Deterioration Diagnosis of Instrumentation and Electrical Equipment

Background and Objective

For long-term operation of nuclear power plants, aging of equipment, pipes and instrumentation and electrical equipment is an important issue that should be taken into account. It has been expected to develop diagnosis method to detect their aging.

In case of SCC crack appearance, continuous operation or repair of component is selected, following the JSME code “Rules on Fitness-for-Service for Nuclear Power Plants”. Phased array UT was applied to measure the defect depth sizing on several components such as pipe and shrouds, etc. However, it was difficult to measure the defect depth sizing on nickel based alloy welds by conventional UT. Therefore, the development of advanced phased array UT technique is required for nickel based alloy welds.

Long-term integrity of cable insulation was confirmed by tests based on the Technical Report published by the Institute of Electrical Engineers of Japan. Especially, the confirmation of integrity (evaluation of material deterioration) of mechanical properties such as strength and elongation of cable insulation is important since cable insulation is deteriorated due to thermal stress and radiation. Therefore, it is required to establish the effective index to evaluate the combined radiation-thermal deterioration of cable insulating materials.

The objectives of this project are to develop the phased array UT technique for measurement of high accuracy for defect depth sizing and to establish the analysis method to evaluate quantitatively radiation-thermal deterioration of cable insulating materials.

Main results

1. Application of Phased Array UT for crack depth sizing on nickel based alloy weld

Advanced Phased Array UT (PAUT) technique, which combines 3-dimensional Phased Array UT (3-D PAUT) and 2-dimensional Phased Array UT (2-D), was investigated. 3-D PAUT technique can be controlled by ultrasound beam steering, objective focal points and high power excitation of ultrasound. Advanced Phased Array UT technique was applied to nickel based alloy weld specimen with EDM notches of 5mm to 40mm depth. At first UT conditions were optimized, and then UT examination was carried out. From the experimental results, defect depth sizing accuracy showed good agreement (defect depth accuracy approximately equal to 1mm) (Fig.1). Therefore, high performance of advanced Phased Array UT technique was shown [Q10031].

2. Mechanical strength degradation of cross-linked polyethylene insulation under radiation-thermal accelerated aging test

Since oxidation seems to be related to material degradation, the samples investigated are three kinds of cross-linked polyethylene sheets with additive antioxidant whose contents were usual, half of usual, and additive-free. These specimens were aged by the irradiation of γ-rays at a dose rate of about 100 Gy/h for various times and temperatures at about 10-30℃ (room temperature, RT), 60℃, and 100℃. Temporal transitions in remaining antioxidant content (n_A), and oxidation degree* were evaluated by thermal analyses as well as the elongation at break (E_b) by tensile test. We found the following results; n_A decreases below a certain content and the oxidation degree and E_b start to change drastically (Fig. 2). Since the n_A and E_b show a negative relationship for all specimens, the nA may be useful for evaluating E_b after the start of rapid oxidation (Fig. 3) [H10014].

* The oxidation degree is defined as the ratio of absorbance due to the C=O bond at 1720 cm^{-1} to that due to the C-H bond at 1462 cm^{-1} in infrared absorption spectrum.

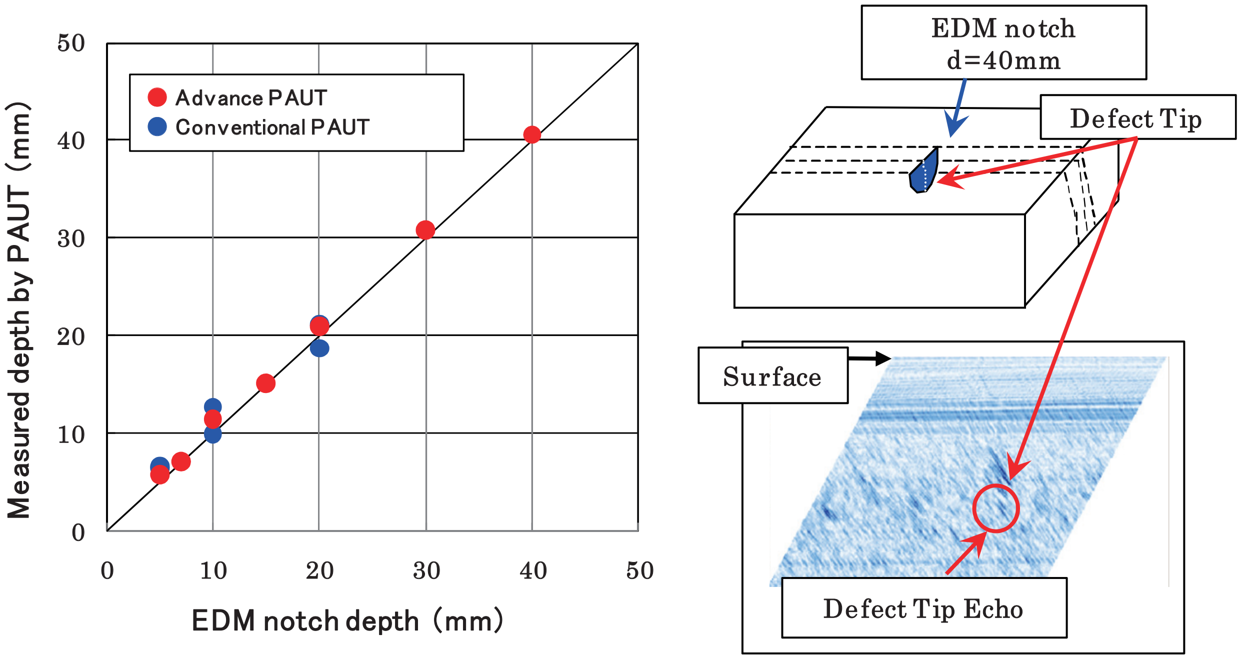

Fig. 1 EDM notch depth sizing by Phased Array UT

Good accuracy is evaluated for defect depth sizing from shallow to deep defect by advanced Phased Array UT.

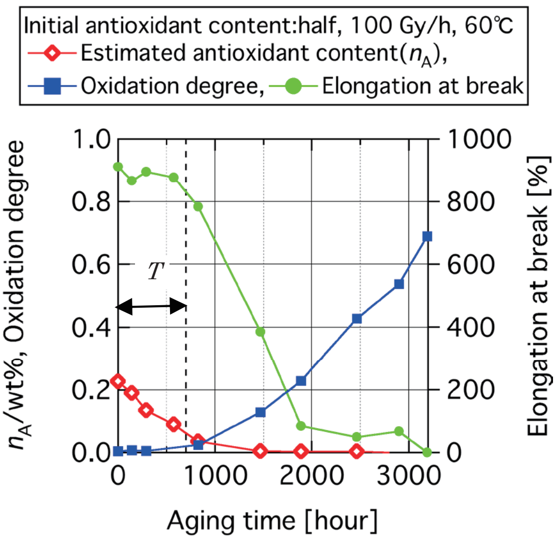

Fig. 2 An example of transitions of Oxidation degree (n_A) and Elongation at break (E_b)

During the initial period (T), n_A and E_b are reasonably stable, but n_A decreases with aging time. After such a period, n_A continues to decrease, and n_A and E_b start to change drastically. It is clarified from these experimental results that there exists a certain antioxidant content that effectively inhibits oxidation.

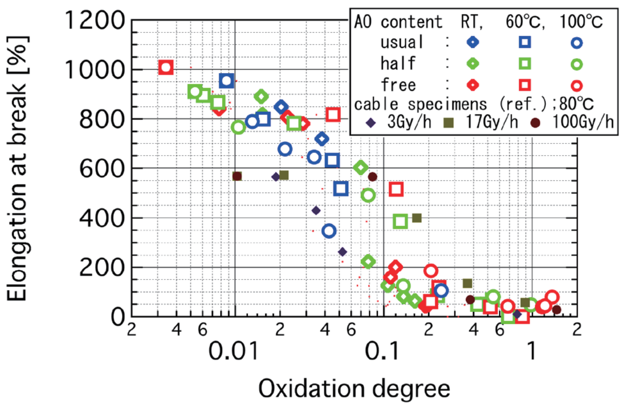

Fig. 3 Relationship between Oxidation degree (n_A) and Elongation at break (E_b)

For all specimens E_b decreases with an increase in n_A. The n_A may be useful for evaluating E_b after the start of rapid oxidation. E_b of reference cable specimens was cited from "The final report of the project of assessment of cable aging for nuclear power plants", JNES-SS-0903, and those specimens were provided from JNES for our chemical analyses.