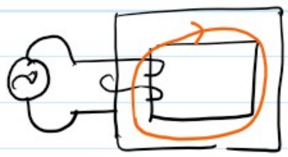
Lecture 17

Wednesday, November 17, 2021 12:08 PM

Ac excitation



$v(t)$
$\downarrow$
$\lambda(t)$ (sinusoidaly varying)
$\downarrow$
$B(t)$
$\downarrow$
using Hysteresis Loop
$\downarrow$
$H(t) \rightarrow$
$\downarrow$
$i(t) \leftarrow$

excitation current is nonsinusoidal current

Fitzgerald book

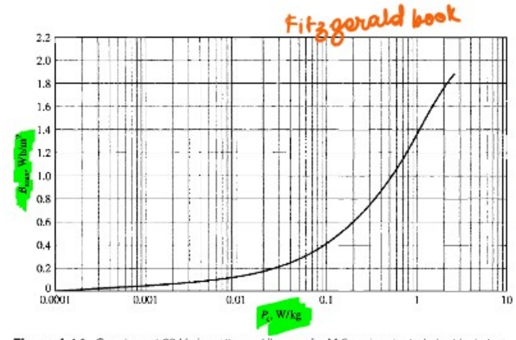


Figure 1.14 Core loss at 60 Hz in watts per kilogram for M-5 grain-oriented electrical stee 0.012 in thick. (*Armco Inc.*)

$v(t)$, $i(t)$ $\qquad p(t) = v(t)\, i(t)$
instantaneous power

P = Average power = $V_{rms} I_{rms} \cos\phi$

$v(t) = V_m \cos \omega t$

$\lambda(t) = \int V_m \cos(\omega t)\, dt$

$\lambda(t) = \frac{V_m}{\omega} \sin(\omega t)$

$\rightarrow \lambda_{rms} = \frac{V_m}{\sqrt{2}\,\omega} \longrightarrow$ $\because$ waveform is sinusoidal peak value & RMS quantities are directly related

$B = \frac{\Phi}{A} = \frac{\lambda}{N} \cdot \frac{1}{A}$

$\rightarrow B(t) = \frac{\lambda(t)}{NA} = \frac{V_m}{\omega N A} \sin \omega t$

$\downarrow$

$B_{rms} = \frac{V_m}{\sqrt{2}\,\omega N A}$

$$\boxed{V_m = \sqrt{2}\,\omega N A\, B_{rms}} \leftarrow$$

definition of RMS value $f(t)$

$$f_{RMS} = \sqrt{\frac{f^2(t)}{T}}$$

$$= \sqrt{\frac{f^2(t_0) + f^2(t_1) + \dots + f^2(t_N)}{N}}$$

$H(t) \longrightarrow H_{RMS}$ using basic definition

$$\boxed{I_{rms} = \frac{H_{RMS}\, l}{N}}$$

$H.l = NI$

$P = V_{rms} I_{rms} \cos\phi$

$\rightarrow S = WNA B_{rms} \cdot \frac{H_{rms} l}{N} = \boxed{W A l \; B_{rms} H_{rms}}$

(Apparent power)

W: frequency

Al: area of core x length of core (volume)

$B_{rms} H_{rms}$: B, H magnetic material properties

Real/Active power $\mapsto$ losses/Heating of the core

Reactive power $\mapsto$ magnetizing

Heating (losses in the core) $\longrightarrow$
- Varying magnetic field
- Hysteresis loop of the magnetic material

$S = W A l \cdot B_{RMS} H_{RMS}$

$S = W \cdot \frac{\rho A L}{\rho} B_{rms} H_{RMS}$ ($\rho A L$ → mass)

mass of magnetic material

$\frac{kg}{m^3} \cdot m^3 = kg$

$\frac{S}{Mass} = \frac{W}{\rho} B_{rms} H_{RMS}$ ($\frac{W}{\rho}$ → k)

$\frac{S}{Mass} = k \cdot B_{RMS} H_{RMS}$ → independent; H_{RMS} → uniquely determined by B

$\frac{W}{kg} \mapsto$ from this losses can be established

Varying field produces voltage (induced EMF)

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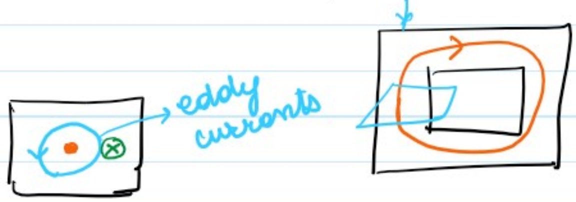
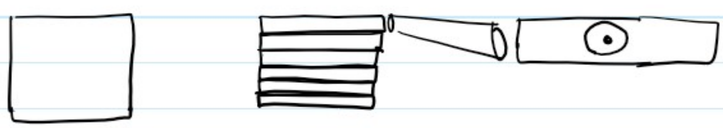


BH - dynamic situation becomes fatter to overcome demagnetization

- Resistance of magnetic material is there
- I_{eddy}

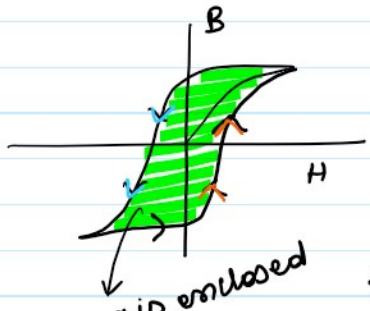
$$P_{eddy} = I_{eddy}^2 R_{mag}.$$

B^2, f^2



laminations are done to reduces losses

Hysteresis losses → due to hysteresis loop & expression for power



H is increased
H is decreased

$p = iV$ $\qquad\qquad$ $V = \frac{d\lambda}{dt}$

$p = i\frac{d\lambda}{dt}$

$\int p\,dt = E = \int i\,d\lambda$ $\qquad$ $\left\{ \begin{array}{l} i = \frac{Hl}{N} \\ \lambda = NBA \end{array} \right.$

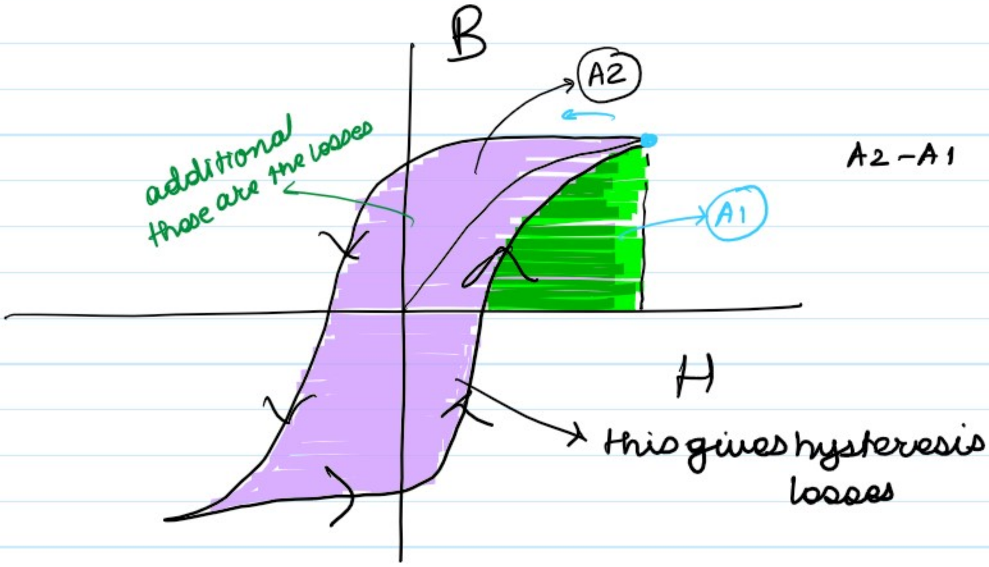
$= \int \frac{Hl}{N} \cdot d(NBA)$

$$= \mathit{Al} \int H\,dB.$$

constant

$$\boxed{E = \int H\,dB}$$

integration gives us the area under the curve.



$A2 - A1$

Eddy & Hysteresis loss