MEASUREMENT OF MAGNETIC PROPERTIES OF FERROMAGNETIC MATERIALS IN STATIC MAGNETIC FIELDS

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A method for measuring intensity of magnetization of ferromagnetic materials which is based on the application of two Hall elements and a differential galvanometer is presented. The basic idea is that one of the two Hall elements measures the exciting field B_o while the other measures the induction in the sample, the difference between the two being proportional to the intensity of magnetization J of the sample. The use of the differential galvanometer enables this difference to be measured directly while both Hall elements have the same working current, so that the measurement is independent of eventual current changes.

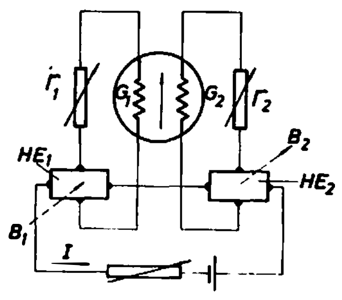

Fig. 1.

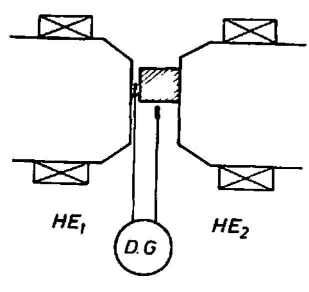

Fig. 2.

The principle of the method is shown schematicaly in Fig. 1. Magnetic induction acts on the Hall ele ment HE_1 and induction B_2 on the element HE_2. The corresponding emfs developed in the elements[1)] are

$$E_1 = k_1 I B_1 \quad \text{and} \quad E_2 = k_2 I B_2 ,$$

where k_1 and k_2 are constants. The currents in the two galvanometer circuits will be

$$I_1 = \frac{k_1 I B_1}{R_1} \quad \text{and} \quad I_2 = \frac{k_2 I B_2}{R_2} , \qquad /1/$$

where R_1 and R_2 are resistances of the two galvanometer circuits respectively ($R_1=r_1+G_1+R_{HE_1}$ and $R_2=r_2+G_2+R_{HE_2}$).

A differential galvanometer[2)] measures the difference between the two currents flowing through its coils. If the galvanometer is adjusted to zero these currents are equal, and from /1/ we get

$$\frac{k_1 B_1}{R_1} = \frac{k_2 B_2}{R_2} \quad \text{or} \quad \frac{B_1}{B_2} = \text{const}\ \frac{R_1}{R_2} . \qquad /2/$$

If B_2 and R_2 are kept constant, from /2/ it follows

$$\frac{\Delta B_1}{B_1} = \frac{\Delta R_1}{R_1} \qquad /3/$$

which means that if B_1 is increased by ΔB_1 in order to keep the galvanometer at zero, R_1 must be increased by ΔR_1.

The magnetization density measuring procedure is as follows: first, the galvanometer is zeroed in the absence of the sample, with both Hall elements in the same field $B_1=B_2=B_o$, whilst $R_1=R_{o1}$ and $R_2=R_{o2}$. Then a cylindrical sample is introduced in such a manner that the element HE_1 measures the induction in the sample while at the same time HE_2 measures the exciting (tangential) field. Now we have $B_1=B_o+\Delta B$ and $B_2=B_o$. To bring the deflection of the galvanometer to zero again, resistance R_1 must be increased from R_{o1} to $R_1'=R_{o1}+\Delta R_1$. In this case equation /3/ may be be written as

$$4\pi J = \Delta B = B_o \frac{\Delta R_1}{R_{o1}}$$

since $\Delta B = 4\pi J$.

References:

1) H.Weiss, Structure and Application of Galvano-magnetic Devices, Pergamon Press.
2) E.Frank, Electrical Measurement Analysis, McGraw-Hill, New York, 1959, p.208.