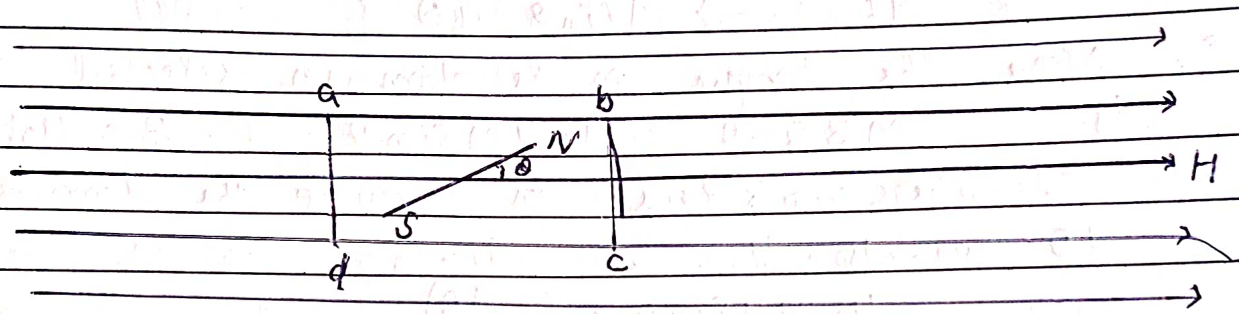
* **Hysteresis loss:—**

Due to hysteresis there is always some loss of energy and this loss of energy per unit volume per cycle of magnetisation is called hysteresis loss.



Only ferromagnetic substances exhibit the property of hysteresis. We know that a ferromagnetic substance consists of local regions called domains, which are made of molecular magnets. When this material is placed in a magnetising field, the molecular magnets set themselves parallel to the field. In this process, the magnetising field has to do work against ~~attraction~~ attraction forces among the molecular magnets. When magnetising field becomes zero, the value of Intensity of magnetisation I does not become zero. Hence the material retains some magnetisation. Therefore, the energy supplied to the material during magnetisation is not fully recovered. The balance of energy left in material is lost due to heat. This is called hysteresis loss.

Let us consider a ferromagnetic substance abcd of unit volume be placed in a magnetic field H. NS is a molecular magnet of magnetic moment M and whose axis makes an angle θ with the direction of H.

Hence components of all molecular magnets along direction of $H = I = \Sigma M \cos\theta$ —— (i)

Since magnetic Intensity perpendicular to H is zero.

$\therefore \Sigma M \sin\theta = 0$

~~Differenti~~ Differentiating eqn. (i)

$dI = -\Sigma M \sin\theta \cdot d\theta$ —— (ii)

Now, the torque on the domain selected at random is $MB\sin\theta = \mu_0 H M \sin\theta$ $(\because B = \mu_0 H)$

$\therefore$ The work done in turning the domain through $d\theta$ towards H

$= \mu_0 M H \sin\theta \times (-d\theta)$

(-ve sign is put because θ is decreased to θ − dθ)

$\therefore$ Work done in increasing I to I + dI

$dW = \Sigma -\mu_0 M H \sin\theta \cdot d\theta$

$= \mu_0 H \times \Sigma -M\sin\theta \cdot d\theta$

$= \mu_0 H \, dI$ (From eqn (ii))

Hence work done per unit volume of the material for one complete cycle of hysteresis curve,

$W = \int dW = \int \mu_0 H \, dI$

$= \mu_0 \int H \cdot dI$ —— (iii)

I-H hysteresis curve is shown here. P and Q are two close points on the curve having same value of H. The value of I changes by dI when we go from P to Q. Hence work done $= \mu_0 H \, dI = \mu_0 \cdot$ Area of PQRS.

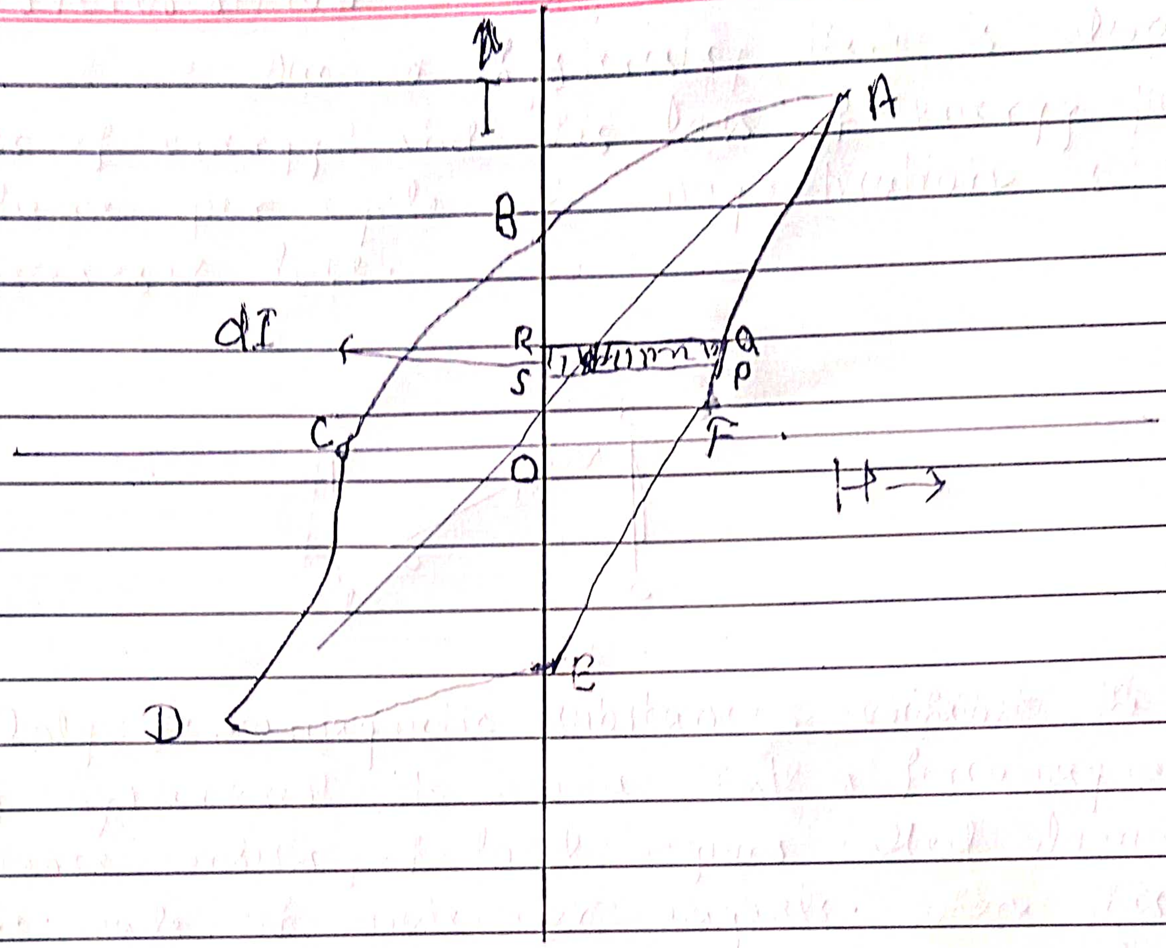
In this way the whole hysteresis curve is supposed to be divided by such parallel regions.

Hence from equation (iii)

$W = \mu_0 \int H \cdot dI = \mu_0 \cdot$ Area of ABCDEFA loop.

$= \mu_0 \cdot$ Area of I-H curve

= loss of energy per cycle.



For B-H hysteresis :-

We have, $B = \mu_0(H + I)$

$\therefore dB = \mu_0(dH + dI)$

Multiplying H on both sides and taking integration for a complete cycle.

$$\int H \cdot dB = \mu_0 \int H \cdot dH + \mu_0 \int H \cdot dI$$

But $\int H \cdot dH = 0$

$$\therefore \int H \cdot dB = \mu_0 \int H \cdot dI = \text{Hysteresis loss.}$$

$\therefore$ Hysteresis loss per unit volume material of one cycle of B-H curve.

$= \mu_0 \times$ Area of I-H curve