15.5

University of Jordan Dept. of Elect. Engg.	Electric Machines (0903471) First Examination	Date:13.7.2014 Time:50 minutes

Name (in Arabic) محمد مصطفى عيسى

Student No. 0115379

1. Answer the following with √ for correct and X for wrong answer.

3marks

1	The rotor flux in induction motor rotates at the same speed of the stator magnetic field	X	×
2	The V-curve is the stator current against field current for synchronous motor of salient poles but not for cylindrical rotor type	X	
3	The staring of synchronous motor can be achieved by starting it by an induction motor at no-load	✓	
4	The rotating magnetic field is produced by three phase winding spaced by 120° mechanical degrees independent of the number of poles	X	
5	Wound rotor induction motors have 3 slip rings and external variable resistances in series with the rotor winding.	✓	×
6	Damper winding of synchronous motors are special bars laid into notches carved in the rotor face and are open circuited at both ends	✓	X

2

2. A 400V, 200kW, 50Hz, star connected synchronous motor operating at 0.8 p[…] factor lagging with a synchronous reactance of 0.2Ω and negligible resistance. [T…] motor operates at the linear part of the characteristics. The field current is adju[…] 40A.

6mark[…]

(i) Calculate the induced emf and the torque angle δ

$$I_a = \frac{200\,000}{\sqrt{3} * 400 * 0.8} = 360.8 A \angle -36.86^\circ$$

$$E_a = V_\phi - jI_a X_s$$

$$= \frac{400}{\sqrt{3}} - j(360.8 \angle -36.86^\circ) 0.2$$

$$\Rightarrow E_a = 196.3$$

(ii) Keeping the load constant, the field current is adjusted to reach input po[…] with unity power factor. Find the value of the necessary field current

@ unity pF

$$I_a = \frac{200\,000}{\sqrt{3} * 400 * 1} \angle 0^\circ = 288.6 \angle 0^\circ$$

$$E_{a_2} = 238 \angle -14^\circ$$

$$\frac{E_{a1}}{E_{a2}} = \frac{I_{f1}}{I_{f2}} \quad (40)$$

$$I_{f2} = 48.5 A$$

(iii) Keeping the load constant, the field current is adjusted to 60A what would [be] the power factor then?

$$\frac{\sin \delta_1}{\sin \delta_3} = \frac{I_{f3}}{I_{f1}}$$

$$\frac{\sin(-17.1)}{\sin \delta_3} = \frac{60}{40}$$

$$\delta_3 = -11.3^\circ$$

$$\frac{E_{a1}}{E_{a3}} = \frac{I_{f1}}{I_{f3}} \quad (196.3,\ 40,\ 60)$$

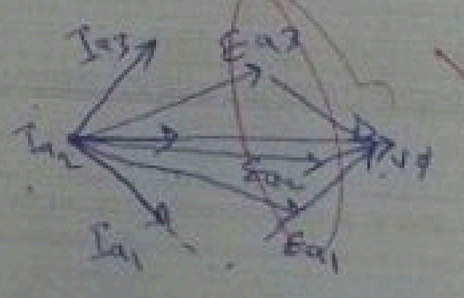
$$E_{a3} = 294.45 \angle -11[…]$$

$$294.45 \angle -11.3 = \frac{400}{\sqrt{3}} - j[…]$$

$$I_a = 408.34 \angle 45$$

PF = 0.7 lead

(iv) Sketch the phasor diagram for the three cases above on the same diagram



5

A factory having the following loads: $\Rightarrow P = \frac{400 * 746}{0.88} = 339$

(i) A 400 hp induction motor of an efficiency of 88% and operating at 0.85 p.f. lagging

(ii) A 400kVA load at 0.7 p.f. lagging

(iii) A lighting load of 200kW at unity p.f.

(iv) A synchronous motor of 600kVA

It is required to get an over all load of the factory of unity p.f. What is the possible mechanical load (in hp) connected to the shaft of the synchronous motor if its efficiency is 90%.

5marks

Load	P	Q	S	PF	θ
IM	334 KW	210.1 KVAR	398.8 kVA	0.85	31.79°
load	280 KW	285.6	400 KVA	0.7	45.5°
Lighting load	200 kW	0	200 KVA	1	0
SM	338 kW	-495.7	600 kVA		
Total	1157 KW	0	1157 KVA	1	0

5

$|S| = \sqrt{P^2 + Q^2}$

$P = \sqrt{S^2 - Q^2} = \sqrt{600^2 - (495.7)^2}$

$= 338 \text{ kW}$

SM $P = 338 \text{ kW} \Rightarrow \frac{338k * 0.9}{746} = 407 \text{ hp}$

total power

$= 1157 \text{ KW}$

$P_{SCL} = 3 I_\phi^2 R_1$

$I = \frac{V_\phi}{Z_{tot}}$

ω_m

4. A 100hp, 400V, 3-phase 50Hz, 4-poles, 1440rpm, Y-connected induction motor of 88% efficiency and 0.85 power factor lagging. Stator resistance = 0.05 Ω. Find: **6marks**

a. The supply current

$P = \sqrt{3} V_L I_L \cos\theta$ (pf)

$P = \frac{100 * 0.746}{0.88} = 84 KW$

$I = \frac{84000}{\sqrt{3} * 400 * 0.85}$

$I = 142.64 A$

b. The stator cupper loss

$P_{SCL} = 3 I_1^2 R_1$

$= 3 * 142.64^2 * 0.05 = 3051.9 W$

c. The airgap power

$P_{AG} = P_{in} - P_{SCL}$

$P_{in} = \sqrt{3} V_L I_L pf$

$P_{in} = \sqrt{3} * 400 * 142.64 * 0.85 =$

$P_{AG} = 80.948 KW$

d. The developed torque

$\tau_{developed} = \tau_{induced} = \frac{P_{AG}}{\omega_{sync}} = \frac{80.948 K}{1440}$

$\tau_{ind} = 56.2$

3.5

e. The mechanical power

$P_{mech} =$

f. The rotational losses