Magnetic eddy current as a novel technique for the internal inspection of CRA-lined pipe

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What are clad and lined pipes?

• **Clad pipe:**
  – Metallurgically clad by
    » Roll bonding
    » Explosion bonding
    » Overlay welding
  – Resulting in a metallic bonding between carrier pipe and CRA pipe

• **Lined Pipe:**
  – CRA pipe is expanded inside a carrier pipe. Pipe ends are made with overlay welding to ensure weldability.

• **Typical Defects:**
  – Many, but mainly internal corrosion of carrier pipe
What can standard technology achieve?

**Ultrasonic Inspection** [1]

- Clad
- Lined

**Magnetic Flux Leakage** [2]

- Regular
- Clad/lined

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Magnetically Biased Eddy Current (MEC™)

TEST PIECE
MAGNETIC FIELD LINES

MAGNETIC CIRCUIT
EDDY CURRENT SENSORS
EDDY CURRENT PROBE FIELD
DEFECT
Increased Magnetic Flux Level
## Test Pipe

<table>
<thead>
<tr>
<th>Carbon Steel carrier pipe</th>
<th>CRA-liner</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OD</strong></td>
<td>8.625” (219 mm)</td>
</tr>
<tr>
<td><strong>ID</strong></td>
<td>6.765” (171.8 mm)</td>
</tr>
<tr>
<td><strong>Thickness</strong></td>
<td>0.812” (20.6 mm)</td>
</tr>
<tr>
<td></td>
<td>0.118” (3 mm)</td>
</tr>
<tr>
<td><strong>Material</strong></td>
<td>X65</td>
</tr>
<tr>
<td></td>
<td>825 Incoloy</td>
</tr>
<tr>
<td><strong>Pipe Type</strong></td>
<td>Seamless</td>
</tr>
<tr>
<td></td>
<td>Long seam seam welded</td>
</tr>
</tbody>
</table>
Set-up for testing

Prototype tool

Workshop set-up for pull tests
Test Defects

External metal loss
Depth: 20%-80% of carrier pipe
Size: 3mm – 24 mm diameter

Internal erosion
20% to 60% of liner
50 x 100 mm
Defects

Crevice corrosion
10%-50%
6-24mm

Cracking
Adjustable Parameter

- **Sensor types**
- **Speed**
  - Varied from 0.02 m/s to 0.75 m/s
- **Frequencies**
  - Higher Frequencies more sensitive to near side
- **Magnetisation level**
  - Effects of auxiliary magnetisation
Far-side defects

Display of data in form of Amplitude colour mapped C-Scans

- Display in impedance plane
- Amplitude time view
- Color mapped signals
Crack-like defects in the CRA-layer

In base material
Potentially found at interface from liner to overlay welding

In a girth weld

1.5mm crack

Crack position
Erosion type defects

Roughly linear relation between signal amplitude and depth
Metal loss in the annulus (crevice corrosion)
Defect type assessment using the phase information and multi-frequency measurement

Defect 24mm x 24 mm with 30% depth in carrier plus 6x6 mm through hole in liner
Conclusions

- The Magnetic Eddy Current inspection technology allows finding and sizing defects in CRA lined pipelines.
- In particular
  - Defects external on the carrier pipe
  - Metal loss on internal side of carrier pipe
  - Crack-like defects in the CRA-layer
  - Erosion-type defects (gradual thinning) in CRA layer
- Technology also seem to be superior in finding small pitting corrosion (3mm diameter) compared to existing inspection technologies.

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