The Second Instrumented Irradiation Test of a Dry Processed Fuel at HANARO

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1. Introduction

The first instrumented irradiation test of a dry processed fuel that was fabricated without any separation of the isotopes except for the volatile material from the spent PWR fuel was performed successfully in February 2004. For the repeatability test, the second instrumented irradiation test was performed. An instrumentation rig where 3 thermocouples were installed was manufactured. The irradiation test was started on March 16, 2006 and it was ended on July 21, 2006. This paper describes the 6th instrumentation rig and the results from the measured 6th irradiation test data.

2. Design of the Instrumented Rig

This 6th instrumented rig is a redesign of the 5th instrumented rig [3]. The total length of the rig is 1,060mm and 3 sensors are established in the rig: The 3 C-type thermocouples are for measuring the pellet center temperature**.** These 3 sensors are connected to the extension cable by a remote connector at the HANARO pool. The big difference in the 6th instrumented rig is that there is no outer tube. There are several advantages gained from removing the outer tube. For example, the rig assembly is easy, waste is decreased and the assembled rig's examination is easy.

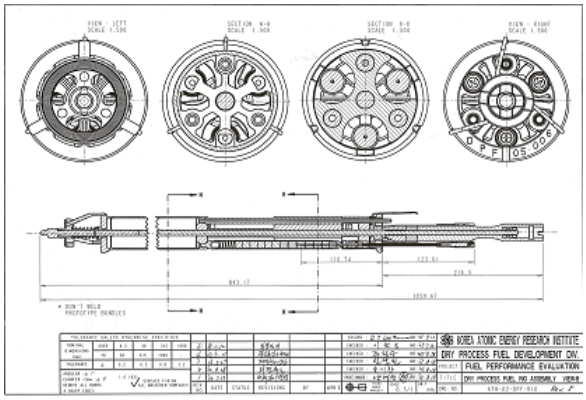

Figure 1. Design of the instrumentation rig

3. Design of instrumented mini-element

Fig. 2 shows the design of the instrumented mini-element. The thermocouple for measuring the pellet centerline temperature is equipped at the center hole of the 3rd pellet. The sealing method of the 5th irradiation test used a swage lock by using a seal tube. But this method could not guarantee a perfect sealing of the mini-element. So, the sealing method of a mini-element was improved by a laser micro-welding as depicted in Fig. 3. The micro-welding work was carried out to obtain the optimum welding parameters for a jointing of the Zr-4 end cap to the tantalum thermocouple sheath [4].

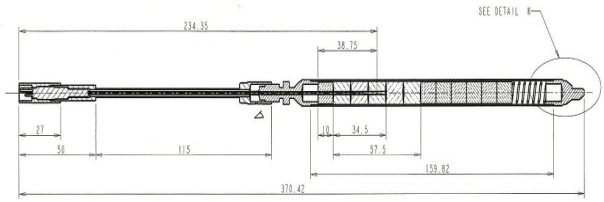

Figure 2. Design of the instrumented mini-element

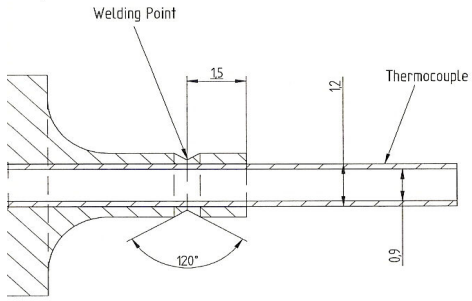

Figure 3. Laser micro-welding of thermocouple

3. Pellet drilling for the thermocouple installation

The upper 3 pellets of the mini-element were drilled to ϕ1.4 mm by using a remote drilling machine in the hot cell. The ϕ1.2 mm C-type thermocouple was inserted into the drilled pellets as depicted in Fig. 4. The ϕ1.4 mm diamond drilling tip was used and the time that it took to drill a pellet was about 30 min at a 20 kg lead load. In the 5th irradiation test, the pellet center hole was drilled elliptically due to the up and down-directional drilling for a pellet. But this caused a considerable stress on the inner boundary of the drilled pellet. Therefore, this pellets drilling used the once pierced method. Also, the gap between the pellet and the thermocouple was an enlarged

space by 0.1mm for considering a thermocouple expansion. Fig. 5 shows the drilled DUPIC pellets.

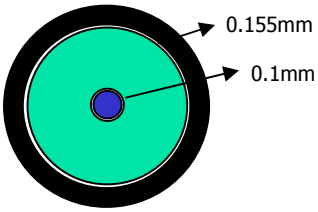

Figure 4. Sectional schematic of the instrumented mini-element

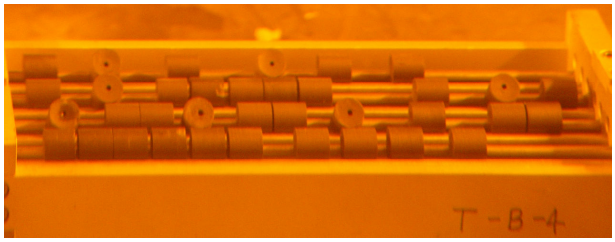

Figure 5. Drilled pellets

4. Measurement data

Fig. 6 shows the measured center temperatures of the first mini-element from March 16 to July 21 during the irradiation period acquired by the DAS. The maximum temperature was about 1,100 °C in the 5th irradiation test of a 26 MW power operation but HANARO's normal operation power for this the 6th irradiation test was 30 MW [1]. So, the measured center temperatures were much higher than the 5th measurement data. The measured maximum centerline temperature of Rod-1 was about 1,400°C and the data of the thermocouple was normal for 3 cycles. But the thermocouples of Rod-2 and Rod-3 were abnormal from the 42 cycle late. That reasons for these results for the Rod-2 and Rod-3 were not conformed. Also, Fig. 6 shows a big difference of centerline temperatures between the first cycle(42 cycle) and the second cycle(43 cycle). It may be caused by a rapid power change and the resultant large radial cracks. That reason can be explained by the measured center temperature and linear heat rate by a code calculation as they do not coincide. The average burn-up was a bout a 4,000 MWd/tHM.

5. Conclusion

Three centerline temperature sensors were installed in each mini-element. Early temperatures of Rod-1, Rod-2 and Rod-3 were measured as 1,250 °C, 1,245 °C and 1,300 °C, respectively. The centerline temperature difference between Rod-1 and Rod-3 was measured to be about 50 °C. It may be explained by the fact that Rod-3 is closer to the reactor core. But as time passes, thermocouples for Rod-2 and Rod-3 were abnormal from the 42 cycle late. The maximum centerline temperature of Rod-1 was about 1400 °C at the 42 cycle and the linear heat rate was 45kw/m. The reasons for the big centerline temperature difference between the first cycle and second cycle will be confirmed from the PIE test.

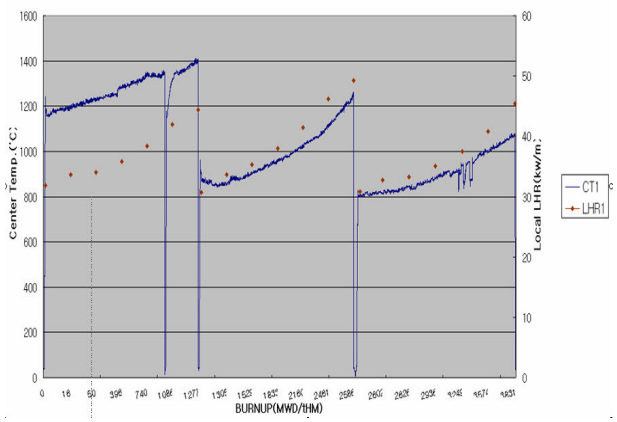

Figure 6. Pellet centerline temperature(#1) acquired by DAS and Linear Heat Rate

Acknowledgement

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