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Inspection of HANARO Research Reactor Fuel Cladding using Eddy Current Test and Real Time X-ray Radiography

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1. Introduction

It is important to establish an inspection process for the HANARO fuel elements cladding because defects on cladding, such as scratch and inclusion, could be caused a serious problem in HANARO reactor. For the inspection of HANARO fuel elements cladding, the multi-frequency eddy current methods was introduced and the optimum inspection condition has been developed. When some defect was detected during ECT, by using Real time radiography, defect type was checked. With these combined NDT techniques, HANARO fuel elements are fabricated successfully without any defects.

1. Eddy Current Testing System

The ECT system for the inspection of the fuel element cladding consists of encircling coil, MIZ-27ET multi-frequency eddy current digital equipment, scanner, and ET analysis software. The test frequencies were selected such as 30 kHz, 15 kHz, 6 kHz and 3 kHz. The standards specimens are fabricated and they have EDM notches of whose depth are 100%, 80, 60, 40, 20, 17 and 13 % of cladding thickness and of whose length are 2 mm. The QA documents require that the fuel element cladding should not have a defect of 17% depth of cladding (0.13 mm) and 2 mm length.

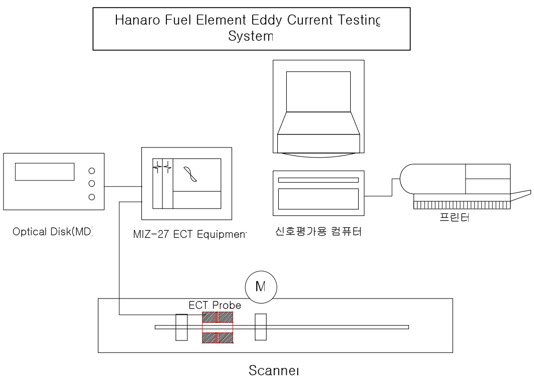

Fig. 1 Block diagram of the ECT system for inspection of the fuel element cladding.

2. Calibration of the ECT System

The calibration of the ECT system is used with 100% EDM notch. The signals from the 100% EDM notch at every frequency are adjusted at 40 degrees. (Fig. 2)

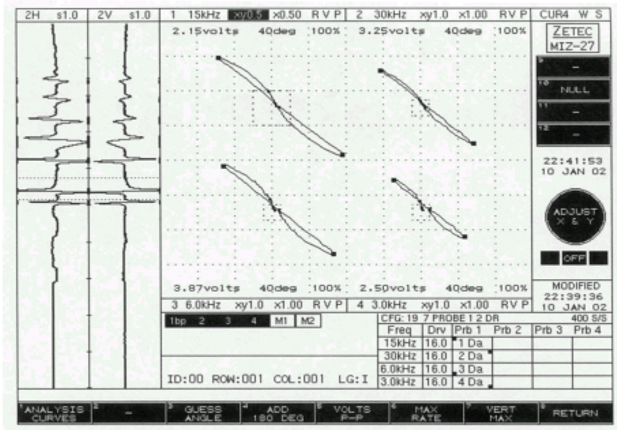

Fig. 2 Calibration Signal of 100% EDM Notch at 30, 15, 6, 3 kHz.

Fig. 3 shows the resolution of this system is enough to detect 13% EDM notches.

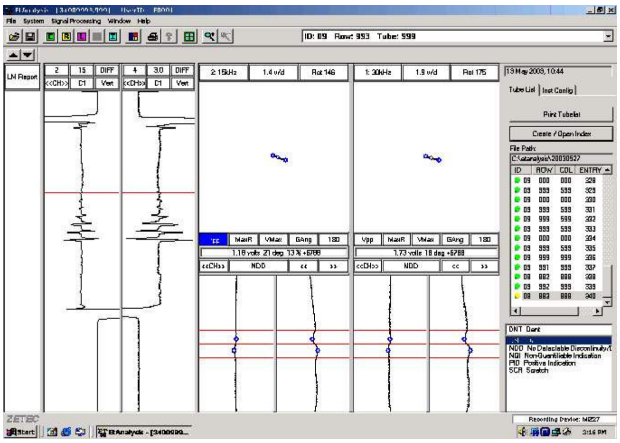

Fig. 3 Calibration Signal of 13 % EDM notch at 30, 15 kHz.

3. Inspection Results of ECT and conformation using RTR

During the inspection, there are typical types of defects such as cladding scratch, fin scratch, inclusion on fin area, cladding area and fuel meat. If it appears that a signal is a defect, in order to conform the defect type, we are using the RTR system, which consist of

160 kV X-ray source, 6 inch mode image intensifier and video camera, image enhancement and analysis subsystem, and manipulator to hold and move the object being examined. For examination of the claddings, they were controlled at 48 to 50kV and 0.08 to 0.1mA respectively.

Fig. 4 shows the typical signal of scratch on cladding and Fig 5 verifies it.

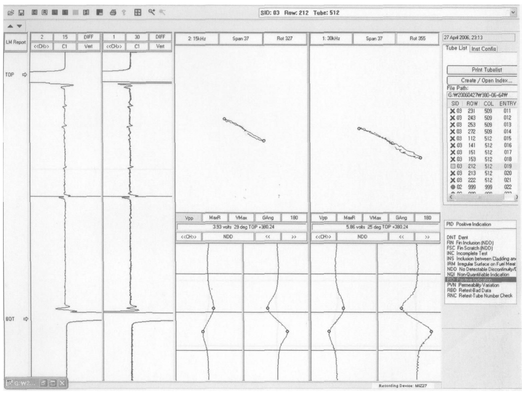

Fig. 4 Typical cladding signal at 15, 30 kHz

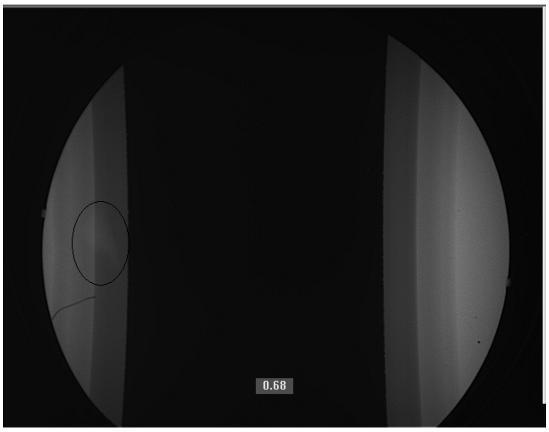

Fig. 5 RTR image showing a scratch on the cladding

Fig. 6 shows the typical signal of inclusion on cladding scratch and Fig 7 verifies it.

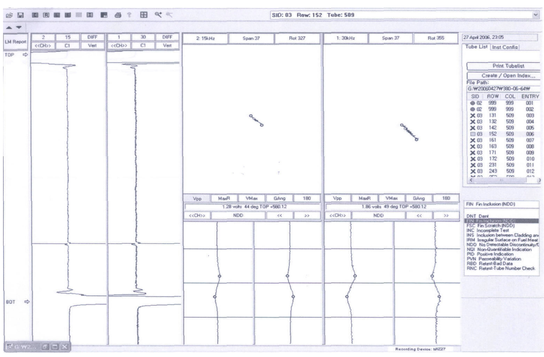

Fig. 6 Typical signal of the inclusion on the cladding

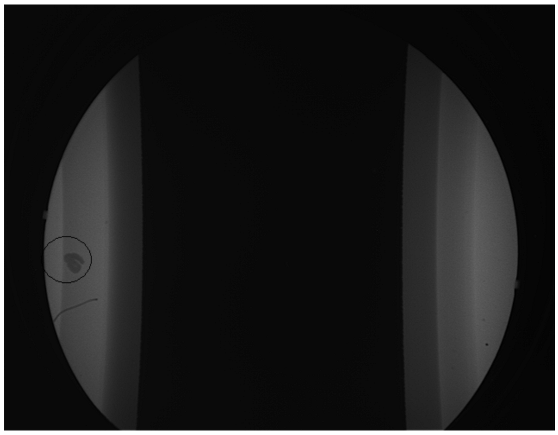

Fig. 7 RTR image showing a inclusion of the fin

5. Conclusion

For the inspection of HANARO fuel elements cladding, the multi-frequency eddy current methods was introduced and the optimum inspection condition has been developed. When some defect was detected during ECT, by using Real time radiography, defect type was checked effectively. With these combined NDT techniques, HANARO fuel elements are being fabricated successfully without any defects.

REFERENCES

[1] Y.S. Lee, KNS Autumn conference, 1999, p206

[2] ASME section V, Article 8