Simulation of Eddy Current Non Destructive Testing using COMSOL Multiphysics®

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Introduction: We perform simulations of the most popular eddy current nondestructive testing Benchmark Problems. In all cases, we observe good or excellent results. The agreement between numerical calculations and experimental measurements verifies the correct application of the modeling method. Owing to the fact that the eddy current problem is a low frequency electromagnetic field problem the choice was the COMSOL ® Multiphysics AC/DC module, which validates its use as a very reliable tool for conducting realistic eddy current testing studies.

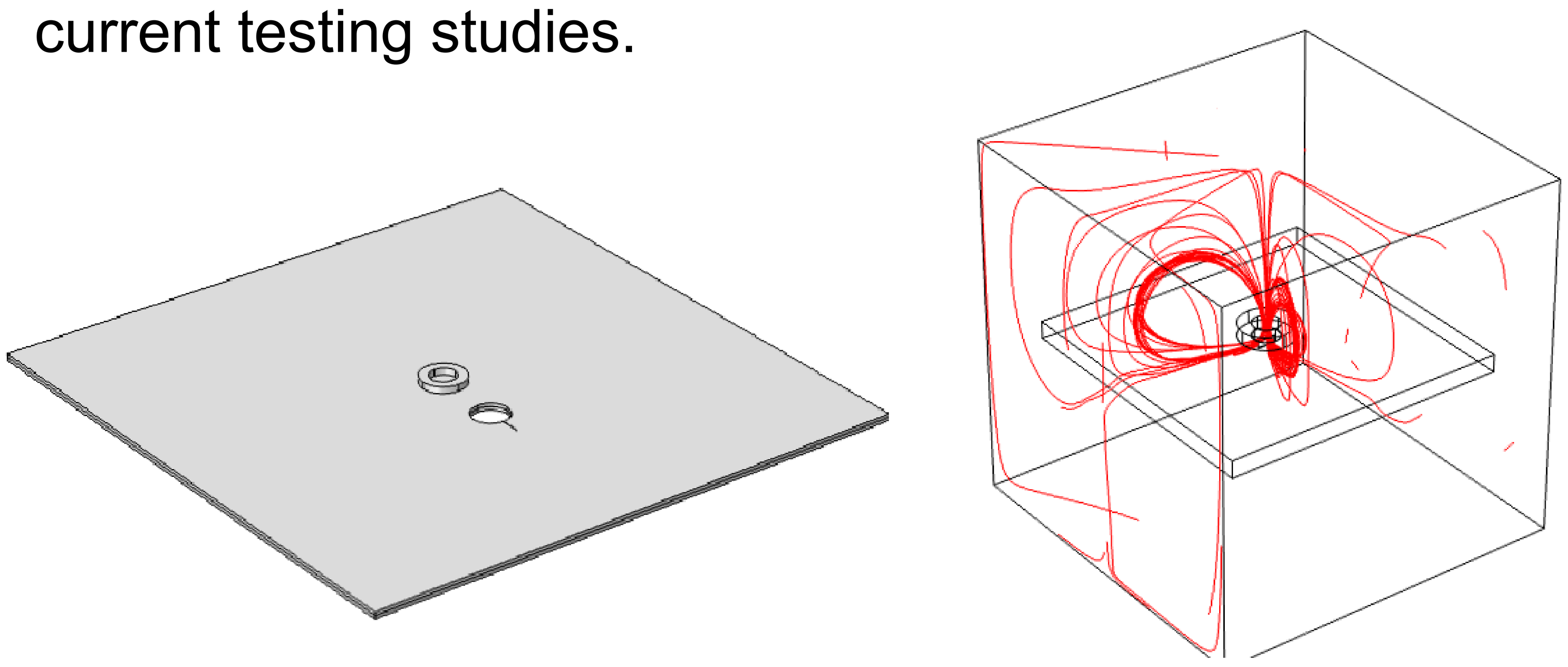

Figure 1. ECT simulation geometry in COMSOL environs.

Computational Method: The equation defining the eddy current flow is derived from Maxwell's equation and is written in terms of the magnetic vector potential, $\mathbf{A}$:

$$\nabla^2 \mathbf{A} - \mu\sigma \frac{\partial \mathbf{A}}{\partial t} = -\mu \mathbf{J}$$

where μ is the magnetic permeability, σ is the electrical conductivity of the medium and $\mathbf{J}$ is the source current. From $\mathbf{A}$ all electromagnetic field quantities are derived as well as the coil impedance.

We gathered the most popular eddy current Benchmark Problems and solved them using COMSOL ® Multiphysics software. All of these problems provide excitation coil impedance measurements in order to identify the presence of a defect in a conductive test piece.

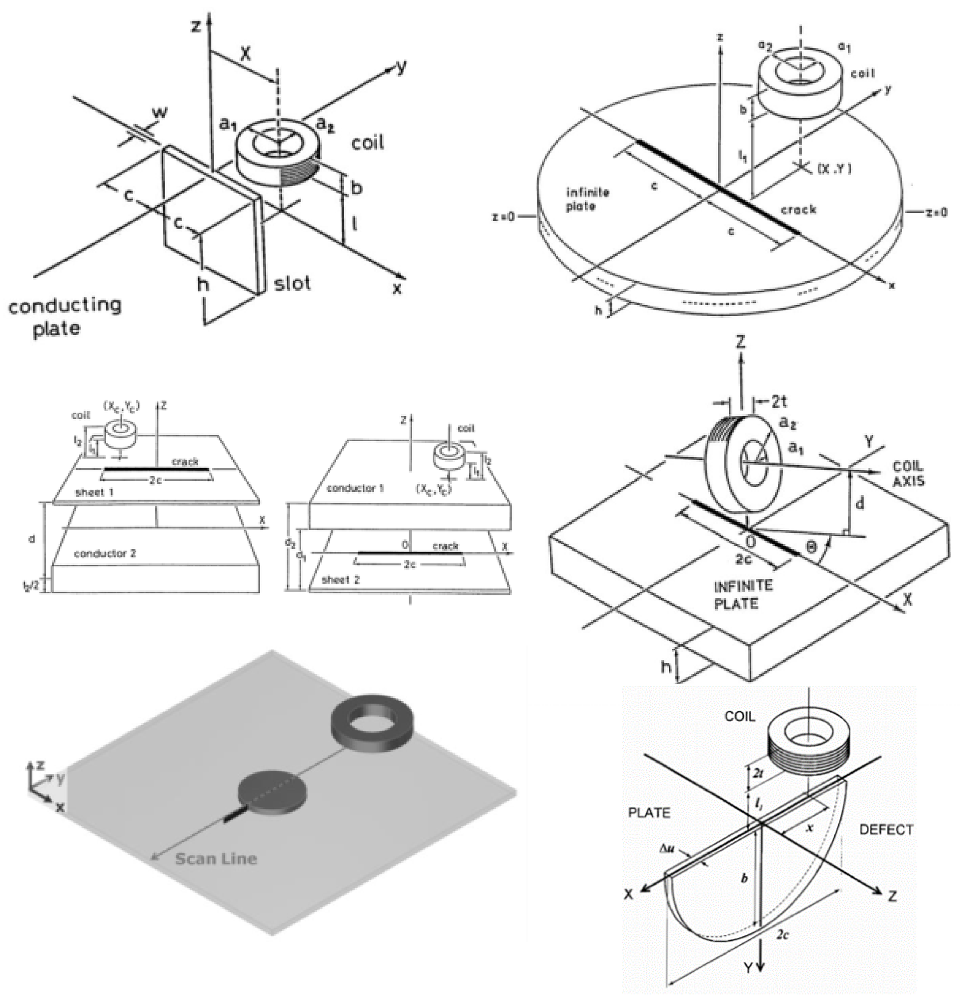

Figure 2. Representative Benchmark Problems sketches

Results:

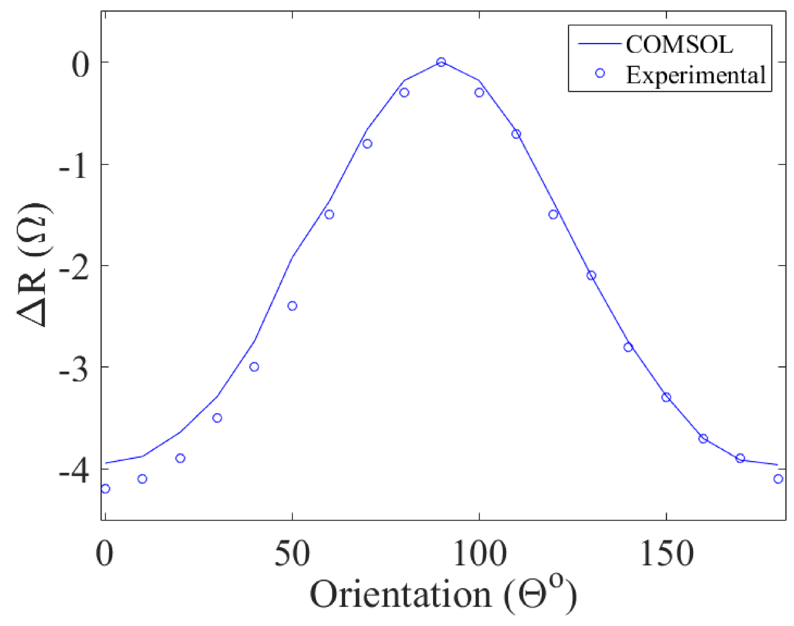

Figure 3. Real Component of coil impedance as a function of coil orientation, DSTO Experimental Result No. 5 [4]

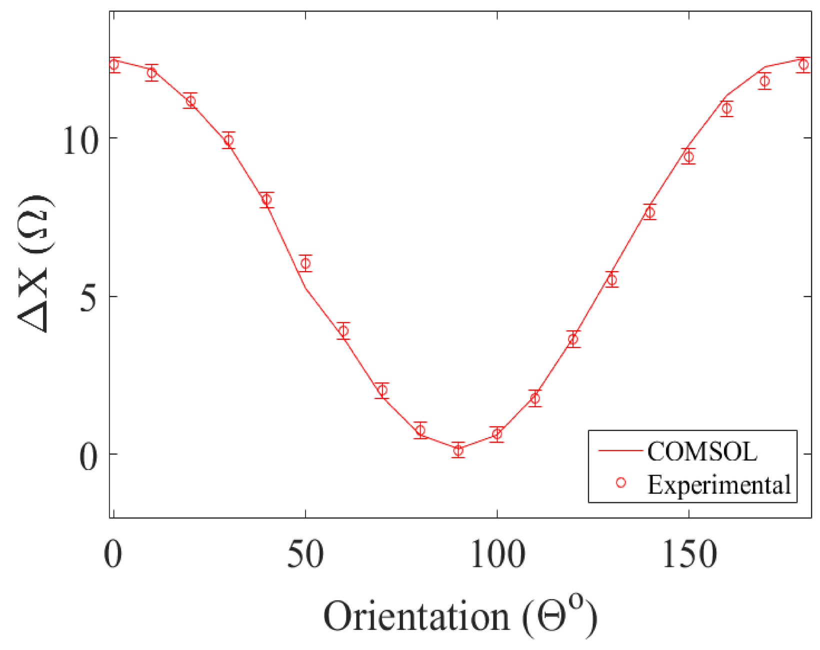

Figure 4. Imaginary Component of coil impedance as a function of coil orientation, DSTO Experimental Result No. 5 [4]

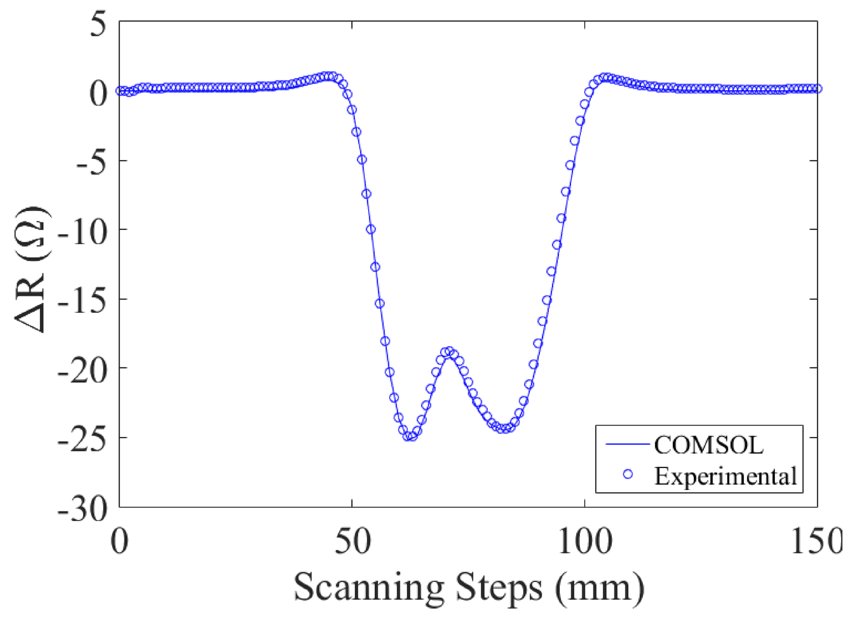

Figure 5. Real Component of coil impedance as a function of scanning steps, WFNDEC EC Benchmark 2013 [6]

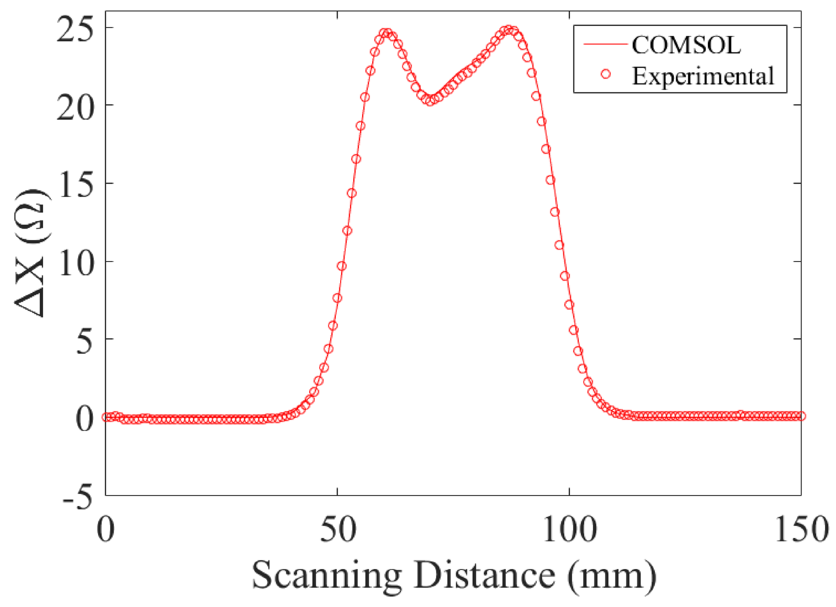

Figure 6. Imaginary Component of coil impedance as a function of scanning steps, WFNDEC EC Benchmark 2013 [6]

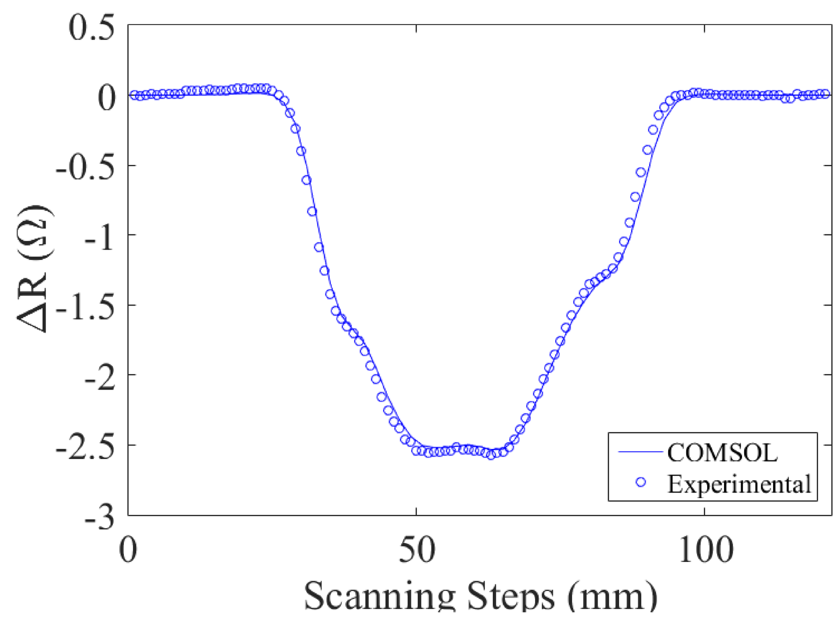

Figure 7. Real Component of coil impedance as a function of scanning steps for D2 defect, Harrison et. al, JNDE, 1996 [7]

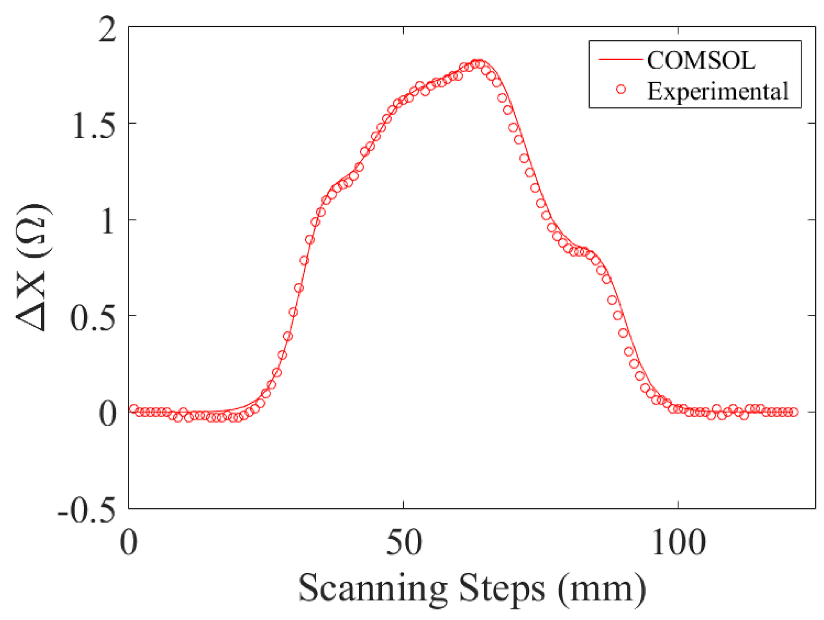

Figure 8. Imaginary Component of coil impedance as a function of scanning steps for D2 defect, Harrison et. al, JNDE, 1996 [7]

Conclusions: We test the capability of the COMSOL ® Multiphysics software for efficiently simulating eddy current nondestructive testing configuration. Overall, it is found to be a reliable, efficient, as well as an economical means of performing ECT studies.

References:

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