Measurement of the Thermal Diffusivity of UO_2 with Sample Holders for PIE in a Hot-Cell

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1. Introduction

Thermal conductivity of UO_2 is a important parameter from the view point of the stability of a fuel rod under reactor operation. The thermal conductivity consists of the thermal diffusivity, specific heat and density. Especially, the thermal diffusivity is dominant. Many researcher have carried out experiments to measure the thermal diffusivity of UO_2 by LFA(Laser Flash Apparatus).

Technical specifications for a sample holder have been discussed and tried to reduce the contact area between a holder and a sample. So, a 3-tip holder was designed and it is useful in a cold laboratory test.

But, in a hotcell or a glove-box, it is too difficult to load a sample on a 3-tip holder not by hand but by a manipulator. In this study, we used a simple holder which is convenient to load a sample. It has a larger sample contact area at the periphery of a sample than the 3-tip holder. We compared the diffusivities of UO_2 with the 3-tip holder and a simple holder, respectively.

2. Experimental

2.1 Apparatus

LFA consists of a laser generator, furnace, IR detector (In-Sb semi-conductor) and a controller. It set up at cold lab. in IMEF temporarily but it will be installed in glove-box. Resonance material for laser is Nd:YAG. The laser capability is 1.064 μm of wavelength and 40 J of a pulse energy[1]. The furnace can be raised upto 2,000 ℃.

Fig. 1 LFA in IMEF

2.2 Sample preparation and holder

Sample was made by UO_2 which had 8.26 mm of a diameter and 1.973 mm of a thickness as well as 95% TD. The holders were made by high pure alumina and aperture caps were one SiC and two alumina.

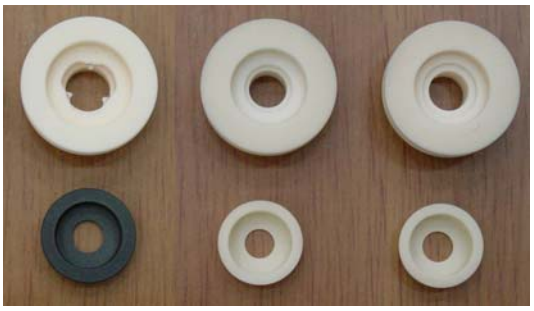

Fig. 2 Sample holders (left : 3-tip holder, middle and right : simple holders)

In the case of the 3-tip holder, a sample was contacted only at the tips but in other cases of the simple holders, the periphery of a sample was contacted with the hole of the holders. Diameters of the holes were 7.5 mm(middle) and 8 mm(right), respectively.

2.3 Procedure and measurement

The holder with a sample was loaded to a furnace and heated upto 1,200℃ with argon atmosphere. Thermal diffusivities were measured three times at every step of 100℃. A laser voltage and a pulse time was 450 V and 0.6 ms, respectively. Applied model was a Cape and Lehman model[2]. Same sample with 3 different holders was measured to obtain the holder effect on the thermal diffusivity.

3. Results

Fig.3 shows the data of UO_2(P-1,P-2,P-3,P-4,P-5) from Ref.3 and the data with the 3-tip holder in this study is also shown in the figure. 3-tip holder was designed to reduce the heat loss of a sample. So its data agreed with published data.

Sim-1 and Sim-2 in fig.4 are 7.5 mm and 8 mm of a hole size in the simple holders. At a low temperature, the difference in the diffusivity is higher than that at a high temperature. 14% of a difference occurred

between the 3-tip and Sim-2 at 100℃, which was decreased as the temperature was increased. Data of Sim-1 were lowest at all temperatures even 60% of a difference with the 3-tip holder was shown at 100 ℃.

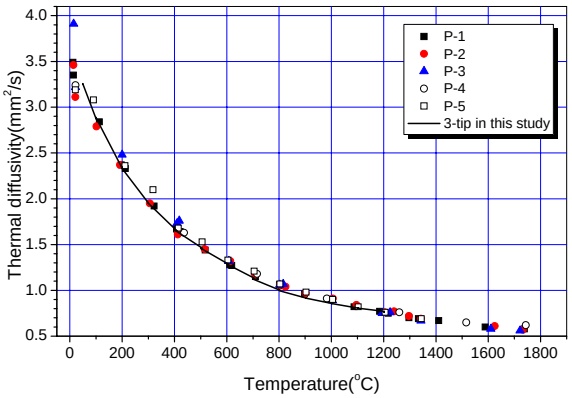

Fig. 3 Thermal diffusivities of UO_2

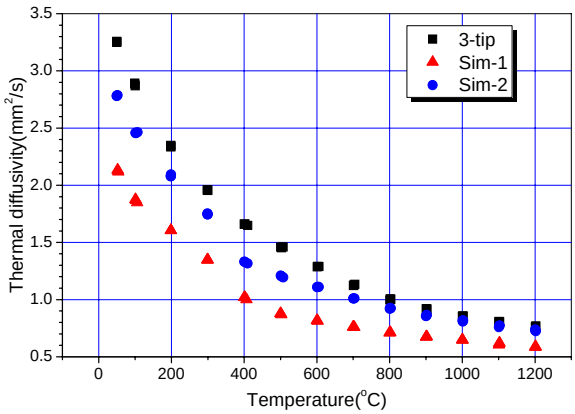

Fig. 4 Thermal diffusivities with holders

4. Conclusion

Thermal diffusivity of UO_2 with the 3-tip holder showed good results when compared to other data. But, the thermal diffusivities with the three holders showed a large difference at a low temperature. With a increase in the temperature, the difference was decreased gradually. When we measure the diffusivity of a fuel sample, a holder such as Sim-1 may be useful due to easily handle it in a grove-box. But, this holder showed under estimations.

Upper window on the furnace, which is the IR detection path, was contaminated after the experiment by a evaporation of UO_2 then, we assumed experiments of Sim-1 and Sim-2 would be carried out with an abnormal IR detection.

Anyway, if the IR detection was normal, we need to consider a calibration factor for the data of Sim-1. So, more analysis for the holder must be studied.

REFERENCES

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