DEFECT DETECTION AND CHARACTERIZATION IN PIPELINES

Current Programs at SwRI

Gary Burkhardt
Southwest Research Institute

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TARGET AREAS

- Inspection of unpiggable pipelines
- Monitoring of cased pipelines
- Characterization of mechanical damage defects
APPLICATION OF RFEC TESTING TO
INSPECTION OF UNPIGGABLE
PIPELINES

U.S. DOT-PHMSA Contract No. DTRS56-02-T-0001

Participation by
Northeast Gas Assn.
Carnegie Mellon
U.S. DOE-NETL
PROBLEM
Some pipelines are “unpiggable” and cannot be inspected

Branch Connections
Non-Circular Valves
90-degree Elbows
Multiple Diameters
No Launch Traps

Low Flow Rates
Low Pressures
Project Objectives

- Develop remote field eddy current (RFEC) inspection system for natural gas pipelines that are currently unpiggable
- Accommodate obstacles such as elbows and Tees
- Integrate RFEC system with Carnegie Mellon robot
- Demonstrate in operating pipeline
APPROACH

- Use remote-field eddy current (RFEC) method
  - RFEC system can adjust to variable pipe size and retract to pass through obstacles
  - Detects ID and OD corrosion defects
  - Can characterize defect depth, length, width

- Integrate RFEC with Carnegie Mellon Explorer II robotic transport system
  - Adjusts to variable pipe size and retracts to pass through obstacles
  - Self-powered
  - Nontethered—wireless remote control
  - Launched while pipe in service
RFEC DESIGN FOR EXPLORER II

CMU Explorer II Robot

SwRI RFEC Inspection Modules

Exciter

Sensor Array
BLIND TEST DEFECT CHARACTERIZATION
(Breadboard System)

Defect Depth

Ideal Response

Trend Line

Defect Length

Typical Defects
CURRENT STATUS/PLANS

- RFEC modules undergoing fabrication and testing
- Integration with Explorer II robot in Spring 2007
- Demonstration on live pipeline in Summer 2007
Expected Outcome

- Inspection system for 6-8 inch pipelines that can negotiate 90 deg. elbows and Tee joints
- Analysis capability to characterize depth, length, & width of wall-loss defects
- Demonstration in live pipeline
- Transfer of technology
LONG-TERM MONITORING OF CASED PIPELINES USING LONG-RANGE GUIDED-WAVE TECHNIQUE

SwRI Project 14.12266 for
NYSEARCH/NGA and DOT/PHMSA
PROBLEM
INSPECTION of CASED LINES AT ROAD CROSSINGS

- High-consequence area
- Require direct assessment (DA)
- Access is difficult, need remote inspection technique
PROJECT OBJECTIVE

- Apply Magnetostrictive Sensor (MsS) long-range guided-wave testing to “cased crossings”
- Develop defect characterization capability
- Develop long-term monitoring capability using permanently installed sensors
- Perform field validation
MsS (MAGNETOSTRICTIVE SENSOR)

- MsS is a guided-wave probe that uses magnetostrictive effects for wave generation and detection.
- Thin, ferromagnetic strips are bonded around pipe with encircling coils over the strips.
- Sensors are inexpensive and suitable for long-term monitoring.
MsS TEST SETUP ON A CASED-LINE MOCKUP

16" Casing

MsS Coils

10" Cased Line

Casing End Seal

Slide 15
Defect signal modeling refined and validated

Defect characterization algorithm development & software improvement underway—complete in March 2007

Field evaluation to begin in April 2007
  - In NGA’s test bed in Binghamton, New York
EXPECTED OUTCOME

- Defect signal simulation software
- Data analysis software for inspection and monitoring
  - Including some capability of defect sizing
- Procedures for sensor installation for long-term monitoring
- Determine capabilities and limitations of long-range guided wave technique for cased pipeline
NONLINEAR HARMONIC (NLH) MONITORING OF GOUGED DENTS IN PIPELINE SPECIMENS UNDER CYCLIC LOADING

U.S. DOT-PHMSA Contract No. DTRS 56-04-T-001 and PRCI Contract GRI 8715
PROBLEM

- Delayed failures from mechanical damage are related to time-dependent accumulation of damage (e.g. fatigue cracking)
- Current ILI systems cannot determine mechanical damage severity
PROJECT OBJECTIVES

- Measure Nonlinear Harmonic (NLH) signals as a function of pressure cycles on full-scale pipe segments containing realistic gouged dents
- Derive NLH-based defect severity criteria related to fatigue life (delayed failure)
- Transfer NLH technology to ILI company (Tuboscope)
NONLINEAR HARMONICS (NLH)

- Uses AC magnetic field to locally infer magnetic properties of steel
- Strain anomalies produced by gouging change magnetic properties of steel and sensed by NLH
NLH RESPONSE TO GOUGING-INDUCED STRAINS

Calipers and other ILI methods may miss re-rounded defects.
NLH DEFECT SEVERITY FACTOR RELATED TO FATIGUE LIFE

severity factor = \frac{\text{gouge length}}{\left(\frac{\text{minimum NLH Intensity}}{\text{average intensity}}\right)^2}

Circumferential Field

- **failed defects**
- **run out defects**
NLH detects strain due to gouge-like defects even after re-rounding.

NLH severity index ranks the severity of gouge-like defects against fatigue (delayed) failure.

NLH severity index specification provided to ILI vendor and demonstrated in analysis software.