Simulation of Eddy Current Non Destructive Testing Using COMSOL Multiphysics®

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Abstract

Nondestructive Testing (NDT) refers to a wide group of methods used in industry to evaluate the properties of a material, component or system without causing damage. These include radiography, ultrasound, electromagnetic and visual, among others.

Eddy-current testing (ECT) is one such method that makes use of electromagnetic induction to detect and characterize surface and sub-surface flaws in conductive materials. A coil of conductive wire is excited with an alternating electrical current. This coil produces an alternating magnetic field which oscillates at the same frequency as the current running through the coil. When the coil approaches a conductive material, currents opposed to the ones in the coil are induced in the material. The so called "eddy currents" contain information on the material properties, the testpiece dimensions and the possible presence of flaws. This information is indirectly reflected on the coil impedance change or on the corresponding magnetic field changes. Eddy current NDT finds application in aerospace, petrochemical industries, nuclear and conventional power generation and metal processing industries.

The mathematical models that are used to simulate eddy current NDT are very important tools for designing probes and inspection procedures, for understanding of the underlying physics phenomena, for training and education, for automatic detection and clarification of defect, for interpretation of results and for evaluation of Probability of Detection (POD) curves. Analytical models can handle only very simple geometries, hence the use of FEM offers a universal tool for simulating realistic eddy current inspections. However, when it comes to simulation, the initial verification of numerical results is mandatory in order to be assured about the validity of the numerical results. The higher authority is the experiment and an agreement between simulation results and experimental measurements implies the correct application of the modeling method.

In this presentation, we gathered the most popular eddy current benchmarks problems and solved them with the COMSOL Multiphysics® software. All of these problems provided coil impedance or magnetic field measurements used to identify the presence of a defect in a conductive test piece. Owing to the fact that the eddy current problem is a low frequency electromagnetic field problem, the choice was the AC/DC Module. In all cases, the agreement between theoretical results experimental measurements is excellent. As a conclusion, the COMSOL Multiphysics® software can be successfully used for efficient eddy current NDT simulation.