An Efficient Procedure for Reconstruction of the Aged Zone in Ferromagnetic Bodies

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I. INTRODUCTION. A thorough analysis of the main results concerning reconstruction of the flaw shapes can be found in [1]. When the flaw is a crack in a conducting material, then the detection and the reconstruction is best performed by eddy-current methods [1]. In ferromagnetic materials under mechanical stresses for instance, some subregions may experience plastic deformations (aging). Replacement is required in order to avoid later failure accompanied by costly operation disruption. Ageing does not practically change the material conductivity but, instead, it leads to local modification of the B-H characteristic. This suggests use of magnetic field procedures for detection and reconstruction of the flaw shape [1]. A half-deterministic procedure of reconstruction is presented in [2]. The entire region considered is used for detection, implying a substantial amount of computation. In this paper we propose the use of a subset of mesh subdomains in order to approximate the flaw geometry. The subdomains selected in the previous steps are used for the final reconstruction of the flaw.

II. THE RECONSTRUCTION PROCEDURE. We choose \( m' \) points in the vicinity of the tube surface where \( 2m' \) radial and longitudinal components of the magnetic flux density are measured. To describe the flaw location the damaged zone is divided into \( n_s \) subdomains. We try to describe the flaw using only a subset of \( n_s \) subdomains. Following the method described in [2], we obtain the possibility vector \( P_k \), whose components give the likelihood that a flaw be localized in a certain element. The first approximate shape of the flaw is obtain by weighted sum of \( P_k \) components, taking into account how many time a subdomain in considered.

III. EXAMPLE. The proposed procedure was tested for a ferromagnetic tube, whose discretized aged zone is shown in Fig. 1. The B-H characteristic is degraded so that, for the same magnetic flux density, the magnetic field intensity has increased 1.2 times. A number of \( m'=11 \) measurement points, with \( m=22 \) flux density values, was used. For simplicity, we consider only 2 sets of subdomains of the flaw region, following the chess table model. With "black" and "white" subdomains we obtain a possibility vector having nonzero components plotted in Figs.2 and 3, respectively. We allowed a number of 10 flaws in each case [2]. By adding the "black" and "white" results we obtain the first approximation of the flaw. Finally, we consider only the subdomains given by the first approximation and, permitting only one flaw, we obtain exactly the shape given by the subdomains \( 9,10,29,30 \). The flaw shape reconstruction needs a computational time of only 32 sec. using a laptop having a 2.3 GHz processor.

References


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