A Novel Self Calibrating Pulsed Eddy Current Probe for Defect Detection in Pipework

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PEC Applications

- Corrosion under Insulation for pipes (CUI)

- Measurement of Scab corrosion (apparently surface but can be deep)

- Other methods to assess exist but both still “hot topics”
The rate of decrease of the eddy currents is monitored by the PEC probe and is used to determine wall thickness and corrosion.
Encircling coil with sensor array enables large area coverage of pipe and gives fairly rapid inspection
- Original system with a thyristor discharge circuit and fluxgate sensors positioned at minimum applied field positions – flaws then produced a deviation from this
- Was shown to work through coverings and detect the pipe
Sensors and deployment
Equipment
Site trials
Difficulties

- Not very portable and difficult to manoeuvre
- Uncertain maximum currents
- Complex software to handle fluxgate sensor outputs. Too slow.
Theoretical work by PhD student, modelling the effects and assisting equipment design

Controlled amplitude step down

Replace fluxgates with GMR’s to simplify receiver electronics

Re-write software and displays.
Research work

- 2D and 3D Models were developed.
- Sensor positions and type of sensors were identified.
- 3D Defect modelling.
- Wall thinning under insulation and covering.
- Coil shielding.
Magnetic Fields during the pulse
Induced current flow
PEC Experimental Platform

- Probe
- DAQ Card
- DC Power Supply
- Driver
- Pipe
- Probe
- Pipe
- PC with Matlab

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## Defect Signals

### 4 sensors

<table>
<thead>
<tr>
<th>Defect Name</th>
<th>Depth (mm)</th>
<th>Length (mm)</th>
<th>Width (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7</td>
<td>100</td>
<td>65</td>
</tr>
<tr>
<td>B</td>
<td>5.2</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>C</td>
<td>6.2</td>
<td>50</td>
<td>80</td>
</tr>
</tbody>
</table>

![Diagram showing defect signals and corresponding waveforms](image)
Features of Indications

- Indications on all 4 channels of one flaw
  - Effectively an encircling coil eddy current test
  - Gives an idea of
    - Total current change from reference
    - Any imbalance between coils (provided only one flaw)
    - Lift off effects (ie closer coil amplifies indication)
- Depth Sizing implications based on indication amplitude
Covering effect on PEC Signal

Air

Aluminium

Stainless Steel

Galvanised Steel
Covering effect on PEC Signal

- Model was solved for 2 scenarios

1. Cladding only (air inside)
2. Cladding and pipe inside

Differential Magnetic field signal (Z component)
- Wall thinning from outside 50mm insulation
- Reference (no flaw) was subtracted from test signal of different remaining wall thickness (large area)
Aluminium and Galvanised Covering

Graphs showing the differential magnetic field Z component over time for Aluminium and Galvanised Steel, with different thicknesses (d) represented by different colors.
Some practical validation

- Experiments for 2 scenarios
  1. Cladding only
  2. Cladding and pipe

**Differential sensor signal**

![Graphs showing experimental and model results for differential sensor output and magnetic field over time.](image)
New prototype
New prototype
Conclusion

- Continued development of PEC system
- Comsol software was successfully used to determine the output of a PEC system for simulated corrosion under insulation situations for
  - Variations in wall thickness.
  - Different cladding materials (Stainless Steel, Aluminium, galvanised steel)
- Validations were carried out for some available samples.
Current Status

- New prototype planned to be completed for end of year for TWI use

- 2 power sources, 2 coil sizes (initially).

- Software (producing C-scan type display) complete for 16 channels
Future work

- Testing to obtain calibration for sizing
- Modelling of corrosion patches under conductive cladding.
- Equipment Development for different sizes