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Development of X-ray Inspection System for Irradiated Fuel Rod in a Hotcell

Heemoon Kim*, Byung Ok Yoo, Dae Gyu Park, Sang Ryul Baek, Yang Hong Jung, Gil-Soo Kim, Sang Bok Ahn
Korea Atomic Energy Research Institute, Yuseong, Daejeon, 305-353 Rep. of Korea
**Corresponding author: hkim1211@kaeri.re.kr*

1. Introduction

An X-ray is useful to observe inside a fuel rod without destruction. For inspection of high radioactive materials such as a fuel rod, the X-ray device must be modified to avoid strong gamma intensity from the sample. In the past, a line scan method with film was generally used in every hot-laboratory in the world. These days, image processing in a computer is preferred to a film system [1].

IMEF (Irradiated Materials Examination Facility) has planned to install an x-ray inspection system in a hotcell for a fuel rod. A purchase contract was made last year, and the system was developed using computer image processing. This system will be delivered to KAERI in May of 2014 [2].

2. Experimental

2.1 Apparatus

An X-ray system consists of an x-ray tube, sample bench, and LDA (Line Detector Array). The system was made by XYLON Co. in Germany. The specifications of the X-ray tube are 450 kV, 15 mA, and 0.4/1.0 mm in focus size. LDA has a 254-μm pitch and 1,984 modules with a CdWO4 scintillator. Its collimator is 0.2–3.0 mm with tungsten.

Fig. 1 High voltage x-ray tube

The sample bench is controlled through precise rotations and up and down movements for sample x-ray scanning.

The software is able to obtain the data signal from the LDA. It shows a 2-D scan with data of each layer and can transfer the scan data to a 3-D program (VG Studio 2.2) to display a CT image with a dimensional measurement. To protect LDA data from gamma rays, the GOST (Gamma Offset Scan Technique) algorithm is applied to reduce gamma noise [3].

Fig. 2 Line detector array (LDA)

All of the components are assembled as shown in Fig. 3. Movement of the LDA is for magnification and high resolution.

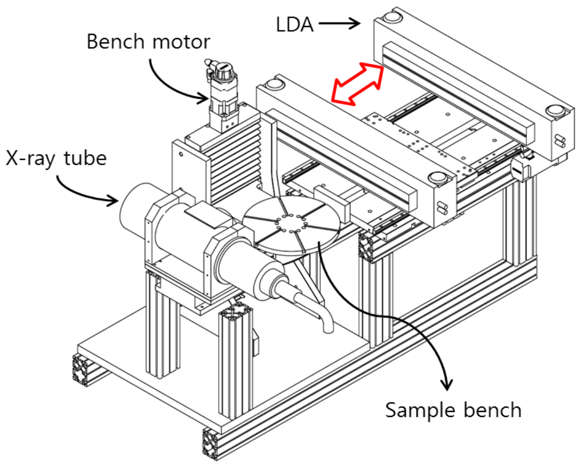

Fig. 3 System layout

2.2 System inspection check

The manufacture of an X-ray system was completed, and a system inspection before shipment was conducted using drawing and a pre-test.

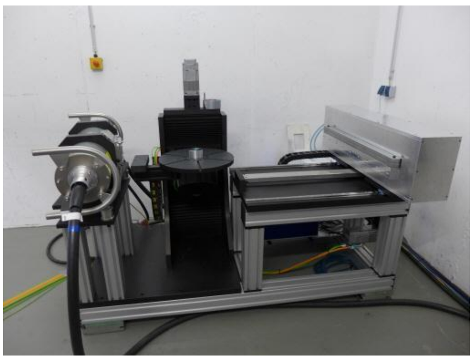

Fig. 4 System inspection check before shipment

Two test samples were prepared for system inspection. These samples were cross pieces (lead and tungsten) in a s/s tube with 8 mm and 10 mm dia., respectively (Fig. 5). As shown in Fig. 6, the cross image (tungsten) was clear, but the horizontal gap between layers was not.

Fig. 5 Test samples

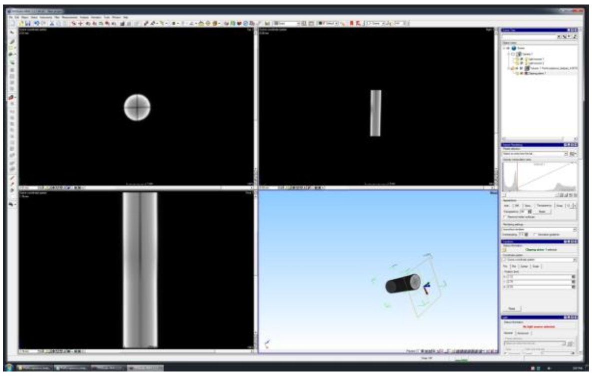

Fig. 6 3-D program (VG Studio) for sample (tungsten)

2.3 Hotcell Installation

The system will be installed in a M1 hotcell, and high-voltage components, a cooler, an electrical cabinet, a control table, and a computer will be placed in the service area and operating area near the M1 hotcell, as shown in Fig. 7.

3. Results

The system inspection was completed and all components were assembled to deliver to KAERI. The data from test samples showed good results.

4. Conclusions

A 450 kV X-ray system has been under development since June of 2013. It will be delivered to KAERI in May of 2014, and installed in IMEF. Radioactive materials as a sample will be inspected to check the gamma noise effect.

REFERENCES

[1] Yoshiaki KATO, et al, “Development of X-ray CT scanner system”, JAEA & KAERI Joint Seminar on Advanced Irradiation and PIE Technologies.(2012)

[2] H.Kim, et al. “Development of X-ray radiography using image processing system for high burnup fuel”, R/D project (2012)

[3] GOST program in YXLON, Co., Germany.

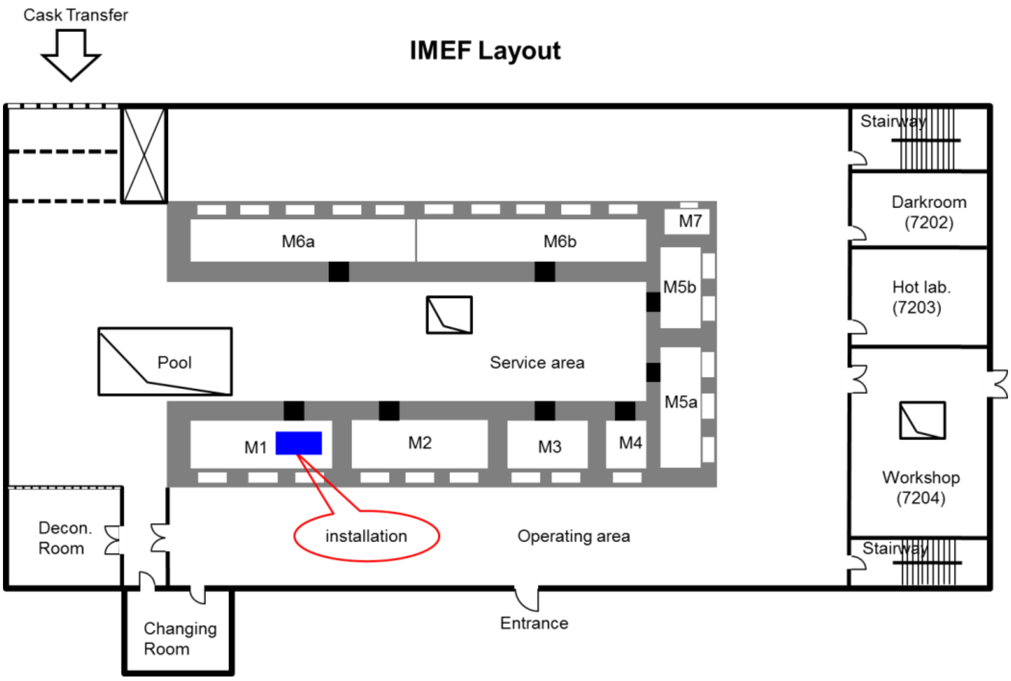

Fig. 7 Installation position in IMEF