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Root Cause Analysis of Background Noise Signals in Full Length Inspection of Steam Generator U-Tubes by using an Eddy Current Bobbin Coil Probe

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1. Introduction

The integrity of steam generator tubes in pressurized water reactors is periodically inspected by the eddy current test methods. Especially, the full length of each u-tube is examined by using a bobbin coil probe in order to screen out suspicious signals existing in any location of the long tube span (~20 m). The detectability of defect is strongly dependent on the value of signal to noise ratio [1] and thus, it is desirable to reduce the background noise signal from bobbin coil probe. The causes of noise signals can be categorized by structural noise and equipment noise. Fig. 1 shows an example of eddy current bobbin coil signals acquired from full length inspection of a steam generator u-tube. The large signals in the square u-bend regions reflect structural noise from the two bent tube geometry. However, the unidentified large noise signals are observed only in the specific region where the coil probe is located beyond the u-bend, as shown in the red line circle of Fig.1. Therefore, it is strongly suspected that bending of signal lead cables travelling across the u-bend region of low radius may cause eddy current background noise signals in the bobbin coil probe inspection. In this work, the evolution and characteristic of background noise signals originated from bending of lead cables in the bobbin coil probes were investigated experimentally.

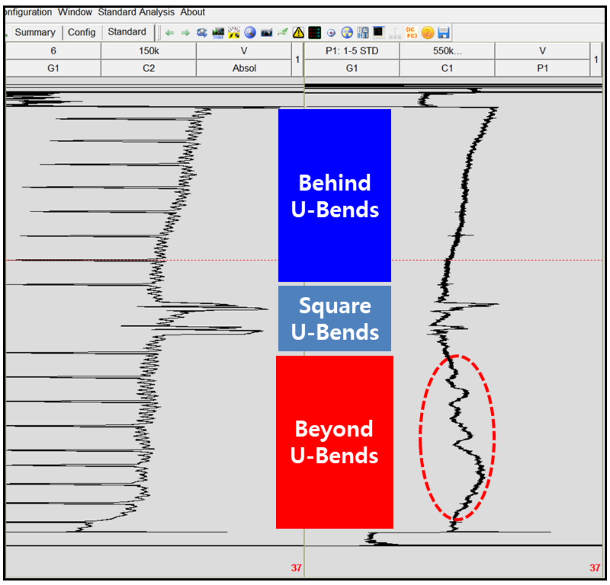

Fig. 1. Example of eddy current bobbin coil signals from full length inspection of a steam generator u-tube.

2. Methods and Results

2.1 Manufacturing of U-Tube Mock-up Bending Block

Considering the various geometry and arrangement of u-tubes in steam generators of Korean OPR-1000, which are consist of u-bend type and square bend type depending upon the row number, u-tube mock-up bending block was manufactured as shown in Fig. 2. The radius of bending block ranges from 4” (row-3) to 11” (row-11) including 10” for square bends. The signal lead cable of bobbin coil probe was subjected to sequential motion of bending and un-bending on the block in order to simulate cable travelling across the tube bend region of each radius.

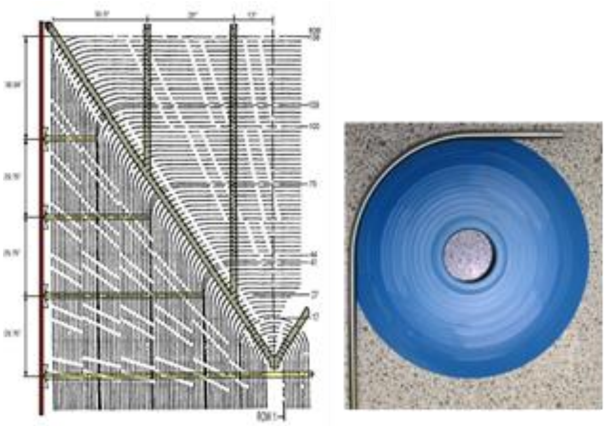

Fig. 2. Geometry and arrangement of u-tubes in steam generator and u-tube mock-up bending block.

2.2 Eddy Current Test

The changes of eddy current background noise signals were examined with a ZETEC® M-ULC bobbin coil probe and MIZ-70 eddy current data acquisition system. Multiple test frequencies of 700, 550, 300 and 150 kHz were chosen, and the signals of both differential and absolute modes in each test frequency were analyzed.

2.3 Results and Discussion

Fig. 3 shows the changes of eddy current background noise signals with sequential bending and un-bending of lead cable on the u-bend block of row-3 with 4” radius. The magnitude of noise signals increased with the increase of test frequency for both differential (odd number channels) and absolute (even number channels) modes.

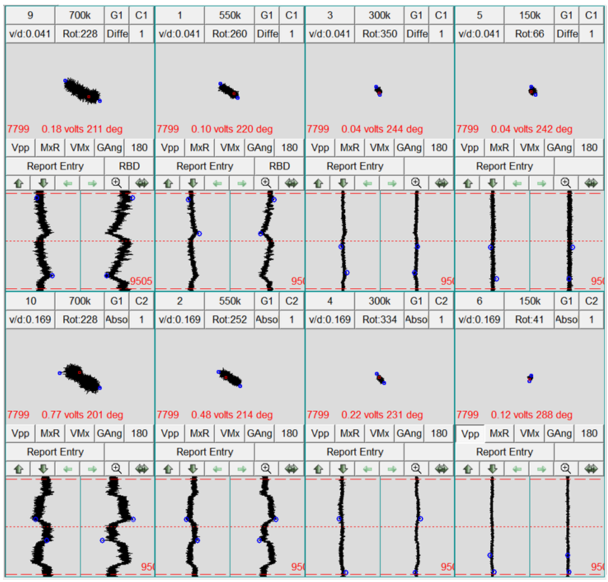

Fig. 3. Noise signals from cable bending on the u-bend block of row-3 with 4” radius.

The changes of eddy current background noise signals from a square bend of 10” radius are shown in Fig. 4. Similar results are observed with those of Fig.3.

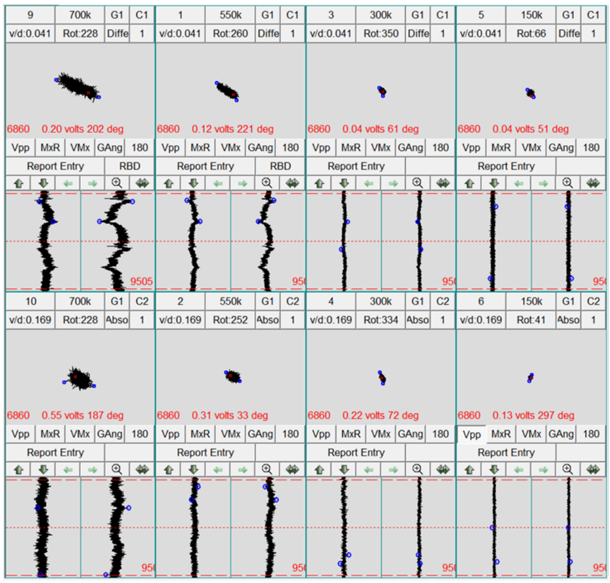

Fig. 4. Noise signals from cable bending on a square bend with 10” radius.

The changes in amplitude of background noise signals with row number and radius of u-bends were measured, and the results for the differential mode were summarized in Fig. 5. It is observed that the noise signals are not dependent upon the radius of cable bending, and only a trend of slight decrease in noise amplitude with the decrease of row number (radius) could be presumed.

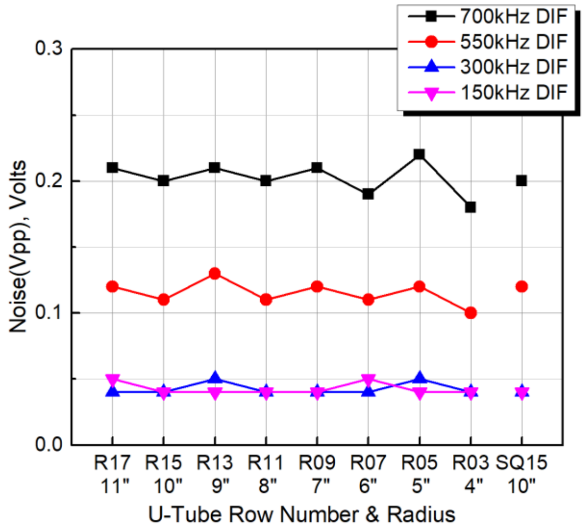

Fig. 5. Changes of noise signal amplitude from cable bending with row number and radius of u-bends, differential mode.

The changes of noise signal amplitudes in absolute mode are shown in Fig. 6. No dependence of noise signals upon the radius of cable bending is observed, but only a trend of slight increase in noise amplitude with the decrease of row number (radius) could be surmised.

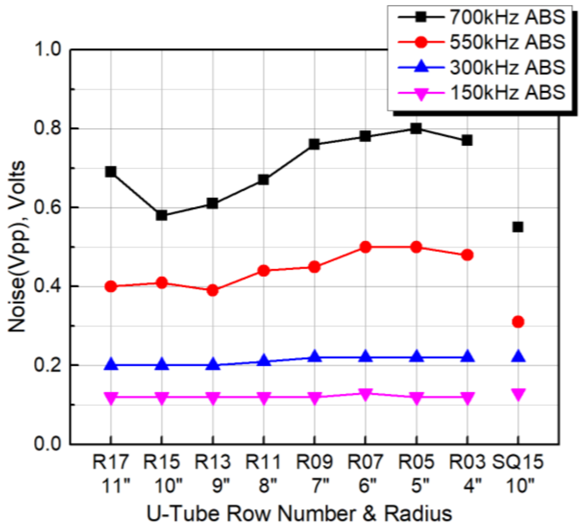

Fig. 6. Changes of noise signal amplitude from cable bending with row number and radius of u-bends, absolute mode.

3. Conclusions

The eddy current background noise signals originated from bending of signal lead cable in a bobbin coil probe could be identified experimentally. The evolutions of background noise signals by cable bending are more notable in the higher test frequency above 300 kHz in both differential and absolute modes. No reliable dependence of noise signal amplitude upon bending radius was observed. Therefore, it is recommended that high frequency eddy current data, obtained in the tube region where the bobbin coil probe head is located beyond the u-bend, should be carefully analyzed considering the large background noises caused by cable bending. Also, the improvements of signal lead cables are required to reduce the noises from bending.

ACKNOWLEDGEMENTS

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REFERENCES

[1] Measuring and Monitoring Noise in Steam Generator Tubing Eddy-Current Data for Tube Integrity Applications. EPRI, Palo Alto, CA: 2008. 1016554.