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Development of a experimental facility for the flow regime identification of two-phase flow in the inclined mini channel

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1. Introduction

Recently, miniaturization is one of popular issues in the engineering design. Based on the successful advance in the semi-conductor industry, the new fabrication method cultivates new devices of tiny size. Generally, these miniaturized gadgets were more efficient than the normal devices. The major physical parameters governing the phenomena are changed as the scale decreases and unexpected effects open a room of improvement. For instant, the phase change phenomena in a micro or mini channel have been known to be enhanced. For developing a compact and efficient heat exchanger, the study on the two phase flow in a miniaturized flow channel is imperative. Furthermore, the produced hydrogen will be fed into the fuel cell which needs to drain out the water generated in the reaction at the diffusion layer of electrode membrane, effective removal of vapor plug is necessary. Also, in the safety study of CANDU reactor several parts of feeder pipes have the incline angles which will affect the accuracy of the safety analysis when the flow regime map of code is ill addressed. In line with the development of the RELAP-CANDU, the present work also is aimed to be studied.

2. Experimental Facilities

As shown in Fig.1, the flow loop is designed by equipping water and air supplier and instrument and controller to provide the designed values of water and air flow.

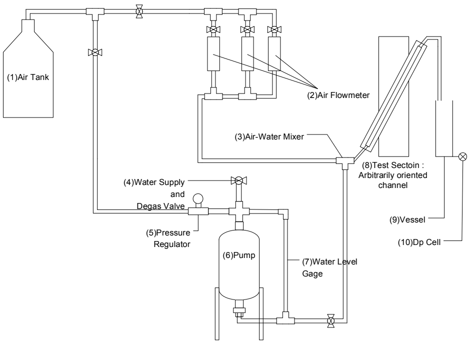


Fig.1 Schematic drawing of the test loop: test section, compressed air chamber, water tank, and necessary instruments and valves to control flow rate

Due to the small diameter of the channel, the system pressure was set little bit high, 10 bar because the pressure drop along the test tube is sometimes over 7.6 bar in the high flow rate. The water is supplied by the imposed pressure of the air chamber. The water flow rate is measured by weighting the drained water with the precise scale. Fig.2 is the facilities constructed.

Fig.2 The photograph of the experimental facility

An impedance sensor is miniaturized to harness the time sequential data of void fraction. Two electrodes are prepared on both side of the channel to provide electric field near uniform. Once the bubble runs in the channel, its small conductivity distorts the electric field so the impedance between two electrodes decreases. This change of impedance is almost linear to the change of void fraction. Miniaturization is made by casting plastic resin to the precisely fabricated mold by mounting tiny electrodes. The small change of the impedance is amplified and transfer to the AD converter to be stored into the computer for the neural network processing.
As a counter measurement system, we employed high speed digital cam coder, which is useful to check the results of the neural network .

3. Results and Discussions

At this moment we have two case studies: horizontal and vertical direction. Because the present facility is designed to harness data of arbitrarily incline channel flow, these two case studies will demonstrate the validity of the system design.

3.1 Horizontal two-phase flow

As shown in Fig. 3, we observed flow patterns at 110 different cases. The harnessed time sequential data of void fraction are processed by the Neural network to obtain the objective identification. At the high liquid flow rate, the signals change in high frequency so that even bubbly flow, the signals look like noise. However, in the low or medium level of liquid speed, the signals clearly represent the existence of the bubbles.

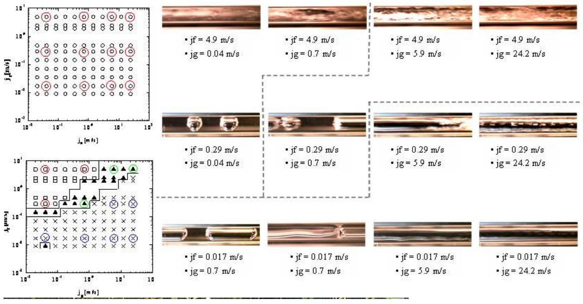
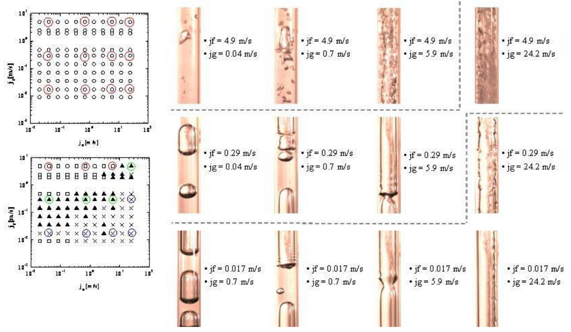


Fig.3 The flow pattern identified and typical images of flow

3.2 Vertical two-phase flow

As shown in Fig. 4, we observed flow patterns in the vertical mini channel at 110 different flow conditions. The harnessed time sequential data of void fraction are processed by the Neural network to obtain the objective identification. At the high liquid flow rate, the signals change in high frequency so that even bubbly flow, the signals look like noise. It is very interesting that even in the mini channel, we can see very tiny discrete bubbles in the bubbly flow regimes. However, in the slug flow regime, we cannot observe the tiny discrete bubbles in the slug column , rather we observed a few number of g cap bubbles following.



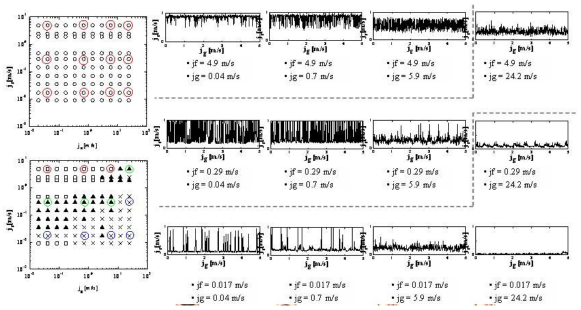


Fig.4 The flow pattern identified and typical images of flow in the vertical mini channel

Figure 5 showed the comparison of the present result with the Mishima-Ishii tramsition criteria. It was found that slug flow and churn flow regimes expand to the direction of the low liquid flow rate and gas flow rate.

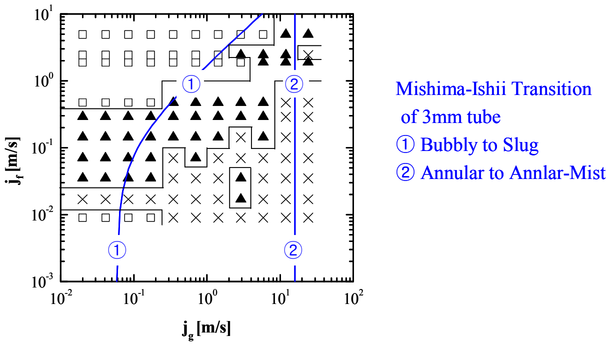


Fig.5 Comparison of the flow regime transition wth the Mishima-Ishii Criteria

4. Conclusions

In the study, we developed a general facility to observe the flow regime in the inclined mini channel. Impedance and neural network successfully determine the flow regimes which showed some diameter effect in the flow regime transition.

Acknowledgement

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