Verification Test for Improved CRDM Damping Mechanism with Dual Hydraulic Cylinder

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1. Introduction

The control rods in a reactor drop by gravity to shutdown the reactor within a certain time limit. It is important to optimize the drop time not only for a safe shutdown but also for the structural integrity and lifetime of the CRDM by considering the impact force during the drop. We have done design verification tests to verify the performance and endurance of an improved damping mechanism which has a dual hydraulic cylinder proposed for an Advanced HANARO Reactor (AHR).

2. Performance and Endurance Test of the CRDM Damping Mechanism

In the CRDM of the HANARO, the damper cylinder and the internal spring are the only mechanisms to reduce the drop speed for the last 80mm from the total drop stroke of 700mm. The drop time is unnecessarily too short and causes high impact forces on the components.

The new concept for the CRDM damping mechanism was developed with an international patent for the AHR. It is a dual-hydraulic cylinder type to reduce the excessive impact force by the distribution of the drop energy into the total stroke. In addition to the HANARO damping mechanism, it has a main cylinder, a flow adjustable main piston and a flow adjustable piston rod as shown in Fig. 1.

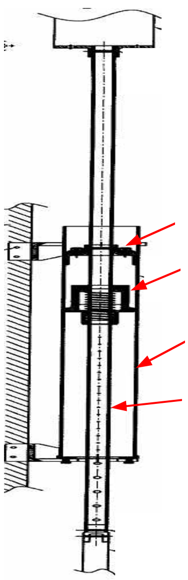

Fig. 1 Improved CRDM damping mechanism

The test facility is composed of a dummy weight of a control rod and its drive mechanism with the damping mechanism installed in the test pool. Optical sensors, an accelerometer and a signal analyzer are the instruments to measure the drop times and impact accelerations at 620mm which is damping start point and 700mm which is the final destination of the control rod.

For the purpose of with a reasonable range of drop times and impact loads of the control rod, the performance test was done in 2007 to find the optimum settings of the design parameters; the gap between the main cylinder and main piston, the gap between the main cylinder and the piston rod, the number of orifice holes on the main piston and the piston rod, and the size of the orifice holes on the damper cylinder. The tests were conducted for a total of 200 times with various geometric opening or orifice conditions [1].

The endurance test of drop test was done in 2008 at the optimum setting for 10,000 cycles to check any variation on the drop times and impact loads.

3. Results and Conclusions

The typical test result of the drop time and impact loads for HANARO CRDM is shown in Fig.2. The impacts are 42g at 620mm and 72g at 700mm for the same drop time as in HANARO.

Figure 3 and 4 show consistent values of the drop curves and drop times during 10,000 cycles for the optimized setting of the improved damping mechanism.

Figure 5 and 6 show the drop time and impact loads at the first cycle and the last cycle of the endurance test for the improved damping mechanism. Fig. 7 and 8 show the history of impact loads during the endurance test. The impact loads are below 17g at 620mm and 6g at 700mm which are less than 1/4 of the HANARO CRDM.

We have verified that the new damping mechanism having a dual hydraulic cylinder shows a considerable improvement from the impact loads. These results are good enough to adopt the improved damping mechanism for the new research reactors.

References

[1] Choon-Gyo Seo, et al. Improvement of the CRDM Damping Mechanism for an AHR , Transactions of the Korean Nuclear Society Spring Meeting, , 2008

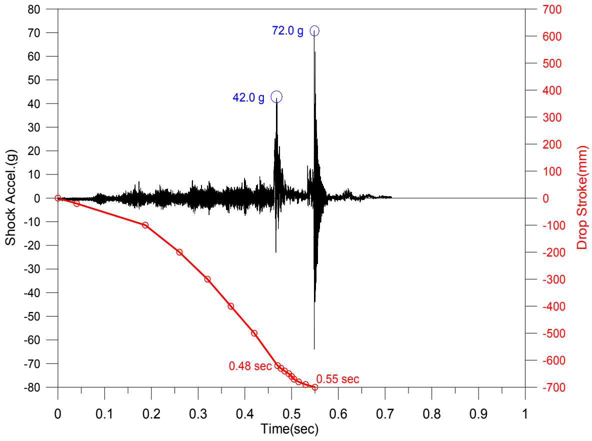

Fig.2 Drop impact for HANARO CRDM

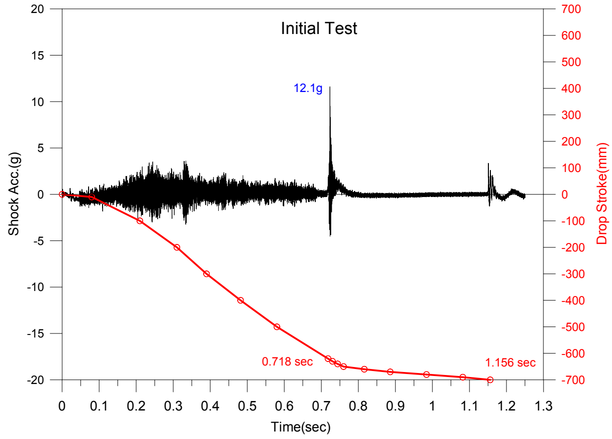

Fig.5 Drop impact at the first drop for improved CRDM

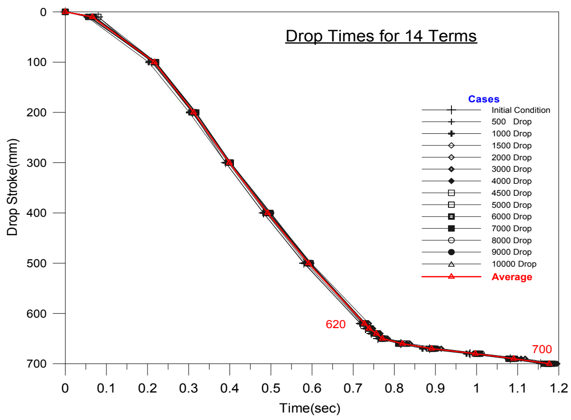

Fig.3 Drop curve for improved CRDM

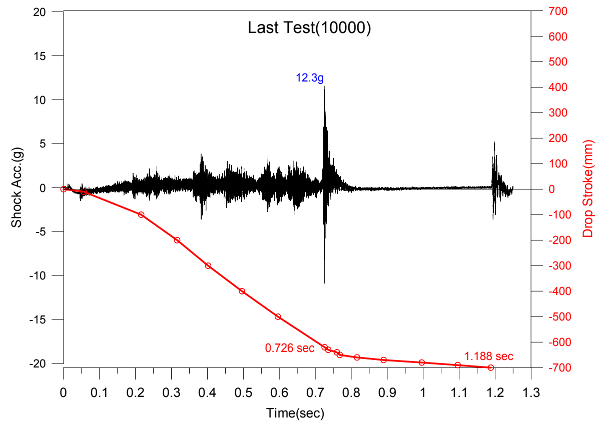

Fig.6 Drop impact at the last drop for improved CRDM

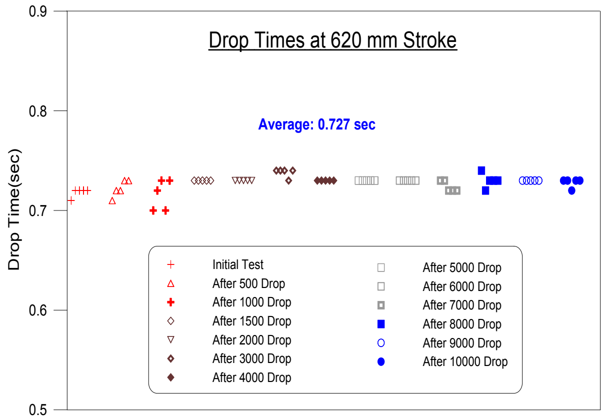

Fig.4 Drop time for improved CRDM

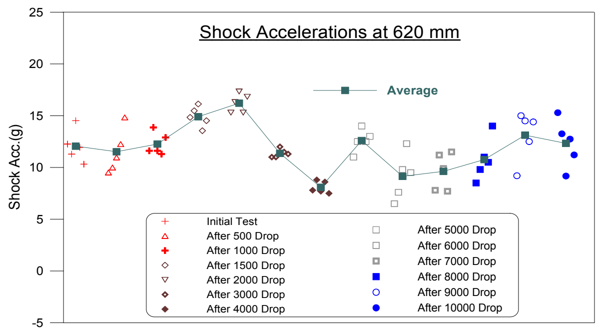

Fig.7 Drop impact at 620mm for improved CRDM

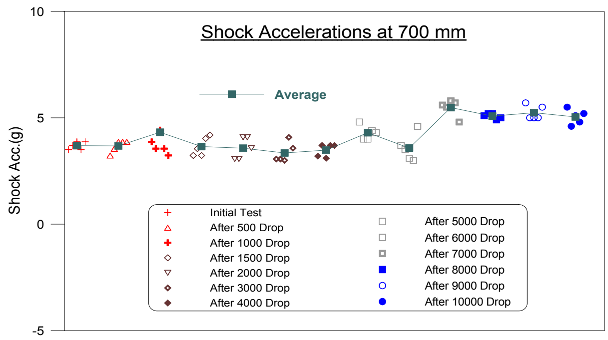

Fig.8 Drop impact at 700mm for improved CRDM