1.1.7. INCREASE IN SENSITIVITY OF RESIDUAL MAGNETISATION TO STRUCTURE OF PRODUCTS MADE OF FERROMAGNETIC MATERIALS

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This report concerns the magnetic testing methods in metallurgy. In the paper we present the means to provide a high sensitivity of the residual magnetization to the structure of products.

1. The coercitive force H_C is known to be a magnetic parameter, most sensitive to the structure of constructional materials. The residual magnetization M_d of products with a large demagnetization factor N is proportional to H_C after their magnetization to technical saturation. Using the elaborated [1] procedure for calculating M_d of a product magnetized in an open magnetic circuit, based on N, H_C, magnetization of saturation M_S, residual magnetization M_R of the material, and intensity H_e of the external magnetizing field, it is established theoretically and verified experimentally [2] that for products with $N \geq 0.04$ at magnetization to a condition far from magnetic saturation, one observes an increase of sensitivity of M_d to the tested properties compared to magnetization to saturation (fig. 1).

The discovered effect is proven for materials for which at variation of the structure, the H_C decreases, while the M_S increases. This regime is efficient for testing non-magnetized products – after consolidation from a liquid state, annealing, quenching, or tempering. Its efficiency is proven at testing the structure of casting products made of malleable cast-iron at the Minsk factory for heating equipment. The increase in sensitivity

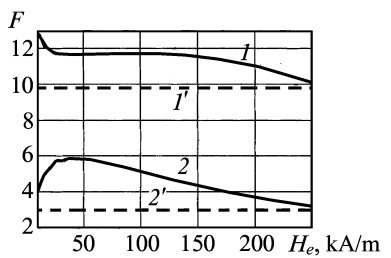

Fig. 1. The dependence on the H_e of the ratio F between the residual magnetization M_d of products with $N \approx 0.2$ made of white cast-iron and the M_d of products made of ferrite malleable (*1*) and gray (*2*) cast-irons. Calculation. *1′*, *2′* show F after magnetization of products in H_e = 1000 kA/m

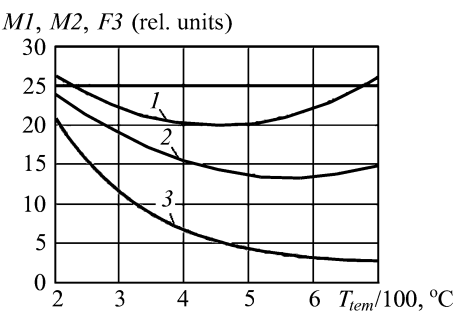

Fig. 2. Diagram of variation of the residual magnetization *M1* (*1*), residual magnetization *M2* (*2*) after the partial demagnetization, and the informative parameter *F3* (*3*) of the elaborated method with T_{tem} of the chilled products made of medium-carbon steels

of the parameter M_d to the structure after magnetization of products in a field of 46 kA/m amounted to 20% compared to magnetization in a closed magnetic loop.

2. Magnetic testing of mechanical properties of products made of medium-carbon steels is particular: H_C and M_d of these products are ambiguously related to the tempering temperature T_{tem} after annealing. For the quality testing of such products, the following is proposed [3]: to magnetize a product, measure M_d (*M1*) after the product leaves the area with the magnetizing field, create a localized area with a constant demagnetizing field of intensity 2 kA/m on the product's pathway, measure the second value of M_d (*M2*) in the product after its partial demagnetization, and judge on the properties of the product based on the relation *F3* of the result of this measurement to the difference of the first and the second measurements. The parameter *F3* has (fig. 2) a high sensitivity to mechanical properties of products made of medium-carbon steels and is independent of variations in sizes of products within technological tolerance.

The physical grounding of the efficiency of the method lies in the following. The dependence of M_d (*M1*) of the chilled products made of medium-carbon steels on T_{tem} has an ambiguous character (fig. 2).

The residual magnetization *M2* of the same products after their partial demagnetization decreases monotonically in the range $0 \le T_{\text{tem}}$ °C ≤ 600°C, although at $T_{\text{tem}} \ge 500$°C the dependence of *M2* on T_{tem} weakens and is often non-monotonic. Nevertheless, the dependence of the parameter $F3 = M2 / (M1 - M2)$ of the elaborated method on T_{tem} stays monotonic in the whole range of the T_{tem} variation (fig. 2). At $T_{\text{tem}} \ge 500$ °C monotonicity of the dependence of *F3* on T_{tem} is provided by the increasing difference $M1 - M2$.

Application of the method enabled a high correlation coefficient $R = 0.85$ in the regression equation between the breaking point of the bolts made of steels 40C, 40CN, 45C and the display of the device implementing the method. This guaranteed the required mechanical properties of the bolts. Thousands of expensive bolts were returned to production after the non – destructive testing. The reliability was increased for all motors produced on the Minsk motor plant [3].

References:

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