Introduction

Studies for the interfacial area transport are being performed to reduce or eliminate the dependency of the flow regime map in the two-phase flow analysis code. The mechanistic study for the interfacial area needs a lot of understanding for the particle interactions and propagation phenomena of a flow. To investigate the fundamental two-phase flow phenomena and to generate an experimental data base for a modeling, an air/water test was performed in this study. The facility has a cylindrical acryl type test section of which the diameter and height are 80 mm and 10m, respectively. The main local parameters to be measured are the void fraction, bubble/liquid velocities, interfacial area concentration and bubble size. To investigate the transport phenomena of the two-phase parameters, a local probe and an impedance void meter(IVM) are installed at three axial elevations of the test section. (L/D=12.2, 42.2, 100.7) The test range covers 0.5~2.85 m/s and 0.04~2.13 m/s of the superficial liquid and gas velocity, respectively, which correspond to the bubbly and slug flow regimes. The system pressure conditions are 0.2~0.3 MPa at the L/D=12.2.

2. Experiments

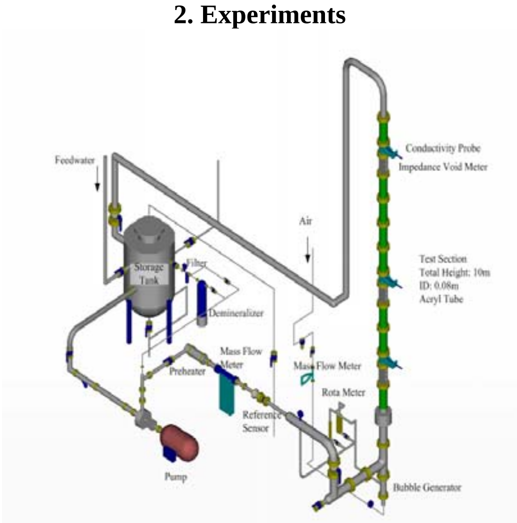

Fig. 1. Bird-eye View of Test Facilities

Figure 1 shows a brief configuration of the air/water test facility. The facility has a cylindrical acryl type test section of which the diameter and height are 80 mm and 10m, respectively. The local bubble parameters are measured by five-sensor conductivity probes. The main local parameters are the void fraction, bubble velocity, bubble frequency, interfacial area concentration and bubble size. To investigate the transport phenomena of the two-phase parameters, a local probe and impedance void meter(IVM) are installed at three axial elevations of the test section. (L/D=12.2, 42.2, 100.7) The RTD is installed below the test section and measures the temperature. The system temperature is controlled with the RTD, a pre-heater in the upstream of the test section and a cooler in the storage tank. The pressures at the three elevations where the conductivity probes are installed are measured by using the ROSEMOUNT transmitters, of which the error is 0.075% of the applied measuring span. The pressure at the first elevation is measured by a pressure transmitter. The pressures at the second and third elevations are measured by two differential pressure transmitters. One of the differential transmitters is connected to the first and second elevations and the other is to the first and third elevations. The operating condition is controlled to the 0.2 MPa or 0.3MPa and 30°C based on the elevation where the first probe is installed. The flow rates of the water and air are measured by using the Micromotion Coriolis flow meter, of which the error is 0.2% and 0.5%, respectively.

3. Results

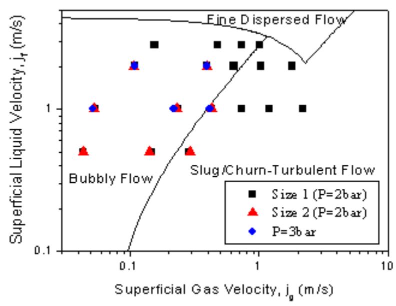

Fig. 2. Test Conditions on the Flow Regime Map

The test matrix covers the bubbly and slug flow regime as shown in figure 2. Test cases consist of three categories: (1) 15 Base cases (2) 8 Small Bubble cases (3) 5 Elevated pressure conditions. The test range covers 0.5~2.85 m/s and 0.04~2.13 m/s of the superficial liquid and gas velocity, respectively, which correspond to the bubbly and slug flow regimes. The system pressure conditions are 0.2~0.3 MPa at the L/D=12.2. Various transport data of local two-phase parameters could be obtained. Figures 3~5 show a results for the two phase transport phenomena for the slug flow condition. As two-phase flow goes upward, the void fraction of the second group bubbles is increased, from which wake entrainment-induced coalescence is considered to be important. Along with the increasing void fraction, also increasing trend is well shown in the bubble and liquid velocity profiles. Figure 4 shows a bubble size distribution at each measuring elevation. It shows that larger bubbles are formed as flow is developing. The transport phenomena can be explained by a mechanistic mechanism related to the particle interaction between bubbles and/or a bubble and local turbulence structure.

3. Conclusions

To investigate the transport phenomena of the two-phase flow, an air/water test was performed. Various local bubble parameters and liquid velocity were measured. From the data of the various two-phase bubble parameters, the mechanisms which affect a variation of the two-phase flow condition could be analyzed. The data produced in this study will be effectively utilized for the development of the interfacial area transport theory.

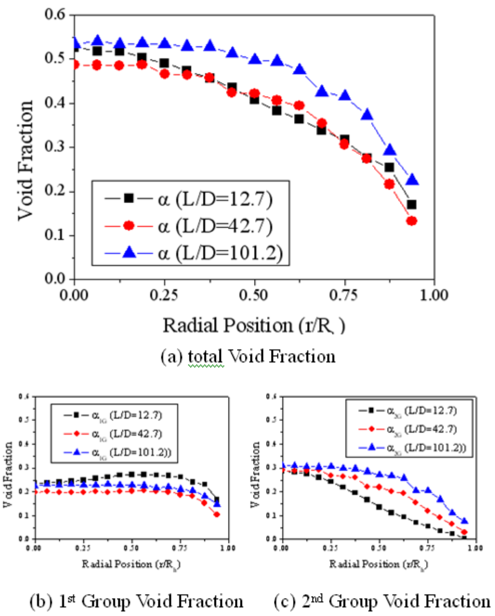

Fig3. Transport of Local Void Fraction (Run16; $<j_f>=1.0$, $<j_g>=0.73$. $<\alpha>_{1st}=31.5\%$)

Acknowledgement

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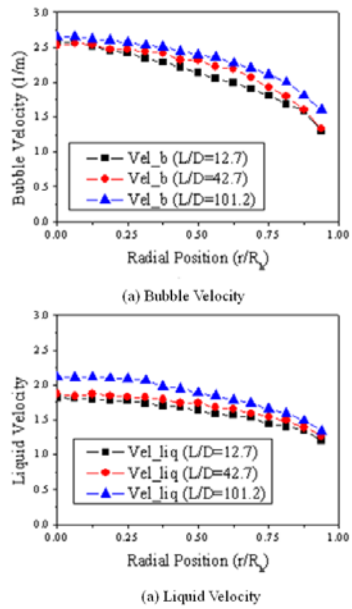

Fig4. Transport of Local Bubble/Liquid Velocities (Run16; $<j_f>=1.0$, $<j_g>=0.73$. $<\alpha>_{1st}=31.5\%$)

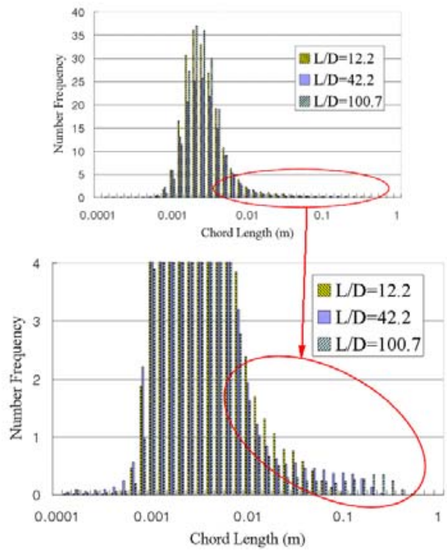

Fig5. Transport of Bubble Size Distribution (Run16; $<j_f>=1.0$, $<j_g>=0.73$. $<\alpha>_{1st}=31.5\%$)