Fuel Performance Analysis for the Fifth Irradiation Test of the Dry Process Fuel

Chang Je Park, Joo Hwan Park, Cheol Yong Lee, Je Seon Moon,
Kweon Ho Kang, Ho Jin Ryu, In Ha Jung, Kee Chan Song
Korea Atomic Energy Research Institute, P.O. Box 105, Yuseong, Daejeon, Korea, 305-600
cjpark@kaeri.re.kr

1. Introduction

The Dry Process Fuel (DPF) is fabricated using the spent PWR fuel with the OREOX process[1] in which most fission products remains without some volatile elements. Thus, the DPF has naturally proliferation resistance and provides efficiency of fuel utilization reusing the spent fuel. To evaluate the fuel performance of the DPF, five irradiation tests are performed in the HANARO reactor. Recently, the fifth irradiation test was successfully carried out from February 2004 to April 2004. The most important characteristics of the fifth irradiation test of the DPF is remote-instrumented test of the pellet centerline temperature, coolant inlet and outlet temperatures, and SPND. From the fifth irradiation test, the remote instrumentation technology has been developed and comes into the ownership of the KAERI including several patents. This paper covers an analysis of fuel centerline temperature using the results of the fifth irradiation test of the DPF.

2. Methods and Results

For the fuel performance analysis, two codes was considered, INFRA[2] and KAOS[3]. The KAOS code system is being developed for the DPF performance updating models of the DPF and experimental results based on the previous code systems. The summary of the fifth irradiation test for the fuel performance is given in Table I.

There are several errors which should be considered. The linear power of fuel rod comes from the analysis code system of the HANARO core because the linear power was not measured during the test. For the linear power, about 10% variation is assumed including axial distribution. Fig. 1 shows the linear power change during the fifth irradiation test of the DPF. It was found that there were abrupt power changes during short time for unexpected event such as snowfall. It was expected that the robustness of the pellet was affected by the steep power variation. Thus, there need another factor which should be considered to correct such a pellet behavior.

Fig. 2 shows the results of fuel performance analysis based on the given linear power change. The measured data are lower than those temperatures expected by the fuel performance code system. To develop the fuel performance code system of KAOS, the "thermal conductivity recovery" phenomenon was used,[4] which should be revealed with not only experiments but also theory. The thermal conductivity of pellet could be corrected with burnup and fission gas release. In this study, the fission gas release is expected low enough considering irradiation period and burnup. But during irradiation, an abrupt power change causes the crack and relocation etc of the pellet. Those phenomena of pellet are assumed to be function of burnup during the irradiation. Therefore, the thermal conductivity (λ) of pellet is corrected as follows

$$\lambda_c = \lambda \times \exp(\alpha \cdot Burnup), \quad (1)$$

where α is chosen as 1.5 for this study.

In Fig.3, the corrected results with recovery effect approach to the measured temperature. But this method is one kind of assumptions to correct the fuel centerline temperature of the DPF. More irradiation data need for the complete establishment of new fuel performance including the DPF and new fuels for future reactors.

TABLE I. Summary Data for the Fifth Irradiation Test of the Dry Process Fuel

Parameter	Value
Coolant temperature	313 K
Coolant pressure	0.4 MPa
Fast flux spectrum	2.40 E13 #/cm^2-sec
Diametral gap	0.314 mm
Stack height	5.8 cm
Cladding outside diameter	1.212 cm
Cladding inside diameter	1.080 cm
Clad thickness	0.660 mm
Hole diameter	0.13 cm
Pellet diameter	1.048 cm
Pellet length	1.160 cm
Grain size	10.0 μm
Initial gas pressure	0.1 Ma

3. Conclusion

The fifth irradiation test of the dry process fuel was performed successfully with achieving the remote instrumentation technology. The measured temperature of fuel center was analyzed using the fuel performance code systems (INFRA and KAOS). When applying the thermal conductivity recovery model, the present fuel performance codes predicted the measured data well. In the future, it is necessary to develop more accurate fuel models including thermal, mechanical, and chemical models based on the irradiation data.

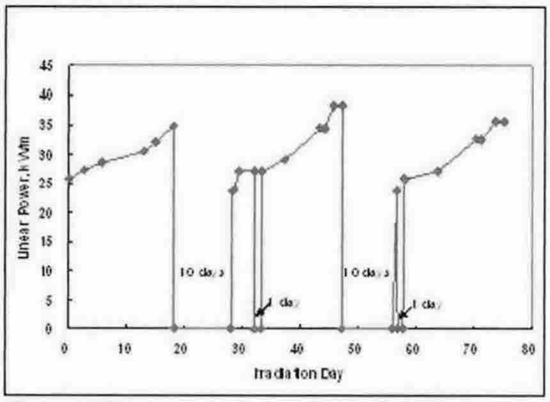

Figure 1. Linear power change during the fifth irradiation test of the dry process fuel.

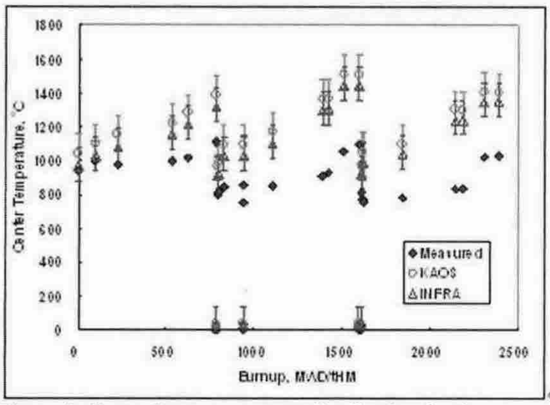

Figure 2. Centerline temperature distribution for the fifth irradiation test of the DPF without recovery effect.

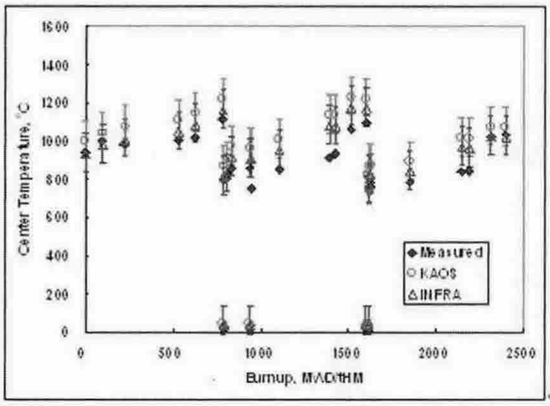

Figure 3. Centerline temperature distribution for the fifth irradiation test of the DPF with recovery effect.

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