EE 114 Power Engineering-1

Assignment-5

Question 1

Length (l) = 0.5m

Magnetic field (B) = 2T

Velocity (v) = $40 ms^{-1}$

(a) When rod is ⊥ to field ($\theta = 90^\circ$)

$Emf = Bvl \cos(90-\theta)$

$= 2 \cdot 40 \cdot 0.5 = \underline{\underline{40V}}$

(b) when rod is 30° with field,

$Emf = Bvl \cos(90-30^\circ)$

$= Bvl \cdot \frac{1}{2} = \underline{\underline{20\ V}}$

Question 2

Area of coil (A) = $(0.1)^2 = 10^{-2} m^2$

turns (N) = 200 turns

speed = 1000 rpm = $\frac{100\pi}{3}$ rads

field (B) = 0.5 T

$\Rightarrow \phi = \phi_m \sin\omega t = NA \cdot B \sin\omega t$

$Emf = \frac{d\phi}{dt} = \underline{\underline{NAB\omega \cos\omega t}}$

(a) at right angle, $\theta = 90^\circ$ / $\omega t = 90^\circ$

$\therefore Emf = \underline{\underline{0V}}$

(b) at 30°, $\omega t = 30^\circ$

$\rightarrow 200 \cdot 10^{-2} \cdot 0.5 \cdot \frac{100\pi}{3} \cdot \cos 30^\circ$

$= \underline{\underline{90.69\ V}}$

(c) in plane of field, $\omega t = 0$

$\Rightarrow Emf = NAB\omega \cdot \frac{100\pi}{3}$

$= \underline{\underline{104.71V}}$

Question 3

turns $(N) = 100$

Area $= \pi \cdot (0.15)^2 = 70.68 \times 10^{-3}\ m^2$

$\omega = \frac{900}{60} \times 2\pi = 30\pi\ rads^{-}$

$B = \mu H = 4\pi \times 10^{-7} \cdot 15 = 188.495 \times 10^{-7}\ T$

$Emf = NABW\cos\theta$

$= 100 \cdot 70.68 \times 10^{-3} \cdot 188.495 \times 10^{-7} \cdot 30\pi \cos\theta$

$= 0.0125 \cdot \cos\theta$

(a) Perpendicular to plane, $\theta = 90^\circ$

$\Rightarrow Emf = 0V$

(b) When $\theta = 30^\circ$,

$\Rightarrow 0.01087\ V$

(c) when $\theta = 90^\circ$

$\Rightarrow Emf = 0.0125\ V$

Question 4

$B = 1T$

$r = 0.1\ m$

$l = 0.3\ m$

$\omega = 377\ rad\ s^{-1}$

Area $= 2r \cdot l = 0.06\ m^2$

(a) $e_{tot}(t) = (A) \cdot B \cdot \omega \cdot \cos(\omega t)$

$\cdot\ 0.06 \cdot 1 \cdot 377 = 22.62\cos(\omega t)$

(b) frequency of voltage produced $= \omega = 377\ rads^{-}$

(c) Current $= \frac{V}{R} = 2.26\cos(\omega t)\ A$

(d) Torque = $(I(t) \cdot A) \times B$

$= 1.35 \times \cos(\omega t) \cdot B \cdot \cos\omega t$

$= 1.35 \cos^2\omega t$ into the plane

(e) instantaneous power $= I^2R = 5.10 \cos^2\omega t \cdot 10$

$= 51 \cos^2\omega t$ W

average power $= 51 \langle \cos^2\omega t \rangle = \frac{51}{2} = 25.5$ W

(f) mechanical power $= (\tau) \cdot \omega$

$= 1.35 \cos^2(\omega t) \cdot 377$

$= 508.95 \cos^2\omega t$

Question 5

frequency $(f) = 133$ Hz

poles $(P) = 4$

rotor speed $(N_r) = \frac{120f}{P} = \frac{120 \cdot 133}{4} = 3990$ rpm

Question 6

area of coil $= 2R \cdot 0.52 = 0.0832 m^2$

(a) $I_1 = 0A$, $I_2 = 8A$.

Torque $= (I_2 \cdot A) \cdot B \cos\alpha = 0.579 \cos\alpha$

(b) Torque $= I_1 \cdot A \cdot B \sin\alpha = 0.361 \sin\alpha$

(c) Torque $= 0.579 (\cos\alpha + \sin\alpha)$

$= 0.818 \sin(45° + \alpha)$

Question 7

$$L = \frac{2L_0}{\left(1 + \frac{x}{x_0}\right)}$$

$L_0 = 70\,mH$

$x_0 = 1.2\,mm$

$R = 135\,m\Omega$

(a) $x = 1.5\,mm$

$I = 7\,A$

magnetic energy $= \frac{1}{2} \cdot \left(\frac{2L_0}{1 + \frac{x}{x_0}}\right) \cdot I^2$

$= \frac{1}{2} \cdot \frac{2 \cdot 70 \times 10^{-3}}{2.083} \cdot 49$

$= \underline{1.646\,J}$

(b) $I = 7\,A$,

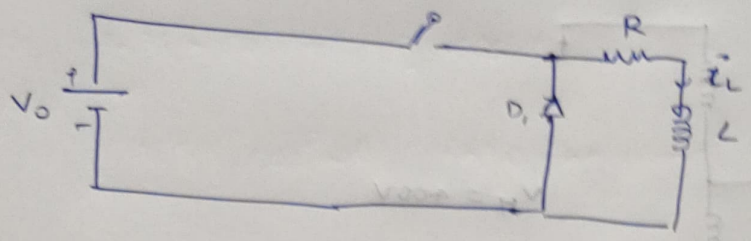
$x = 2.5\,mm$

$E = \frac{1}{2} \cdot \frac{2 \cdot 70 \times 10^{-3}}{1 + \frac{2.5}{1.2}} \cdot 4.9$

$= 1.112$

$\Delta E = \underline{0.533}$

Question 8



initially,

$$i_0 = \frac{V_0}{R}$$

after closing the switch,

$$L\frac{di}{dt} = -i.R$$

$$\int_{i_0}^{i} \frac{di}{i} = -\int_0^t \frac{R}{L}\,dt$$

$$\ln \frac{i}{i_0} = -\frac{R}{L}t$$

(a) $$\boxed{i = i_0 e^{-\frac{R}{L}t}} \quad \left(i_0 = \frac{V_0}{R}\right)$$

(b) initially, energy $= \frac{1}{2} \cdot L \cdot \frac{V_0^2}{R_0}$

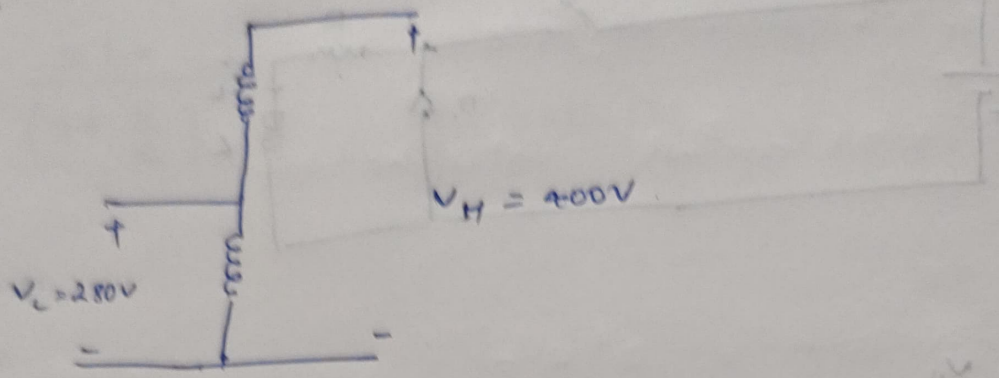
finally, energy $= 0$ //

(c) → energy in inductor as function of time

$$= \frac{1}{2} \cdot L \cdot i_0^2 \cdot e^{-\frac{2R}{L}t}$$

· total dissipated energy in resistor $= \frac{1}{2} L \frac{V_0^2}{R^2}$

Question 9



• → rated current for single phase transformer for 120v side,

$$= \frac{48000}{120} = 333.3A$$

∴ kVA rating for this auto transformer = 400×375

$= 150$ kVA