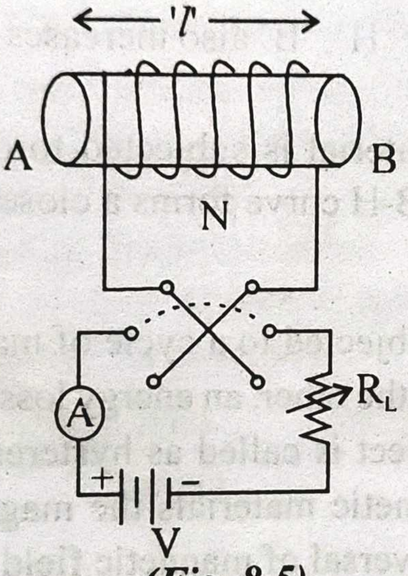
MAGNETIC HYSTERESIS

When a magnetic material is subjected to a cycle of magnetisation i.e. it is magnetised first in one direction and the direction will change after saturation. So the magnetic flux density 'B' of the magnetic material will lag behind the applied magnetising force (H). This phenomenon is known as magnetic hysteresis.

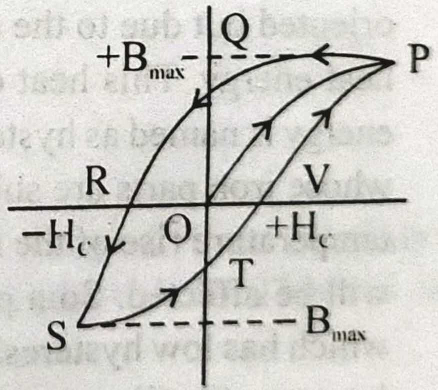
The phenomenon of lagging of flux density (B) behind the magnetising force (H) in a magnetic material subjected to cycles of magnetisation is known as "**magnetic hysteresis**".

In order to explain this B-H curve we have to take a specimen which is a unmagnetised iron wound with 'N' no. of turns as shown in *(fig. 8.5)*.



(Fig. 8.5)

The unmagnetised iron bar AB is wound with N turns with a Double pole Direct throw (DPDT). This switch is used to reverse the direction of current through the coil. A voltage 'V' is applied across the iron bar AB with the battery current 'I' is varied by varying the load resistance (R_L). As 'I' is varied the magnetising force (H) also varies. i.e. $\boxed{I \propto H}$.



(Fig. 8.6)

A plot is drawn in *(fig. 8.6)* between B and H. As 'H' varies 'B' also varies.

(i) **0 to P :** As the current 'I' in *(fig. 8.5)* is varied, magnetic field strength (H) varies and such that 'B' also varies upto 'P' and there the magnetic flux density is maximum, such that saturation occurs.

P to Q : Again the current (I) is reduced such that 'H' will be reduced and 'B' is also reduced. At 'Q' we found that if $H = 0$, $B = B_r = OQ$. This is the residual flux density of the material. It means that after the removal of H, the iron piece still remains some magnetism. In other words 'B' lags behind H.

Q to R : Now the magnetic force (H) is reversed by reversing the battery terminal or switch. As 'H' is gradually increased in the reverse direction, B-H curve follows the path QR so that when $\boxed{H = 0R}$ the residual magnetism is zero. The value of ($H = 0R$) required to wipe out the residual magnetism is known as coercive force. (H_c)

R to S : If 'H' is now further increased in the reverse direction, the flux density 'B' will increase in that direction (–B), again –ve saturation point will come at S and there flux density $= -B_{max}$.

S to T : If 'H' is now gradually decreased to zero, the flux density also decreases and the path will be ST. At 'T', the magnetising force is zero but there is still residual magnetism.

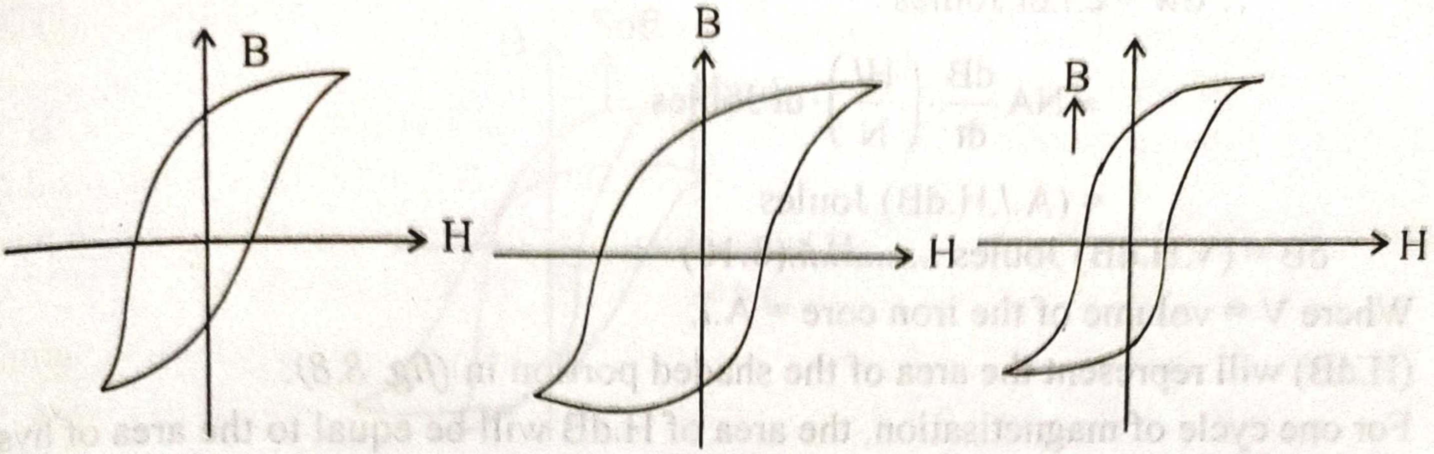
T to U : Again the polarity of the battery is reversed and in the path TV, if H increases the value of 'B' also increases and at U it is seen that if $H = 0U$, $B = 0$. Hence the residual magnetism ceases.

U to P : Lastly with increase of 'H', 'B' also increases and again come to the saturation state at P.

Thus when a magnetic material is subjected to one cycle of magnetisation, 'B' always lag behind 'H' that the B-H curve forms a closed loop, called hysteresis loop.

8.6 HYSTERESIS LOSS :

When a magnetic material is subjected to a cycle of magnetisation i.e. it is magnetised first in one direction and then in the other, an energy loss takes place due to the molecular friction in the material, that effect is called as hysteresis. Hysteresis is due to inertial effect i.e. in case of ferro magnetic materials the magnetic dipoles are not uniformly oriented but due to the quick reversal of magnetic field, some energy gets dissipated as heat energy. This heat energy will overcome the opposition of hysteresis. This loss of energy is named as hysteresis loss. These losses are taking place in all electrical machines whose iron parts are subjected to cycles of magnetisation. Due to this loss there will be temperature rise of the machines, hence the performance and operation of the machines will be affected. So a preferable magnetic material should be taken into consideration which has low hysteresis loss. The most preferable materials which show low hysteresis loss are : (i) silicon steel (ii) CRG (cold rolled grained steel) (iii) hot rolled grained steel etc.



(i) **(ii)** **(iii)**

(Fig. 8.7)

(Sillicon steel) ***(Hard steel)*** ***(Wrought iron)***

Hysteresis loop for hard steel in *(fig. 8.7 (ii))* indicates the material has high retentivity and coercivity. Hence hard steel is quite suitable for making permanent magnets and it has greater hysteresis loss.

Similarly considering *(fig. 8.7 (i))*, the hysteresis loop of silicon steel has a very small area and has small hysteresis loss. So silicon steel is widely used for making transformer cores, rotating machines, which are subjected to rapid reversals of magnetisation. The histeresis loop for wrought iron in *(fig.8.7 (iii))* shows that this material has fairely good residual magnetism and coercitivity. Hence it is suitable for making cores of electro magnets.