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国際宇宙ステーションにおける沸騰・二相流実験でのヒートロス評価

Heat Loss Estimation of Microgravity Flow Boiling Experimental Set-up Onboard International Space Station

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The application of boiling and two-phase flow is one of the most effective way to improve the cooling performance of avionics systems and the thermal performance of temperature control systems of satellites and spacecrafts. We have investigated flow boiling of n-Perfluorohexane onboard International Space Station (ISS) as a part of TPF (Two-Phase Flow) experiment promoted by JAXA. In the flow boiling experiments onboard ISS, since the avionics air flows inside the experimental apparatus to maintain the stable operation of instruments and to prevent excessive temperature rise of components, the amount of heat loss from the test fluid is larger than those in the terrestrial flow boiling experiments without active cooling. As shown in Fig. 1, the evaluation of the heat loss $\dot{Q}_{loss}$ is necessary for obtaining accurate test fluid conditions at the inlet of metal heated tube, i.e. degree of liquid subcooling $\Delta T_{\mathrm{sub,\,MHT,in}}$ and vapor quality $x_{\mathrm{MHT,in}}$. Preliminary experiments with liquid single-phase flow were conducted onboard ISS to develop the heat loss models for the subcooled flow boiling and saturated flow boiling experiments. In the preliminary experiments, the heat loss characteristics of the preheater and the thermal resistances of heat loss path in the piping section between the preheater and the metal heated tube were evaluated from the temperature changes of liquid single-phase test fluid and the heating amount of the preheater. The detailed developments of the heat loss models are described in Inoue et al[1, 2]. Figure 2 shows examples of the estimated vapor quality change due to the heat loss $\Delta x_{\mathrm{MHT,in}}$ at the metal heated tube inlet for the saturated flow boiling experiments conducted onboard ISS. The amount of $\Delta x_{\mathrm{MHT,in}}$ cannot be ignored for the accurate investigation of flow boiling, and it becomes larger in the conditions of lower mass velocity G. Thus, it can be concluded that the development of accurate heat loss models are extremely important issue for obtaining reliable microgravity heat transfer data in the ISS experiment.

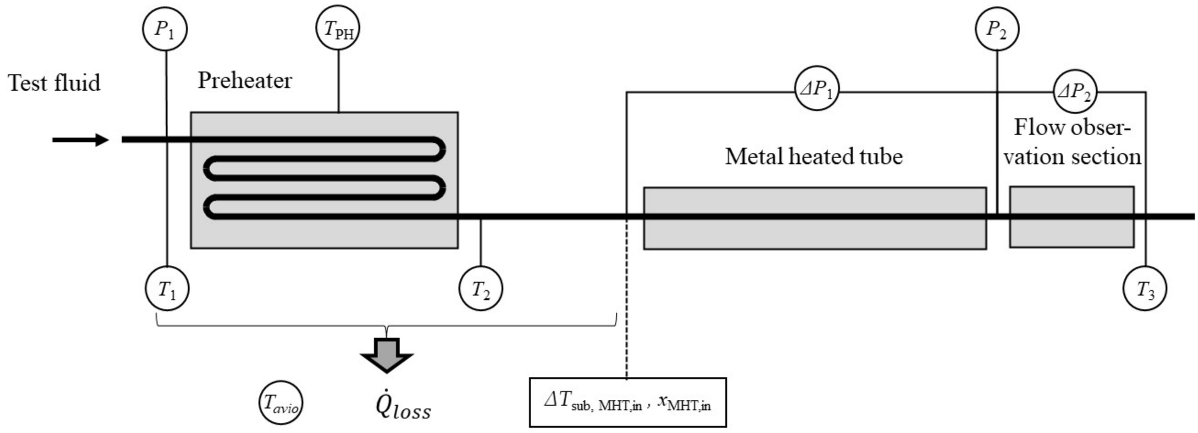

Fig. 1 Heat loss model for evaluating test fluid condition at metal heated tube inlet onboard ISS.

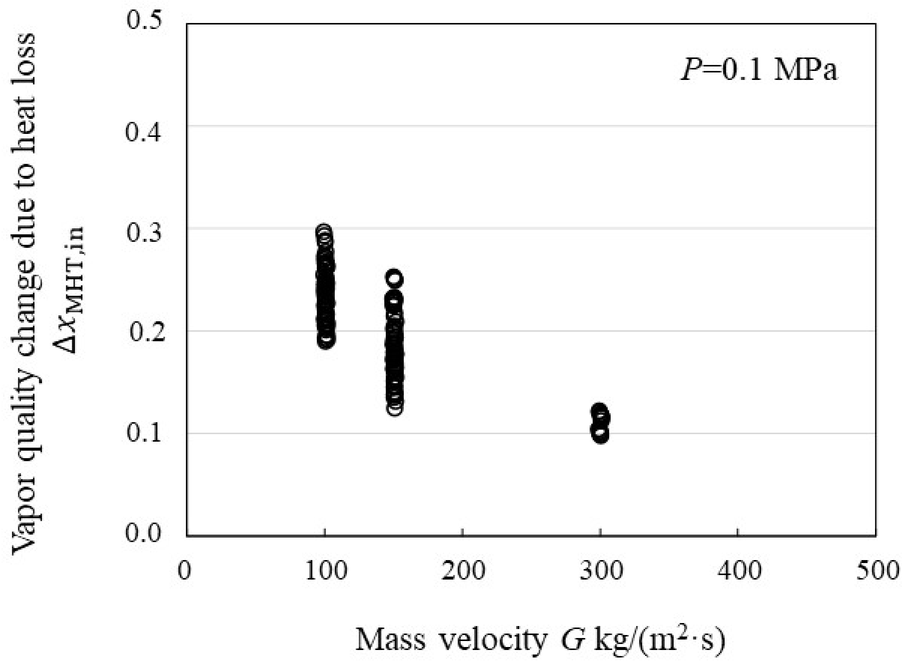

Fig. 2 Vapor quality changes due to heat loss at the inlet of metal heated tube for saturated flow boiling experiments.

References

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