Project Research — **Further Improvement of Facility Operations and Maintenance Technologies**

Deterioration Diagnosis of Instrumentation and Electrical Equipment

Background and Objective

For long-term operation of nuclear power plants, aging of components, piping, and electrical instrumentation equipment is an important issue that should be taken into account. It has been expected that a diagnostic method will be developed to detect such aging.

In case of SCC crack appearance, phased array UT was applied to measure the defect depth sizing on service components such as pipe, core shroud and so on. However, it has been difficult to measure the defect depth sizing on nickel based alloy welds using conventional UT. Therefore, the development of an advanced phased array UT technique is required for nickel based alloy welds.

Long-term integrity of cable insulation was confirmed by tests based on a 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 the strength and elongation of cable insulation is important, since cable insulation can be degraded due to heating and irradiation stresses. Therefore, it is required to establish an effective index to evaluate the combined degradation of the heat and irradiation of cable-insulating materials.

The objectives of this project are to develop a phased array UT technique for the measurement of crack depth sizing with high accuracy and to construct a model to be able to accurately evaluate the degradation of cable-insulating materials in environments with both heat and radiation combined.

Main results

1 Application of Phased Array UT for Crack Depth Sizing on Nickel based Alloy Welds

Phased array UT (PAUT) procedure for high performance crack depth sizing on nickel based alloy welds was investigated and proposed. The major advantage of this technique is the improved discrimination capability of noise signals from crack tip signals using two-dimensional PAUT (linear array UT) and three-dimensional PAUT (matrix array UT) techniques. Phased array UT technique was applied to nickel based alloy welds with SCC cracks. From the examination results, the relation between SCC crack depth through destructive testing and the measured depth by UT showed good agreement (i.e., the sizing error of crack depth approximately being equal to 3 mm) (Fig. 1). From these results, the effectiveness of a phased array UT technique for crack depth sizing on nickel based alloy welds was shown. Therefore, a UT procedure for crack depth sizing was verified.

2 Investigation of the Degradation behavior of Cable insulating Materials and Devising a New Deterioration Model

The experiments and research conducted so far have made it clear that antioxidants play an important role in the degradation of the mechanical properties of polymeric insulating materials (H10014). However, existing degradation models do not incorporate such antioxidant behavior. For this reason, a new model has been constructed that reflects the so-called “critical concentration characteristics,” in which degradation advances below the critical concentration threshold of an antioxidant. This model also involves the application of diffusion equations for oxygen and the antioxidant (Fig. 2). In this way, an attempt has been made to estimate the concentration distribution of the antioxidant and its change over time. The simulation result obtained using this model roughly reproduces temporal changes in the distribution of degradation products, which was observed using a test sheet (Fig. 3). Thus, it has been confirmed that this model is effective in evaluating degradation including estimating the concentration distribution of antioxidants (H11007).

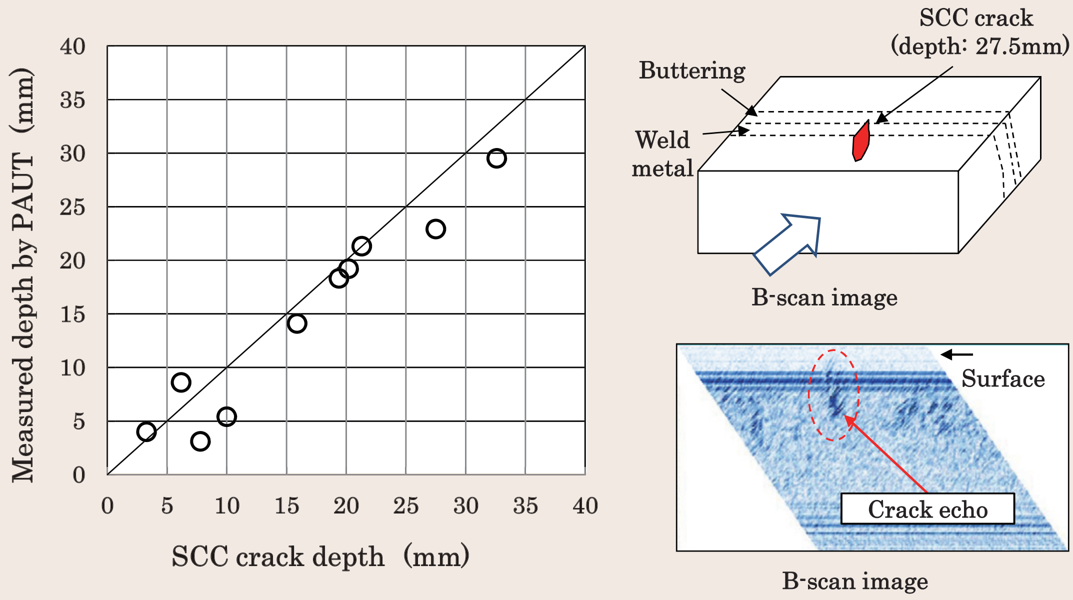

Fig. 1: SCC crack depth sizing using Phased Array UT

The measurement of SCC crack depth sizing with high accuracy on nickel based alloy welds was carried out using Phased array UT technique.

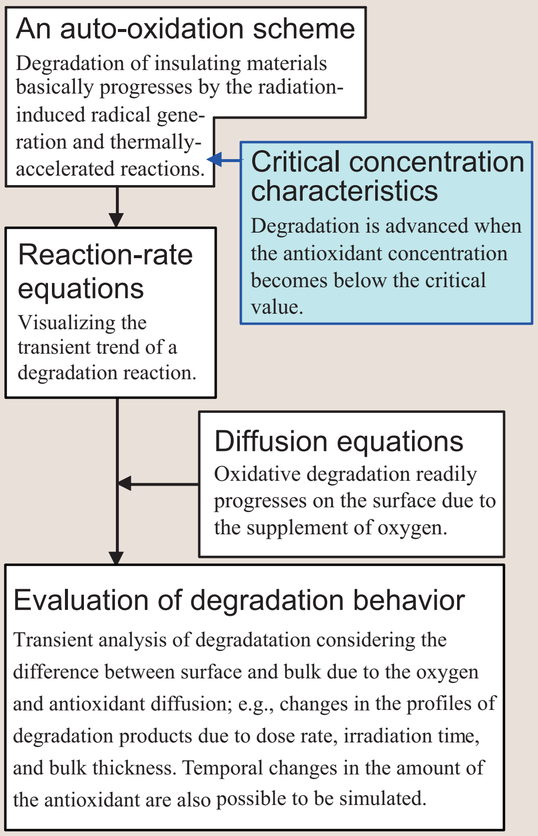

Fig. 2: Constitution of the new degradation model

With this new deterioration model, degradation is evaluated using reaction-rate equations for oxidation reactions that reflect the critical concentration characteristics of antioxidants and diffusion equations.

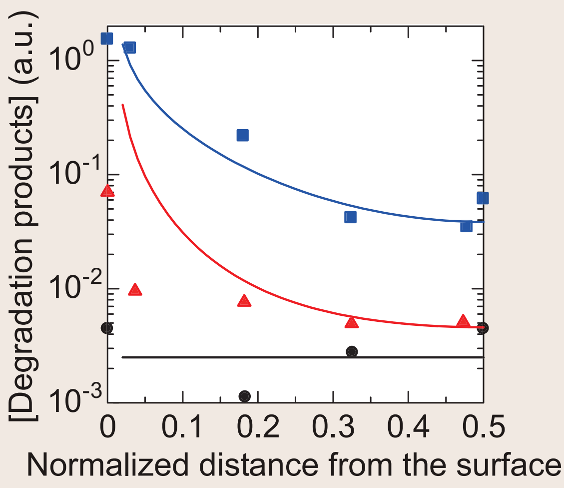

Fig. 3: Comparison of the amount of degradation products in an insulating material experimentally observed and one simulated using the new degradation model

Distance 0 and 0.5 in the figure represent the edge and central point of the bulk sample, respectively. The experiment was carried out using a thermally accelerated test and was evaluated by the infrared absorbance ratio. ●: before deterioration, ▲: degraded for 8 hrs at 180°C, ■: degraded for 44 hrs at 180°C; the solid lines are simulated using the new model in corresponding conditions.