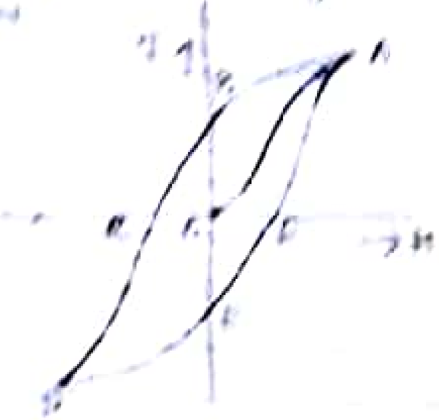
[illegible]

Q. What do you mean by magnetic hysteresis and hysteresis loss? Show how is hysteresis related to the area of the loop.

Ans. If a piece of iron is slowly magnetised, the intensity of magnetisation I increases with the magnetising field H. When the intensity I reaches its saturation value, (where any further increase in H would not increase I), the bar has acquired a state of magnetic saturation. Now the field H is decreased slowly to zero, then I decreases but not to zero. The value of I is represented by OB and is called residual magnetism or intensity of magnetisation or Retentivity or Remanence.



If the direction of H is now reversed, the curve BC is established and residual magnetism vanishes at C. This OC is called coercive force of the material necessary to demagnetise the bar. By further increasing H to [illegible] reach the saturation point D. H is again reduced to zero and then again increased to reach the point A. The path ABCDEFA is called hysteresis loop. This shows that the value of I or B always lags behind H.

This lagging of magnetic induction behind the magnetising force through a cycle of magnetisation is called hysteresis.

Hysteresis loss :- Energy loss due to hysteresis.

The act of magnetisation involves the expenditure of energy. The energy required for magnetising a specimen is not then completely recoverable on removing the magnetising field. Thus there is a loss of energy and is represented by the area of a hysteresis loop.

Hysteresis loss from I-H cycle :- Let us consider a unit volume of specimen containing N elementary magnets and M be the magnetic moment of one of the elementary magnet whose axis makes an angle θ with field H.

Then component of M $\parallel$ to H $= M\cos\theta$

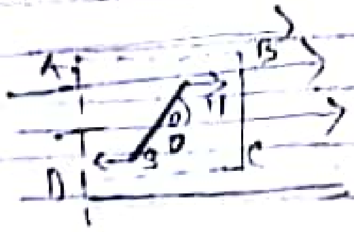
" " M $\perp$ to H $= M\sin\theta$

∴ Total mag. moment parallel to H

$= \Sigma M\cos\theta$

and total moment $\perp$ to H

$= \Sigma M\sin\theta$



When θ is increased by $d\theta$ then mag. moment per unit volume increases by

$$dI = d\,\Sigma M\cos\theta = 0 - \Sigma M\sin\theta . d\theta \quad \text{— (1)}$$

The couple acting on each molecular magnet

$= MH\sin\theta$

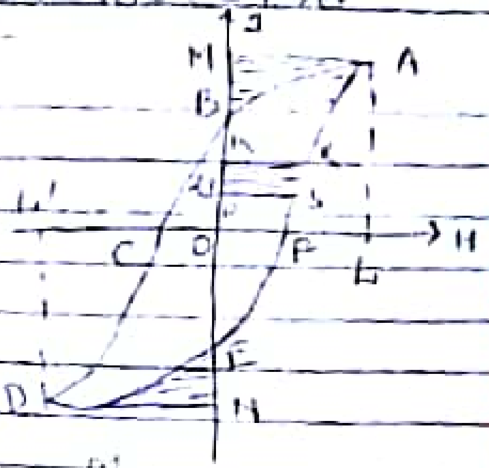
If the angle is decreased by angle $d\theta$, then work done in rotating it through $(-d\theta)$ $= -MH\sin\theta . d\theta$.

∴ Work done in rotating all the magnets in a unit volume $= -\Sigma MH\sin\theta . d\theta$

$= H . dI$.

∴ the work done in changing the value of I from I_1 to I_2 $= \int_{I_1}^{I_2} H . dI$ (Warburg's law)

Loss of energy per cycle: Let us consider a complete cycle of magnetisation ABCDEFA. Let PQ be the small step of magnetisation in which I increases by dI.



∴ Work done per unit volume $= H \cdot dI$

= area PQRS

(1) When H is increased from OL to L, I changes from −OE to +OM

∴ Work done per unit volume $= \int_E^M H \cdot dI$

= area EFAMBOE

(2) When H is decreased from OL to zero, I decreases from OM to OB

∴ Work done on specimen per unit volume

$= \int_M^B H \cdot dI$ = area AMBA

(3) When H again changed in opposite direction from O to OL', I changes from +OB to −ON

∴ Work done on specimen per unit volume

$= \int_B^N H \cdot dI$ = area BCDNEOB

(4) When H is again decreased to zero, I decreases from −ON to −OE.

∴ Work done by specimen per unit volume

$= \int_N^E H \cdot dI$ = area DNED

∴ Loss of energy per unit volume per cycle due to Hysteresis = area of ~~the~~ loop A

(area EFAMBOE + area BCDNEOB) − (area ABBA + area DNED)

~~= area of I−H loop (ABCDEFA)~~