Finite Element Modeling of Pulsed Eddy Current Applied to Ferrous and Titanium Fasteners in F/A-18 Airplane Wing Structures

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Outline

• Introduction
• Finite element modeling
• Results and Comparison with Experiment
• Summary
Pulsed Eddy Current/Eddy Current

- PEC method has potential application of detection of defects in thick multilayered structures at greater depth than conventional eddy current techniques.
Stress corrosion cracks develop between fasteners. Locations of cracks at depth are not normally inspectable by conventional techniques (ET or UT) and require removal of both skin and fasteners.
Sample, PEC Probe and FE Model

- Driver Core
- Driving Coil
- Pickup Core
- Pickup Coil
- Skin
- Spar
- Fastener
- Crack Block
Flux Penetration: Ferrous vs. Titanium

- **Ferrous**:
  - \( \mu = 66 \)
  - \( \sigma = 3.6 \times 10^6 \text{ S/m} \)

- **Titanium**:  
  - \( \mu = 1 \)
  - \( \sigma = 2.0 \times 10^6 \text{ S/m} \)
  
- **Insulator**:
  - \( \mu = 1 \)
  - \( \sigma = 2.6 \times 10^7 \text{ S/m} \)
Pickup Absolute Signals: Ferrous vs. Titanium

Model

Experiment
Modeled Pickup Differential Signals from a Defect

![Graph showing modeled pickup differential signals from a defect with current density over time for ferrous and titanium materials.]

- **Ferrous**
- **Titanium**
Differential Signals: Effect of Probe Shift

**Ferrous**

![Graph showing current density change over time for Ferrous material]

**Titanium**

![Graph showing current density change over time for Titanium material]

Diagram showing probe with a pickup coil pair and a fastener.
Summary

• FE Modeling of a PEC Probe along with a simulated F/A-18 Hornet sample provides useful information about flux penetration in ferrous and titanium fasteners and generation of output signal.

• The PEC signals are stronger and detection depths are larger for the case of ferrous fasteners as compared with titanium fasteners. A change in signal analysis will be required to accommodate these differences.

• The differential PEC signal is very sensitive to probe off-centering for ferrous fastener as compared to titanium, especially when the shift is parallel to the line joining the coil pair. However, the signals are not affected as much when the shift occurs perpendicular to this line.