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**DEPARTMENT: Electrical/Electronic Engineering**

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**ASSIGNMENT**

**Question 1**

1. A 6-Pole, 50Hz, 3 Ø slip ring induction motor has a resistance of 0.5Ω per phase and a reactance of 5Ω per phase in the rotor state. Calculate;
2. The speed at which the torque is at maximum
3. The ratio of the starting torque to the maximum torque
4. Value of the external resistance per phase needed so that the starting torque is half of the max torque

**Solution**

1. Rotor resistance per phase R2=0.5Ω

Rotor standstill reactance per phase X2= 5Ω

Torque under running conditions is maximum at the value of slip

Slip corresponding to maximum torque, Smax= R2/X2= $\frac{0,5}{5}$= 0.1

Speed corresponding to maximum, s = 

 = Nr=Ns-sNs = 1000-(0.1) \*(1000) = 900rpm

1. Ratio of rotor resistance to rotor standstill resistance

 a= R2/X2 = $\frac{0.5}{5}$= 0.1

Ratio of $\frac{Maximum torque}{Starting torque}$ = a2+1/2a = (0.1)2+1/2(0.1) = 5.05

1. Ratio of starting torque Tst and maximum torque Tmax

Tst/Tmax = 2a/a2+1 = 0.5 recalling a = 0.1

 Where Tst = $\frac{1}{2}$Tmax

Then a2-4a+1=0

Solving quadratically we have;

a = $\frac{4\pm \sqrt{16}-4}{2}$= 0.268

If the torque is half the normal value then

R2+r/X2 = 0.268

Making r subject of formula

r = 0.268X2-R2 = (0.268 × 5) – 0.5 = 0.84Ω

Therefore, the external resistance added will be 0.84 ohms

**Question 2**

1. The starting and max torque of a 3 – Ø induction motor are 1.5 and 2.5 times its full load torque respectively. Determine the percentage change in the rotor circuit resistance to obtain a full load slip of 0.03. Neglect the stator impedance

**Solution**

Starting torque Tst = 1.5T

Maximum torque Tmax = 2.5T

 Tst/Tmax = 1.5/2.5 = 0.6

 3a2-10a+3=0

(3a-1) (a-3) = 0

a=$\frac{1}{3}$

 R2/X2= a = $\frac{1}{3}$

Rotor resistance R2 = $\frac{1}{3}$ X2

TF ÷ Tmax = 2aSf ÷ a2+Sf2

1 ÷ 2.5 = 2a×0.03/a2+(0.03)2

Tmax = 2.5T , SF= 0.03

a2- 0.15a + 0.0009 = 0

by using quadratic equation we have;

a = $\frac{0.15\pm \sqrt{0.0225}-4×0.0009}{2}$ = 0.1437 or 0.00626

but 0.1437 is more feasible,

Percentage change in rotor resistance =  = 56.9%

**Question 3**

1. A 3- Ø, 50Hz induction motor has a starting torque which is 1.25 times full load torque and a maximum torque which is 2.5 times full load torque. Neglecting stator resistance and rotational losses and assuming constant rotor resistance. Calculate
2. The slip at full load
3. Slip at maximum torque
4. Rotor current at starting in per unit of full load rotor current

**Solution**

Starting torque Tst= 1.25T

Maximum torque Tmax = 2.5T

Tst / Tmax = 2a/a2+1 = $\frac{1.25}{2.5}$= 0.5

Therefore, solving quadratically,

 = a2-4a+1 = a= $\frac{4\pm \sqrt{16}-4}{2}$ = 0.268

 Tf / Tmax = 2aSf / a2+SF2

 1/2.5 = 2×0.268/ (0.268)2+Sf2

 Sf2-1.34Sf+0.0718=0

1. Full load slip Sf = $\frac{1.34\pm \sqrt{1.7956}-4×0.0718}{2}$ = 0.056 = 56%
2. Smax= a = 0.268 = 26.8%
3. Rotor current at stator

Ist= 

Rotor current at full load

If = 





= 

**Question 4**

1. A 3-Ø, 4 pole, 50Hz induction motor at standstill has 120v induced across its star-connected terminals. The rotor resistance and standstill resistance per phase are 0.2 and 1.0Ω respectively. Calculate the speed when the rotor is drawing a current of 16A at particular load, also calculate the speed at which the torque is at the corresponding value of rotor input.

**Solution**

I2 =  where R2 = 0.2 and X2 = 1.0 Ω, E2 = $\frac{120}{√3}$ , I2 = 16

making s subject and imputing all the values

then s= 0.04747

motor speed N= Ns(1-S) = $\frac{120f}{p}$(1-s) = $\frac{120f}{p}\left[1-0.04747\right]$ = 1.420rpm

Smax = R2/x2 = 0.2/1 = 0.2

Slip corresponding to the torque N= Ns(1-Smax) = $\frac{120f}{p}$(1-s) = $\frac{120×50}{4}[1-0.2]$ = 1,200rpm

Rotor impedance Z2 = 

= 

Induced Emf in rotor per phase = SE2 = 0.2 × $\frac{120}{√3}$ = 13.856v

 Rotor current per phase I2 =  = $\frac{13.856}{0.283}$ = 49A

Power factor of rotor circuit, cosØ2 =  = 

Power supplied to rotor = Ø2

= 