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17/ENG06/085
Mechanical Engineering
Question 1:

b)

415V
3-phase
4-wire
50Hz
0.7 lagging
85%

i) Unity = I

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

→ KVAR = P × (tan actual P.f − tan target Pf)

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

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

$= 45.57$

$\tan(45.57) = 1.0201$

target P.f ⇒ $\cos\theta = 1$

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

$\tan\theta = 0$

KVAR = 74.6 × (1.0201 − 0)

= 76.0995

≃ 76.10//

c) $= \frac{76.10}{2\times\pi\times 50\times\left(\frac{415}{\sqrt{3}}\right)} = 0.000014 \simeq 1.4\times10^{-6}$ C//

ii) 0.9 Lagging

actual Pf = 10201

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

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

$= 154.16$

$\tan\theta = -0.48$

KVAR $= 74.6 \times (10201 - (-0.48))$

$= 111.90$

$\simeq 112$ //

$= \frac{KVAR}{2\pi f V^2} = \frac{112}{2 \times \pi \times 50 \times \frac{415^2}{\sqrt{3}}} =$

$= 2.068 \times 10^{-6} C$ //

Question 2

V = 415V

No of Pole = 6

f = 50Hz

K = 5/6 = 0.83

$Z_1 = 0.25 + j0.75$ ... stator

$Z_2 = 1.173 + j0.52$ ... rotor

i)

supply voltage per phase

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

Referring to rotor

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

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

$R_{02} = 1.347\Omega$

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

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

$= 1.041$

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

$= 1.347 + j1.041$

$Z_{02} = \sqrt{1.347^2 + 1.041^2} = 1.7\Omega$ //

10 find rotor current

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

Recall that $E_2 = KV_1$

$= 239.6 \times 0.85 = 199.67V$

$I_2 = \frac{199.67}{1.7} = 117.45A$

Question 2

Recall speed constant equation

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

making N_{ac} subject of the formular

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

$$2000 \times \frac{202.52V}{209.5V}$$

$$N_{ac} = 1933.37 \text{ rpm}$$

Power factor, $\cos\phi = \frac{E_{bac} + IR}{V}$

$$= \frac{202.52 + 10}{220} = 0.96 \text{ lagging}$$

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

$$I_{ac} = \frac{E_{bac} \times I}{\omega}$$

where ω is speed in rad/s

$\omega = 2\pi n$, where n is rev/hr

$$I_{ac} = \frac{E_{bac} \times I_c}{2\pi \times \frac{N_{ac}}{60}}$$

$$\frac{202.52 \times 0.7 \times 60}{2\pi \times 1933.37}$$

0.700Nm //

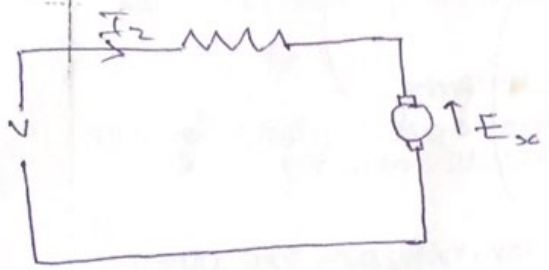
Question 3

$f = 50Hz$, $V = 220V$ 15Ω and 0.25H

On DC supply

Supply voltage = 220V

current draws, $I = 0.7A$



$V = E_2 = I_2 = I_2 * R$

$V - [I_2 * R] = E_b$

$E_b = 220 - [0.7 * 15]$

$= 209.5V$

Speed on DC

$N_{do} = 2000rpm$

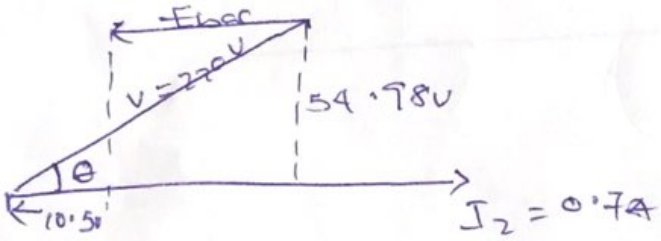
Reactance drop $= I_1 * R = 0.7 \times 15 = 10.5V$

Reactance voltage drop $= I_2 X_{t_2} = 0.7 \times 2\pi fL$

where $X_L = j\omega L = 2\pi fL$

$= 0.7 \times 2\pi \times 30 \times 0.25$

$= 54.98V$ //



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

$= \sqrt{(220)^2 - (54.98)^2} - 10.5$

$= 202.52V$ //