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Design of the Instrumented Fuel Capsule(05F-01K) for the Dual Instrumented Fuel Rods Irradiation Test at HANARO

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1. Introduction

The instrumented capsule for the nuclear fuel irradiation test (hereinafter referred to as "instrumented fuel capsule"), which is crucial for the verification of a nuclear fuel performance and safety, has been developed at HANARO(High-flux Advanced Neutron Application Reactor). The irradiation test of the first instrumented fuel capsule(02F-11K) was carried out in March 2003 and the irradiation test of the second instrumented fuel capsule(03F-05K) was carried out in April 2004.[1][2] Through the irradiation tests of the two capsules, the design specifications and safety of the instrumented fuel capsule were verified successfully. Figure 1 shows the instrumented fuel capsule and Table 1 shows the results of the two irradiation tests using the instrumented fuel capsules.

In the first instrumented fuel capsule(02F-11K), only the technologies for measuring the center temperature of the nuclear fuel and neutron flux were implemented. In the second instrumented fuel capsule(03F-05K), the technologies for measuring the center temperature of the nuclear fuel, the internal pressure of the fuel rod, the elongation of the nuclear fuel and the neutron flux were implemented.[1][2] 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 the irradiation test using the instrumented fuel capsule.[6]

This paper presents the design of the 05F-01K instrumented fuel capsule for the irradiation test of dual instrumented fuel rods.

Figure 1. Instrumented Fuel Capsule

2. Design of the Instrumented Fuel Capsule (05F-01K)

2.1 The Dual Instrumented Fuel Rods

There are six different types of dual instrumented fuel rods. The different functions of these six types 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 pellet, 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 pellet, 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.[6]

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[3], the elongation detector and the LVDT are used to measure the elongation of the fuel pellets[4], and the SPND(Self-Powered Neutron Detector) with a rhodium emitter is used to measure the neutron flux.[5]

Table 1. The results of irradiation tests using instrumented fuel capsules

Irradiation Test Subjects	02F-11K	03F-05K
HANARO Power (MW)	24	24 ~ 30
Experimental Vertical Hole	OR5	OR5
Maximum Linear Power (kW/m)	53.2	50.1
Average Linear Power (kW/m)	49.2	46.3
Average Burn-up (MWD/MTU)	5,930	5,556
Effective Full Power Days	53.84	59.5
Center Temperature (℃)	1,375	1,316
Irradiation Test Period	2003.3.14 ~ 6.1	2004.4.27 ~ 10.1

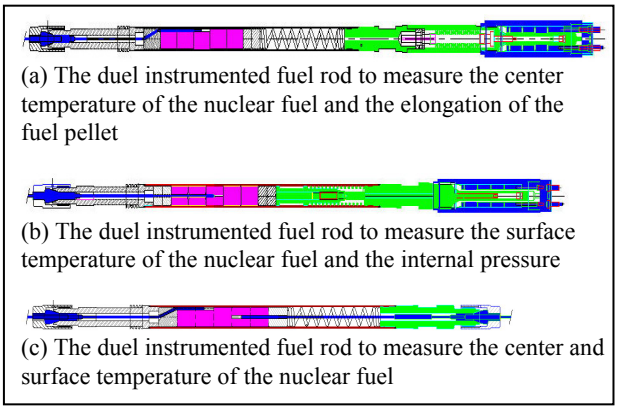
2.2 Design the Instrumented Fuel Capsule

Three of the six dual instrumented fuel rods, as shown in Figure 2, will be installed in the 05F-01K instrumented fuel capsule. The irradiation test of the other three dual instrumented fuel rods will be carried out next year.

The 05F-01K instrumented fuel capsule was designed and is being manufactured for a design verification test of the dual instrumented fuel rods.

The estimated maximum linear power of the 05F-01K instrumented capsule was calculated at 545.17 W/cm by the MCNP code. Assuming the HANARO fuel assembly is 0 mm, the center of the fuel stacks of the instrumented fuel rods were designed at the relative elevation of -22.5 mm. Figure 3 shows the relative

elevation of the fuel stacks for the three capsules(02F-11K, 03F-05K and 05F-01K). Three SPNDs(Self-Powered Neutron Detectors) will be installed at same elevation of the fuel stacks.



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

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

(c) The duel instrumented fuel rod to measure the center and surface temperature of the nuclear fuel

Figure 2. Three dual instrumented fuel rods in the 05F-01K instrumented fuel capsule

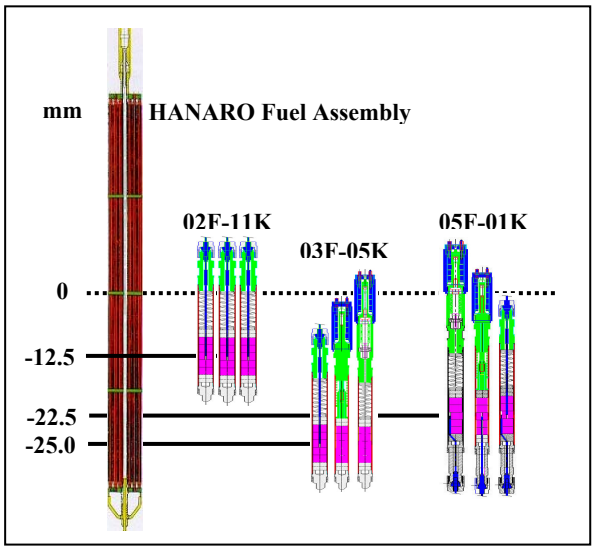


Figure 3. Elevation of instrumented fuel rods for irradiation test

Conclusion

The 05F-01K instrumented fuel capsule has been successfully designed and is being manufactured. The irradiation test of the 05F-01K instrumented fuel capsule will be carried out in the OR5 vertical experimental hole of HANARO at the end of this year.

The dual instrumented technologies for measuring the nuclear fuel characteristics will contribute to enhancing the efficiency of the irradiation test using an instrumented fuel capsule at HANARO.

Acknowledgement

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