§9. Thermo-mechanical Evaluation for Flibe Test Blanket Module

Hashizume, H. (Tohoku Univ.),
Sagara, A.

In order to verify the possibility of Flibe blanket system, it becomes crucial to demonstrate the design of Flibe blanket not only for demo reactor but for the ITER system. The final goal of this study is to propose the Flibe blanket system satisfying allowable maximum temperature required for the structural material (550 °C) and show the way to the blanket system for demo reactor. Based on the above strategy, it was showed that there exists design window of Flibe blanket for the ITER by increasing the ratio of BeF_2 in Flibe to decrease the melting temperature of Flibe.

In the previous analysis, the following empirical correlation was used[1)],

$$Nu_D = C(f_w Re_w)^a (Pr)^b [\arctan\{(D/d) - 1 + \tan(1)\}]^c \quad (1)$$

(820<Re<33500, 5.1<Pr<31.8, 1.3<D/d<3.0)

where D and d are diameters of pipe and sphere, respectively, and f_w and Re_w are wall modified friction coefficient and wall modified Reynolds number, respectively. The coefficients in the equation are summarized in table 1

D/d	*C*	*a*	*b*	*c*
3.0, 2.0	0.5912	0.6443	0.3931	4.0466
2.2, 1.3	1.2648	0.6202	0.3931	-0.1598

Using the correlation, the following design was proposed as one of the candidates for the ITER;

<FLibe>
LiF: BeF_2 =55:45
Inlet temperature = 450 °C
(40 °C higher than melting temperature)
<Sphere-packed pipe>
pipe diameter, D =30mm
wall thickness 2 mm
sphere diameter, d= 23mm (D/d=1.3)
<Flow condition>
velocity = 1.0 m/sec
pressure drop =0.24 MPa/m

As shown in fig.1, however, heat transfer coefficient used in the analysis increases when BeF_2 ratio increases in case of v=2.0 m/sec. This is not correct since the increase in BeF_2 ratio leads to increase in the Pr number and therefore to degradation in the heat transfer coefficient. The discrepancy is caused by applying eq.(1) for larger Pr number over 100 or 200. In order to verify the validity of eq.(1) for large Pr number, heat transfer experiment was performed with using Silicon oil whose Pr number is 100. Fig.2 shows comparison of Nu number between experimental and predicted data. In the experiment, the temperature difference between inlet and outlet was controlled to be about 3 °C, 6 °C or 9 °C. Since the Nu number does not depend on the temperature change, the experimental data is reliable. The results indicate that the difference in the Nu number is about 20% in case of Re_D=1000, which leads to 10 °C increase in temperature in the thermal boundary layer. The final margin of the temperature above the melting temperature is evaluated to be about 30 °C. In order to increase the margin, the follow velocity should be increased with larger pressure drop.

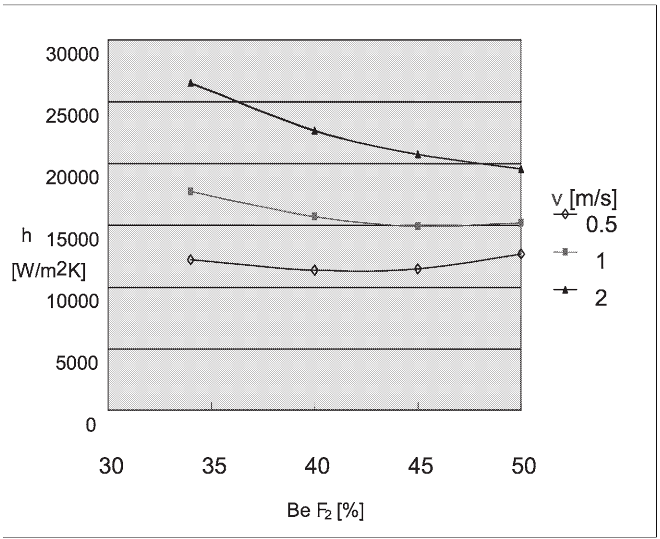

Fig.1 Heat transfer coefficient predicted by eq.(1)

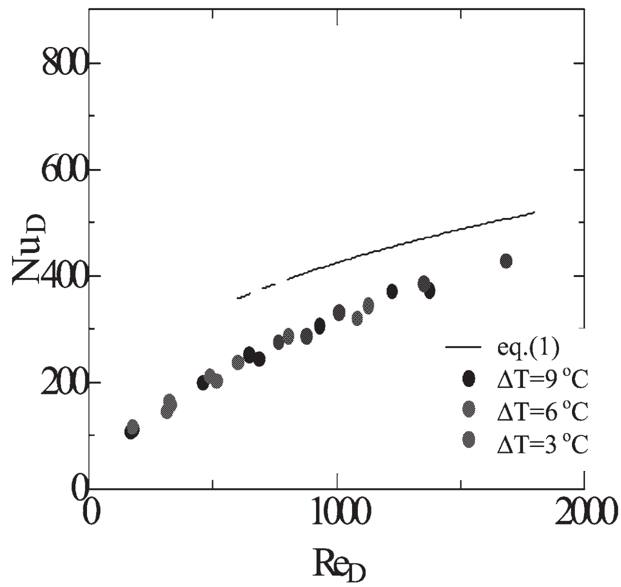

Fig.2 Comparison of Nu number between experimental and predicted data (Pr=100)

1) Feasibility Study for Flibe TBM based on Thermofluid Analysis , TOFE 18th, to be published