Development of Measurement Technique for Thermal Diffusivity of Oxide Fuel in Hot-Laboratory

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1. Introduction

The thermal conductivity of irradiated fuels such as UO_2 is important factor to observe the fuel behavior under the reactor operation. It consists of the thermal diffusivity, the specific heat and the density. The first of them is more dominant factor. The measurement of the thermal diffusivity has been carried out but it is not clear in the case of the irradiated UO_2. Especially, the technique of measurement has not been known with a UO_2 pellet which is already cracked by irradiation in reactor. So far, a cracked piece of UO_2 pellet is chosen for measurement unlike the sample preparation in cold test.

In this study, measurement with the cracked piece was carried out and its data were compared to the reference data following the sample holder design.

2. Experimental

2.1 Apparatus

A laser flash method is well known for the thermal diffusivity measurement. The LFA(Laser Flash Apparatus) was installed in IMEF and tested before the measurement with irradiated fuels[1]. It consists of a furnace, a laser generator and an infrared detector. The furnace can be rasied up to 2,000 ^{o}C by the graphite heat source. The laser is generated by Nd:YAG with 1.064μm of wavelength and 40 J of pulse energy. The crystal of IR detector is In-Sb. The LFA in IMEF can be operated in the gas flowing state not the vacuum state.

2.2 Sample preparations

The fuel samples were made with the fresh UO_2 and the SIMFUEL. Both of them were natural enrichment and 97%~98% of the theoretical density. The sample shape was disk(8mm of dia. And 2 mm of thick.) and piece types as shown in Fig. 1 and Fig. 2 as well as the UO_2 disk samples with different thickness with 1 mm, 2 mm, 3 mm and 4 mm as shown in Fig. 3.

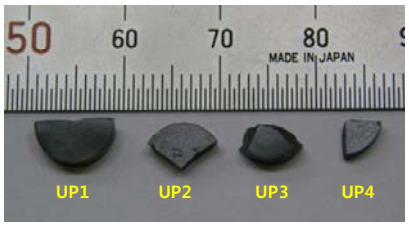

Fig. 1 The 4 piece samples of UO_2

Fig. 2 The piece samples of SIMFUEL

Fig. 3 4 UO_2 samples with different thickness

2.3 Sample holder design

The sample holder was designed with considerations as follows;

- Easy loading and handling sample with tools in hot laboratory.
- A piece of UO_2 pellet as sample would be cracked and dropped under the measurement.

The sapphire tray was applied in new holder as shown in Fig. 4[2].

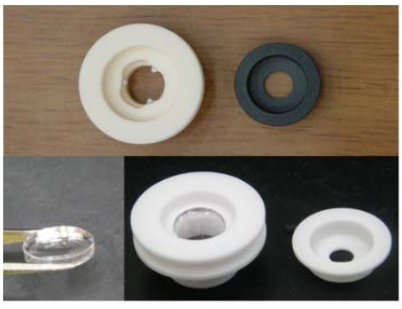

Fig. 4 A standard holder(top) and the new holder with the sapphire tray(bottom)

3. Results

Before the measurement for the fuel samples, the atmosphere of LFA in IMEF must be verified by comparison with reference data in vacuum state[3]. Fig. 5 shows the data were coincident in all temperature ranges with ignorance of theoretical density.

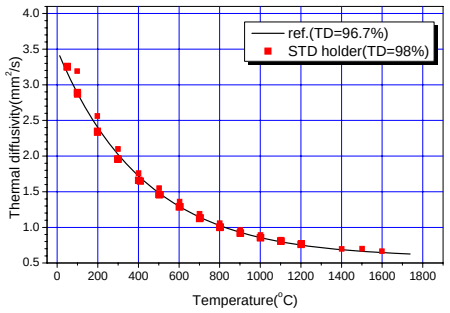

Fig. 5 Comparison between atmosphere in current system and vacuum state(UO_2 disk sample with standard holder)

The data difference between standard holder and new holder were shown in Fig. 6. At the lower temperature, the data showed 15% of difference but at high temperature, both data were coincident.

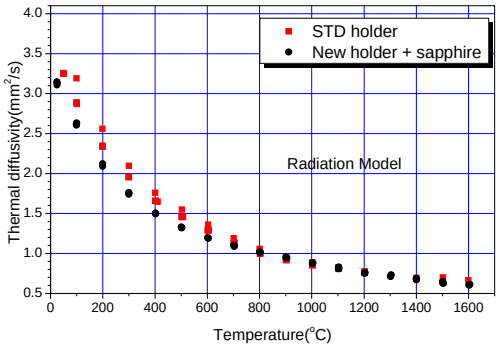

Fig. 6 The data with the new holder and the standard holder (UO_2 disk sample)

In the case of the thickness effect, the data of 4 samples were shown in Fig. 7. It seems that the thicker sample showed much more difference.

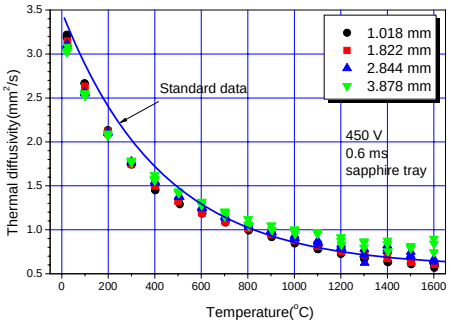

Fig. 7 The data of the different thickness of UO_2 disk samples

In the case of the UO_2 piece samples, the data agreed with the disk data with a new holder as shown in Fig. 8.

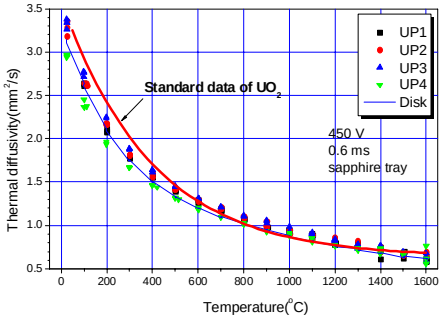

Fig. 8 The data of UO_2 piece samples

In the case of the SIMFUEL piece samples, the data were lower than the data of disk samples(SS1, SS2,SS3) and the data of SP3(high additives) were lower than other data due to burnup effect.

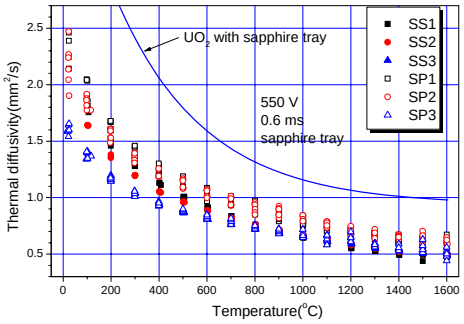

Fig. 9 the data of SIMFUEL samples(disk and piece)

4. Conclusions

The thermal diffusivity measurement for irradiated UO_2 fuels must be developed due to the sample treatment and the drop accident under test. The new sample holder with sapphire tray was designed. The data between holders were a little different at low temperature but were coincident above 800 °C. The data between disk and piece samples showed a good agreement in UO_2 test, while the data of SIMFUEL showed the difference.

REFERENCES

[1] LFA-427 Manual, NETZSCH, Germany.
[2] Expert advice for the sapphire tray, ITU, Germany
[3] Mutsumi Hirai,"Thermal diffusivity of UO_2-Gd_2O_3 pellets",J.Nucl.Mater.,**173**, 247p.(1990).