Inspection of Steel Vessels with Cladding Overlay, using MWM-Array Technology

Neil Goldfine, Yanko Sheiretov, Brian Manning, Zachary Thomas, Todd Dunford and Scott Denenberg
JENTEK Sensors, Inc., 110-1 Clematis Avenue, Waltham, MA 02453-7013 USA

Rasheed Al Rushaid, Frederick Haught, James Bayangos
Al Rushaid Technologies Co., Al Turki Business Park, Office Villa #4; 7244 King Saud Road, Ad Doha Al Janubiyah, Dhahran 34455, Kingdom of Saudi Arabia

Ali Minachi
Saudi Aramco, Dhahran 31311, Kingdom of Saudi Arabia
Technical Approach

- **Goal:** Detect hydrogen blisters in weld overlay clad vessels
  - Detect substrate cracks
- **Equipment:** 8200 GridStation® Electronics
- **Software:** GridStation autonomous data analysis
- Preliminary demonstration and mock up performed in Waltham, MA, USA
- Inspection performed in Saudi Arabia, during 8 day period (April 2014) on four large vessel units
- Scans performed of over 50% of the internal clad surface
Technology Overview

1. Sensors: flexible eddy current arrays
   - Paradigm shift in sensor design (first priority is predictable response based on physics-based modeling)

2. Next Generation Electronics
   - 10x signal-to-noise improvement
   - Very low frequencies (deep penetration)
   - Crack detection through up to 0.5 inches of material
   - Reduced drift

3. GridStation Software using Hyperlattices®
   - Rapid, autonomous data analysis
     Performs multivariate inverse method (MIM) using precomputed databases
     - Defect Images
     - Performance Diagnostics
     - Noise Suppression
Inverse Method: 4-Unknown HyperLattice Databases

1. Lift-Off
2. Cladding Permeability
3. Cladding Thickness
4. Gap thickness
Vessel Scanner: Manual

Manual Scanning Cart and Sensor

Flexible Array Sensor FA216

MWM-Array Sensor

Scanning elements

Detail
Vessel Scanner: Automated

Vessel Mock-Up

MWM-Array Sensors

PEU Electronics

MWM-Array Sensor

Vessel Wall

MWM-Array Sensor
Test Set Up, JENTEK Sensors, Waltham, MA

Scanner supports, scanner rail and mount on vessel mock-up

System

Scanner rail

Scanner mount for sensors
Map of Reported Blister Locations

Vessel Map

- Scan Path
- N (North)
- S (South)
- W (West)
- E (East)
- Circumference = 432 in. (~11 meters)

Legend:
- Large Blister
- Medium Blister
- Small Blister
- Substrate Anomalies

Circumferential Position (in)

Vertical Position (in)

510-558 in
404-459 in
337-345 in
238-275 in
169-194 in
104-130 in
0-45 in
Example Gap Thickness C-Scan

[Diagram showing gap thickness scan with regions A and B highlighted.]
Gap Thickness C-Scan and 3-D Plot

Corresponding 3D plot localized around the location of a blister
Summary

- Program **goal** was to demonstrate imaging and **characterization of blister volume** using MWM-Array sensor technology

- A successful **first service for inspection** for hydrogen blisters in weld overlay clad vessels was completed at a major facility in Saudi Arabia

- Hydrogen blisters were **successfully mapped** and **digitally registered**

- **Suspect cracks** in the steel substrate below the cladding were also **identified**