1.2.2. REGULARIZED EDDУ CURRENT TOMOGRAPHIC RECONSTRUCTION BASED ON A FINITE ELEMENT FORWARD MODEL

Trillon A., Paul N., Girard A., Sirois F., Goussard Y., Idier J.,
Electricite de France, Research and Development Division, France;
Ecole Polytechnique de Montreal, Canada;
IRCCyN (CNRS UMR 6597), France

Eddy current tomography is a non-destructive evaluation technique applicable to metallic surfaces and devices. Data are acquired by measuring the impedance variation of a sensing coil, which is tightly coupled to the metallic surface under investigation. Our goal is to determine the relative conductivity of the voxels in a discretized version of the metal object. This problem is nonlinear and ill-posed which make it difficult to solve. This explains why only a few methods are presently available. Several of them make use of neural networks [1] but the most classical methods are based on contrast source inversion (CSI) [2]. CSI requires the evaluation of Green matrices which is possible only for specific geometries and requires a significant amount of computation. Adapting them to arbitrary geometries might be difficult, especially in a 3D context. However finite element methods (FEMs) are more flexible and can be adapted more easily to arbitrary defect shapes. FEMs are based on the resolution of a discretized weak formulation of the Maxwell equations. Here we propose a method based on this kind of model.

The PEM yields a bilinear system of equations. As opposed to several methods that turn this bilinear system into a linear system through the Born approximation [3], or other methods which turn it into an highly nonlinear system by suppressing entirely the electromagnetic variables [4], our approach takes advantage of the bilinearity with respect to the magnetic field and the relative conductivity through a contrast source inversion-like scheme. This scheme alternatively minimizes a criterion with respect to the electromagnetic variable and the relative conductivity.

As opposed to multiplicative regularized CSI [5], the ill-posedness is dealt with by imposing additive regularization terms to the criterion in order to take into account the piecewise constant nature of the flaws. Furthermore, the relative conductivity is constrained to be included between 0 and 1 through a bound constrained minimization algorithm. A typical result obtained with synthetic data is presented in fig. 1. It can be observed that both the length and the depth of the flaws are well estimated. These results were obtained with a moderate amount of computation. This indicates that our technique presents a good trade off between computational burden and quality of results.

In this paper, details about the method and its performance with synthetic data are presented.

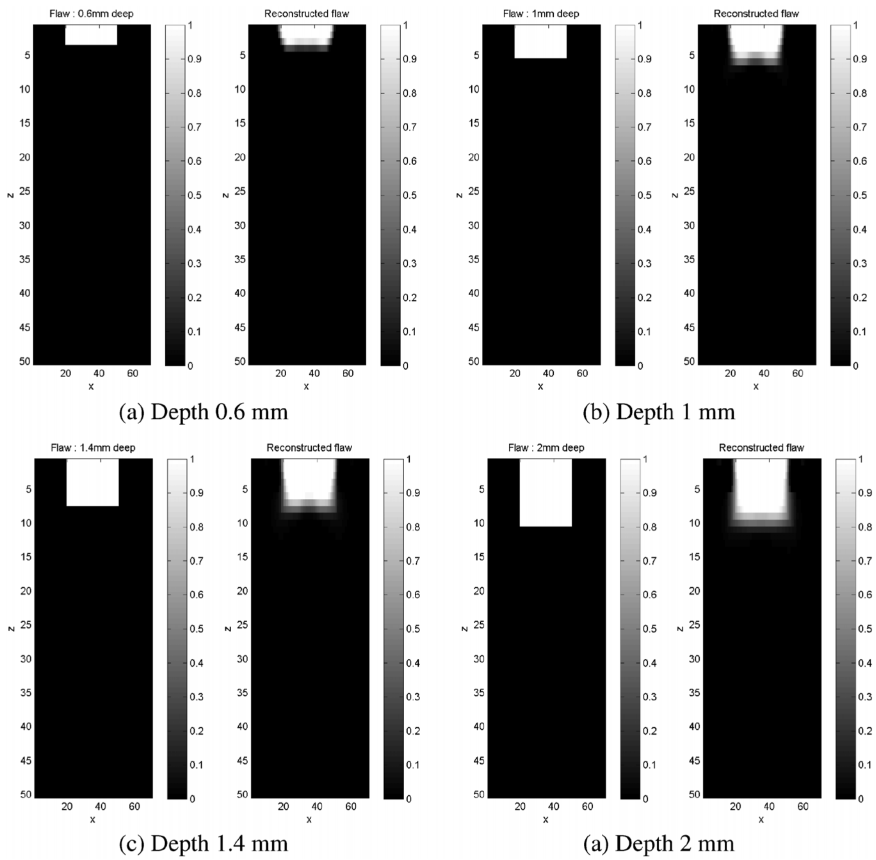

Fig. 1. Several reconstructed flaws with different depths

References:

1. **Yusa N., Chen H. Miya K.** “Sizing of stress corrosion cracking on austenitic stainless piping in a nuclear power plant from eddy current NDT signals” // Non-destructive Testing and Evaluation. – 2005. – Vol. 20. – N. 2. – P. 103 – 114.
2. **Reis D.D., Lambert M., Lesselier D.** “Eddy-current evaluation of three-dimensional defects in a metal plate” // Inverse Problems. – 2002. – Vol. 18. – N. 6. – P. 1857 – 1871.
3. **Dubost S., Chatellier L., Peisey P., Goussard Y., Guichard R.** “Characterization of small surface-breaking defects with eddy current sensor measurements”, in Proc. ECNDT 2006, (Berlin, Germany), sep. 2006.
4. **Soleimani M., Lionheart W.R.B., Peyton A.J., Ma X., Higson S.R.** “A three dimensional inverse finite-element method applied to experimental eddy-current imaging data” // IEEE Transactions on Magnetics. – 2006. – Vol. 42. – N. 5. – P. 1560 – 1567.
5. **Abubakar A., Hu W., van den Berg P. Habashy T.** “A finite-difference contrast source inversion method” // Inverse Problems. – 2008. – Vol. 24. – N. 6. – P. 065004 (17 p.).