JASMAC
Conference of the Japan Society of Microgravity Application

OS3-6

国際宇宙ステーション沸騰・二相流実験で得られた観察部での気液界面構造の評価

Evaluation of Gas-Liquid Interfacial Structure at the Observation Section Obtained in Microgravity Flow Boiling Experiments Onboard International Space Station

浅野等 [1]，河南治 [2]，井上浩一 [3]，鈴木康一 [4]，今井良二 [5]，新本康久 [6]，松本聡 [7]，大田治彦 [6]
Hitoshi ASANO[1], Osamu KAWANAMI[2], Koichi INOUE[3], Koichi SUZUKI[4], Ryoji IMAI[5], Yasuhisa SHINMOTO[6], and Satoshi MATSUMOTO[7], Haruhiko OHTA[6]
1 神戸大学，Kobee University
2 兵庫県立大学，University of Hyogo
3 北九州市立大学，The University of Kitakyushu
4 東京理科大学，Tokyo University of Science
5 室蘭工業大学，Muroran Institute of Technology
6 九州大学，Kyushu University
7 宇宙航空研究開発機構，Japan Aerospace Exploration Agency

Two-phase flow loop cooling system has been attracting attention for space structures instead of single-phase flow system due to its higher energy density in heat transfer and easy temperature control under saturation condition. The understandings on thermo-fluid dynamics of gas-liquid two-phase flows with phase change under microgravity is required in the design of the system. Therefore, two-phase flow experiments had been carried out as a JAXA project named TPF experiment under the stable microgravity condition in Japanese Experimental Module “KIBO” of International Space Station (ISS).

Heat transfer and pressure loss characteristics of gas-liquid two-phase flows strongly depend on the gas liquid interfacial structure. The gas-liquid interfacial structure under microgravity will be different from that under normal gravity due to the loss of buoyancy. For example, in nucleate boiling, bubble departure diameter will be larger than that in vertically upward flow on the ground. In annular flows which will be main flow pattern, the liquid film thickness and the characteristics of ripple and disturbance waves will affect the heat transfer coefficient of boiling and condensing heat transfer. Therefore, to observe and measure the interface structure of boiling two-phase flow in more detail, especially 3D structure must be important, an adiabatic observation section was directly connected downstream of each heating section.

The cress-sectional shape of the observation section is shown in Fig. 1 with the optical system. The observation section was made of transparent polycarbonate resin. To make the effect of refraction through the outside wall smaller, the exterior shape is formed into a rectangular, and then a circular channel with a diameter of 4 mm was drilled. The inner wall was carefully polished. For three-dimensional observation, a method of stereoscopic photography had been applied. Two images from two orthogonal directions can be photographed by one camera. The optical system consists of one compact high frame-rate video camera whose maximum frame-rate is 1000 fps, four metallic mirrors, and two flicker-free LED panels for the back-lighting. It had been confirmed in the preliminary component test that the actual liquid film thickness can be measured from the image within ± 25 μm accuracy [1)]. Continuous image of 750 frames was recorded for each condition.

Extracted frames from images obtained by the high frame-rate camera are shown in Fig. 2 (a) to (d).

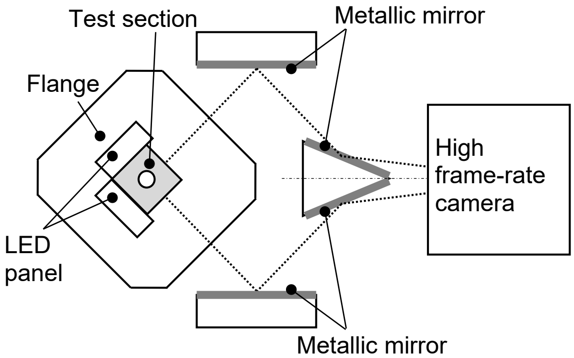
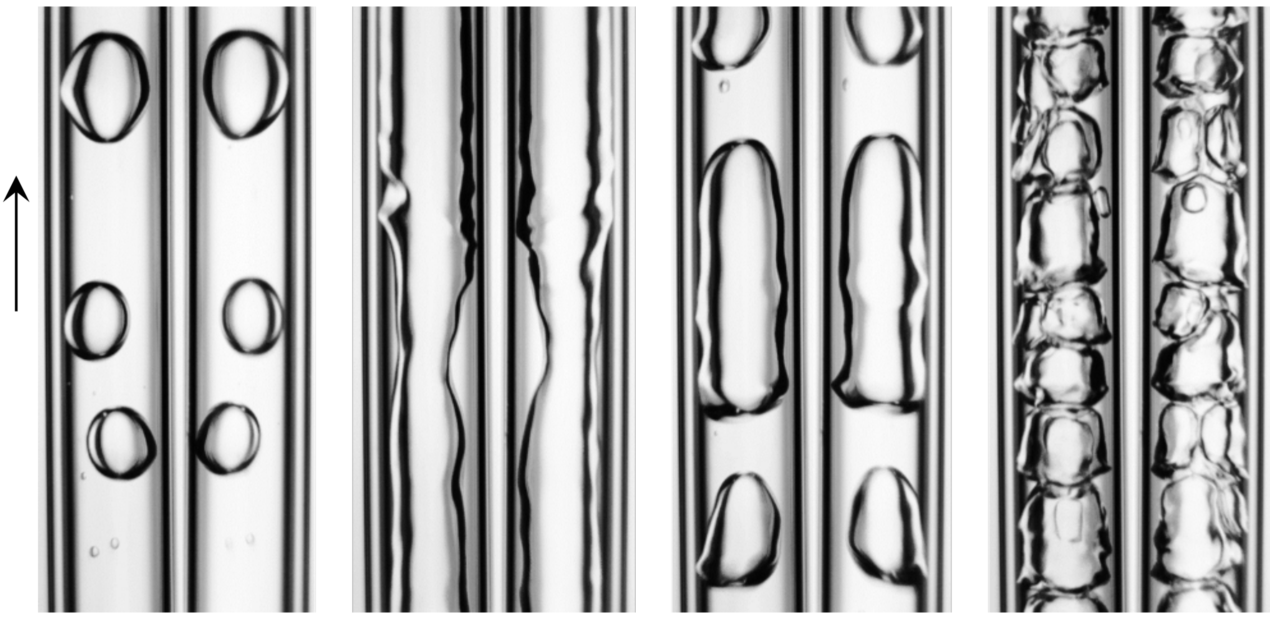


Fig. 1 Cross-sectional shape of the adiabatic observation section
with the arrangement of optical system for stereoscopic imaging.

The flow pattern in Fig. (a) was classified as a bubbly flow, because flowing bubbles were smaller then the channel diameter. Such bubbly flow was mainly observed for subcooled boiling. The velocity of each bubble was nearly equal, and the distance between bubbles was kept constant. The flow pattern in Fig. (b) was classified as a semi-annular flow. Elongated vapor phase with constrictions at intervals was observed. The constriction might be formed by bubble coalescence. The flow pattern in Fig. (c) was classified as a slug flow. Since the bubble shape at the tail was almost flat while the nose shape was rounded, it was clear that interfacial shear stress caused by velocity difference was acting on slug bubbles. The flow pattern in Fig. (d) is a flow pattern which cannot be observed in channel flows on the ground. Relatively short babbles were densely and continuously flowing. Bubble coalescence might be suppressed because bubbles was flowing at the almost same velocity. The flow pattern is named as a continuous bubble flow.



Left Right Left Right Left Right Left Right

(a) G=100 kg/(m²s) x= 0.012 (b) G=100 kg/(m²s) x= 0.11 (c) G=150 kg/(m²s) x= 0.027 (d) G=330 kg/(m²s) x= 0.024

Fig. 2 Flow behaviors observed at the adiabatic observation section.

References

1) T. Gomyo, et al., Development of Boiling and Two-Phase Flow Experiments on Board ISS (Void Fraction Characteristics in the Observation Section just at the Downstream of the Heating Section), *Int. J. Microgravity Sci. Appl.*, **33**(1) (2016) paper No. 330104.