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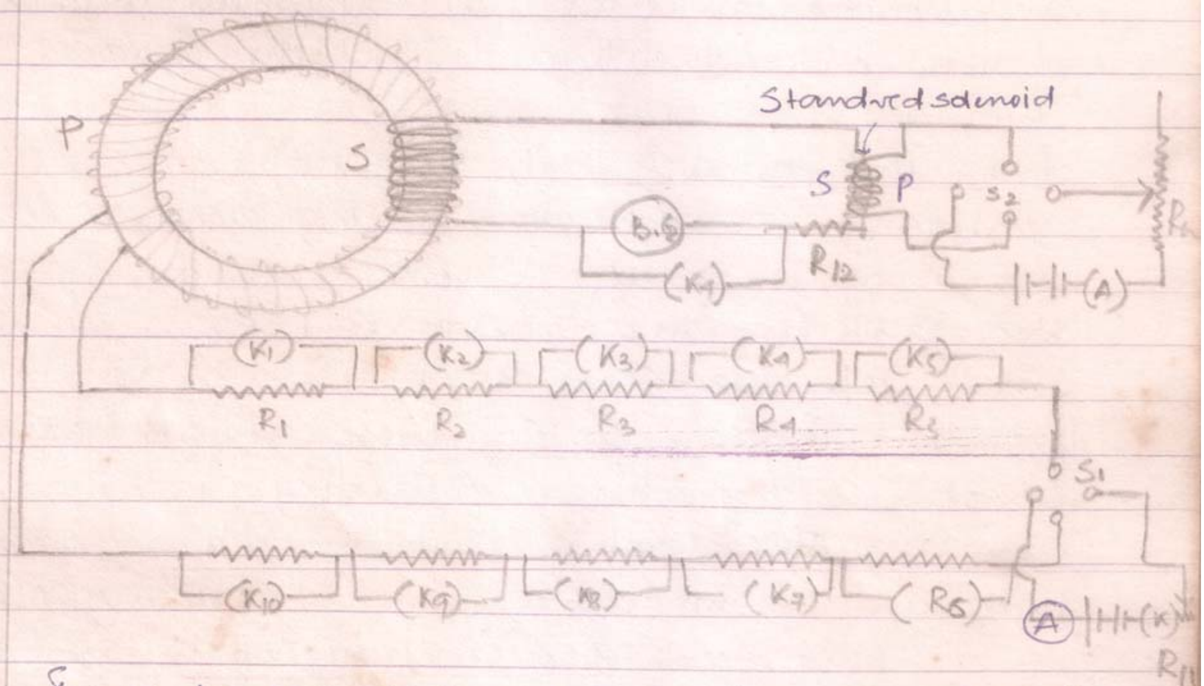
Determination of Susceptibility and permiability of Ferromagnetic material by drawing M-H curve : B-H curve:

- By Ballistic galvanometer method:



Drawbacks of the magnetometer method:

(1) The exact positions of the induced poles in the sample can not be known accurately.

(2) There is leakage of magnetic flux from the sides of the solenoid which makes the intensity of the magnetising field maximum in the middle of the specimen and nearly half the value at the ends.

Description: In ballistic galvanometer method the Specimen is taken in the form of a ring known as anchor ring of circular or Square cross-section, no free pole is developed & therefore there is no demagnetising field. More over the magnetising field in the Specimen is Same at every point equal to that calculated from the dimensions of the toroied and the current through it.

P is the primary coil, closely spaced and uniformly wound over the ring and is connected in Series to a Set of resistances $R_1, R_2 \cdots R_{10}$. Resistance R_1 is the largest and R_{10} is Smallest and Separate Keys $K_1, K_2 \cdots K_{10}$ are provided across each of these resistances for Short circuiting them. A battery circuit through an ammeter and a resistance Rh is connected through a commutator S_1 to the primary coil.

A Secondary coil 'S' of few turns is wound over the primary and is connected to a ballistic galvanometer and the Secondary of a Standard Solenoid. The primary of the Standard Solenoid is connected to a battery circuit and an ammeter through commutator S_2. This circuit is connected for callibrating the B.G in the usual way.

Experiment :

(1) The anchor ring is throwly demagnetised by using A.C.

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(2) R_1 ...... R_{10} are all short circuited, Rh is decreased till on closing the commutator S_1, the galvanometer gives a full scale deflection. current in the circuit in this case is max^{m}.

(3) All the keys across R_1 to R_{10} are operated (Resistance in the circuit is maximum), the commutator S_1 is suddenly closed and the consequent ballistic throw in the galvanometer is noted. The ballistic throw is caused by the change in magnetic flux linked with the secondary.

(4) Resistance R_1 is short circuited by closing K_1 and commutator S_1 is suddenly closed and the deflection in B.G is noted. The same is continued till key K_{10} is closed i.e the current in the primary is maximum.

(5) The current is then decreased in steps by opening the keys K_1 to K_{10} in turn and corresponding deflection in each step is noted.

(6) Using commutator the direction of current in the primary is reversed and steps (4) & (5) are repeated.

(7) To find the galvanometer constant K, a current is passed through the primary of the standard solenoid & suddenly reversed this current

with the commutator S_2, a change in flux through the Secondary of the Solenoid is produced and the corresponding deflection in the B.G is noted.

Theory: Given:

n_1 = The number of turns per unit length in the primary coil P.

N_2 = The total no of turns in the Secondary coil

A = Area of cross-section of the anchor ring
= The area of cross-sections of the primary & Secondary coils also.

K = constant of the Ballistic galvanometer.

Let I_0 = current passed through the primary P initially

θ_0 = Corresponding ballistic throw in the ballistic galvanometer.

∴ $H_0 = n_1 I_0$ amp/mt = The magnetising field produced by the primary — (1).

Let B_0 = The magnetic induction developed in the anchor's ring due to the magnetising field H_0.

Change in flux through the Secondary coils
$= B_0 A N_2$

∴ Induced e.m.f ∝ rate of change of flux ∝ $B_0 A N_2$

Induced current flowing through the coil's ∝ $\frac{B_0 A N_2}{R}$

Where R is the total resistance of the Secondary circuit.

$$\therefore \frac{B_0 A N_2}{R} = K\theta_0\left(1+\frac{\lambda}{2}\right) \quad (2)$$

Where 'λ' is the logarithmic decrement of the B.G coil.

Let the current through the primary circuit be increased by I_1.

In this step, the magnetising field, produced by the primary $H_1 = n_1 (I_0 + I_1)$ amp/mt ——— (3)

B_1 = Corresponding change in flux density inside the anchor's ring.

∴ Change in flux through the Secondary coil $= B_1 A N_2$.

Let θ_1 be the corresponding ballistic throw

$$\therefore \frac{B_1 A N_2}{R} = K\theta_1\left(1+\frac{\lambda}{2}\right) \quad (4)$$

Thus closing the keys K_2 to K_{10} Successively; the corresponding ballistic throw $\theta_2, \theta_3 \cdots \theta_{10}$ are recorded from the galvanometer.

From the recorded values of $\theta_0, \theta_1, \theta_2 \cdots \theta_{10}$ we can calculate $B_0, B_1, B_2 \cdots B_{10}$ respectively provided K & λ are known.

Using eqn (1), (3) . . etc we can calculate H_0, H_1 ---- etc from the readings of the ammeter in the primary circuit.

Thus with the values of H & corresponding B;

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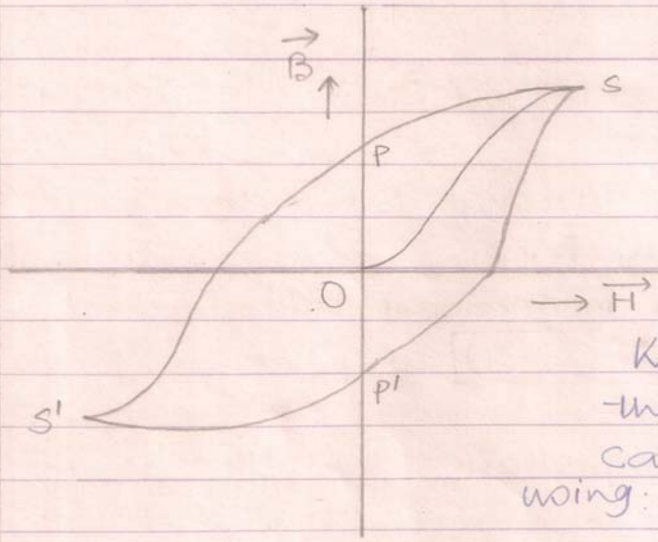
Obtained from the above Calculation B-H curve can be plotted which is found to be as follows



Knowing B and H; Permiability of the Specimen can be Calculated by using the formula

$$\mu = \frac{B}{H} \quad (6)$$

Knowing permiability of the Specimen Susceptibility can be calculated by using:

$$\mu = \mu_0 (1 + \chi_m) \quad (7)$$

SPL: Discussion: $\frac{dB}{dH}$ = incremental Permiability
(Disadvantage): Page 357
$\frac{dM}{dH}$ = incremental Susceptibility

To find K:

Let I' = current flowing through the primary of the Standard Solenoid.

n_3 = no. of turns per unit length in the primary of the Standard Solenoid.

N_4 = Total no of turns in the Secondary coil of the Standard Solenoid.

α = Area of cross-section of the secondary.

θ' = Corresponding Ballistic throw.

$$\therefore B = \frac{\mu_0}{2} n_3 I'$$

$\therefore$ Change in flux $= (B)\alpha N_4$

$\therefore$ Induced current:

$$\frac{\mu_0}{2} \frac{n_3 I' \alpha N_4}{R} = K\theta' \left(1 + \frac{\lambda}{2}\right) \quad (8)$$

from (5) K can be Calculated. 'λ' is calculated following the usual methods in B.G.