

Design and varification of HANARO irradiation test capsule for mini plate fuel

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1. Introduction

KJRR (KiJang Research Reactor) is designing at KAERI and will be constructed and operated to produce the significant radioactive isotopes (RI) and neutron transmutation doping (NTD) Si and verify the exportation model of research reactor. U-7wt%Mo / Al-5wt%Si dispersion fuel fabricated by atomization process is the candidate fuel material of KJRR. Although a few in-pile tests for U-7wt%Mo / Al-5wt%Si dispersion fuel were conducted, all tests were used by the rod shape fuels. Because the plate shape fuel is considered in KJRR, its performance must be verified throughout the irradiation test.

The irradiation hole of HANARO is small to accommodate the full size KJRR fuel. Therefore, 'mini plate fuel' downsized was considered to irradiation-test at HANARO. Three irradiation test plans were scheduled for the mini plate fuel[1].

Irradiation test capsule was designed to irradiate the mini plate fuel. To verify integrity and compatibility with HANARO core of the irradiation test capsule, the out-pile test was conducted up to 120 days by mock-up. In this paper, the design features of irradiation test capsule and verification results from out-pile test were discussed.

2. Results and Discussions

2.1 Design of the irradiation test capsule for the mini plate fuel

All irradiation tests for the mini plate fuel will be conducted at the OR irradiation hole. Therefore, the irradiation test capsule was designed, based on the design features of 18-elements fuel loaded at OR irradiation hole. Fig. 1 shows the schematic diagrams of irradiation test capsule for the mini plate fuel. Total 8 mini plate fuels were accommodated in a capsule. The center position of between the lower and upper mini plate fuels will be located at HANARO fuel center position when the irradiation test capsule is loaded in the OR irradiation hole. However, the design of HANARO fuel is central-rod type that can't ensure the loaded location of inner fuels. Because the OR irradiation holes are located outside of the core, neutron physical properties are different with the location in the OR irradiation hole[2]. To expect the irradiated fuel features such as burn up and local power is important for the fuel integrity and irradiation behavior, so the ensuring design for loaded position was applied.

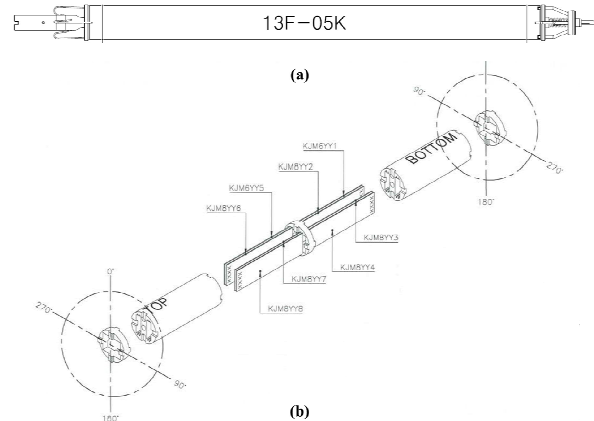


Fig. 1. The schematic (a) outer and (b) inner part diagrams of the irradiation test capsule (13F-05K) for the mini plate fuel

2.2 Out-pile test of irradiation test mock-up capsule

To irradiate the mini plate fuels at HANARO, the safety of irradiation test capsule under normal operation condition must be verified. Therefore, 12F-28K, the irradiation test mock-up capsule for the mini plate fuel, was manufactured and hydraulic-tested at the single channel test loop as the out-pile test facility. Fig. 2 shows the picture of the out-pile test for the vibration measurement at the single channel test loop. From the out-pile test, 3 verification items were observed as follows[3].

(1) Hydraulic compatibility between HANARO core and the irradiation test capsule: The flow rate must be lower than 12.7 kg/s at the differential pressure of 209 kPa.

(2) Vibration feature analysis: The maximum vibration displacement must be lower than 300 μ m and the characteristic frequency is analyzed.

(3) Durability: The resistance of wear and damage for inner and outer parts of the irradiation capsule must be verified.

Table 1 shows the results of out-pile test for the irradiation test capsule. At the differential pressure of 209 kPa, same with HANARO core, the flow rate of 6.38 kg/s was measured. It was the lowest value among the other irradiation-tested capsules. Lower flow rate can be problem due to the shortage of cooling ability at abnormal operation condition. From abnormal operation analysis for the mini plate fuel using above flow rate, the cooling ability will be maintained. The vibration of irradiation test capsule was measured at the position of

grapple head by Laser Doppler Vibrometer (LDV) shown in Fig. 2. The maximum vibration and root mean square (RMS) displacement was lower than 38 and 11 μm , respectively. The characteristic frequency was similar with the other capsules. Also the endurance test was conducted. During the endurance test, the 10% flow rate was increased than HANARO operating condition due to the conservative verification. No wear and damage parts were observed at 12F-28K up to 120 days (4 HANARO irradiation cycles).



Fig. 2. The picture of the out-pile test for the vibration measurement of 12F-28K at the single channel test loop

Table 1. The results of the out-pile test for the irradiation test mock-up capsule

Verification item	Result	Satisfaction / Dissatisfaction
Hydraulic compatibility	Flow rate : 6.38 kg/s at 209 kPa	Satisfaction
Vibration	RMS displacement < 11 μm Characteristic frequency : Satisfaction	Satisfaction
Durability	OK up to 120 days	Satisfaction

From above out-pile test results, the performance of irradiation test capsule under HANARO normal operation condition was verified. 13F-05K, the first irradiation test capsule for the mini plate fuel is manufacturing and will be irradiation-tested at HANARO OR3 irradiation hole since October, 2013. Fig. 3 shows the schematic diagram of loaded irradiation test capsule at HANARO OR3 irradiation hole.

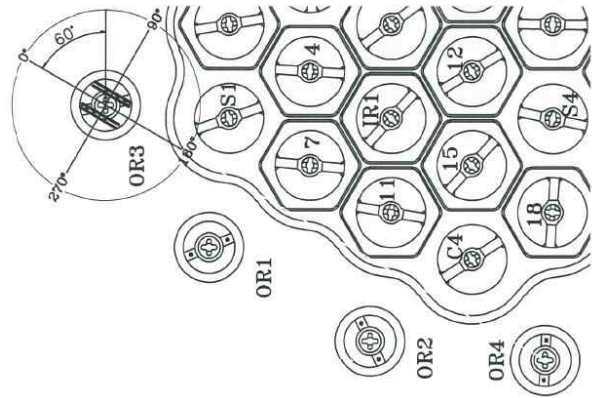


Fig. 3. The schematic diagram of loaded irradiation test capsule (13F-05K) at HANARO OR3 irradiation hole (Bold line: Mini plate fuels)

3. Conclusion

In order to irradiate and verify the mini plate fuel, the irradiation test capsule was designed. The irradiation test mock-up capsule was manufactured for the out-pile test. From hydraulic compatibility, vibration and durability test, the performance of designed and fabricated irradiation test capsule was verified.

ACKNOWLEDGEMENT

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP).

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