Progress (I) on the 2nd Irradiation Test of the Metallic Fuel for SFR in the HANARO

Bong Goo Kim*, Junehyung Kim, Jin-Sik Cheon, ByoungOon Lee, Chan Bock Lee
Korea Atomic Energy Research Institute, Daedeok-daro 989-111, Yuseong-gu, Daejeon, 305-353, Korea
*Corresponding author: bgkim1@kaeri.re.kr

1. Introduction

KAERI initiated its program to develop SFR metal fuel technology in 2007. As an effort to validate the relevant fuel design and fabrication technologies, the first fuel irradiation test, SMIRP-1, was successfully performed in HANARO. There were 12 rodlets which consist of 6 rodlets of U-10%Zr and 6 rodlets of U-10Zr-5Ce slugs with T92 cladding [1]. Among them, the inside of four rodlets had a thin Cr layer which was electroplated. And then PIE of the irradiated fuel rods was finished at IMEF of KAERI [2]. Now the second irradiation test, SMIRP-2, is preparing. There are also 12 rodlets which consist of 6 rodlets U-10%Zr and 6 rodlets U-10%Zr-5% RE (chemical composition of RE; 53%Nd-25%Ce-16%Pr-6%La) slugs, four kinds of cladding, such as T92, HT9, HT9M1, and HT9M2. Among them, the inside of 6 rodlets had a thin Cr layer which was electroplated. Compared with SMIRP-1 irradiation device, the design of SMIRP-2 was modified. After approving the design of a mock-up irradiation device, SMIRP-2M (14F-09K), it was fabricated. And then, out-of-pile testing including measurement of the pressure drop, vibration, and endurance is carrying out to validate the modified design of the irradiation device. This report describes the design, fabrication of SMIRP-2M, briefly. Confirmed the modified design of the device, the SMIRP-2 device will be fabricated to start the second irradiation test from the end of 2015.

2. Irradiation Test

2.1 Objectives

The objective of the second irradiation test, SMIRP-2, is to prepare for technologies to irradiate a series of fuels with the HANARO under a temperature and a linear power higher than to that of the first irradiation test, SMIRP-1. There are two kinds of fuel slug, U-10%Zr and U-10%Zr-5%RE having a diameter of 5.54 mm and 3.90 mm, put into the fuel rodlets, as shown in Fig. 1. RE contains Nd, Ce, Pr and La as a representative of the rare earth elements to examine the level of impurities not harmful for fuel performance. It is also intended to identify the characteristics of the Cr barrier which is being developed in order to suppress a eutectic reaction between the metal fuel and cladding. Table 1 shows the configuration of fuel rodlets in the irradiation rig. Each fuel rod was contained in a sealing tube. There is a gap between cladding and sealing tube to attain a temperature jump for the desirable cladding temperature.

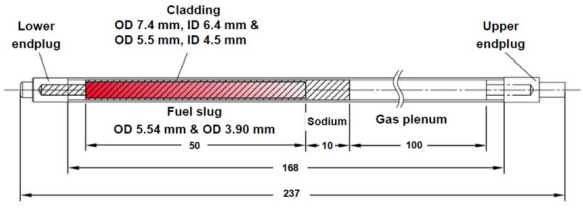

Fig.1. A schematic of the fuel rodlets for the second irradiation test.

Table 1. Configuration of fuel rodlets in the irradiation rig.

Location	No.	Fuel	Cladding	Barrier
Upper	1	U-10%Zr	HT9M1	-
	2	U-10%Zr-5%RE	HT9M1	Cr
	3	U-10%Zr	HT9M2	-
	4	U-10%Zr-5%RE	HT9M1	Cr
	5	U-10%Zr	HT9	-
	6	U-10%Zr-5%RE	HT9	Cr
Lower	1	U-10%Zr	T92	-
	2	U-10%Zr-5%RE	T92	Cr
	3	U-10%Zr	T92	-
	4	U-10%Zr-5%RE	T92	Cr
	5	U-10%Zr	T92	-
	6	U-10%Zr-5%RE	T92	Cr

2.2 Schedule

The SMIRP-2 irradiation under normal operating conditions is planned to be complete with a maximum burnup of about 6 at%. In 2018 PIE will be conducted.

3. Irradiation Device

As shown in Fig. 2, the design of bottom parts and upper parts in SMIRP-1 irradiation device for SMIRP-2 was partially changed to improve the compatibility with test hole in HANARO [3]. In case of the design change of irradiation device, the compatibility of the device with test hole and requirements (pressure drop, vibration, etc.) should be verified before starting irradiation test in HANARO. And then, the mock-up of device, SMIRP-2M, was designed and fabricated.

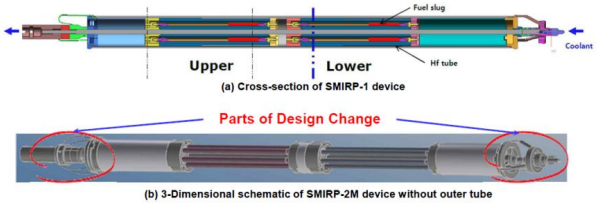

Fig. 2. Comparison of design for (a) SMIRP-1, and (b) SMIRP-2.

4. Fabrication of SMIRP-2M Device

The fabrication of SMIRP-2M was finished at the end of 2014 [4]. Fig. 3 shows SMIRP-2M. Out-of-pile tests including the measurement of pressure drop and vibration at the top of the device, and an endurance test, is on-going to confirm the requirement for irradiation test in HANARO core. Compatibility with the test hole and requirements, such as the pressure drop (> 200 kPa at 12.7 kg/sec of rated flow) and vibration (less than 300 μm at 110% of rated flow) will be verified. And then, the significant evidence of any wear and the mechanical integrity on some parts of SMIRP-2M, contacting with flow tube, will be also checked periodically during carrying out the endurance test at 110% of rated flow. After confirming the requirement, the SMIRP-2 will be prepared, and the irradiation of SMIRP-2 will be started from the end of 2015 in HANARO. Before performing the irradiation testing of SMIRP-2 for metallic fuel, the safety analysis including ONB and reactivity evaluation will be carried out to make sure of the compatibility with the test hole of HANARO and the irradiation performance of the fuel.

Fig. 3. Photograph of SMIRP-2M before starting of out-of-pile test.

5. Summary

As an effort to validate the relevant fuel design and fabrication technologies for SFR metallic fuel, the first fuel irradiation test, SMIRP-1, was successfully performed in HANARO. And then PIE of the irradiated fuel rods was finished. Now the second irradiation test, SMIRP-2, is preparing. Compared with SMIRP-1 irradiation device, parts of the sectional design of SMIRP-2 were modified. After approving the design of a mock-up irradiation device, SMIRP-2M (14F-09K), it was fabricated. Now, out-of-pile testing including measurement of the pressure drop, vibration, and endurance by using SMIRP-2M is carrying out to validate the modified design of the irradiation device. After confirming the modified design of the device, the SMIRP-2 device is being fabricated for the second irradiation test of SFR metallic fuel from the end of 2015.

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