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ELECTRICAL CONDUCTIVITY DETERMINATION OF METAL PLATES WITH PLANAR CIRCULAR COILS

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Planar circular coils are widely used in eddy-current nondestructive inspection of metal samples. There are several advantages of planar coils in comparison with conventional air-cored eddy current coils: (1) straightforward manufacture using printed-circuit-board technology; (2) high sensitivity to cracks; (3) possibility of inspection of complex geometries. In the present paper a theoretical model for determination of electrical conductivity of metal plates with planar circular coil is developed. Suppose that a planar circular coil carrying an alternating current is situated at a height $z = h$ above an isotropic electrically conducting plate of constant thickness d. The electrical conductivity of the plate is constant (but unknown). The relative magnetic permeability of the plate is equal to 1. In this case the system of Maxwells equations can be written in terms of the vector potential A which has (due to axial symmetry) only one non-zero component. The corresponding system of linear partial differential equations for the components of the vector potential in free space and in the plate can be solved analytically by the method of Hankel transform.

Traditional approach in eddy current nondestructive testing is based on the evaluation of the change in impedance of the coil due to the presence of a conducting medium. The change in impedance of a planar circular coil due to the presence of the conducting plate is obtained in terms of improper integral containing Bessel and Struve functions. The final expression for the change in impedance is a nonlinear function of σ (the electrical conductivity of the plate). The value of σ can be estimated by minimizing the L_2 norm between experimentally obtained values of the change in impedance of the coil due to the presence of the conducting plate at different frequencies and theoretical values expressed in terms of improper integral. In addition, corrections for non-ideal coil behavior can also be applied in order to improve the accuracy of the obtained estimate. Software package Mathematica is used to solve the corresponding nonlinear optimization problem in order to estimate the value of σ. Reasonable agreement between the actual and predicted values of the electrical conductivity of the plate is found.