

Question 1

- a)
(i) The two types of losses are hysteresis losses and Eddy Current loss.

Hysteresis losses - The ~~area~~ loss is proportional to area to the B-H loop.

- The narrower the core, the less the loss. ✓
- depends on material change on core.

Eddy Current loss - The laminations are insulated ~~and the core~~ from each other.

- Magnetic flux is ~~found~~ on the core.

P.T.O

$$(ii) |E_2| = 4.44 f N_2 \Phi_{max}$$

$$\therefore N_2 = \frac{E_2}{4.44 \times f \times \Phi_{max}}$$

$$= \frac{240}{4.44 \times 60 \times 0.075}$$

$$= 12.012 \quad \times$$

$$N_1 = N_2 \times \frac{5500}{200}$$

$$N_1 = 330.33 \text{ turns} \quad \times \quad (330)$$

b)

(i) M_L

$$\begin{aligned} P_1 &= \text{load} \times \text{power factor} \\ &= 5.5k \times 0.78 \\ &= 4.29k_w \quad \checkmark \end{aligned}$$

$$\begin{aligned} Q_1 &= \sqrt{\text{load}^2 - P_1^2} \\ &= \sqrt{5.5^2 - 4.29^2} \\ &= 3.44k \quad \checkmark \end{aligned}$$

P.T.O

3
✓

M₂

$$P_2 = 15.2k \times 0.85 \\ = 12.92k \text{ W} \quad \checkmark$$

$$Q_2 = \sqrt{15.2k^2 - 12.92k^2} \\ = 8.007k \quad \checkmark$$

$$P_3 = 3.5k \times (3.5k)^3 \\ = 12.25k \text{ X } 10,500 \text{ W}$$

$$\text{Total } P = P_1 + P_2 + P_3 \\ = 4.29k + 12.92k + 12.25k \text{ X} \\ = 29.46k \text{ W}$$

$$\text{Total } Q = Q_1 + Q_2 \\ = 3.441k + 8.007k \\ = 11.448k \quad \checkmark$$

$$\text{Total } |S| = \sqrt{P_{\text{Total}}^2 + Q_{\text{Total}}^2} \\ \text{~~29.46k^2 + 11.448k^2~~} \\ = 31.61k$$

$$I_s = ?$$

$$I_p = ?$$

$$(ii) \text{ Power factor} = \frac{\text{Total } P}{\text{Total } |S|}$$

$$= \frac{29.46}{31.61} = 0.932 \text{ lagging.} \quad \text{X}$$

P.T.O

⑧
✓①
✓

Question 2

- a)
- (i) di/dt rating Shows the rise off current. when triggered, it won't give out unequal current distribution which will cause hot spots on the device junction resulting in failure.
- dv/dt Shows rise in anode-cathode voltage which won't trigger the device.

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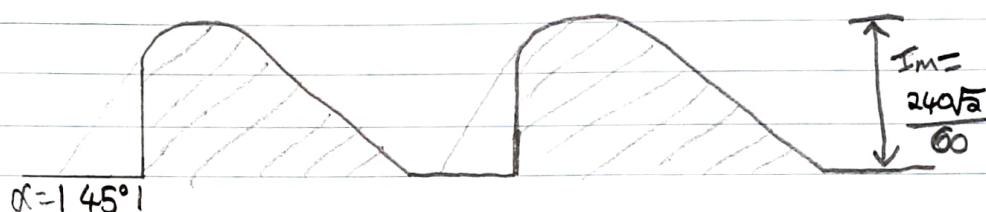
- (ii) dist in the device is limited by a series inductor. dv/dt is controlled by a RC 'Snubber Network' between the anode-cathode.

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b)

(i)



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(ii) $I_{rms}^2 = \frac{\text{Power dissipated}}{\text{Resistance}} = \frac{870}{60} = 14.5$

$I_{rms} = \sqrt{14.5} = 3.808 \text{ A}$

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(iii) $I_{mean} = \frac{1}{\pi} \int_{\alpha}^{\pi} I_m \sin \theta d\theta$ if $I_m = \frac{V_m}{R}$

$I_{mean} = \frac{V_m}{\pi R} \int_{\alpha}^{\pi} \sin \theta d\theta$

$I_{mean} = \frac{V_m}{\pi R} [1 + \cos \alpha]$

$I_{mean} = \frac{V_m}{\pi R} \int_{\alpha}^{\pi} [-\cos \theta]_{\alpha}^{\pi}$

$I_{mean} = \frac{240 \times \sqrt{2}}{\pi \times 60} [1 + \cos 45]$

$I_{mean} = \frac{V_m}{\pi R} \int_{\alpha}^{\pi} [1 + \cos \alpha]$

$I_{mean} = 1.801 [1.525]$

8



= ?

Question 3

$$(i) \omega_m = 2\pi \times \frac{\text{Speed}}{60}$$

$$= 2 \times \pi \times \frac{2100}{60}$$

$$= 219.91 \text{ rad/s} \quad \checkmark$$

$$R_a = 0.48 \Omega$$

$$\text{Load} = 68 \text{ Nm}$$

$$b = 0.02 \text{ Nm/rad/s}$$

$$\text{Speed} = 2100 \text{ rpm}$$

$$I_a = 74.5 \text{ A}$$

$$V_a = 250 \text{ V}$$

$$T_m = T_L + b \times \omega_m$$

$$K_m \times I_a \leftarrow = 68 + 0.02 \times 219.91$$

$$= 72.4 \text{ Nm/rad/s}$$

$$K_m = \frac{T_m}{I_a}$$

$$= \frac{72.4}{74.5}$$

$$= 0.972 \text{ Nm/A} \quad \checkmark$$

$$V_a = E_a + I_a R_a$$

$$E_a = V_a - I_a R_a$$

$$E_a = 250 - 74.5 \times 0.48$$

$$= 214.24 \text{ V/rad/s}$$

$$K_e = \frac{E_a}{\omega_m}$$

$$= \frac{214.24}{219.91}$$

$$= 0.974 \quad \checkmark$$

P.T.O

8

(ii) Load = 80 Nm

$$T_m = T_L + b \times \omega_m$$

$$T_m = k_m \times I_a$$

$$k_m I_a = T_L + b \times \omega_m$$

$$I_a = \frac{T_L + b \times \omega_m}{k_m}$$

$$I_a = \frac{80 + 0.02 \times \omega_m}{0.972} \quad \text{①}$$

$$V_a = E_a + I_a R_a$$

$$E_a = k_e \times \omega_m$$

$$V_a = k_e \times \omega_m + I_a R_a$$

$$250 = 0.974 \omega_m + 0.48 I_a \quad \text{②}$$

Sub ^{equation} ① into ^{equation} ②

$$250 = 0.974 \omega_m + 0.48 \times \left(\frac{80 + 0.02 \omega_m}{0.972} \right)$$

$$250 = 0.974 \omega_m + 39.506 + 0.009 \omega_m$$

$$250 = 0.983 \omega_m + 39.506$$

$$\omega_m = \frac{250 - 39.506}{0.974} = 296.18 \text{ rad/s}$$

⑤
✓

Sub ω_m into ^{equation} ①

$$I_a = \frac{80 + 0.02 \times 296.18}{0.972}$$

$$I_a = 88.4 \text{ A}$$

P.T.O

(iii) Load¹ = 68 Nm , 74.5 A

Mechanical power

$$\begin{aligned} P_m &= T_m \times \omega_m \\ &= 72.4 \times 219.91 \\ &= 15921.48 \text{ W} \end{aligned}$$

Electrical power

$$\begin{aligned} P_e &= V_a \times I_a \\ &= 18625 \text{ W} \end{aligned}$$

$$\begin{aligned} \text{Efficiency} \% &= \frac{P_m \times 100}{P_e} \\ &= 85.5 \% \end{aligned}$$

Load² = 80 Nm , 88.4 A

$$\begin{aligned} T_m &= T_L + b \times \omega_m = 80 + 0.02 \times 296.18 \\ &= 85.9 \end{aligned}$$

$$\begin{aligned} P_m &= 85.9 \times 296.18 \\ &= 25441.86 \text{ W} \end{aligned}$$

$$\begin{aligned} P_e &= 250 \times 88.4 \\ &= 22100 \text{ W} \end{aligned}$$

$$\begin{aligned} \text{Efficiency} \% &= \frac{25441.86 \times 100}{22100} \\ &= 115.12 \% \end{aligned}$$

errors
carried
forward

3
✓