〈Technical Note〉

INVESTIGATION OF THE CNS HOLE SHAPE AND A PROPOSED INSTALLATION METHOD FOR A VACUUM CHAMBER FOR THE HANARO REACTOR

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The HANARO reactor has a vertical hole for a cold neutron source (CNS) in the heavy-water reflector tank, i.e., the CNS hole, which was considerably deformed during its welding to the horizontal cold neutron (CN) beam tube. This paper presents an investigation of the form of the CNS hole for the optimal design of the a vacuum chamber for the CNS. In addition, the installation method of the vacuum chamber into the CNS hole for minimizing the water thickness between the vacuum chamber and the nose of the CN beam tube is proposed.

KEYWORDS : HANARO, Cold Neutron Source, CNS hole, Vacuum Chamber, Water Film

1. INTRODUCTION

IThe HANARO, n open-tank-in-pool type research reactor of 30MWth power in Korea, has been in operation for 10 years since its initial criticality in February 1995. The reactor has a vertical hole for the cold neutron source (CNS) in the heavy water reflector tank, the CNS hole, which was directly welded to the nose of a horizontal cold neutron (CN) beam tube for extracting cold neutrons. The CNS hole is a Ø160mm x 1200mm long tube welded to a zircaloy reflector vessel. It has a center hole, Ø42mm on the grid plate at the bottom of the CNS hole, and a flange welded to the aluminum chimney at the top of the CNS hole. The CNS hole was deformed during welding to the CN beam tube, as shown in Figure 1.

Therefore, the diameter of the hole was reduced by about 3mm at the nose of the CN beam tube, and the concentricity was changed to match those of the grid plate hole and the chimney flange.

A vacuum chamber, which contains the main part of the CNS, is to be installed in the CNS hole with a light water film that should be as thin as possible to reduce the cold neutron absorption. Therefore, the real dimensions of the CNS hole need to be investigated, especially the diameter and eccentricity at the elevation of the nose, to design and install the vacuum chamber.

Unfortunately, the real dimensions of the CNS hole are not consistent with its design in terms of diameter, straightness, and concentricity. Thus, we measured them in 2004 to obtain accurate values.

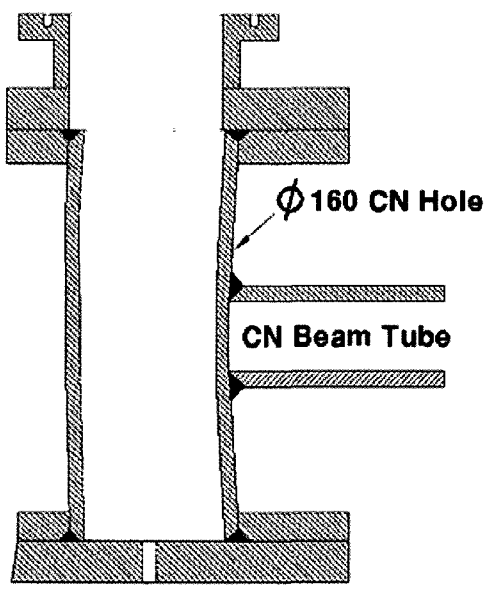

Fig. 1. Section View of CNS Hole

2. MEASUREMENT OF THE CNS HOLE SHAPE

Because performing measurements under the high radiation field was very difficult work, special tools and a stable working platform were required to measure the dimensions of the hole located 12m below the uppermost water level in the reactor pool. A mechanical dial gauge was a good probe for obtaining accurate and reliable data under the high radiation field. The main part of the measuring tools was a dial gauge that runs vertically on two linear motion guides mounted on a robust shaft. The shaft of the tool could also be rotated circumferentially at each 15 degrees, as shown in Figure 2, while its axis was maintained on the line of sight connecting the center of the grid plate hole and the center of the chimney flange.

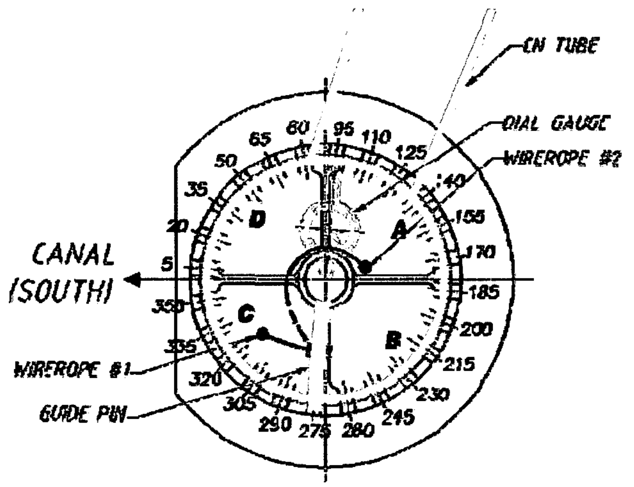

Fig. 2. Circumferential Position Measurement

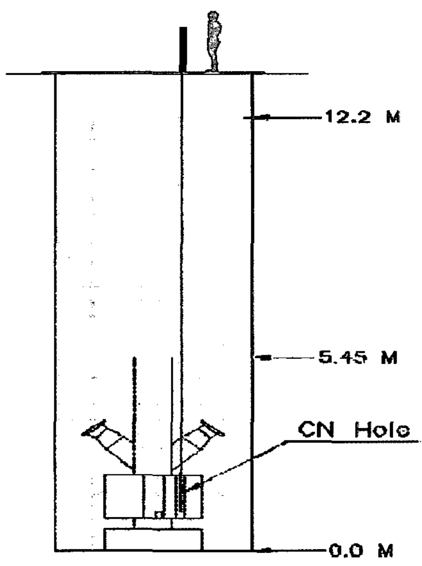

Fig. 3. Measurement Concept of the CNS Hole Shape

The radius of the CNS hole could be measured circumferentially and vertically. The positioning of the dial gauge was done via manipulation at the top of the pool with a reference rule and position guide, as shown in Figure 3. The accuracy and repeatability of the measurement data were verified by using a test rig with a dummy CNS hole.

The dial gauge, with an accuracy of 0.01mm, was readable by a radiation-hard camera and a kit of underwater mini-lamps. From the measured radii, we obtained valuable data, such as the diameter and straightness for most of the area of the CNS hole and the eccentricity from the center of the grid plate hole and the chimney flange.

3. MEASUREMENT RESULTS AND VERIFICATION

All the measured data were plotted using Microsoft Excel to know the shape of the CNS hole and the thickness of the light water when a vacuum chamber of a certain size is installed.

Figure 4 shows the radius data at the nose of the CN beam tube and at the opposite part along the axis of the CNS hole. Figure 5 shows a top view of the radius at the elevation of the nose. We confirmed that the shape and dimensions are similar to the as-built information on the CNS hole.

Introducing plug gauges into the CNS hole, we verified that the accuracy of the measurement is better than 0.11mm in diameter.

Figure 6 shows the thickness of the light water film when a tube of Ø156.6mm is installed in the CNS hole. The water thickness at the nose is almost zero. This result confirms that the water film at the nose could be minimized

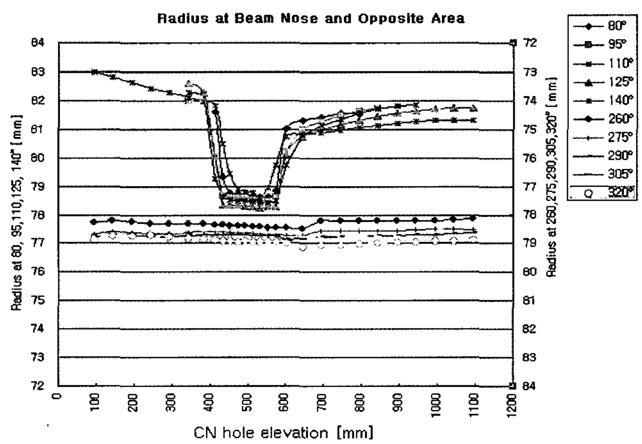

Fig. 4. Radius of the CNS Hole - Side View

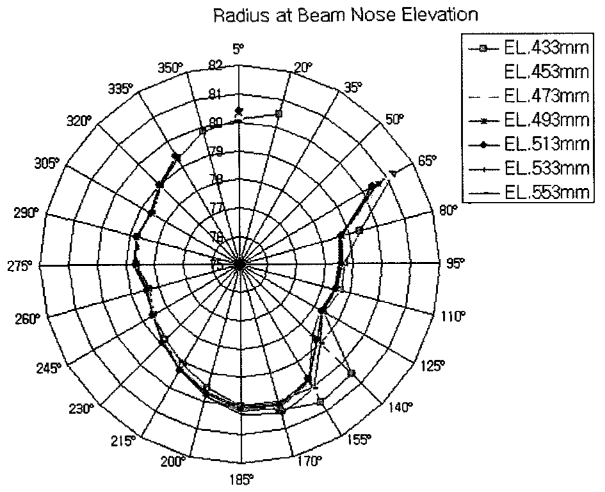

Fig. 5. Radius of the CNS Hole at the Nose of CN-Beam Tube – Top View

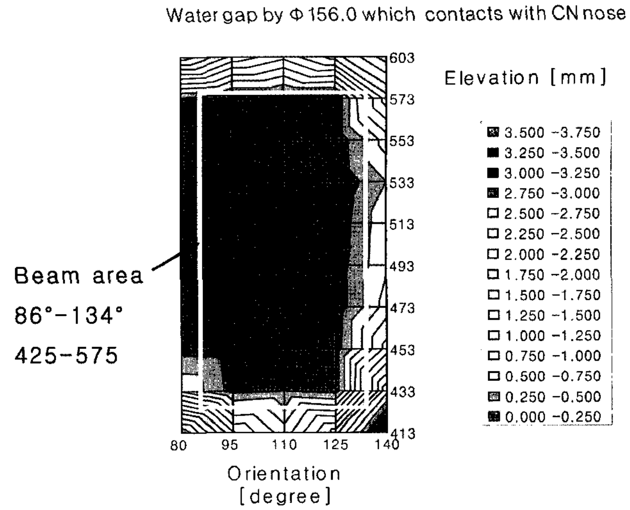

Fig. 7. Thickness of Water Film at Nose with a Proposed Vacuum Chamber of Ø 156.0 mm

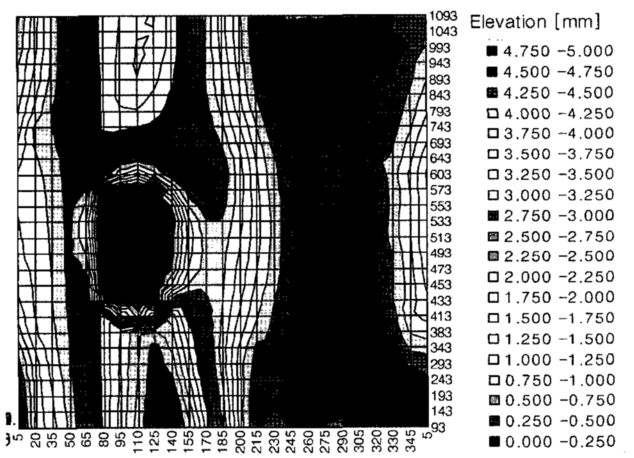

Fig. 6. Thickness of Water Film around a Maximum Tube of Ø 156.6 mm

with the installation of a properly sized vacuum chamber.

A proper clearance between the vacuum chamber and the CNS hole is necessary for practical installation. Therefore, we propose to install a vacuum chamber slightly smaller than the tube with the maximum available diameter and to lean the vacuum chamber against the nose of the CN beam tube to minimize the thickness of the water film. Figure 7 shows the thickness of the light water at the nose when the diameter of the vacuum chamber is Ø156.0 mm. About 85% of the beam area maintains a water thickness less than 0.25 mm. Thicker water film at the edges is unavoidable unless the shape of the vacuum chamber is machined according to the local deformation at the edges of the nose.

4. IMPLEMENTATION OF THE INSTALLATION METHOD

The vacuum chamber is set at the desired position by the two fixing points as shown in Figure 9. The assembly of the vacuum chamber has spring mechanisms at the grid plate hole and the chimney flange to obtain a proper horizontal force, which results in contact between the vacuum chamber and the nose of the CN beam tube when the vacuum chamber is inserted. The top of the vacuum chamber assembly should be firmly bolted and fixed at the chimney flange, horizontally and vertically. However, the bottom should be free in the vertical direction at the position of the grid plate hole to allow the thermal cycle of the CNS operation. The assembly should also maintain proper horizontal force at the nose of the CN beam tube.

On the reactor chimney wall, at about 1.5m above the chimney flange, a clamp would be installed to support the vacuum chamber assembly in the horizontal direction only. Figure 8 shows a conceptual configuration of the vacuum chamber secured at the chimney flange and the chimney wall. Figure 9 shows the vacuum chamber mounted at the chimney flange and the grid plate hole.

To minimize the water thickness between the vacuum chamber and the nose of the CN beam tube, the installation and mounting method will be verified using a dummy chamber assembly in a mock-up facility.

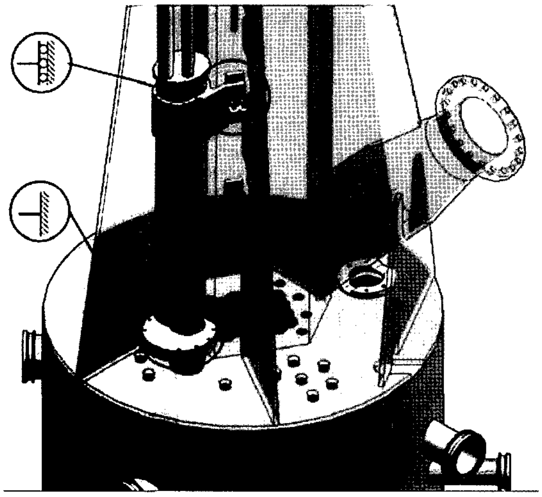

Fig. 8. Mounting of the Vacuum Chamber at the Chimney Flange and Chimney Wall

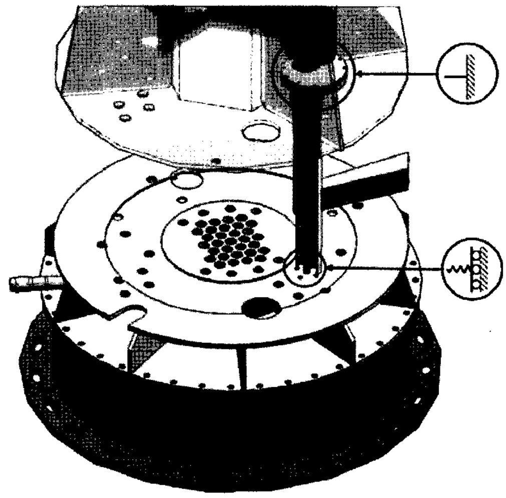

Fig. 9. Mounting of the Vacuum Chamber at the Chimney Flange and Grid Plate Hole

5. CONCLUSIONS

The CNS hole in the HANARO reactor was considerably deformed during welding to the horizontal CN beam tube. The shape of the CNS hole was measured and investigated for an optimum design of the vacuum chamber for the cold neutron source. The installation method of the vacuum chamber into the CNS hole was proposed based on the measured data and will be verified by a mock-up test to obtain a detailed configuration.

REFERENCES

[1] Yeong-Garp Cho, Yun-hang Choung, Jung-Hee Lee, Jeong-Soo Ryu and Young-Ki Kim, "Measurement of CN Hole Dimensions for Optimal Design of Cold Neutron Source", Proceedings of the Korean Nuclear Society Autumn Meeting, 2004