§4. Design Study on Flibe Non-isothermal Forced Convection Loop

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For the development of fusion reactor with liquid LiF-BeF_2 (Flibe) blanket system[1], compatibility of structural materials with liquid Flibe is one of the critical issues. The corrosion characteristics of the structural materials are influenced by temperature, impurity concentration, shear stress worked on the surfaces, mass transfer and electro-chemical conditions. Therefore, design study on Flibe non-isothermal forced convection loop, in which above- mentioned condition can be controlled, was performed.

The schematic of loop and the bird's eye view are shown in Figs. 1 and 2, respectively. The loop consists of expansion tank, mechanical pomp, heater, test section, cooler, flow meter and damp tank. The inventory of the loop correlates with the temperature difference in loop and flow rate. These are summarized in Table 1. The loop with the inventory more than 100L is out of scope because the acquirable amount of BeF_2 is limited.

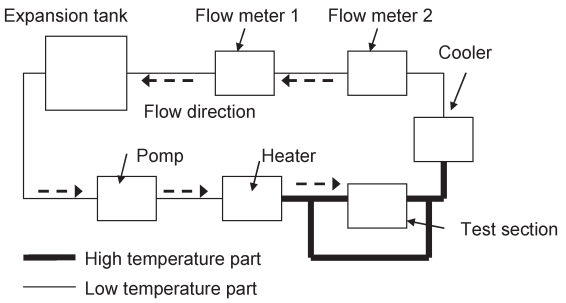

Fig. 1 Schematic of Flibe non-isothermal forced convection loop

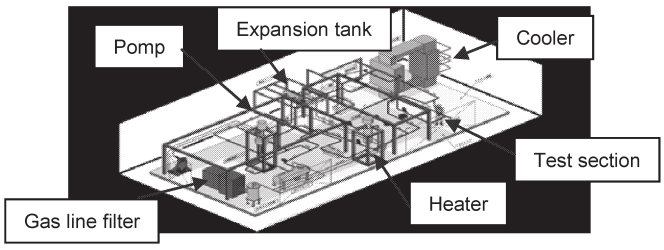

Fig. 2 Bird's eye view of loop

In the operation at 600°C with the temperature difference of 30°C and flow rate of 40L/min, the temperature distribution is summarized in Table 2. The thermal stress of the loop pipe around test section was calculated as shown in Fig 3. These values were lower than the allowable stress when the loop is constructed by SS304 pipe.

The test section in the loop is shown in Fig. 4. The specimen holder which mounts plate type specimens is inserted. The Flibe flows in flow channels above and below the specimens. In this test section, pressure drop is estimated as 0.479MPa when the flow rate is 40L/min, and this occupies 84.3% of the total pressure drop. Flow rate and flow velocity can be changed due to the experimental purpose by the use of various type of specimen holder and the control of pomp power.

The design study on the loop was performed, and it was found that the construction of the loop with present-day technology is possible even though the improvement of heater and pomp is required.

Table 1 Correlation between loop inventory, temperature difference and flow rate Unit: L

Flow rate (L/min)	Temperature difference (°C)				
	10	20	30	40	50
10	77.4	84.1	91.5	96.2	101.2
15	81.9	91.6	99.2	107.8	115.2
20	84.9	97.1	107.9	117.9	128.0
30	95.6	107.7	128.3	146.8	163.2
40	145.8	171.1	192.6	-	-

Table 2 Temperature distribution in loop

	Inlet of expansion tank	Outlet of expansion tank	Inlet of pomp	Outlet of pomp
Flibe temperature (°C)	572.4	572.2	571.6	570.8

Inlet of heater	Outlet of heater	Inlet of test section	Outlet of test section	Inlet of cooler	Outlet of cooler
570.5	600.5	600	599.8	599.3	573.2

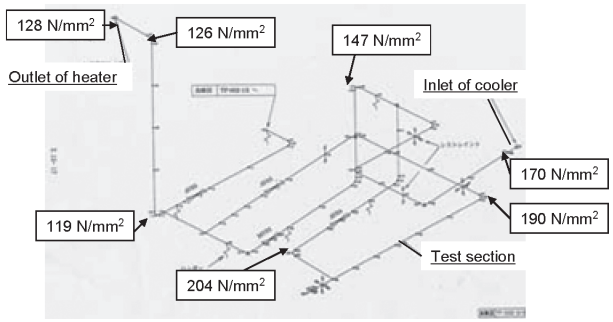

Fig. 3 Result of thermal stress evaluation around test section

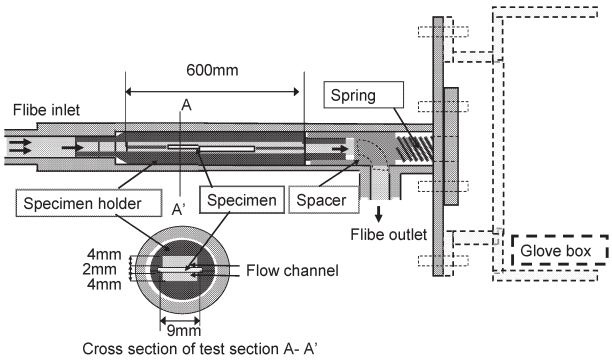

Fig. 4 Test section of the loop

Reference
1) Sagara, A., et al., Fusion Engineering and Design, **81** (2006) 2703