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Sizing Performance of the Newly Developed Eddy Current System

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1. Introduction

There are some non-destructive examination (NDE) methods for the inspection of components in nuclear power plants, such as ultrasonic, radiographic, eddy current testing, etc. The eddy current testing is widely used for the inspection of steam generator (SG) tubing because it offers a relatively low cost approach for high speed, large scale testing of metallic materials in high pressure and temperature engineering systems. The Korea Hydro & Nuclear Power Co., Ltd. (KHNP) developed an eddy current testing system for the inspection of steam generator tubing in nuclear power plants. This system includes not only hardware but software such as the frequency generator and data acquisition-analysis program. The foreign eddy current system developed by ZETEC is currently used for the inspection of steam generator tubing in domestic nuclear power plants. The equivalency assessment between two systems was already carried out [1] in accordance with the EPRI steam generator examination guidelines. This paper describes the comparison results of sizing performance for two systems.

2. Sizing Methods for Eddy Current Data

2.1 Inspection Methods of SG Tubing

The eddy current testing is being widely used for the inspection of steam generator tubing as stated above. It uses electromagnetic induction to detect flaws in conduct materials. Two types of eddy current probes are normally used for the inspection of steam generator tubing: the bobbin probe and the rotating probe.

The bobbin probe has a self-comparison different coil arrangement as shown in Fig. 1 (a). Two narrow coils wound opposite to each other compare different sections of a tube during the examination process. As the probe is withdrawn, any differences detected by each coil are reflected as changes in coil impedance and are displayed as eddy current signal responses on a screen. This probe is excellent for detecting small localized flaws and axial cracks, but it is relatively insensitive to circumferential cracks due to the direction of the induced current. The entire tube length can be quickly examined using the bobbin probe.

The rotating probe is normally used for the inspection of a tube's circumference. The surface riding coils of this type of probe ensure maximum performance of the signal-to-noise ratio. It excels in finding circumferential flaws in critical areas such as roll transitions and regions affected by deposits in steam generator tubes.

(a) (b)

Fig. 1 Bobbin probe (a) and rotating probe (b)

2.2 Depth-Sizing Methods for Bobbin Data

As described above, the bobbin probe can be used for the volumetric flaws, such as pitting, inter-granular attack corrosion, and wear, but it is not suitable for detection of cracks, especially a circumferential crack. In general, wear, stress corrosion cracking and pitting have been found in steam generator tubes [2]. In this paper, we describe the depth-sizing methods for very small volumetric flaws like pitting, and relatively large volumetric flaws like wear.

According to the examination technique specification sheets, the voltage normalization is performed in the main lissajous window and is set to 4 volts for 4 x 20% flat bottom holes (FBHs) of the ASME calibration standard at each channel, in order to get the depth size from the unknown flaw. Also, the phase of the 100% through-wall (TW) hole is set to 40 degrees for all channels.

The phase angle calibration curve is normally used for the pinhole type flaws like pitting. It was achieved from the 100%, 60%, and 20% FBHs in the ASME calibration standards as shown in Fig. 2 so that the depth-size of small volumetric flaws can be determined.

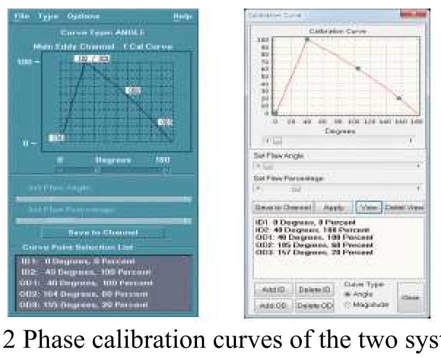

Fig. 2 Phase calibration curves of the two systems

The depth-size of flaw type like wear by the anti-vibration bar is obtained from the amplitude calibration curve of 40%, 20% and 0% wear scars in the calibration standard as shown in Fig. 3

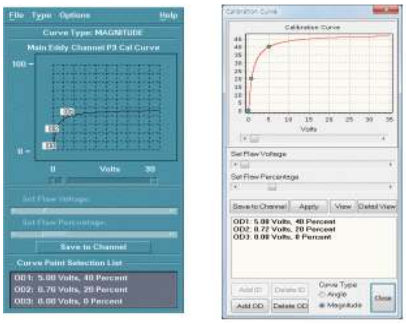

Fig. 3 Amplitude calibration curves of the two systems

3. Results

Two eddy current systems were used for the comparison of the depth-size of various artificial flaws, one is the MIZ-70 foreign system and the other is the newly developed domestic system. The artificial flaws were arbitrarily made in the form of flat bottom hole and wear scar. For the flat bottom hole, the comparison results of the amplitude, phase angle, and the depth-size obtained from the foreign and domestic systems are shown in Table 1 and Fig. 4 to 5, respectively.

Table 1: Performance comparison for the FBHs between the foreign and domestic systems

Flaw ID	F-1			F-2			F-3		
	A	P	D	A	P	D	A	P	D
MIZ-70	0.68	140	33	1.46	119	49	3.98	90	70
K-Sys.	0.70	142	32	1.42	118	51	3.88	89	71
∣Diff.∣	0.02	2	1	0.04	1	2	0.10	1	1

In table 1, A is an abbreviation for amplitude in volts, P for phase angle in degree, and D for depth-size in percent.

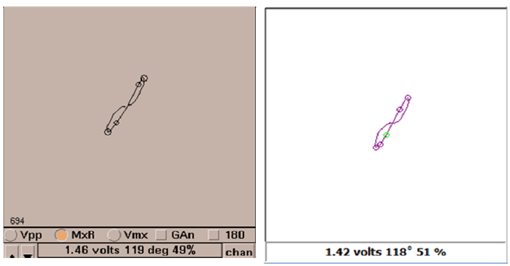

Fig. 4 Signals of the flaw F-2 obtained from the foreign and domestic systems

As shown in Table 1 and Fig. 4 to 5, the depth-sizing results, amplitudes and phase angles for the newly developed system are in good agreement with the MIZ-70 qualified system.

For the wear scar, the comparison results of the amplitude and depth-size obtained from the two systems are shown in table 2 and Fig. 6, respectively.

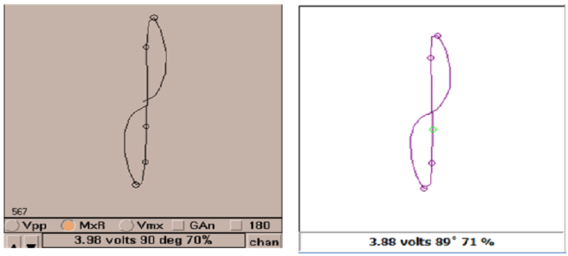

Fig. 5 Signals of the flaw F-3 obtained from the foreign and domestic systems

Table 2: Performance comparison for the wear scars between the foreign and domestic systems

Flaw ID	W-1		W-2		W-3	
	A	D	A	D	A	D
MIZ-70	0.50	15	1.31	27	5.63	41
K-Sys.	0.50	16	1.39	28	6.06	41
∣Diff.∣	0.00	1	0.08	1	0.43	0

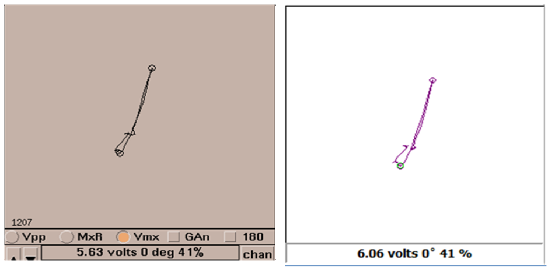

Fig. 6 Signals of the flaw W-3 obtained from the foreign and domestic systems

4. Conclusions

The KHNP developed a new eddy current testing system for the inspection of steam generator tubing in domestic nuclear power plants. The equivalency assessment of the newly developed system with the EPRI-qualified system was already carried out. In this paper, the comparisons of depth-sizing performance for the artificial flaws between two systems were performed. The results show that the newly developed system is in good agreement with the qualified system. Therefore, it is expected that the newly developed eddy current system can be used for the inspection of steam generator tubing in nuclear power plants.

REFERENCES

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