Improved Inspection of Small Diameter Pipe Welds

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Presentation Outline

- Issues with radiography
- Issues with manual and AUT
- Cobra – the ONDT solution
- Mechanical advantages
- Ultrasonic advantages
- Sample results
- Conclusions
Typical Inspection Application

Limited space during construction

Even worse for In-Service applications.
Problems with radiography

- Radiation safety
- Licensing
- Environmental side effects from chemicals
- Film storage
- Poor planar defect detection
- Comparatively slow
- Subjective interpretation
- Production disruption: For small diameter pipes in particular, =>usually many welds in close proximity.
Issues with Manual and Automated UT

◆ Manual ultrasonics
  – slow
  – operator dependent
  – no auditable record

◆ Automated ultrasonics
  – scanners must be small enough to fit
  – beam defocuses in small diameter pipes
  – cost generally high.
Cobra – small diameter pipe inspections

- Low profile delivery system
- Operates with OmniScan
ASME - Small Diameter Codes

- ASME B31.1 Code Cases 179 permits AUT of small diameter pipe girth welds
- CC 179 is workmanship-based Code Case
- ASME B31.3 CC 181 permits AUT
- CC 181 Fracture Mechanics-based => B31.3 Code Case 181 needs accurate defect sizing and dimensioning.
Small Pipe Diameter Market

- Potentially many applications:
  - Boilers
  - Process piping
  - Product piping in refineries
  - Ship-building
  - Power plants
  - Pharmaceuticals
  - Nuclear construction
  - In-service applications
Cobra - Mechanics

- Semi-automated -> saves costs, is technically easier and more convenient for small diameter welds
- Encoded for full data collection & auditing
- Scanner adaptable to a range of sizes, which can be matched to the pipe diameter
- As spring-loaded, scanner can inspect both carbon steel and non-magnetic materials
- Scanner provides good coupling for 360° round the pipe, which is essential.
Cobra – Mechanical Specs

- Pipe diameters from 21 mm (0.84”) OD to 115 mm (4.5”) OD
- Clearance – including the low profile array - is only 12 mm
- Waterproof, rust-free and CE compliant
- Portable and light
- Easy to change the arrays and wedges
- Encoder resolution is 32 steps/mm, which is plenty for AUT of welds.
Cobra – One-sided Weld Access

- For welds with one-sided access only (e.g. flanges or pipes-to-component)
- Scanner can be re-configured for single access.
Cobra – Powered by OmniScan

Uses relatively low-cost PA unit
Scan Plan-based set-ups
Full data storage
Selection of displays
Much faster, more cost-effective than manual UT or RT

Two-sided scan being performed on small diameter vertical pipe
Cobra – Focused Arrays

- Lateral oversizing major problem
- Particularly true for small diameter pipes
- Performed R&D project to determine optimum array focusing and focusing technique
- Initial modeling; followed by experiments
- Compared 2D matrix arrays, curved arrays and unfocused at 5 MHz
- Modeling showed only two curvatures needed for all pipe diameters.
Modeling – Results at 5 MHz

Results from:
- Matrix array (top)
- Curved array (middle)
- Unfocused (bottom)
Matrix and mechanically curved arrays gave similar focusing results.

- Flat array much worse for defocusing.
- (Wall thickness relatively unimportant due to skipping in thin pipe)

Curved arrays much cheaper and easier to use -> prefer mechanically curved arrays.

Confirmed with 10 MHz modeling.

Tested on pipes of 70 and 38 mm diameter.
Modeling showed that

- One probe with 40mm radius of curvature is suitable for pipe OD greater than 25mm diameter
- One probe with 30mm of radius of curvature for pipe OD smaller than 25mm

Two curved arrays effectively covered all pipe diameters.
Experimental Confirmation of Modeling

- 70 mm pipe and a 38 mm pipe used.
- Two wedges were contoured to match the pipe diameters, as per standard practice.
- Appropriate notches and holes were used as reflectors.
- Notches and holes scanned using typical phased array inspection procedures based on S-scans.
- Same setup was used for the two probes except the gain was necessarily reduced for the curved probe.
- 6 dB drop criterion was used for sizing.
Experimental Results (1)

Left: Flat probe. The measured notch length is 9.6mm.
Right: Curved probe. The measured notch length is 7.1mm.

70 mm pipe. Detection of the 6.9mm long notch using the flat and curved probes (single skip).
Experimental Results (2)

Left: Flat probe. The measured length is 10mm
Right: Focused probe. The measured length is 3.6mm

38 mm pipe. Detection of the OD end of the 1mm thru-hole with the flat and curved probes (double skip)
Experimental Results - Conclusions

- Results consistent:
  - smaller diameter tubes gave more severe defocusing (beam spread) than larger diameters
  - focused arrays gave much better lateral sizing results than flat arrays.

- Cobra manufacturing compromises:
  - 5 MHz and 10 MHz arrays modeled; in practice, a 16 element 7.5 MHz chosen.
  - A compromise single radius of 35 mm was chosen.
  - $60^\circ$ natural angle wedge for high angles
  - $\Rightarrow$ this became the Cobra “standard”.
Sample Cobra Scan Results (1/6)

Note different results with different set-up parameters (1/4).
Sample Cobra Scan Results (2/6)

Cursors readily available for analysis and detailed sizing.
Many choices of views possible:

- A-scans,
- B-scans,
- C-scans,
- D-scans
- Combinations
Sample Cobra Scan Results (4/6)

Illustrative scans only

Note that all set-up parameters are available within OmniScan.
Sample Cobra Scan Results (5/6)

Example of very small diameter, thin pipe scanned by Cobra.

25 mm dia., 3 mm wall, carbon steel

Notches visible.
Sample Cobra Scan Results (6/6)

25 mm dia, 3 mm stainless steel pipe

More difficult to detect notches as stainless.
Conclusions

- Olympus NDT has produced a novel semi-automated small diameter pipe scanner with two major features:
  - Low profile for clearance, and
  - Focused arrays to minimize lateral beam spread (and hence overcalls).

- The scanner has a number of useful features:
  - Adaptable from 21 mm to 115 mm diameters
  - One-side access scanning
  - Works on both carbon and stainless steel

- The experimental results confirm that using the scanner and focused arrays produce significantly better defect length estimates.
Thank you

Any questions?