Introduction
on
Magnetic Properties of Matter

Manoj Kr. Das
Associate Professor
Department of Physics
J N College, Boko

What is Magnet?

- The substance consists of an oxide of iron(Fe_3O_2),which posses attractive & directive properties.
- These properties weak in natural magnet, but strongly developed in some metals or alloys.
- Prepared magnets are called Bar Magnets, Horse-shoe magnets etc.
- Recently many alloys like tungsten-steel, cobalt-steel are used.
- It seems that alloys have greater degree of quality than iron, nickel etc.

Coulomb's Law:

This law states that if two poles are placed at a distance then force between them is

$$F = K\, m_1 m_2/r^2$$

Where m_1 & m_2 are pole strength and r is the distance between them.

K depends on nature of medium & the unit in which force is measured

In SI unit $K = \mu/4\pi$

Magnetic Intensity:

Force experienced by a unit N-pole around it is called intensity at that point.

SI unit is Newton/Weber

Lines of force:

Path along which a unit N-pole placed in a magnetic field is directed called line of force. The tangent at any point on this curve gives direction of intensity at that point.

Flux:

Magnetic lines of force lie in all planes around a magnet is known as flux.

SI unit is Weber.

1 W = 10^8 Maxwell

The flux per unit area is flux density, it is denoted by B and known as Magnetic Induction.

It depend on magnetic field & nature of medium.

$$B = \mu H$$

Magnetic Moment:

It is the product of one of pole strength and magnetic length.

$$M=2ml$$

m is pole strength

2l is length of magnet

Magnetic Potential:

The work done to bring unit N-pole to a certain point is known as magnetic potential at that point.

Let Φ_A and Φ_B be the potential at point A and B respectively, then the magnetic intensity

$$H = \Phi_A - \Phi_B / AB$$

If AB is very small and the field is non uniform then

$$H = -d\Phi/dx$$

$$\text{or } d\Phi = -H\,dx$$

Where $d\Phi$ is the potential difference across AB, dx is distance between them and (–) indicates that work is done against the force. So intensity of magnetic field is define as rate change of magnetic potential at that point.

Intensity of Magnetization:

If a magnetic substance is placed in a magnetic field, it acquires magnetism due to induction. So the substance possesses a magnetic moment. This moment per unit volume is called the intensity of magnetization.

Let a circular cylinder SN of length 2l and cross-sectional area A, its S-end acquires south polarity (–m) and N-end acquires north polarity (+m), so magnetic moment M=2ml and

Intensity of magnetization (I_m) = Magnetic moment/Volume

$$=2ml/2l\times A=m/A$$

Therefore intensity of magnetization may also be defined as the pole strength acquired by the magnetic substance per unit area.

Magnetic Shell:

Magnetic shell is the thin sheet of ferromagnetic materials and uniform thickness and magnetized so that the direction of magnetization is everywhere normal to the surface of the sheet.

Shell are made up of large number of dipoles situated in such a way that materials have opposite polarities at two faces.

Magnetic moment are the vector sum of constituent dipoles

The strength of the shell is equal to the magnetic moment per unit area.

Now I_m = Magnetic moment/Volume

$= M/V$

$= m \times t / A \times t$

$= m/A$

$m = I_m \times A$

Therefore

Magnetic moment of the shell= $m \times t$

$= I_m \times A \times t$

So strength of the shell

$$\Omega = \text{Magnetic moment} / \text{Area}$$

$$= I_m \times A \times t / A$$

$$= I_m \times t$$

Here I_m is the intensity of magnetization, t is the thickness of shell, A is the surface area, V is the volume, m is the pole strength.

Magnetic Permeability & Susceptibility:

If a magnetic substance is placed in a magnetic field the two types of lines of force may be taken into consideration

(i) Due to magnetizing field

(ii) Due to magnetization of substance

Let a cylindrical bar of cross-sectional area A is place in a magnetic field H.

If the bar is non magnetic the lines of force crossing the cylinder will be $A \times H$

But if bar is magnetic substance the substance itself will be magnetized by induction.

Then in addition of original lines of force, a certain number of lines of force enter into the substance due to magnetization.

Therefore the degree to which the lines can penetrate into a magnetic substance is known as permeability.

It depends on the nature of the substance.

In other words the ratio of magnetic induction (B) produced in a magnetic substance to the magnetizing field (H) is called the permeability of the medium.

Therefore

$$\text{Permeability } (\mu) = B/H$$

Here $\mu = \mu_0 . \mu_r$

μ_0 is the permeability for free space

μ_r is the relative permeability of the medium

Again the ratio of magnetization of a magnetic substance to the magnetizing field is called susceptibility of the medium.

Susceptibility $(\chi) = I_m/H$

The relation between them is

$$\mu = \mu_0(1+ \chi)$$