Fast Solver for Large Scale Eddy Current Non-Destructive Evaluation Problems

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Abstract

Eddy current testing plays a very important role in non-destructive evaluations (NDE) of conducting test samples. Based on Faraday’s law, an alternating magnetic field source generates induced currents, called eddy currents, in an electrically conducting test specimen. The eddy currents will also generate induced magnetic fields in space that oppose the direction of the inducing magnetic field in accordance with Lenz’s law. In the presence of discontinuities in material or property or defects in the test specimen, the induced eddy current paths are perturbed and the associated magnetic fields can be detected by coils or magnetic field sensors, such as Hall elements or magneto-resistance (MR) sensors, giant magneto-resistance (GMR) sensors and so on. Due to the complexity of the test specimens and the inspection environments, the availability of theoretical simulation models is extremely valuable to guide or optimize the detection designs for various cases.

Theoretical models of the forward problem are necessary for the training and validation of automated testing equipment and essential for studying the basic field/flaw interactions in order
to obtain a fuller understanding of NDT phenomena. Theoretical models generate defect signatures that are expensive to replicate experimentally. In general, modelling methods can be classified into two categories: analytical and numerical. Although analytical approaches offer closed form solution, they are generally not possible to obtain largely due to the complex sample and defect geometries, especially in three-dimensional (3-D) space. Numerical modelling has become popular with advances in computer technology and computational methods. However, due to the huge time consumption for large scale problems, accelerations/fast solvers are really needed for numerical models.

This dissertation describes a the numerical simulation model for eddy current problems using finite element analysis. A novel direct integral solver for eddy current problems and GPU-based implementation is also investigated in this research.

Publications

Journal Publications:

- Junjun Xin, Naiguang Lei, Lalita Udpa and Satish S. Udpa, ”Rotating Field Eddy Current Probe with Bobbin Pickup Coil for Steam Generator Tubes Inspection”, NDT&E International, Vol.54, March 2013, pp. 4555
• Naiguang Lei, Jian Wang, “Influences of the Structures of Elliptical Core Photonic Crystal Fibers with Elliptical Pores on the Polarization Properties”, Journal of Qingdao Technological University, Vol.27 No.3 2006, pp.86-89,103

Journal Publications In Preparation:

Conference Publications:
• Junjun Xin, Naiguang Lei, Lalita Udpa, Satish S. Udpa, “Nondestructive inspection using Rotating Field Eddy Current (RoFEC) Probes”, 14th Biennial IEEE Conference on Electromagnetic Field Computation (CEFC), 2010


