

Irradiation Test of Dual Instrumented Fuel Rods by using an Instrumented Fuel Capsule(05F-01K) at HANARO

Jaemin Sohn, Sungjae Park, Yoontaeg Shin, Choongsung Lee, Keenam Choo, Mansoon Cho,
Jongmyung Oh, Bonggoo Kim, Harkrho Kim
Korea Atomic Energy Research Institute, 150 Deokjin-dong, Yuseong-gu, Daejeon 305-353, Korea
jmsohn@kaeri.re.kr

1. Introduction

The purpose of this paper is to verify the performance of dual instrumented fuel rods. The dual instrumented fuel rods, which allow for two characteristics to be measured simultaneously in one fuel rod, have been designed to enhance the efficiency of an irradiation test using an instrumented capsule for the nuclear fuel irradiation test(hereinafter referred to as “instrumented fuel capsule”) in HANARO(High-flux Advanced Neutron Application Reactor). Six types of dual instrumented fuel rods have been designed. The types of dual instrumented fuel rods are summarized as follows; 1) to measure the center temperature of the nuclear fuel and the internal pressure of the fuel rod, 2) to measure the center temperature of the nuclear fuel and the elongation of the fuel pellets, 3) to measure the surface temperature of the nuclear fuel and the internal pressure of the fuel rod, 4) to measure the surface temperature of the nuclear fuel and the elongation of the fuel pellets, 5) to measure the center and surface temperature of the nuclear fuel, and 6) to measure the center temperature of the nuclear fuel of the upper and lower part[1]. And 05F-01K instrumented fuel capsule has been designed for an irradiation test of three dual instrumented fuel rods[2].

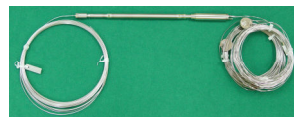
This paper presents the manufacturing of the dual instrumented fuel rods and 05F-01K instrumented fuel capsule, and the results of the irradiation test.

2. Manufacturing and Irradiation Test of the Dual Instrumented Fuel Rods

2.1. Manufacturing of the Dual Instrumented Fuel Rods

Three of the six dual instrumented fuel rods, as shown in Figure 1, have been manufactured and installed in the 05F-01K instrumented fuel capsule. Each rod contains five fuel pellets, cladding, spacers, plenum spring basically. In the dual instrumented fuel rods, the C-type thermocouple is used to measure the center temperature of the nuclear fuel, the K-type thermocouple is used to measure the surface temperature of the nuclear fuel, the pressure transducer and the LVDT(Linear Variable Differential Transformer) are used to measure the internal pressure of the fuel rod, the elongation detector and the LVDT are also used to measure the elongation of the fuel

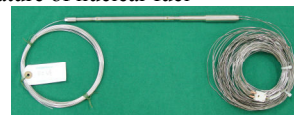
pellets, and the SPND(Self-Powered Neutron Detector) is used to measure the neutron flux[3].



(a) The dual instrumented fuel rod to measure the center temperature of the nuclear fuel and the elongation of fuel pellets



(b) The dual instrumented fuel rod to measure the center and surface temperature of nuclear fuel



(c) The dual instrumented fuel rod to measure the surface temperature of the nuclear fuel and the internal pressure of fuel rod

Figure 1. Three dual instrumented fuel rods in the 05F-01K instrumented fuel capsule

A helium leak occurred in a dual instrumented fuel rod, which measures the center and surface temperature of nuclear fuel, therefore a mockup fuel rod was installed instead.

2.2. Manufacturing of the 05F-01K Instrumented Fuel Capsule

05F-01K instrumented fuel capsule has been manufactured as shown in Figure 2. Two dual instrumented fuel rods, a mockup fuel rod and three SPNDs have been installed in this capsule. The out-pile-test of this capsule has been successfully carried out in the 1/2 half core test loop.

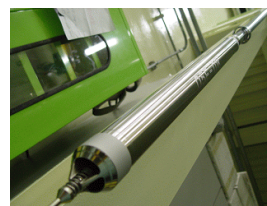


Figure 2. 05F-01K Instrumented Fuel Capsule

2.3. Irradiation Test of the Dual Instrumented Fuel Rods in HANARO

The irradiation test of the 05F-01K instrumented fuel capsule, which contains the dual instrumented fuel rods, was carried out in the OR5 vertical experimental hole of HANARO from February 12, 2007 to April 15, 2007 for 45.84 EFPD(Effective Full Power Days) as shown in Table 1. and Figure 3.

Table 1. The results of the irradiation test of 05F-01K instrumented fuel capsule

Irradiation Test Subjects	05F-01K
HANARO Power	30 MW
Experimental Vertical Hole	OR5
Maximum Linear Power	47.73 kW/m
Average Linear Power	44.73 kW/m
Average Burn-up	4,069 MWD/MTU
Effective Full Power Days	45.84
Maximum Surface Temperature of Nuclear Fuel	385 °C
HANARO Operation Cycles	46 ~ 47
Irradiation Test Period	2007.2.12 ~ 4.15

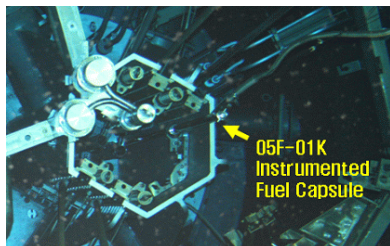


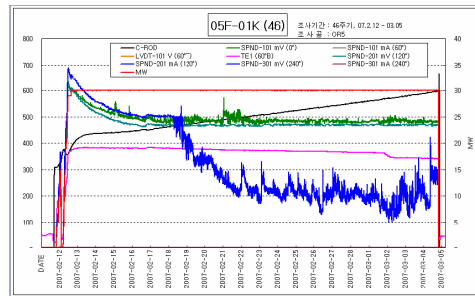
Figure 3. 05F-01K instrumented fuel capsule was loaded into the OR5 vertical experimental hole of HANARO

During the irradiation test, data for the following measurements was acquired; thermocouple signal for the surface temperature of the fuel, LVDT signals for the internal pressure of the fuel rod and the elongation of the fuel pellets, and the SPNDs' signals(mV and mA) for the neutron flux. Data of HANARO's reactor power level(MW) and control rod height(mm) were also acquired. Figure 4 shows the typical measured data of the 05F-01K instrumented fuel capsule during the 46th and 47th HANARO operation cycles. This data has been collected over 1-minute intervals. A SPND was broken in the middle of the 46 HANARO operation cycle.

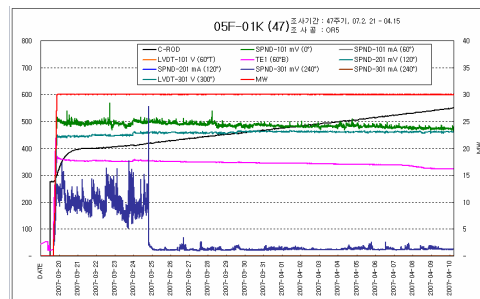
3. Conclusion

The irradiation test of the dual instrumented fuel rods was carried out successfully. The dual instrumentation technologies for measuring the nuclear fuel characteristics during the irradiation at HANARO by using an instrumented fuel capsule are very appropriate and the results of the irradiation test showed a good agreement. This technology will be used continuously for studying nuclear fuel characteristics by

using an instrumented fuel capsule and the 3-pin FTL(Fuel Test Loop) at HANARO. The irradiation test of the other three dual instrumented fuel rods will be carried out using the 06F-01K instrumented fuel capsule.



(a) Irradiation test data during the 46th HANARO operation cycle (2007.2.12~2007.3.5)



(b) Irradiation test data during the 47th HANARO operation cycle (2007.3.30~2007.4.15.)

Figure 4. Irradiation test data of the 05F-01K Instrumented Fuel Capsule

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REFERENCES

- [1] J.M.Sohn, "Design of the Dual Instrumented Fuel Rods to Measure the Nuclear Fuel Characteristics during Irradiation Test at HANARO", Korea Nuclear Society, 2005.5.
- [2] J.M.Sohn, "Design of the Instrumented Fuel Capsule(05F-01K) for the Dual Instrumented Fuel Rods Irradiation Test at HANARO", Korea Nuclear Society, 2005.10.
- [3] J.M.Sohn, "Development of the Measurement Technologies for Nuclear Fuel Characteristics by using the Instrumented Capsule for Nuclear Fuel Irradiation Test at HANARO", Proceedings of the International Symposium on Research Reactor and Neutron Science, 2005.4.