Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, November 2-3, 2006

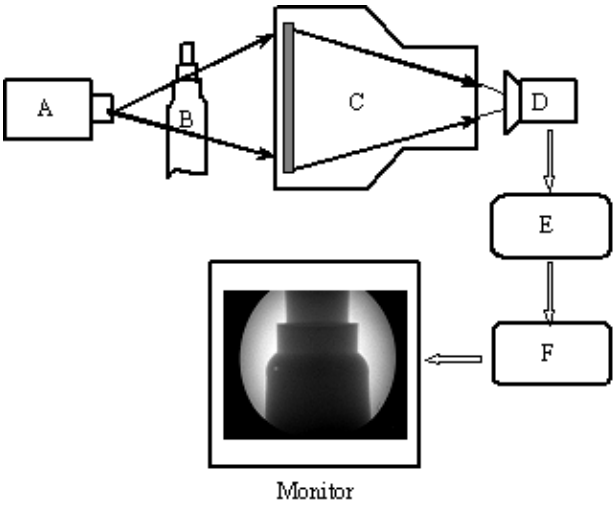
Evaluation of the RTR System Performance for Welds on the End Plug of HANARO Fuel Rods

Don-Bae Lee, Yoon Sang Lee, Seok-Jin Oh, Chang-Kyu Kim
Korea Atomic Energy Research Institute, Dukjin-Dong 150, Yesong-Gu, Daejeon, 305-353, Korea
dblee@kaeri.re.kr

1. Introduction

It is important to establish an inspection process for the end plug welds of HANARO driver fuel elements because welding defects of end plug weld, such as a pore and lack of fusion, could be caused a serious problem in HANARO reactor. For the inspection of HANARO reactor fuel end plug welds, the X-ray real time radiography technique was introduced and the optimum inspection condition has been developed. Real time radiography, using developed image digitization and image processing program has a good image quality and is easier methods to evaluate the defect type and size, compared with conventional film radiography. As the results of applying this system for the HANARO fuel inspection, it was conformed that it was very effective, producible and reliable system.

2. Real Time X-ray Radiography System



A : X-ray source, B : Specimen, C: Image intensifier
D : CCTV camera, E : A/D converter,
F : Computer image processor
Figure1. Block diagram of the RTR system for inspection of the end plug welds.

The RTR system for inspection of the end plug welds 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. Figure 1 is the system block diagram. The distance between the radiation source and image intensifier screen set at 500 mm. The fuel rod for examination can be moved in rotating and up-down by manipulator with 3 axes which are controlled by a single joystick.

3. Evaluation of the RTR System Performance

3.1 Evaluation by Wire Image Quality Indicators

To evaluate contrast sensitivity of the image obtained at the RTR system the wire IQI Al 10 DIN has been used. A specimen was made of the same material Al 1060 and the end plug form as the test object. The contrast sensitivity was 1.3% according to ASME regulations. The real time X-ray radiography conditions were at 48kVof acceleration voltages and at 10 ㎛ of spot size. The image processing parameters of 256 frame averaging and high level sharpening were applied. Figure 2 is the RTR image showing the contrast sensitivity of the imaging system for the inspection of the end plug weld.

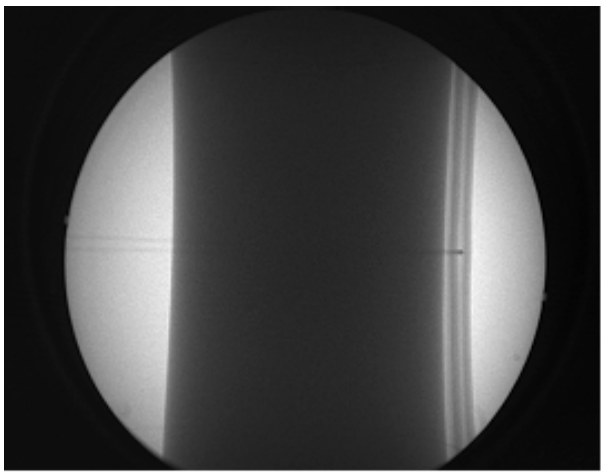


Figure2. The RTR image showing the contrast sensitivity of the RTR imaging system(wire diameter 0.12mm specimen diameter 7.8mm).

3.2Evaluation of the System Resolution

X-ray test pattern 07-750 has been used to evaluate the RTR system resolution. ASME regulation for real time radioscopic examination requires that RTR system should exhibit a spatial resolution of 3.0 Lp/mm. The RTR system showed 3.0 line pairs per millimeters at 50kV acceleration voltages and 0.1mA beam currents.

The imaging parameters applied 256 frame averaging and high level sharpening.

Figure 3 shows the measurement result of the RTR system resolution by line pair gage.

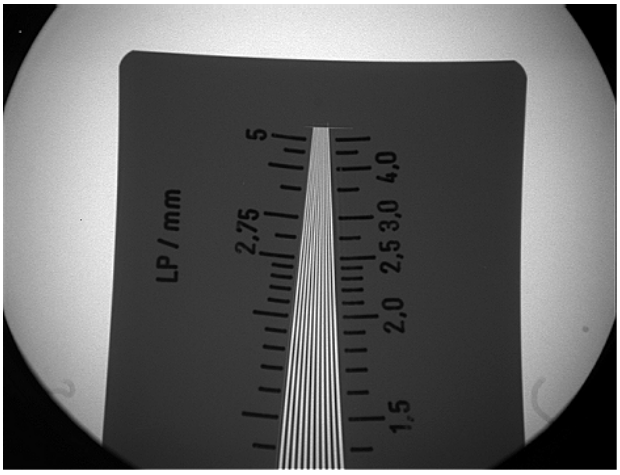


Figure 3 The RTR image showing the measurement result of the spatial resolution.

3.3 An accuracy of the measurement on the RTR image

A calibration block has been made of Al 1060 rod as the same material fuel end plug to examine whether X-ray image on display monitor could be measured accurately or not. And then the measurements on the image were compared with measurements by projector. An average deviation of the measurements was about 0.02 mm. The result appeared that RTR imaging system is appropriate for inspection of the end plug welds. Figure 4 shows the calibration block.

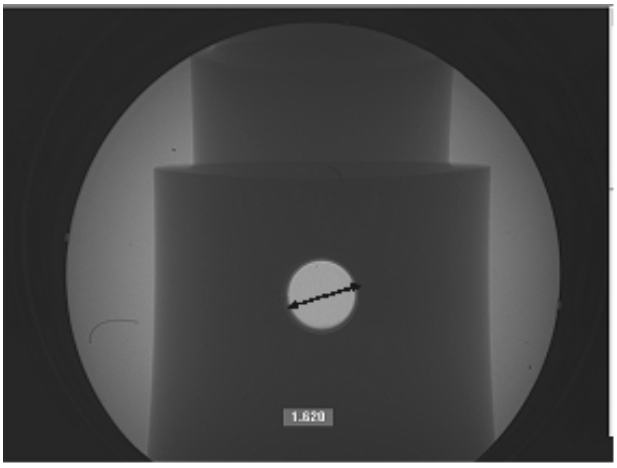


Figure 4 The calibration block for measuring of the RTR image.

4. Real Time X-ray Radiography for End Plug Welds

RTR system and fuel rod were arranged like a figure 5 and distance between X-ray source and image intensifier screen was set at 500mm. A test object was positioned at 25mm from the X-ray source.

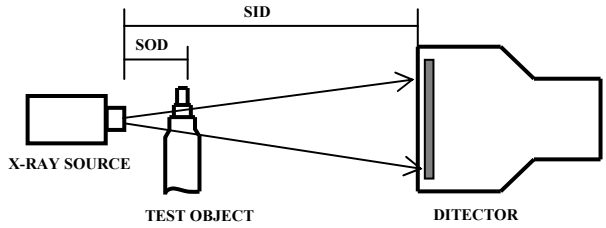
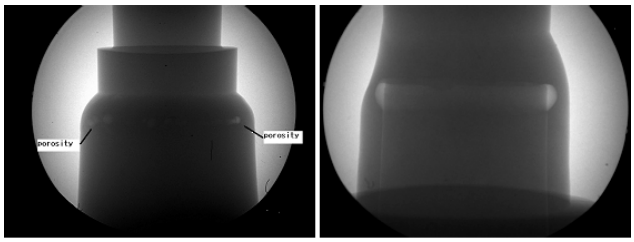


Figure5 Schematic diagram of the inspection system arrangement for HANARO fuel end plug weld

The contrast of image is controlled by acceleration voltages and beam currents. For examination of the end plug weld, they were controlled at 48 to 50kV and 0.08 to 0.1mA respectively. The examination was performed as produced condition without any surface treatment for the end plug weld. The test object is rotated by rotary manipulator and if a discontinuous area on the X-ray image is appeared, the area is positioned at 3 or 9 o'clock by the manipulator and then measurement of the sound weld is performed on averaged and sharpen image. The RTR images of end plug weld with typical defect were shown in Figure 6.



a) pore b) lack of fusion

Figure 6 RTR images showing defects in end plug welds

5. Conclusion

The Real time X-ray radiography system for the inspection on fuel end plug welds using image digitization and image processing program has a good image quality and is easier methods to evaluate the defect type and size, compared with film radiography. As the results of applying this system for the HANARO fuel inspection, it was conformed that it was very effective, producible and reliable system.

REFERENCES

[1] Proceedings of a symposium held at Newbury, Berkshire in November 1988

[2] ASME section V, Article 2, APPENDIX II