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A Development of Automated Analysis Technique for Bobbin Data to Detect ODSCC on the OPR1000 SG Tubes.

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1. Introduction

Steam Generator(SG) tube is an important component of Nuclear Power Plant(NPP) and works as a pressure boundary between the primary and secondary systems. The integrity of SG tube has been confirmed by the eddy current test every outage. The eddy current technique adopting bobbin probe is currently the main technique for the steam generator tubing integrity assessment.

Eddy current signal analyst for steam generator tubes continuously analyzes many data for a long time. Therefore, there are possibilities that the analyst gets tired with the signal analysis, misses indications and cannot separate the true defect signal from complicated signal caused by his biased view and makes wrong decisions in the signal analysis. In order to avoid these possibilities, automatic analyses are adopted in foreign countries.

Axial ODSCC(Outside Diameter Stress Corrosion Cracking) defects on the tubes of OPR1000 steam generator have been found on the tube areas contacted with tube support plates. In this study, an automatic analysis technique for bobbin eddy current signal is introduced, which is devised to detect axial ODSCC on the OPR1000 Steam Generator Tubes. Moreover, experiment results using practical data are provided and discussed.

2. Method and Results

2.1 Automated Analysis Software

Most foreign nuclear power plant utilities use one of the Westinghouse, Zetec, AREVA's automated analysis softwares which are qualified by EPRI(Electric Power Research Institute). The performance of the automated analysis software should be verified through EPRI AAPDD(Automated Analysis Performance Demonstration Database) test before practical application.

Even if the software passed the AAPDD it cannot be used directly to the inspection of the steam generator tubes in the nuclear power plants. The AAPDD qualification does not mean that the software is applicable to the nuclear site because the ECT signal appears differently depending on the characteristics of steam generator degradation mechanism. In order to use nuclear site inspection, the automated analysis software should be adjusted to fit the variables (defect location, detection frequency, signal degree, voltage, etc) of the concerned steam generator model and related defect. In this study we used basically the automated analysis software made by Zetec. The name of the software is the CDS(Computer Data Screening).

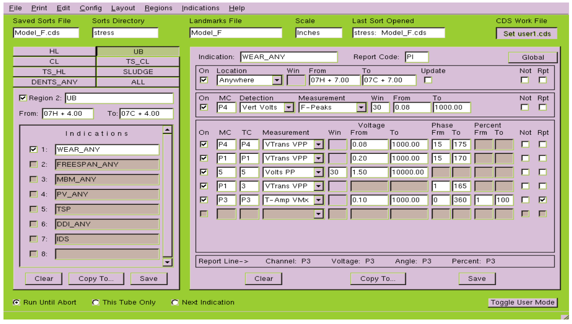

Fig.1 CDS automated analysis sotware

2.2 Analysis of Axial crack signal characteristics

Putting accurate variables in the automated analysis software is the most important to the ECT automated analysis, because the detection results depend on how appropriately the variables are selected. In other words, the selected variables strongly affected to the inspection results such as the detectability and the number of detection.

The adequate variables for the automated analysis software can be obtained by analyzing the exact ECT signal characterization. To reduce the miscalls and minimize the detection of overcalls, the eddy current signal characteristics shall be understood carrying out the signal analysis for each channel. After completing this process, the accurate variables can be set. Therefore, the ECT signal of axial cracks was analyzed before setting the variables.

The axial cracks in the OPR1000 steam generators tubes are mainly observed in the support area. The tube support structure of OPR1000 steam generator consists of 2 inch and 1 inch height plates and has a lattice-like appearance, so it called "eggcrate".

In the eddy current bobbin probe inspection, detected axial crack signals are reported DSI(Distorted Support Indication). The combined signal of the axial crack and the support plate is within the DSI because axial crack exists in the support area.

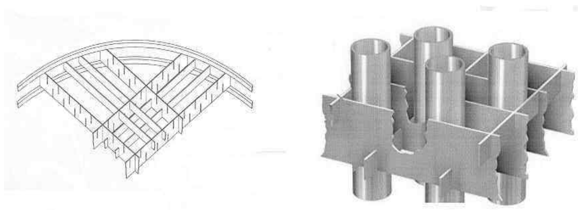

Fig.2 OPR-1000 SG tube support(Eggcrate)

From the results of DSI signal analysis, process channel P1(550-150kHz) is more easy to detect for the support plate boundary region and channel 3(300kHz) is better for the other region.

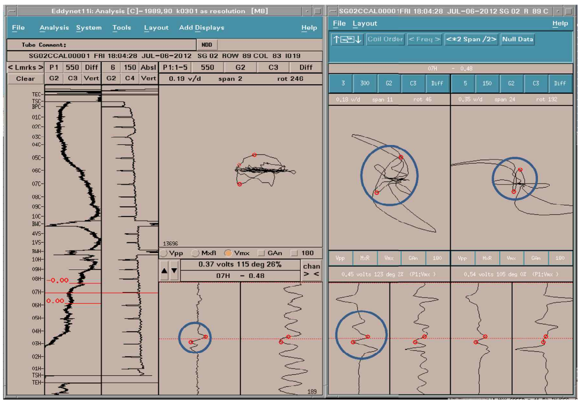

Fig.3 Axial ODSCC ECT signal(OPR-1000 SG)

2.3 Variables setting within CDS software

EPRI defined that ECT techniques shall be considered to be qualified for detection if they demonstrate a POD (Probability of Detection) of 0.80 or greater at a 90% CL(Confidence Level).

In this study, it is tried that the results of automated analysis meet more than 90% detection rate and EPRI criteria. First, the analysis was performed using EPRI AAPDD axial ODSCC variables with a small number (about 100) of crack signals. It was confirmed that the detection rate was 63.3% that was below the detection criteria. The analysis for detecting the cracks was performed applying four sets of variables to find variables satisfying the detection criteria. The variables of Set-4 met the criteria. The Adjustments or additions of key variables were made to improve the detectability and reduction of overcalls. Limiting the detection area in the Set-1 because the axial cracks only appeared in the hot-leg side of the steam generator, the overcall rate was reduced. The detection rate increased in the Set-2 by lowering the value of signal amplitude after reflecting the results reviewed to the set. The detection rate increased by analyzing the signals at the ends and central areas in the supports separately applying the Ch. 7(20kHz) information in the Set-3.

In case of Set-4 set, bandpass filter process channel, P15(550kHz-150kHz), was added in order to reduce overcall rate caused by signal noise. From the results of performing the automated analysis with Set-4 set, the POD of over 80% at a 90% CL is obtained.

Table 1. History of set modifications

Set No.	Detection Channel	Modifications
AAPDD	3/P1	-
Set-1	3/P1	AAPDD +Limited detection area
Set-2	3/P1	Set-1 + lowered signal amplitude
Set-3	3/7/P1	Set2 + Channel 7(20kHz)
Set-4	3/7/P1/P15	Set-3 + Channel P15

Table 2. Results of Automated Analysis History

Set No.	Detection rate(%)	Missing rate(%)	Overcall rate(%)
AAPDD	63.3	36.7	-
Set-1	81.5	18.5	618.9
Set-2	82.9	17.1	641.0
Set-3	90.2	9.7	306.5
Set-4	95.2	4.8	153.1

3. Conclusion

The optimum variables are determined for detecting the axial cracks on OPR1000 steam generator tubes in this study. Applying these variables, the automated analysis was performed in order to detect the axial cracks OPR-1000 steam generator tubes. In this analysis the POD of over 80% at a 90% CL was obtained. In the view of that results, the automated analysis could be considered to substitute for human analysts.

The automated analysis is applicable to detect the axial ODSCCs on the steam generator tubes of nuclear power plants in Korea. The automated analysis technique would increase the reliability of the ECT test.

REFERENCES

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