Basic Design of the HANARO Cold Neutron Source Using MCNP Code

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1. Introduction

The design of the Cold Neutron Source (CNS) for the HANARO research reactor is on progress. The CNS produces neutrons in the low energy range less than 5meV using liquid hydrogen at around 21.6 K as the moderator. The primary goal for the CNS design is to maximize the cold neutron flux with wavelengths of around 2 ~12 Å and to minimize the nuclear heat load.

In this paper, the basic design of the HANARO CNS is described.

2. Model for MCNP Simulation

For the performance evaluation of the CNS, the brightness was analyzed at the entrance of the CN guide using the MCNP 4C code [1], to count the neutrons entering into the guide within the critical angle. The entrance of the CN guide is placed in 144cm away from the CNS center. The brightness is defined as the "neutron flux per unit wavelength per unit solid angle at the entrance of the CN guide."

In the previous study on the CNS design [2], it was found that a double cylinder with open cavity type was suitable for the HANARO moderator cell. The diameter of the moderator cell has been selected as 130 mm to maximize the moderator surface.

The radial thickness of the liquid hydrogen is maximum 3cm and the inner cylinder is shifted towards the CN beam tube by 50 mm. The wall of the moderator cell is made of Al 6061 T6 and has the thickness of 1.2 mm. The vacuum chamber made of Al 6061 T6 has the wall thickness of 8 mm. The moderator for the CNS is the liquid hydrogen and is allowed 20% of void fraction.

3. Basic design

The CNS axial thickness from the top of the inner cylinder has been selected as 30 mm to maximize the cold neutron brightness of less than 5 meV and to minimize the nuclear heat load [3]. When the liquid hydrogen is circulated in the thermo-siphon loop, there will be no flooding phenomenon maintaining the certain liquid level of the hydrogen [4]. The inner cylinder is open toward the beam tube to minimize the possibility that the cold neutron can get the energy by up-scattering. To optimize the height of the inner cylinder, sensitivity analyses were conducted by changing the height of the double cylinder type with open cavity. As a result, the optimum point of cold neutron brightness is found in a 150 mm height which is consistent with the CN beam tube height. The open cavity of the inner cylinder is alined with the CN beam tube horizontally; it is assumed that the open cavity of the inner cylinder may increase the area is facing that the CN beam tube.

The sensitivity calculations were conducted on varying the curvature of the outer cylinder; the effect of the curvature is negligible on the cold neutron brightness. To increase the fluidity of the hydrogen, the upper and lower parts of the outer cylinder are modified to have a curved line.

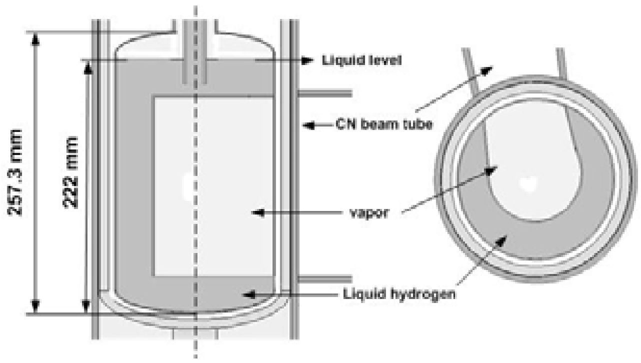

Fig. 1 The HANARO CNS:
Double cylinder type with open cavity

The basic design philosophy of the HANARO CNS is to rely on the manufacturing feasibility and the fluidity of the hydrogen as well as the higher brightness and lower heat load. The design based on these concepts is shown in Fig. 1. The height of the moderator cell is 257.3 mm and the liquid hydrogen, 0.974 liter, is filled up to 222 mm height in the moderator cell.

The peak point of the cold neutron brightness shown in Fig. 2 lies at 2 Å. The brightness of the HANARO

CNS is about 33 % higher than that of the NBSR below 6 Å, however, is about 12 % less above 9 Å.

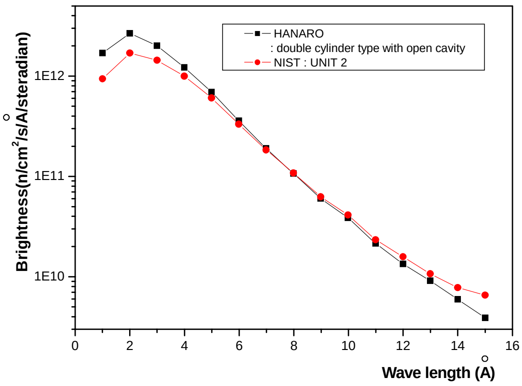

Fig. 2 Brightness comparison with the NIST Unit 2

It is analyzed that the brightness decreases at the longer wavelength due to the large absorption cross section of the light water film between the vacuum chamber and the wall of the CN hole. The horizontal CN beam tube is welded on the CN hole, so the CN hole was a little bent by the welding. Therefore, there is a light water in the gap between the vacuum chamber and the CN hole. Accordingly, a plan is on progress in order to minimize the light water film by the proper installation of vacuum chamber.

The specification of the basic design for the HANARO CNS is described in the table 1.

Table 1 The Design Specification
of the HANARO moderator cell
- Doble cylinder with open cavity type

Volume of the moderator cell			2.926	ℓ
Mass of moderator in moderator cell (0.9 liquid level, 20%void)			102.6	g
Temperature			21.6	K
Dimension	Outer cyl.	Diameter	130	mm
		Height	257.3	mm
		Thickness	1.2	mm
	Inner cyl.	Height	150	mm
		Thickness	1.2	mm
Moderator cell wall	Material		Al 6061 T6	-
	mass		확인요	g
Vacuum chamber	Material		Al 6061 T6	-
	Thickness		6~8	mm

4. Conclusion

The basic design of the HANARO CNS is on progress using the MCNP code according to the manufacturing feasibility, the fluidity, the higher brightness and lower heat load. The height of the moderator cell is 257.3 mm and the liquid hydrogen is filled up to 222 mm.

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