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LETTER TO THE EDITOR

DETERMINATION OF HOMOGENEITY OF AMORPHOUS SOFT MAGNETIC MATERIALS[1])

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ОПРЕДЕЛЕНИЕ ОДНОРОДНОСТИ АМОРФНЫХ МАГНИТОМЯГКИХ МАТЕРИАЛОВ

In the elaboration of applications of amorphous soft magnetic materials (further abbreviated ASMM) to the research, development and manufacture of complicated laboratory instruments and devices the monitoring of the longitudinal homogeneity of the magnetic properties of ASMM strips is gaining importance. Furthermore the investigation of the time stability of their basic magnetic properties is important and the longitudinal homogeneity under their actual operating conditions.

The complicated interaction of the electromagnetic field with the ASMM ribbons can be adequately described with the aid of the complex permeability u^*. Measurements were carried out on two ASMM samples. These were ribbon samples on the basis of CoFeCrBSi marked 8 116/217 (further only sample No. 1) — width 12 mm, and 8 116/223 (further only sample No. 2) — width 9 mm. Both samples were prepared at the Institute of Physics of the Electrophysical Research Centre of the Slovak Academy of Sciences in Bratislava. Relative measurements of the complex permeability were carried out on the Magnatest I 3.610 instrument in a single-coil mode with a dia. 20 mm through coil at a magnetic field strength in the measuring coil of $H_1 = 16\,\mathrm{Am^{-1}}$ [1]. The operating frequency of 30 kHz was selected with regard to a sufficient sensitivity and the possibility of eliminating the skin effect. The results of measurements on lower frequencies are comparable, with the exception of a lower sensitivity.

The linear homogeneity of the ASMM ribbon is defined as the function

$$u^*(x) = u'(x) + \mathrm{j}\, u''(x) \qquad (1)$$

where u^* is the complex permeability and u' together with u'' are its two components.

Since in our case we are concerned with relative measurements, it can be written

$$u^*(x) = \alpha Y(x) + \mathrm{j}\, \beta X(x) \qquad (2)$$

where α and β are the measurement constants and $Y(x)$ and $X(x)$ are measured quantities. As it follows from the relation (2), the quantity $Y(x)$ is proportional to the permeability of the sample and the quantity $X(x)$ is proportional to the conductivity of the sample.

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The measurements were carried out in n measuring points ($n = 20$ for sample 1 and $n = 100$ for sample 2) with coordinates x_i mutually spaced by $\Delta x = x_{i+1} - x_i = 10\,\mathrm{cm}$. Let us further introduce the mean values and the dispersion of the two quantities X and Y.

$$\bar{X} = n^{-1} \sum_{i=1}^{n} X(x_i) \qquad (3)$$

$$s_x = \left((n-1)^{-1} \sum_{i=1}^{n} (X(x_i) - \bar{X})^2 \right)^{1/2} \qquad (4)$$

$$\bar{Y} = n^{-1} \sum_{i=1}^{n} Y(x_i) \qquad (5)$$

$$s_y = \left((n-1^{-1} \sum_{i=1}^{n} (Y(x_i) - \bar{Y})^2 \right)^{1/2} \qquad (6)$$

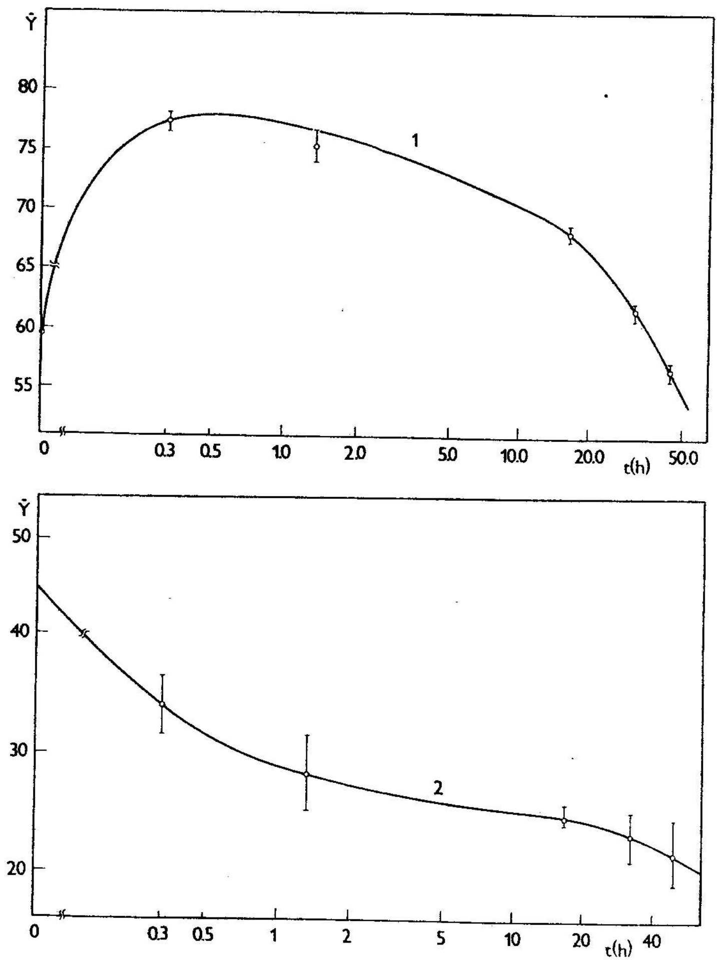

Fig. 1. Dependence of $\bar{Y}$ on the annealing period for the samples No. 1 and 2.

which are a critarion of the mean conductivity (3) and its longitudinal homogeneity (4), as well as the mean magnetic conductivity (5) and its longitudinal homogeneity (6). The described measurements together with coercivity determinations (on open samples with the Koerzimat 1.095 instruments — [2]) were carried out on the samples. No. 1 and 2 in their natural state and after various heat treatments. The series of heat treatments was carried out at 180 °C in air for a period of 20 minutes up to 50 hours. The results of the performed measurements are shown graphically in Figs. 1 to 3.

It can be stated in conclusion that after approx. 2 hours of annealing there occurs a certain stabilization of the parameters (see especially sample No. 1) and a substantial improvement of the longitudinal homogeneity. This is probably caused by the relieving of internal stresses and a diffusion equalization of the chemical composition. Upon a very long-term annealing process (above approx. 10

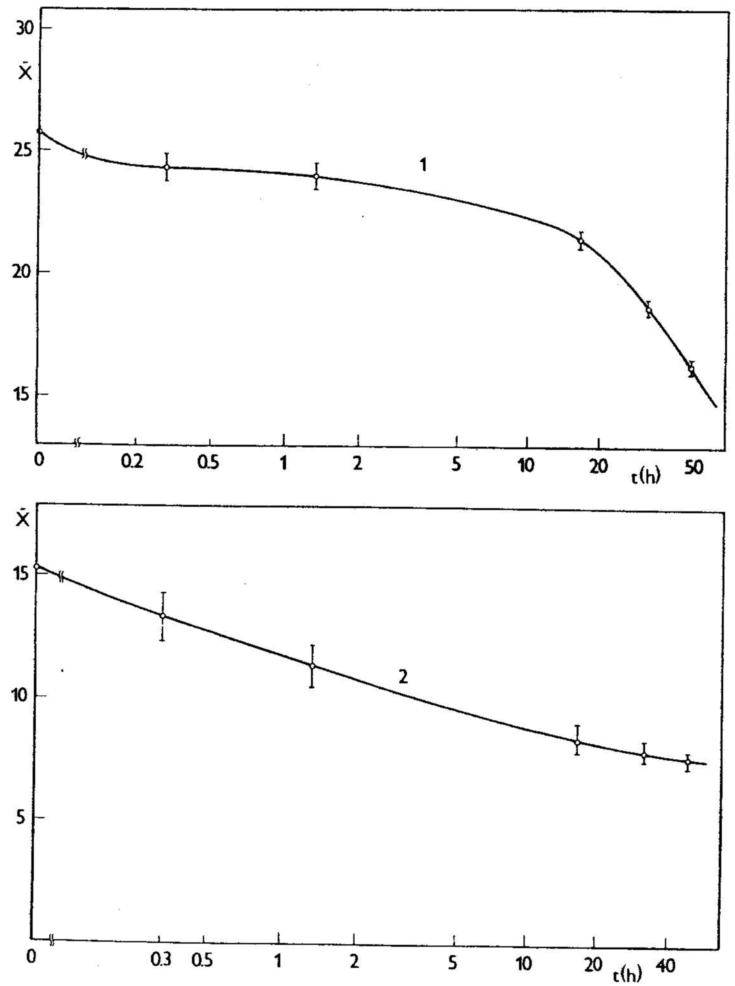

Fig. 2. Dependence of $\bar{X}$ on the annealing period for the samples No. 1 and 2.

hours) there again occurs a deterioration of the magnetic properties of the samples, as well as of their longitudinal homogeneity. The cause of this can be an interaction with the atmosphere and a beginning of crystallization, respectively see above all sample No. 2.

The determined values of both coercivity and permeability are in good agreement with the results of measurements that have been carried out by other methods on the same or related samples [3], [4].

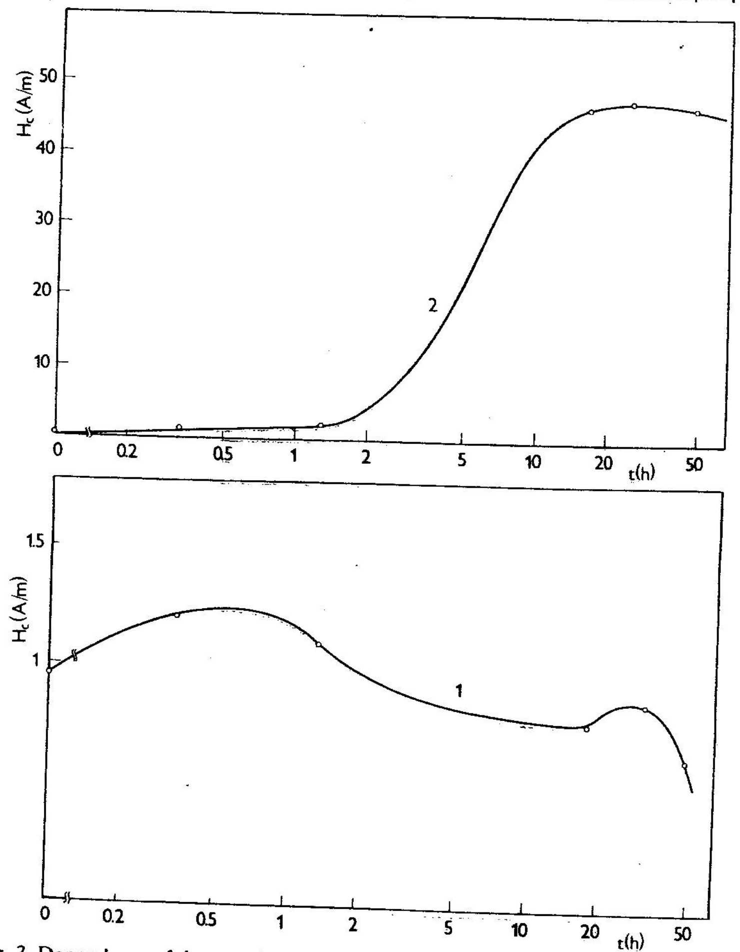

Fig. 3. Dependence of the coercivity H_c on the annealing period for the samples No. 1 and 2.

REFERENCES

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