Design and Fabrication of the Double Cladding Instrumented Fuel Rods and the Instrumented Fuel Capsule(07F-06K) for the Irradiation Test at HANARO

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

1. Introduction

An instrumented capsule for a 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 to measure the fuel characteristics, such as the centerline and surface temperatures of the nuclear fuel, the internal pressure of a fuel rod, the elongation of the fuel pellet and the neutron fluxes during an irradiation test at HANARO(High-flux Advanced Neutron Application Reactor). The irradiation test of the first instrumented fuel capsule(02F-11K) was carried out for verification test at HANARO in March 2003 as shown in Fig. 1. Through the irradiation tests of the some capsules, the design specifications and safety of the instrumented fuel capsule were verified successfully [1,2]. And the dual instrumented fuel rods, which allow for two characteristics to be measured simultaneously in one fuel rod, have been developed to enhance the efficiency of the irradiation test using the instrumented fuel capsule [3,4].

In this paper, we designed and fabricated a double cladding fuel rod to control the high temperature of nuclear fuels during an irradiation test at HANARO. And we design an instrumented fuel capsule(07F-06K) for an irradiation test of the double cladding fuel rods.

We have designed and fabricated the double cladding fuel rod mockups and performed the out-pile tests using these mockups. The purposes of the out-pile tests were to analyze an effect of a gap size(between an outer cladding and an inner cladding) on the temperature and the effect of a mixture ratio of helium gas and neon gas on the temperature. Through the results of the out-pile tests, we have obtained the effects of a gap size and a gas mixture ratio on the temperature of nuclear fuels [5].

Therefore an double cladding fuel rod and the 07F-06K instrumented fuel capsule were designed on the base of the results of the out-pile tests using the mockups .

Fig. 1. Instrumented Fuel Capsule

2. The double cladding fuel rods to control the temperature during the irradiation test

A double cladding fuel rod contains five UO_2 pellets(17x17 PWR type, 2.42w/o), an inner cladding, an outer cladding, two thermocouples, a gas-in tube and a gas-out tube and two alumina insulators as shown in Fig. 2, Fig 3 and Fig. 4. A C-type thermocouple was used to measure the centerline temperature of the nuclear fuels, a K-type thermocouple was used to measure the surface temperature of an inner cladding. A fuel rod has a gap between an outer cladding and an inner cladding. The helium and neon mixed gas flows through this gap.

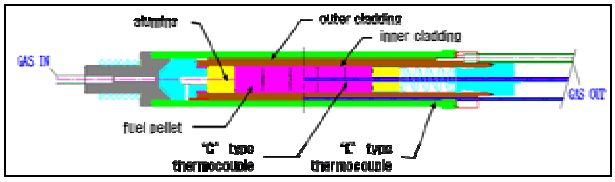

Fig. 2. Design of the Double Cladding Fuel Rod

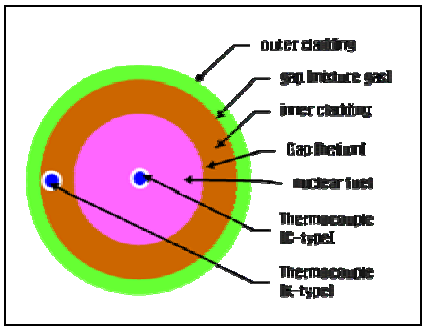

Fig. 3. A Cross Section of Double Cladding Fuel Rod

Fig. 4. A Double Cladding Fuel Rod (before and after assembling)

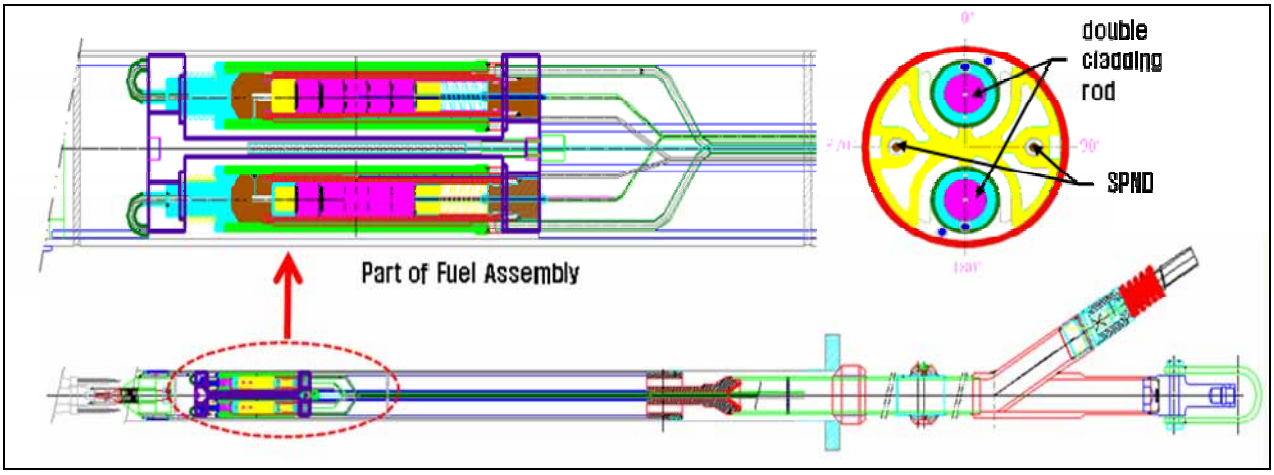

Fig. 5. Drawings of the Instrumented Fuel Capsule(07F-06K) for a Irradiation test of the Double Cladding Instrumented Fuel Rods

3. The double cladding fuel rods to control the temperature during the irradiation test

An instrumented fuel capsule(07F-06K) was designed and is being fabricated for a design verification test of a double cladding instrumented fuel rod. Two double cladding instrumented fuel rods and two rhodium type SPNDs(Self-Powered Neutron Detector) will be installed in this capsule.

The estimated maximum linear power of the 07F-06K instrumented capsule was calculated at 331.4 W/cm by the MCNP code. Assuming the center of HANARO fuel assembly was 0 mm, the center of the fuel stacks of the double cladding instrumented fuel rods were designed at the relative elevation of -22.5 mm as shown in Fig. 6. Two SPNDs(Self-Powered Neutron Detectors) will be installed at same elevation of the nuclear fuel stacks.

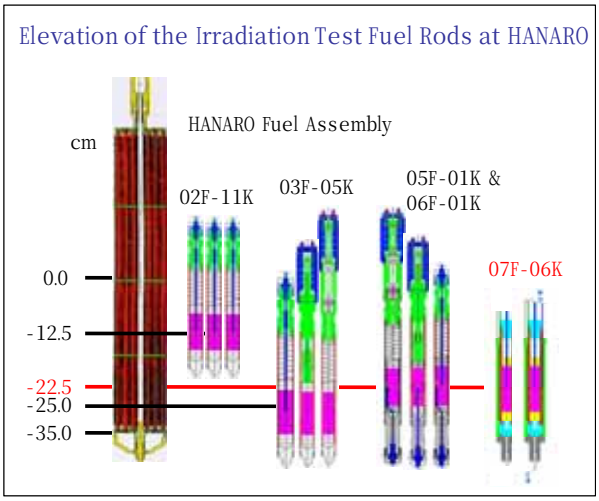

Fig. 6. Elevation of instrumented fuel rods for irradiation test at HANARO

4. Conclusion

The double cladding instrumented fuel rod and 07F-06K instrumented fuel capsule have been successfully designed and fabricated. The irradiation test of the double cladding fuel rods will be carried out in the OR5 vertical experimental hole of HANARO at the end of this year.

The high temperature control technologies of the nuclear fuels using a double cladding fuel rod will be utilized for the development of the new type nuclear fuels.

Acknowledgement

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