Development of Non-Destructive Test for Fuel Rods using X-ray CT in Hotcell

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1. Introduction

Non-destructive test of PIE for fuel rod is important to develop fuel performance. Especially, an X-ray is useful to observe inside a fuel rod without destruction. Most hot laboratories have used X-ray inspection with film for fuel rod. But, 3-D image and CT technology have developed and been applied to industry in these days. In nuclear industry, a hot laboratory in Japan already installed X-ray CT system and produced its data[1].

Following Japan, an X-ray CT inspection system was installed in hotcell in IMEF (Irradiated Materials Examination Facility). It will be activated for irradiated fuels and materials.

2. Experimental

2.1 Apparatus

An X-ray system consists of an X-ray tube, sample bench, and LDA (Line Detector Array).

Fig.1 Installation of 450 kV X-ray

The system was made by YXLON 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 elements with a CdWO4 scintillator. Its collimator is 1.0 mm gap with tungsten. It took 1 year to make all system including installation[2]. Two PCs with two programs were supplied; one was X-ray scan program to produce profiles of object and the other was 3-D image processing program. Especially, GOST algorithm is applied to X-ray scan program for gamma noise reduction[3]. Additionally, dimensional measurement of sample was possible in 3-D program. All system was shown in Fig. 1.

2.2 fuel test

After installation in a hotcell, the alignment between X-ray tube and LDA was carried out and beam was calibrated. Preliminary tests with several fuel rods with burnup were performed to check resolution with gamma noise reduction.

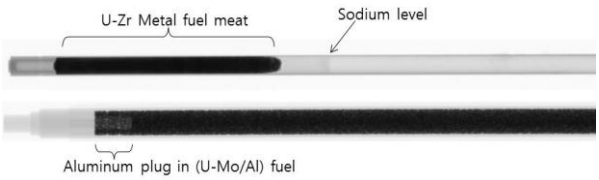

Fig.3 DR scan image of fuel rods

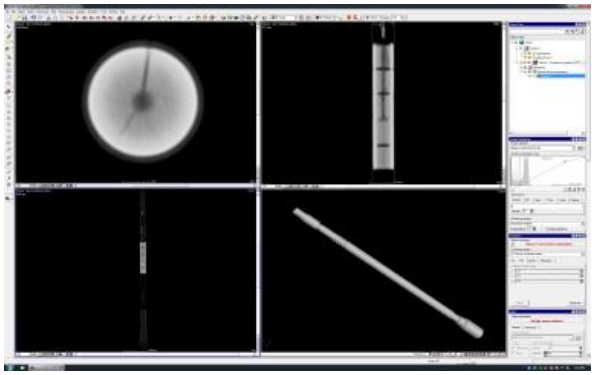

Fig.4 Fuel image in 3-D software

As shown in Fig.2, Fig.3 and Fig. 4, all CT tests gave good results and GOST algorithm for gamma reduction,

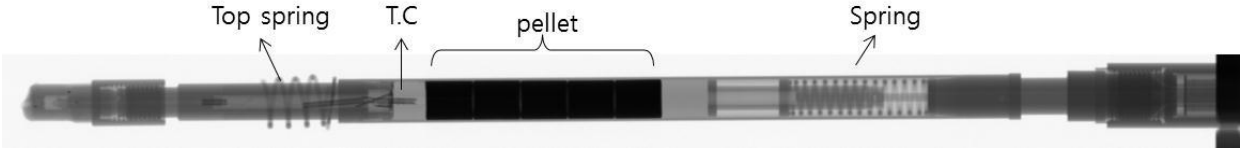

Fig. 2 Fuel Rig for irradiation test

was not needed in low gamma noise after resolution comparison.

3. Results

The system was installed in IMEF and showed good results after calibration and alignment. 450kV energy was available to see UO_2 inside for irradiated fuel rods. The center hole in UO_2 was shown and crack on surface was observed by 3-D images. Additionally, a spacer-grid, nuclear structural material, was inspected for possibility of dimensional measurement as shown in Fig. 5. After installation, KINS safety inspection for license will be performed soon.

4. Conclusions

The X-ray inspection system will be good for users who want to see inside of fuel rod and materials. IMEF will provide good quality data and produce expert of X-ray system in hotcell.

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 Inspection System for Irradiated Fuel Rod in a Hotcell", Spring meeting, Transactions of the Korea Nuclear Society.(2013)
[3] GOST program in YXLON, Co., Germany

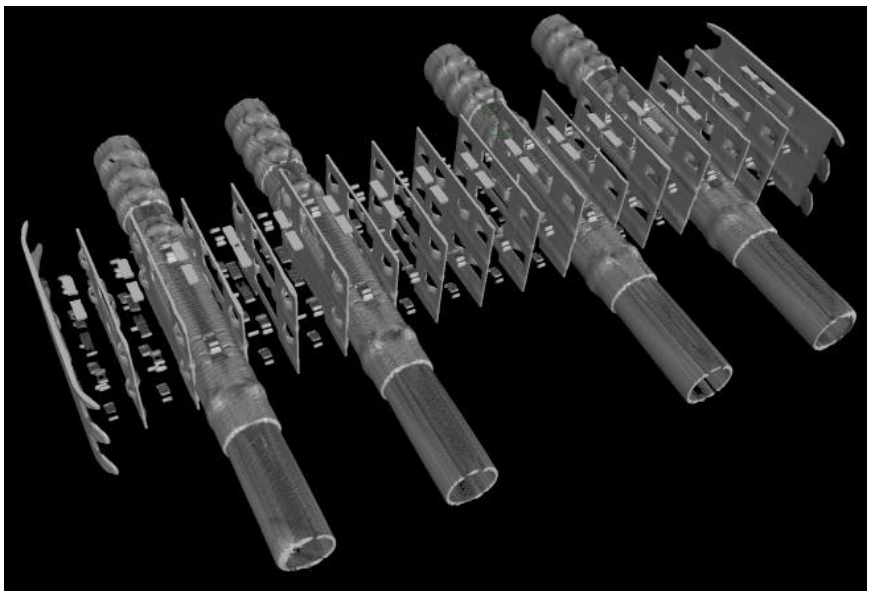

Fig.5 3-D image of spacer grid