Helium Hydraulic Tests in the Printed Circuit Heat Exchanger

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1. Introduction

Nuclear reactors have been developed over the decades. Even though water cooled reactors are very popular now, gas cooled reactors are expected to be Next Generation Nuclear Reactors for the future. VHTRs(Very High Temperature Reactors) are very useful for producing the hydrogen with high efficiency. But new components in VHTRs are necessary to stand more severe conditions than in the water cooled reactors. A new heat exchanger is required for the indirect cycle of the gas cooled reactors. The requirements are to stand high temperature, high pressure without the leakage of gas and to have a small size and high effectiveness. A PCHE (Printed Circuit Heat Exchanger) was developed as a critical component for satisfying these requirements by diffusion bonding process. A Helium test loop was being constructed to study the performances of the PCHE.

2. KAIST He Test Loop and Methodology

In this section, the KAIST Helium test loop and measurement methods were described. The Helium test loop consisted of a circulator, a 150kW Heater, a PCHE, two coolers, and a helium tank, and so on.

2.1 KAIST He Test Loop

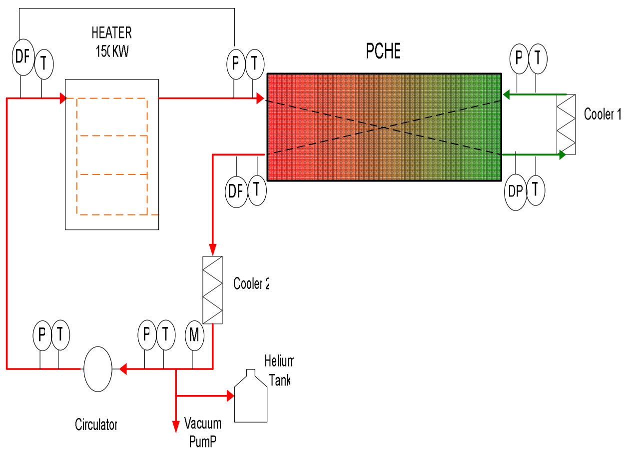

Figure 1. KAIST Helium test loop.

KAIST He test loop was described in figure 1. One of objectives is to perform thermal hydraulic test. Only hydraulic tests have been done so far. First a vacuum pump was operated to extract the natural gas in the test loop. Then, helium gas was put into the loop in front of a circulator. Hydraulic experiments were done in the laminar region with Re<1500. The condition was 13-18bar and 20-25℃. The pressure was measured using the pressure transmitter with an accuracy of ±0.1%. The differential pressure gauge has an accuracy of ±0.2% over the full of range of 100kpa. The temperature was measured using K-type thermocouples with an accuracy of ±1.5℃. The mass flow rate range was 40kg/h -130kg/h with ±1% accuracy of over full scale of 13-130m3/h. Fanning factor in PCHE was calculated by (2.1) measuring pressure and temperature before and after the PCHE..

$$f_{hot} = \frac{\Delta P_{hot} D_h \bar{\rho}_{hot}}{2 G_{hot}^{\ 2} L_{hot}} \qquad (2.1)$$

2.2 PCHE

A PCHE is a compact heat exchanger with high effectiveness and structural integrity due to the chemical etching and diffusion bonding process. The KAIST PCHE was from Heatric, U.K. The core dimensions are 150mm×896mm×144mm. The dry mass is 146kg. The specification of the PCHE is described in table 1.

	Channel		Hydraulic	Area	
	Number	Diameter (mm)	Diameter (mm)	Heat transfer	Free flow m²
Hot	1280	1.51	0.922	3.80m²	0.001155
Cold	1280	1.51	0.922	3.80m²	0.001155

Table 1. Specification of PCHE.

2.3 Results

Pressure drops in the PCHE consist of friction loss and form loss, while a straight pipe has only friction loss. Fanning factors in the PCHE were higher than those in the semi-circular straight pipe (Figure 2).

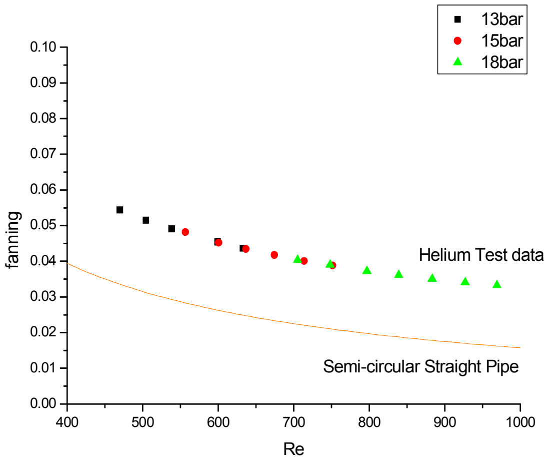

Figure 2. Fanning factors in the PCHE and semi-circular straight pipe.

The parameter of fanning factor x Re had linearity (Figure 3) to Reynolds number with 450<Re<1100.

$$f_{fanning} \cdot \mathrm{Re} = 19.94 + 0.34 \cdot \mathrm{Re} \qquad (2.2)$$

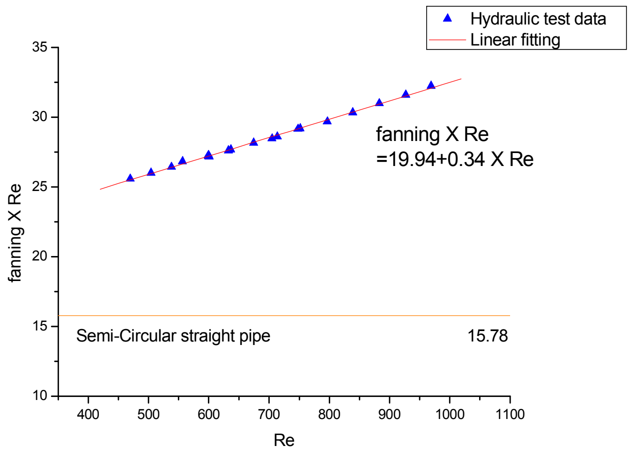

Figure 3. Fanning x Re in terms of Re in the PCHE and semi-circular pipe

The air test loop was designed (Song et al, 2005). Both fanning factors in helium test and air test using the KAIST PCHE had similar linear dependency on Re with an increase in Reynolds number (Figure 4).

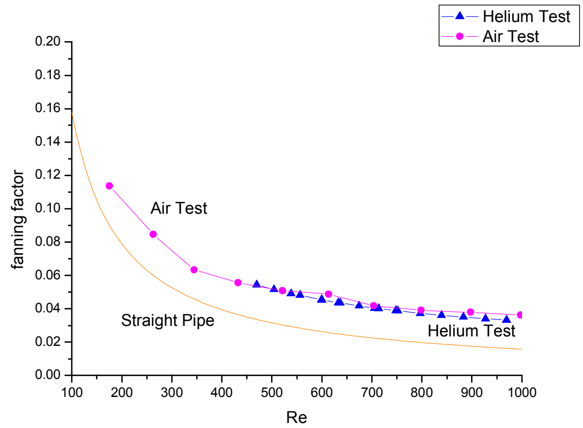

Figure 4. Fanning factors in terms of Re in helium test and air test using the KAIST PCHE

3. Conclusion

The Fanning factors in the PCHE are higher than those in a semi-circular straight pipe. They had a linear dependency on Reynolds number. The He thermal tests will be done to measure the heat transfer coefficient in the PCHE.

REFERENCES

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