Effect of Heat Flux on the Specimen Temperature of an LBE Capsule

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1. Introduction

For application of high-temperature irradiation tests in the HANARO reactor for Gen IV reactor material development, a number of newly designed LBE capsules have been investigated at KAERI since 2008 [1-4]. Recent study on heat transfer experiment of an LBE capsule with a single heater [1] has shown that the specimen temperature of the mock-up increased linearly with an increase of heat input. The work highlighted only the heat transfer capability of an LBE capsule with a single heater as a simulated specimen in a liquid metal medium. Hence, a new LBE capsule with multi specimen sets has been designed and fabricated for the heat transfer experiment of an LBE capsule of 11M-01K.

In this paper, a series of thermal analyses and heat transfer experiments for a newly designed LBE capsule was implemented to study the effect of an increase in the value of heat input and its influence on temperature distribution in the capsule mock-up.

2. The design of an LBE Capsule

The overall shape of a new LBE capsule is quite similar to the previous LBE capsule [2-4] except for the number of specimen sets or heat fluxes per unit volume. The main body of the capsule, which is about 56mm in diameter, consists of 3 heaters of 7 kW each as a simulated specimen, LBE as a thermal media, an internal tube as an LBE container, and an external tube. Figure 1 shows the photography of a newly fabricated capsule mockup. The dimensions of the capsule are shown in Table 1.

Fig. 1. Newly fabricated capsule mockup

Table 1. Design Data of a New Capsule

Main body	External tube diameter/thickness(mm)	56/2
	Internal tube diameter/thickness(mm)	50/2
	Gap between external and internal tube(mm)	1
Heater	Outside diameter(mm)	19
	Power(kW)	7
	Hot length(cm)	60
Thermal media	LBE(44.5w/o Pb+55.5 w/o Bi)(kg)	5.4

3. Thermal Analysis

The temperature calculations for a newly designed capsule were performed using a finite element analysis program, ANSYS [5]. The analysis model for the circular cylinder of the double containment concept is generated by the coupled-field elements of PLANE223 with a 2-D structural-thermal field. Fig. 2 shows the two-dimensional analysis model for a new capsule with 3 heaters as a heat source. For this numerical study heating rates for the material specimens, the LBE, and the structural materials were not considered except for only the heat flux of a heater (27.5kW/m^3). The boundary conditions in the FE analysis are symmetrical for 0- and 120-degrees in the cylindrical coordinates. The heat transfer coefficient used in this study is 33.0 KW/m^2.C, which was evaluated from the heat transfer experiments [1], and the reactor coolant temperature is 40 ^oC.

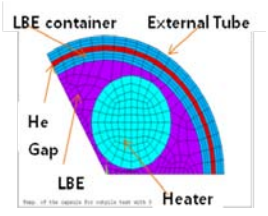

Fig. 2. Finite element model

Fig. 3 shows the effect of heat flux on specimen temperature of a newly designed capsule. As seen in the figure, the specimen temperature or maximum temperature

increased almost linearly with the heat input. In addition, although the heat flux per unit volume increased from 43.7 to 82.5 kW/m^3, the temperature increase rate was found to be lower than that of the previous 09M-01K capsule mockup. This trend is believed to be related to the good thermal properties of LBE [4] and the relative increase in the heat transfer area of multi-heat sources.

This result indicates that the new concept has the potential as a high temperature testing device and becomes more favorable for user's required tests.

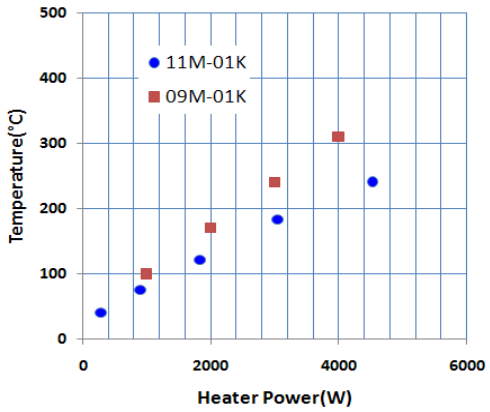

Fig. 3 Effect of heat input on specimen temperature of a newly designed capsule

4. Conclusions

A new concept of an LBE capsule with multi heat sources was proposed for the application of high temperature irradiation tests. The effects of heat input on specimen temperature are investigated. It was demonstrated that the concept has potential as a high temperature testing device and can provide a more favorable choice for high temperature tests.

ACKNOWLEDGEMENTS

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