17/ENG04/048
Elektrical/Elektronics Engineering
300L
ELECTRICAL MACHINES TEST

Question 1

ABUAD Mango juice factory is served by a 415V 3-phase, 4-wire 50Hz. This supply powers the main drive motor having an output of 74.6KW and running on full load at a power factor of 0.7 lagging with an efficiency at 85%. Identify the drive motor type and sketch the motor-supply circuit with a direct online starter
Determine capacitance per phase of mesh-connected capacitors necessary to raise the power to (i) Unity (ii) 0.9 lagging?

Solution

$V_c = 415$ V, 3-ϕ, 4-wire, $f = 50Hz$
$P = 74.6$ p.f = 0.7, % eff. = 85%

i) Unity = $V_c = 415$

$V_p = \frac{415}{\sqrt{3}} = 239.6$

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

$KVAR = P \times (\tan \text{actual p.f} - \tan \text{target p.f})$

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

target p.f $\Rightarrow \cos\theta = 1$
$\theta = \cos^{-1} 0.7$

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$KVAR = 74.6 \times (1.0201 - 0)$
$= 76.0995$
$\simeq 76.10$

$C = \frac{76.10}{2\times\pi\times 50\times 415^2(239.6)^2}$

$= 0.0000014$ $= 42.2\times10^{-6}\,C$ //
$\simeq 1.4\times10^{-6}\,C$ //

(11) 0.9 lagging
actual p.f $= 1.0201$

target p.f $= \cos\theta = -0.9$
$\theta = \cos^{-1}(-0.9)$
$= 154.16$
$\tan\theta = -0.48$

$KVAR = 74.6 \times (1.0201 - (-0.48))$
$= 111.90$
$\simeq 112$

$= \frac{112}{2\times\pi\times 50\times 415^2(239.6)^2}$
$= 0.00086$
$= 8.6\times10^{-4}\,C$
$= 0.0000062$ //
$= 6.2\times10^{-6}\,C$ //

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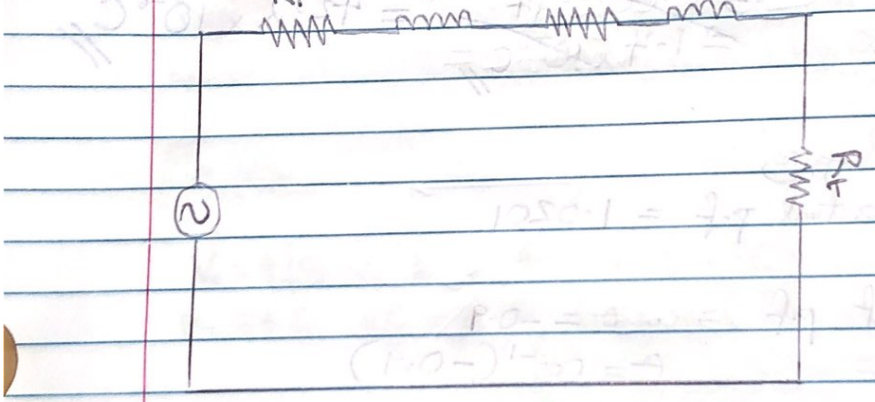
Question 2

(1) $V = 415V$
No of poles = 6
$F = 50Hz$
$K = 5/6 = 0.83$
$Z_1 = 0.25 + j0.75$ ---- stator
$Z_2 = \underset{R_1}{1.173} + j\underset{X_1}{0.52} \quad \underset{R_2}{} \quad \underset{X_2}{}$ ---- rotor



Supply voltage per phase $= \frac{415}{\sqrt{3}} = 239.50V$

Refering to rotor

$R_{02} = (R_2 + K^2R_1)$
$= (1.173 + (5/6)^2 \times 0.25)$
$= 1.347\Omega$

$X_{02} = (X_2 + K^2X_1)$
$= j(0.52 + (5/6)^2 \times 0.75)$
$= 1.041$

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$Z_{02} = R_{02} + X_{02}$
$= 1.347 + j1.041$
$Z_{02} = \sqrt{1.347^2 + 1.041^2}$
$= 1.7\Omega$

In order to get rotor current
$I_2 = \frac{\mathcal{E}_2}{Z_{02}}$
Recall that $\mathcal{E}_2 = KV_1$
$= 239.6 \times 0.85$
$= 199.67N$

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

Question 3

$F = 50Hz$, $\frac{1}{4}hp$, $N_2 = 2000rpm$ $V = 220V$
$R = 15\Omega$ and $0.25H$

On DC supply
Supply Voltage, $= 220V$
Current draws, $I = 0.7A$
$V - \mathcal{E}_b = I_2 \times R$
$V - [I_2 \times R] = \mathcal{E}_b$
$\mathcal{E}_b = 220 - [0.7 \times 15]$
$= 209.5V$
Speed on DC
$N_{dc} = 2000rpm$

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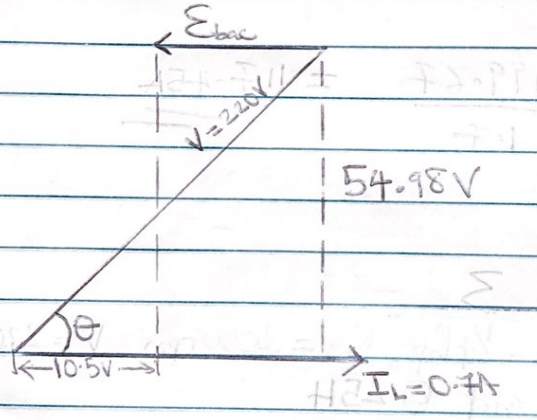
On AC supply
Supply Voltage = 220V
Current draw, I = 0.7A
Reactance drop = $I_2 \times R = 0.7 \times 15 = 10.5V$
Reactance Voltage drop = $I_2 \times X_2$
$= 0.7 \times 2\pi fL$

where $X_L = j\omega L = 2\pi fL$
$= 0.7 \times 2 \times 50 \times 0.25$
$= 54.98V$



$\mathcal{E}_{back} = \sqrt{V_2 - X_2} - IR$

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

$= 202.52V$

(1) Recall speed constants equation

$$\frac{N_2}{N_1} = \frac{\mathcal{E}_{b2}}{\mathcal{E}_{b1}}$$

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$$\frac{N_2}{N_1} = \frac{\mathcal{E}_{b_2}}{\mathcal{E}_{b_1}}$$

$$\text{So } \frac{\mathcal{E}_{bac}}{\mathcal{E}_{bdc}} = \frac{N_{ac}}{N_{dc}}$$

Make N_{ac} the subject of formula

$$N_{ac} = N_{dc} \times \frac{\mathcal{E}_{bac}}{\mathcal{E}_{bdc}}$$

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

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

(ii) Power factor, $\cos\phi = \frac{\mathcal{E}_{bac} + IR}{V}$

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

$$= 0.968 \text{ Lagging}$$

(iii) Torque developed $T_w = \mathcal{E}_{bac} \times I$

$$T_{ac} = \frac{\mathcal{E}_{bac} \times I}{\omega}$$

ω is speed in rad/s

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

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

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

$$= 0.700 Nm$$

(iv) The type of motor to be used for this is Universal motors