Design Improvement of the Bottom Guide of a Material Irradiation Capsule : Dowel Pin Type

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1. Introduction

A material capsule system was developed for an irradiation test of non fissile materials in HANARO [1-4]. The capsule system has been actively utilized for the various material irradiation tests requested by users from research institutes, universities, and the industries. 12 instrumented and 2 non-instrumented capsules have been designed, fabricated and successfully irradiated in HANARO CT and IR test holes since 1995.

Because of the up-stream of the coolant in HANARO, the instrumented capsule is supported or fixed at 4 points of the capsule main body and protection tube to satisfy the seismic requirements of the reactor. The instrumented capsule is fixed to the reactor flow tube by a bottom guide assembly of the main body. First bottom guide assembly of an instrumented capsule that was used in a high pressure and velocity of the coolant was designed and fabricated on the basis of the design of the HANARO drive fuel and has been partially modified due to various undesirable matters which occurred during the irradiation tests of the capsules [5]. From the 03M-06U capsule, a new type of bottom guide assembly (B(bolt) type) was designed and applied to solve these problems and it's integrity was proven through in- and out-pile tests [6]. However, several undesirable technical points about the bolt type bottom guide were discussed at a specialist committee. Therefore, another type of bottom guide assembly (C(dowel pin) type) was designed and fabricated according to the committee's suggestion to solve the technical points. The new design will be applied to all of the material and creep capsules in HANARO.

2. Capsule Irradiation Test in HANARO

The instrumented capsule consists of three main parts which are connected to each other: protection tube (5m), guide tube (9.5m) and capsule main body. The main body including the specimens and instruments is a cylindrical shape tube of 60mm in diameter and 829mm in length. The main body has 5 stages with independent micro-electric heaters and contains 14 thermocouples and 5 sets of Fe-Ni-Ti and Al_2O_3 Sapphire neutron fluence monitors to measure the temperatures of the specimens and fast neutron fluences, respectively. Heaters and thermocouples are connected to a capsule temperature controlling system through a guide tube and junction box system. The temperature of the specimens during an irradiation is initially increased by the gamma heating and then roughly adjusted to an optimum condition by the gas control system and then finally adjusted to a desired value by a micro-electric heater. Because of the up-stream of the coolant in HANARO, the instrumented capsule is supported or fixed at 4 points which are the bottom and top of the main body, the top of the reactor chimney, and the capsule robot arm's site as shown in Fig. 1. The capsules were mainly designed for an irradiation of the RPV (Reactor Pressure Vessel), reactor core materials, and Zr-based alloys. 5,600 specimens from 32 domestic research institutes, 2 nuclear industry companies and 67 universities, were irradiated in HANARO for 53,000 hours using the irradiation capsule system. After an irradiation test, the main body of a capsule is cut off at the bottom of the protection tube with a cutting system and it is transported to the IMEF hot cell and dismantled for post irradiation tests.

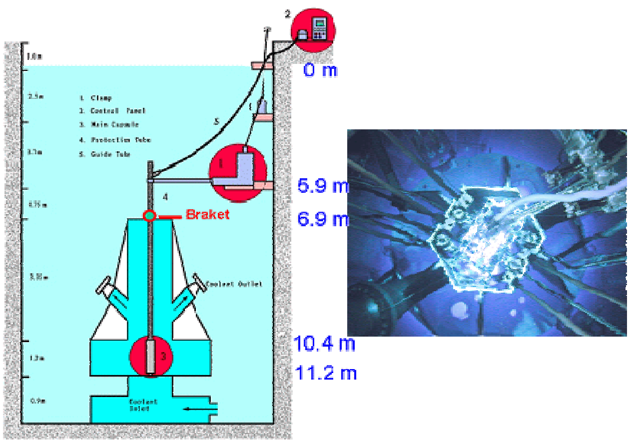

Figure 1. Schematic view of an instrumented capsule system and the reactor core during an irradiation test in HANARO.

3. Design Changes of the Bottom Guide of Capsule

To satisfy the reactor's seismic requirements, an instrumented capsule is supported or fixed at 4 points of the capsule the main body and protection tube. The capsule is fixed to the reactor structure by the bottom guide assembly of the main body and supported by the upper guide spring at the top of main body in the flow tube. As shown in Fig. 1, the capsule protection tube is also fixed by the in-chimney bracket and capsule robot arm.

First bottom guide assembly (Fig. 2, type A) of an instrumented capsule that was used in a high pressure and velocity of the coolant was designed and fabricated on the basis of the design of the HANARO 36-pin drive fuel and has been partially modified due to various undesirable matters which occurred during the irradiation tests. Several failures had occurred at the ring and arm parts of type A bottom guide assembly during the capsule irradiation tests. Although they were attributed to a coolant FIV (Flow Induced Vibration) failure, it is still unclear [6].

Figure 2. Design changes of bottom guide of the HANARO capsule.

From the 03M-06U capsule, a new bottom guide assembly (Fig. 2, type B(bolt)) was designed and applied to solve these problems and it's integrity was proven through in- and out-pile tests. However, several undesirable technical points about the bolt type bottom guide assembly were discussed at a specialist's committee. The bolt type bottom guide assembly was proven to have a larger vibration due to a severe coolant turbulence than the type A bottom guide assembly and an intrinsic loosening problem. Therefore, a new type of bottom guide assembly (Fig. 2, type C(dowel pin)) was designed and fabricated to solve these technical problems.

The dowel pin type bottom guide assembly is scheduled to be applied to the 04M-17U capsule that will be irradiated in the CT test hole of the HANARO of a 30MW reactor output power at 300℃ for 2 cycles(about 46days). Before the reactor irradiation test, the new bottom guide assembly will be tested and analyzed to satisfy several reactor requirements concerning the coolant flow and the vibration properties. These out-pile tests will be performed using the 1-channel and half core test facilities in the Engineering building. Fig. 3 shows the characteristics of the coolant flow and the vibration obtained with the various bottom guide assemblies. Through parametric out-pile tests, an optimal design of the dowel pin type bottom guide assembly was suggested.

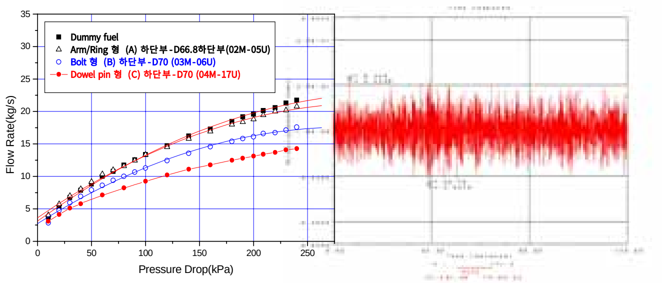

Figure 3. Characteristics of coolant flow and vibration of various bottom guide assemblies.

After a successful irradiation test of the 14M-17U capsule, the new design will be applied to all of material and creep capsules in HANARO.

3. Conclusion

A new bottom guide assembly (dowel pin type) was designed and out-pile tested to improve the safety of the HANARO irradiation capsule. The dowel pin type bottom guide assembly has improved the coolant flow property and the intrinsic safety. It will be applied to all of the material and creep capsules in HANARO.

Acknowledgement

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