# CHAPTER II

## CHARACTERISTIC OF MAGNETIC MATERIAL

The magnetomotive force.

The magnetic flux in the air around the wire carrying a current is due to the stream of electron along the wire. In fact; there is such a strict propertionality between them that a current is usually measured by means of the magnetic flux associated with it. With a solinoid it is easily seen that the number of turns of wire is important as the value of current. The magnetic effect of current is measured in ampere-turn.

The magneto-motive force F due to a current I ampere in a coil of N turns is given by the relation.

$$F = NI \qquad \text{ampere turn.}$$

$$\text{or} \quad F = 0.4\pi NI \qquad \text{gilberts}$$

The reluctance.

The reluctance of the magnetic circuit R is given by the relation.

$$R = \frac{l}{\mu A}$$

Where $R$ = reluctance of magnetic circuit.

$l$ = length of magnetic circuit

$A$ = cross section area of magnetic circuit

$\mu$ = permeability = $\frac{1}{\rho}$ and $\rho$ is the reluctivity

The magnetic flux.

The relation between the amount of magnetic flux and the applied magnetomotive force F is

$$\phi = \frac{F}{R} \qquad \text{lines}$$

or in word

$$\text{magnetic flux} = \frac{\text{magnetomotive force}}{\text{reluctance}}$$

The magnetic flux density.

The magnetic flux density is the flux per unit area when the measured area is normal to the direction of the flux and its unit is measured in gausses and denoted by the symbol B so that.

$$B = \frac{\phi}{A} \qquad \text{gausses}$$

The magnetic intensity H.

The amount of magnetomotive force may be distributed one a magnetic circuit of a considerable length the relation of the magnetic intensity is

$$H = \frac{F}{l} \qquad \text{ampere turns/cm.}$$

The relation between B and H.

From above relation of B we have

$$B = \frac{\phi}{A} \qquad \text{gausses}$$

$$\text{and} \quad \phi = \frac{F}{R} \quad \text{lines}$$

$$F = 0.4 \pi NI \quad \text{gilberts}$$

$$B = \mu_o \frac{0.4 \pi NI}{l}$$

$$B = \mu H. \quad \text{gausses}$$

The B - H curve of ferromagnetic material

The relation between the magnetizing force H and the flux density or magnetic induction B which it produces in a ferromagnetic material is very importance to the electrical engineer. It is conveniently expressed by means of characteristic curve. The ferromagnetic material is placed in a region when the magnetic field intensity can be varied, such as in a solinoid.

The magnetizing force is varied through charging current in it and the material is originally demagnetized. The value of H is given by $0.4 \frac{\pi NI}{l}$ and the flux density B of the corresponding to the value of H is obtained by the value of flux in the specimen (measured by the ballistic galvanometer) by the cross-sectional area of the specimen. When we plot H and B we will get a curve shown below.

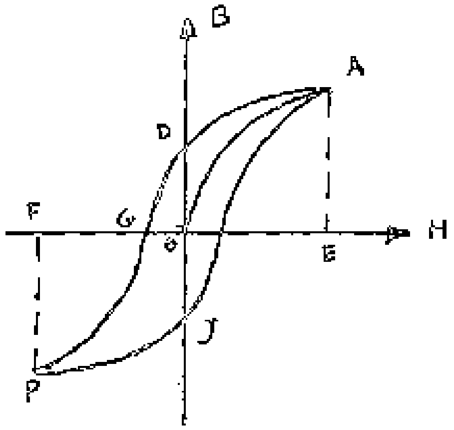

Fig. 1 Hysteresis loop

When a ring of specimen is magnetized by a current that starts at zero (point O) and steadily increases to a final value, the resulting flux density increases as shown by the curve OA. Suppose that the point A has been reached, the current is decreased gradually to zero. By investigation as the current is slowly decreased, the magnetization of the specimen does not decrease to its former value as shown by AD, and when the current reaches to zero a large amount of residual or remanence magnetization still remains. The ordinate OD shows the residual flux density when the current has been decreased to zero. In reversing this residual flux density to zero, it requires a reversed magnetic intensity equal to OG. This negative value of H is called "coercive force" of the specimen. If the reverse H is increased to value of OF equal and opposite to OE, the material is found to be magnetized as strongly as before but in opposite direction, and it will hold this magnetization just as persistently as the other. If H is increased to zero and again increased to OE. The flux density follows as shown by curve PJA. The traced loop is called "hysteresis curve".

Engineer prefers the material that gives the small OG and OD to the material that gives large OG and OD. In theory he needs the smallest area under this hysteresis loop, because the material require the power in reversing the flux density. This energy is the loas in magnetic core.

The table shown below is the properties of same magnetic materials.

Properties of Some Magnetic Materials[7]

| Material | Resistivity<br>microhm-cm. | Hysteresis loss ergs/cm$^3$/cycle | Total core lose watt/lb<br>29 gauge 60 cps<br>Bmax.=10000gauss. |
|---|---|---|---|
| Permalloy 78.5% Ni | 16 | 200 | 0.34 |
| Permalloy 7.85% Ni 3.8% Cr | 65 | 200 | |
| Mipernik 50% Ni | 35 | 220 | 0.2 |
| Muntal | 25 | 200 | |
| Silicon steel 4.25%Si | 60 | 1340 | 0.60 |
| Silicon steel 1.0% Si | 24 | 2660 | 1.17 |

Note : This table from "Magnetic circuit and transformer" M.I.T. staff.