

1.1.34. THE MAGNETO-DYNAMIC METHOD AND GAUGES FOR TWO-LAYER COATINGS TESTING

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Separate testing of two-layer coatings' thickness in general case is multi-parametric task, because irrespective of measurement method, informative parameter is function of thicknesses of the layers, their properties, and characteristics of primary transducers. For testing of two-layer coatings (a non-magnetic layer on nickel, which is coated on a non-magnetic base), the optimal decision is the magneto-dynamic method of thickness measurement [1 – 4]. In this case, informative signal is function of thicknesses of the two-layer coatings' components, nickel properties, and characteristics of magneto-dynamic transducers. It seems impossible to choose transducer parameters so that the signal is determined by only one component of a two-layer coating; it is necessary to have two transducers, which should differ in resolution for the two-layer coating' components, and the difference should be tenfold and more. Testing task becomes two-parametric if both transducers provide excluding or minimization of the informative signal component dependent on structural state of nickel. For realization of this condition, selection of parameters of the transducers was so that nickel magnetization approached to the saturation magnetization and at the same time, the resolution was sufficient.

In the paper, results of numerical calculations of nickel magnetization distribution (including the presence of a chrome layer) depending on value of the primary magnetizing field (the magnet energy), which is generated by a high coercive bar magnet of a transducer are presented. Calculations of value of induction flux of the secondary magnetic field (it is the informative parameter) as a function of thicknesses of chrome and nickel are made; results of experimental investigations are presented. It is determined that when the magnet energy increases starting from 15 mJ, magnetization of informative volume of the coating rises, so when the magnet energy is 180 mJ, the magnetization is close to the saturation magnetization of nickel, which is without or under a non-magnetic layer with thickness about 200 μm . The fig. 1 shows the form of the dependence.

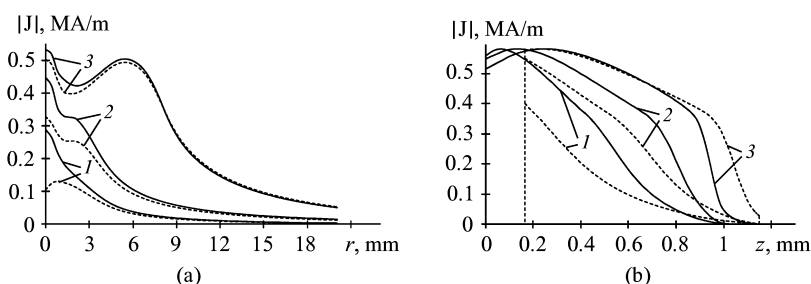


Fig. 1. Distribution of the module $|J|$ of nickel magnetization:

(a) – in the line of the radius r ; (b) – the depth z ; the curves 1 correspond to computer model of the transducer with the magnet energy about 15 mJ; 2 – 55 mJ; 3 – 180 mJ; the solid lines correspond to non-coated nickel, the dashed lines – to nickel under a chrome layer with thickness 150 μm

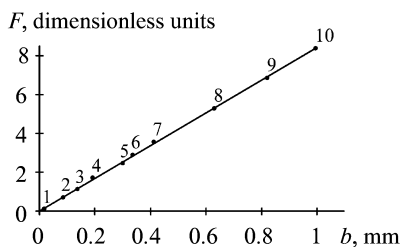


Fig. 2. Dependence of the signal F of the transducer with the magnet energy

about 180 mJ on the thickness b of nickel:

1, 2, and 3 – measures of nickel coatings with thickness 15 μm , 84 μm , and 135 μm ; 4, and 6 – samples of chrome-nickel coatings with nickel thickness 190 μm , chrome thickness 90 μm , and nickel thickness 335 μm , chrome thickness 135 μm ; 5, 7, 8, and 10 – nickel plates with thickness 300 μm , 410 μm , 630 μm , and 995 μm ; 9 – a sample of a nickel coating with nickel thickness 820 μm ; 1, and 2 – laboratory galvanic; 3, 4, 6, and 9 – industrial galvanic; 8, and 10 – milling with further grinding and polishing; 5 – rolling with amount of deformation 30%, 7 – 15%

Experimental data showing how the informative signal depends on thickness of nickel in its different structural states, including when nickel is under a chrome layer are given in the fig. 2.

Experimental and calculated data show that with the strong magnetizing field irrespectively of nickel structural state and the presence of a non-magnetic layer with thickness up to 200 – 250 μm , there is a linear dependence of the informative signal on nickel thickness up to 1000 μm . Thus, the transducer with the magnet energy 180 mJ provides testing of only nickel in the two-layer coating irrespectively to non-magnetic layer's thickness up to 250 μm and nickel structural state. Estimation of the measurement error is made; the structural component in the signal does not exceed 5%, the component dependent on a non-magnetic layer – 5 – 10% depends on layers thicknesses.

The transducers with the magnet energy 15 and 55 mJ provide linear dependence on chrome thickness. With nickel thickness about 150 μm the resolution is 0.2 – 0.3 μm , and further it increases with growth of nickel thickness. When the magnet energy is 55 mJ, the resolution is slightly smaller, however as it follows from the fig. 1, magnetization of the informative volume is approximately twice bigger and therefore the structural component of the error will be considerably smaller. In general case, when optimizing parameters of transducers intended for testing thickness of a non-magnetic layer on nickel, it is necessary to take into account the ranges of thicknesses of the two-layer coatings' components and amount of homogeneity of nickel structural properties. Galvanic nickel coatings including thick-layer are deposited by approximately same technology therefore the structural difference should be insignificant. In this case, it is desirable reducing the magnet energy; this procedure when testing of the components of two-layer coatings will lead to increasing of the resolution for the non-magnetic layer and decreasing of nickel permissible minimum thickness, which makes possible thickness measuring.

References:

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