Hydraulic Test for Performance Verification of Power Ramp Testing Technology to be applied in HANARO

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1. Introduction

We have developed power ramp testing technology to investigate fuel behavior under abnormal condition to be applied in HANARO OR irradiation hole [1]. The power ramp testing technology is able to adjust fission power of test fuel by axial movement. The movement of test fuel is driven by rotation of screw rod at the center of device, but hydraulic resistance is expected to be considerably large because the high speed coolant flows upward. In addition, applicability of electric motor, non-contact magnetic coupling, screw rod, bearing and the other components should be verified. Therefore, a hydraulic test was carried out to simulate the power ramp test under the condition of OR irradiation hole.

In this paper, the result of hydraulic test using a single channel test loop is shown. A mock-up test device was designed and fabricated to conduct the test. Aluminum dummy rods were used to simulate the test fuel. The visualization windows were machined for visual observation. The upward and downward movements of the dummy rods were investigated under the normal operation condition of HANARO. The result of this test will be used as a basic data for the development of power ramp testing technology.

2. Test device

Fig. 1 shows a schematic diagram of the fuel ramp testing technology to be applied in the HANARO OR irradiation hole. The test fuel is moved axially by the rotation of the screw rod located at the center of device. Before the test, the test fuel is located at the upper position to minimize depletion. The rotation of the screw rod is accomplished by non-contact magnetic coupling to isolate the electric components from the cooling water. At the start of the test, the power of the electric motor is transferred to the screw rod via non-contact magnetic coupling to move the test fuel to the proper position. The position of the test fuel is tracked by the control panel through the input of the number of turns of the screw rod.

Fig. 2 shows the fabricated mock-up test device designed for hydraulic test to verify the power ramp testing technology. The mock-up test device was fabricated to observe the effect of hydraulic test and to be able to exchange the components. If the coolant penetrates into the electric components, they can be damaged. Therefore, three O-rings were used for the isolation. In addition, visualization windows were machined to allow observation from the outside of the outer tube. The movement of the dummy rods by the rotation of screw rod could be set to adjust the speed from 1 to 300 mm per minute.

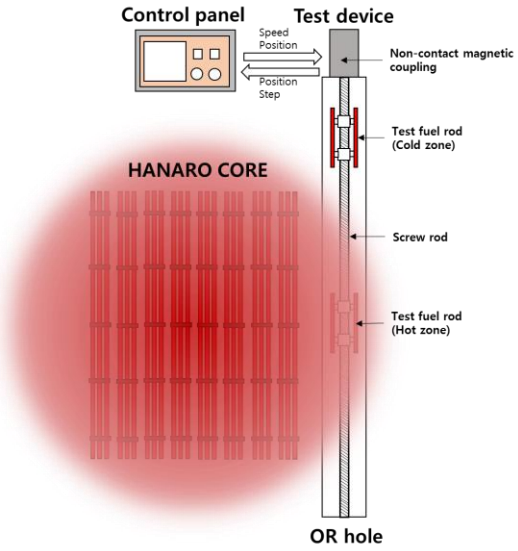

Fig. 1. A schematic diagram of the power ramp testing technology to be applied in the HANARO OR irradiation hole

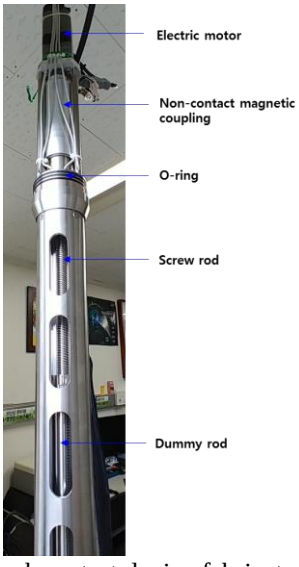

Fig. 2. The mock-up test device fabricated and designed for hydraulic test to verify the power ramp testing technology

3. Test results

The hydraulic test of the mock-up device was performed using the single channel test loop that is a facility that can simulate one test channel. The flow rate under the normal operation at the differential pressure of 209 kPa was not constant, because the cross-sectional area of the flow path was changed as the dummy rods were inserted or withdrawn into the channel. The most important item of this test is the possibility of axial movement of test fuel by screw rod under operating condition in spite of high hydraulic resistance. Fig. 3 shows the axial position of the dummy rods according to the test time, which is the result of insertion and withdrawal into the channel four times at a rate of 5 mm per minute. The axial movement of dummy rods was found to be performed without any major problems. Therefore, the axial driven mechanism of test fuel through the screw rod can be applied for the power ramp test.

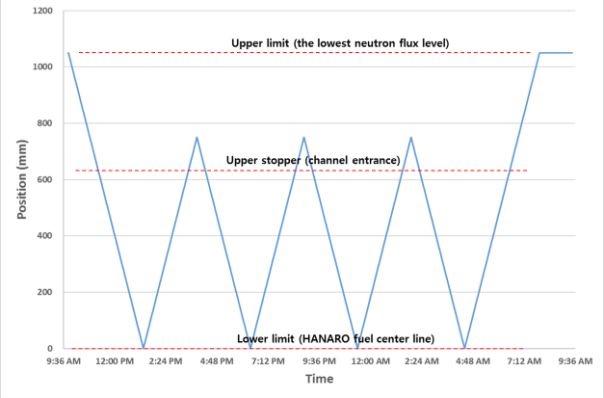

Fig. 3. The axial position of the dummy rods according to the test time

However, some improvements were necessary through the hydraulic test.

(1) The axial movement of the test fuel was not satisfactory by visual observation at the end of the flow tube of the single channel test loop where the hydraulic resistance is predicted to be the greatest. It is considered that the effect is accelerated because the flow hole of the upper stopper is not machined in the mock-up device. It is necessary to compare the hydraulic behavior after the improvement of upper stopper.

(2) A bearing component was damaged by hydraulic resistance. It is necessary to properly change a substitute.

(3) The O-rings for isolating the electric components from the coolant water were broken. The design of the O-ring connection component should be improved.

(4) The positional deviation of the dummy rods tracked in the control panel occurred. It is necessary to improve the design of the counter sensor.

4. Conclusions

The mock-up device was prepared for the verification of the power ramp testing technology to be applied in HANARO OR irradiation hole and hydraulic test was conducted. It was verified that the power ramp test can be sufficiently achievable by the axial driven mechanism of the fuel rod through the rotation of screw rod using non-contact magnetic coupling. However, some improvements and additional tests are needed. The results of this test will be used as an important data for realization of power ramp testing technology in the future.

REFERENCES

[1] S. Yang, S. Park, H. Cho, Y. Shin, M. Cho, K. Choo, B. Jun, Evaluation of Application of Fuel Power Control Test in HANARO, Transactions of the Korean Nuclear Society Autumn Meeting 2017, October 26-27, 2017, Gyeongju, Korea.