Neutron Radiography with Kyoto University research Reactor : Defect Detection in Plastics, Fine Ceramics and Metals

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Neutron Radiography with Kyoto University Research Reactor : Defect Detection in Plastics, Fine Ceramics and Metals

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Experiments ware carried out to study the image quality of the neutron radiography with Kyoto University Research Reactor (KUR). Radiography was made of nylon wires of diameters from 52 to 170 μm embeded in samples of plastic, fine ceramic, aluminum and lead to find the minimum detectable diameter. The minimum detectable diameter was 70 μm for the plastic sample of 1-mm thickness and the fine ceramics sample of 7-mm thickness. For aluminum and lead samples of thickness of about 30 mm, the minimum detectable diameter was 52 μm

1. Introduction

In recent years considerable attention has been paid to neutron radiography. The technique of using thermal neutrons is demanded because of its high inspection ability for hydrogeneous material such as plastics, water, explosives and nuclear fuel capusles irradiated. The inspections for various composite materials, as well as fine ceramics and metals, plastics and glass fibers, etc. have progressed in industry by neutron radiography. It is now nessesary to develop a suitable sensitivity indicator for various materials. The inspection data obtained by using it would give quantitative evaluation of composites. Generally characteristics of the neutron beam and the radiographic image quality are evaluated with a "Beam Purity Indicator" and a "Sensitivity Indicator" approved by ASTM, and a "System Image Quality Indicator" devised by Barton[1]. In the present experiment, we used a sensitivity indicator made by ourselves[2] to measure the radiographic image quality.

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2. Experimental and Results

KUR is a swiming-pool type research reactor with the maximum power of 5 MW. There are several beam holes in radial and tangential geometries. There is also a graphite thermal column combined with a heavy water tank, as shown in Fig.1.

E-2 hole was used for the present neutron radiography work. The equipment is shown schematically in Fig. 2. The irradiation hole is about 5-m long and beam diameter is 160 mm at the exposure position. Table 1 shows the characteristics of the facility.

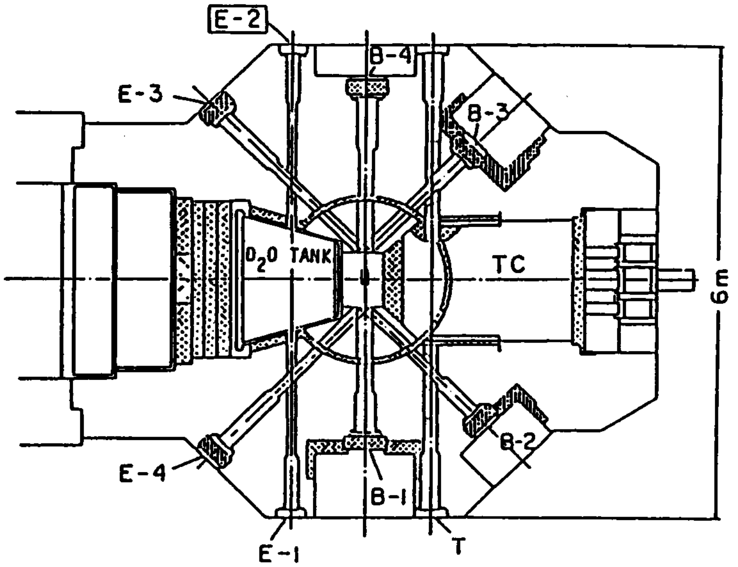

Fig. 1 Plan view of beam tube layout of KUR.

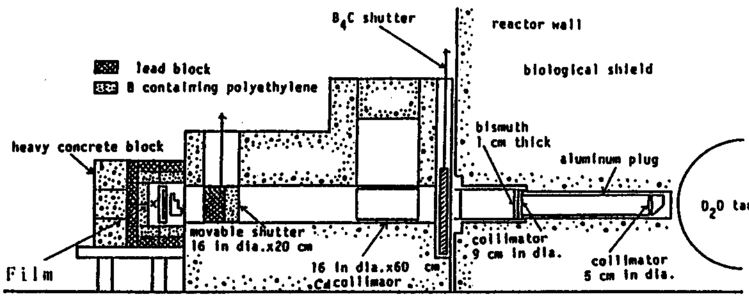

Fig. 2 Schematic layout of the irradiation hole used.

Table 1. Characteristics of E-2 neutron facility. Φ_{th} represents thermal neutron flux. L/D represents collimation ratio and L is collimator length.

Operation power	5000kw
Peak Φ_{th} in core	6×10^{13} n/cm^2 • sec
Range of L	500cm
Standard L/D	100
Φ_{th} at film position	1.2×10^{6} n/cm^2 • sec
Cd ratio of gold foil	400
n/γ ratio	10^6/cm^2 • mr
Film size available	16 cm in diameter

The defect detection by radiography depends on the quality and thickness of the sample. In neutron radiography, the images are usually obtained with an X-ray film attached to a Gd foil converter contained in a casette. The converter used is a metal sheet made by vapour-phase deposition (25-μm thickness). The film used is Kodak SR of single-coated film. Figure 3 shows the detection limits for plastic samples. A nylon wire of 70-μm diameter was observed for the plastic sample of 1-mm thickness. Figure 4 shows the detection limits for fine ceramics, aluminum and lead. The minimum detectable diameter was 70 μm for the fine ceramics sample of 7-mm thickness, and was 52 μm for aluminum and lead samples of 30-mm thickness.

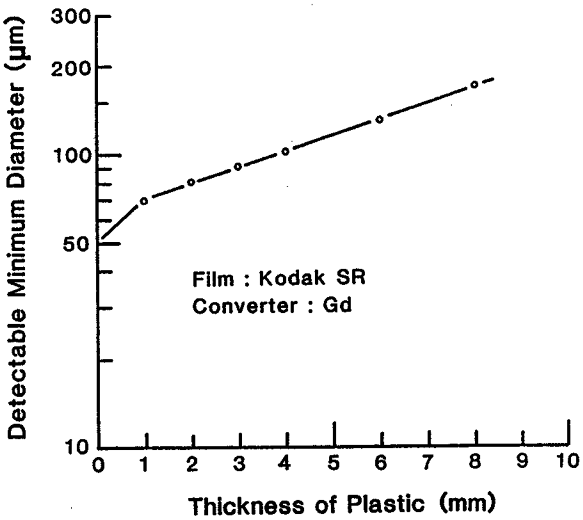

Fig. 3 Experimental results for the minimum detectable diameter of nylon wires in plastic samples.

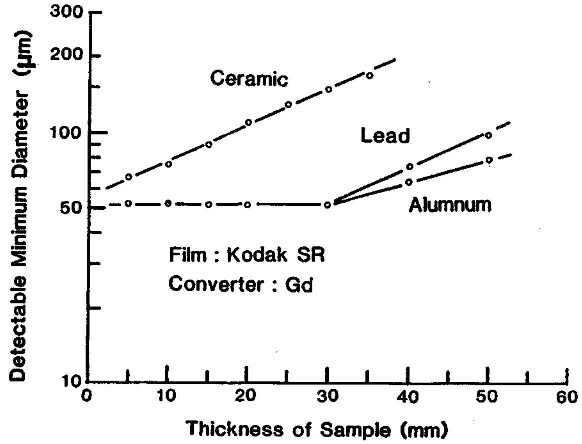

Fig. 4 Experimental results for the minimum detectable diameter of nylon wires in samples of ceramic, aluminum and lead.

3. Conclusion

Experiments were carried out for the quantitative evaluation of detection limits for several sample materials. The results can be summarized as follow: The fault sensitivity is about 2% for plastic samples of thicknesses above 6mm, below 1% for fine ceramic samples of thicknesses above 7mm, and below 0.5% for metal samples of thicknesses above 30mm.

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