Deterioration Diagnosis of Instrumentation and Electrical Equipment

Background and Objective

For long-term operation of nuclear power plants, the ageing of equipment, pipe and instrumentation and electrical equipment is one of the important issues that should be taken into account. It has been expected to develop diagnosis method to detect their ageing.

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 pipes 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 is 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 an 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

At first, phased array UT examination was carried out to select the UT condition using by side drilled holes specimen. The UT conditions were optimized on phased array probe aperture, focal depth of ultrasound and so on. Phased array UT technique was applied to nickel based alloy weld specimen with EDM notches. Defect depth could be measured up to 5mm by phased array UT and the relation between actual and measured EDM notch depth showed a good agreement (defect depth accuracy approximately equal to 1mm) (Fig.1). From the experimental results, the superior performance of phased array UT technique for inside inspection was shown.

2. Study of deterioration diagnosis index of radiation-thermal deterioration of cable insulation materials

To find useful analysis tools to detect radiation-thermal deterioration through changes in material characteristics and microscopic structures of cable insulating materials, we applied chemical luminescence analysis, micro Fourier transform infrared spectroscopy, the X-ray diffraction method and the nano indentation method, and evaluated changes of material characteristics. As a result, it was found that the micro Fourier transform infrared spectroscopy was one of the useful methods to evaluate oxidation (Fig. 2) and the X-ray diffraction method was one of the most useful methods to evaluate microscopic structure change. Also, it was confirmed that chemical luminescence analysis and positron annihilation spectroscopy were new methods that were highly sensitive in detecting oxidation and microscopic structural changes, respectively.

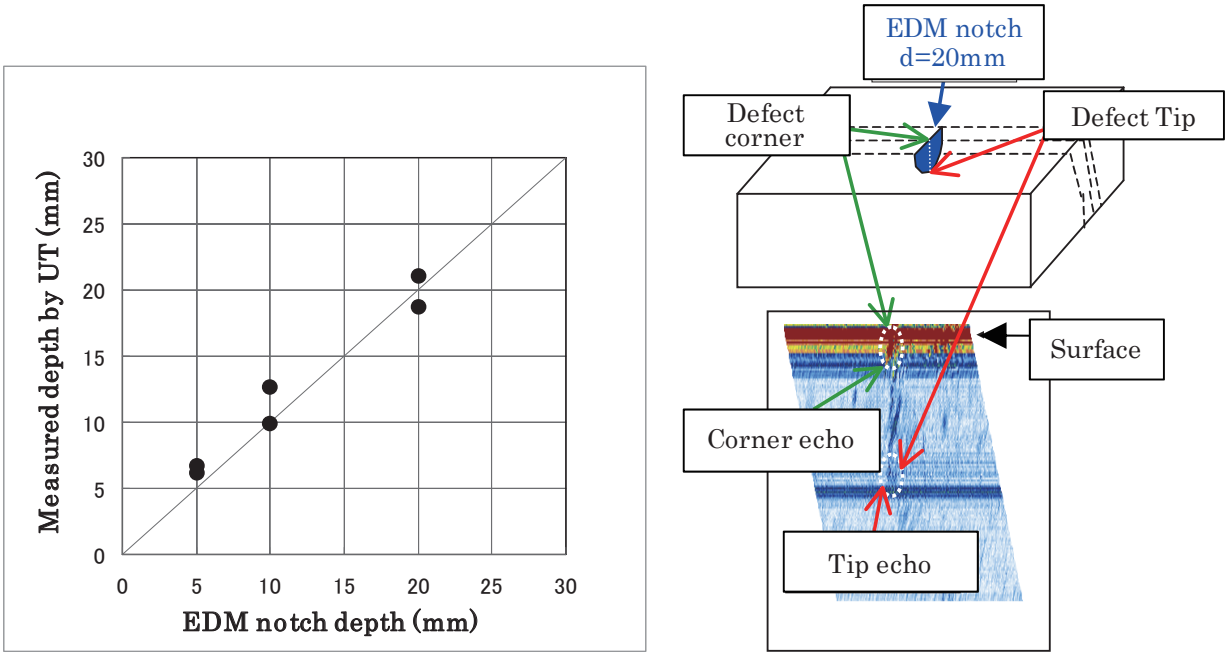

Fig.1 EDM notch depth sizing result

Good accuracy is evaluated for defect depth sizing by phased array UT.
(Average error: 0.92mm, RMS error: 1.58mm)

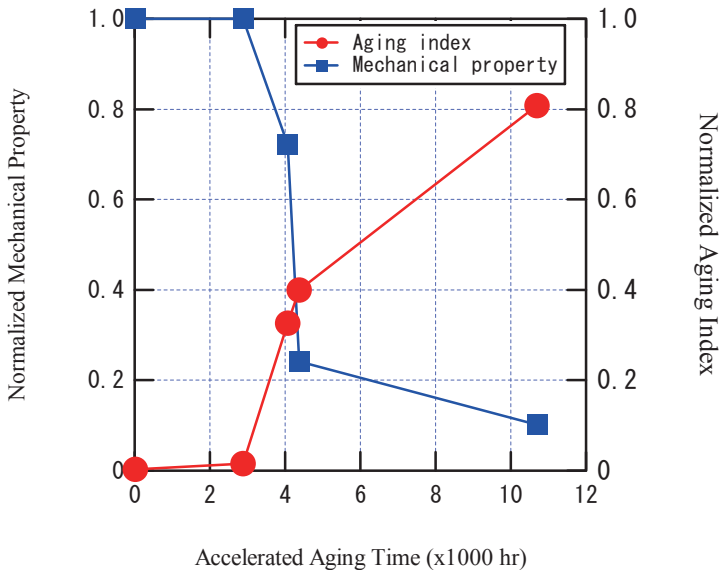

Fig. 2 Mechanical property (elongation) and deterioration index (oxidation degree) of cable insulation as a function of accelerated aging time

Elongation of cable insulation with accelerated radiation-thermal deterioration and its oxidation degree measured by the micro Fourier transform infrared spectroscopy show dependence on accelerated aging time, and the increase in the oxidation degree and the decrease in elongation show a similar tendency. Therefore, the integrity of mechanical strength can be evaluated with the aging index on the basis of the oxidation degree.