Development of CIA’s Remote Robotic Crack Detection Service

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Today’s Presentation

• Brief Background on CIA
• ACFM Development
• Field Trials
• Next Steps
CIA Background

• CIA invented the concept of laser scanning for coke drums in 1990
• Over 1000 inspections for 75 clients in 22 countries
• Comprehensive service - laser scan & zoom video of all circ welds, follow-up ACFM
• Performed between coking cycles – typically under 4 hours
• Immediate results – final report written and usually delivered to client before leaving site
• Partner in coke drum reliability

CIA Comprehensive Coke Drum Inspection Program

• Ultimate failure mechanism is crack initiation in plate-plate welds due to low cycle fatigue
• Almost all cracking occurs on circumferential welds
• Drums fail in a leak-before-break failure mode
• Comprehensive reliability program helps manage drum life – key to preventing drum failure
Inspection Results

- Is This A Crack?
- If so, how deep and how long is it?

![Graph showing inspection results](image)

Development of Remote Robotic Crack Detection

- CIA identified there was a need to quantify crack type indications in a quick, cost effective and accurate way in conjunction with our existing online service
- Standard UT methods usually require shutdown or extended cycle times, difficult to manage, expensive
- Took 18+ years of laser & visual inspection experience and developed new technique
- Chose ACFM - Alternating Current Field Measurement
What is ACFM?

- Developed by TSC in England
- Originally developed for sizing fatigue cracks on underwater welds
- Used as replacement for magnetic particle and penetrant testing
- Electromagnetic technique for detecting & sizing surface breaking defects
  - Works through coatings, works at welds, underwater, on hot or cold surfaces and on all metals

ACFM operates by inducing a locally uniform AC field into the test surface. This field flows in a thin skin in the surface of the material and is disturbed by the presence of surface breaking defects.

These changes are detected by two sensors mounted in the probe which measure the magnetic field resulting from the applied electric field.
Development of ACFM for Coke Drums

- Deploy ACFM probe remotely from drill stem similar to existing inspection system & used in conjunction with laser scanner – retracting boom
- Crawler mounted probe placed inside coke drum wall directly at areas of interest to allow quick local surveys
- 16 sensor pair probe (4.25” wide) customized by TSC for use in coke drums & tuned to detect defects as small as 0.330 inches in length & 0.04 inches in depth
- Several field trials – top entry, bottom entry, crawler & probe

ACFM Equipment
Video – Crawler on drum wall

Field Trial Results

- October 2010
  - Refinery in Canada
  - Drum was out of service (crack repair)
  - Swing stage built inside drum – ACFM probe & crawler driven across known, verified indications
  - Collect data & correlate findings with existing indications (correlated with grind out depths at indication sites)
Field Trial – crawler on drum wall
Analysis – Field Results

• **Repeatability**  - same area, examined multiple times, should produce near identical results when examined by the same analyst
  
  • Of 3 areas where multiple readings were taken (1 x 4, 2 x 2 readings), the maximum difference was 0.098” and the average (using the max) was 0.059” in crack depth

• **Internal Consistency** - same data is analyzed by different trained users the results should be similar
  
  • Of 11 matching readings, average difference was 0.036”, maximum was 0.084” in crack depth
Analysis – Field Results

• **External Consistency** - When defects are analyzed by another technique, results should be close, with allowances for limitations of each technique in specific situations
  - Of 7 areas with comparable results, the average difference was 0.063” in crack depth

• **Reliability** - No defects of a specific minimum size should be missed. For coke drums a starting point is defects longer than 0.75 inches and deeper than 0.1 inches.
  - Other than very short (< 0.5”) point defect flaws, no defects were missed. Some shallow defects were reported where no LDP was present.
  - One defect was reported as 0.340” instead of 0.110” in depth due to its proximity to a repair.

Further Verification – March 2012

• March 2012 – refinery in Canada
• Collect more field data and validate different types of crack indications
• Went into drum on scaffold with crawler and collected more data
• Specifically effects of large indications mixed with weld repairs – what works?
• Other UT data compared to ACFM – in progress
Client identified area

Section as scanned:

2 Repairs & 1 Indication Above Weld

1 Repair & 2 Indications Below Weld

CIA results

Section after sandblasting:

2 Repairs & 1 Indication Above Weld

1 Repair & 2 Indications Below Weld

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Results – Lessons learned

- Able to extract useful information even in repair areas which are inherently difficult to inspect with any technique due to differential metallurgy, inclusions, undercut and general roughness.

- Need for good visuals in these areas so drum cleaning should be emphasized in areas where known weld repairs have been completed.

- ACFM is a viable method for evaluating crack type indications internally

- No technique is uniquely qualified to inspect under all conditions.
Applying ACFM to Coke Drums

Candidates for ACFM:
- Mid life stage drums - starting to see bulges and crack type indications
- Drums with visible crack type indications (after verification by video inspection)
- Drums that have crack type indications that are not in areas of repair (affected by different metallurgy/repair methods)
- Stress cracking of the cladding - cracks beyond that?
- Shutdown of drum is not an option - need verification first and need it fast
- Planning for further repairs - pre-turnaround planning

Summary

- CIA has a long & successful track record for developing & implementing innovative technologies for coke drums
- ACFM is a work in progress – industry acceptance & experience
- “Screening tool” – used to verify surface breaking defects
- This is the first step – quick, remote, non-intrusive
- Robotic crack detection is next breakthrough technology that will enhance drum knowledge
ACFM Development

• Industry contributors to this development:

  • Mechanical Integrity (PetroChem Inspection Services)
  • TSC Inspection Services
  • ConocoPhillips
  • Chicago Bridge & Iron
  • Flint Hills Resources
  • Suncor Energy

CIA – Coke Drum Management through Knowledge

www.cia-inspection.com