A COMPARATIVE STUDY BETWEEN DIFFERENT GUIDED WAVES

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Outline

• BACKGROUND TO EDDYFI & GUIDED WAVES
• WAVEMODES IN PIPES
• TYPICAL APPLICATIONS
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TELETEST – NOW AN EDDYFI BRAND

Involved in all aspects of Teletest

- Manufacturing
- Sales
- Support services
- R&D and bespoke solutions
- Training

Acquired in October 2017
Still over 20 years of history
GUIDED WAVES ON PIPELINES

- Low frequency Ultrasound (20-100kHz)
- Developed for Corrosion Under Insulation
- First introduced into the market in 1997 by TWI Ltd
- Established method for screening pipelines
- Inspection of inaccessible areas
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CONVENTIONAL UT VERSUS LRUT

- Conventional Transducer
- Localised Inspection
- Weld
- Metal loss
- Conventional Transducer
- Flange
- Guided wave transducers
- Guided Wave
- Metal loss
- Weld
- Metal loss
- 100% Coverage

Pipe Cross-section
- Guided wave transducers
WAVE MODES IN PIPES

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Longitudinal

Torsional

Flexural
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PIPE WALL DISPLACEMENTS

- L-wave
- T-wave
- F-Wave (Vertical)
- F-Wave (Horizontal)
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DISPERSION CURVES - PIPES

![Dispersion Curves Diagram]

- **L(0,1)**
- **L(0,2)**
- **T(0,1)**
- **F(1,2)**
- **F(1,3)**

Group velocity (m/s) vs Frequency (kHz)

- **L(0,1)**
- **L(0,2)**
- **T(0,1)**
- **F(1,2)**
- **F(1,3)**

Frequency (MHz)

- 0.00
- 0.02
- 0.04
- 0.06
- 0.08
- 0.10

Group velocity (m/s)

- 0.0
- 2.0
- 4.0
- 6.0

Frequency (kHz)

- 20
- 40
- 60
- 80
- 100

Group velocity (m/s)

- 2000
- 4000
- 6000
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GUIDED WAVE RESPONSES

Symmetrical mode

Amplitude (mV) vs. Range (m)

- Symmetrical mode - black
- Vertical flexural mode - blue
- Horizontal flexural mode - Red
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DIFFERENT REFLECTED WAVES

- Reflected axi-symmetric wave
- Reflected flexural wave
- Flange
- Corrosion
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PROPAGATION OF AXI-SYMMETRIC WAVES

• Axi-symmetric waves, Longitudinal or Torsional, will propagate in both directions from a single ring.

• To prevent the wave from propagating in both directions a second ring is introduced. This ring will be phase delayed with respect to the first one.

• When using the Longitudinal wave mode it is necessary to dampen the unwanted L(0,1) wave mode. This necessitates a third ring.

• For optimum cancellation of L(0,1) the spacing between the rings must be equal to the L(0,1) wavelength, so the test frequency needs to be adjusted accordingly.

• The delay between the signals applied to the rings is equal to the spacing divided by the wave velocity.
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MULTIMODE MODULES
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GOOD DATA QUALITY – 180M 590’ IN EITHER DIRECTION
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REVERBERATIONS – LIQUID FILLED LINES
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REVERBERATIONS

The L(0,2) wavemode propagates along the pipe in a similar manner to the S0 plate wave. This causes out-of-plane displacements through the wall thickness. When this wavemode interacts with a weld, the triangular cross-section of the weld concentrates the displacements and causes the root to 'punch' into the fluid in the pipe. This sends pressure waves through the fluid from one side of the pipe to the other, where they are mode converted back into guided waves and return to the tool.
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TORSIONAL ONLY MODULES

• 3 Ring torsional only modules
  - 3rd Ring Provides 66% greater sound energy

• 5 transducers at 2 spacings
  - 30mm
  - 45mm

• Specifically for lines unsuitable for Longitudinal
  - Liquid filled lines
  - Thick pipes

• Proven better penetration over 2-ring
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5-RING TORSIONAL

![Graph showing the comparison of guided waves for different ring sizes and thicknesses. The x-axis represents frequency in kHz, and the y-axis represents amplitude in arbitrary units. The graph includes lines for 3 ring, 30mm; 3 ring, 45mm; 2 ring, 30mm; and 2 ring, 45mm.](image-url)
Suppose a pebbles that are visualized in red in the diagram. The reflector size of the reflector is doubled. If the size defect is doubled again and it is re-scanned and the amplitude of the reflector also increases. It can be seen that there is a linear relationship between defect size and the amplitude of its reflection.
However, it is not the only way this experiment could be run. If we continue in this fashion, we will generate a different curve. The defect could be increased in size by increasing its depth instead. It can now be seen that there is an exponential relationship between defect size and the amplitude of its reflection.
The relationship between a defect of known size and its amplitude can be ascertained.

The problem is that in reality the amplitude of the defect is known and we are trying to ascertain its size.

As information about the defects aspect ratio is not known, an error is introduced into the estimation of the defects true size.

The real size of the defect could be anywhere between X and Y, depending on whether it is shallow and wide or deep and narrow.
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C-SCAN TO COMPLEMENT A-SCANS

• Also called synthetic focussing
• Single wave mode transmitted
• Pipe features cause mode conversion
• The collection of reflected modes is analysed
• The inferred location and extent of features is presented on a map
SECONDARY FOCUSING

- Focusing allows the energy to be concentrated where the defect is, increasing sensitivity and giving position and size information
- Sound energy concentrated in one region
- Focus results link directly to Report Manager
- Rotation 8 times around pipe
- 4 times greater sensitivity
- Multi defect focus capability

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INSPECTION OF FURNACE TUBES

• Difficult to inspect using conventional techniques
• Cut the U-bends off for access and an internal tool
• Expensive in cost and time
• Guided Waves can screen pipes quickly during shut-down
• Access is difficult for conventional tooling
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**INSPECTION OF FINNED TUBES**

- Torsional: nothing could be seen using Torsional mode
- Longitudinal: both the pipe end and the defect could be identified
- Only Teletest capable of Longitudinal
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LONGITUDINALLY WELDED PIPE SUPPORTS