JASMAC Conference of the Japan Society of Microgravity Application

OS3-4

国際宇宙ステーション沸騰・二相流実験における金属伝熱管の熱伝達解析

Heat Transfer Analysis of Metal Heated Test Tube in Microgravity Flow Boiling Experiments Onboard International Space Station

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

Flow boiling has been considered as one of the most important research topics for the realization of large-capacity and high-performance space thermal systems. Most of previous flow boiling experiments have been conducted in a short-term microgravity environment realized by aircrafts, drop towers, etc[1,2]. Thus, the reliable experimental microgravity heat transfer data available for the design of future thermal space systems has not been accumulated sufficiently. We experimentally studied flow boiling heat transfer in the metal heated tube onboard International Space Station (ISS) as a part of TPF (Two-Phase Flow) experiment promoted by JAXA.

Figure 1 shows the structure of metal heated tube. The metal heated tube is made of copper and has an inner diameter of 4.0mm, outer diameter of 12mm, a heated length of 368mm. Electric sheath heaters are wrapped in the outer grooves of the metal heated tube. Table 1 summarizes the experimental conditions of the ISS experiments. *n*-Perfluorohexane was employed as the test fluid.

As pointed out in the previous report, the heat loss is not negligible amount due to the avionics air flowing inside of the experimental apparatus for the evaluation of test fluid conditions at the metal heated tube inlet. On the other hand, the heat loss from the metal heated tube also has a serious effect on the evaluation of local heat flux and heat transfer coefficients in the metal heated tube. The heat loss from the heated section of the metal heated tube occurs in the radial and axial directions as shown in Fig. 2. All thermal resistances of the heat loss path R were determined by the preliminary experiments with liquid single-phase test fluid conducted in ISS.

Figure 3 shows an example of the relation between local heat transfer coefficients α and vapor quality x for the saturated flow boiling experiments performed in ISS. The experimental conditions are mass velocity G=100kg/(m^2·s), inlet vapor quality $x_{MHT,in}$=0.54, heat flux q=7.1W/m^2 (set value). The evaluated heat transfer characteristics of the relationship between α and x change significantly depending on whether the heat loss is taken into consideration or not. The shift along the horizontal axis of Fig. 3 is mainly due to the heat loss at the section upstream from the inlet of metal heated tube, i.e. the preheater and piping, and the shift along the vertical axis of Fig. 3 is caused by the reduction of net heat flux due to the heat loss from the metal heated tube. Excessive increases in α near both ends of metal heated tube disappear by considering the heat loss. Evaluated relation between α and x considering the appropriate heat loss show the typical heat transfer characteristics of two-phase forced convection. This result suggests that the developed heat loss models and the evaluation methods for α are valid for the investigation of flow boiling heat transfer in the ISS experiments.

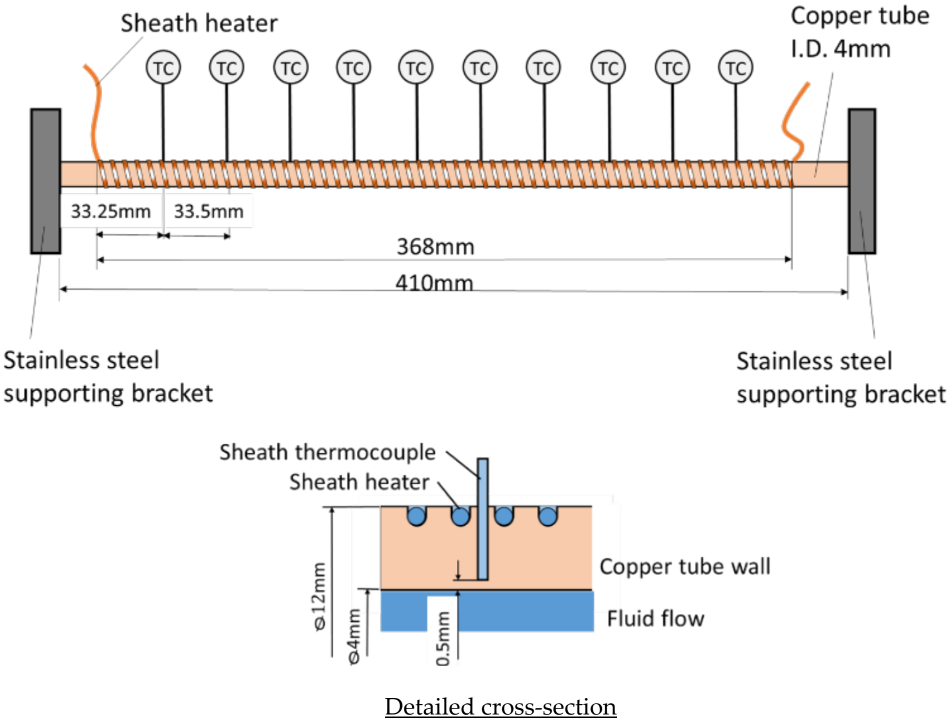

Fig. 1 Metal heated test tube.

Table 1 Experimental conditions of flow boiling experiments onboard ISS

Pressure P	~ 0.1 MPa
Mass velocity G	30-600 kg/(m²s)
Maximum degree of liquid subcooling at the test section inlet $\Delta T_{sub,\mathrm{MHT}in}$	30 K
Maximum vapor quality at the test section inlet $x_{\mathrm{MHT}in}$	0.5
Maximum heat flux in the metal heated tube q	30 kW/m², except CHF exp.

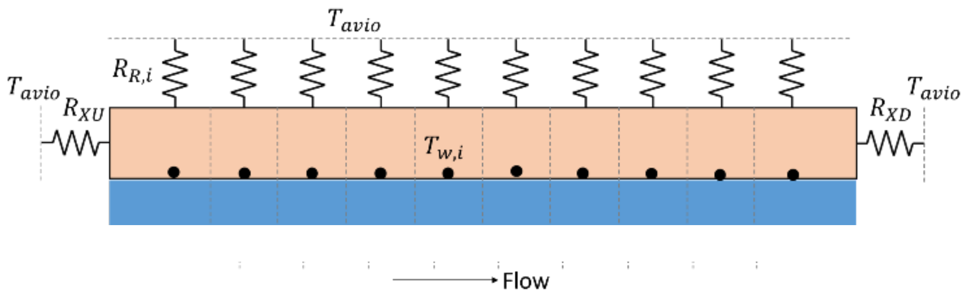

Fig. 2 Heat loss model of metal heated tube.

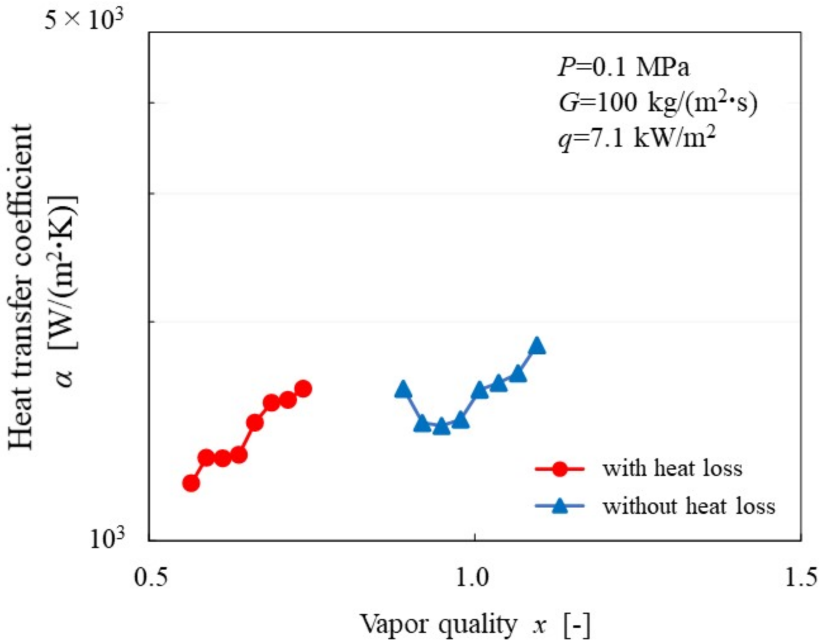

Fig. 3 Effects of heat loss on the evaluation of heat transfer characteristics.

References

1) M. Narcy and C. Colin: Interfacial Phenomena and Heat Transfer **3** (2015), 1.

2) I. Mudawar.: Advances in Heat Transfer **49** (2017), 225.