Eddy Current Array inspection of Carbon Steel and inspection of 300 series Stainless Steel with Dynamic Lift-off Compensation.
Agenda

- Magnetic Particle Impact on Carbon Steel
- Penetrant Inspection Impact on 300 Series Stainless Steel
- MagnaFORM Solution
- How it Works
- Results
- Improvement
- Conclusion
Magnetic Particle and Penetrant Inspection
Problems and Advantages
Summary: MPI and PT Positive Impacts

- Very Simple of Use
- Applicable to Various Parts or Geometries
- Widely Spread, Many Operators
- Well Suitable for Bare Metal (Ferromagnetic and Non-Ferromagnetic)
- Great Sensitivity and Resolution
- Affordable Direct Cost
Summary: MPI and PT Negative Impacts

- Paint Removal & Re-Application
  - Chemicals & Environmental Concerns
  - Bare Metal → Liability
  - Down Time ( Entire Process)
  - Costs of Entire Process

- No Sizing

- No Easy Archiving

- Multiple Passes Required

- False Indication (Rough Surfaces)
The MagnaFORM Solution
(Distinctive Benefits and Features)
Paint Removal is History

- Eddy Current Sensors inspect through up to 5 mm Paint Thickness
Large coverage
Single Pass Scanning for weld inspection

- Covers HAZ, Toe, Crest and Crevices
- Maintains Detection
No More Lift-Off Headaches

- Flexible Array Probe Ensures *Most* Contact
- New *Dynamic Lift-Off Compensation* Corrects Sensitivity
Durable Inspection

- Rugged Construction (Drop-Tested)
- Wear Face Tested on 22 km Scan Before Needing Replacement!
- Contact with the part is not required
Ready to Inspect

- Hand Scanner, Semi-Automatic Scanners and motorized scanners
The Power of Imaging

- Instant Interpretation
- Archiving of Inspection Files
- Post Analysis is Possible
Dynamic Lift-Off Compensation

How it Works
Basic Elements

- Eddy Current Array Probe
- Encoder Cable
- Position Encoder
- Cart (MagnaFORM scanner)
Probe Close-Up

Detachable Connector

Pre-Shaped “Wedge”

Sensitive Face
Tool-Free Removal

1. [Image of tool without strap]
2. [Image of tool with strap removed]
3. [Image of tool with strap folded back]
4. [Image of tool with strap attached]

OLYMPUS
Fits Most Pipes & Vessels

- Flat
- Large Internal
- Large External
- Smaller External
Flexible Sensor Array

16 + 16 Sensors (two types)

Active Circuitry

Eddy Current Sensors: Multi-Layer PCB Etched Coils
Two (Eddy Current) Sensor Types

Type 1
Crack Detector

Type 2
Lift-Off Gauge
Type 1 Sensor: Crack Detector

- PCB equivalent to Cross-Wound Coil
- Ideal for Carbon Steel
- Widely used in “Weld ECT Probes” (WeldScan)
- Easily Detects Surface-Breaking Defects
- Detects through paint but affected by Lift-Off
Type 2 Sensor: Lift-Off Gauge

- Eddy-Current Sensor
- PCB version of “Sliding Probe”
- Stable Lift-Off Measurement
Powerful Combination

(Raw) Crack Signal

Lift-Off Measurement

Dynamic Lift-Off Compensation

Compensated Crack Signal
Dynamic Lift-Off Compensation

- Dynamic = Real Time Software Processing
- Increases Sensitivity of Crack Detectors when Lift-Off is Increased
  - No/Minimal Lift-Off = Normal Gain
  - More Lift-Off = More Gain to Crack Detectors
- Maintains Uniform Sensitivity Independently from Lift-Off
Independant Sensors

16 Independent Crack Detectors

+ 16 Independent Lift-Off Gauges

= 16 Independent Dynamic Lift-Off Compensated Channels
MagnaFORM on Weld

Flexible Probe

Good Contact

Increased Lift-Off
Weld Close-Up

Lift-Off

Raw Crack Signal

Compensated Crack Signal
Weight Watchers

Maintains Sensitivity

Before
(No Lift-Off)

After (3 mm Lift-Off)
MagnaFORM Representation

Live Impedance Plane

Vertical Amplitude

C-Scan View (2D Mapping)

Color Palette (uses vertical Amplitude)

Index Axis (Probe Coverage)

Scan Axis (Distance or Time)
Is Sizing Possible?

- Depth of Surface-Breaking Defects has Direct Effect on Amplitude
How About Toe of Weld…?

Probe Profile

Reduced Sensitivity due to Increased Lift-Off (Wrong Sizing)

Sensitivity Dynamically Compensated Helps Fix Sizing
MagnaFORM Sizing = Depth Evaluation

Depth Reading

Selection Cursor (when Paused)

Selection Length is Taken into Account in Sizing Process

Depth = 1.9 mm

Length X = 25.00 mm

Length Y = 0.00 mm

Gain: H: 35.0 V: 35.0

V Max.: 5.5

Enc. Scan: 204.0 mm

Display:

Scan Start (mm): 118.50

Index Start (mm): 48.30

Length Selection (mm): 25.00

Angle Selection (°): 0.0

New feature: Depth Evaluation and Selection Length.
Sizing Demonstration
#1 – Weld Inspection of Carbon Steel

- Crack in all directions can be detected
- Inspect through up to 3 mm paint thickness
- Wedges for weld profiles
- Inspect through paint
- Not sensitive to abrasive surface
- Magnetic wheel can be used (carbon steel)
- Low noise to ratio signal
- Length and depth evaluation (carbon steel)
#1 – Results

**Coverage (~ 3”)**

**Circumferential Axis (360°)**

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<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Gain (dB)</td>
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<td>V Max (volt)</td>
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<tr>
<td>Depth (mm)</td>
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<td>Length X (mm)</td>
<td>52.00</td>
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<tr>
<td>Length Y (mm)</td>
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</tr>
</tbody>
</table>

HAZ

Weld

Weld Inspection

Eddy Current

Special

Cursors

Encoders (Simplified)

Display

Encoder 1: Scan From...

Continuous

Length (mm)

Enc. Resol. (Step/mm)

Normal Enc. Direction

Normal Probe Orientation
#2 – SCC on Carbon Steel with Corrosion

- Crack in all directions can be detected
- Inspect through up to 3 mm Paint Thickness
- Can be done on painted surface
- Not sensitive to abrasive surface
- Magnetic wheel can be used (carbon steel)
- Low noise to ratio signal
- Length and depth evaluation (Carbon steel)
#2 – Results

(3x) EDM

L = 10 mm, D = 1 / 3 / 5 mm

EDM in Corrosion

L = 10 mm, D = 3 mm

Corrosion Mostly Cancelled and Compensated for Lift-Off
MagnaFORM Solutions Improvement
#3 – Weld Inspection on Stainless Steel 304

- Crack in all directions can be detected
- Inspect through up to 5 mm Paint Thickness
- Can be done on painted surface
- Not sensitive to abrasive surface
- Low noise to ratio signal
- Length evaluation
# 3 Results (Longitudinal scan)

Edge effect caused by high lift-off

Lack of fusion = 2 mm  
Lack of fusion = 20 mm
#4 – SCC on Stainless Steel 304

- Crack in all directions can be detected
- Inspect through up to 5 mm Paint Thickness
- Can be done on painted surface
- Not sensitive to abrasive surface
- Low noise to ratio signal
- Length evaluation
Conclusion

▪ Weld Inspection of Carbon Steel

▪ Stress Corrosion Cracking Inspection of Carbon Steel on Corroded Surface

▪ Weld Inspection of 300 Series Stainless Steel Alloys

▪ Stress Corrosion Cracking Inspection of 300 Series Stainless steel alloys
Benefits

- Inspect through Paint
- Dynamic Lift-Off Compensation
- Single Pass Weld Inspection
- Stress Corrosion Cracking
- Depth Evaluation
- Imaging and Archiving
Thank you!