Alignment of neutron guides for the in-pile plug assembly and the primary shutter

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1. Introduction

KAERI has been developing a neutron guide system for cold neutron research facilities in HANARO since 2003. The neutron guide system plays an important role in transporting cold neutrons from the cold neutron source to the neutron scattering instruments in the neutron guide hall [1]. A beam port assigned for the cold neutron (CN) has been used for an 8-m SANS without neutron guides until early 2008. The old instrument at the CN beam port was removed and a completely new system has been installed, which is composed of an in-pile plug assembly with in-plug guides, a primary shutter with in-shutter guides, removable shielding blocks, and a vacuum system as shown in Fig. 1.

It is very important to align the neutron guides accurately in order to minimize a loss of cold neutrons which are transferred to scattering instruments. The alignment is one of significant factors together with a reflectivity and a manufacturing accuracy, which decide the performance of neutron guides. So it is necessary to develop special alignment tools and techniques to align the neutron guides successfully. There exist some limits of accessibility and workability to use conventional optical measurements while aligning the neutron guides for the in-pile plug assembly and the primary shutter because of a high radiation level at the CN beam port. So we adopted a laser tracker as a measurement system to align the neutron guides in a radiation environment. The accurate alignment of neutron guides was safely achieved by a laser tracker through measuring the coordinates of neutron guides at far and offset positions of the beam port.

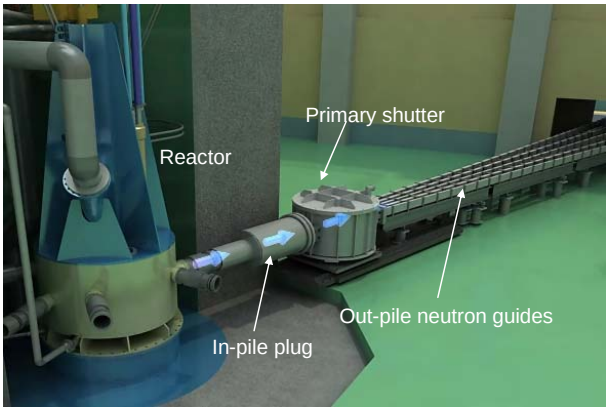

Fig. 1. The neutron guide system at HANARO

This paper presents the successful result of the installation and alignment of neutron guides for the in-pile plug assembly and the primary shutter using a laser tracker.

2. Method and Procedure

A global coordinate system is defined in order to align the neutron guides from the CN beam port in the reactor hall to scattering instruments in the neutron guide hall. The origin of the coordinate system is a point of intersection between the CNS surface and the center line of the CN beam port which is defined as x-axis. The z-axis is a normal line to water level. The neutron guides in the in-pile plug assembly start at a distance of 1833mm from the origin along x-axis as shown in Fig. 2. The coordinates of neutron guides can be extracted from this coordinate system, which are required to be entered into the operating software for the laser tracker to compare with measured data.

There are several operations for aligning the neutron guides towards the final installation. Tolerance requirements of each operation are listed on the Table I. The laser tracker used in this project has a 70m diameter measuring range and achieves 0.025mm 3-D single point accuracy. It showed a great performance while aligning the neutron guides at the beam port.

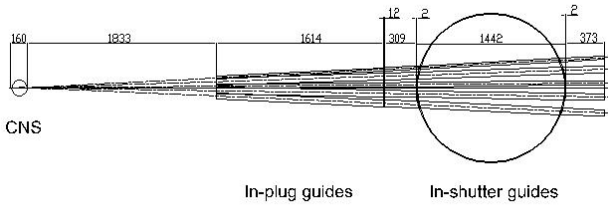

Fig. 2. The arrangement of neutron guides for the in-pile plug assembly and the primary shutter

Table I: Tolerances for the guide alignment

Alignment operation	X	Y	Z
Guides in the cassette	± 0.1	± 0.05	± 0.05
Cassette in the in-pile plug	± 0.1	± 0.05	± 0.05
Cassettes in the primary shutter	± 0.1	± 0.05	± 0.05
In-pile plug in the beam port	± 0.5	± 0.2	± 0.2
Primary shutter at the beam port	± 0.5	± 0.2	± 0.2

The whole procedure can be summarized into three main steps to align the neutron guides. The first step is to align each guide in guide cassettes of the in-pile plug assembly and the primary shutter. The next step is to make the coordinate system of the beam port in the reactor hall. It is needed to make many reference marks in the reactor hall to indicate the coordinate system because the laser tracker should be moved many times to measure target points of neutron guides [2]. The final step is to align every cassette of the in-pile plug assembly and the primary shutter using the coordinate system and reference marks in the reactor hall. The flow chart for the alignment procedure in detail is shown in Fig. 3.

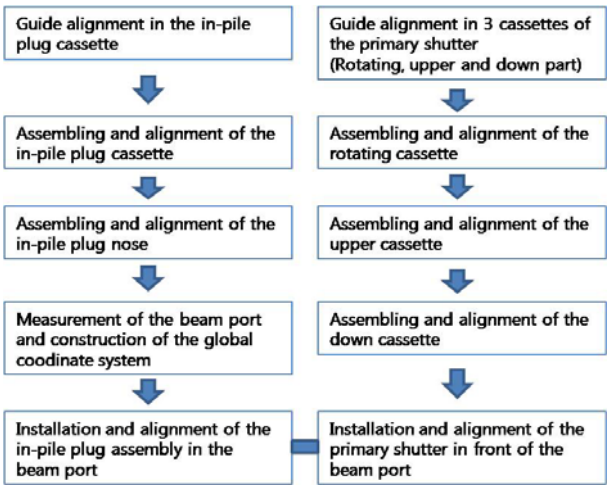

Fig. 3. The flow chart of the neutron guide alignment for the in-pile plug assembly and the primary shutter

3. Result

The alignment of neutron guides in every cassette was fulfilled as shown in Fig. 4. There is one guide cassette for the in-pile plug assembly and three guide cassettes for the primary shutter. Each cassette has five neutron guides with adjustment parts which are used for the alignment and fixation. All guides in cassettes were aligned within 0.1mm tolerance using the laser tracker and the alignment tools.

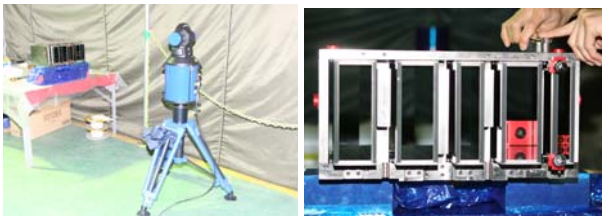

Fig. 4. The alignment of neutron guides in the guide cassette

Guide cassettes were assembled into the in-pile plug and the primary shutter after aligning the neutron guides as shown in Fig. 5. The in-pile plug assembly was installed in the CN beam port and the in-plug guides were measured again to fix the final positions of neutron guides as shown in Fig. 6. Finally the primary shutter was installed just after the beam port flange with 5mm gap. The upper stream guides, rotating guides and downstream guides of the primary shutter are also well aligned within 0.1mm tolerance. The final positions of downstream guides were measured and saved in the software of the laser tracker, which will be used for aligning out-pile neutron guides on the stage of next installation.

Fig. 5. Assembling guide cassettes into the in-pile plug and the primary shutter

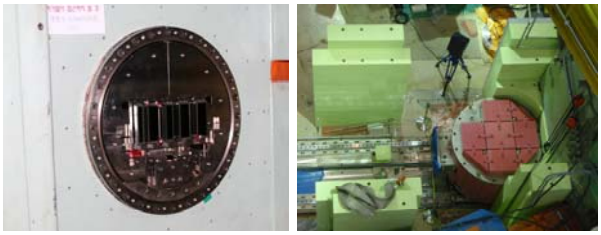

Fig. 6. The installation and alignment of the in-pile plug assembly and the primary shutter

4. Conclusion

KAERI installed the neutron guides for the in-pile plug assembly and the primary shutter in September 2008. The construction of the global coordinate system and the accurate alignment of neutron guides were achieved successfully. A laser tracker was used for measuring the CN beam port and the alignment of neutron guides. The guide supporting structures and out-pile neutron guides will be installed in 2009.

REFERENCE

[1] J. W. Shin, Y. G. Cho, B. S. Seong, S. J. Cho and J. S. Ryu , “Conceptual Design of the In-pile Plug Assembly and the Primary Shutter for the Cold Neutron Research Facility in HANARO,” Transaction of the Korean Nuclear Society Autumn Meeting, pp. 70-71, 2006
[2] J. W. Shin and Y. G. Cho, “Method for a neutron guide alignment in guide cassettes using a laser tracker,” Transaction of the Korean Nuclear Society Autumn Meeting, pp. 645-646, 2008