# Heat Transfer Experiments for an LBE Capsule Development

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## 1. Introduction

A major advantage of a high-temperature irradiation capsule using an LBE as a thermal medium is expected to be its excellent performance at high temperatures [1]. In an effort to enable the required design and performance of an LBE capsule and to provide design recommendations for establishing the fabrication techniques for LBE capsule development, a capsule mock-up, which was designated as 09M-01K, was designed and manufactured [2]. Heat transfer experiments by using the capsule mock-up were also conducted to measure effective heat transport coefficients needed for heat transfer calculations in higher performance regimes.

This paper describes the heat transfer experiment and thermal analysis based on the experimental results using ANSYS code for the thermal characteristics of an LBE capsule mockup.

## 2. Heat Transfer Experiment

For the heat transfer experiments, a mockup capsule was fabricated. A heater, which was placed at the center as shown in Fig. 1, was used to simulate the expected heat source which will be presented during irradiation. The capsule mockup was instrumented with fourteen type K thermocouples at 3 different levels, as shown in Fig. 1, for monitoring and controlling the surface temperature of the heater's cladding(the specimen temperature), bulk temperature of an LBE, and the surface temperature of an internal tube (LBE container). The dimensions of the fabricated mockup are presented in the reference [2]. Fig. 1 is a photograph of the instrumented capsule's mockup that was used and shows the thermocouple locations installed in the test mockup.

The heat transfer experiments were performed at a single channel test loop using a full-scale mock-up of an LBE capsule. The gas mixing system of the I&C system (GSF-2002) was used to understand the effects of the gas mixing ratio and the heater power on the specimen temperature, as shown in Figure 2. The main test conditions are the mass flow rates of 50 cc/min of He/Ne gas, a gas pressure of 2 kg/cm$^2$, a heater power of 1 to 9.6 kW with 4 different mixing ratios of He to Ne gas.

From the test results as shown in Fig.3, it was found that the specimen temperature of the mockup increase linearly with an increase of the heater power, the regional temperature distribution of a mockup in the horizontal direction was relatively uniform, which can provide a more favorable environment for a high temperature test. This appears to match well with the expectation from the data calculated by ANSYS analysis [3].

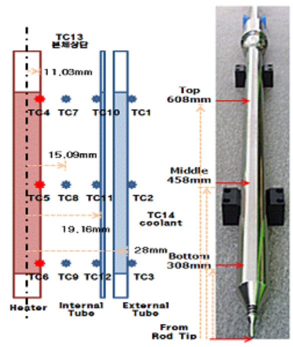


Fig. 1 Thermocouple locations of the Capsule's Mockup (09M-01K)

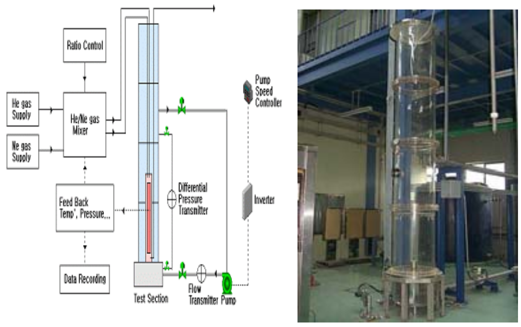


Fig. 2 Schematic diagram of a single channel test loop

Fig 3 shows the measured temperature difference between the inside of the internal tube and the coolant with an increasing of heater power up to 3kW at a constant He gas pressure of 2 kg/cm$^2$. The relationship is found to be almost linear. As the gap size between external and internal tube is 1mm, thus the contribution of radiation to $\mathbf{K_{eff}}$[4] is expected to be quite small. From the slope of the

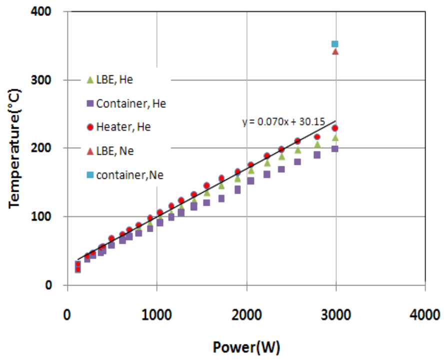


Fig. 3 Regional temperature with variation of heater power at 2 kg/cm$^2$ of He gas.

curve in Fig. 4, the effective thermal conductivity $K_{eff}$ was estimated around 22 kW/m.°C. Temperature distribution of each regions of the mockup is also almost equivalent to the previous data [3] calculated from the thermal analysis using ANSYS code [5].

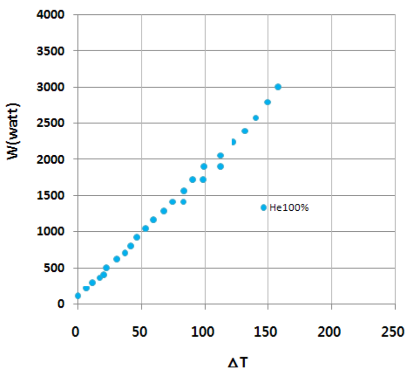


Fig. 4 Temperature difference between inside of the internal tube and the coolant with increasing a heater power up to 3kW at constant He gas pressure of 2 Kg/cm$^2$.

### 3. Conclusions

The heat transfer experiment with a full-scale mockup of an LBE capsule was performed in order to understand the thermal characteristics of an LBE capsule. From the test results, it was found that the specimen temperature of a mockup increased linearly with an increase of heat input and the regional temperature distribution of a mockup in the horizontal direction was relatively uniform, which can provide a more favorable environment for a high temperature test. The effective thermal conductivity $K_{eff}$ was also estimated around 22 KW/m.C at constant He gas pressure of 2 Kg/cm$^2$. This data will be also used directly for the safety evaluation of an LBE capsule.

**ACKNOWLEDGEMENTS**

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