1.1.31. THICKNESS MEASURING OF NICKEL COATINGS ON STEELS WITH VARIOUS MAGNETIC PROPERTIES

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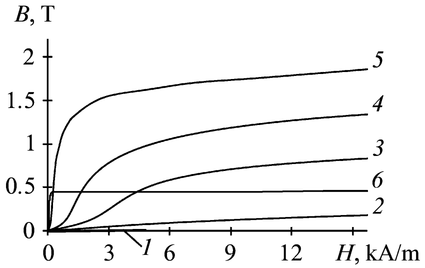
In the thickness measurement practice, testing of nickel coatings is one of the difficult tasks because of strong nickel physical properties dependence on structural state of this material. In the case of nickel coatings on non-magnetic basis, the magneto-dynamic method of thickness measurement [1 – 3] eliminates the influence of structural properties on measurement error, provides high resolution, and widens measuring range up to 1000 μm and more at the expense of a strong magnetizing field of a transducer. As the calculations [3] show, selection of magneto-dynamic transducer's parameters provides magnetization of the informative volume of a nickel coating close to the saturation magnetization. Elimination of structural influence on testing results is checked out experimentally [2].

For nickel coatings on steels, the situation is considerably complicated. With grows of the primary magnetizing field, depth of the informative area (mainly at the expense of a base) and value of the non-informative component in the measurable signal increase, what leads to decreasing of the resolution and the measuring range. The range of testing thickness of nickel coatings on low-carbon steels for any type of existing thickness gauges is limited to approximately 150 μm. The practical requirement is considerably wider, because thickness testing of nickel (including thick-layer) coatings on steels with various magnetic properties is required. In the paper, possibilities of the magneto-dynamic method of testing of nickel coatings on five steel grades, which include the range of magnetic properties from low-carbon to practically non-magnetic steel 12H18N10T, are given and analyzed. Magnetic properties of steels 12H18N10T, 12H21N5T, 06H15N6MVFB, 03H12N10MTR-VD, steel 3 in delivery state on annular examples by the instrumentality of the plant UIMH [4] were investigated. Normal magnetization curves for these steels and pure nickel are shown in the fig. 1.

Taking into account the magnetic properties of pure nickel and these steels, numerical calculations of induction flux of the secondary magnetic field (the flux is the informative parameter of the magneto-dynamic thickness measurement) as a function of thickness of nickel coatings are made. Calculations by the finite element method of computer models of magneto-dynamic transducers with the magnet energy (it is the product of hard magnetic material energy and volume of this material) approximately 15, 55, 180 mJ are carried out. In the fig. 2 results for a transducer with the magnet energy 55 mJ are shown; the same dependence character is in the other cases. However, the resolution and especially the feasible testing range for the examined combinations of the coating and the base properties fundamentally depend on the magnet energy. It is determined that for steels with magnetic properties, which are above nickel properties (see the curves 3, 4, 5 in the figures), when the magnet energy is 15 or 55 mJ, the testing thickness range is 100 – 150 μm; when the magnet energy is 180 mJ, independently of nickel thickness the signal is practically changeless.



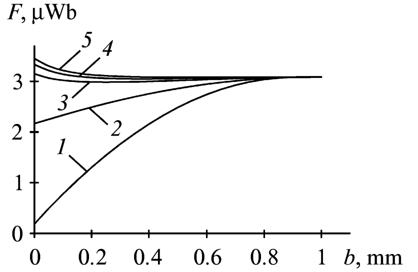


Fig. 1. Normal magnetization curves of the coating and the base materials: the curve 1 (it practically interflows with the axis *H*) corresponds to steel 12H18N10T; 2 – to steel 12H21N5T; 3 – to steel 06H15N6MVFB; 4 – to steel 03H12N10MTR-VD; 5 – to steel 3 in delivery state; 6 – to pure nickel

Fig. 2. Dependence of the flux *F* of the magnetic induction on the thickness *b* of the nickel coating when magnetic properties of the base are different (for the magnet energy ~55 mJ): the curve 1 corresponds to steel 12H18N10T; 2 – to steel 12H21N5T; 3 – to steel 06H15N6MVFB; 4 – to steel 03H12N10MTR-VD; 5 – to steel 3

The thickness measurement practice of nickel coatings on steels well checks out all of these results when the testing range is about 100 µm. When using the magneto-dynamic transducer with the magnet energy approximately 15 mJ, the range can be widen up to 150 – 200 µm subject to properties of the base. For non-magnetic and weak-magnetic steels (see the curves 1, 2 in the figures), the resolution and the measuring range depend on the magnet energy too; magnetic properties of the base determine the degree of the dependence. With growth of the magnet energy, the testing thickness range increases up to 1500 µm.

In the paper, results of numerical calculations of distribution of magnetization in the informative area's volume of the coating and the base materials are presented too. The results allow optimizing parameters of the transducers for maximum value of the magnetization.

References:

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