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THE EFFECT OF THE SAMPLE LENGTH ON THE SHAPE OF THE POWER SPECTRUM OF THE BARKHAUSEN IMPULSES

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It was shown in some previous papers [1–3], that the Barkhausen effect depends upon the geometrical shape of the sample. This fact was usually associated with the changes of the demagnetization factor [4]. In connection with this Storm [5] investigated, how the shape of the power spectrum of the Berkhausen impulses changes in dependence upon the sample length. His results have shown that the longer the sample, the more rapid is the decrease of the power spectrum of the Barkhausen impulses in the region of low frequencies. In the region of medium frequencies the power spectrum decreases approximately equally for all samples. Such a dependence of the spectrum shape upon the sample length indicates that with the increasing sample length also the mean width of the elementary Barkhausen impulses increased. Qualitatively the same conclusions were arrived at also in the theoretical paper [6]. Considering that the author of paper [5] did not investigate the course of the spectrum in the region of high frequencies ($f > 10$ kHz), it was not possible to draw any conclusions about the correlation of the Barkhausen jumps from his measurements. We decided therefore to investigate how the sample length affects the shape of the whole spectrum of the Barkhausen impulses, that is also in the region of high frequencies.

Our measurement were made on wire samples with a maximal length of 344 mm, prepared from pure iron. The sample was shortened by chemical etching from this length to the desired value. The samples were magnetized along the branch of the hysteresis loop with a frequency of 0.05 Hz. The power spectrum of the Barkhausen impulses was registered at the external magnetic field corresponding to the value of the coercive force of the used samples (about 0.2 Oe).

The frequency characteristic of the power spectrum of the Barkhausen impulses registered during the magnetization reversal of our samples is given in Fig. 1, where dependence 1 is for the shortest (20 mm) and depencence 4 for the longest (344 mm) sample. These dependences are qualitatively the same as those shown in paper [5], with the difference that the decrease in the middle part of the spectum is not the same for all samples, but decreases proportionally to f^{-x}, where $x \in \langle -2.4, -1.63 \rangle$. A frequency independent part of the spectrum was observed in the region of high frequencies, cor-

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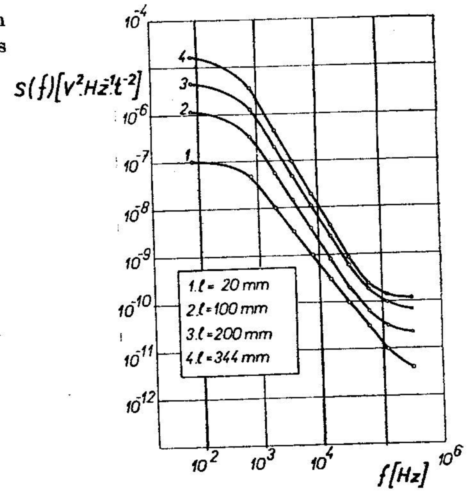

Fig. 1. Power spectrum of the Barkhausen impulses at 20 °C. (Diameter of the samples 0.8 mm).

responding to statistically independent impulses. This fact allowed us to estimate – using the relations given in [5] – the number of elementary Barkhausen impulses in one cluster. The mean number of impulses in one cluster was in our case from about 10^4 to 10^5 impulses, and the number of impulses in the cluster decreased with the decrease of the sample length. This decrease may be connected with the decrease of the time constant of transient processes connected with the realization of the Barkhausen jump in the conducting sample, when the sample volume is reduced. The decrease of the time constant of the Barkhausen jumps results in longer time intervals between impulses induced in the search coil, and so there is also less probability of cluster originating. The mechanism described in paper [7] has also similar consequences; in paper [7] there is derived for the time interval between two Barkhausen impulses the following relation

$$\Delta t = \frac{2NI_s}{V \frac{dH}{dt}} v, \tag{1}$$

where N is the demagnetization factor of the sample, I_s is the saturation magnetization, v is the volume, in which the magnetization was reversed by an elementary Barkhausen jump, V is the sample volume and dH/dt is the rate of the change of the external magnetic field. In the real conducting samples apparently both mechanisms take place.

We also studied – using the same samples – how the total number of the registered Barkhausen jumps varies with the sample length (Fig. 2). With the increasing sample length the number of the registered impulses initially rises, this being due to the increase of the sample volume. The number of impulses increases also when the sample length exceeds the length of the search coil. However, starting from a certain sample length, the number of impulses begins to decrease even when the sample volume increases. Paper [6] as well as our measurements of the course of the power spectra helped us to make this paradox clear. The course of these power spectra indicates that the mean

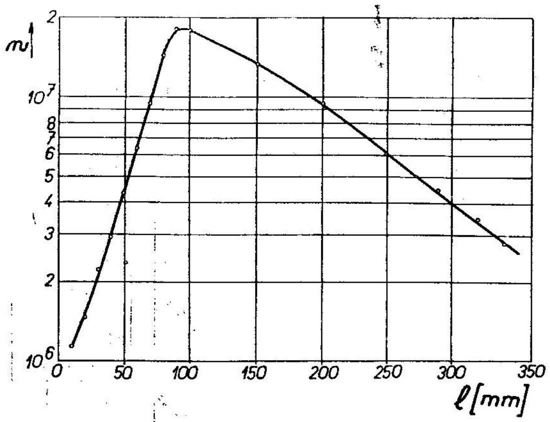

Fig. 2. The dependence of the total number of the registered Barkhausen impulses upon the length of the sample. (Length of the search coil 25 mm).

width of the elementary Barkhausen impulses and also the mean number of the elementary Barkhausen impulses in one cluster (registered as a single jump) increases with the increasing sample length. When we consider the fact that the search coil may register only the Barkhausen jumps originating in the definite sample volume, and this volume does not increase with the increase of the sample length [8], then the necessary consequence of this is the decrease of the number of the registered impulses with the increasing sample length.

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