Endurance Test for the Lifetime Extension of the Shutoff Units in HANARO

Yeong-Garp Cho, Jung-Hee Lee, Sang-Ik Wu, Jeong-Soo Ryu, Jong-Sup Wu, Kyoung-Rean Kim
HANARO Center, Korea Atomic Energy Research Institute
150 Deokjin-dong Yuseong-gu Daejeon, 305-353, R.O. KOREA
Tel: 82-42-868-8487, E-mail: ygcho@kaeri.re.kr

1. Introduction

The HANARO, an open-tank-in-pool type research reactor of a 30MWth power in Korea, has been operating for 10 years since its initial criticality in February of 1995.

The reactor trip or shutdown is accomplished by four shutoff units by insertion of the shutoff rods. The shutoff rod(SOR) is actuated by a directly linked hydraulic cylinder on the reactor chimney, which is pressurized by a hydraulic pump. The rod is released to drop by gravity, when triplicate solenoid valves are de-energized to vent the cylinder.

This paper summarizes the endurance test results for the lifetime extension of the shutoff units from the view point of operation cycles.

2. Drop Cycle and Life Extension Program for the Shutoff Units

The reactor power has been gradually increased to the full power through the service period. Therefore the reactor age is very young from the viewpoint of the ageing effect on the reactor structure and components by a neutron irradiation when considering the expected reactor lifetime. Nevertheless, the shutoff units have aged more rapidly than the other components because the number of rod drop cycle was much higher than that that expected at the design stage. The system commissioning tests, periodic performance tests, and the short operation cycles for the first decade have contributed to the high frequency of the rod drop. As of the end of 2004, the drop cycles of SOR reached 1091, 73% of the endurance-verified number, 1500 cycles. It is certain that the number of SOR drops will reach the verified numbers far before the end of the reactor life. It is thought that the high cycles of impact loads by the drop of the shutoff rods are of more concern from the safety point of view rather than by the wear of the moving system which can be detected by the change of the drop performance.

Therefore, we have tested in 2005 an additional endurance test for the extended number of drops with a spare unit at an out-pile test facility as shown in figure 1. The test facility is composed of a 1/2- core test loop of Hanaro, a full system of shutoff unit, and an automatic measurement system. The 1/2-core test loop was built to simulate the flow pattern of Hanaro reactor with a full sized half core. The hydraulic system was installed as similar as possible to those in HANARO.

We installed the spare unit which had already been tested up to 1500 cycle's drop during the endurance test at the design verification stage, and tested more than 4000 cycle's drop to verify the validity of the use of the current shutoff units for the expected lifetime of the reactor, 30 more years.

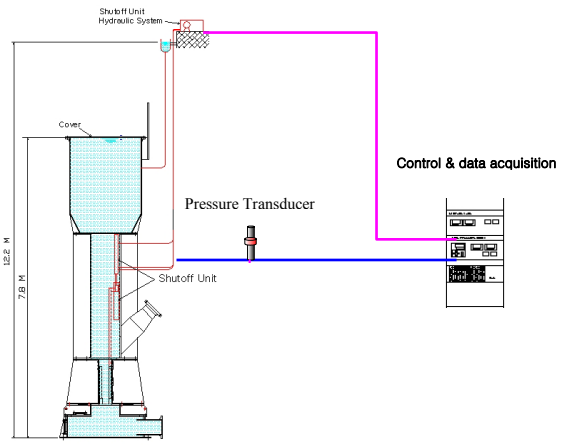

Fig. 1 Experimental Facility for Shutoff Unit

3. Endurance Test

The test facility maintained the test conditions such as core flow rate, water temperature, and water level as similar as in HANARO reactor. The hydraulic system of shutoff unit was calibrated to get proper margins around the normal settings of system control valves.

The shutoff unit was operated more than 6000 cycles including system commissioning and calibration. During the endurance test, all moving parts were dismantled and inspected 6 times, about every 1000 cycles, to find any abnormal finding or detectable amount of wear.

4. Test Results

Figure 2 shows the drop time and withdrawal time for the shutoff rod during the endurance test. The withdrawal times are mostly in the range of 30-60 seconds with minor adjustment of control valves within ±1/4. The withdrawal time was sensitive to the pool temperature variation as same as in HANARO reactor due to the inherent characteristics of the hydraulic system. The drop times for 647 mm stroke are very similar to those in HANARO and less than 1.13 seconds except some cases due to the change of pool temperature and water level. After calibration of all systems, during the scheduled endurance test more than 4000 cycles, the shutoff unit does not show deterioration of the performance.

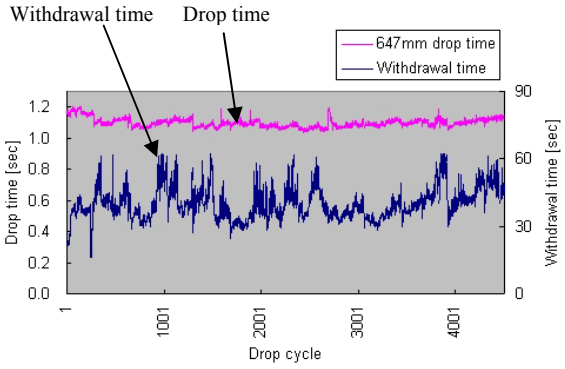

Fig.2 Performance during Endurance Test

The visual inspection results for the moving parts showed very minor scratches on rubbing surfaces such as the piston, cylinder, absorber rod, shroud tube and flow tube. The maximum amount of wear measured for main components are 0.025mm at the damper piston and 0.03mm at the carriage assembly after more than 6000 cycle's operation. These wear did not have an effect on the performance of the shutoff unit. The structural integrity of the absorber assembly, which experienced the impact loads on connecting pins of the absorber rod during the rod drop by gravity, have been kept during the endurance test.

The performance of the down switch, which is for indication of rod full-down, was irregular but it was not deteriorative through the whole test period.

5. Conclusions

For the 10 years of the HANARO operation, we confirmed that the performance and integrity of the shutoff units are being maintained well with a few replacements of the off-the-shelf items. There is no problem on mechanical components installed in the reactor structure, but the drop cycles for shutoff rods are much higher than the expected number. Therefore we have performed an additional endurance test to verify the performance and integrity for the lifetime extension of the existing shutoff units. We confirmed that the shutoff unit keeps the consistent performance and the structural integrity without remarkable deterioration during the extended drop test up to 4000 cycles. This will give us a confidence to use the current shutoff units for 30 more years from the view point of mechanical performance.

References

[1] Y.G. Cho, J.H.Lee, J.S.Wu , Y.H.Choung, , "Status of Life Extension Program for HANARO Shutoff Units", Proceedings of KNS Sprig Meeting, 2005