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 38mm 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.
- 6dB 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° natural angle wedge for high angles
  - => this became the Cobra “standard”.
Sample Cobra Scan Results (1/6)

115 mm diameter, 12.7 mm thick weld scanned using variations in set-up parameters (1-4).

Note different results with different set-up parameters (1/4).
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?