17/ENG06/055

MECHANICAL ENGINEERING 300LEVEL 17/06/2020

(1)

V = 415V, 3-ϕ 4 wire

f = 50Hz

P = 74.6 KW

P.f = 0.7

Efficiency (%) = 85%

(i) Unity = 1

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

Pf = cos θ = 0.7

θ = cos⁻¹ (0.7)

θ = 45.57°

actual Pf = tan (45.57) = 1.02

KVAR = P x (tan actual Pf x tan t.Pf)

T.P.f = cos θ = 1

cos⁻¹ (1) = 0

tan 0 = 0

∴ KVAR = 74.6 x (1.02 − 0)

= 76.092

$$C = \frac{76.092}{2\pi \times 50 \times 415^2} = 1.4 \times 10^{-6} C$$

(ii) 0.9 lagging

actual P.f = 1.02

T Pf = cos θ = −0.9

∴ θ = cos⁻¹(−0.9) = 154.158°

tan (154.158) = −0.48

KVAR = 74.6 x (1.02 − (−0.48))

= 111.9

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

$$\frac{111.9}{2\pi \times 50 \times 415^2}$$

$= 2.065 \times 10^{-6}$ C

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(2) $V = 415v.$

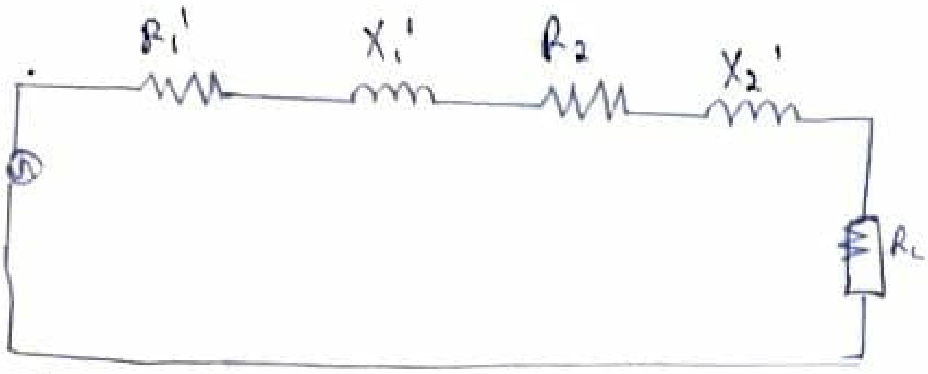
$P = 6.$

$f = 50\ Hz$

$K = 5/6 = 0.83.$

$R + Z_1 = 0.25 + j0.75$ — stator

$Z_2 = 1.173 + j0.52$ — rotor.



Supply voltage per phase, $V = \frac{415}{\sqrt{3}} = 239.60V.$

referring to rotor.

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

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

$= 1.347\Omega$

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

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

$= 1.041.$

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

$= 1.347 + j1.041$

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

$= \underline{1.7\Omega}$

rotor current

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

recall that $E_2 = KV.$

$= 0.83 \times 239.60 = 198.89V.$

$$I_2 = \frac{198.89}{1.7} = 116.99A$$

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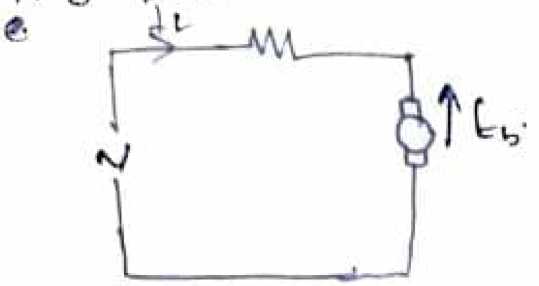
(3) $f = 50Hz$, $1/4 hp$, $N = 2000 rpm$, $V = 220V$, $R = 15\Omega$, $L = 0.25H$

On DC supply:

Supply voltage = 220V.



$V - E_b = I_L \times R$

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

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

$= 209.5V.$

Speed on dc = 2000 rpm

On ac supply:

Supply voltage: 220V.

$I_L = 0.7A.$

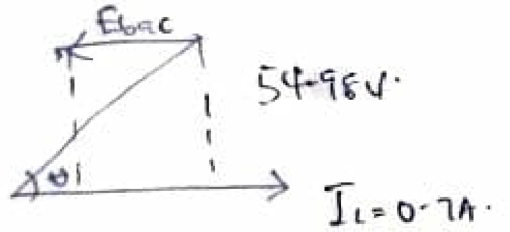
Reactance drop = $I_L \times R = 0.7 \times 15 = 10.5V.$

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

$X_L = jwL = 2\pi fL.$

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

$= 54.98V$



$E_{bac} = \sqrt{V^2 - [X_L]^2} - I_R.$

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

$= 202.52V.$

(i) $\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}}$

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

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

$= \frac{202.52 \times 2000}{209.5V} = \frac{405040}{209.5}$

$= 1933.36 \text{ rpm}$.

(ii) Power factor $\cdot \cos\phi = \frac{E_{bac} + IR}{V}$.

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

$= 0.968$ lagging

(iii) Torque developed $T\omega = E_{bac} \times I$

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

ω = speed in rads per second.

$\omega = \frac{2\pi N}{60}$.

$\therefore \omega = \frac{2\pi \times 1933.36}{60} \approx 202.46 \text{ rad/s}$.

$T_{ac} = \frac{202.52 \times 0.7}{202.46} = \underline{\underline{0.700 \text{ Nm}}}$

(iv) Universal Motor.