The Thermal Hydraulic Test of SFR Irradiation Test Capsule

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1. Introduction

Irradiation test using a capsule has been performed for fuel or material performance test in the test reactor. Irradiation capsule for the HANARO reactor must satisfy the hydraulic conditions and structural integrity from a out-pile test. Items of a out-pile test are pressure drop, flow-induced vibration test and endurance test. The results of test must show that a test capsule satisfy the HANARO operational requirement with sufficient margin [1-2]. This paper describes the devices of thermal hydraulic test and the results of SFR test capsule.

2. Capsule for SFR Irradiation Test

The SFR metal fuel capsule for irradiation test of the HANARO's OR hole is designed for the purpose of showing the hydraulic conditions and structural integrity. Fig. 1 shows drawing of SFR capsule and fabrication. The total length of the capsule 961mm and two stage assemble of metal fuels are positioned in the outer tube. This capsule is a non-instrumented capsule that has no instrumentation sensors. Top guide of the capsule upper and guide of the capsule lower adopt the design of the HANARO fuel [3].

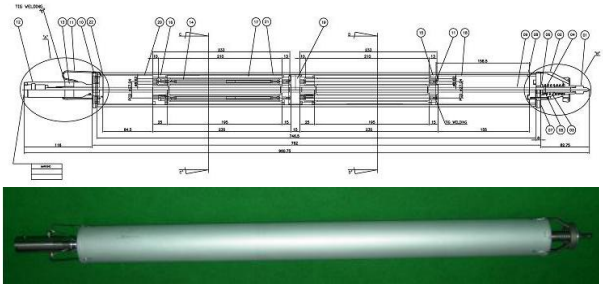

Fig. 1. Drawing of SFR Capsule and Fabrication

3. Thermal Hydraulic Test of SFR Capsule

A single channel test loop was fabricated for the irradiation capsule as shown in Fig. 2. In this facility, the performance tests of capsule are loading/unloading, pressure drop, vibration and endurance test. Test conditions are; flow temperature is 40 ℃, pressure drop is above 209 kPa and flow rate is 12.7 kg/s. The main body of this facility is clear acryl, so it is possible to observe flow phenomenon. The other facility of Fig. 3 is a half channel test loop for the HANARO flow simulation. This facility is composed of half core structure assembly, a flow circulation system and a support system. The circulation pump of the flow circulation system circulates cooling water as a flow rate of 410 kg/s.

Fig. 2. Single Channel Test Loop

Fig. 3. 1/2 Channel Test Loop

4. Test Results and Consideration

For the Test purpose, the pressure drop and vibration test was carried at one channel loop and the endurance was tested at the half channel test loop.

4.1 Pressure Drop Test

The pressure drop test was carried before the endurance test. The flow rate of SFR capsule was measured at 209 kPa without change of flow rate. The flow rate was 6.82 kg/s and its results were less than the limit condition of HARARO (12.7 kg/s). We can be presumed because the structure of SFR capsule has a small space for cooling water.

4.2 Vibration Test

A vibration test was done at the grapple head of the SFR capsule. As in Fig. 4, the laser vibrometer was used and measurement items were peak amplitude, RMS amplitude and frequency amplitude. At the same condition of pressure drop test, RMS displacement was 3.1 ㎛ and the maximum displacement was 23 ㎛ less than the maximum limit 300 ㎛.

Fig. 4. Vibration Measurement using a Laser Vibrometer

4.3 Endurance Test

The endurance was carried after pressure drop and vibration test at the half channel test loop. As the condition of core flow rate of 269 kg/s and coolant temperature of 40 ℃, the endurance test had been conducted for 15 days. There were some problems to operate cooling towers to maintain 40 ℃ but test ended safely. There were no traces of tiny wear and oxidations as results in Fig. 5.

Fig. 5. SFR Capsule Disassamble After Endurance Test

5. Conclusion

The SFR capsule that consisted of two fuels assembles for HANARO irradiation test was fabricated. The tests for thermal hydraulic and vibration were conducted at one channel test loop and the endurance test was tested at the half channel test loop. The flow rate was 6.82 kg/s at the pressure drop of 209 kPa. At the same condition, RMS displacement was 3.1 ㎛ and the maximum displacement was 23 ㎛ less than the maximum limit 300 ㎛. As the condition of core flow rate of 269 kg/s and coolant temperature of 40 ℃, the endurance test had been conducted for 15 days and there were no traces of tiny wear and oxidations as results.

As a future plan, this SFR capsule will proceed to an irradiation test at the HANARO reactor.

Acknowledgement

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REFERENCES

[1] J.S. Chung et al., “Endurance Test for DUPIC capsule”, KAERI/TR-1367/99, 1999.
[2] J.S. Moon et al., “Endurance Test of DUPIC Irradiation Test Rig-003”, KAERI/TR-1810/2001, 2001.
[3] C.Y. Lee et al., “The Thermal Hydraulic test of SFR Irradiation Test capsule”, KAERI/TR-4069/2010, 2010