Development of Evaluation Technology for Detection of Axial Crack at Eggcrate Intersection of Steam Generator Tube

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1. Introduction

The occurrence of outer diameter (OD) axial stress corrosion crack at eggcrate intersection of steam generator tube in operating power plant is inspected primarily by the eddy current test using bobbin coil probe. Therefore, the characteristics of the bobbin coil signal from the axial crack at eggcrate intersection of steam generator tube should be understood for the accurate and earlier detection of the crack. In this study, the mockup assembly simulating the steam generator tube with OD axial stress corrosion crack and tube support eggcrate was manufactured, and the characteristics of bobbin coil eddy current signal was examined in order to extract the improved evaluation technique for the detection of the crack.

2. Manufacturing of Mockup Assembly

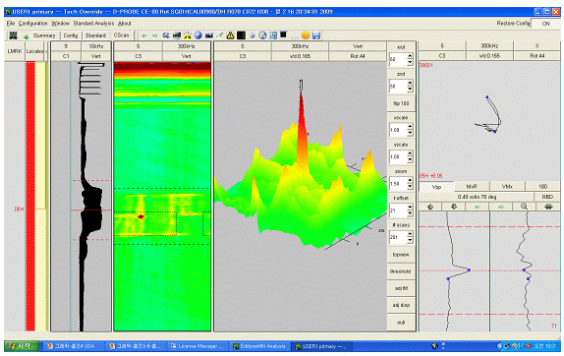
2.1 Steam Generator Tube Specimen with OD Axial Stress Corrosion Crack and Tube Support Eggcrate

The axial stress corrosion crack was manufactured on outer surface of Alloy 600 steam generator tube. The tube specimen, the outer surface of which was masked excluding an axial slit, was immersed into corrosive solution with internal pressurization so that a stress corrosion crack could be selectively introduced at the location of axial slit [1]. The tube specimens with OD axial crack were assembled into a tube support eggcrate of AISI 409 stainless steel. Fig. 1 shows the photograph of a mockup assembly manufactured.

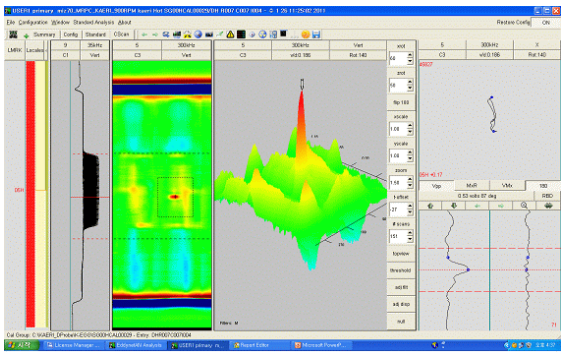
Figure 1. Mockup assembly of steam generator tubes with OD axial crack and eggcrate.

2.2 Verification of Mockup Assembly Manufactured

In order to verify the identity of mockup assembly simulating the axial crack at eggcrate intersection in operating power plant, the eddy current signals obtained by using a motorized rotating pancake coil(MRPC) probe were analyzed for comparison. Fig. 2-a and Fig. 2-b show the results of MRPC +Point Coil signal obtained from a steam generator tube cracked at eggcrate intersection in an operating power plant and that from a steam generator tube in manufactured mockup assembly, respectively. It can be recognized that two figures are almost the same and thus the mockup assembly precisely simulates the vulnerable location in steam generator of operating power plant.



(a)



(b)

Figure 2. Signal of MRPC Probe +Point coil from (a) a steam generator tube cracked at eggcrate intersection in an operating power plant and (b) a steam generator tube specimen in manufactured mockup assembly.

3. Characteristics of Bobbin Coil Signal

3.1 Dependence of Signal Amplitude upon Test Frequency and Mixing Channel

Eddy current signals of single and mixing frequency channels are simultaneously obtained by bobbin coil probe inspection. The signal of mixing frequency channel (P1:550-150kHz, P2:550-300kHz) is used for the detection of defect at supports because it suppress the signal from support and clearly reveal the defect signal from the tube. Fig. 3 shows the variation of relative signal amplitude in frequency channels with the depth of drilled hole in ASME standard specimen. It is clearly seen that the signal from single mid-frequency channel (300, 150kHz) shows much higher detectability in terms of relative magnitude of signal amplitude, compared to that from mixing frequency channel (550-150kHz, 550-300kHz).

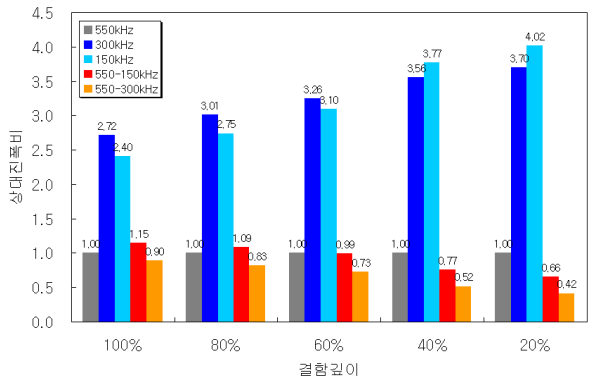


Figure 3. Variation of relative signal amplitude in frequency channels with depth of drilled hole.

3.2 Characteristics of Bobbin Coil Signals from Steam Generator Tube Specimen in Manufactured Mockup Assembly and Steam Generator Tube Cracked at Eggcrate Intersection in an Operating Power Plant

Fig. 4 shows eddy current signals of single and mixing frequency channel of bobbin coil probe from a steam generator tube specimen in manufactured mockup assembly. Coincidently with the results of Fig. 3, the signal amplitude of single frequency channel from the OD axial crack at eggcrate intersection exhibits 0.95V which is about two times larger than that of the mixing frequency channel (0.46V).

Fig. 5 shows eddy current signals of single and mixing frequency channel of bobbin coil probe from a steam generator tube cracked at eggcrate intersection in an operating power plant. It is recognized that the crack can not be detected by mixing frequency channel but the single mid-frequency channel clearly shows crack signal of large amplitude. Thus, it can be suggest that signal of single mid-frequency channel should be used with priority for accurate and earlier detection of OD axial crack at eggcrate intersection as well as signal of mixing frequency channel.

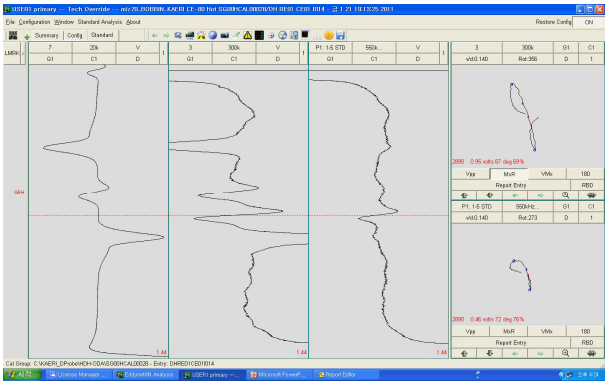


Figure 4. Eddy current signals of single and mixing frequency channel of bobbin coil probe from a steam generator tube specimen in manufactured mockup assembly

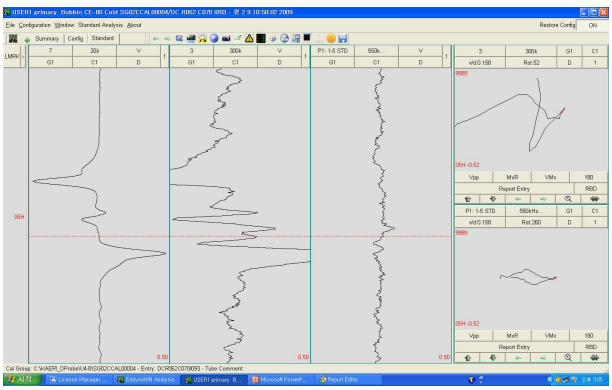


Figure 5. Eddy current signals of single and mixing frequency channel of bobbin coil probe from a steam generator tube cracked at eggcrate intersection in an operating power plant.

3. Conclusions

The manufactured mockup assembly precisely simulates the OD axial crack at eggcrate intersection of steam generator tube in operating power plant. For accurate and earlier detection of OD axial crack at eggcrate intersection, it is suggested that signal of single mid-frequency channel should be used with priority as well as signal of mixing frequency channel.

REFERENCES

[1] D. H. Hur et al, Laboratory-Grown Axial Cracks in the Secondary Side of Steam Generator Tubes, Transactions of Korean Nuclear Society Spring Meeting, 2008