Basic Experiments on IHTS Simplification in LMR Heat Transfer System

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1. Introduction

LMR(Liquid Metal Reactor) has a IHTS(Intermediate Heat Transfer System) for heat transfer. Although the reactor core is safe, the effects of a sodium-water reaction by tube leaks in such a system is a prime problem to be solved. A concept of IHTS simplification was proposed for the reduction of installation cost and the improvement of safety by integration or elimination of the intermediate system between the primary system and the steam generator from the present loop type reactor as shown in Fig. 1 [1].

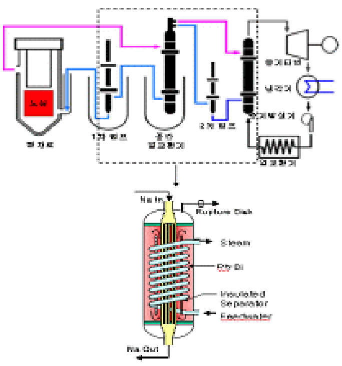


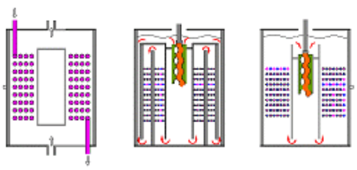
Figure 1. The concept DWG of the IHTS simplification.

2. Experiment

This IHTS simplification experiment is to verify the computer model. It is based on the concept of generating the steam by heating water using some other intermediate medium which is heat transferred by the high temperature primary sodium.

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 convective heat transfer coefficient which is needed to analyze the performance of the three fluids system. T-3,4 and 4 are the test sections for the three fluids system producing data for verifying the computer model. Each test section is a heat exchanger having helical coils. The size of the tubes is 6mm and the number of the tubes is 19 and 42~45, for two fluids and three, respectively, and the height of the tube bundle is 0.20m. The inside diameter of the shell is 0.178 and 0.298m, respectively.

The temperature is 165°C for high-temp. fluids, 160°C for intermediate-, and 75°C for low-. The flow rate is variable according to the experiment. In case of the experiment in the plural regional type of test section with three fluids, the flow rate is 0.014~0.28, 0.01~0.2 and 0.014~0.28 for high-temp. fluids, intermediate-, and low-, respectively.



Exp.		1st tube (water)	Shell (wood)	2nd tube (water)	hot /cold	Flow Sep.	Remark
2-fluid	T.1	O	O	×	-	No	Heat transfer coefficient
	T.2	×	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 experiment with two fluids is to produce convective heat transfer coefficient which is needed to analyze the performance of the three fluids system.

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 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

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

The temperature profile in the verifying conditions in the two fluids system is shown in Figure 3. The temperature of water and Wood's alloy is 150°C and 110 °C, respectively. The flow rate of the water was varied from 4.86 to 17 l/min keeping the flow rate of the Wood's alloy constant. It was estimated that the temperature decreases according to the length of the tube, and the heat transfer effect decreases according to the water flow rate.

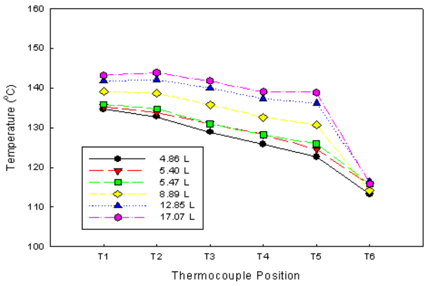


Figure 3. Temperature profile in the two fluids system.

The experiment with three fluids is to analyze the geometrical effects on the heat transfer. Fig. 4 and 5 shows the temperature profile in the test section verifying

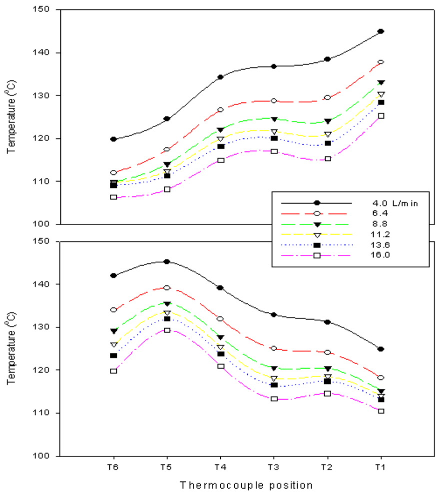


Figure 4. Temperature profile vs. flow rate of the high temperature fluid in the test section..

the flow rate of the high-temperature water and intermediate-temperature Wood's alloy keeping the flow rate of the low-temperature water constant. The test section is separated into two parts with a separation cylinder.

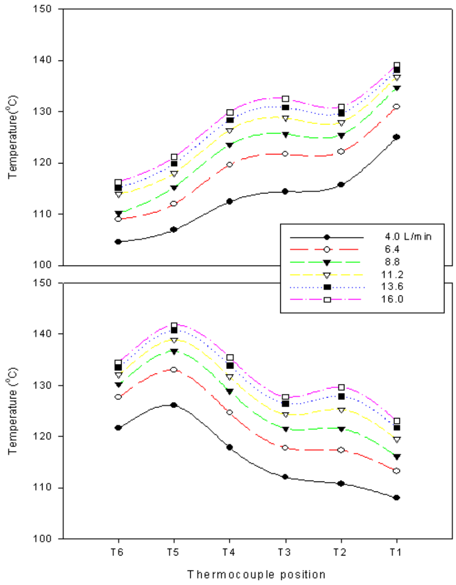


Figure 5. Temperature profile vs. flow rate of the low temperature fluid in the test section..

As shown in Fig. 4 and 5, the two experiment has similar curve. When the water flow rate increases, the temperature of the internal tube has a rising tendency while the temperature of the external tube dropping.

4. Conclusion

The physical properties of the Wood's alloy used as a intermediate medium was measured. For the IHTS simplification we have a plan to perform two kinds of experiment with two fluids and three kinds with three fluids. The test results described here is a part of that. The temperature decreases according to the length of the tube, and the heat transfer effect decreases according to the water flow rate in the two 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 dropping

REFERENCES

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

Acknowledgement

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