17/ENG06/060
MECHANICAL ENGINEERING
300Level
OFOTOKU DESMOND.O

Question 3.

$V - E_b = I \times R$

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

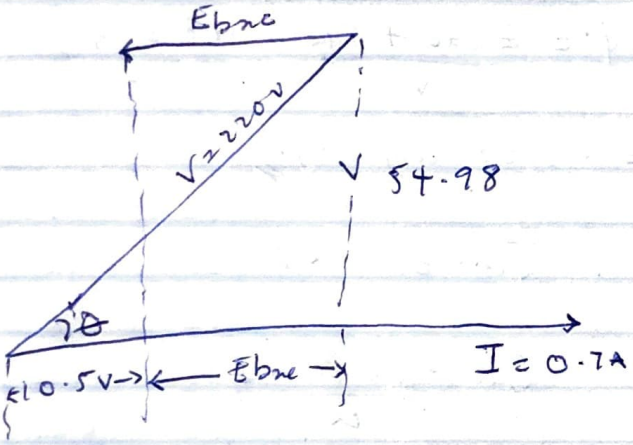
$= 209.5V$

Reactive voltage drop $= I \times R$

$= 0.7 \times 2\pi FL$

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

$= 54.98\Omega$



$IR = 10.5$

$E_{bac} = \sqrt{V^2 - (Ix)^2} - IR$

$= \sqrt{[220]^2 - [54.98]^2} - 10.5$

$E_{bac} = \sqrt{48400 - 3022.8} - 10.5$

$E_{bac} = \sqrt{45377.2} - 10.5$

$E_{bac} = 213.019 - 10.5$

$E_{bac} = 202.51V.$

Recall speed control equation

$$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} = \frac{E_{bac}}{E_{bdc}} = \frac{N_{ac}}{N_{dc}}$$

$$N_{ac} = N_{dc} \times \frac{E_{bac}}{E_{bdc}}$$

$N_{dc} = 2000 rpm$

$E_{bac} = 202.51V$

$E_{bdc} = 229.5V$

$$N_{ac} = 2000 \times \frac{202.51}{209.5}$$

$N_{ac} = 2000 \times 0.882$

$= 1764.8$ ~~1764.8~~ $1933.37 rpm$

i) Speed: $N_{ac} =$ ~~1764.8 rpm~~ $1933.37 rpm$

ii) power factor, $\cos\phi = \frac{E_{bac} + IR}{V} = \frac{202.51 + 10.5}{220}$

$\cos\phi = 0.968$ lagging

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

$$T_{ac} = \frac{E_{bac} \times I}{w}$$

$w = 2\pi n$

$$T_{ac} = \frac{E_{bac} \times I}{2\pi \times \frac{N_{ac}}{60}}$$

$$= \frac{202.51 \times 0.7 \times 60}{2\pi \times 1933.37} \qquad = \frac{202.51 \times 0.7 \times 60}{2\pi \times 1934.8}$$

$$= \frac{8505.42}{12149.3} \qquad T_{ac} = \frac{8505.42}{11090.0}$$

$= 0.700 Nm$ $T_{ac} = 0.767 Nm$

$T_{ac} = 0.700 Nm$

Question 2

$V_{ac} = 415V$

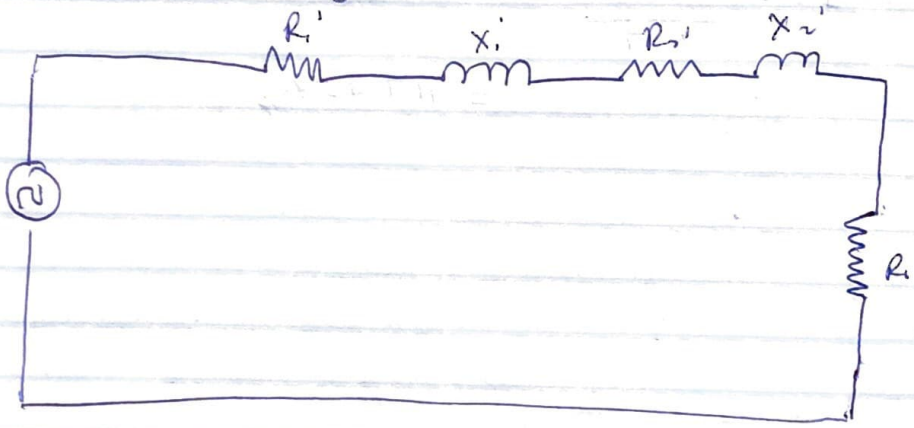
No of poles = 6

$F = 50Hz$

$k = 5/6 = 0.83$

$Z_1 = 0.25 + j0.75$ ——— stator

$Z_2 = 1.173 + j0.52$ ——— rotor



supply voltage per phase, $V = \frac{415}{\sqrt{3}}$

$= 239.60V$

Refering to rotor side

$R_{02} = (R_2 + k^2 R_1)$

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

$R_{02} = 1.347 ohms$

$X_{02} = (X_2 + k^2 X_1)$

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

$= 1.041$

$Z_{02} = R_{02} + X_{02}$

$= 1.547 + j1.041$

$Z_{02} = \sqrt{1.547^2 + 1.041^2}$

$= 1.7 ohms$

to find the rotor current

$$I_2 = \frac{E_2}{Z_{02}}$$

Note that $E_2 = kV_1$

$= 239.6 \times 0.85$

$= 199.67V$

$$\therefore I_2 = \frac{199.67}{1.7}$$

$= 117.45A$

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Question 1

1b) V = 415V, 3phase,
4 wire, f, 50Hz, P = 74.6
Power factor = 0.7
efficiency = 85%

i) unity = 1

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

$\therefore$ KVAR = P x (tan actual p.f − tan target p.f)

actual p.f = $\cos\theta = 0.7$

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

$= 45.57$

$\tan(45.57) = 1.0201$

target p.f => $\cos\theta = 1$

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

$\tan 0 = 0$

KVAR = 74.6 x (1.0201 − 0)

= 76.0995

≈ 76.10

$$C = \frac{76.10}{2\pi \times 50 \times 415^2} = \frac{76.10}{54113095}$$

$= 0.0000014 = 1.4 \times 10^{-6} C_A$

ii) 0.9 Lagging

actual p.f = 1.0201

target p.f = $\cos\theta = -0.9$

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

$= 154.16$

$\tan\theta = \tan(154.16)$

$= -0.48$

kVAR = $74.6 \times (1.0201 - (-0.48))$

$= 111.90 = 112$

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

$= \frac{112}{2\pi \times 50 \times 415^2} = \frac{112}{54113095}$

$= 2.07 \times 10^{-6} C$ $= 0.0086$

$= 8.6 \times 10^{-4} \mu F$