Pipeline & Specialty Services

Development of a pig based inspection tool utilising MAPS stress measurement technology

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Introduction

Weatherford P&SS have developed a technique to determine absolute biaxial stress in pipelines using a magnetic measurement technique

- Measurement technology licensed from ESR Technology (formerly AEA’s engineering safety and risk group)
MAPS Basics

- What is MAPS?
  - Technique for direct measurement of stresses in ferromagnetic material
  - Alternating magnetic field induced in material
  - Amplitude and phase of induced field measured
  - Gives measurements of magnetic parameters
  - Determination of principal axis stress values from these parameters
MAPS - In-line Inspection

What is it?

– A new type of intelligent pig that measures true stress in the pipeline

– Measurement technique originally developed by the UK Atomic Energy industry for North Sea offshore, also used in automotive and aerospace industries

• Why are we interested?

– Pipeline operators are keen to know how highly stressed their pipelines are

– There are no easy ways of doing this currently available
MAPS

- Other applications - detecting Flaws in railway tracks
MAPS

• Why measure stress in a pipeline?
  – Pipeline movement can cause major increases in bending stresses
  • Washouts, frost heave, spans, lateral buckles
• Why measure stress in a pipeline?
  – Metal loss (corrosion) results in higher stresses in the pipe wall
  – Cracks, pitting, general metal loss
  – Mechanical damage (dents etc) increases stress locally
MAPS in Static Applications

- Non-contacting probes
- Measurement of average biaxial stress value over area of probe
- Frequency dependent depth of penetration
  - 0.15 to 7mm
Validation of Static Measurement

• Accuracy of 10-20 N/mm achievable, down to less than ±1 N/mm under optimum conditions

• Previously Tested for Static Applications
  – Against strain-gauge techniques
  – Against X-ray diffraction
MAPS - Dynamic Measurement

• In-line inspection requires:
  – Ability to correct for magneto-dynamic effects at normal pigging speeds
  – Ability to take readings rapidly enough to provide meaningful axial resolution
  – Three simultaneous measurements to resolve stress components
Aims of Dynamic Test Work

• Test program aimed at demonstrating dynamic capture of MAPS data.
  – Measurement of stress distribution along pipe
  – Detection of applied load
  – Demonstration of repeatability of measurement
  – Characterisation of dynamic effects
• Previous work
  – 6 metre length of 24” pipe
  – Stress the pipe with a hydraulic jack
  – MAPS sensor on trolley
  – Move trolley at speeds up to 4 m/s
  – Compare results with strain gauge measurements
Direct Measurement of Stress

Delta (Loaded - Unloaded)

From strain gauges

Encoder Position / mm

Hoop delta

Hoop Stress / MPa
Prototype Tool Build

- Prototype specification
  - 24” diameter
  - Partially populated with sensors, 2-3mm standoff
  - Full specification for environment and range
Prototype Requirements for Field Testing

• 24” prototype pig
• 25% coverage of pipe wall from 16 sets of probes.
• Probe standoff – minimal, 1-2mm.
• Suitable to be part of, or used as a commercial tool.
• Environmental Capability

- Compatible with upstream oil and gas pipeline products, with normal levels of CO\textsubscript{2} and H\textsubscript{2}S
- Operating Temperature -10\degree C to 50\degree C
- Operating Pressure 200 bar max
- Operating Range 72 hours
Bending Stress Testing

• Pigging Loop
  – 24” X60 pipe
  – 34m test section
  – 0.4m/s to 1.1m/s

• Two main aims:
  – Demonstrate piggability
  – Demonstrate stress measurement
Test-loop layout
Applying Stress

• Bending Stress applied by lifting pipe

• Measured by
  – Height of lift
  – External strain-gauging

• Max stress of approximately 40% of yield applied
Hoop-stress Testing

- Rig modified for pull-through
- Wire-line unit used to pull pig through pressurised line
- Allows imposition of realistic hoop-stresses (up to 30% yield)
Hoop-stress test set-up
Outcomes

• Setup allowed successful testing of the pig

• Mechanical design assessed
  – Robustness
  – Performance

• Measurement System assessed
  – Accuracy
  – Repeatability
Future Programme

• Detailed assessment of test results
  – Calibration
  – Comparison with external measurements

• Preparation of tool for field trials
  – Mechanical refinements
  – Sensor population