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国際宇宙ステーション沸騰・二相流実験向け凝縮器の熱流動特性評価

Evaluation of Thermal and Fluid Behavior in Condenser of Microgravity Flow Boiling Experimental Set-up Onboard International Space Station

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1. Introduction

Future spacecraft will tend to be larger, and the required heat rejection amount will increase accordingly. As a result, it is essential to develop a two-phase heat management system which has a great advantage in system weight. In the two-phase boiling flow experiment (TPF = Two Phase Flow) conducted at the International Space Station, the purpose is to clarify the thermal and fluid behavior of the forced flow boiling in a circular pipe under micro gravity condition by flow visualization, temperature measurement, etc. In this experimental system, the test section consists of a transparent heated tube, a metal heated tube, and an adiabatic visualization tube, and the boiling two-phase flow formed by these is returned to the liquid phase by the condenser and recirculated. This paper describes the design of the condenser and the evaluation results of the heat transfer performance through TPF experiments.

2. Evaluation of thermal characteristics of condenser

Figure 1 shows the structure of the condenser. A rectangular tube is placed on a flat cold plate, and the test liquid is flowed inside the circular tube formed in the rectangular tube. In addition, cooling water is circulated in the cold plate. A thermal mathematical model was constructed for this condenser, and the thermal design of the condenser was performed using this model, and the main specifications of the condenser were determined[1)]. In the thermal design of the condenser, it is necessary to calculate the heat transfer coefficient of forced flow condensation in the tube under microgravity, but there are no significant evaluation formulas or empirical formulas for these. On the other hand, Keshock obtained the result by numerical analysis that the heat transfer coefficient under microgravity is about half that under normal gravity[2)]. In this study, we used this knowledge to determine the required heat transfer area of the condenser, the length of the condenser tube, and other specifications. Also the heat transfer characteristics of the condenser were evaluated based on the flight test and PFM test data. For the outlet temperature in the condensing tube according to the above-mentioned thermal mathematics model, the correction coefficient for the value of the heat transfer coefficient under ground gravity was calculated so that the result of the above experiment agrees with that of the thermal mathematics. Table 1 shows the above correction coefficients under each experimental condition. The table shows that the correction coefficient becomes smaller under microgravity and the heat transfer coefficient of condensation decreases under microgravity environment.

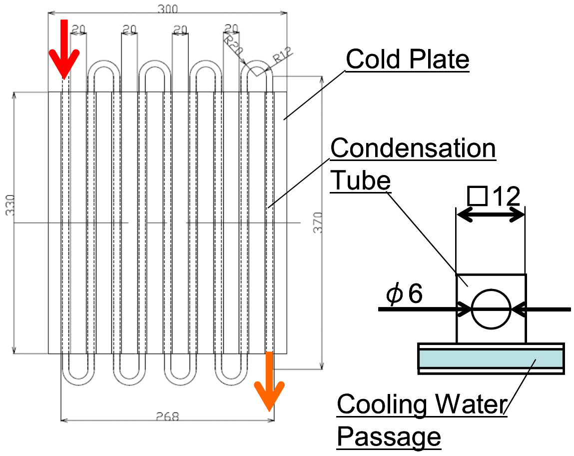

Fig.1 Structure of Condenser for TPF Experiment

Table 1 Evaluated Results for Thermal Performance of Condenser

	Run	Mass flux [kg/m^2/s]	Inlet temp. [°C]	Outlet temp. of 1st condenser tube [°C]	Outlet temp. of condenser [°C]	Inlet equilibrium thermodynamic quality [-]	Inlet temp. of coolant water	Correlation factor for condensed heat transfer [-]
Flight Exp.	Run 2 MHT 1 - 2	148.00	59.44	57.99	23.30	1.00	18.00	0.10
Flight Exp.	Run 6 MHT 1 - 2 R	300.00	60.00	58.38	28.52	0.77	18.07	0.10
Flight Exp.	Run 6 MHT 1 - 2 R	300.00	60.14	57.86	28.48	0.66	18.27	0.09
Flight Exp.	Run 7 MHT 1 - 3 R	150.00	60.63	59.59	23.64	0.84	18.10	0.10
Flight Exp.	Run 7 MHT 1 - 3 R	150.00	60.34	58.37	23.36	0.74	18.05	0.10
Flight Exp.	Run 7 MHT 1 - 3 R	150.00	60.44	59.89	24.16	0.96	18.25	0.10
Flight Exp.	Run 18 MHT 2 - 4	100.00	60.21	56.36	21.66	0.96	17.95	0.15
PFM	20151209	100.00	58.66	55.85	22.89	1.00	20.14	0.30
PFM	20151211	143.52	58.02	56.63	25.12	0.98	20.73	0.50

References

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