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Improvement the CRDM Damping Mechanism for an AHR

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1. Introduction

A control absorber unit or control rod drive mechanism (CRDM) is a part of a reactor regulating system, and its function is to insert, withdraw or maintain a neutron absorbing material at any required position within a reactor core, in order to control the reactivity of the core [1,2]. The gravity drop of a neutron absorber is mostly used 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. This study is to verify the performance of a new concept of the damping mechanism proposed for an Advanced HANARO Reactor (AHR).

The performance of the damping mechanism of the AHR was compared with that of HANARO by a performance test with a simulated CRDM at a test pool.

2. Performance 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 8cm from the total drop stroke of 70cm. The drop time is unnecessarily too short and causes high impact forces on the components. The new concept for the CRDM damping mechanism for an AHR is a dual-hydraulic cylinder type to reduce the excessive impact force by the distribution of the drop energy into the total stroke. This mechanism includes a main cylinder, a flow adjustable main piston and flow adjustable piston rod in addition to the HANARO damping mechanism as shown in Fig. 1.

The test facilities include a dummy weight of a control rod and its drive mechanism with the damping mechanism installed in the test pool as shown in Fig.2. Optical sensors, an accelerometer and a signal analyzer are the instruments to measure the drop times and impact accelerations at 620mm and 700mm. The performance test was done to find the effects of the 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.

3. Results and Conclusions

The test results for the typical cases are shown in Table 1. Fig. 3 and 4 show the drop curves and the time history of the vertical accelerations for the typical cases for HANARO (Case 1-6) and AHR (Case 2-4). The drop velocity curves for two kinds of the damping mechanisms are compared to each other in Fig. 5. The impact values for the new damping mechanism for the AHR are only 15-20% of that for the HANARO.

We verified that the new damping mechanism shows a considerable improvement with a reasonable range of drop times of the control rod.

A theoretical approach for the drag effects of the hydraulic behavior using the obtained test data and the endurance test will be done for the detail design of the CRDM in the future.

References

[1] KAERI, Design manual for KMRR Control Absorber Unit, Technical report, 1990.
[2] KAERI, KMRR Control Absorber Unit Test Report, Technical report, 1994.
[3] J.M. Donis, A mathematical model of a control rod drop, Nuclear engineering and Design, Vol.23 p.107, 1972.

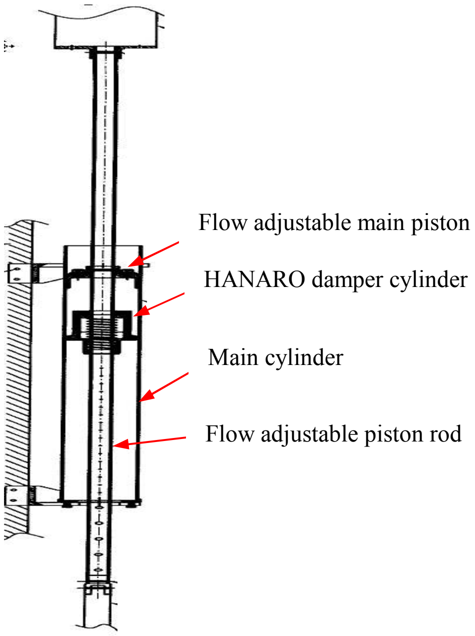

Fig. 1 CRDM damping mechanism for AHR

a. Dummy weight b. Damping Mechanism c. Test pool d. Drive mechanism

Fig. 2 Facilities for CRDM damping test

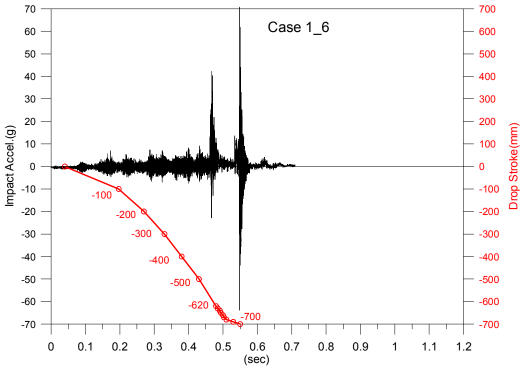

Fig. 3 Test results for CRDM of HANARO

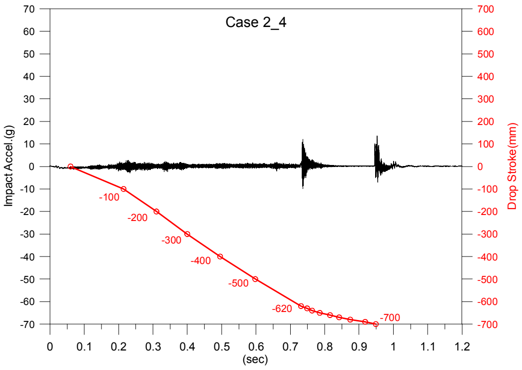

Fig. 4 Test results for CRDM of AHR

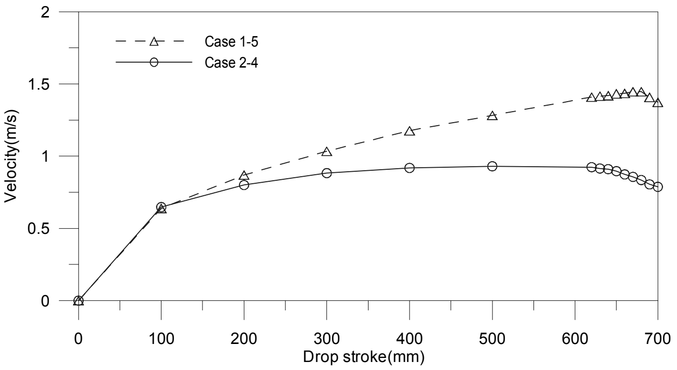

Fig. 5 Relation between drop stroke and velocity

Table 1 Average drop time and vertical acceleration

Case		Cylinder opening (mm)	Piston orifice	Flow area between main cylinder and piston rod (mm^2)	Piston rod orifice	Drop time at 620 mm (sec)	Drop time at 700 mm (sec)	Peak acc.(g) at 620 mm	Peak acc.(g) At 700 mm
HANARO	1-1	2.0/ 2.0	closed	1910	none	0.420	0.470	51.0	48.5
	1-2	3.0/ 3.0	closed			0.430	0.470	46.5	63.5
	1-3	2.5/ 2.5	closed			0.420	0.460	55.0	73.3
	1-4	2.5/ 2.5	closed			0.443	0.493	51.6	71.6
	1-5	1.0/ 1.0	closed			0.440	0.510	49.7	67.0
	1-6	0.0/ 0.0	closed			0.447	0.530	56.0	61.7
AHR	2-1	0.0/ 0.0	open	110	various	0.810	1.020	5.1	11.2
	2-2	0.0/ 0.0	open			0.775	0.996	6.2	11.5
	2-3	0.0/ 0.0	open			0.733	0.950	6.0	11.0
	2-4	0.0/ 0.0	open			0.731	0.949	11.6	13.2