Carry-Over

16/ENG04/031 - 400 level - Elect/Elect Engineering

Question number 1;

ABUAD mango juice factory is serviced by a 415V, 3-Ø, 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 of 85%. (a) Identify the drive motor type (b) sketch the motor - Supply circuit with a direct - Online Starter. (c) 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.

Soln

Given parameters;

$V_{line} = 415v$; no of phase = 3; f = 50Hz

$P_{out} = 74.6KW = 74.6 \times 10^3 W$; Pf = 0.7 lagging. Efficiency, $\eta = 85\%$

$V_{phase} = V_{line}/\sqrt{3} = 415/\sqrt{3} = 239.60V$

(a) →

(b) (i) The Capacitance per phase of a mesh-connected capacitor to raise the pf to Unity, 1;

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

⇒ running on full-load at P.f 0.7 lagging;

$\cos\Phi = 0.7$

$\Phi = \cos^{-1}(0.7) = 45.573°$. $\tan(45.573) = 1.02$

At Unity, 1;

$\cos\Phi = 1$

$\Phi = \cos^{-1}(1) = 0$

$\tan^{-1}(0) = 0$

Reactive power, KVAR = $74.6 \times (1.02 - 0)$

$= 76.092$

(1) continuation

16/ENG04/031 - 400 level - Electrical/Electronics Engineering.

$$C = \frac{KVAR}{2\pi f V_{max}^2} = \frac{76.092}{2 \times \pi \times 50 \times (239.6)^2}$$

$$= \frac{76.092}{18,035,305.37} = 4.22 \times 10^{-6} F \text{ or } 4.22 \mu F.$$

ii.) At 0.9 lagging;

from 0.7 lagging $= \cos\theta = 0.7$

$\theta = \cos^{-1}(0.7) = 45.573°$

$\tan^{-1}(45.73) = 1.02°$

$P_f = \cos\theta = 0.9$

$\theta = \cos^{-1}(0.9) = 25.84°$

$\tan^{-1}(25.84) = 0.48°$.

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

$\Rightarrow KVAR = 74.6 \times (1.02 - 0.48)$

$\therefore KVAR = 40.284$.

$\Rightarrow C = \frac{40.284}{2 \times \pi \times 50 \times 239.6^2} = \frac{40.284}{18,035,305.37} = 2.23 \times 10^{-6} F$

$\therefore C = 2.23 \mu F.$

Carry-Over

16/ENG04103/1 - 400 Level - Electrical/Electronics Engineering.

Question Number 2;

A 25hp, 415V (line-line), 6-Pole, 50Hz sta.-sta. connected, 3-Phase induction moto. has used in the production factory of PZ Cussons. Stato./roto. phase voltage ratio of 6/5. The stator & roto. impedences pe. phase are $(0.25 + j0.75)$ ohms & $(1.173 + j0.52)$ respectively. Using the approx. circuit version 2 referred to the roto. side at a slip of unity. Find the following;

i) Draw the equivalent circuit diagram referred to the roto. side

ii) Roto. (secondary) current, I_2.

Solo

Given parameters;

hp. horsepowe., $h_p = 25hp$.

$V_{line} = 415v$.

P number of poles, $P = 6$ poles

Frequency, $f = 50Hz$

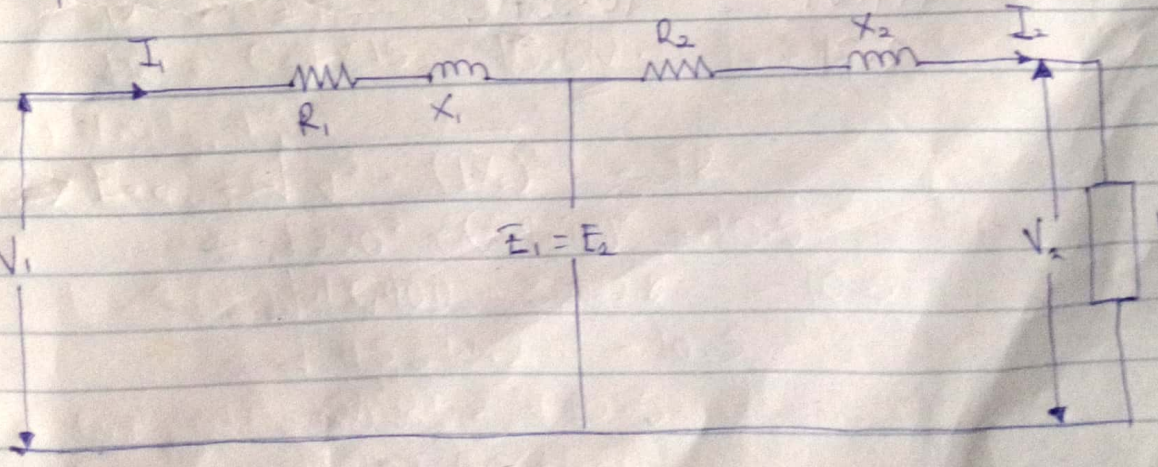
Voltage ratio, $K = 6:5 = 6/5 = 1.2$.

Stato. Impedance, $Z = (0.25 + j0.75)\Omega$ (R_1, X_1)

Roto. Impedance, $Z = (1.173 + j0.52)\Omega$ (R_2, X_2)

Slip, $S = \text{Unity}, 1$.

i) Equivalent Circuit diagram referred to the Roto. (secondary) side;



V_{phase} is given as $= \frac{415}{\sqrt{3}} = 239.600v$.

(2) continuation

16/ENG04/031 - 400 level - Electrical / Electronics Engr.

⇒ referring to the rotor (secondary) side

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

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

$\therefore R_{02} = 1.53\ \Omega$.

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

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

$X_{02} = j1.6$

$\Rightarrow Z_{02} = R_{02} + jX_{02}$

$= 1.53 + j1.6$

$= \sqrt{(1.53)^2 + (1.6)^2}$

$\therefore Z_{02} = 2.21\ \Omega$.

ii.) The Rotor Current, I_2;

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

But $E_2 = kV_1$

$= 239.6 \times 0.83$

$= 199.67\text{v}$.

or $I_2 =$ [illegible] $=$ [illegible].

$\therefore I_2 = \frac{199.67}{2.21} = 90.35\text{A}$.

Carry-Over

16/ENG04/031 - 400level - Electrical/Electronics Engineering.

Question 3:

A 50Hz, ¼hp motor runs at 2Krpm and takes 0.7A when connected to a 220V AC source. If the resistance & Inductance of the machine are given as 15Ω & 0.25H respectively. Determine the following when the motor is connected to a 220V, 50Hz AC supply & is loaded to take 0.7A of current;

i.) Speed of the motor ii.) The P.f of the motor iii.) Torque developed by the motor iv.) What type of motor could be used for this application?

Soln

Given Parameters;

f = 50Hz, N = 2000rpm(dc); R = 15Ω; L = 0.25H

I = 0.7A; V = 220V.

$E_{ac} = V - IR$

$= 220 - 0.7A \times 15$

$E_{ac} = 209.5V$.

$$E_{ac} = \sqrt{V^2 - (IX_L)^2} - IR$$

finding IX_L; as $X_L = 2\pi fL$

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

$= 54.98$

$I_R = I$

$I_R = 0.7 \times 15 = 10.5V$.

$\Rightarrow E_{ac} = \sqrt{V^2 - (IX_L)^2} - IR$.

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

$= \sqrt{48,400 - 3,022.8} - 10.5$

$= \sqrt{45,377.2} - 10.5$

$= 213.02 - 10.5$

$\therefore E_{ac} = 202.52V$

(3 continuation)

16/ENG04/031 - 400level - Elect/Elect Engineering.

i.) The Speed of the motor (AC);

From the eqn.

$$\frac{N_{ac}}{N_{dc}} = \frac{E_{ac}}{E_{dc}}$$

$$\frac{N_{ac}}{2000} = \frac{202.52}{209.5}$$

$$N_{ac} = \frac{2000 \times 202.52}{209.5}$$

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

ii.) The power factor of the AC supply motor;

$$P.f = \frac{E_{ac} + IR}{V} = \frac{202.52 + 10.5}{220} = \frac{213.02}{220} = 0.968.$$

iii.) The torque developed by the motor;

$$\tau = \frac{EI}{2\pi N_{ac}/60}$$

$$\Rightarrow \tau = \frac{202.52 \times 0.7}{2 \times \pi \times 1933.37/60} = \frac{141.764}{\frac{12,147.72}{60}} = \frac{141.764}{1} \times \frac{60}{12,147.72}$$

$$= \frac{8,504.84}{12,147.72} = 0.70 \text{ Nm.}$$

iv.) The type of motor that could be used for this application is a Universal motor because it's designed to be able to run on either DC or single phase AC supply.