Application Note

Assessing Circumferential Cracking in Non-Ferromagnetic Heat Exchanger Tubes

Heat exchangers are used to heat and cool various fluids across a wide spectrum of industries. This is especially critical to the power generation and petrochemical industries where fixed equipment reliability is paramount. Tubes in heat exchangers made of such materials as austenitic stainless steel and Inconel™ are plagued by circumferential cracking, which conventional, single-coil eddy current testing (ECT) cannot reliably detect.

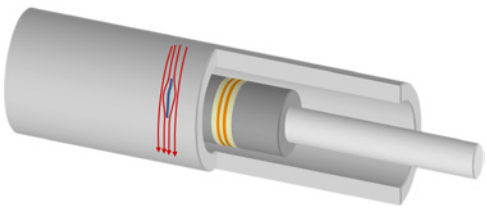
This application note explores how an innovative probe technology is able to address this challenge.

The Challenge

Non-ferromagnetic heat exchanger tubing is susceptible to circumferential cracking in the vicinity of the tubesheet. These cracks are induced by the localized stress created during the tube-to-tubesheet rolling process.

Circumferential cracking is very difficult to detect and characterize with standard eddy current bobbin probes, currently the norm in the industry to inspect tubes, because:

- bobbin probes are very sensitive to tube expansion and ferromagnetic materials, out of which tubesheets are usually made. When analyzing bobbin coil data, it is very difficult to isolate a small-volume crack from a complex signal comprised of a crack, a geometry change, and added material;
- the orientation of standard bobbin coils is not well suited to circumferential cracks because eddy currents flow parallel to the indications.



Common heat exchanger components experiencing this problem include feed water heaters and condensers at power plants, as well as heat exchangers in petrochemical refineries. Operators of such exchangers, of course, want to identify tubes leaking because of this issue, but are more interested in identifying tubes showing signs of cracks that may grow to 100% through wall while the heat exchanger is in service.

The Solution

This application called for a three-part solution. The first is the Ectane®. It is Eddyfi's workhorse tester that can be configured for almost any type of inspection technique, including ECT and eddy current array (ECA).

The second part of the solution is Magnifi®, Eddyfi's acquisition and analysis software for graphical display (C-scan), record keeping, and reporting.

The final part of the solution is the patented DefHi® ECA tubing probe. It leverages ECA technology to accurately detect, size, and characterize circumferential cracking defects, differentiating them from other unwanted signals, such as those from the tubesheet and roll transition.

The Challenge

Detecting, sizing, and positioning circumferential cracks in the vicinity of the tubesheet on non-ferromagnetic heat exchanger tubes.

The Solution

Using a multiplexed eddy current array tubing probe to distinguish crack signals from tube sheet signals.

The Benefits

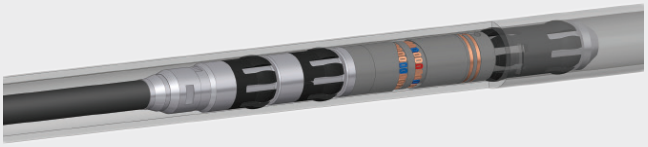
Very rapid assessment of circumferential cracks in the most challenging location with full 3D imaging for easier interpretation.

ECA technology uses several individual coils, grouped together into one probe. The coils are excited in sequence to eliminate interference from mutual inductance (something referred to as multiplexing). So doing, coils work together to completely sweep the interior surface of each tube.

The DefHi's coils work in a transmitter-receiver fashion. Array coils are multiplexed and yield absolute signal responses with phase and amplitude information.

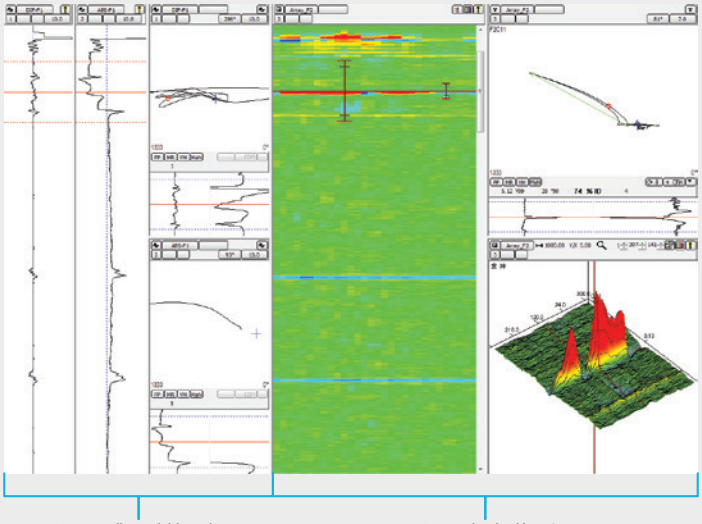
Because of the coil configuration in the probe, eddy currents flowing in the inspected tube are perpendicular to circumferential defects, making them easier to identify. Eddyfi's ECA technology know-how has also made it possible to optimize the distance between the transmitter and the receiver coils so that the expansion signal detected by the probe is flat compared to others, making it extremely simple to isolate.

Finally, the probe is designed in such a way that it is easy to select an operating frequency that will be optimal for the non-ferromagnetic material under test, while at the same time yielding a tubesheet signal that is clearly identifiable from the circumferential cracking signal.



Through multiplexing, several array coils of the DefHi can detect defects and allow the operator to estimate their circumferential length and position, something a standard bobbin probe cannot do.

Magnifi uses the inspection data to produce 2D and 3D C-scans, which use color patterns to distinguish between the tubesheet and the circumferential cracking defect. Because the tubesheet gives an angular response compared to the defect, the latter is clearly displayed on the C-scans as having a circumferential length and a depth, making it easy to identify and characterize. Applying an appropriate high-pass filter is then simple to completely isolate the defect.



Actual field results showing cracking under tubesheet

In addition, individual array coils not only provide amplitude, but also phase information. In a 2D C-scan the ability to rotate the phase component of the signal is key to getting a high-definition defect response.

Actual testing of the solution demonstrated detection and sizing of circumferential cracks at the tubesheet as early as 50% wall loss and 30% in the free span area.

The Benefits

- Compared to standard ECT bobbin probes, the solution can discriminate between the various complex geometries inside heat exchanger tubing to allow accurately detecting, sizing, and characterizing small-volume circumferential cracks.
- Compared to rotating probe technology, which scans tube ends at approximately 40 seconds per tube, Eddyfi's solution can scan tube ends at 5 seconds per tube. The solution also does not require a mechanical probe pushing device to accurately control the axial speed of the probe.
- Other benefits of the solution include:
- Quantifying the circumferential extent of crack defects
- Accurate axial location and characterization of crack defects in the vicinity of the roll transition
- The standard ECT bobbin coil of the DefHi can serve as a reference point for typical ECT data signals
- Unlike rotating probes, the solution can be used for full-length tube examinations
- Seeing is believing—personnel without extensive ECT data analysis experience can view the solution's 3D data and be confident about the inspection results
- As you can see, ECA technology can greatly improve the speed and quality of results in this challenging application. But this is only a fraction of what we do.

Don't hesitate to talk to us about your own project specifications.

info@eddyfi.com www.eddyfi.com

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