

Ultrasonic Application Solutions

Large Diameter Tubing – UT & EC Inspection

Application

- The Customer needed a mobile inspection system for large diameter tubes (around 5" diameter, 0.25" thick, 5' long high strength, magnetic steel) that are in the field. The system should be self-contained watertight and be able to move from location to location.
- To inspect a large diameter pipe (mobile enough to be placed into a tank) for ID surface flaw as well as subsurface defects in the tube wall and on the OD, an inspection system was needed to include both UT and EC techniques.
- Ultrasonic Inspection Strategy – Probe with Multiple Inspection Angles - Optimal Defect Coverage
- Eddy Current Inspection Strategy – An array probe with coils small enough and in the optimal configuration to detect small flaws in magnetic material.

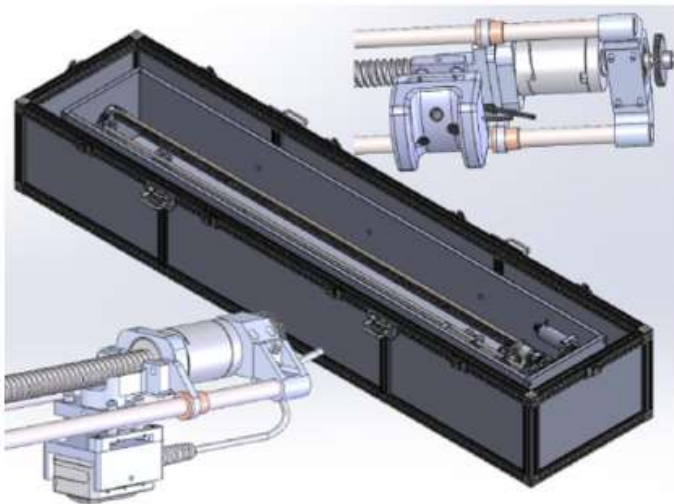


Figure 1: Schematic of self-contained motor-driven mechanical assembly showing UT and ET probes

Customer challenge

- The team was challenged to find very small cracks, pitting, corrosion and inclusions on the ID and within the tube wall of large diameter ferromagnetic tubing for a military customer.
- The solution included a method of delivering the probes down and around the lengths of the pipe which provided 100% coverage, overlapped raster scans and full digital data capture verifying precise positional accuracy.
- For the UT inspection, the solution required a waterproof enclosure that enabled the probes to be coupled to the test pipe. In order to find all the various orientations of defects, three differently oriented transducers were used in the setup.
- For the eddy current inspection, a flexible array probe was used which was configured to find both axial and circumferential flaws at the same time. Scan plan developed for 100% coverage, overlap and complete digital data capture.
- The critical flaw size requirement was for 0.005" Depth and 0.010" Length in both axial and circumferential orientations.
- A means of transport down the length of the ID is required for both UT (flooded) and EC (Dry) probes. For complete coverage, the pipe also had to be rotated as the probes traversed slowly down the length.

Our Solution:

The team successfully built a prototype which demonstrated both techniques.

- A Calibration Ring (including notches of various sizes and orientations) was machined to attach to the end of the tube.
- Self-contained motor-driven mechanical assembly - A Prototype self-contained Test System was designed and built that included an encoded lead screw assembly that allowed probes to be driven axially down the length of tube. It also used motor-driven engagement for encoded rotation of the tube around the lead screw and probes.
- Ultrasonic Inspection Strategy - A probe with Multiple Inspection Angles for Optimal Defect Coverage
 - 0° Longitudinal Wave Radial Examination - which targets embedded flaws (voids, inclusions, etc.)
 - 45° Axial Shear Wave Inspection - Flaws oriented in the radial/circumferential plane connected to the OD or ID
 - 45° Circumferential Shear Wave Inspection - Flaws oriented in the axial/radial plane connected to the OD or ID
- Eddy Current Inspection Strategy - An array probe with coils small enough and in the optimal configuration to detect small flaws in magnetic material. Array probes can determine the orientation of an indication (axial or circumferential) by multiplexing the coils excitation patterns. Also, different configurations of coils were explored for this material by using a custom probe which was designed for the 3 different topologies:
 - Impedance - Standard Absolute Coils - this topology can detect discontinuities oriented in any direction, especially where there is very little liftoff variation.
 - SDD - Short Double Driver (Transmit/Receive) - This topology uses two coils, excited simultaneously, acting as one large transmitter. The large area (ergo higher resolution) offers - over the single-driver topology - a better response and sensitivity to small defects
 - LDD - Long, Single Driver (Transmit/Receive) - Longer distance between coils - Single Driver/Single Pickup - is the best to detect large and/or subsurface defects, and offers a better tolerance to liftoff than the double-driver topology.

Solution benefits:

- Designed motor and encoder electronics for accurate control and positioning. This was a requirement for accurate analysis and location of flaws along the length of tubing.
- Achieved the required Probability of Detection to ensure the capability of finding the very small required flaw sizes
- Integrated two separate inspection methodologies into one inspection system

Test Equipment:

- UT: Mentor UT Platform – Modified PA connector to allow 3 single channel UT channels using “MultiGroup” capability
- ET: Array Multiplexing Instrument and Hi Res Array Probe. 32 coils 2mm diameter



Figure 2: Prototype Tube inspection system – self-contained water tight inner shell within outer transport case.

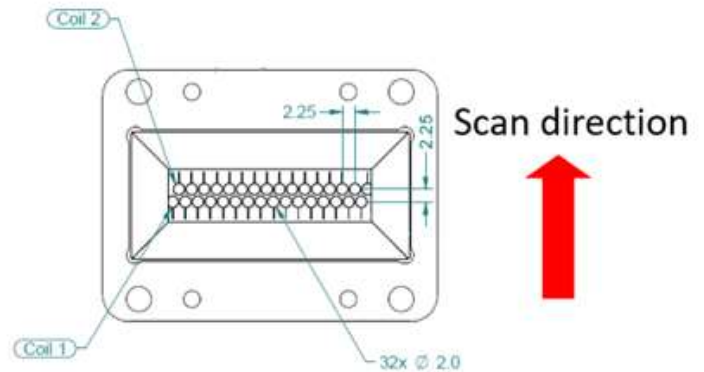
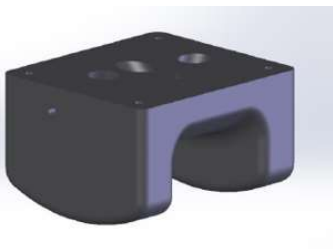


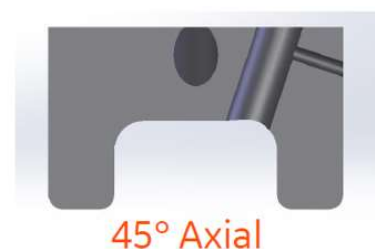
Figure 3: Eddy Current Array Probe



0° Radial



45° Circumferential



45° Axial

Figure 4: Ultrasonic Inspection Strategy – Multiple Inspection Angles for Optimal Defect Coverage

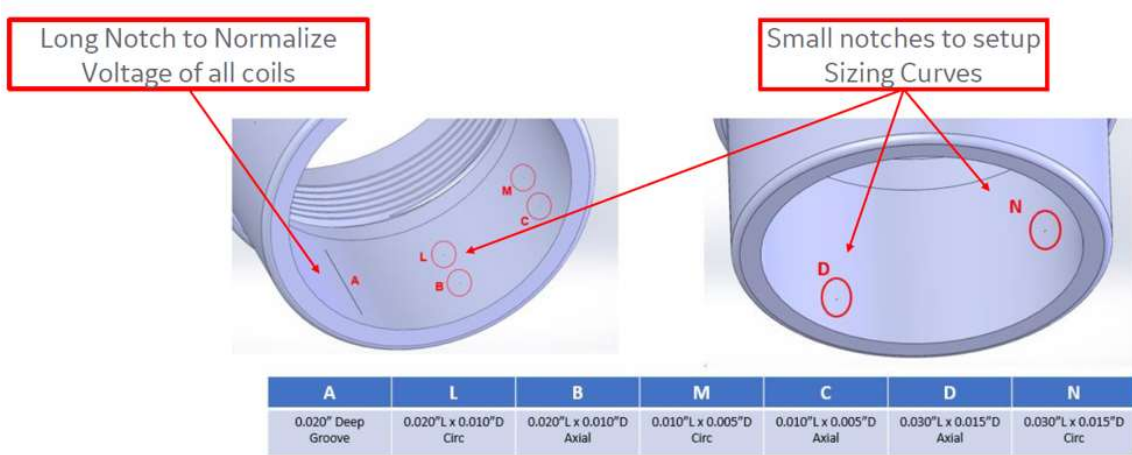


Figure 5: Calibration Ring machined to same dimensions as Tube. Various sized notches installed for instrument inspection referencing.

Outside Diameter Flaws 12-24"

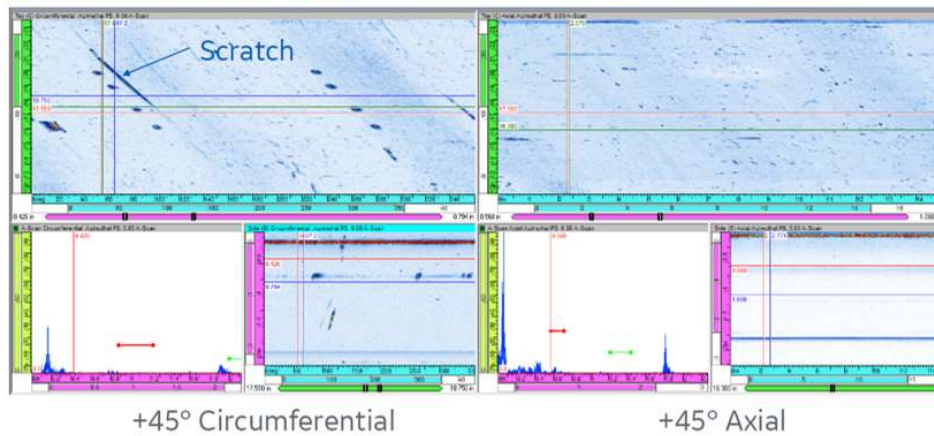
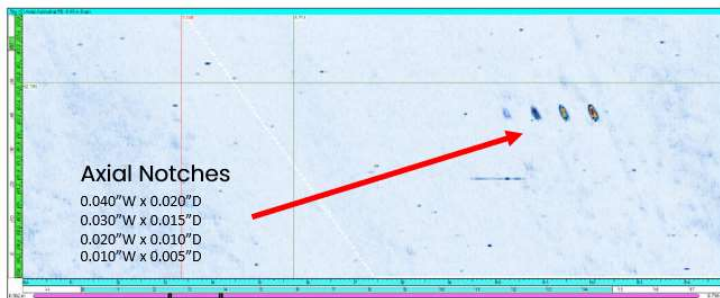


Figure 6: Shear Wave Testing Data Analysis

Axial Shear Wave Exam



Circumferential Shear Wave Exam

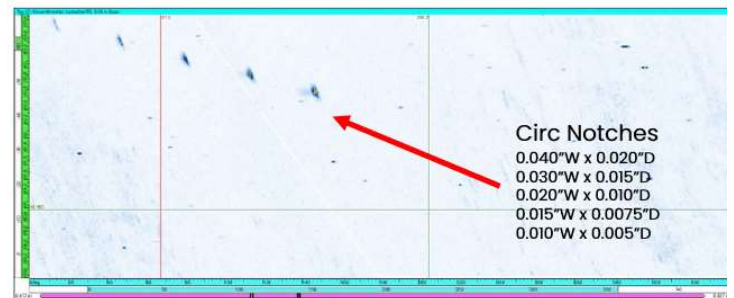


Figure 7: UT Axial and Circ Shear Wave results

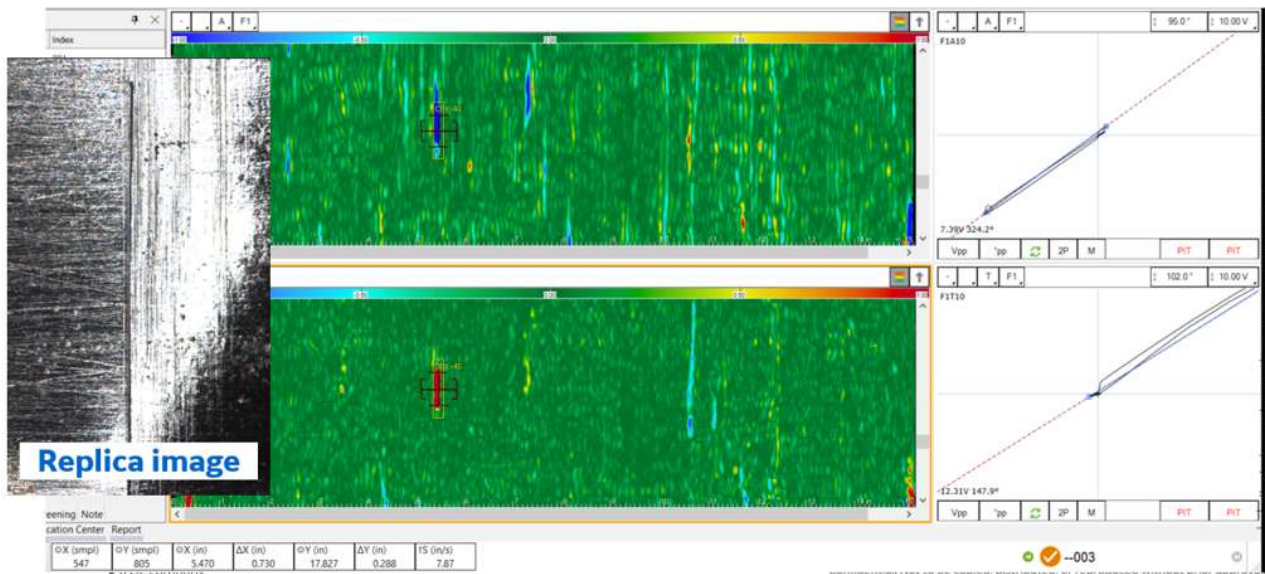
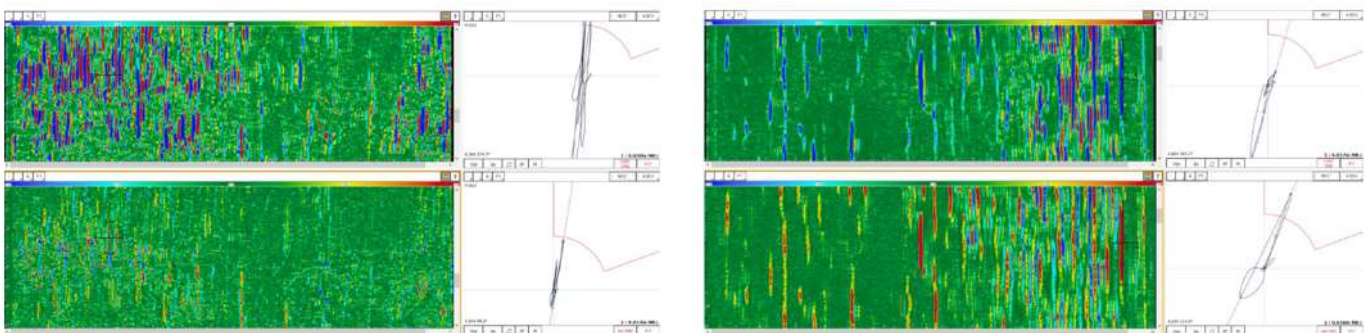


Figure 8: Eddy Current Array results on axial notch – the two c-scans show opposite response from different topology. Also shows replica taken of notch.



Examples of SCC X=3.54 Y=21.59

Example of Axial Indication 3.38v 3.87"Long X=7.39 Y=45.66

Figure 9: Eddy Current Inspection results of field serviced Tube – shows large amount of suspected stress corrosion cracking in 2 different areas of the tube.