Irradiation Test of Dual Cladding Fuel Rod by Using an Instrumented Fuel Capsule(09F-08K) at HANARO

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1. Introduction

The purpose of this paper is to verify the performance of dual cladding fuel rod. The dual cladding fuel rods, which have an inner and an outer cladding, have been designed to control the high temperature of nuclear fuels during the 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). And the 09F-08K instrumented fuel capsule has been designed for an irradiation test of the two dual cladding fuel rods[1].

This paper presents the fabricating of the dual instrumented fuel rods and 09F-08K instrumented fuel capsule, and the results of the irradiation test.

2. Fabricating and Irradiation Test of the Dual Cladding Fuel Rods

2.1. Fabricating of the Dual Cladding Fuel Rods

Two dual cladding fuel rods have been fabricated as shown in Figure 1. Each fuel rod contains five UO_2 pellets(17x17 PWR type, 0.71 w/o(NU)), an inner cladding, an outer cladding, two alumina insulators and a plenum spring. In the dual instrumented fuel rods, a C-type thermocouple was installed to measure the centerline temperature of the nuclear fuel. Table 1 shows the specifications of the nuclear pellets and inner and outer claddings.

Figure 1. Parts(top) and assembly(bottom) of a dual cladding fuel rod

Table. 1. Specifications of Nuclear Fuel and Claddings

Items		Specifications
Nuclear Fuel	Type	PWR 17x17 UO_2
	Ext. diameter	8.192 mm
	Length	10.24
	Thermocouple Hole	1.48 mm (ø)
	Curvature of Dish	12.83 mm
	U-235 Enrichment	0.71 w/o (NU)
	Density	10.517 g/cm^3
	Grain Size	≥ 5 μm
	Chamfer	0.51 mm(W) / 0.17 mm(D)
Cladding	Material	STS 316L
	External Diameter	(inner)14.36 mm / (outer)18.00 mm
	Thickness	(inner)3.00 mm / (outer) 1.72 mm
	Length	(inner)111.15 mm / (outer)109.15 mm
	Gas-Gap	-167 μm (between pellet and inner cladding) - 100 μmm (between inner and outer cladding)
	Filler Pressure	1.2 bar (Helium)

2.2. Fabricating of the 09F-08K Instrumented Fuel Capsule

As shown in Figure 2, the 09F-08K instrumented fuel capsule was fabricated for a design verification test of the double cladding fuel rod. Two dual instrumented fuel rods and two SPNDs(Self-Powered Neutron Detector) were installed in this capsule. The rhodium type SPND was used to measure the neutron flux[3]. Assuming the HANARO fuel assembly was 0 mm, the center of the nuclear fuel stacks of the double cladding fuel rods were designed at the relative elevation of -22.5 mm. The part of fuel assembly that contains two double cladding fuel rods and a cooling block was newly fabricated and other parts that contain an outer tube, protection tube, bottom guide, etc. were fabricated

the same as in the standard instrumented fuel capsule. The out-pile-test of this capsule has been successfully carried out in the single core test loop. The out-pile test contained the measurement of weight in air and in water, the testing to install and uninstall of this capsule at OR5 experimental vertical hole and the endurance test of this capsule with the same hydraulic conditions as HANARO.

Figure 2. 09F-08K Instrumented Fuel Capsule

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

The irradiation test of the 09F-08K instrumented fuel capsule, which contains the two dual cladding fuel rods, was carried out in the OR5 vertical experimental hole of HANARO from January 10 to February 9, 2010 for 24.99 EFPD(Effective Full Power Days) as shown in Table 2.

During the irradiation test, the data for the following measurements was acquired; thermocouple signal for the centerline temperature of the fuel, 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. These data were collected over 1-minute intervals. The acquired maximum centerline temperature of nuclear fuels was 770 ℃ as shown in Table 2. Two rods and two SPNDs were located at OR5 experimental vertical hole of HANARO as shown in Figure 3.

Table 2. The results of the irradiation test of the dual cladding fuel rods by using 09F-08K instrumented fuel capsule

Irradiation Test Subjects	09F-08K
HANARO Power	30 MW
Experimental Vertical Hole	OR5
Maximum Linear Power	13.0 kW/m
Average Linear Power	11.73 kW/m
Burn-up	2,620 MWD/MTU
Effective Full Power Days	24.99 EFPD
Maximum Centerline Temperature of Nuclear Fuel	770 ℃
HANARO Operation Cycles	62 th
Irradiation Test Period	2010.1.10 ~ 2.9

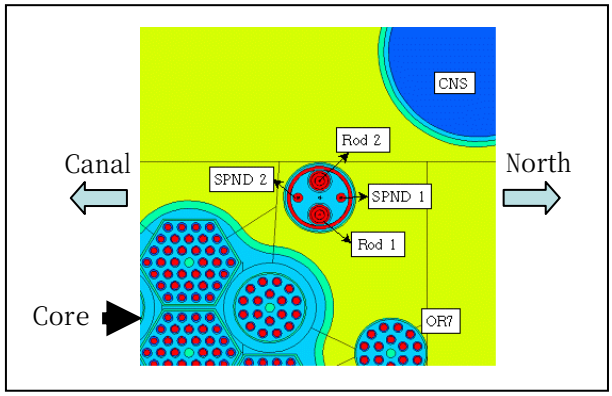

Figure 3. Direction of double cladding fuel rods and SPNDs at OR5 experimental vertical hole of HANARO

3. Conclusions

The irradiation test of the dual cladding fuel rods was carried out successfully. The dual cladding technologies for high temperature of nuclear fuels during the irradiation test at HANARO using an instrumented fuel capsule were very appropriate and the results of the irradiation test showed a good agreement. This technology will be studied continuously to control the temperature of the nuclear fuels during the irradiation test at HANARO.

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