Measurement of Physical Clearance for SOR/CAR Movement in HANARO

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1. Introduction

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

The reactor structure is composed of a stainless steel plenum and grid plate, a zircaloy reflector vessel, an aluminum chimney, and zircaloy flow tubes as fuel channels.

The shutoff rod(SOR) is actuated by a directly linked hydraulic cylinder on the chimney, which is pressurized by a hydraulic pump. The rod is released to drop by gravity for reactor trip.

The control absorber(CAR) is actuated by electric stepping motor-powered ball-screw drives at the pool top. The rod's lower carriage is linked to a middle carriage at the chimney top (i.e., in place of the SOR's cylinder), which is linked in turn to the drive through a long, angled tie-rod. For emergencies, an electro-magnet coupling can release the rod and carriages from the ball nut and they drop into the core. Figure 1 shows a plan view for the main components of the reactor including the inner shell, flow tubes, the absorbers rods composed of 4 SOR's and 4 CAR's.

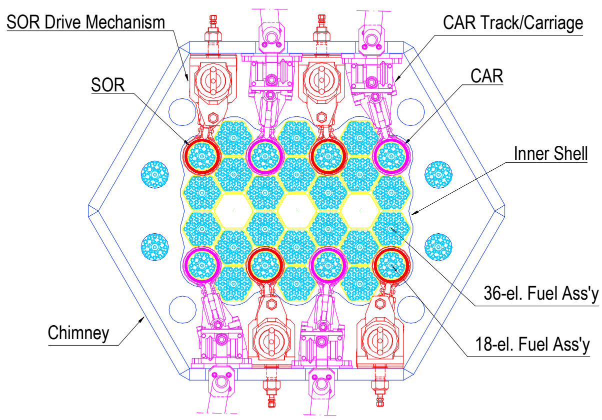

Fig.1 Plan View of Reactor Core

The absorber is made of hafnium and zirconium welded together. The flow tube and shroud are made of zirconium alloy. It is expected that the dimensional changes occur on the zirconium parts due to an irradiation effect. There are relatively small clearances for the vertical movement of the absorbers, at lower position between the flow tube and the absorber, and at upper position between the absorber and the shroud as shown in figure 2. The periodic measurement of the clearances is required every 10 years to confirm the smooth movement the absorbers in surrounding parts.

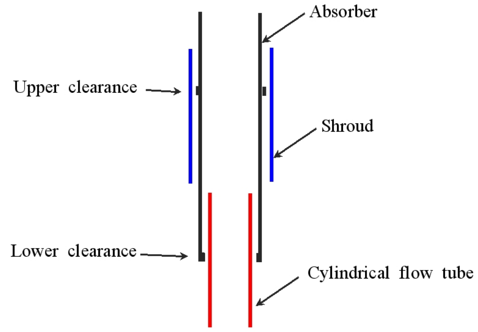

Fig.2 Configuration of Absorber and Surrounding Parts

2. Methods and Results of Measurement

We developed various kinds of special tools to measure outer diameter of the cylindrical flow tube, inner diameter of the absorber lower bearing, outer diameter of the absorber upper bearing, and inner diameter of the shroud.

The reactor components can not be removed to air because these have been irradiated for 11 years reactor operation. The pool water can be drained down to around chimney top. All the tools were designed for the work to be possible from the pool top or chimney top remotely.

The outer diameter of the cylindrical flow tubes was measured as installed in the core by a special tool, as shown in figure 3, with a 4m extension tube. The concept of this tool is a GO/NO-GO type with a ring gauge which is replaceable with other sizes. This tool can be extended with a 12 m long tube if we need the measurement work without the drain of pool water.

The inner diameter of the absorbers was measured in the service pool as removed from the core by the 6m absorber gripper and the GO/NO-GO type plug gauges mounted on a rack. There are GO/NO-GO type ring gauges mounted on the same rack to measure the outer diameter of the absorbers at the same time. Figure 4 shows the measurement work for the absorber in the service pool.

The dimensional variation along the length was expected not to be considerable for flow tubes and absorbers which were machined. Therefore the GO/NO-

GO type gauges were enough to measure the maximum or minimum dimensions to check the minimum clearance.

The shroud was deformed by about 1-2mm in roundness during the fabrication around the upper and lower brackets which were welded to the outer surface of the shroud. Therefore we developed a special tool for the shroud to measure the actual diameter for every designated position. The concept of this tool is a remote operable caliper for inner diameter measurement. Figure 5 shows the measurement concept of the inner diameter of the shroud. The inner diameter of two shrouds was measured in the service pool as removed from the core, but other three shrouds were measured as installed in the core.

The GO/NO-GO type plug gauge and ring gauge were made of 0.1mm increment. The accuracy of the tool for the shroud measurement is 0.05mm. All the as-built dimensions of the plug gauges, ring gauges, and shroud gauges were qualified with an accuracy of 0.01mm.

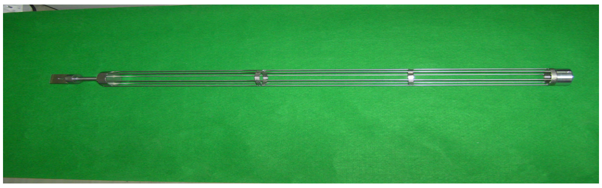

Fig.3 Ring gauge for flow tube

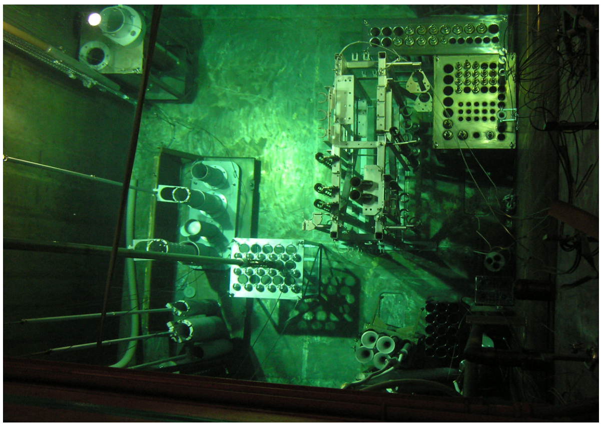

Fig.4 Diameter measurement absorber in service pool

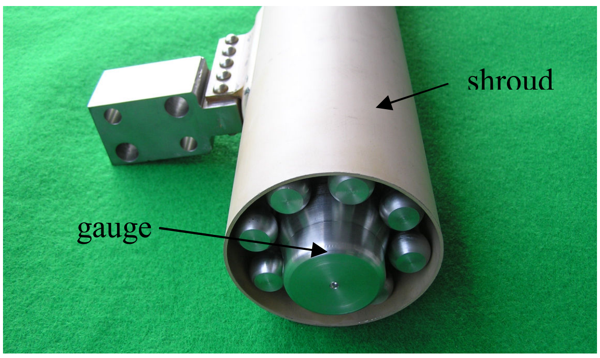

Fig.5 Concept of diameter measurement of shroud

We performed in 2006 the first measurement ever, for four SOR(SOR1 to SOR4) sites and one CAR(CAR4) which is the severest site considering the as-built dimension of the fabrication history docket. All the operation was successful and efficient even with the long tools. The minimum clearance is calculated using the measured data for each site as in the table 1. The learances are bigger then the requirements (0.2mm in diameter) for the smooth movement of the absorber surrounded by a flow tube inside and a shroud outside. The absolute values of the measured dimensions are close to the original values for all parts.

Table 1. Result of the measurement (mm)

Measured value	SOR1	SOR2	SOR3	SOR4	CAR4
Flow tube max. OD (A)	62.70	62.70	62.79	62.62	62.70
Absorber min. ID (B)	63.38	63.38	63.38	63.38	63.38
Lower clearance (C=B-A)	0.68	0.68	0.59	0.76	0.68
Absorber max. OD (D)	81.79	81.79	81.79	81.79	81.79
Shroud min. ID (E)	82.80	82.80	82.60	82.80	82.80
Upper clearance (F=E-D)	1.01	1.01	0.81	1.01	1.01

3. Conclusions

We performed, in 2006, the first dimensional measurement to check moving clearance for absorbers (SOR and CAR). The remote measurement for the absorbers, flow tubes and shrouds with the specially developed tools was successful. We confirmed that there is no considerable change in dimensions due to the neutron irradiation, and all the absorbers and the surrounding parts maintain enough clearances for the safe reactor operation.

References

1. Yeong-Garp Cho, Jong-Sup Wu, Jung-Hee Lee, Jeong-Soo Ryu, Yun-Hang Choung and Byung-Jin Jun, 'Status of Ageing for Reactor Components in HANARO', Proceedings of the International Symposium on Research Reactor and Neutron Science, In Commemoration of the 10th Anniversary of HANARO - KAERI(2006)