Bubble size effect on the interfacial area transport in gas liquid two-phase flow

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1. Introduction

The introduction of interfacial area transport equation (IATE) has been proposed in order to replace the traditional flow regime maps and regime transition criteria in the two-phase flow analysis codes. Accurate data sets on the axial development of local flow parameters are dispensable to validate the modeled source and sink terms in IATE. The experimental data of Hibiki et al. [1] gave a comprehensive set of local parameter measurements; however, the initial condition was not controlled. In order to investigate the bubble size effect on two-phase flow evolution and to provide a data set for developing the physical models to describe the bubble-induced turbulence effect and also for validating the code developed for predicting two-phase flow behavior, a series of local parameter measurements were conducted using the five-sensor conductivity probe technique in air-water vertical-upward flow condition in which the initial bubble size is controlled by a specially designed bubble generator. The photographic method using high speed camera was applied in order to investigate the interaction mechanism between phases.

2. Experiments

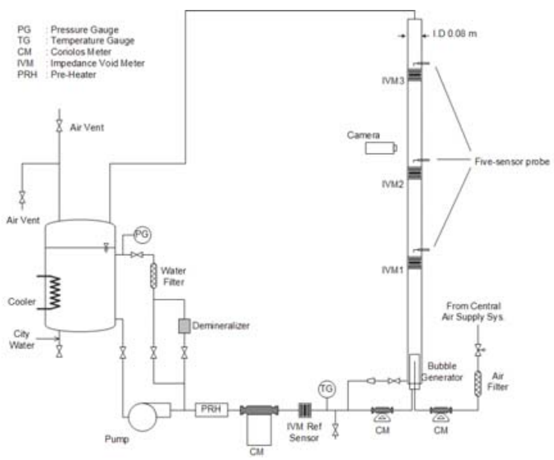

Fig 1: VAWL experiment facility

The vertical air-water loop (VAWL) has been used for investigating the transport phenomena of two-phase flow at Korea Atomic Energy Research Institute (KAERI). A schematic diagram of the test facility is shown in Fig. 1. Further details about test facility as well as the uncertainty of measurement can be found in [2]. In our experimental facility, the initial bubble size is controlled by a specially designed bubble generator which was depicted in Fig. 2.

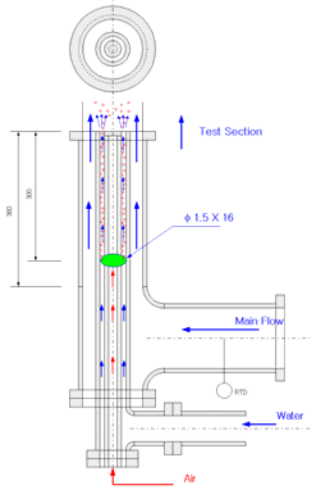

Fig 2: Bubble generator

The main water flow forms at both sides of the bubble generator. The bubble generator is securely connected to the test section through piping. Some of the main water is injected into the bubble generator. Air is also injected into the central region of the bubble generator through air chamber consisting of 16 holes with 1.5 mm in diameter and mixed with the injected water and enters the test section. The generated bubble size is determined by the degree of the turbulence that is created by the injected water and airflow as well as the size of the nozzles inside the bubble generator. Hence, this bubble generator can control the bubble size by changing the bypass flow rate without changing the main water flow or the air flow. The loop temperature was kept at a constant temperature (30^0C) by a preheater and a cooler. The loop is pressurized to 2 and 3 bars to avoid the effect of the difference in hydrostatic heads along the channel on the bubble growth, and the system pressure is automatically maintained and controlled by a special valve installed at the top of the water storage. The local measurements using the five-sensor conductivity probe and bidirectional flow tube were performed at three axial locations of z/D = 12.2, 42.2, and 100.7. With this method, the data for void fraction and interfacial area concentration are obtained and classified into two groups, that is, the small spherical bubble group and the cap/slug one. The accuracy of local measurements is assured by integrating the local flow parameters over the flow channel and comparing with the area-averaged measurements by impedance void meter, gas and liquid flow meters. The photographic method using high speed camera was applied in order to investigate the interaction mechanism between phases. The test flow conditions for low superficial liquid velocity are tabulated in Fig. 3.

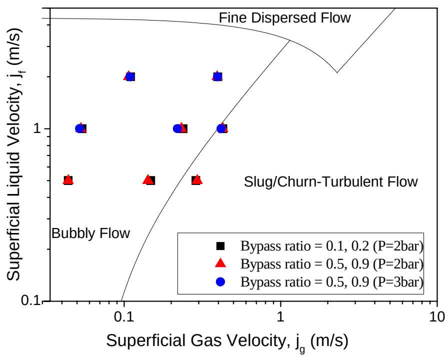

Fig 3: Test matrix

3. Results

For $<j_f>$ = 0.5 m/s, $<j_g>$ = 0.044 m/s, a well-developed wall peaking void fraction profile was observed with the bypass ratio of 0.9 at the bubble generator even at the first measuring station, whereas a well-developed core peaking void fraction profile was observed with the bypass ratio of 0.1 (Fig. 5). In the former case, the initial bubble size was uniformly distributed so that there is no appearance of large bubble and then the bubble coalescence due to the wake entrainment mechanism is unlikely to occur. The bubbles are small and they have tendency to migrate toward the wall resulting in wall peaking void fraction profile as previously achieved by Song et al. [3].

The bubble size became gradually increased along the flow direction by the expansion due to the axial pressure reduction, and then the large bubble had tendency to migrate toward the centre of channel at the second and the third measuring points. In the latter case, large bubbles were even formed at the first measuring point. Therefore, the bubble coalescence would be enhanced because of wake entrainment effect. It should be noted that the gas and liquid profiles of the former case are flatter than those of the latter case.

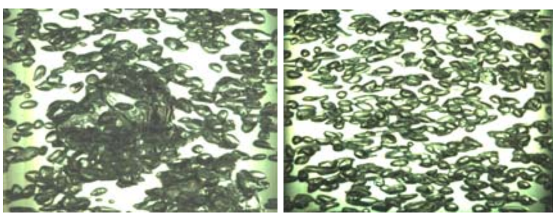

Fig 4: Visualization results at L/D = 42.4 with bypass ratio = 0.1 and 0.9 ($<j_f>$ = 0.5 m/s, $<j_g>$ = 0.044 m/s)

4. Conclusions

The initial bubble size condition has also a big influence on the interaction mechanism between phases. Compared with the experimental data of Hibiki et al. [1], our data is very unique considering the initial bubble size effect and is very useful with capability of two-group of bubble information which is indispensable for two-group IATE development.

ACKNOWLEDGEMENTS

This work was supported by the Nuclear Research & Development Program of the National Research Foundation (NRF) grant funded by the Korean government (MEST). (grant code: M20702040003-08M0204-00310)

REFERENCES

[1] T. Hibiki, M. Ishii, Z. Xiao, Axial interfacial area transport in bubbly flow systems, Int. J. Heat and Mass Transfer, 44, p. 1869-1888, 2001.
[2] D.J.Euh, V.T.Nguyen, B.J.Yun, C.-H.Song "Transport of Local Two-Phase Parameters in Vertical Air/Water Flow for Bubbly and Slug Flow Regime", KNS Spring meeting, Pyoungchang, Korea (2010)
[3] C.-H. Song, H.C. No, M.K. Chung,. "Investigation of bubble flow developments and its transition based on the instability of void fraction wave''. Int. J. Multiphase Flow 21, p. 381-404, 1995.

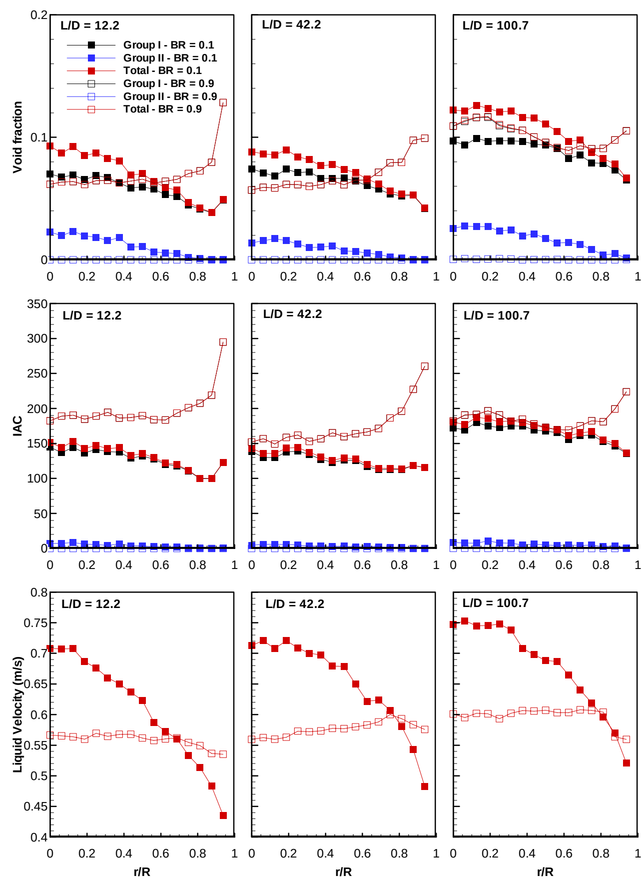

Fig 5: Visualization Results