17/ENG06/040

Mechanical Engineering

300 Level

Question 1

$V = 415$

$3-\phi$

4 wire

$f = 50Hz$

$P = 74.6$

$P.f = 0.7$

$eff = 85\%$

b(i) Unity = 1

$$C = \frac{KVAR}{2\pi f V^2}$$

KVAR = P x (tan actual P.f x tan target P.f)

actual P.f

$\cos\theta = 0.7$

$\theta = \cos^{-1} 0.7$

$\theta = 45.57$

$\tan(45.57) = 1.02$

target P.f

$\cos\theta = 1$

$\theta = \cos^{-1} 1 = 0$

$\tan 0 = 0$

$KVAR = 74.6 \times (1.020 - 0)$

$KVAR = 76.092$

$KVAR = \sim 76.1$

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$$C = \frac{76.1}{2\pi \times 50 \times 415^2} = 0.000\,000\,14 \approx 1.4 \times 10^{-6} C$$

ii) 0.9 lagging

actual P.f = 1.02

target Pf = $\cos\theta = -0.9$

$\theta = \cos^{-1}(-0.9)$

$= 154.16$

$\tan\theta = -0.48$

KVAR = $74.6 \times (1.020 - (-0.48))$

$= 111.90 \approx 112$

$$C = \frac{KVAR}{2\pi f V}$$

$$= \frac{112}{2\pi \times 50 \times 415^2}$$

$= 0.000\,086$

$= 8.6 \times 10^{-4} C$

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Question 2

$V = 415V$

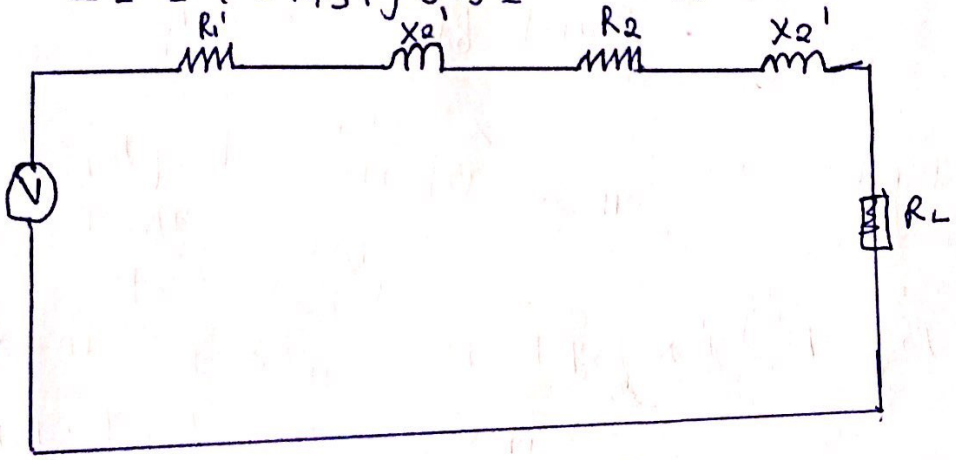
No of poles = 6

$F = 50Hz$

$K = 5/6 = 0.83$

$R \times Z_1 = 0.25 + j0.75$ —— stator

$Z_2 = 1 - 173 + j0.52$ —— Rotor



Supply voltage $V = \frac{415}{\sqrt{3}} = 239.60V$

refering to

$R_{O_2} = (R_2 + K^2 R_1)$

$= (1.173 + (5/6)^2 \times 0.25)$

$= 1.347\Omega$

$X_{O_2} = (X_2 + K^2 X_1)$

$= (0.52 + (5/6)^2 \times 0.75)$

$= 1.041$

$Z_{O_2} = R_{O_2} + X_{O_2}$

$= 1.347 + j1.041$

$Z_{O_2} = \sqrt{1.347^2 + 1.041^2}$

$= 1.7\Omega$

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~~I_{2}~~ rotor current

$$I_2 = \frac{\epsilon_R}{Z_{0.2}}$$

Recall that $\epsilon_2 = KV$

$$= 0.83 \times 239.60 = 198.87V$$

$$I_2 = \frac{198.87}{1.7} = 116.99A$$

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Question 3

$V = \epsilon_b = I_{load} \times R$

$\epsilon_b = 220 - [15 \times 0.7]$

$\epsilon_b = 209.5V$

For the reactive Voltage drop;

$I_L \times R = 0.7 \times 2\pi FL$

When $F = 50Hz$, $L = 0.25$

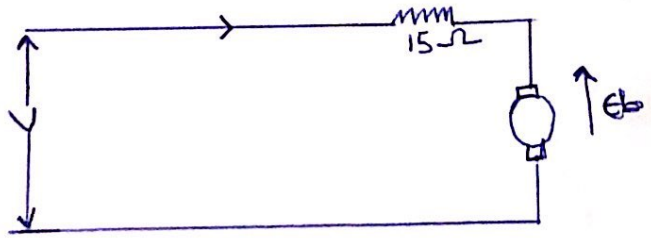
$I_L \times R = 0.7 \times 2\pi \times 50 \times 0.25$

$= 54.9V$

For AC Supply

The Supply Voltage = 220V

Current drawn = 0.7A



$V - \epsilon_b = I_L \times R$

$V - I_L \times R = \epsilon_b$

$\epsilon_b = 220 - [15 \times 0.7]$

$\epsilon_b = 209.5V$

∴ The speed on AC supply will have a back emf of 209.5V

On AC Supply

Supply Voltage = 220V

Current drawn $I = 0.7A$

Resistance drop $= I_L \times R = 0.7 \times 15 = 10.5V$

Resistance Voltage drop $= I_L \times X_L = 0.7 \times 2\pi FL$

Where $f = 50$, $L = 0.25$

$\therefore I_L X_L = 0.7 \times 2\pi \times 50 \times 0.25$

$= 54.9V$

$$E_{bae} = \sqrt{V^2 - [I_x]^2} - IR$$

$$= \sqrt{[220]^2 - [54.9]^2}$$

$$E_{bae} = 213V$$

Recalling Speed control Equation

$$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}}$$

$$\frac{E_{bae}}{E_{bde}} = \frac{N_{ae}}{N_{de}}$$

$$N_{de} E_{bae} = N_{ae} E_{bde}$$

$$E_{bde} N_{ae} = E_{bae} N_{de}$$

$$N_{ae} = \frac{E_{bae} N_{de}}{E_{bde}}$$

$$N_{ae} = \frac{213 \times 2000}{220}$$

(i) $N_{ae} = 1936$ rpm

(ii) Power factor, $\cos\phi = \frac{E_{bae} + IR}{V} = \frac{213 + 10.5}{220}$

$\cos\phi = 1.01$ lagging

(iii) Torque developed $T_w = E_{bae} \times I$

$$T_{ae} = \frac{E_{bae} \times I}{w}$$

$w = 2\pi n$

$$T_{ae} = \frac{E_{bae} \times I_L}{2\pi n \times \frac{2}{60}}$$

$$T_{ae} = \frac{213 \times 0.7 \times 2000 \times 60}{2\pi \times 1936} = 1470 \text{ Nm}$$