Nondestructive Testing Simulations Using QuickField

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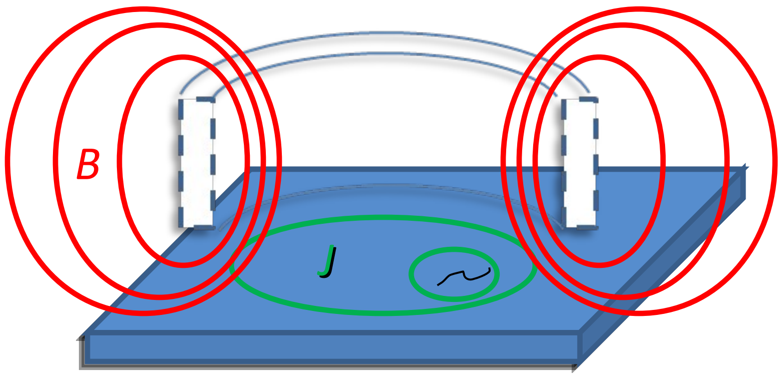
NDT Topics

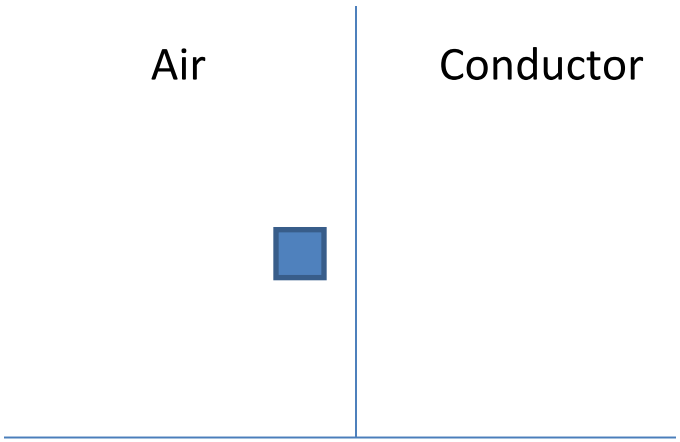
- Eddy Current NDT Simulations
  - Principles of eddy current NDT
  - Circular and planar drive coils
  - Simulations varying frequency, flaw depth, lift off, etc.
  - Pulsed eddy current inspection
  - Calculating the flaw response from the unperturbed eddy current density using the Biot-Savart law
- 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



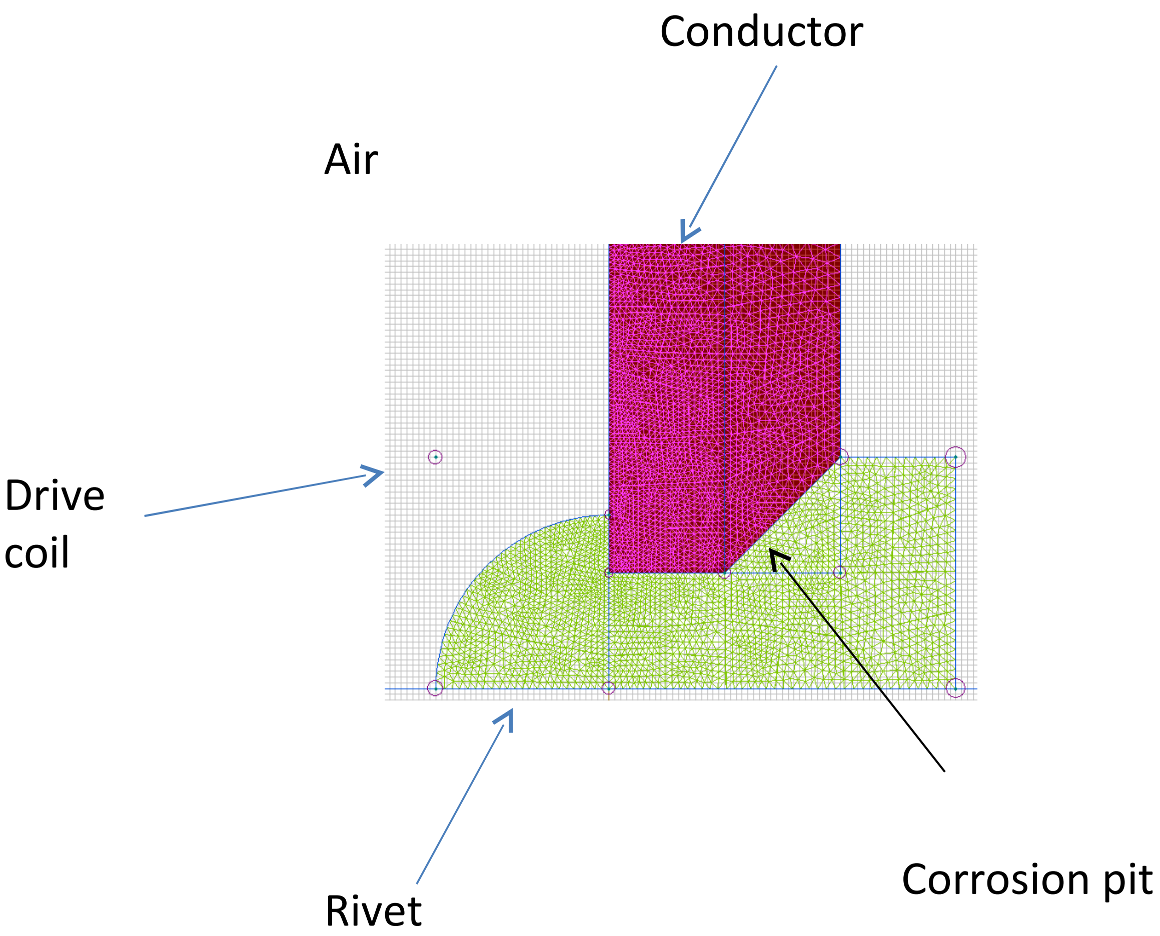
Problem Type:

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

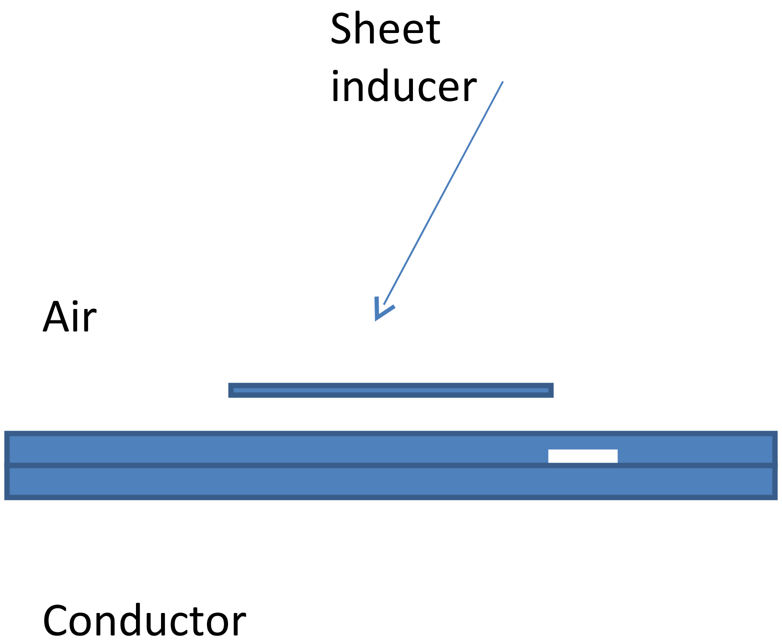
Problem Type:

AC Magnetics

Geometry:

r-z symmetry

Sheet Inducer Above a Planar Conductor with Corrosion Pit



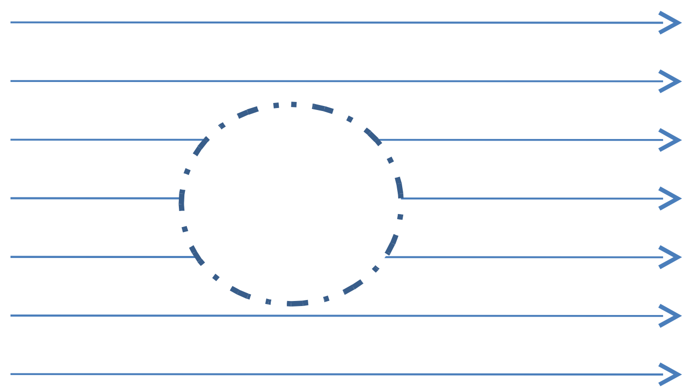
Problem Types:

AC Magnetics
Transient Magnetics

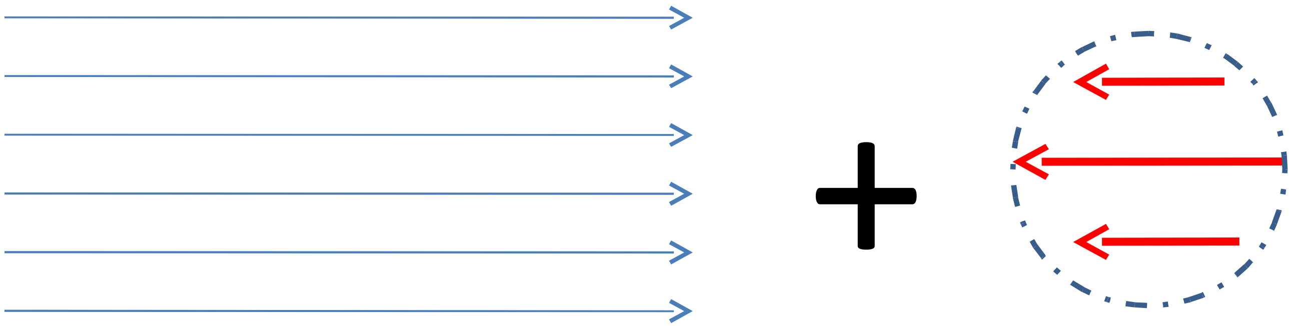
Geometry:

x-y symmetry

Calculating the flaw response from the unperturbed eddy current density



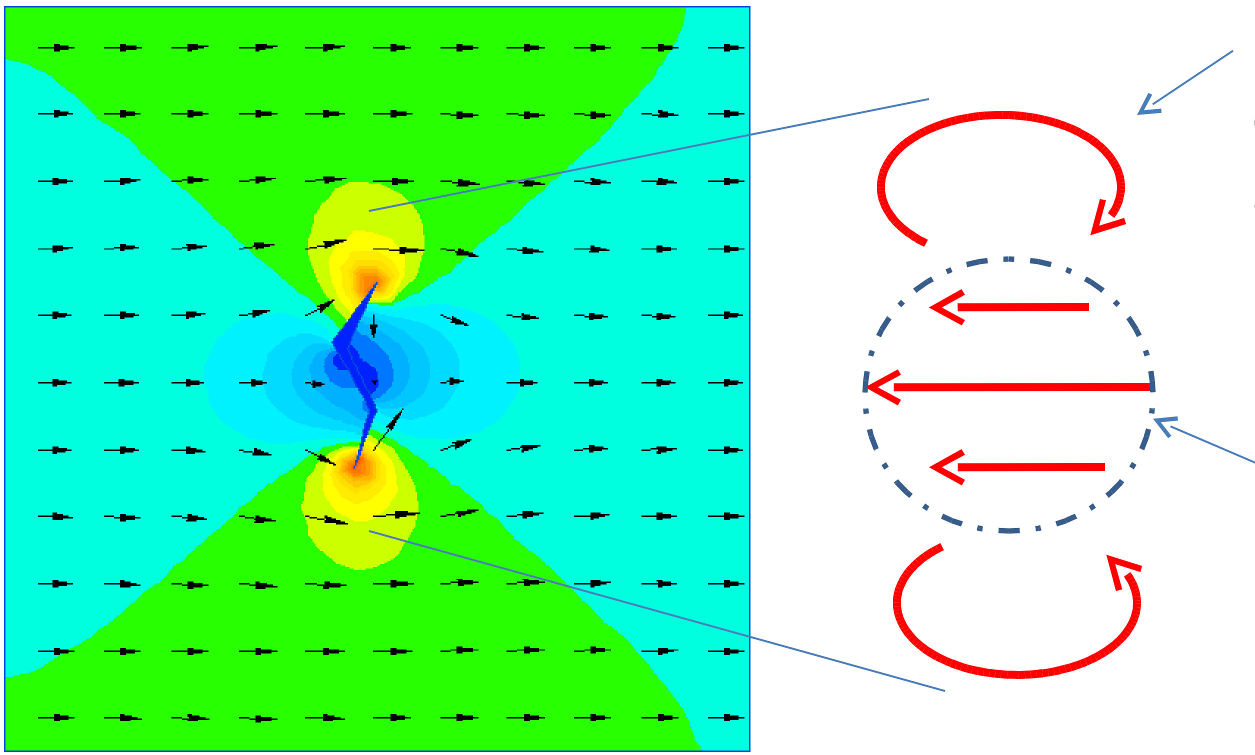
Zero current in flaw volume



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

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



Magnetic dipole components attenuate as 1/r

Current dipole components attenuate as 1/r

AC Current Flow Simulation in QuickField

Calculating the flaw response from the unperturbed eddy current density

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

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

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

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

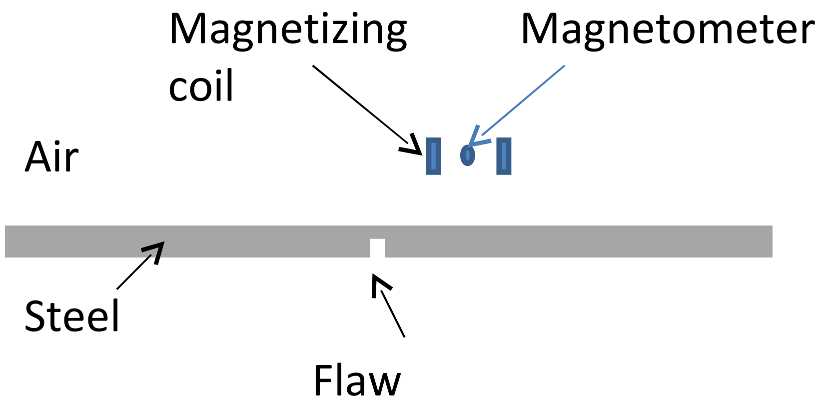
Calculating the flaw response from the unperturbed eddy current density

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

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

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

Permeability Mapping Using A Sharp-Tip Ferrite



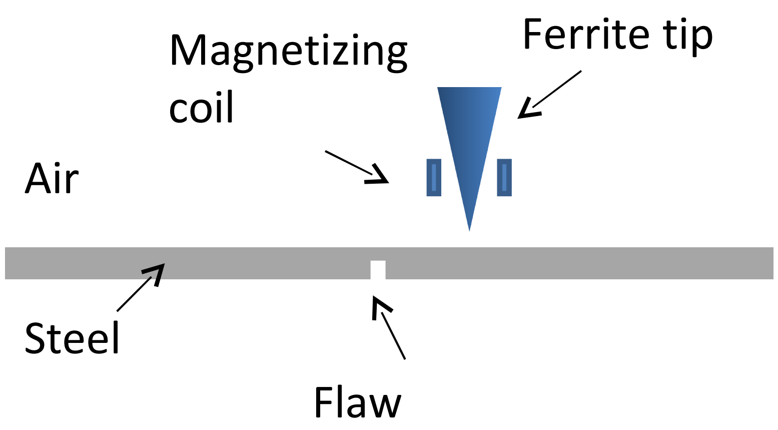
Problem Type:

Magnetostatics

Geometry:

planar x-y symmetry

Permeability Mapping Using A Sharp-Tip Ferrite



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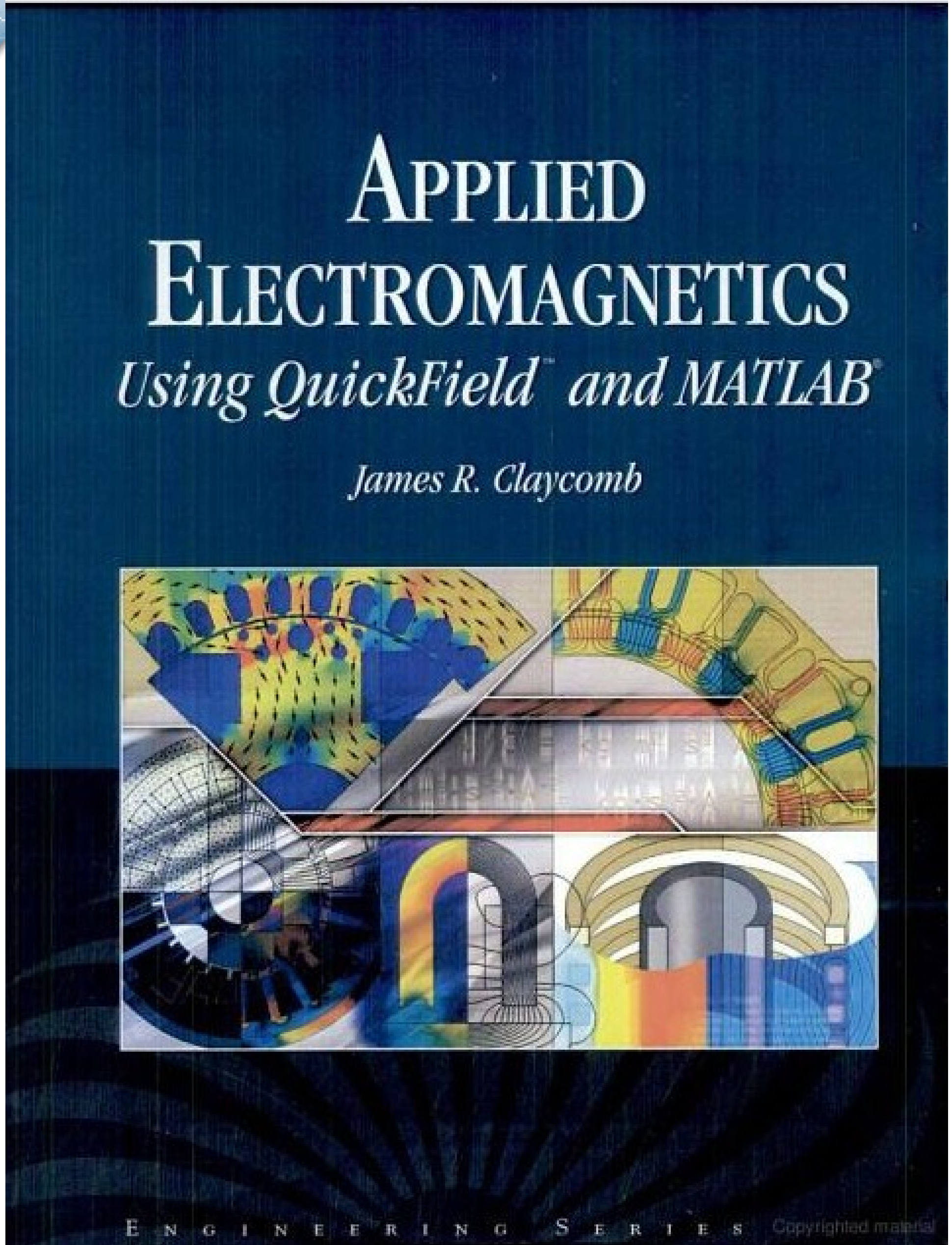

Chapter 1: Mathematical Preliminaries
Chapter 2: Solutions to Laplace's Equation
Chapter 3: A Walk Through QuickField
Chapter 4: Electrostatics
Chapter 5: Magnetostatics
Chapter 6: Time Harmonic Magnetics
Chapter 7: Transient Magnetics
Chapter 8: Superconductivity
Chapter 9: DC Current Flow
Chapter 10: AC Current Flow
Chapter 11: Thermal Analysis
Chapter 12: Stress Analysis
Chapter 13: Electrical Circuits