

17/ENG01/027

MECHANICAL ENGINEERING

300 L

(2)

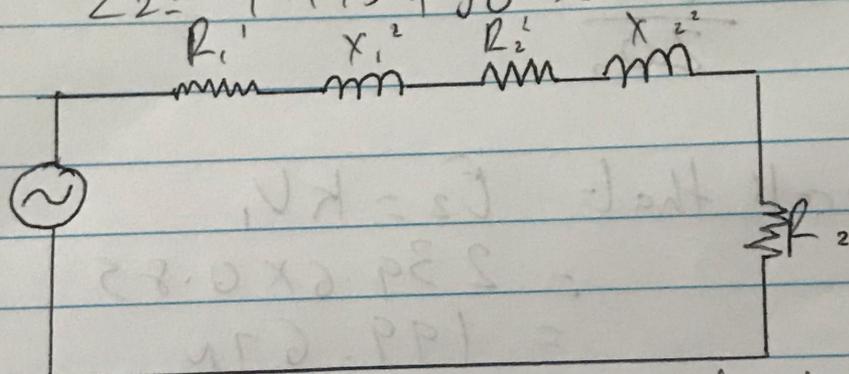
No of Poles = 6

$$f = 50 \text{ Hz}$$

$$k = 5/6 = 0.83$$

$$Z_1 = 0.25 + j0.75 \quad \dots \text{Stator}$$

$$Z_2 = 1.173 + j0.52 \quad \dots \text{rotor}$$



$$\text{Supply Voltage per Phase, } V_1 = \frac{415}{\sqrt{3}} = 239.60 \text{ V}$$

Referring to rotor

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

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

$$R_{02} = 1.347 \Omega$$

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

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

$$\text{Mag } X_{02} = 1.041$$

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$$\text{Q. } Z_{02} = R_{02} + jX_{02}$$

$$= 1.347 + j1.041$$

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

$$= 1.7 \Omega$$

To find rotor current

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

Recall that $E_2 = KV_1$

$$= 239.6 \times 0.85$$

$$= 199.67 \text{ V}$$

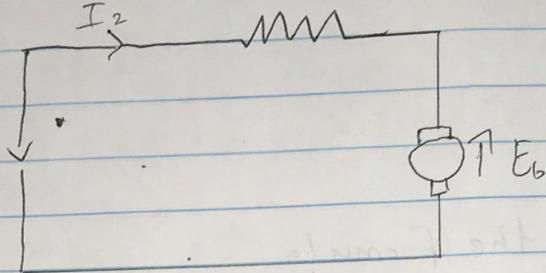
$$\therefore I_2 = \frac{199.67}{1.7}$$

$$= 117.45 \text{ A}$$

(3)

$f = 50 \text{ Hz}$, $\frac{1}{4} \text{ hp}$, $N_f = 2000 \text{ rpm}$, $V = 220 \text{ V}$, $I = 0.7 \text{ A}$
~~Resistance = 15 Ω , Inductance = 0.25 H~~ Resistance = 15Ω , Inductance = 0.25 H

On DC Supply.



$$V = E_b = I_2 \times R$$

$$V - [I_L \times R] = E_b$$

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

$$= 209.5 \text{ V}$$

Speed on DC

$$N_d = 2000 \text{ rpm}$$

On AC supply

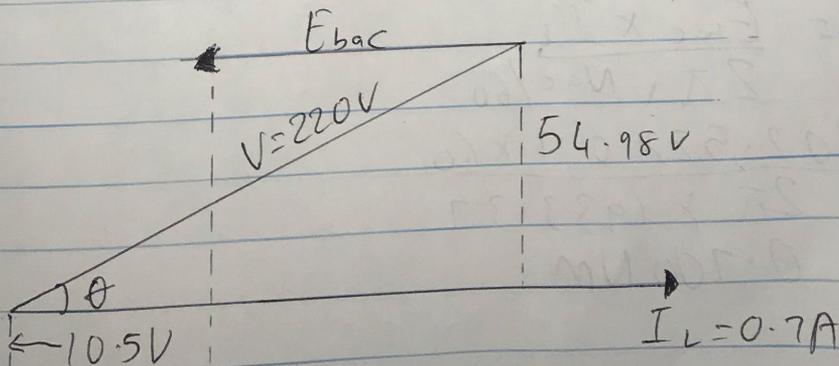
$$\text{Resistance Drop} = I_L \times R = 0.7 \times 15 = 10.5 \text{ V}$$

$$\text{Reactance Voltage Drop} = I_L \times X_L = 0.7 \times 2\pi f L$$

$$\text{Where } X_L = j\omega L = 2\pi f L$$

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

$$= 54.98 \text{ V}$$



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$$E_{bac} = \sqrt{V^2 - [X_s I]^2} - IR$$
$$= \sqrt{(220)^2 - (54.98)^2} - (0.5V)$$
$$= 202.52V$$

i) Recall Speed. Constant equation

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

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

Making N_{ac} subject of the formula

$$N_{ac} = N_{dc} \times \frac{E_{bac}}{E_{bdc}}$$
$$= 2000 \times \frac{202.5V}{209.5V}$$

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

ii) Power Factor, $\cos \phi = \frac{E_{bac} + IR}{V}$

$$= \frac{202.52 + 10.5}{220}$$

$$= 0.968 \text{ Lagging}$$

Torque developed $T_w = E_{bac} \times I$. $T_{ac} = \frac{E_{bac} \times I}{\omega}$

$\omega = 2\pi n$. ω is in speed in rad/s

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

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

$$= 0.700 \text{ NM}$$

iv) Universal motor

MATRIC NO: 17/ENG101/027

DEPARTMENT: MECHANICAL ENGINEERING

300 LEVEL

Electrical Machines

1) $V = 4/5 \text{ V}$, 3- ϕ

$$F = 50 \text{ Hz}$$

$$\text{P.F.} = 0.7$$

$$\% \text{ eff} = 85\%$$

$$\text{PF} = 74.6$$

$$U_{\text{ntg}} = 1$$

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

$$\rightarrow \text{kVAR} = P \times (\tan \theta_{\text{actual P.F.}} - \tan \theta_{\text{target P.F.}})$$

actual P.F. $\Rightarrow \cos \theta = 0.7$

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

$$= 45.57$$

$$\tan(45.57) = 1.0201$$

target P.F. $\Rightarrow \cos \theta = 1$

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

$$\tan 0 = 0$$

$$\text{kVAR} = 74.6 \times (1.0201 - 0)$$

$$\approx 76.10$$

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

$$= 0.000014$$

$$= 0.000014$$

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$$\approx 1.4 \times 10^{-6} \text{ C}$$

ii) Actual P.F. = 1.0201

Target P.F. = $\cos \theta = -0.9$

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

$$= 154.16$$

$$\tan \theta = -0.48$$

$$\text{KVAR} = 74.6 \times (1.0201 - (-0.48))$$

$$\approx 111.90$$

$$\approx 112$$

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

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

$$= 0.00086$$

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