Current Status of Nuclear Fuel Irradiation Test at HANARO

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1. Introduction

HANARO irradiation facility has supported some national R&D programs such as the irradiation test of SMART steam generator tube and research reactor core material, so their irradiation performance was verified and used for the licensing database [1-4]. Because the in-pile testing demand of not only the reactor core and structure material but also the nuclear fuel is recently increased to verify its irradiation performance, some fuel irradiation tests were planned and conducted using the irradiation test capsule in OR irradiation hole at HANARO. In this paper, the current status of irradiation test for the nuclear fuels at HANARO is reported.

2. Irradiation Test Fuels

2.1 Mini Plate Fuel for Research Reactor

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. Also it is candidate material for RERTR (Reduced Enrichment for Research and Test Reactor) program. Therefore, its performance must be verified throughout the irradiation test.

The irradiation hole of HANARO is small to accommodate the full size KJRR fuel. Therefore, downsized 'mini plate fuel' was considered to irradiation-test at HANARO. 3 irradiation tests were scheduled for the mini plate fuel [5]. Table 1 shows the irradiation test data of mini plate fuels.

Table 1. The irradiation test data of mini plate fuel

Mini plate ID	Capsule ID	Dimension (mm)	Irrd. requirement (U consumption)
HaMP-1	13F-05K	Fuel meat 0.51x25x70 Plate 1.27x35x130	Avg. 45 at%
HaMP-2	13F-06K	Fuel meat 0.51x25x70 Plate 1.27x35x130	Avg. 65 at%
HaMP-3	13F-07K	Fuel meat 0.51x25x600 plate 1.27x35x640	Peak. 85 at%

Fig. 1 shows 8 mini plate fuels, HAMP-1, irradiated in OR3 irradiation hole. It has been irradiated from January 27, 2014. Fig. 2 shows the irradiation test capsule for HAMP-1, 13F-05K. The irradiation test of HAMP-2 and HAMP-3 will be conducted at HANARO from October and May, respectively. Additionally, the irradiation test for fission Mo target that will be used at KJRR for the production of radioactive Mo was planned. It will be started on October.

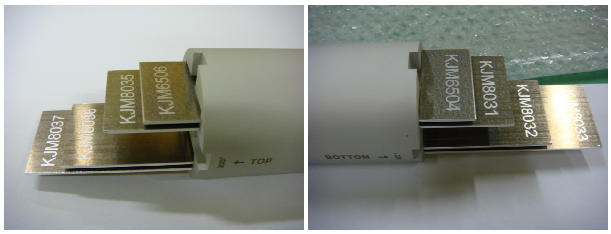

Fig. 1. The mini plate fuels for irradiation (HAMP-1)

Fig. 2. The irradiation test capsule for HAMP-1

Fig. 3 shows the average burnup and U consumption rate of HAMP-1 after 1 irradiation cycle (27.51 EFPDs) evaluated by HANARO Fuel Management System (HANAFMS). In order to meet the U consumption rate of HAMP-1, additional 2~3 irradiation cycles are necessary.

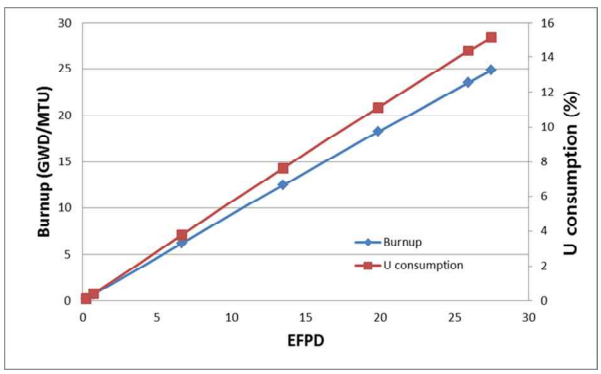

Fig. 3. The average burnup and U consumption rate of HAMP-1 after 1 irradiation cycle

2.2 Coated Particle Fuel for VHTR

Coated particle fuel (CPF) is developed as the candidate fuel material for VHTR (Very High Temperature Reactor) by KAERI. Because the diameter of fuel particle is only about 1 mm, the fuel compact that consists of graphite containing fuel particle is used for the irradiation test. Fig. 4 shows the irradiation test capsule (12F-01K) for CPF. 14 fuel compacts were contained in 12F-01K. The irradiation test of 12F-01K was started on August 2013 in OR5 irradiation hole at HANARO.

Fig. 4. The irradiation test capsule (12F-01K) for CPF

Fig. 5 shows the average power history of CPF during 4 irradiation cycles (104.66 EFPDs) evaluated by HANAFMS. At the beginning of the irradiation test, the average particle power was low due to the low power operation of HANARO. Fig. 6 shows the average burnup and FIMA (fission per initial metal atom). The average FIMA of CPF was 3.83% after 4 irradiation cycles. The irradiation test of 12F-01K will be terminated after additional 1 irradiation cycle.

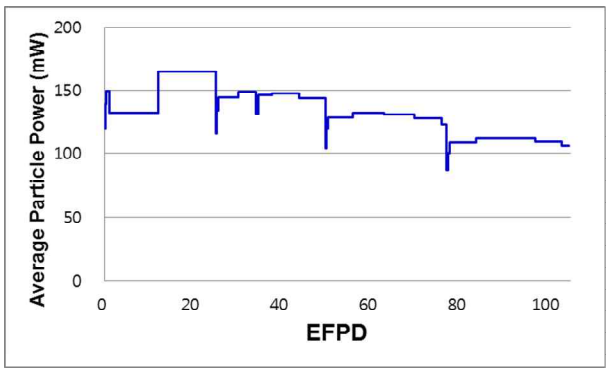

Fig. 5. The average power history of CPF

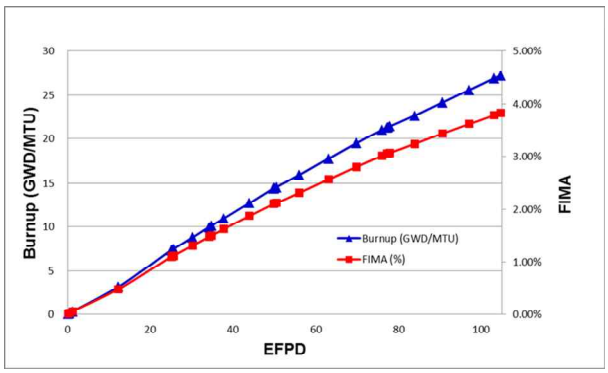

Fig. 6. The average burnup and FIMA of CPF

2.3 Improved Fuel Pellet for LWR

The irradiation test capsule for hybrid fuel containing both dual cooled fuels and high performance fuel pellets has been irradiated in OR4 irradiation hole from September 2011. Its irradiation test will be terminated on July 2014. After the irradiation test of hybrid fuel, the irradiation plan of 2nd hybrid fuel containing both boron bearing pellets for replacement of rare earth element and micro-cell pellets for the development of accident tolerant fuel will be planned. The design of irradiation test capsule is conducted by nuclear and mechanical analysis for 2nd hybrid fuel irradiation.

2.4 Metallic Fuel for SFR

U-Zr and U-Zr-Ce metallic fuels were irradiated in HANARO from December 2010 during about 150 EFPDs to verify the irradiation performance. Since 2nd irradiation test of metallic fuel will be conducted from 2015, the conceptual design of irradiation test capsule was started.

3. Conclusions

The current status of nuclear fuel irradiation test was reported. The irradiation test for plate, particle, pellet and metallic fuel for the development of research reactor, VHTR, LWR, SFR was planned and conducted at HANARO.

ACKNOWLEDGEMENTS

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REFERENCES

[1] K. N. Choo et al., Design, Fabrication and Test Report on HANARO Instrumented Capsule (09M-02K) for Irradiation Test of Steam Generator Tube Material of SMART at OR Hole, KAERI/TR-4083/2010.
[2] K. N. Choo et al., Design, Fabrication and Test Report on HANARO Instrumented Capsule (10M-01K) for Irradiation Test of Steam Generator Tube Material of SMART at CT Hole, KAERI/TR-4314/2010.
[3] K. N. Choo et al., Design, Fabrication and Test Report on the 3rd HANARO Instrumented Capsule (11M-03K) for Irradiation Test of Steam Generator Tube Material of SMART, KAERI/TR-4394/2011.
[4] S. W. Yang et al., The Irradiation Test Report for Research Reactor Materials at HANARO, KAERI/TR-5494/2011.
[5] Y. W. Tahk et al., Test Plan for Mini-Plate Irradiation with U-7Mo Dispersion Fuel in HANARO, KJ-374-KN-442-012.