Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 10-11, 2007

A Study for ECT Signals Influenced by the Crack Created on MBM on Steam Generator tubes

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1. Introduction

In the course of fabricating steam generator (SG) tubes, sometimes the abrasion marks are created on the tubes. The steam generator tubes in nuclear power plant are inspected during shutdown period to evaluate the integrity. Eddy current testing (ECT) is used for the steam generator tube inspections since the ECT can be performed remotely and fast. The ECT signal is influenced by the manufacturing burnish mark (MBM). The interaction between MBM and flaws changes the signal and affects the detect ability of flaws. Therefore, it is desired to understand the change of the signal amplitude and phase affected by MBM to improve the flaw detection capability. This study describes the method to analyze the signals of the notch on MBM and gives guidance for additional test of plant inspection.

2. Experiments and Results

The artificially fabricated MBM specimens are used in the experiment of this study. The notches are oriented axially and circumferentially on the MBM of the steam generator tubes.

2.1 Experiments method

The experiment system is composed of a MIZ-70 frequency generator, a 10D-4 probe pusher, ECT bobbin probes developed by Zetec Inc., a HP workstation with Eddynet program and MBM specimens. The analysis signal setup is the same as the plant inspection, set the phase to 40˚ for a 100% through hole and the amplitude to 4Volt for 4*20% flat bottom hole of ASME standard using differential highest channel and normalizing the others. The signal acquisition specification is shown in Table 1.

Table 1. Signal acquisition specification.

Items	Specification
Tube material	Inconel 600MA
Tube outer diameter	19.05mm
Tube thickness	1.067mm
Frequency	550/300/100/20kHz
Probe scanning speed	24inch/sec
Sampling speed	1600sample/sec

This experiment is proceed by acquiring ECT signal for artificially fabricated MBM specimens without notches and then compares the difference between the signal of MBM specimens with and without notches. The specimens have different depth and length of MBM as shown as real tubes, and different depth notches oriented by axial and circumferential direction on the SG tubes. The specimens are shown in Table 2.

Table 2. The composition of specimens; all notches have 0.15mm width and 4mm length.

Specimen No.	MBM depth(mm)	Flaw Type
STD #03	0.06/0.11/0.15/0.21	No Flaw
STD #04	0.1	OD Axial /Cir. 20/40/60% depth Notch
STD #05	0.15	
STD #06	0.2	

2.2 ECT Signals for MBM specimen without notches

The ECT signal for the specimens is similar to typical MBM signal comparing by channels.

Table 3. Signal amplitude(Volts) according to the MBM depth (mm) using STD #03 specimen.

MBM Dep / Ch.	0.06	0.11	0.15	0.21
550kHz Diff	0.48	0.76	1.75	2.28
300kHz Diff	1.23	2.81	3.41	5.24
100kHz Abs	0.96	2.65	3.60	5.75

Table 4. Signal phase(˚) according to the MBM depth (mm) using STD #03 specimen.

MBM Dep / Ch.	0.06	0.11	0.15	0.21
550kHz Diff	166	153	176	171
300kHz Diff	122	109	125	123
100kHz Abs	57	59	74	67

This signal shows that the amplitude is increased as the MBM depth is deeper and the signal rotation according to the frequency is similar as that of outer diameter wear, which are shown as Figure 1 & 2.

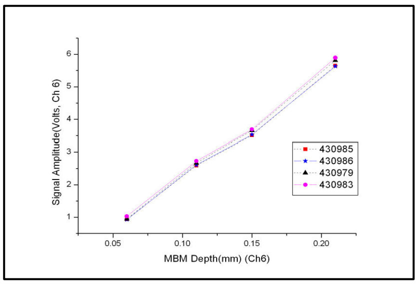
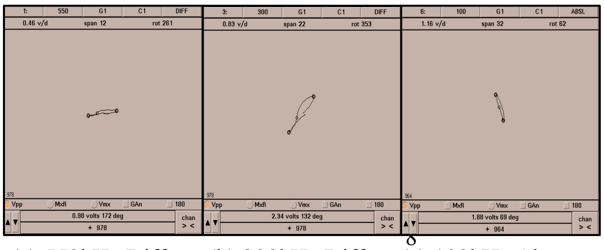


Figure 1. Signal amplitude due to MBM depth without notch using STD #03 specimen.



(a) 550kHz Diff (b) 300kHz Diff (c) 100kHz Abs

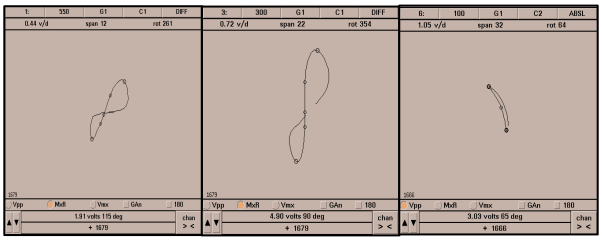
Figure 2. ECT signal of MBM (0.1mm depth) without notch.

2.3 Signal Analysis of MBM specimen with axial notches

The axial notches on MBM's cause the signal distortions for the amplitude and phase. The amplitude change is prominent at channel 6 (100 kHz, Abs), and the phase change is prominent at channel 1 (550kHz, Diff) using MxR phase analysis method.

Table 5. Amplitude and phase change caused by axial notch depth on MBM; the phase using MxR method.

Var. / MBM dep	Amp(Volt) @ Ch 6		Phase(°) @ Ch 1	
	40%	60%	40%	60%
MBM 0.1	0.46	1.18	-88	-62
MBM 0.15	0.44	0.85	-24	-42
MBM 0.2	0.43	1.18	-30	-53



(a) 550kHz Diff (b) 300kHz Diff (c) 100kHz Abs

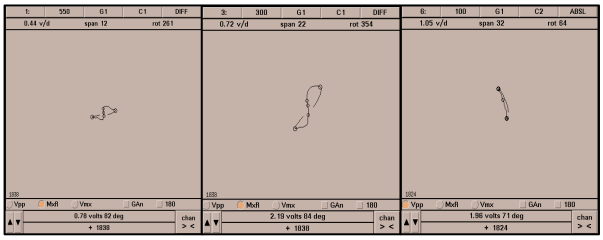
Figure 3. ECT signal of MBM (0.1mm depth) with 60% axial notch; percent thickness reduction related to tube wall.

2.4 Signal Analysis for MBM specimen with circumferential notches

The circumferential notches on MBM's cause signal distortions as the axial notches. However, the amplitude change at Ch 6 is not sufficient to distinguish the probe change variables. The phase change at Ch 1 is sufficient to distinguish the variables even the signal size is smaller than that of the axial notches.

Table 6. Amplitude and phase change caused by circumferential notch on MBM; the phase using MxR method.

Var. / MBM dep	Amp(Volt) @ Ch 6		Phase(°) @ Ch 1	
	40%	60%	40%	60%
MBM 0.1	0.06	0.07	2	-94
MBM 0.15	0	0.1	2	-42
MBM 0.2	0	0.1	-9	-21



(a) 550kHz Diff (b) 300kHz Diff (c) 100kHz Abs

Figure 4. ECT signal of MBM (0.1mm depth) with 60% circumferential notch; percent thickness reduction related to tube wall.

3. Conclusion

The results in this study show the difference between the ECT signals of MBM's with and without notches. The differences related to the notch depth and type; the signal amplitudes of axial notches are bigger than circumferential notches. It is more difficult to distinguish the difference if the MBM depth is deeper because the MBM affects the notch signal more. Moreover, the difference of the signal using the phase is more useful than the signal using the amplitude because the amount of the difference is much larger than the variable of probe change.

Nuclear power plants have different type of SG's and have experienced the different aspect of MBM's. Even the typical signals of the MBM's are similar, the size of the signals of the MBM's are different. In order to apply the results to plants, further technical consideration should be needed.

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