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MECHANICAL ENGINEERING
300



1) Abuad mango juice factory is serviced by a 415V, 3-phase, 4-wire, 50Hz. This supply powers the main drive motor having an output ~~factor of 0.7 lagging to to lagging~~ ~~with an effic~~ of 74.6kW and running on full load at a power factor of 0.7 lagging with an efficiency of 85%.
Identify the drive and sketch the motor-supply circuit with a direct-online starter
Determine the capacitance per phase of a mesh-connected capacitor necessary to raise the power factor to:
i) Unity
ii) 0.9 lagging
Sketch the phasor diagram using an appropriate scale showing the computed values of currents.

solution

V = 415V, 3-∅, 4-wire, f = 50Hz, P = 74.6, P.f = 0.7
% eff = 85%

i) $C = \frac{kVAR}{2\pi f v^2}$ , Unity = 1

⇒ kVAR = P × (tan actioned p.f and tan target p.f)

actual p.f → cos θ = 0.7
θ = $\cos^{-1}$ 0.7
= 45.57
tan(45.57) = 1.0201

target p.f ⇒ cos θ = 1
θ = $\cos^{-1}$ 1 = 0
tan 0 = 0
KVAR = 74.6 × (1.0201 − 0)
= 76.10

$$C = \frac{76.10}{2 \times \pi \times 50 \times 41.5^2}$$
= 0.0000014
≃ $1.4 \times 10^{-6}$ C

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(1)

b) 0.9 lagging

~~act~~

actual p.f = 1.0201

~~target p.f =~~

~~target p.f = cos θ = -0.~~

~~cos θ = -0.9~~

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

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

$= 154.16$

$\tan\theta = -0.48$

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

$= 111.90$

$\simeq 112$

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

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

$= 0.00086$

$\simeq 8.6 \times 10^{-4}\, C$

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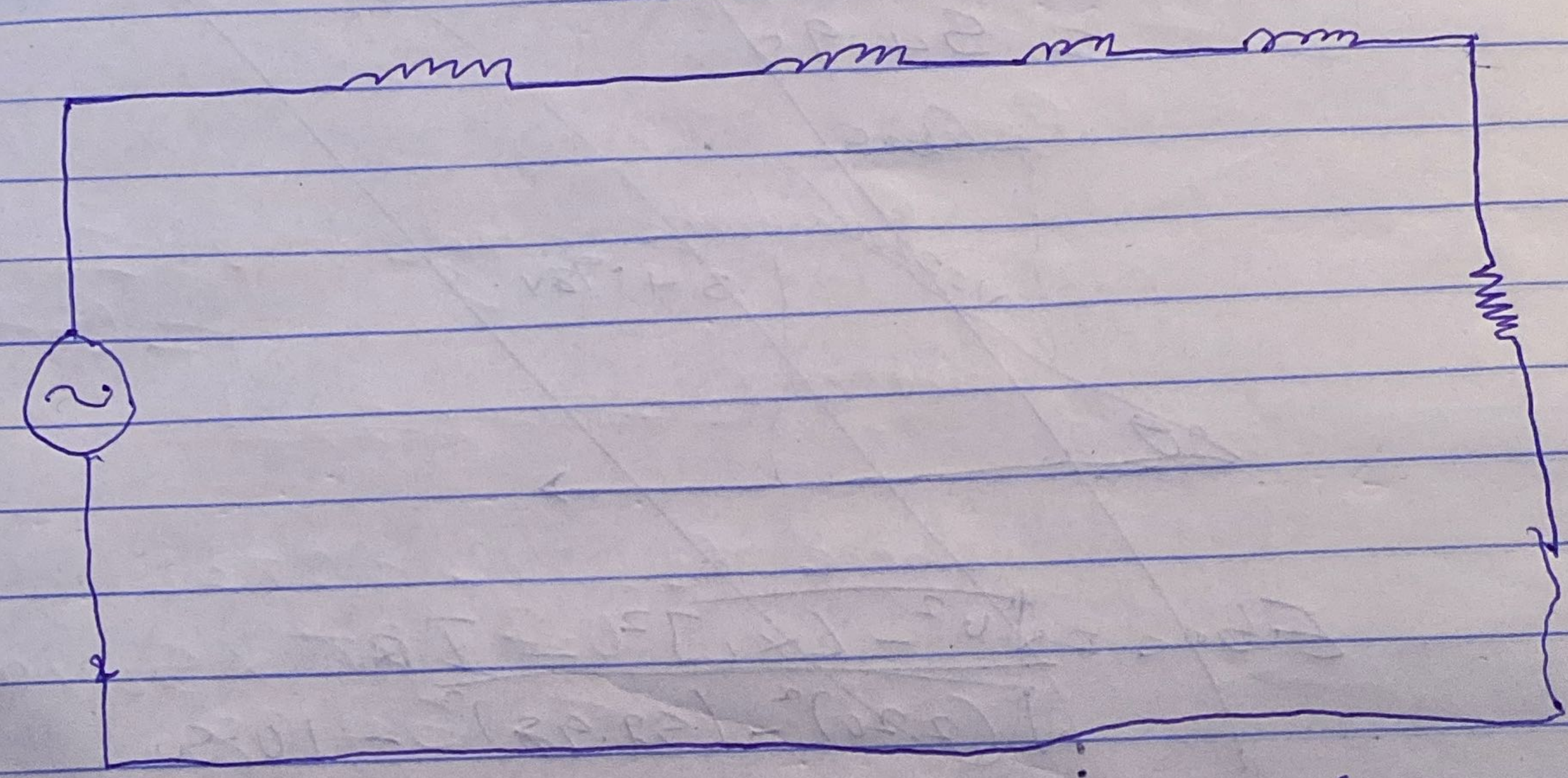
2) $V_L = 415v$
No of pole = 6
F = 50Hz
$K = 5/6 = 0.83$

$Z_1 = 0.25 + j0.75$ - stator
$Z_2 = 1.173 + j0.52$ - rotor



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

Referring ~~voltage~~ to rotor
$R_{02} = (R_2 + k^2 R_1)$
$= (1.173 + (5/6)^2 \times 0.25)$
$R_{02} = 1.347 \Omega$

$X_{02} = (x_2 + k^2 x_1)$
$0.1 (0.52 + (5/6)^2 \times 0.75)$
$= 1.041$
$Z_{02} = R_{02} + X_{2}^{L}$
$= 1.347 + j1 = 0.41$
$Z_{02} = \sqrt{1.347^2 + 1.041^2}$
$= 1.7 \Omega$

To find rotor current
$I_n = \frac{E_2}{Z_{02}}$
Recall that $E_2 = kv_1$

$= 2.39.6 \times 0.83$
$= 1.9967 \Omega$
$\therefore I_2 = \frac{199.67}{1.7} = 117.45A$

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3i) Speed constant is equation

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

so $\frac{E_{bac}}{E_{bac}}$

Making Nac subject of the formula

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

$$2000 \times \frac{200.52V}{207.5V}$$

~~Nac~~

$N_{ac} = 1933.37$

ii) Power factor of the motor

~~cos~~

~~cos~~

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

$$= \frac{202.52 + 10}{220}$$

$= 0.968$ lagging

iii) Torque developed by the motor

~~T~~

$T\omega = E_{bac} \times I$

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

$\omega$ = speed in rad/s

~~w~~

~~w = 2πn~~

$\omega = 2\pi n$, n is speed in

$$T_{ac} = \frac{E_{bac} \times I_2}{2\pi N_{ac}/60}$$

$$= \frac{202.52 \times 0.7 \times 60}{2\pi \times 1933.37} = 0.700 Nm$$

iv) AC supply

Supply voltage = 220V

Current drawn, $I_2 = 0.7A$

Reactance = $I_L R = 0.7 \times 15$

$= 10.5V$

~~Rea~~

~~Reac~~

Reactance voltage drop = $I_L \times X_L$

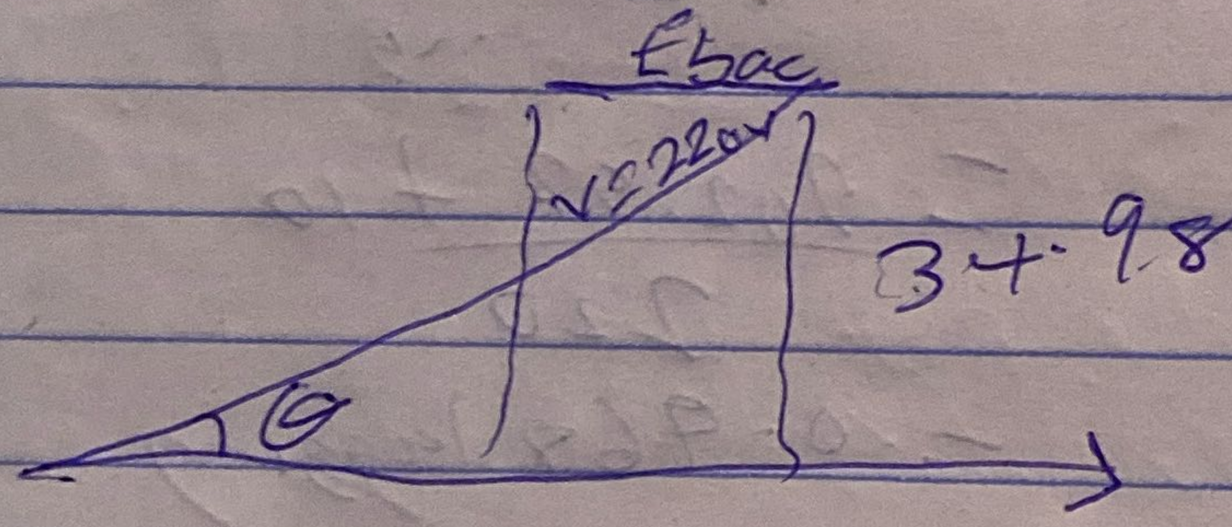
$= 0.7 \times 2\pi f L$

~~where $X_L = j\omega L = 2\pi f L$~~

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

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

$= 54.98V$




$E_{bac} = \sqrt{V^2 - (X_L)^2} - I_R$

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

$= 202.52V$