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A parameter inversion approach based on a MCMC sampling method in Eddy-Current Testing

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Abstract

In Eddy Current Testing (ECT), we are often interested in getting details about the flaw presented in the inspected parts, such as size, location, shape, etc. For this objective, inversion approaches are employed to estimate the flaw parameters. Among the variety of inversion approaches, Bayesian methods have great potential in giving accurate estimations. However, their computational costs are usually very high. This makes them unsuitable for practical applications. Since most of the Bayesian estimation approaches need the help of a Markov Chain Monte Carlo (MCMC) method or an iterative optimization algorithm to get the final estimations of flaw parameters, the forward model is required to be employed many times in a Bayesian approach. This is the main reason why they are so expensive in terms of the computational cost.

In this work, we first propose to use a metamodeling method to approximate the traditional forward model. In such a way, the Posterior Mean (PM) estimation method can best reduce the computational cost. To solve the PM estimation problem, a random walk MCMC method is proposed. The metamodel can highly reduce the computational cost while the MCMC sampling method characterizes the estimation uncertainty at the same time. This makes the combined approach become very attractive in practical applications.

Simulations and laboratory controlled experiments are conducted to test the performance and robustness of the method. The results show that one can estimate accurately the flaw parameters by using this Bayesian inversion method, no matter it is a dimension characterization problem or a flaw location problem. The results also show that the estimation uncertainty depends upon the size of the flaw. In general, small flaws have poor estimation certainty. As for the computational time, it depends exponentially on the dimension of the unknown flaw parameters.

Key words: Markov Chain Monte Carlo (MCMC), inverse problem, metamodeling and Eddy-Current Testing (ECT).