1.2.28. PRINCIPLES OF ELECTROMAGNETIC COMPUTER METHODS DURING SELECTIVE MEASUREMENT AND TESTING OF MAGNETIC PARAMETERS AND DIMENSIONS OF FERROMAGNETICS

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Theses deal with results obtained by the author during elaboration of problematic matters of selective measurements of magnetic parameters and dimensions of ferromagnetics using electromagnetic computer method.

I. Eddy-current method. Analytical problem of determination of transverse-tangential component of complex amplitude of magnetic field intensity of typical surface defect over-magnetized by uniform magnetic field with intensity vector directed along the crack cavity is solved. Desired filed components are presented by means of improper integrals with application of infinitely thin layer of current [1].

Detailed numerical calculations are presented for dependences of amplitudes of real ReH_y and imaginary J_mH_y components on gap, coordinates of measurement points, depth δ of field penetration into a medium, defect width and excitation current frequency. It is shown that with critical field frequency, ReH_y achieves the maximal value and remains the constant value.

Topography of transverse-tangential field component depending on gap, depth of field penetration into a medium, coordinates of observation points, and defect parameters is studied [2].

Problem of determination of complex amplitude of the normal component of field is resolved. It is shown that ReH_z oscillates depending on δ with sensitivity being higher by the factor of 10 and more than one during measurement of transverse-tangential and longitudinal-tangential components of field [3].

Results of calculation of specific conductivity γ of non-magnetic metals exposed to two-dimensional magnetic field are presented. Theory is applied for determination of γ of 30 non-magnetic metals. As a result, the following is established: error for 29 of them does not exceed 10%; minimal error for vanadium – 0.97%; for other metals, error varies within 6 to 10% [4].

II. Magnetostatic method. Efficient method for calculating the reference magnetic induction, magnetization on sections and coercive force of ferromagnetic is developed. Fundamental formulas for calculation of coercive force for any particular hysteresis loop are derived. Probability of existence of finite jumps of coercive force in the neighborhood of zero points is proven theoretically and experimentally for the first time [5].

III. Magnetostatics of deformed bodies. Magnetostatics of deformed bodies is a new direction having exceptionally high scientific and applied importance.

Magnetostatic method based on the nonlinear interaction of mechanical stresses with constant magnetization field is developed for the first time.

Linear differential equations as a function of mechanical stress depending on controlled variable X and strain ε_m, as well as of variables X and ε_m are derived.

It is shown that obtained expressions contain linear dependences (Hooke law), as well as nonlinear interactions. Three methods of measurement of relative strain are developed [6].

Contactless method for measurement of elasticity modulus using generalized coercive force is described [7].

IV. Some electric methods. Infinitely thin current layer. Due to introduction of the new term "generalized specific conductivity", the number of problems of measurement of electric parameters of non-magnetic media were resolved successfully. Normal components of electric induction and surface charge density for various media depend only on generalized specific conductivity of these media.

Universal law establishing relationship between the basic frequency of primary field and specific conductivity of a material with universal constant is derived. This law was applied in order to find basic frequencies for 30 non-magnetic metals [5].

V. Topography of magnetic field of bead of the ferromagnetic welded joint. New discrete compensation and truncated methods for calculating resulting magnetizations in different situations are developed. Analytical expressions of tangential and normal components of magnetic field of the weld bead from its charged sides and "magnetic planes" in neutral zone are derived. Obtained results are used for some practical tasks [8].

In order to resolve many applied problems, a necessity to introduce new notion – "mean unit electromagnetic function" – occurs. This function is examined in details, in particular, within the wide range of over-magnetization field from various phase shifts. Furthermore, it is sensitive to the parameters of substrate and upper layer of specimen [9].

As a basis for calculation of properties and lateral dimensions of two-layer specimens, simplified physical-mathematical model was adopted. Using this model, it is shown that at certain conditions, design factors of filling substrate and upper layer of specimen coincide practically with given ones [10].

Average electromotive force of complex differential sensor during measurement of substrate parameters is proportional to mean unit function.

Summarized results and new regularities of one- and two-layer problems are presented. It is shown that desired electromotive forces of sensors are proportional only to factors of substrate and upper layer of specimen, depend on shift and do not depend on electromagnetic properties. Much attention is given to the matter of derivation and analyses of equations of measurement algorithms. Equations of second-order curves are obtained [11].

References:

1. **Magazine "Testing. Diagnostics"**: [1] – 2003, 1; [2] – 2004, 4; [3] – 2006 , 3; [4] – 2006, 8; [5] – 2006, 7; [6] – 2006, 11; [7] – 2006, 12; [8] – 2008, 5, 6; [9] – 2008; [10] – 2008, 11; [11] – 2008, 12.