Neutron Radiography with Kyoto University Research Reactor (III) Defect Detection in Fine Ceramics and Metals

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Neutron Radiography with Kyoto University Research Reactor (Ⅲ) Defect Detection in Fine Ceramics and Metals

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The image evaluation of neutron radiographic photographs was studied by use of sensitivity indicators developed by the authors. They are constructed by a combination of a wire type indicator having nylon wires with 7 different diameters and a bacillus type indicator having 30 nylon wires with the same diameter and the length. From the neutron radiographic photographs, the detectable minimum diameters were determined. For this experiment, fine ceramics plates and copper plates were employed as samples. It has been found that the detactable minimum diameters of nylon wires obtained by the two types of indicators are nearly equal at the bacillus sensitivity of 50%. The fault sensitivities obtained by the sensitivity indicators were below 1% of the thickness of the samples.

1. Introduction

The progress of neutron radiography technique is desired eagerly because of its high inspection ability for composites consisting of metal and hydrogeneous materials, Recently the inspection of various composite materials, such as fine ceramics and metals, plastics and glass fibers, etc. has been developed in industry by neutron radiography. The study of evaluation method for image quality in neutron radiographs of composites consisting of fine ceramics and copper has been carried out with Kyoto University Research Reactor (KUR).

This paper describes the evaluation of detection limit for defects in fine ceramics and copper plates. In the neutron radiography, the characteristics of the neutron beams and the radiographic image quality are generally evaluated with the "Beam Purity Indicator" and the "Sensitivity Indicator (ASTM-E545)" approved by ASTM (American Society for Testing and Materials)[1,2,3] and the "System

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Image Quality Indicator" devised by Barton.[3] In the present experiment, we used a sensitivity indicator developed by the authors[4] to measure the radiographic image quality.

2. Experimental and Results

Thermal neutron beams produced by heavy water in KUR[4,5] were used in this experiment. The thermal neutron flux at the exposure position was about 1.2 × 10^6n/cm^2/sec. The sensitivity indicator made by the authors were used for the image evaluation of neutron radiographic photographs in this study. The sensitivity indicator is a combination of two kinds of indicators. One of them is the nylon wire type indicator and the other is the bacillus type indicator consisting of nylon wires. The structures of them are shown in Fig.1. They are

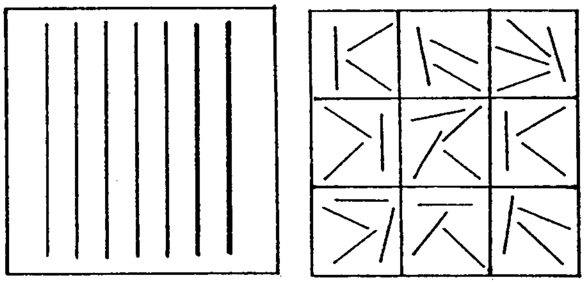

Fig. 1 The structure of wire type and bacillus type sensitivity indicators.

square plates of 45mm×45mm and 0.1mm in thickness. In the bacillus type indicator, thirty pieces of nylon wires with the same diameter and the same length are placed randomly inside the square. In the wire type indicator, seven nylon wires with the same length and different diameter are set in the order of the diameter size inside the square. Fine ceramic plates and copper plates with different thicknesses were employed. The sensitivity indicators were used to evaluate detection limits for defects in test samples. The neutron radiographic images of test pieces were photographed by the use of a conventional gadlinium film system.[5] The x-ray films used were single coated films (Kodak SR). The sensitivity indicators were set on the source side surface of a test sample to take a radiographic photograph. From the photographs, the detectable minimum diameter of the wire type indicator and numbers of wires in the bacillus indicator were determined. Figures 2a and 2b show the relationship between the diameter of the bacillus indicator and the ratio of the detected numbers of wires to the thirty wires in the bacillus indicator (bacillus sensitivity) for the fine ceramics plates and the copper plates, respectively. The parameters in the figures represent the thickness of these plates. From Fig.2a, it can be seen that in the fine ceramics plate of 30-mm thickness the bacillus sensitivity is 50% for the wire of 128μm diameter and 100% for the wire of 170 μm diameter. Figures 3a and 3b show the relationship between the detectable diameter (minimum for the wire type indicators, 100 % sensitivity for the bacillus type) and the thickness of fine ceramics and copper plates, respectively. The stars in Fig.3a and 3b represent the data of the bacillus type indicators. The circles in Fig.3a and 3b represent the data of the wire type indicators. In Fig 3a and 3b, it is found that the detactable minimum diameters of the wire type indicators are amaller than those at 100% bacillus sensitivity for fine ceramics and copper plates, respectively. Figures 4a and 4b show the relationship between the detectable diameter at 50% bacillus sensitivity and the thickness of fine ceramics and copper plates, respectivly. In this figures, the stars represent the data of the bacillus type indicator, and the circles represent the same data of the wire type indicator as shown in Fig.2. From these figures, it is found that the detectable minimum wire diameters obtained by the wire type indicators are nearly equal to those by bacillus type indicators in fine ceramics plates and copper plates. Figures 5a and 5b show the relationship between the fault sensitivity and thickness of fine ceramics and copper plates, respectively. Stars represent fault sensitivities obtained with the bacillus type indicators, and circles represent those with the wire type indicators. From these figures, it is clear that the values of fault sensitivities for fine ceramics and copper plates are below about 1% of their thickness.

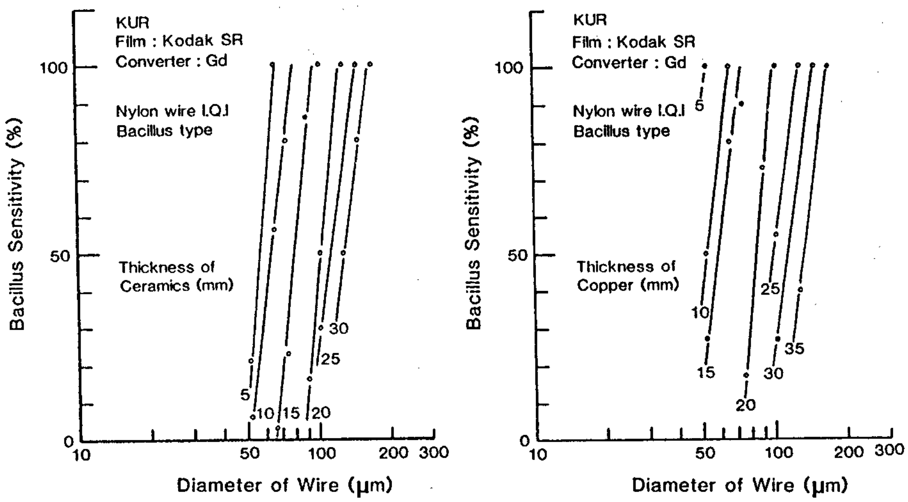

Fig. 2 Relationship between the detectable minimum diameter of the bacillus type indicator and the bacillus sensitivity in percentage. 2a, for fine ceramics plates; 2b for copper plates.

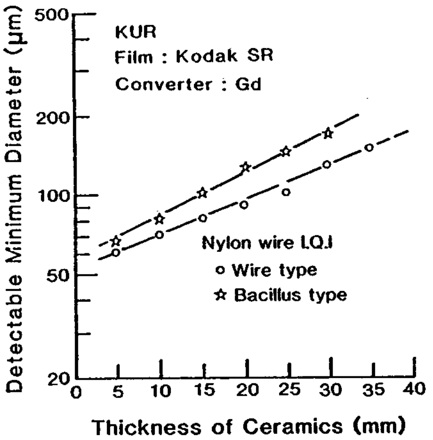

Fig. 3a Relationship between the detectable diameter and the thickness of fine ceramics plates at 100% bacillus sensitivity.

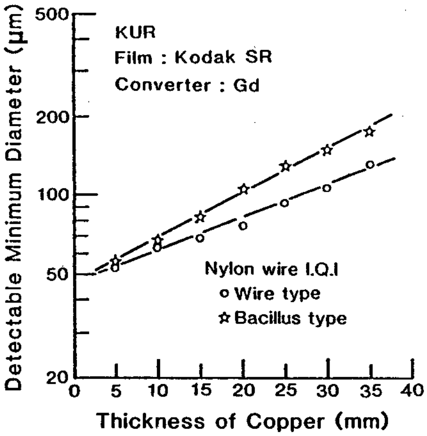

Fig. 3b Relationship between the detectable diameter and the thickness of copper plates at 100% bacillus sensitivity.

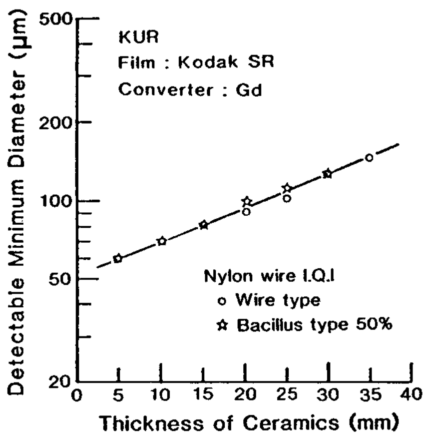

Fig. 4a Relationship between the detectable diameter and the thickness of fine ceramics plates at 50% bacillus sensitivity.

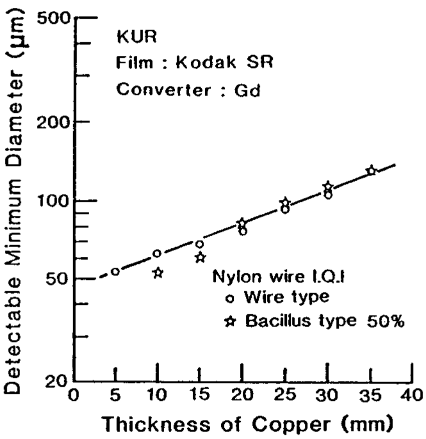

Fig. 4b Relationship between the detectable diameter and the thickness of copper plates at 50% bacillus sensitivity.

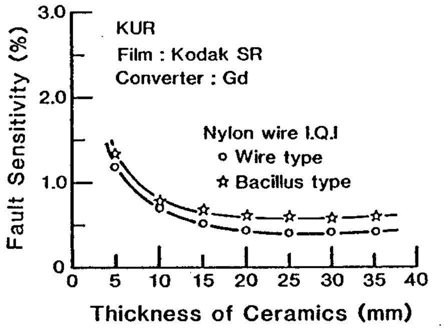

Fig.5a Relationship between the fault sensitivity and the thickness of fine ceramics plates.

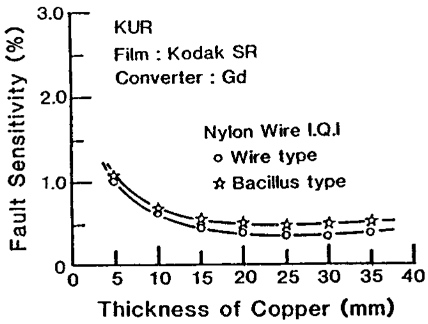

Fig.5b Relationship between the fault sensitivity and the thickness of copper plates.

3. Conclusion

Experiments were carried out for the quantitative evaluation of detection limits of fine ceramics and copper plates by using two kinds of indicators. The results can be summarized as follows:

(1) The detectable minimum diameters by the wire type indicator are smaller than those at 100% bacillus sensitivity for fine ceramics and copper plates.

(2) However, their detectable minimum diameters at 50% bacillus sensitivity are nearly equal to those obtained by the wire type indicators. (3) The values of fault sensitivities obtained by the two kinds of indicators for fine ceramics and copper plates are below about 1% of the thickness of fine ceramics and copper plates.

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