FINE DEFECT DETECTION BY EDDY CURRENT ARRAY.

PATRICK CABANIS
Senior Application Specialist NDT Level 3.
OLYMPUS INDUSTRIAL SYSTEMS EUROPA
patrick.cabanis@olympus-europa.com
tel : 33 1 45 60 68 40
mobile : + 33 6 77 88 46 00
WE MUST NEED TO DETECT THE DEFECT

INSPECTION SOLUTION

FINES DEFECT

CONTEXT

ECA
PRESENTATION PLAN

- Eddy current History and Theory
- Eddy current array (ECA) technology
- ECA equipment
- High-frequency applications
- Low-frequency applications

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History

Yesterday

Today

Tomorrow
Historique théorie

e = \frac{\Delta \Phi}{\Delta t} \quad \text{or} \quad \Phi = L i \quad \text{donc} \quad |\Delta \Phi| = L |\Delta i|

J_x = J_0 e^{-\left(x \sqrt{\pi \mu \sigma_f}\right)} \sin \left(2\pi ft - x \sqrt{\pi \mu \sigma_f}\right)

\theta = 57 \frac{x}{\delta} \quad J = 100 \cdot \exp \left(-\frac{x}{\delta}\right) \quad \delta = 50 \sqrt{\frac{\rho}{f \mu_r}}

U^2 = R^2 I^2 + L^2 \omega^2 I^2 = (R^2 + L^2 \omega^2) I^2

D'où \quad U = I \sqrt{R^2 + L^2 \omega^2}

Donc \quad Z = \frac{U}{I} = \sqrt{R^2 + L^2 \omega^2}
CONTEXT

- Two elements disturbs the EC
- The Lift off
- The followed profile
Lift-off effects on the probe sensitivity

- The graphic shows the normalized defect signal for different lift-off conditions.
  - For a 2 mm coil.
  - For a 5 mm coil.
  - For a 15 mm coil.

- The signal is maximized when in contact with the part and decreases with lift-off.

- For a small coil, a lift-off of only 1 mm decreases the defect signal to 25 % of its maximum signal (when the lift-off is 0 mm).
Eddy Current Array – Basic Concept

- In ECA, several eddy current coils are placed in the same probe assembly to:
  - Allows larger coverage in a single probe pass while maintaining a high resolution.
  - Reduces the need for complex robotics to move the probe; a simple manual scan is often enough.
  - Improves flaw detection and sizing with C-scan imaging.
  - Inspect complex shape with a probe made with to the profile of the parts
What is Eddy Current Array?

- Eddy current array technology is the ability to **electronically drive several eddy current sensors**.

- Data acquisition is performed by **multiplexing the eddy current sensors**.

- Most eddy current probes and techniques for flaw detection can be used.
Equipment

1CH
BNC connector used for one single-coil eddy current probe using conventional eddy current technique.

4CH/MUX
19-pin connector used for eddy current probes that have up to four single coils.

EC ARRAY
R/D Tech® connector used for eddy current array inspection technique.
ECA – Signal Representation

- The C-scan can only show one component of the signal at a time (X or Y component).
- In the example below, the C-scan shows the vertical component of the signal (Y axis) and this is why the lift-off, which has been rotated horizontally, is almost not visible.
Fine defect detection application

- Tubes inspection
- Gaz Turbine
- Pipe
- Dovetail
- Train axis
- Doubler edge
- FSW (weld)
- Blade
BOEING 757 LAP SPLICE C-SCAN INSPECTION
Calibration Sample

- inspection procedure to Part 6, 53-30-06.

**NDT 588**

5/32 and 6/32 rivet hole

Typical cross-section

EDM notch:
- length .1 in from rivet shank
- Thickness: through 1st skin
Results

Good rivet hole

Rivet hole with notch
Method of ECA High-frequency inspection of the lower skin for scribe mark

0.06 in to 1 in to the edge
Method of ECA high-frequency inspection of the lower skin for scribe mark

- One pass inspection
- Notch detection from 0.06 to 1 in to the edge
- Reliable inspection (100% full coverage)
- Easy interpretation on Cscan
- No need for encoder
- General procedure
Engine disk dovetail slot Inspection

- ECA probe
- 32 elements (2 x 16)
Engine disk dovetail slot Inspection
Inspection in the maintenance shop

CFM56
GE-90
GE-115
GP-7200
Sam-146

Disk CHP D1

Tooling
GE90 : ECA HF Inspection method

- Cscan with EDM notches and calibration notches in the calibration sample
Gas turbin  ECA Flexible probe and holder

- Special probe holder
- Flex probe 32 elements
Gaz turbin

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TUBE INSPECTION

Eca flex probe kit
Custom probe holder
TUBE INSPECTION

- Reference standard
ECA - Flexible Probe

Flex probe FBB-051-500-032
Frequency 50KHz to 4MHz
ECA - Flexible Probe

➢ Two mode

**Absolut**
Need a encoder

**Reflection**
ECA – Surface Pipe inspection

Scan direction

Defect orientation

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ECA – Surface Pipe inspection

Result on standard

Horizontal  45 degre  vertical

Good area

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Boeing 737 Skin crack detection at doubler edge

- The inspection referenced in the NTM737 NDT 53-30-25 part 6, is done from the outside and crack as small as 0.240” long by 0.010” deep located at the edge of the doubler need to be detected.

- Benefits:
  - Simple manual inspection
  - C-Scan allows easy location of the doubler edge for fast and simple detection of the initiating cracks
  - Better reliability
  - Better reproducibility
  - Time saving:
    » Normal time: 200 hours
    » With ECA: 48 hour
**Boeing 737 Skin crack detection at doubler edge**

- The user can see very well the doubler edge represented by the light to dark green color transition.

- Fastener will show up in light green.

- Defect above the rejection level are in red like shown in this picture.
Weld Inspection
Notches identification on the C-Scan view

length: 6mm, depth: 1.2mm, width: 0.2mm
Conclusions about ECA

- Deployed in the field for many applications
- Referenced in procedures for aircraft and engine maintenance
- Fast (large area)
- Reliable (Full coverage and Cscan imaging)
- Many ECA standard probes
- Omniscan ECA module compatible with Bondmaster C-Scan.
- More to come…
BEST REGARDS