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Heat Transfer Experiment in a Three Fluids System with a Separator for the IHTS Simplification in a LMR

Jong-Hyeun Choi, Kyeong-Chae Jeong, Byoung-Hae Choi, Byung-Ho Kim
Korea Atomic Researcher Institute
E-mail: jhchoi2@kaeri.re.kr

1. Introduction

A concept of a IHTS simplification was proposed for a reduction of the installation cost and improvement of the safety by a integration or elimination of the intermediate system between the primary system and the steam generator from the present loop type reactor as shown in Figure 1 [1]. This IHTS simplification experiment is to verify the computer model.

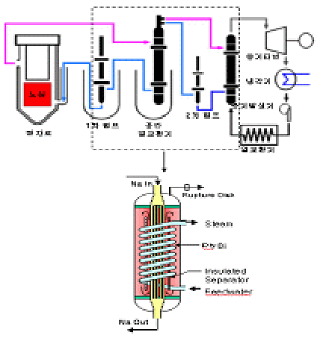
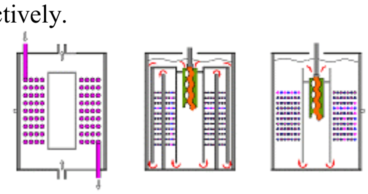


Figure 1. The concept DWG of the IHTS simplification.

2. Experiment

Figure 2 shows the several types of test sections for the heat transfer experiment. T-1,2 is the test section for the two fluids system producing a convective heat transfer coefficient which is needed to analyze the performance of the three fluids system. T-3,4 and 5 are the test sections for the three fluids system to analyze the geometrical effects on the heat transfer producing the data for verifying the computer model. This paper describes the T-4 test for a three fluids system with a cylindrical separator between the hot and cold fluid tubes. The temperature is 165°C for a high-temperature fluid, 160°C for intermediate-, and 75°C for low-temperature fluid. The flow rate is 0.01~0.22, 0.2~5.0 and 0.01~0.22 for a high-temperature fluid, intermediate-, and low- temperature fluid, respectively.



T-1,2 T-3,4 T-5

Exp.		1st tube water	Shell wood	2nd tube water	hot /cold	Flow Sep.	Remark
2-fluid	T.1	O	O	X	-	No	Heat transfer coefficient
	T.2	X	O	O	-	No	
3-fluid	T.3	O	O	O	Mixed	Yes	Geometry effect
	T.4	O	O	O	Sep.	Yes	
	T.5	O	O	O	Mixed	No	

Figure 2. The shapes of the heat transfer test sections and the experimental types.

3. Result and Discussion

The properties of the Wood's alloy used as a intermediate medium, is shown in the Table. 1.

Table 1. The properties of the Wood's alloy

Temperature (°C)	90	120	150	160	180
Specific heat (J/g.K)	0.261	0.167	0.158	-	0.150
Thermal conductivity (W/m.K)	2.95	2.00	4.06	-	4.15
Density (kg/m^3)	9.51	9.50	9.53	-	9.51
Viscosity (cO)	7.0	5.1	5.0	5.1	-

The heat transfer through the tube wall is defined as

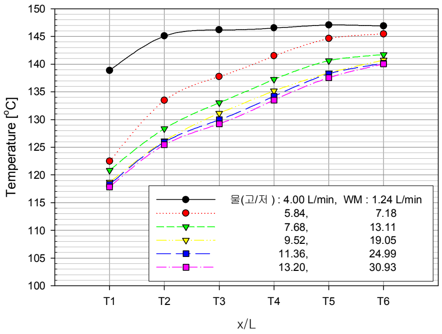
$$\Delta Q = U \Delta A_o \Delta T_o \quad (1)$$

Where ΔT_o denotes the average temperature difference and the heat transfer area is given by $\Delta A_o = \pi d_o \Delta L$. The overall heat transfer coefficient based on the outside diameter of the tube is rearranged in the form of

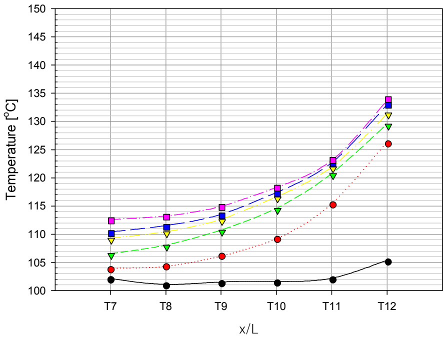
$$U = \frac{1}{\left(\frac{1}{h_s} + \frac{1}{h_{Fs}} + \frac{d_o}{2k}\ln\frac{d_o}{d_i} + \frac{d_o}{d_i}\frac{1}{h_{Fw}} + \frac{d_o}{d_i}\frac{1}{f_w}\right)} \quad (2)$$

In this test section, a high- and low-temperature water flow in the tube side inside and outside of the separator, respectively, and the intermediate-temperature Wood's alloy flows in the shell side. The high-temperature water flows from the top(T6) to the bottom(T1) of the test section, and the cold-temperature water flows in reverse.

Figure 3 shows the axial temperature profile inside and outside of the separator in the test section for verifying the flow rate of the three fluids. In this test, the high- and low-temperature water flow at the same rate. As shown in Figure 3(a), inside the separator, the temperature increased from the bottom to the top and at the lower flow rate. The temperature profile outside of the separator, as shown in Figure 3(b), was on the contrary for the inside.



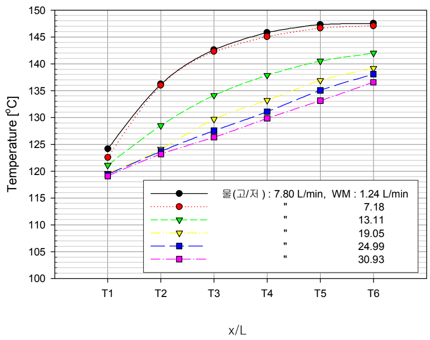
(a)



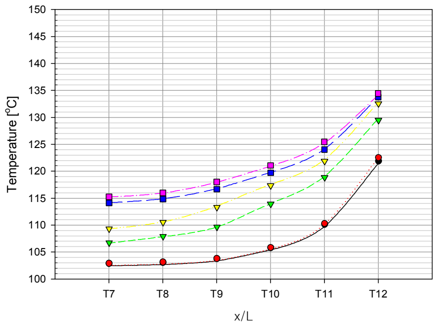
(b)

Figure 3. Axial temperature profile in the test section verifying the flow rate of the hot and cold fluid at a same rate and verifying the intermediate fluid : (a) inside of the separator, (b) outside of the separator.

Figure 4 shows the axial temperature profile inside and outside of the separator in the test section for verifying only the flow rate of the intermediate-temperature Wood's alloy and keeping the flow rate of the high- and low-temperature water at a fixed rate. In comparison with the Figure 3, the tendency of the temperature was similar except the case of the lowest flow rate.



(a)



(b)

Figure 4. Axial temperature profile in the test section verifying the flow rate of the intermediate fluid and keeping the flow rate of the hot and cold fluid at a fixed rate : (a) inside of the separator, (b) outside of the separator.

In addition to these two tests, two more tests with a variation of the flow rate were performed in the same test facility.

4. Conclusion

The physical properties of the Wood's alloy used as a intermediate medium was measured. For the IHTS simplification we performed two kinds of experiments with two fluids and three kinds of experiments with three fluids and a different geometry. The test results described here are a part of these experiments. The temperature decreases according to the length of the tube, and the heat transfer effect decreases according to the water flow rate in the three fluids system, and when the water flow rate increases, the temperature of the internal tube has a rising tendency while the temperature of the external tube is dropping.

Acknowledgement

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REFERENCES

[1] Y. S. Sim, "Experimental Requirement for the IHX/SG Simplification Concept", LMR/FS 100-XR-01, 2003