Investigation on Feature Guided Waves

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Motivation

- Large area inspection by guided wave
• Inspection of plate with weld

J.Sargent (BAE systems), 2006
Semi-Analytical Finite Element (SAFE) method:

Finite element modelling
SAFE results – compression mode

Phase velocity

- 6mm plate S0
- 10mm plate S0
- SH0 in a steel plate
- Weld guided mode
- Leaky
- Non-leaky

Frequency in kHz

0 50 150 250 350 450

Phase velocity in m/s

6000

150 kHz

200 kHz

300 kHz
Discovery of a new mode – shear mode

**Phase velocity**

- **3500 m/s**
- **100 kHz**

**SH0 in a steel plate**

**Weld guided mode**

**Fan & Lowe**

*Proc. R. Soc. A, 2009*
Why the waves are trapped?

SAFE method

Analytical method

Weld + Plate

\[ x_1 \]
\[ x_2 \]
\[ x_3 \]
Why the waves are trapped?

- **Condition 1: Similar mode shape**

![Graph showing phase velocity vs. frequency for different modes: Longitudinal, Torsional, Flexural 1, Flexural 2.]

<table>
<thead>
<tr>
<th>Weld cap</th>
<th>Plate</th>
</tr>
</thead>
<tbody>
<tr>
<td>L mode</td>
<td>S0 mode</td>
</tr>
<tr>
<td>F mode 1</td>
<td>SH0 mode</td>
</tr>
<tr>
<td>F mode 2</td>
<td>A0 mode</td>
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</tbody>
</table>

Feature Guided Wave

NDT Laboratory
Why the waves are trapped?

- Condition 2: Lower velocity in the weld

plate (faster)  ➞  weld (slower)
Why the waves are trapped?

- Condition 2: Lower velocity in the weld

![Graph showing phase velocity vs frequency in kHz with different wave modes: S0, L mode, S0 mode, SH0 mode, F mode 1, and A0.]

Trapped modes:

- L mode
- S0 mode
- SH0 mode

Exciting mode for inspection
Typical results from FE (crack parallel to the weld)

Absorbing region

Feature Guided Wave NDT Laboratory
Typical results from Experiment

30mm slot parallel to the weld

0.14
0.1
0.12
0.06
0.08
0.0

Reflection Coefficient

Frequency (kHz)

100 kHz

60 kHz

Feature Guided Wave
Discussion - crack parallel to the weld

Different length of the crack:

- 30 mm
- 24 mm
- 16 mm

SH0 wave interaction with axial crack on a plate

Reflection Coefficient

Length of crack to wavelength ratio
Discussion - crack parallel to the weld

FE results

Experimental results

Possible reason: difference between the milled slot (experiment) and the FE crack

Feature Guided Wave

NDT Laboratory
Discussion - crack normal to the weld

Possible reason: un-uniform of the weld geometry
Discussion: Flat-bottom hole

Different depth of the hole:

FE results

Experimental results

Reflection coefficient

Length of diameter to wavelength ratio
The feature guided wave has been studied by the SAFE method. Both the compression mode and the shear mode have been investigated and compared.

The reason for the trapping effect has been discussed and summarized.

Experiments have been taken to validate the existence of the trapping mode and its sensitivity to certain defects.