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Measurement of the thermal conductivity on elevated compression load for Li_2TiO_3 pebble bed using laser flash method

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1. Introduction

The functional materials of the solid breeding blanket are mainly used in the form of pebble bed [1]. Since the pebble bed is continuously heated by the exothermic reaction of neutrons and lithium-6 during normal operation of the fusion reactor, compressive load will be applied to the pebble bed by the thermal expansion of itself pebbles. The compressive load will also affect the contact area between the pebbles. It is important to measure the effective thermal conductivity of the pebble bed, which affects the performance of the breeding blanket under fusion environment.

To measure the effective thermal conductivity of the pebble bed, laser flash method was used with the advantages such as high accuracy and repeatability with wide range of measurement, easy sample preparation and fast measurement time and absolute measurement technique [2]. However, the laser flash method using a disc-type standard sample is mainly applied to measure the thermal properties of bulk materials, it is necessary to develop a new sample holder for the pebble bed and to establish and verify the measurement technique [3].

This study focuses on investigating the effective thermal conductivity of Li_2TiO_3 pebble bed under compressive loading conditions applied at room temperature. Considering the compressive load, additional devices such as dial gauge, load transducer, and pressure indicator are installed in the conventional laser flash apparatus, and experiments are conducted under various load conditions using this device.

2. Experimental

2.1 Sample preparation

The average diameter of Li_2TiO_3 pebble is 1.1 mm. The weight of Li_2TiO_3 pebble bed is 3 g. The thickness of Li_2TiO_3 pebble bed was measured by instron universal testing machine. Cyclic compressed load up to 10 N is applied to the assembled sample holder in order to arrange the pebbles. After 10 cycles, the thickness of the pebble bed was saturated. At that time, the saturated thickness of the pebble bed was about 6.47 mm.

2.2 Compression Load device

The compression load device is shown in Fig.1. The compression load device was pressured up to 10 MPa maximum. The compression gas is air. The compression load stamp was specially designed and fabricated from graphite. The changed thickness of the Li_2TiO_3 pebble bed on compression load was measured by the dial gauge.

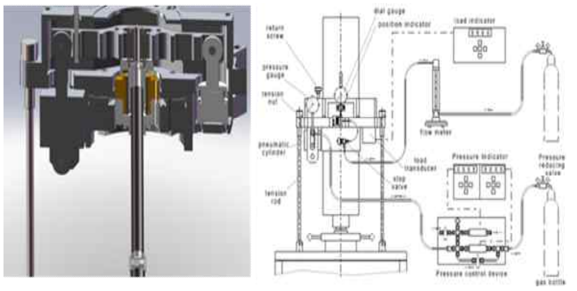

Fig.1 Compression load device

2.3 Measurement of thermal diffusivity

The thermal diffusivity of Li_2TiO_3 pebble bed on elevated compression load was measured by the laser flash method at room temperature. The atmosphere in the measuring chamber of the laser flash apparatus was flowing helium with ultra-high purity. The thermal diffusivity of Li_2TiO_3 pebble bed was calculated by 3-layers measurement technique. We know the thermal diffusivity of Layer 1 and Layer 3, calculate the heat diffusivity of Layer 2 from the measurement results, and calculate the thermal conductivity from these values. The Table I is shown in 3-layer method parameter.

Table I: Parameter of 3-layer method

	Layer 1	Layer 2	Layer 3
Material	Graphite	Li_2TiO_3 Pebble bed	Graphite
Thickness (mm)	1	6.47	1,
Thermal diffusivity (mm^2/s)	76.2	?	76.2
Diameter	18	18	18

3. Results and discussion

3.1 Verification of compression load device

The thickness of Li_2TiO_3 pebble bed on elevated compression load is shown in Fig 2. The Table II shows the comparison between dial gauge data and instron machine data. The two values are almost identical. The accuracy of dial gauge device is verified.

Table II: Thickness of Li_2TiO_3 pebble bed

	Compression load device (mm)	Instron universal testing machine (mm)
Initial value	6.47	6.47
Final value	6.37	6.31

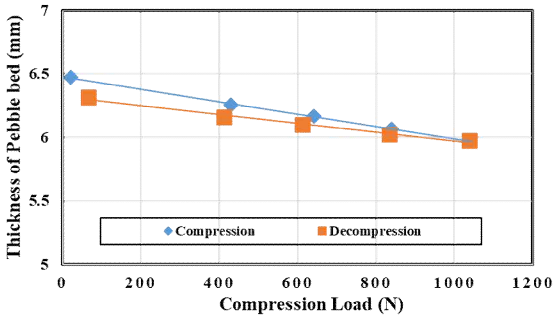

Fig.2 Thickness of Li_2TiO_3 pebble bed

3.2 Effective thermal conductivity of Li_2TiO_3 pebble bed

The Li_2TiO_3 pebble bed was tested at room temperature with various compression loads. The true density of Li_2TiO_3 pebble is 3.08 g/cm^3 [3]. The density of Li_2TiO_3 pebble bed was divided volume of pebble bed by weight of pebble bed. The weight of Li_2TiO_3 pebble bed is 3 g. The volume of Li_2TiO_3 pebble bed was calculated as inner sample holder area times thickness.

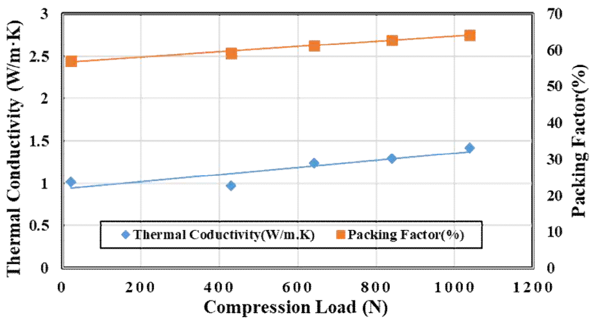

Fig.3 Thermal conductivity of Li_2TiO_3 pebble bed

The changed thickness of Li2TiO3 pebble bed on compression load was measured by dial gauge. So, the packing factor increases under compressive load condition from 57 % to 64 %. The effective thermal conductivity is increased by increasing packing factor. The result of effective thermal conductivity Li_2TiO_3 pebble bed is shown in Fig. 3.

3. Conclusions

The effective thermal conductivity of Li_2TiO_3 pebble bed under compressive loading conditions was successfully measured by the laser flash method. When the contact area between the pebbles increases under the compressive load condition, heat transfer is relatively improved, so the effective thermal conductivity of the pebble bed tends to increase. In the future, the thermal conductivity of the pebble bed will be measured with compressive load condition at several operational temperatures.

Acknowledgments

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