Instrumentation Irradiation Test of Dry Process Fuel in HANARO

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1. Introduction

Dry process fuel is fabricated without any separation of isotopes except volatile material from the spent PWR fuel. All fabrication processes are achieved in hot cell by a remote manner. Most of the irradiation tests of the dry process fuels have been carried out in the non-instrumented test rig in HANARO reactor [1,2]. Recently, the instrumented irradiation rig for the dry process fuel has been developed and designed. Using the present invented rig, the 5th irradiation test of the dry process fuel was performed in HANARO reactor and this paper described the instrumented rig and measured data of the dry process fuel.

2. Instrumentation Rig

The non-instrumented rigs have been used for most of irradiation tests of dry process fuel. Even if one of the test rigs has been designed as the semi-instrumented rig which was attached SPND sensor, it was not enough to evaluate the performance of the dry process fuel. Recently, the instrumented rig has been developed and performed irradiation test in HANARO.

2.1. Development of Instrumented Rig

Fig.1 shows the design of instrumented Rig. The total length of Rig is 1,060mm and 6 sensors are established in the rig; 3 thermocouples for measurement of pellet center temperature, 2 thermocouples for measurement of coolant inlet and outlet temperature and 1 SPND for thermal neutron flux measurement. And those 6 sensors are connected to the extension cable by remote connector.

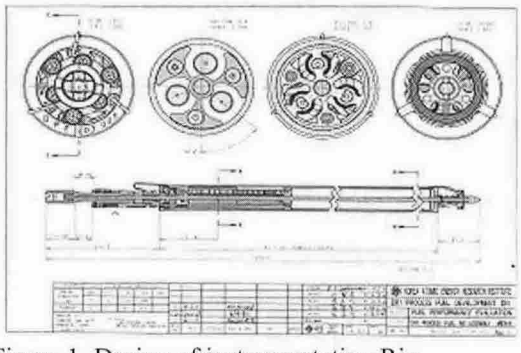

Figure 1. Design of instrumentation Rig

2.2. Mini-element of Instrumented Rig

Fig.2 shows the design of mini-element. The thermocouple for the measurement of pellet centerline temperature is set up in the center hole of the 3rd pellet. Pellet was drilled to ϕ1.2mm using drilling machine. During setting up the thermocouple, the seal is most important. Sealing method was adapted with Halden design method. C-type thermocouple was welded with seal tube and assembled with swage lock's method. Assembled mini-element was carried out with He-leak test.

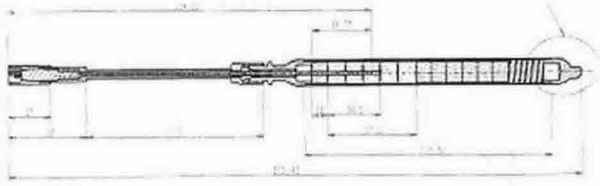

Figure 2. Design of mini-element

3. Measurement Data of Irradiation Test

Two thermocouples were installed in the center hole of dry process pellets but not installed in UO_2 pellet. The irradiation test performed in HANARO OR5 hole.

3.1. Measurement Data

The 6 sensors were connected to Data Acquisition System and the measured data were monitored at every 10 second. Fig.3 shows the measured center temperatures of Rod1 and Rod2 during the irradiation. The irradiation period was 75 days from Feb. 2004 to April 2004 and average burn-up is 2,133 MWd/tHM.

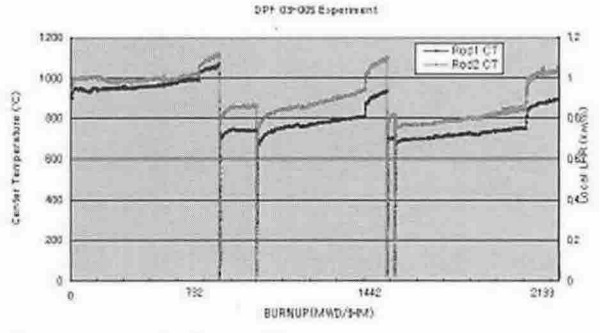

Figure 3. Trend of centerline temperature

The HANARO reactor is operating 18 days normal operation and 10 days shutdown. Total 3 operating cycles (30-1 cycle, 30-2 cycle, 31-1 cycle) was conducted during the present irradiation period. Although the normal operating power of HANARO reactor is 24MW, the operating power was increased by

1MW step up to 27MW during the present irradiation period.

3.2. Analysis of Measurement Data

- Centerline temperature at 30-1 cycle

As shown in Fig.3, the temperature difference between Rod1 and Rod2 is about 50 °C because Rod2 was located near CT hole. At the end of 30-1 cycle, the increasing temperature of 40 °C is caused by 1MW increase of the reactor power. The maximum temperature of Rod2 was measured by 1,110 °C at the end of the first cycle.

- Centerline temperature at 30-2 cycle

There was temperature difference about 150 °C between 30-1 cycle and 30-2 cycle under the normal operating condition. It may be noted that the pellet crack was formed by thermal shock of pellet during power shutdown and startup.

- Centerline temperature at 31-1 cycle

The center temperature difference between 30-2 cycle and 31-1 cycle was measured by 120 °C. It may also be caused by a sudden power change as the previous cycles. The temperature increase rate during cycle 31-1 cycle is lower than that during 30-2 cycle. And the measured temperatures of Rod1 and Rod2 were 890 °C and 1,030 °C at the end operation, respectively.

Figs. 4 and 5 show the centerline temperatures vs. linear element powers of Rod1 and Rod2. As shown in Fig. 4, its linearity is being kept and temperature difference is big between 30-1 cycle and 30-2 cycle. But The temperature dependency on Rod2 power for each cycle is not clear and temperature difference is small as shown in Fig. 5.

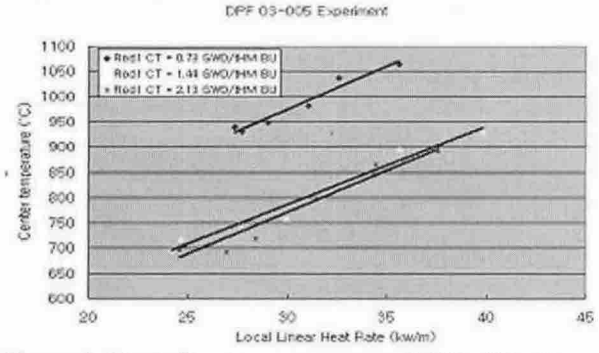

Figure 4. Centerline temperature vs. LLHR of Rod1

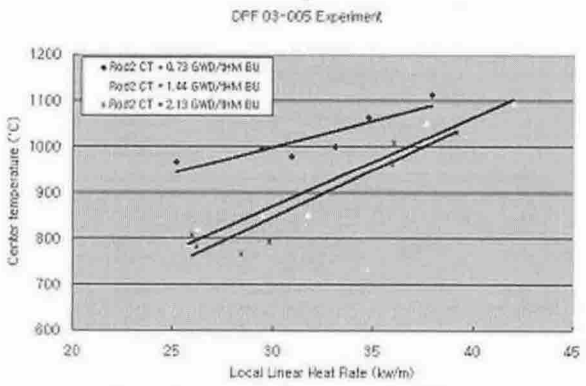

Figure 5. Centerline temperature vs. LLHR of Rod2

4. Conclusion

The irradiation test of dry process fuel using an instrumented rig was performed for 75 days in HANARO since February 2004. From the present study, the instrumented rig has been developed. And three centerline temperature sensors were installed in each mini-element and input/output temperature sensors and thermal neutron sensor are attached around the element assembly. Instrumentation sensors & cables are connected to the remote connectors. From HANARO irradiation test, measurement data of in/out temperature were not accurate but the centerline temperatures of two Rods were measured successfully. Maximum temperatures of Rod1 and Rod2 were 1,060°C and 1,110°C, respectively. Post irradiation examination is processing and the performance of the dry process fuel will be analyzed more.

Acknowledgement

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