



Nondestructive Testing Simulations Using QuickField

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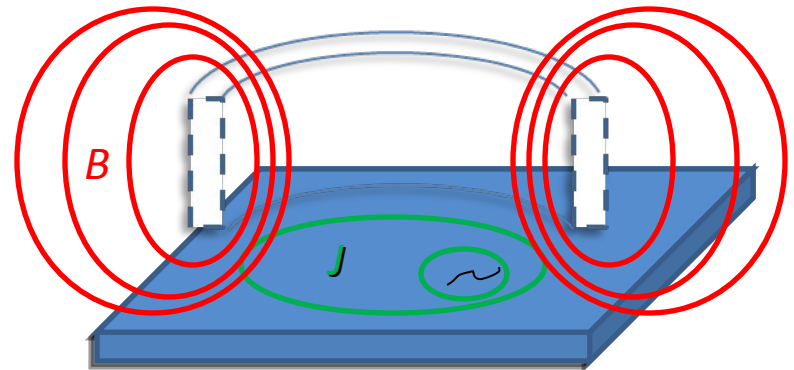


NDT Topics

- Eddy Current NDT Simulations
 - Principles of eddy current NDT
 - Circular and planar drive coils
 - Simulations varying frequency, flaw depth, lift off, etc.
 - Pulsed eddy current inspection
 - Calculating the flaw response from the unperturbed eddy current density using the Biot-Savart law
- Permeability mapping
 - magnetic field perturbation near defects in magnetic materials
- Stress Distribution Near Cracks
 - Under loading
 - Thermal expansion

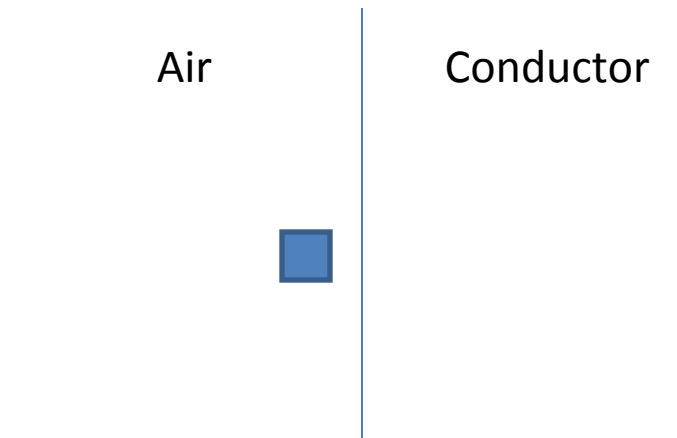
Principles of Eddy Current NDT

- AC excitation coil induces eddy currents in nearby object under inspection
- Flaws in the conductor deviate the current flow path in the test objects
- The impedance of the drive coil (or secondary coil) is altered by the flaw perturbed eddy current flow
- Alternatively, the change in magnetic field can be monitored to reveal the presence of defects





Circular Drive Coil Above a Semi-Infinite Conducting Half Plane



Problem Type:

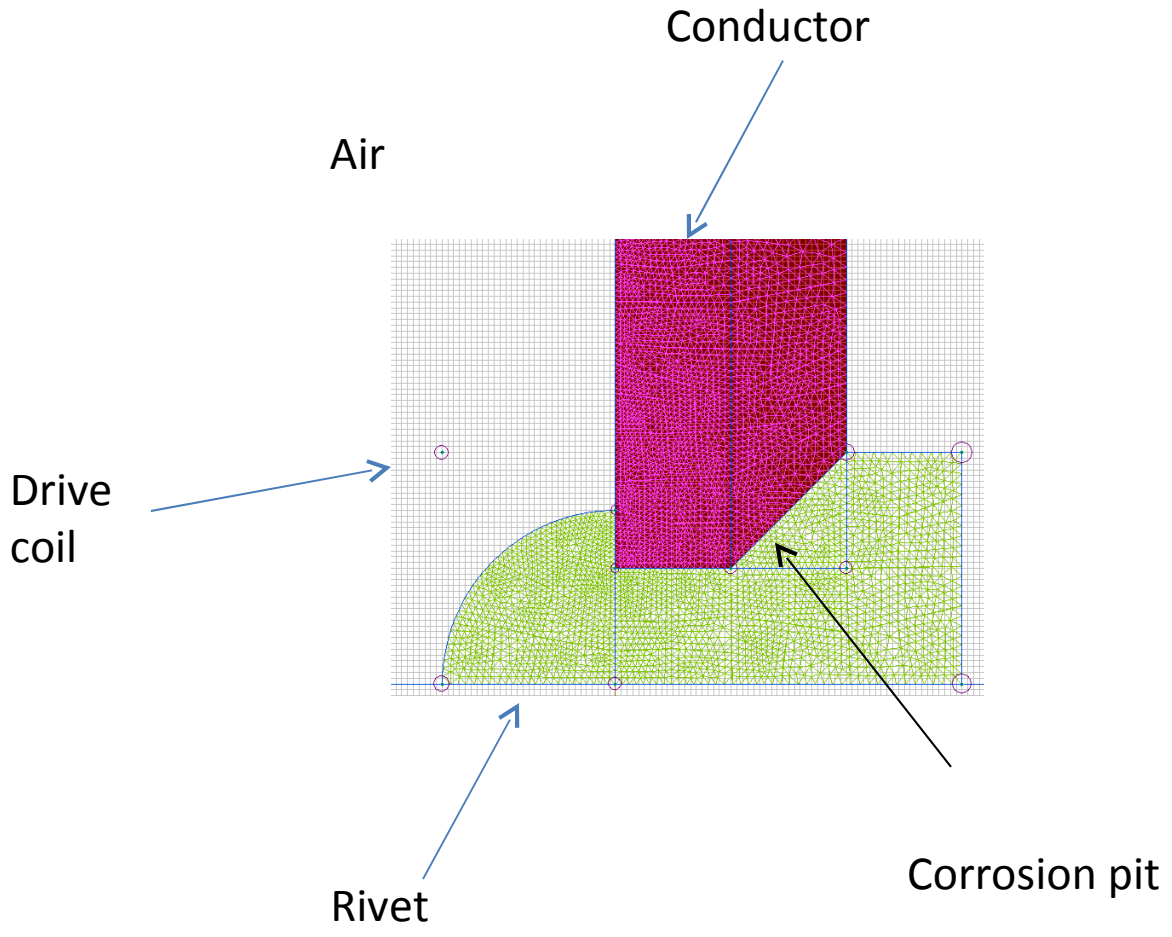
AC Magnetics

Geometry:

r-z symmetry



Circular Drive Coil Above a Rivet with Corrosion Pit



Problem Type:

AC Magnetics

Geometry:

r-z symmetry



Circular Eddy Current Coils Surrounding a Pipe containing a Flaw

Air

Conductor

Problem Type:

AC Magnetics

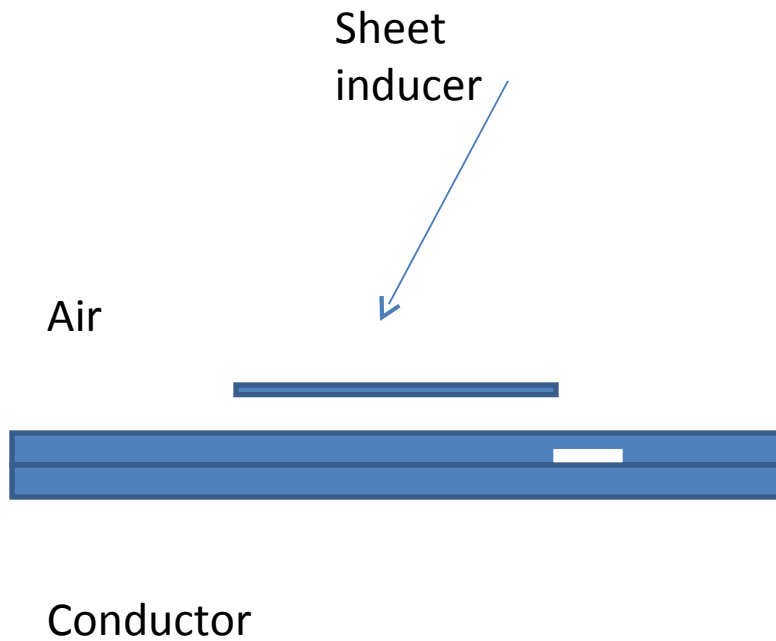
Geometry:

r-z symmetry





Sheet Inducer Above a Planar Conductor with Corrosion Pit



Problem Types:

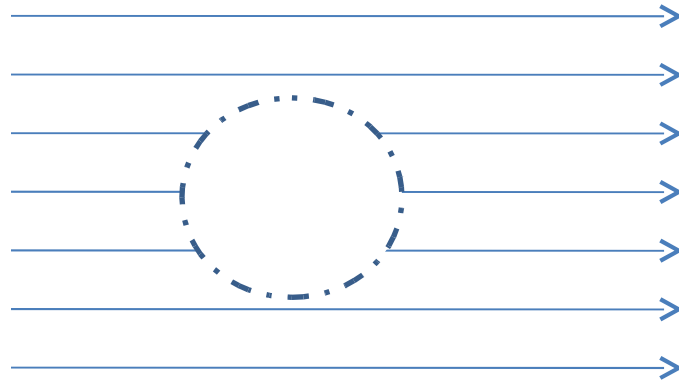
AC Magnetics
Transient Magnetics

Geometry:

x-y symmetry



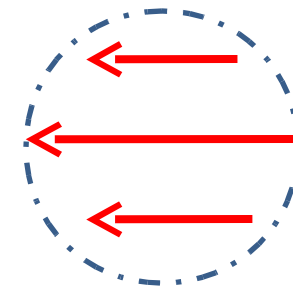
Calculating the flaw response from the unperturbed eddy current density



Zero current in flaw volume



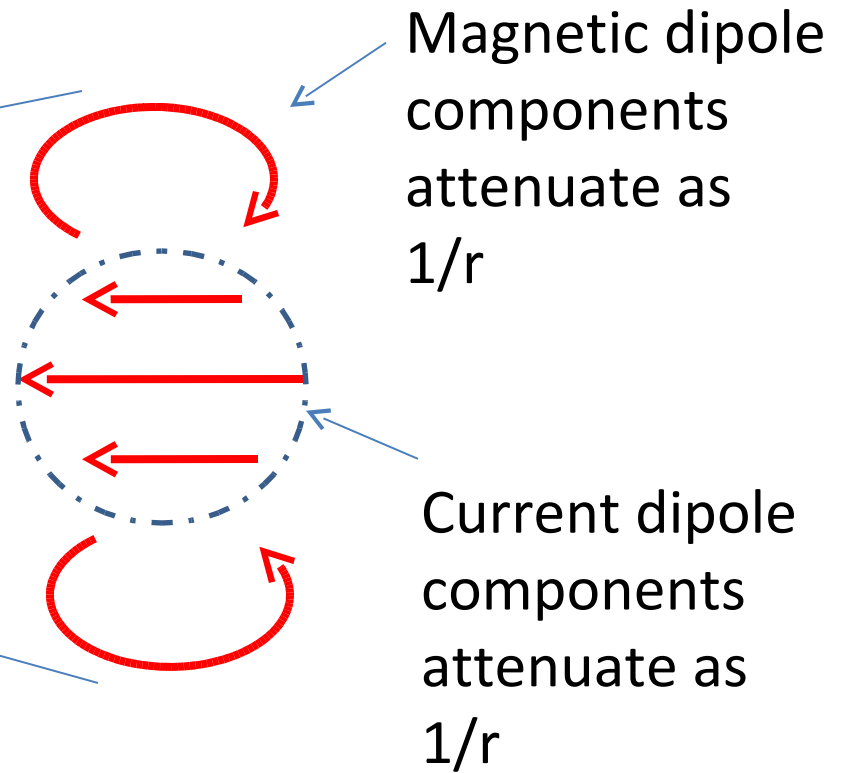
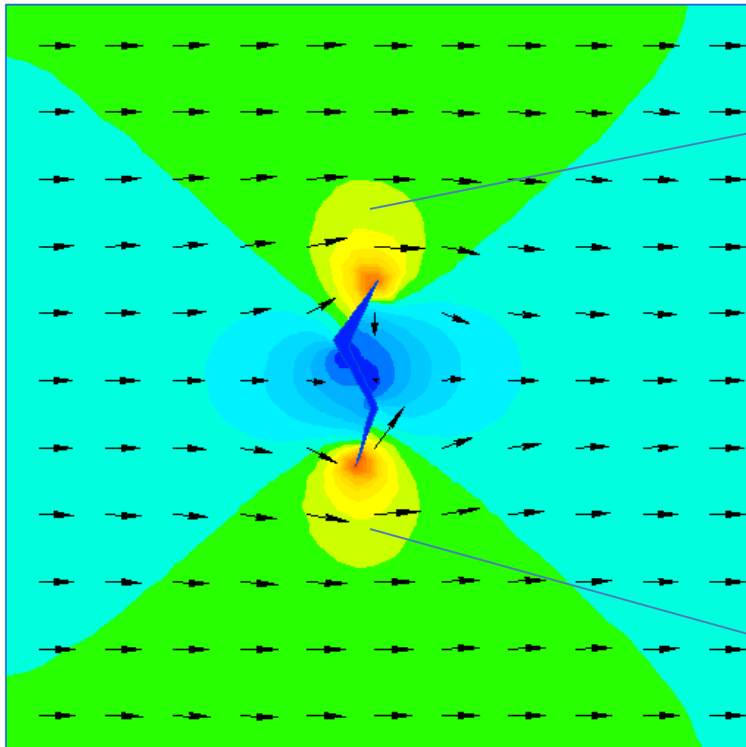
+



$$\mathbf{J}_{\text{flaw}} = -\mathbf{J}_{\text{eddy}}$$

The total current is approximated as a sum of unperturbed eddy current and an opposing current dipole

Flaw field: Current dipole and magnetic dipole components



AC Current Flow Simulation in QuickField



Calculating the flaw response from the unperturbed eddy current density

$$\mathbf{J}_{\text{flaw}} = -\mathbf{J}_{\text{eddy}} \quad \Delta \mathbf{B}_{\text{flaw}}(\mathbf{r}) = \frac{\mu_0}{4\pi} \iiint_{\text{vol}} \frac{\mathbf{J}_{\text{flaw}}(\mathbf{r}') \times (\mathbf{r} - \mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|^3} dv'$$

For small flaws (unperturbed eddy current density does not vary appreciably over the volume of the flaw)

$$\Delta \mathbf{B}_{\text{flaw}}(\mathbf{r}) = \frac{\mu_0}{4\pi} \frac{\mathbf{J}_{\text{flaw}}(\mathbf{r}') \times (\mathbf{r} - \mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|^3} V_{\text{flaw}}$$



Calculating the flaw response from the unperturbed eddy current density

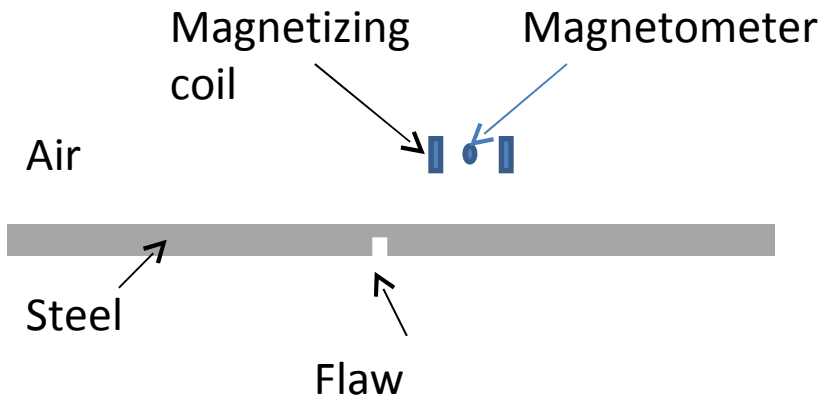
For small flaws (unperturbed eddy current density does not vary appreciably over the volume of the flaw)

$$\Delta \mathbf{A}_{\text{flaw}}(\mathbf{r}) = \frac{\mu_0}{4\pi} \frac{\mathbf{J}_{\text{flaw}}(\mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|} V_{\text{flaw}}$$

$$\Delta V_{\text{flaw}} = - \oint_{\Gamma} \Delta \mathbf{E}_{\text{flaw}} \cdot d\boldsymbol{\ell} = i\omega \oint_{\Gamma} \Delta \mathbf{A}_{\text{flaw}} \cdot d\boldsymbol{\ell}$$



Permeability Mapping Using A Sharp-Tip Ferrite



Problem Type:

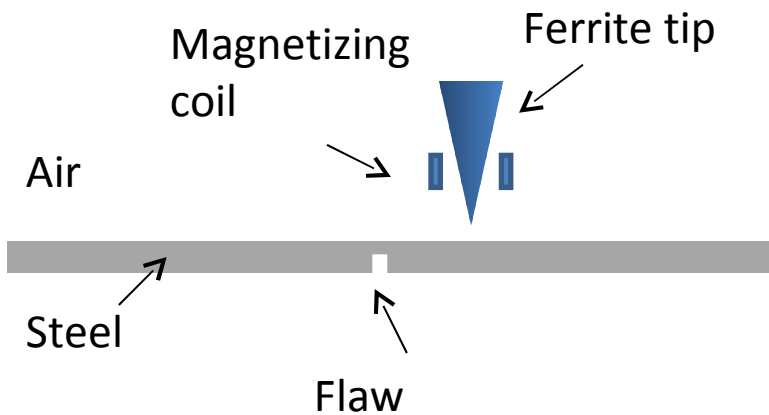
Magnetostatics

Geometry:

planar x-y symmetry



Permeability Mapping Using A Sharp-Tip Ferrite



Problem Type:

Magnetostatics

Geometry:

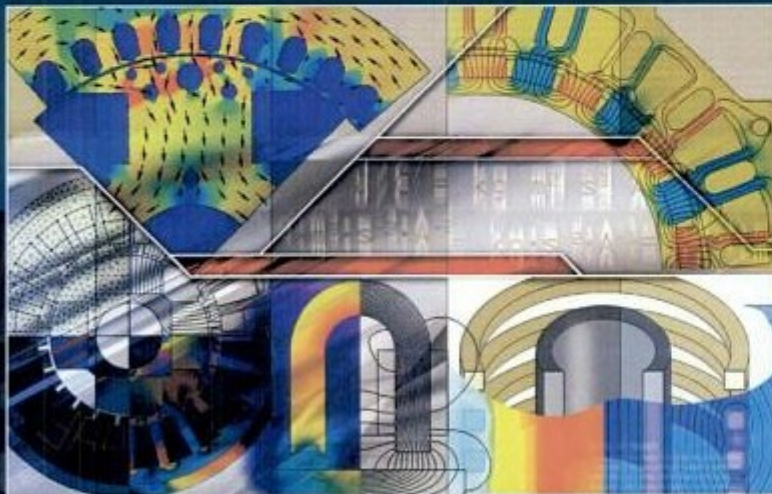
planar x-y symmetry



APPLIED ELECTROMAGNETICS

Using QuickField™ and MATLAB®

James R. Claycomb



Chapter 1: Mathematical Preliminaries

Chapter 2: Solutions to Laplace's Equation

Chapter 3: A Walk Through QuickField

Chapter 4: Electrostatics

Chapter 5: Magnetostatics

Chapter 6: Time Harmonic Magnetics

Chapter 7: Transient Magnetics

Chapter 8: Superconductivity

Chapter 9: DC Current Flow

Chapter 10: AC Current Flow

Chapter 11: Thermal Analysis

Chapter 12: Stress Analysis

Chapter 13: Electrical Circuits