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Machines - Assignment - 1

Q:- 1

ⓐ **Real power:-**

The power actually consumed by the resistive load is called real power, represented by (P) and unit (watt)

$$\boxed{P = VI\cos\theta}$$

Reactive power:-

The power actually consumed by the reactive load [capacitor / Inductor] is called reactive power ~~with~~

$$\boxed{Q = VI\sin\theta}$$ with unit (Volt Amp Reactive)

Appearent power:-

The product of Voltage and Current flowing through and present across the load is appearent Power:- represented by (S) and unit is (Volt Amp) -

$$\boxed{S = VI}$$

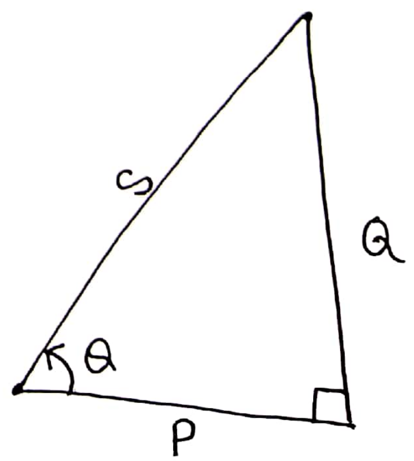
Relation b/w P, Q, and S -

$$S^2 = P^2 + Q^2$$

$$S = \sqrt{P^2 + Q^2}$$

$S = VI$, $P = VI\cos\theta$

$Q = VI\sin\theta$



(b) Hysteresis :-

Property of a feromagnetic material, the tendency of domains of a material to stay aligned even after the removal of external magnetic field means the domains do not instantly return back to normal position. Hysteresis allows us to make permanent magnet.

Eddy Current loss :-

The changing magnetic flux induces voltages within a ferromagnetic material (core) that causes swirls of current to flow within the core which is a resistive material hence, some power is being consumed by the core results in the loss of energy in the form of current. More the current flows, more the energy losses and power consumption.

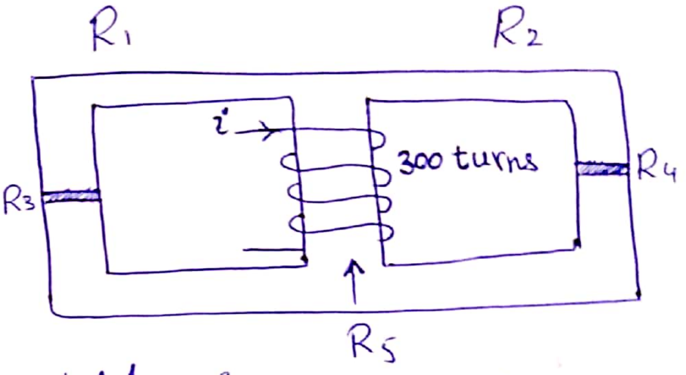
How to minimize ?

Eddy current loss can be minimized by designing the core as a set of thin sheets/laminations in parallel to the magnetic field. Each sheet has to be coated with a thin layer of varnish or oxide film to reduce the induced EMF

Q:- 2

$u_r = 1500$

$N = 300$



Let R_1, R_2, R_3, R_4, and R_5 be the reluctances of the Left side, Right side, Left air gap, right air gab, and center leg of the core respectively-

$$R_1 = \frac{l_1}{\mu_r \mu_0 A_1} = \frac{(30+3.5+3.5+30+3.5+3.5+30+3.5+3.5)\text{cm}}{(1500)(4\pi \times 10^{-7})(0.07)(0.05)} \Rightarrow \boxed{168.25\text{K}}$$

$$R_2 = \frac{l_2}{\mu_r \mu_0 A_2} = \frac{111\text{ cm}}{(1500)(4\pi\times10^{-7})(0.07)(0.05)} \Rightarrow \boxed{168.25 \text{ KA } t/wb^{-1}}$$

$$R_3 = \frac{l_3}{\mu_r \mu_0 A_3} = \frac{0.07\text{ cm}}{(1)(4\pi\times10^{-7})(0.05)(1.05)(0.07)} \Rightarrow \boxed{151.6 \text{ KA } t/wb^{-1}}$$

$$R_4 = \frac{l_4}{\mu_r \mu_0 A_4} = \frac{0.05\text{ cm}}{(1)(4\pi\times10^{-7})(0.07)(1.05)(0.05)} \Rightarrow \boxed{108.3 \text{ KA } t wb^{-1}}$$

$$R_5 = \frac{l_5}{\mu_r \mu_0 A_5} = \frac{37\text{cm}}{(1500)(4\pi\times10^{-7})(0.05)(0.07)} \Rightarrow \boxed{56.1 \text{ KA } t wb^{-1}}$$

$$R_{eq} = R_T = R_5 + \frac{(R_1+R_3)(R_2+R_4)}{R_1+R_2+R_3+4} \Rightarrow \boxed{204.5 \text{ KA } t wb^{-1}}$$

$$f = NI = \phi R, \quad \phi_T = \frac{Ni}{R_T} = \frac{(300)(1)}{(204.5\times10^3)}, \quad \boxed{\phi_T = 1.47\text{mWb}}$$

$$\phi_{left} = \phi_T \times \frac{(R_2+R_4)}{R_1+R_2+R_3+R_4} = \frac{(1.47\times10^{-3})(168250+108300)}{R_1+R_2+R_3+R_4}, \quad \boxed{\phi_{left} = 0.68\text{mwb}}$$

$$\phi_{right} = \phi_T \times \frac{(R_1+R_3)}{R_1+R_2+R_3+R_4} = \frac{(1.47\times10^{-3})(168250+151600)}{R_1+R_2+R_3+R_4}, \quad \boxed{\phi_{right} = 0.79\text{ mwb}}$$

$$\boxed{\phi_{center} = \phi_T = \boxed{1.47\times10^{-3}}}$$

$$B_{left} = \frac{\Phi_{left}}{A} = \frac{0.00068}{(0.07)(0.05)(1.05)} = \boxed{B_{left} = 0.185\,T}$$

$$B_{right} = \frac{\Phi_{right}}{A} = \frac{0.00079}{(0.07)(0.05)(1.05)} = \boxed{B_{right} = 0.215\,T}$$

Q:- 3

$N_1 = 600$, $i_1 = 0.5A$, $\mu_r = 1200$

$N_2 = 200$, $i_2 = 1.0A$,

$l_{Total} = (50+15+50+15+50+15+50+15)cm = 2.6 m$

$\mathcal{F} = Ni = N_1 i_1 + N_2 i_2 = (600)(0.5) + (200)(1)$, $\boxed{\mathcal{F} = 500 At}$

$R_T = \frac{l_T}{\mu A} = \frac{l_T}{\mu_r \mu_0 A} = \frac{2.6}{(1200)(4\pi\times10^{-7})(0.15)(0.15)}$ $\boxed{R_T = 76.63K}$

$\phi = \frac{\mathcal{F}}{R_T} = \frac{500}{76.63\times10^3}$ $\boxed{\phi = 6.5m\ wb}$

Q:- 4

$A_{ag} = 18 cm^2 = 0.0018 m$, Diameter of rotor = 4cm

(a) From the gig figure, the maximum reasonable flex density can be around-

$\boxed{B = 1.25T}$

(b) $\phi = ?$

$\phi = B.A = (1.25)((0.04)(0.04))$

$\boxed{\phi = 2m Wb}$

(c) $i = 1A$, $N = ?$

to find N we can use $Ni = \phi R_{Tot}$

$N = ?$, $i = 1$, $\phi = 2m$, $R_{Tot} = ?$

at $B = 1.25T$ (from part b), $\mu_r = 3700$

$$R_{l_c} = \frac{l_c}{\mu A} = \frac{0.48}{(3700)(4\pi\times10^{-7})(0.04)(0.04)}$$

$$\boxed{R_{l_c} = 64.52 \text{ KAtWb}^{-1}}$$

$$R_{l_r} = \frac{l_r}{\mu A} = \frac{0.04}{(3700)(4\pi\times10^{-7})(0.04)(0.04)}, \quad \boxed{R_{l_r} = 5.38 \text{ KAtWb}^{-1}}$$

$$R_{lg} = \frac{l_{g_1}}{\mu A} + \frac{l_{g_2}}{\mu A} = \frac{2 l_g}{\mu A} = 2\left[\frac{0.0005}{(4\pi\times10^{-7})(0.0018)}\right]$$

$$\boxed{R_{lg} = 442.1 \text{ KAtWb}^{-1}}$$

$$R_T = R_{lr} + R_{lg} + R_{lc} = \boxed{R_T = 512 \text{ KAtWb}^{-1}}$$

using $Ni = R_T \Phi$

$$N = \frac{R_T \Phi}{i} = \frac{(512\times10^{3})(2\times10^{-3})}{1}$$

$$\boxed{N = 1024 \text{ turns}}$$

Q:-5

$B = 0.5T$, $l = 1m$

$R = 0.25\Omega$, $V = 100V$

ⓐ $F_i = ?$ $i = ?$

$i = \frac{V}{R} = \frac{100}{0.25} \Rightarrow \boxed{400A = i}$

$F_i = i \times l \times B = (400)\times(1)\times(0.5)$

$\boxed{F_i = 200N}$ acting towards the right side-

ⓑ speed of bar $V_b = ?$

V = induced emf $= V_b B l$

$100 = V_b (0.5)(1)$, $\boxed{V_b = 200 ms^{-1}}$

ⓒ $v = ?$ $\eta = ?$ $F = 25N$

$F = ilB$, $i = \frac{F}{lB} = \frac{25}{(1)(0.5)}$ $\boxed{i = 50\ A}$

emf induced $= V - iR = 100 - (50)(0.25)$, $\boxed{e = 87.5\ V}$

Velocity/speed $= \frac{V}{Bl} = \frac{e}{Bl} = \frac{87.5}{(0.5)(1)}$ $\boxed{v = 175\ ms^{-1}}$ — 1

$P_{in} = V_B i_B = (100)(50)$, $\boxed{P_{in} = 5000\ W}$

$P_{out} = V_{out} i_B = e\, i_B = (87.5)(50)$. $\boxed{P_{out} = 4375\ W}$

$\eta = \frac{P_{out}}{P_{in}} \times 100 = \frac{4375 \times 100}{5000}$

$\boxed{\eta = 87.5\%}$