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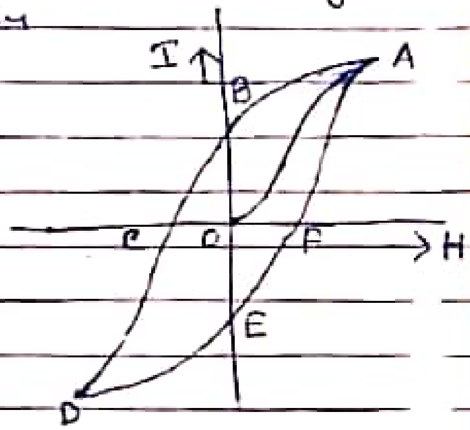
B-H-Curve

What do you mean by magnetic hystresis and hystresis loss? Show how is hystresis related to the area of B-H loop.

Ans:- If a bar of iron is slowly magnetised, the intensity of magnetisation I increases with the magnetising field H as shown in fig. At A it reaches a saturation value, when 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 become zero. This 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 BCD is obtained and residual magnetism vanishes at C. This is called coercive force of the material necessary to demagnetise the sample. By further increasing H we reach the saturation point D symmetrical to A and then it again decreases so as to reach the point A. The path ABCDEFA is called hystresis 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 Hystresis.

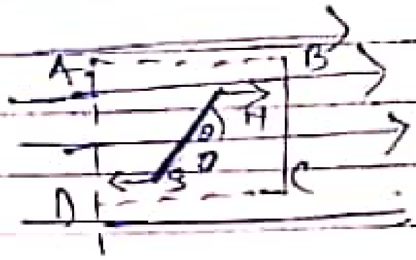
~~Hystresis loss~~ Energy loss due to hystresis.

The act of magnetisation involves the expenditure of energy. The energy required to magnetise a specimen is not completely recoverable on reversing the magnetising field. Thus there is a loss of energy and is represented by the area of a hystresis loop.

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

Then component of M ∥ to H $= M\cos\theta$
" " M ⊥ to H $= M\sin\theta$

∴ Total mag. moment parallel to H
$= \Sigma M\cos\theta$
and total moment ⊥ to H
$= \Sigma M\sin\theta$



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

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

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 $= -\Sigma MH\sin\theta . d\theta$.
$= H . dI$.

or 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]

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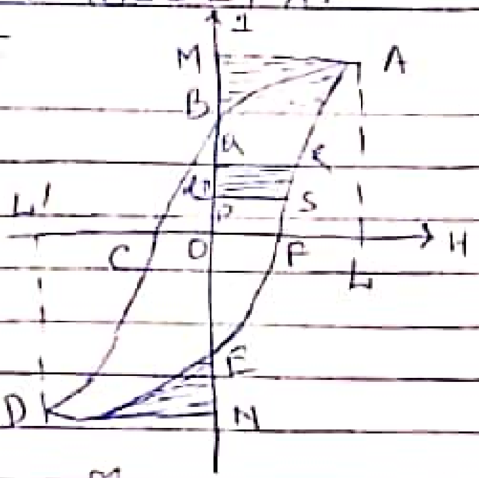
Loss of energy per cycle: Let us consider a complete cycle of magnetisation ABCDEFA. Let PQ be the small step of magnetisation ~~in~~ in which I increases by dI.



∴ Work done per unit volume = H·dI
= ~~Are~~ area PQRS

(1) When H is increased from 0 to L, I changes from −OE to +OM ~~in specimen~~

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

= area EFAMBOE

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

∴ Work done ~~per~~ by specimen per unit volume

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

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

∴ workdone on specimen per unit volume

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

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

∴ Work done by specimen per unit volume

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

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

(area EFAMBOE + area BCDNEOB)
− (area ABBA + area DNED)
~~= area of I−H loop (ABCDEFA)~~

Hysteresis loss from B-H Curve

We know $B = H + 4\pi I$

$\therefore dB = dH + 4\pi dI$

$\therefore H dB = H.dH + 4\pi H dI$

$\therefore H dI = \frac{1}{4\pi}(H dB - H dH)$

$W = \int H dI = \frac{1}{4\pi}\int (H.dB - H.dH)$

$= \frac{1}{4\pi}\int H.dB$

$= \frac{1}{4\pi}$ area of B-H Curve