Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 29-30, 2009

Optimum Frequency for Eddy Current Testing Method of SMART SG tubes

Yoon-Sang Lee, Hyun-Kyu Jung, Yun-hang Choung
Korea Atomic Energy Research Institute, Dukjin-Dong 150, Yesong-Gu, Daejeon, 305-353, Korea
yslee@kaeri.re.kr

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 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 2.5 mm varieties, it was doubted that the Eddy Current Testing Method (ECT) would be a feasible method.

Therefore we are trying to simulate the bobbin probe signal for SMART SG tubes and comparing it to PWR SG ECT probe signal using VIM software, checking for the applicability of ECT. Also we are trying to compare the ECT signal of 2.5 mm thick stainless tubes to check if they are possible substitute material.

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.

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 select 100 kHz and 150 kHz.

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

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

The conductivity of Alloy 690 and STS304 is 871,080 S/M and 1,388,900 S/M.

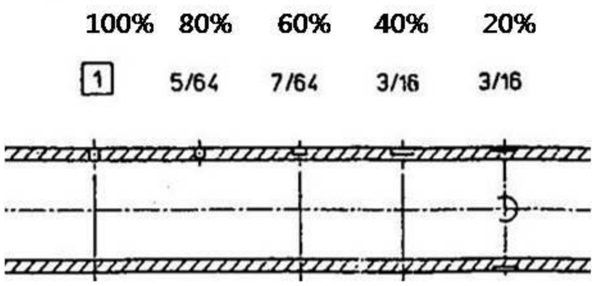

Fig. 1. Modeling region like ASME STD defects

3. Results

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. [2]

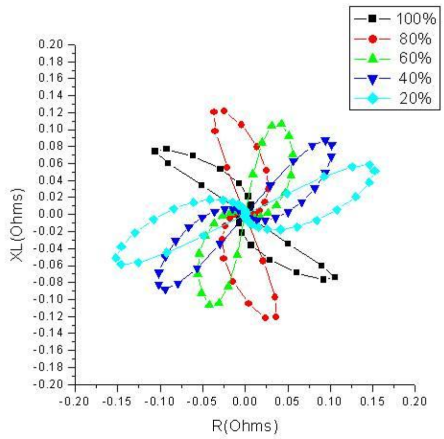

Fig. 2 The ASME defects signals at 150 kHz for the SMART tube Alloy 690 tubing.

In Fig. 2, for SMART SG tube at 150 kHz, the phase angle from a 100% hole to 20 % defects is about 116 deg. If the phase of 100 % hole is adjusted to 40 deg from – x axis, then the phase of 20% will be 156 deg. This is optimal angle for the depth estimation of PWR steam generator usual practice.

As shown in Fig. 3, for SMART SG tube at 100 kHz, the phase angle from 100% to 20 % signal is about 84 deg. and this is about 124 deg. from –x axis. This could be basis frequency according to ASME Sec. V code.

But it would be no better than 150 kHz in the view point of resolution.

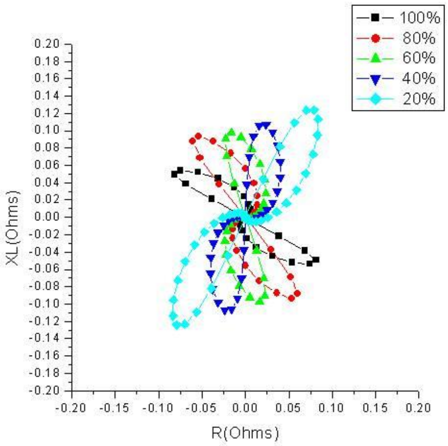

Fig. 3 The ASME defects signals at 100 kHz for the SMART tube Alloy 690 tubing.

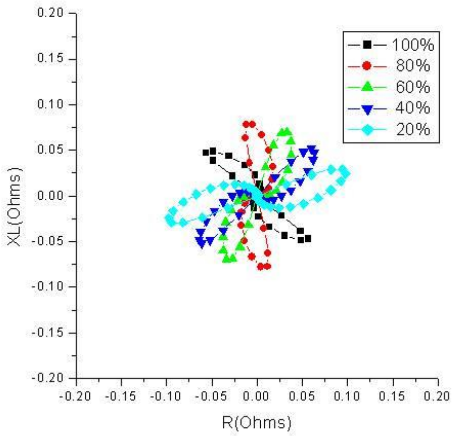

Fig. 4 The ASME defects signals at 100 kHz for the substitute tube SUS 304 tubing.

As shown in Fig. 4, for 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 basis frequency for the SUS304 tube.

As shown in Fig. 5, for PWR SG Alloy 690 tube at 550 kHz, the phase angle from 100% to 20 % signal is about 88 deg. and this is about 128 deg. from –x axis. This is used as basis frequency for the normal practice.

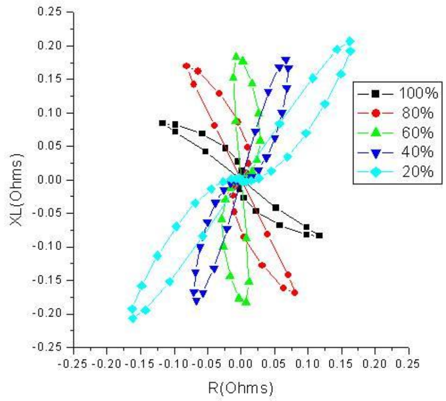

Fig. 5 The ASME defects signals at 550 kHz for PWR SG Alloy 690 tubing.

4. Conclusion

In order to calculate the optimum frequency, 150 kHz is considered to be best for SMART SG tubing ECT. Compared to STS304 results, STS304 could be used as substitute material for Alloy 690 if the inspection frequency were lowered.

Acknowledgements

The authors would like to express their appreciation to the Ministry of Education, Science and Technology (MEST) of Korea for its support of this work through the National Nuclear R&D Project.

REFERENCES

[1] 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.
[2] ASME code Sec. V Art. 8 App. I-862, 1992.