Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 17-19, 2017

Inspection of Defect in Component of NBI System using Fast-Neutron Imaging

Young-Seok Lee*, Jong-Gu Kwak, Hee-Soo Kim, and Seung-Tae Oh
KSTAR research center, National Fusion Research Institute, Gwahangno 169-148, Daejeon 34133, Korea
**Corresponding author: yslee@nfri.re.kr*

1. Introduction

Fast-neutron imaging is a non-destructive testing method similar to the well-known X-ray and gamma-rays imaging techniques. Neutron can provide a better contrast than both techniques, because the interaction cross sections and therefore transport properties for neutrons and X-rays in matter are very different.

The cross section for neutrons depends on the specific nucleus and its nuclear structure. Light elements in combination with heavier elements are difficult to image with X-rays, since they provide very little contrast [1, 2]. From this point of view, fast-neutron imaging technique is useful technique not only for fusion applications but also industrial applications such as inspection of defects in casting and so on [3-6].

On the other hand, according to the increasing of power of the deuterium-deuterium (D-D) plasma operation of the KSTAR every year, performance and reliability of devices and components of vacuum vessels under the KSTAR plasma operation is one of critical issues in safety concerns. The D-D plasma operations have performed with ohmic heating and auxiliary heating such as neutral beam injection (NBI) and ion cyclotron range of frequency (ICRF). Especially, the neutral beam injection (NBI) system is essential for the next-step in fusion research devices, such as the International Thermonuclear Experimental Reactor (ITER), for an auxiliary heating and current drive to achieve long pulse or continuous steady-state burning experiments [7].

A defect of devices and components of vacuum vessels can cause a failure of the plasma operation.

This work aims to demonstrate applications of fast-neutron imaging in various fields including tokamaks. In order to carry out this work, a fast-neutron imaging technique has applied to investigate the cause.

More details will be described in this paper.

2. Experimental

In this work, we have used a film-based fast-neutron imaging technology [1]. And then a series of measurements of film-based fast-neutron imaging have carried out by using the SODERN pulsed DD neutron generator (GENIE35 model) with neutron fluence of 10^8 n/sec.

Fig.2 shows a schematic drawing for the film-based fast-neutron imaging in this work. As shown in the figure, the film was directly exposed to the neutrons.

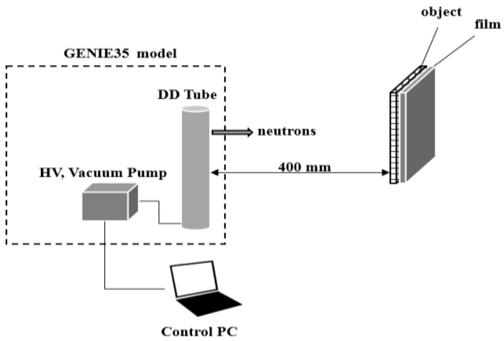

Fig. 1. Schematic drawing for the film-based fast-neutron imaging in this work.

For the fast-neutron imaging by film method, an accelerating electrode of NBI to be tested as shown in Fig.1 was placed on the front of film.

Fig. 2. Photograph of an accelerating electrode of NBI. In the figure, the red box represents a defective site.

3. Results

The resulting imaging of accelerating electrode of NBI is shown in Fig. 3. It was obtained the fast-neutron imaging with an industrial X-ray film using the commercially available D-D neutron generator having neutron yield of 10^8 neutrons/sec.

The defect of the accelerating electrode is clearly seen in Fig. 3. It is found that the fast neutrons are passed with ease through metals, and the integrity of materials made of high-Z elements can be investigated preferably with neutrons.

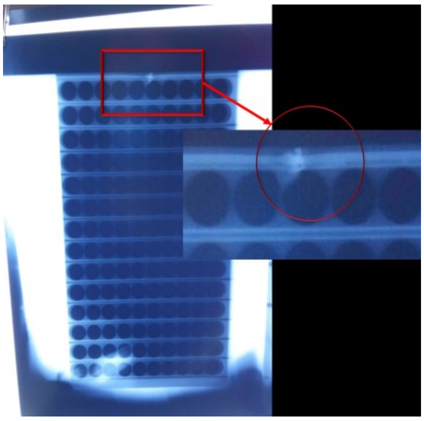

Fig. 3 Photograph of the fast-neutron image for the accelerating electrode of NBI. The red circle in the figure indicates the enlargement of defective site.

Therefore, fast neutron imaging can be considered as a complementary technique to X-ray and Gamma-rays imaging if the composition of the sample requires visualization of light materials in the presence of high-Z materials.

4. Conclusions

We have demonstrated the fast-neutron imaging technique can be extended the applicability of the fast- neutron imaging for fusion applications as well as industrial applications.

In the work, it was obtained the film-based fast-neutron images using commercially available D-D neutron generator.

In conclusion, the film-based fast-neutron imaging technique is acceptable for the applicability of the fast-neutron imaging techniques in a wide range of areas, even though the digital imaging method on the basis of CCD camera offers highest speed comparing to the film-based imaging technique. The present result is rather preliminary and further study will be needed.

ACKNOWLEDGMENTS

The authors thank Dr. S.I. Park and the related staff for their great help to arrange the experiment and operate the DD neutron generator at Gunsan Plasma Technology Research Center of NFRI.

REFERENCES

[1] Y.S. Lee, et al., "Feasibility of Fast Neutron Imaging at the KSTAR Tokamak", 8th International Topical Meeting on Neutron Radiography, ITMNR-8, 4-8 September 2016, Beijing, China.

[2] Y.S. Lee, et al., "Development of Fast-Neutron Imaging Techniques in Korea", Transactions of the Korean Nuclear Society Spring Meeting, May 11-13, 2016, Jeju, Korea.

[3] E.Bogolubov, et al., "CCD camera detectors for fast neutron radiography and tomography with a cone beam", Nucl. Instr. Meth. A542, p. 187-191, 2005.

[4] J.T. Cremer, et al., "Large area imaging of hydrogeneous materials using fast neutrons from a DD fusion generator", Nucl. Instr. Meth. A675, p. 51-55, 2012.

[5] R. W. Babai, et al., "Fast neutron tomography of low-Z object in high-Z material shielding", Physics Proceedia 69, p. 275-283, 2015.

[6] V. Dangendorf, et al., "Fast neutron resonance radiography in a pulsed neutron beam", Physics Proc. 69, p. 275-283, 2015.

[7] J.G. Kwak, et al., "Neutron emission in neutral beam heated KSTAR plasmas and its application to neutron radiography", "doi:10.1016/j.fusengdes.2016.02.037.