EVALUATION OF THE THERMAL RESISTANCE OF CT-SLHX BASED ON MATERIAL TYPE

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ABSTRACT

Household refrigerators are equipped with components that facilitate heat exchange between the capillary tube and suction line, incorporating a non-insulated capillary tube to enhance reliability and efficiency. This configuration is referred to as a Capillary Tube-Suction Line Heat Exchanger (CT-SLHX). In this study, experiments were conducted to evaluate the heat transfer performance of a CT-SLHX with an existing copper suction line and a type using alternative materials to reduce component cost. Subsequently, a comparative analysis of thermal resistance performance for each sample will be conducted based on the experimental results.

KEY WORDS

CT(Capillary tube), SL(suction line), Water mass flow rate, closed-loop system.

1. INTRODUCTION

Recently, extensive research has been conducted to improve the thermodynamic efficiency of CT-SLHX through various modifications to the conventional design. Joel et al.[1] analyzed the thermal performance of CT-SLHX in terms of temperature effectiveness across various geometric configurations. Yang et al. [2] also carried out the experimental and numerical investigations on different lateral CT-SLHX. In this study, experimental analysis is conducted with a focus on the material of the CT-SLHX, comparing the conventional copper configuration to a sample utilizing alternative materials to address global copper price fluctuations.

2. EXPERIMENTS

2.1 Experimental apparatus

Fig. 1 presents a schematic diagram of the experimental apparatus developed in this study. The experimental apparatus was established as a closed-loop system using water as the working fluid. The experimental setup comprises a constant temperature water bath to provide a stable heat source on both the hot and cold sides, two brazed plate heat exchangers to regulate the feed water temperature at the CT and SL inlets, and two pumps to manage the high-pressure drop across the capillary tube. The test section was encased in insulation to eliminate the impact from ambient temperature fluctuations. RTD sensors were installed to obtain accurate measurements of the CT-SLHX inlet and outlet temperatures, while thermocouples were installed to monitor the internal temperature of the test section and the surrounding ambient temperature. Additionally, adhesive thermocouples were installed to measure the temperature at the junction between the capillary tube and the suction line. Pressure transducer was installed to measure the water pressure. The uncertainty of the measuring instruments is provided in Table 1.

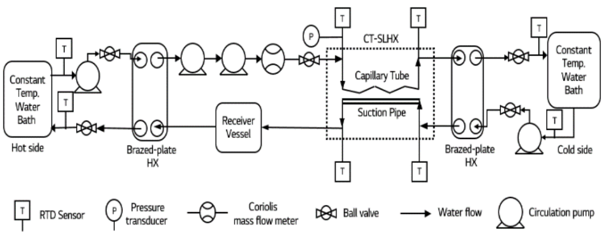

Fig. 1: Schematic diagram of experimental apparatus.

Table 1: Uncertainty of the measuring instruments

Measuring instruments	Uncertainty
RTD sensor	± 0.05 K
Thermocouple (T-type)	± 0.1 K
Pressure transducer	±0.25% of reading
Coriolis mass flow meter	± 0.5% of reading

2.2 Test section and samples

Test two CT-SLHX samples that are geometrically identical but distinct only in the suction pipe material. Sample 1 employs copper, the material commonly used in conventional non-insulated capillary tubes, while Sample 2 utilizes aluminum. The geometric specifications of the samples are presented in Table 2.

Table 2: Geometric specifications of the samples

Content	Sample-1	Sample-2
Material(CT/SL)	Cu/Cu	Cu/Al
CT length	2765mm	
SL length	2000mm	
Heat exchange length	1795mm	

2.3 Experimental operating conditions

To keep the working fluid in a single-phase state, the CT inlet temperature is set the range of 40-80 °C, and the SL inlet temperature is set the range of 10-

30 °C. The mass flow rate is varied, with the mass flow rates of the capillary tube and suction line maintained at equal levels. The experimental conditions are presented in Table 3.

Table 3: Experimental operating conditions

Operating parameter	Value
CT inlet temperature	60 °C
SL inlet temperature	20 °C
Ambient temperature	20 °C
Water mass flow rate	1.5 g/s

3. RESULTS AND DISCUSSION

Data are obtained for the CT outlet temperature and SL outlet temperature. The thermal resistance at the junction is experimentally determined using the modified Wilson plot method. [3] The single-phase convective heat transfer coefficient(h) of the working fluid is calculated based on the Dittus-Boelter correlation (1) and is expressed as a linear function of the mass flow rate.

$$\frac{hD}{k} = Nu_D = 0.023Re^{0.8}Pr^n \qquad (1)$$

By performing regression analysis within the attainable mass flow rate range, the slope and intercept of the linear equation are derived, where the intercept represents the thermal resistance. Through this methodology, the conductive thermal resistance of each sample will be obtained and evaluated experimentally.

REFERENCES

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