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Feasibility Test with a STS304 tube of the Eddy Current Test using a Bobbin Probe for the SMART SG Tube Inspection

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1. Introduction

The SMART SG tubes will be made of Alloy 690. The outside diameter will be 17 mm and the thickness will be 2.5 mm.

They will be assembled helically around, and their innermost diameter will be about 600 mm and the total length will be about 32 meters. For the sake of safety, SMART SG tubes are designed for use with thick tubes such as 2.5 mm thickness compared to about 1 mm thickness of normal Korean standard pressurized water reactor tubes.

Due to using thick tubes such as the 2.5 mm varieties, it was doubted that the Eddy Current Testing Method (ECT) would be a feasible method.

Therefore we are trying to check the feasibility of the ECT using the substitute material STS304 tube instead of Alloy 690 tubes with the bobbin type ECT probe.

The previous paper [1] reported the feasibility of the ECT using modeling, but this paper will report the preliminary experimental results and comparison with the previous results of the modeling for the STS304 tube.

2. Modeling

$$E_i(\vec{x}) = E_i^0(\vec{x}) - q^2 \sum_j \int_v G_{ij}(\vec{x},\vec{x}')E_j(\vec{x}')dv'$$

The VIM computer simulation code is to calculate a change of electric field strength due to a defect. [2]

Where,

E_i^0 : I'th component of the field in the absence of a flaw.

$q^2 = 2i/\delta$: where δ is the skin depth of the material

G_{ij} :a component of the electic field Green's tensor for the unflawed part.

For calculating the phase angle due to a frequency change, we selected 100 kHz.

The modeling condition is for the ASME Standard defects such as 100%, 80%, 60%, 40% and 4-flat bottomed 20% holes shown as Fig. 1.

The fill factor of the bobbin probe is about 83% and the number of coil turns is 110.

The conductivity of the STS304 is 1,388,900 S/M.

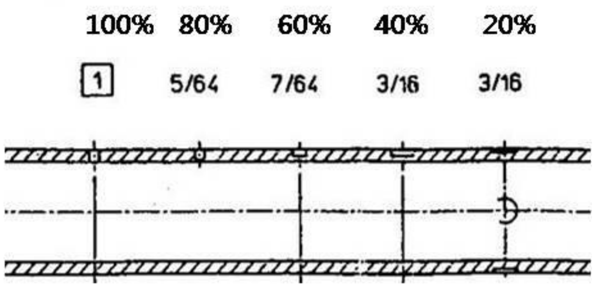


Fig. 1. Modeling region like ASME STD defects

The variable for the VIM simulation was frequency. The ASME code Sec. V Art. 8 describes that the basis frequency is chosen so that the phase angle of a signal from the four 20% flat bottom defects is between 50 deg. and 120 deg. rotated clockwise from the signal of the through-wall hole. [3]

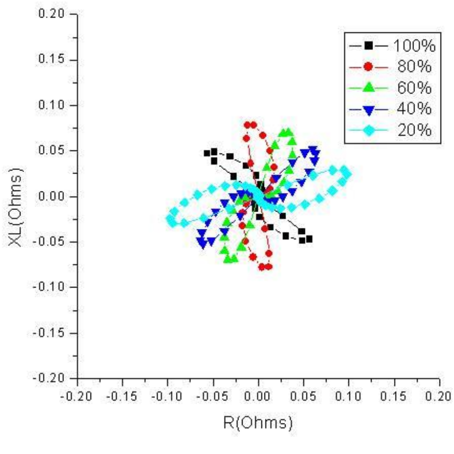


Fig. 2 The ASME defects signals at 100 kHz for the substitute tube SUS 304 tubing.

As shown in Fig. 2, for the SUS304 tube at 100 kHz, the phase angle from 100% to 20 % signal is about 120 deg. and this is about 160 deg. from –x axis. This could be the basis frequency for the SUS304 tube.

3. Experiment

For the experiment, a bobbin probe (Fig. 3), MIZ-27 (Fig. 4), specimen (Fig. 5) was used.

The inspection frequencies selected were 100, 80, 60, 40, 20 kHz.

In the specimen, there are 100, 80, 60, 40, 20% ASME standard defects and a 5 mm x 0.2 mm 60%, 40%, 20 % circumferential notch.

Fig. 3 ECT bobbin probe

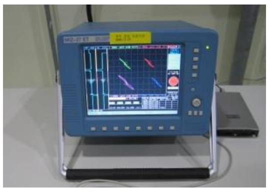
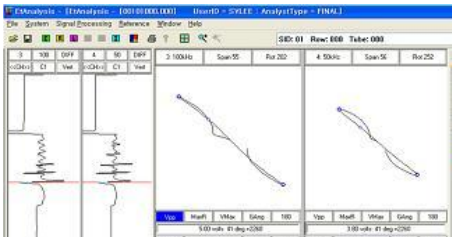


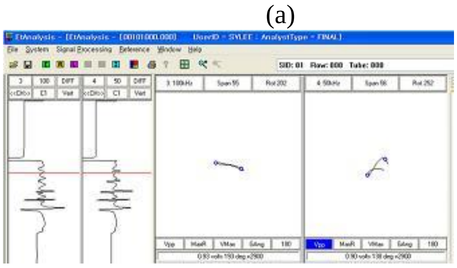
Fig. 4 ECT equipment (MIZ-27)

Fig. 5 ECT specimen

4. Results



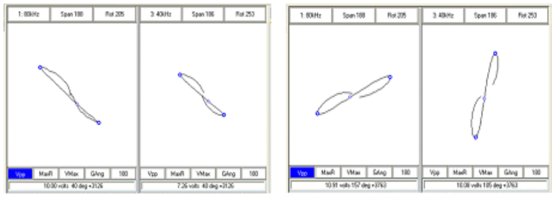
(a)



(b)

Fig. 6 (a) ASME 100%, (b) 20% flat bottom holes signal at 100 kHz.

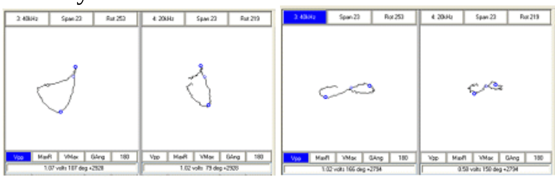
As shown in Fig. 6, the phases of an ASME 100% defect, and 20% defects are 40 and 193deg. respectively.



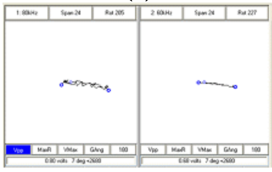
(a) (b)

Fig. 7 (a) ASME 100%, (b) 20% flat bottom holes signals at 80 kHz and 40 kHz.

As shown in Fig. 7, the phases of an ASME 100% defect and 20% defects at 80 kHz are 40 and 157 deg. respectively.



(a) (b)



(c)

Fig. 8 (a) 60%, (b) 40% (c) 20% 5 x 0.2 mm notch signals at 40 kHz and 20 kHz.

As shown in Fig. 8, the 60% and 40% notch could be distinguished but the 20% notch could not be distinguished with noise signals.

5. Conclusion

The conclusion of the feasibility test of applying the ECT technique on the thick STS304 tube with 2.5 mm thickness with a bobbin probe is that it can be successfully detect an ASME 100% hole, and 20% of flat bottom holes.

The limitation of detection was a 20% 5 x 0.2 mm circumferential notch. The phase spread angle between 100% and 20% defect was 117 deg at 80 kHz, so it could be a primary frequency. There was some discrepancy between the modeling and the experiment.

The ECT technique is considered to be a good method for the SMART SG tubing ECT.

Acknowledgements

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REFERENCES

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[2] Kim Murphy and Harold A. Sabbagh, "A Boundary Integral Code for Electromagnetic Nondestructive Evaluation," 12th Annual Review of Progress in Applied Computational Electromagnetics, Mar. 18-22, 1996.
[3] ASME code Sec. V Art. 8 App. I-862, 1992.