Modelling of flawed riveted structure for EC inspection in aeronautics
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The industrial demand is to detect efficiently flaws located nearby a fastener.

- Need of Eddy Current inspection for flawed fastened structure

The semi-analytical model

The state equation

\[ \mathbf{E}_h(x) = \mathbf{G}^{(2)}(x) - j\omega \mu_0 \sum_{\ell} \int_{V_h} \mathbf{G}^{(0)}_{\ell}(x, x') [\mathbf{h}_\ell(x') - \mathbf{f}_\ell(x')] \, dx' \]

Primary field in the layer \( a \)

Dyadic Green’s functions

Linear system from state equation (MoM) Solution by Matrix inversion or iterative resolution

Theoretical Formulation

The dyadic Green’s functions are solution of

\[ \nabla \times \nabla \times \mathbf{G}^{(0)}(x, x') - j\omega \mu_0 \mathbf{G}^{(0)}(x, x') = \delta(x-x') \]

The response of the probe is obtained via the reciprocity theorem

\[ \mathbf{I}_f \, \Delta s = \sum_{\ell} \int_{V_h} [\mathbf{h}_\ell(x') - \mathbf{f}_\ell(x')] \mathbf{G}^{(0)}_{\ell}(x, x') \cdot \mathbf{E}_0(x') \, dx' \]

where \( \mathbf{I}_f \) is the current density of the probe, \( \Delta s \) the excitation volume and \( \epsilon \) the dielectricity constant.

Configuration Zeng & al (ACES’07)

Good agreement with the data published in “Reduced Magnetic Vector Potential and Electric Scalar Potential Formulation for Eddy Current Modeling”

Z. Zeng & al

Validation on an aeronautical configuration

Flaw response (\( = \) total response – rivet response)

Conclusion

- Comparison with published data (Zeng & al configuration)
  Good agreement with the Potential Formulation

- Validation with experimental data (aeronautical configuration)
  Good agreement with FE once calibrated, exhibiting Typical signature of the flaw in simulations

Perspectives

- Optimization of the discretization in order to improve the simulation of a flawed rivet
  Best efficiency of the method

- Simulation of other rivet inspection techniques

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