ELECTRICAL MACHINES TEST INEBUJO DELIGHT

17/ENG/0610/43 MECHANICAL ENGINEERING

Question 1

(i) Given V = 415 V, 3-pole, 4-wires, F = 50Hz, P = 74.6, P.F = 0.7 @ efficiency = 95%

Unity = 1

$C = \frac{KVAR}{2\pi FV^2}$

→ KVAR = Px (tan actual PF − tan target PF)

where actual PF = $\cos\theta = 0.7$

$\theta = \cos^{-1} 0.7 = 45.57$

hence tan (45.57) = 1.0201

target PF = $\cos\theta = 1$

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

$\tan 0 = 0$

KVAR = 74.6 × (1.0201 − 0)

= 76.09946

≈ 76.10

$C = \frac{76.10}{2\pi \times 50 \times 415^2} = 0.0000014$

≈ $1.4 \times 10^{-6} C$

ii) Lagging

actual PF = 1.0201

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

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

= 154.16

$\tan\theta = -0.48$

KVAR = 74.6 × (1.0201 − (−0.48)) = 111.90 ≈ 112

$C = \frac{KVAR}{2\pi FV}$

$= \frac{112}{2\pi \times 50 \times 415^2}$ = ~~0.000186~~ 2.07×10^{-6}

~~≈ 2.07 × 10^-6 C~~

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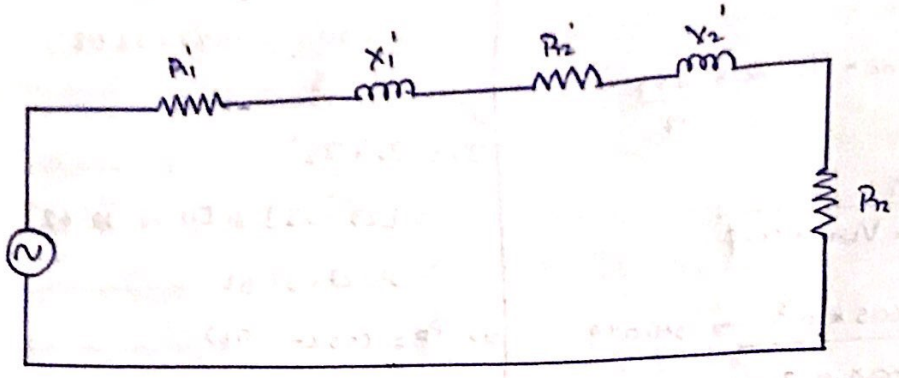
Question 2

$V_{line} = 415V$ $F = 50Hz$ $Z_1 = 0.29 + j0.79$ (Stator)

No of poles = 6 $k = 5/6 = 0.83$ $Z_2 = 1.173 + j0.82$ (Rotor)



Supply Voltage per phase

$V_{line} = \sqrt{3}\, V_{phase}$ $\therefore V_{phase} = \frac{V_{line}}{\sqrt{3}} = \frac{415}{\sqrt{3}} = 239.60V$

Referring to rotor

$R_{o2} = (R_2 + k^2 R_1)$

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

$R_{o2} = 1.347\,\Omega$

$X_{o2} = (X_2 + k^2 X_1)$

$= j(0.82 + (5/6)^2 \times 0.79)$

$= 1.041$

$Z_{o2} = \sqrt{R_{o2}^2 + X_{o2}^2}$

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

$= 1.702\,\Omega$

To find rotor current

$I_2 = \frac{E_2}{Z_{o2}}$ Recall that $E_2 = kV_1$

$= 239.6 \times 0.85$

$= 199.67V$

$\therefore I_2 = \frac{199.67}{1.702} = 117.315\,A$

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Question (3)

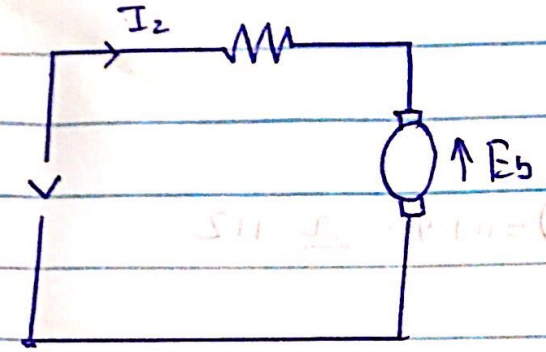
(3) Given 50Hz, Y the motor runs $N_2 = 2000$ rpm $I = 0.7$ $V = 220$

$R = 15\Omega$ $L = 0.25$ H

on Dc supply

supply voltage $= 220$ V

current drawn $= I = 0.7$A



$V - E_b = I_L * R$

$V - [I_L * R] = E_b$

$E_b = 220 - [07 * 15]$

$= 209.5$ V

Speed on Dc

$N_2 = 2000$ rpm

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Continuation of 3

On dc supply

supply voltage = 220V

current drawn $I_L = 0.7A$

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

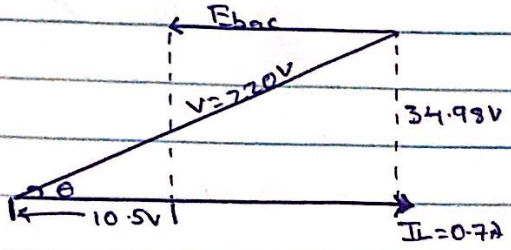
Reactance Voltage drop = $I_L \times X_L = 0.7 \times 2\pi fL$

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

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

$\therefore = 0.7 \times [2 \times \pi \times 50 \times 0.25]$

$= 54.98V$



$E_{bac} = \sqrt{V^2 - [IX_L]^2}$ — IA

$= \sqrt{(220)^2 - (54.98)^2}$ — 15×0.7

$= 202.52V$

Recall speed equation

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

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

Making Nac the subject of formular

$N_{ac} = \frac{N_{dc} \times E_{bac}}{E_{bdc}} = \frac{2000 \times 202.52V}{209.9V}$

$= 1933.37$ rpm

Power factor: $\cos\phi = \frac{E_{bac} + IA}{V} = \frac{202.25 + 10}{220}$

$= 0.969$ Lagging

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3) Continuation

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

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

where $w = 2\pi n$, where n = speed in rev

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

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

$$= 0.700 \text{ Nm}$$