令和６年度国際交流基金
国際学術交流のための教職員海外派遣事業（短期）報告書

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2. 参加学会名

第 3 回アジア熱科学会議(3rd ACTS)
（Third Asian Conference on Thermal Sciences）

3. 開催日時

2024 年 6 月 23 日～27 日

4. 開催地

上海（中国）

5. 学会規模

アジア熱科学会議（ACTS）は日本伝熱学会，韓国機械学会，中国熱物理学会，オーストラリア熱流体学会及びインド伝熱学会の共催で行われる学術会議である。アジア地域最大規模の熱関連国際会議である。いままで韓国の済州と日本の福岡にて２回開催されてきた。韓国で開催された第 1 回 ACTS では参加者が 700 名を超えていた。今回ではアジアを中心に世界から約 850 人が参加し，625 編の論文発表がなされた。そのうち，8 件のプレナリー講演，45 件の基調講演があった。熱科学に携わる研究者が多数参加するため，最先端研究のディスカッションが行われた。

6. 発表要旨

As one of the cooling methods for the blanket in a fusion reactor, forced convection using helium gas has been considered as one of the promising candidates. In this study, we focused on forced convection heat transfer of helium gas flowing in a minichannel, and conducted forced convection heat transfer experiments of helium gas in a minichannel with different length at various velocities. The heat generation rate in the test minichannel increased exponentially at various increasing rates. The purpose of this study was to investigate the characteristics of forced convection heat transfer in a minichannel. Based on the experimental data, following results were obtained. (1) The heat transfer coefficient gradually increased for the e-folding time shorter than about 1.5 s. (2) The heat transfer coefficient for a minichannel increased with the decrease in diameter. (3) The heat transfer showed a weak dependence on the tube length at 30 mm and 50 mm. (4) The Nusselt numbers obtained from the experimental results for a diameter of 0.8 mm showed larger values than those of Gnielinski's correlation.

7. 学会への関わり状況（例えば、セッションチェアマン、組織委員会委員等）

発表者

8. その他自由記述

発表論文の写しは添付のとおり。

Two-Page Extended Abstracts of the Third Asian Conference on Thermal Sciences, 3rd ACTS
June 23-27, 2024, Shanghai, China

ACTS-O-0255

HEAT TRANSFER FOR FORCED CONVECTION OF HELIUM GAS IN A MINICHANNEL WITH DIFFERENT LENGTH

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KEY WORDS: Convection heat transfer, Helium gas, Minichannel, e-folding time

1. INTRODUCTION

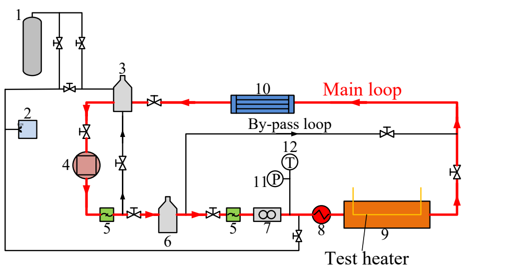
As one of the cooling methods for the blanket in a fusion reactor, forced convection using helium gas has been considered as one of the promising candidates. In this study, we focused on forced convection heat transfer of helium gas flowing in a minichannel, and conducted forced convection heat transfer experiments of helium gas in a minichannel with different length at various velocities. The heat generation rate in the test minichannel increased exponentially at various increasing rates. The purpose of this study was to investigate the characteristics of forced convection heat transfer in a minichannel.

2. EXPERIMENTAL APPRATUS

The experimental apparatus and method were reported in the authors' previous study[1]. A schematic diagram of the experimental setup is shown in Fig. 1. Helium gas is supplied from a gas cylinder and circulated by a compressor. The flow rate in the test section is measured by a flow meter. The gas flowing through the test section is cooled by a cooler and returned to the compressor. A detailed diagram of the test section is also reported in the previous study[1]. A platinum tube with a diameter of 0.8 mm was used as the test heater (minichannel), and copper electrodes were fixed to both ends of the test heater. The tube is covered with Bakelite plates for thermal and electrical isolation. A silicone sheet is inserted between the Bakelite plate and the electrode to prevent gas leakage. The test heaters were 50 mm and 30 mm in length.
In this experiment, a heat generation rate is applied to the test heater with exponentially increasing rate. It is shown as the following equation.

$$\dot{Q} = Q_0 \exp(t/\tau) \quad (1)$$

where, $\dot{Q}$ is heat generation rate, Q_0 is initial heat generation rate, t is time, and τ is the e-folding time



1.Gas cylinder 2.Vacuum pump 3.Suction surge tank
4.Compressor 5.Filter 6.Delivery surge tank 7.Flow meter
8.Pre-heater 9.Test section 10.Cooler 11.Pressure transducer
12.Thermocouple

Fig. 1 Schematic diagram of the experimental apparatus.

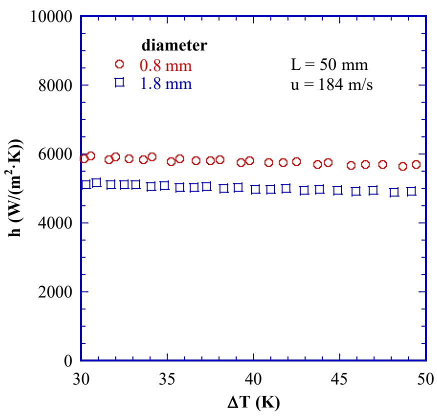


Fig. 2 The relation of heat transfer coefficient with temperature difference at various diameters.

3. EXPERIMENTAL RESULTS

Figure 2 shows the relationship between the heat transfer coefficient, h, and the surface temperature difference between inner surface temperature and bulk temperature, ΔT, for a length of 50 mm at a velocity of 184 m/s, e-folding time of 16.6 s, and inner diameters of 0.8 mm and 1.8 mm[2]. The inlet temperatures are 283 K for

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0.8 mm, and 295 K for 1.8 mm. And the inlet pressures are 528 kPa for 0.8 mm and 501 kPa for 1.8 mm. As shown in the figure, the heat transfer coefficient asymptotically approaches a constant value with respect to the surface temperature difference, and the heat transfer coefficient for the diameter of 0.8 mm was about 17% higher than that for diameter of 1.8 mm[2]. It is considered that the heat transfer coefficient for a small diameter tube improved with the reduction in the diameter.

Figure 3 shows the heat transfer coefficient, h, at various e-folding time, τ, and various flow velocities. The heat transfer coefficients are approximately constant for the e-folding time longer than about 1.5 s under the same flow velocity. The heat transfer coefficients gradually increase for the e-folding time shorter than about 1.5 s. These results indicate that the heat transfer process is in a quasi-steady state for the e-folding time longer than about 1.5 s, and it is in a transient state for the e-folding time shorter than about 1.5 s.

Figure 4 shows Nusselt number, Nu, at various e-folding time for the tube lengths of 30 mm and 50 mm. The inlet temperatures are 296 K for 30 mm length, and 283 K for 50 mm length. And the inlet pressures are near 525 kPa for both lengths. As shown in the figure, Nusselt numbers for 30 mm length tube agree well with those of 50 mm tube in the quasi-steady state, and show some increases at very short e-folding time ($\tau < 0.1$ s) in the transient state. It is indicated that the heat transfer shows a weak dependence on the length. The Nusselt number can be also obtained at various Reynolds number. Compared with conventional forced convection heat transfer correlation by Gnielinski[3] in a circular tube, the experimental results for the diameter of 0.8 mm show approximately 70% higher values than those by the Gnielinski's correlation[3].

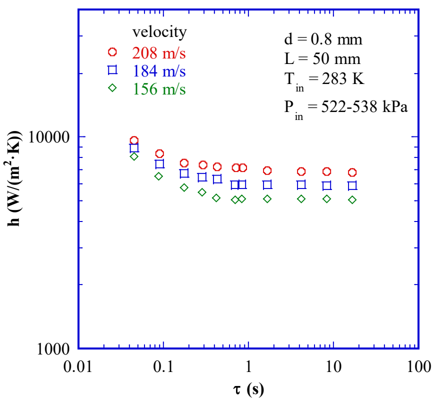

Fig. 3 The relation of heat transfer coefficient with e-folding time at different flow velocity.

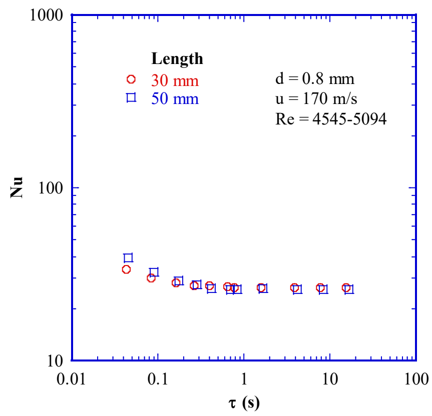

Fig. 4 The relation of Nusselt number with e-folding time at different length.

4. CONCLUSIONS

Forced convection heat transfer experiments were conducted for helium gas flowing in minichannel with a diameter of 0.8 mm at various lengths, velocities and e-folding time of exponentially increasing heat generation rate. Following results were obtained.

(1) The heat transfer coefficient gradually increased for the e-folding time shorter than about 1.5 s.
(2) The heat transfer coefficient for a minichannel increased with the decrease in diameter.
(3) The heat transfer showed a weak dependence on the tube length at 30 mm and 50 mm.
(4) The Nusselt numbers obtained from the experimental results for a diameter of 0.8 mm showed larger values than those of Gnielinski's correlation.

ACKNOWLEDGMENT

This study was funded by the Japan Society for the Promotion of Science (JSPS) (Grant-in Aid for Scientific Research(C), KAKENHI, No. 18K03979).

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