Analysis on SCC of Retired Steam Generator Tubes by Using a Multi-Parameter Algorithm and Destructive Method

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1. Introduction

Thanks to its rapid inspection, safe and easy operation, an eddy current testing (ECT) is one of the nondestructive techniques to measure defect morphology on steam generator (SG) tubes in nuclear power plants. In this paper, SCC defects of the pulled out steam generator tubes were analyzed by using the MPA (Multi Parameter Algorithm) that was developed by ANL and operated in MATLAB. The nondestructive analysis results were compared with real crack morphologies of the cracks taken by a destructive examination.

2. Analysis

2.1 Sample preparation

Main form of the degradation of the SG tubings was pitting, primary water stress corrosion cracking (PWSCC), outer diameter stress corrosion cracking (ODSCC) and intergranular attack (IGA). The selected tubes that were based on the ECT signal during ISI were transferred to a hot laboratory at the Korea Atomic Energy Research Institute (KAERI) and being analyzed by destructive method.

2.2 ECT Data acquisition

The ECT data were acquired by using the MIZ-30 acquisition system with a magnetically biased rotating pancake coil (RPC) probe. Before acquiring the ECT data for the pulled out tubes, a copper piece was attached on to the tube surface to identify a position of the flaws and the motion of the probe. A magnetically biased MRPC (Motorized Rotating Pancake Coil) probe was used to compensate a distortion of the ECT signals. Though a sensitivity of this probe is less than the normal probe, it has a benefit for tubes where the ECT data were corrupted by a noise and others which cause negative impacts in the ECT signal.

2.3 Destructive analysis of pulled out tubes

The pulled out tubes transferred to a hot laboratory at the KAERI were destructively examined. Before cutting the tubes and examining a cross-section of defects by using a scanning electron microscopy (SEM), an estimated defect position was obtained based on the nondestructive technique such as ECT.

3. Results and discussion

3.1 Data analysis by MPA

The data were acquired through channels with various frequencies. Only one of the data sets acquired with a pancake coil at 400 KHz was analyzed. Figure 1 is a terrain plot which is a part among several processing stages in MPA when analyzing defects. From Figure 1, two defects were confirmed to be detected. Two indicators of Cu and TTS which can be specified randomly by a user were used to identify the position of a defect. An exact defect information, however, may not be estimated accurately only by Figure 1. The defect depth or length can be analyzed by comparing many assessment results. Figure 2 is an image display and defect depth profile. To obtain a depth profile, the cross-bar was usually positioned on defects that have the maximum depth. From the depth profile, it has 75% tube wall (TW) penetration in depth and 9.5 mm in length. It is difficult to obtain a depth profile when the defect shape is complicated. In this case, several results such as axial and circumferential direction profiles, 3D terrain plot were examined.

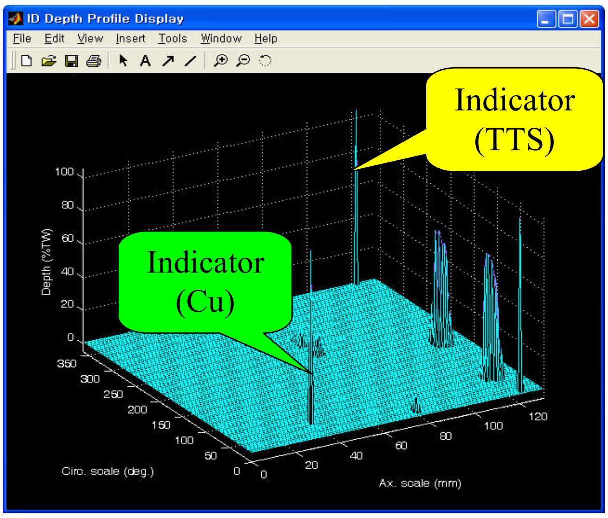

Figure 1 3D-terrain plot orienting from the ID of the tube_A1

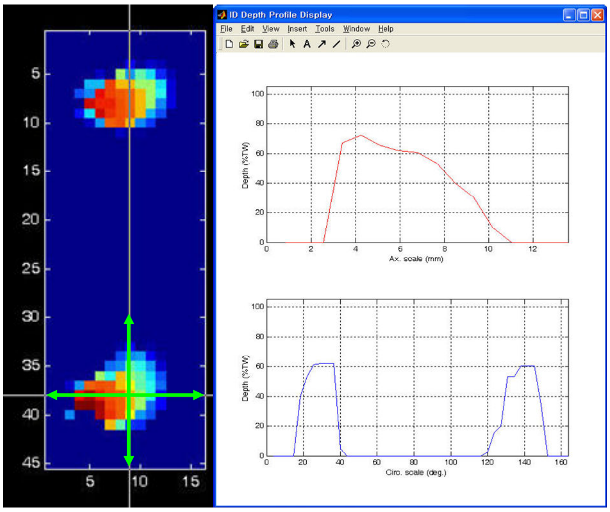

Figure 2 Image display and estimated depth profile by locating the cross-bar on the defect image.

3.2 Comparison with Fractography and EC NDE

In order to confirm the MPA reliability, the fractography on the tubes was compared with EC NDE results. Table 1 shows the evaluation results for the pulled out tube by estimation methods: destructive and nondestructive methods. The tube has two axial defects which were originated from the ID of the tube. The flaw-1 was placed on the tube 90mm in axial length and 230° in circumference away from the Cu marker analyzed by MPA. Even though the cracks were penetrated by 100% through wall, it was hard to quantify the depth. Because the cracks are so tight and crack opening is not enough to show a big ECT signal. Generally, EC signals begins be detected from the probe reaches the defect and continues even after the probe passes the defect. Due to this reason, the difference between the estimation results could be understandable

4. Conclusions

◆ The selected SG tubes that were based on the ECT signal were transferred to a hot laboratory at KAERI.

◆ ECT data with magnetically biased probe were obtained to compensate for the distortion of an ECT signal and utilized a multi parameter algorithm to analyze ECT data of pulled out tubes.

◆ The sensitivity of the magnetically biased probe is less than the non-magnetically probe but it has a benefit for tubes where the EC data was corrupted by a noise

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Table 1 List of flaws of the tube_A1 and their analysis results by using the evaluation methods

Tube_A1	Test method	Flaw type	Cu	Length	Max. Depth
flaw-1	Fractography	MA crack (ID)	238.7°	TTS+1.74~8.77 (7.03mm)	100%TW
	Onsite ECT	MAI (ID)	250°	TTS+5.23~16.91 (11.68mm)	·
	MPA	Axial (ID)	230°	9mm	70%TW
flaw-2	Fractography	MA crack (ID)	342.7°~351.9°	TTS+1.74~9.57 (7.83mm)	100%TW
	Onsite ECT	MAI (ID)	358°	TTS+7.51~17.42 (9.91mm)	·
	MPA	Axial (ID)	350°	9.5mm	75%TW