Enhanced Steam Generator Tube Foreign Object Wear Detection Using the Bobbin Eddy Current Coil

Extended Abstract

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The eddy current examination of steam generator tubing continues to challenge outage schedules, outage risk evaluation, radiation protection, personnel dose, and overall outage costs. Localized geometric changes on steam generator tubes, such as the transition from expanded tube in tubesheet to unexpanded freespan tube regions above tubesheet as shown in Figure 1, can complicate the detection of degradation at these locations using the bobbin eddy current inspection probe.

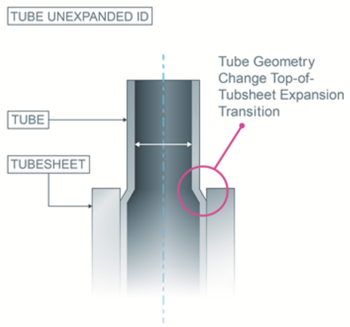

Figure 1. Cross section of Top-of-Tubesheet Expansion Transition Region

Traditionally supplemental probe examination (such as the +POINT[1] probe or X-PROBE[2]) has been used for identification of steam generator tube mechanical wear at these locations. Such supplemental examination resulted in increase of inspection schedule, cost, additional dosage and radiation waste. The new method qualifies the high-speed (up to 120 inches per second) bobbin probe – which is the probe used to inspect the remainder of the tubes' length for foreign-object-induced wear – to adequately inspect the top-of-tubesheet expansion transition region for the presence of foreign-object induced wear.

The standard bobbin probe technique uses a mix of 2 to 3 combined frequencies to detect specific type of degradations at geometric changes in the tube. However, standard mixing techniques are limited when it comes to refining the bobbin probe's ability to detect volumetric degradation at the top-of-tubesheet expansion transition region.

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[1] *+POINT is a trademark of Zetec, Inc., in the US and/or other countries. Other names may be trademarks of their respective owners.*
[2] *X-PROBE is a trademark of Zetec, Inc., in the US and/or other countries. Other names may be trademarks of their respective owners.*

To improve these outcomes, Westinghouse introduced two methods that can be applied singularly and independently, or combined, which are the implementation and analysis of a three-frequency mix channel together with the application of the Westinghouse Auto History Compare software. The Auto History Compare (AHC) software compares bobbin probe examination data from two different outage inspection campaigns. The AHC algorithm suppress the common mode signals and extracts the signal that illustrates a change between the two outages' inspection data.

In addition to that, these applications have been supported with Real-time Auto Analysis software to measure the noise condition at the expansion transition region.

The qualification of this technique has been performed on digital flaw samples by merging eddy current loose part wear scar signals together with tubesheet expansion transition signals, using the Westinghouse Data Union Software.

A study was performed in early 2016 by Westinghouse to show that the bobbin probe's detection capability using the three-frequency mix noise method was adequate to satisfy industry tube integrity requirements.

In addition to that, the Auto History Compare Software has been qualified, to show that foreign-object induced tube wear degradation could be reliably detected.
An example of signal extraction using the Auto History Compare software on one of the digitally generated specimens is shown in Figure 2.

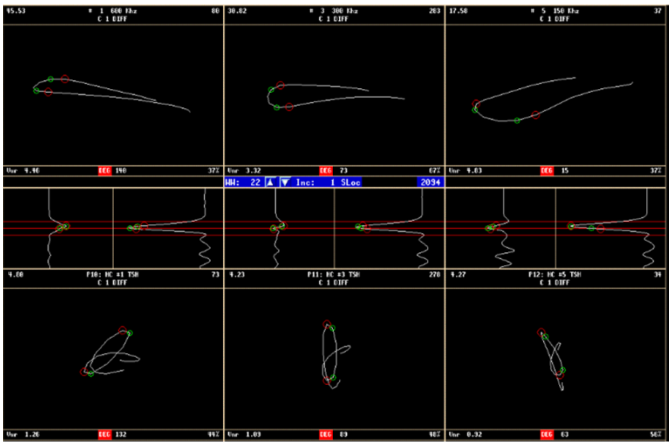

Figure 2: Westinghouse Auto History Compare Software example

The top row signals represent the bobbin coil single frequency channels which show no flaw-like components. The bottom row signals are the Auto History Compare extracted signals; flaw-like components are shown in each analysis channel.

During the first outages, using the bobbin probe to detect volumetric degradation at the top-of-tubesheet expansion transition, the number of supplemental probe examinations had been reduced from approximately 8,000 to only 4. The reduction of additional tests on the steam generator tubes resulted in a saving of up to 49 hours on the critical path and required approximately 42% less probes along with the decreased dose and potential human performance events.

Another benefit stems from use of the Real-time Data Analysis software, which monitors for noise. An increasing trend in noise at the top-of-tubesheet expansion transition may indicate bobbin probe failure. This early warning can reduce the potential for missed wear indications. It may also be used to adjust the setup of the probe conduit to remove unintended influence on probe performance, resulting in improved overall eddy current inspection efficacy.