Problems

① A 6 pole lap wound dc shunt motor has 500 conductors in the armature. The resistance of the armature is 0.05Ω the resistance of the shunt field is 25Ω Find the speed of the motor when it takes 120A from a 100V dc supply. φ per pole is 20mwb

→ $E_b = \frac{P\phi ZN}{60A}$

$P = 6$ $\quad N \Rightarrow ?$ $\quad R_a = 0.05$

$\phi = 20m\,wb$ $\quad R_f = 25\Omega$

$\cancel{I_a} = 120A$ $\quad A = 6$

$V = 100V$ $\quad Z = 500$

$I_L = 120A$

$I_f = \frac{V_f}{R_f} = \frac{100}{25}$

$= 4A$

$I_L = I_f + I_a$

$I_a = I_L - I_f$

$= 120 - 4$

$= 116A$

$V = I_a R_a + E_b$

$100 = 116(0.05) + E_b$

$E_b = 94.2V$

$N = \frac{E_b \times 60A}{P\phi Z}$

$= \frac{94.2 \times 60 \times 6}{6 \times 20 \times 10^{-3} \times 500}$

$N = 565.2\,rpm$

Calculate the speed when the load on the motor is reduced by 20%.

Soln → Load reduced by 20%

$I_L = \frac{120 \times 20}{100} = 24 = I_{L1}$

$\therefore$ I_L is reduced by $120 - 24 = 96 A$

$N = \frac{94.5 \times 60 \times 6}{6 \times 20 \times}$ $\quad I_a = I_L - I_f$

$= 96 - 4 = 92 A$.

$V = 92 \times (0.05) + E_b$

$100 - 4.6 = E_b$

$E_b = 95.4 V$

$N = 95.4 = 572.4 rpm$.

iii) 50% of load

$I_L = \frac{120 \times 50}{100} = 60 A$ $\quad I_a = I_L - I_f = 56 A$.

$V = 56 \times (0.05) + E_b$

$100 - 2.8 = E_b$.

$E_b = 97.2 V$

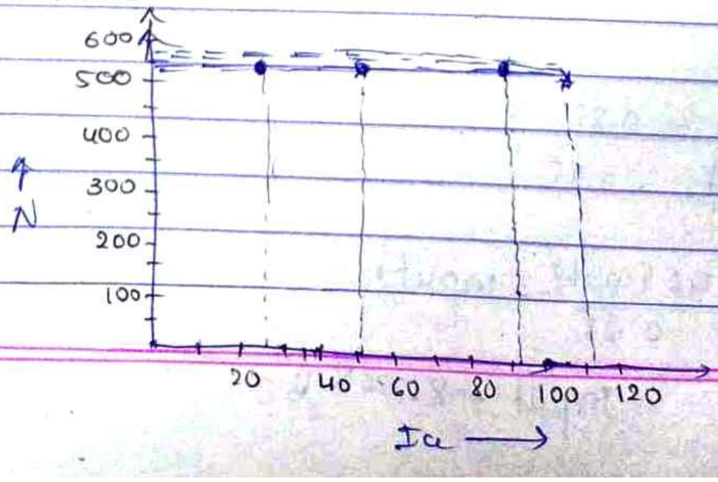
$N = 583.2 rpm$.

iv) 25% of 120A.

$I_L = 30$ $\quad I_a = 30 - 4 = 26 A$.

$E_b = 100 - 1.3 = 98.7$

$N = 592.2$



② A 230V motor has an armature circuit resistance of 0.6Ω if the full load armature current is 30A and no load armature current is 4A Find the change in back emf. Find the % change in back emf from no load to full load.

Soln: $V = 230V$ $\quad$ $R = R$

$R_a = 0.6\Omega$

$I_{a_{FL}} = 30A$

$I_{a_{NL}} = 4A.$

$E_b = V - I_aR_a$

$E_b = 230 - 30(0.6)$

$= 212V$

$E_b = V - I_aR_a$

$= 230 - 4(0.6)$

$E_b = 227.6$

Change in back emf :- $227.6 - 212 = 15.6$.

% change in back emf : $\frac{15.6}{227.6} \times 100 = 6.85\%$

③ A 440V DC shunt motor has an armature resistance of 0.8Ω and field resistance of 200Ω Determine E_b when giving an output 7.46 kwatt at 85% efficiency.

$R_f = 200\Omega$ $\quad$ $P_{o/p} = 7.46kW$

$R_a = 0.8\Omega$

$\eta = 0.85$

$\frac{\text{output}}{\text{input}} = 0.85$

$V = I_a(R_{se} + R_a) + E_b$

$\eta = 0.85$

$\frac{\text{output}}{\text{input}} = 0.85$

$\frac{7.46}{E_b} \times 100 = \frac{85}{100}$

$\frac{7.46\ \text{kwatt}}{0.85} = \text{input}$

$\text{input} = 8.776 \times 10^3$

output hp → horsepower

$\boxed{1hp = 746\,watt}$

$P_{o/p} = 7.46\,kW$

Input power : $8.776 \times 10^3 = V \times I_L$

$I_L = \frac{8.776 \times 10^3}{440}$

$= 19.946A.$

output $= 7.46kW$

$= 10hp$

$\therefore \quad I_a = I_L - I_f$

$= 17.746A$

$I_f = \frac{V}{R_f} = 2.2A$

$E_b = V - I_a R_a$

$= 440 - (17.746)(0.8)$

$E_b = 425.8V$

(Q) A 250V DC series motor has an armature resistance of 0.08Ω and field resistance of 0.02Ω and produces full load torque when running at 500rpm and taking the current of 40A. Calculate:

i) ~~Aram~~ Armature current ii) speed when producing half of the full load torque

$V = 250V \quad R_a = 0.08\Omega \quad R_{fe} = 0.02\Omega$

~~N = 8~~ $N = 500rpm \quad \cdot I_L = 40A$

$I_a = I_L = 40A$

~~Eq~~:

$V = I_a(R_{fe} + R_a) + E_b.$

$250 = 40(0.08 + 0.02) + E_b$

$E_b = 246V$

$\cancel{E_b = \frac{P\phi ZN}{60A}}$

$T \propto I_a^2$

$T_1 \propto 40^2 \quad — (1).$

$0.5T_1 = T_2 \propto I_{a_2}^2 \quad — (2)$

$\frac{\cancel{T_1}}{0.5\cancel{T_1}} = \frac{40^2}{I_{a_2}^2}$

$I_{a_2} = 28.28A$

$E_b \propto \phi N$

$\phi \propto I_a$

$E_b \propto I_a N$

$$\frac{E_{b_1}}{E_{b_2}} = \frac{I_{a_1} N_1}{I_{a_2} N_2}$$

$E_{b_2} = V - I_{a_2}(R_a + R_{se})$

$= 250 - 28.28\,(0.1)$

$E_{b_2} = 247.172$

$$\frac{246}{247.172} = \frac{40(500)}{28.28 N_2}$$

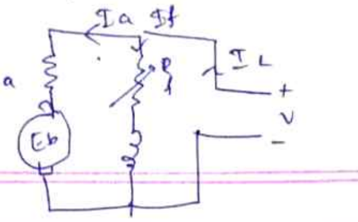
$E_{b_1} = V - I_{a_1}(R_a + R_{se})$

$= 250 -$

$$N_2 = \frac{40 \times 500 \times 247.172}{246 \times 28.28}$$

$N_2 = 711.4$ rpm.

30/7/22
Lesson plan.



(3) $\phi = 30 m wb$ $V = 220V$ $I_f = 1A$

$A = 4$ ~~$P_o = 5.6kW$~~ T ~~$I_L = 32A$~~

$Z = 540$ $R_a = 0.1\Omega$

$P = 4$.

$$E_b = \frac{P\phi Z N}{60A} = \frac{4 \times 30 \times 10^{-3} \times 540 \times N}{60 \times 4} = 216.9$$

$$N = \frac{216.9 \times 60 \times 4}{4 \times 30 \times 10^{-3} \times 540}$$

$$N = 803.33 rpm$$

$E_b = $ $I_L = I_a + I_f$

$I_a = 31A$.

$V = I_a R_a + E_b$

$220 = 31 \times 0.1 + E_b$

$E_b = 216.9$

$$T = 0.159 \phi Z I_a \frac{P}{A}$$

$$= 0.159 \times 30 \times 10^{-3} \times 540 \times 31 \times \frac{4}{4}$$

$$= 79.84 Nm.$$

---

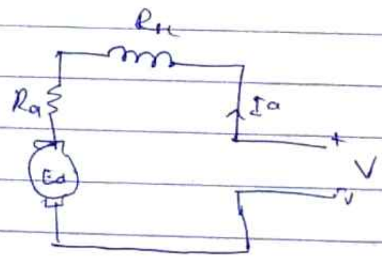
(4) $V = 220V$ $N_{initial} = 700 rpm$ $I_a = 100A$

Series motor $R_a + R_{se} = 0.1\Omega$ $T_2 = 0.7T_1$

$V = I_a (R_{se} + R_a) + E_b$

$220 = 100(0.1) + E_b$

$E_b = 210$



$$\frac{T_1}{T_2} = \frac{I_{a_1}^2}{I_{a_2}^2}$$

$$\frac{T_1}{0.7T_1} = \frac{(100)^2}{I_{a_2}^2}$$

$I_{a_2}^2 = 7000$

$I_{a_2} = 83.66A$

$$\frac{N_1}{N_2} = \frac{I_2}{I_1}$$

$$\frac{700}{N_2} = \frac{83.66}{100}$$

$$N_2 = \frac{700 \times 100}{83.66}$$

$$N_2 = 836.72 rpm.$$

Torque is reduced by 30% = 70% of starting torque

PMDC motor $I_f = 0$ permanent magnets are used.

$$\frac{E_{b_1}}{E_{b_2}} = \frac{I_{a_1} N_1}{I_{a_2} N_2}$$

$$E_{b_2} = V - I_{a_2}(0.1)$$
$$= 220 - 8$$
$$= 211.63$$

$$\frac{210}{211.63} = \frac{100 \times 700}{83.66 \times N_2}$$

$$210 (83.66 \times N_2) = 100 \times 700 \times 211.63$$
$$N_2 = \frac{100 \times 700 \times 211.63}{83.66 \times 210}$$
$$= 843.21 \text{ rpm}$$

c) $R_a = 0.2\Omega$ $V = 24V$ $I_f = 0$ $N_1 = 1200 \text{ rpm}$
$I_L = 0.5A$ $N_2 = 1120 \text{ rpm}$ $P = ?$

$$E_{b_1} = V - I_{a_1} R_a$$
$$= 24 - 0.5 \times 0.2$$
$$E_{b_1} = 23.9V$$

$$E_b = \cancel{\frac{P\phi Z N}{60 A}}$$

$$\frac{23.9}{E_{b_2}} = \frac{1200}{1120}$$
$$E_{b_2} = 22.3V$$

$$E_b = V - I_{a_2} R_a$$
$$22.3 = 24 - I_{a_2}(0.2)$$
$$I_{a_2} = 8.5A$$

$$P = V \times I_{a_2}$$
$$= 24 \times 8.5$$
$$= 204 \text{ watt}$$

4/7/22 **Three phase Induction Motor**

- It is widely used for all industrial application
1) It has a rugged construction
ii) it is self starting
iii) it has higher efficiency & less maintenance
iv) it can cater to both constant speed & high starting torque application.

Three phase induction motor:

i) Stator ii) Rotor

in 3ϕ induction motor, stator receives 3ϕ AC input voltage

- 3ϕ AC voltage as input
- AC voltage is given to stator
- Armature RYB together will form one pole.
- flux is produced in stator.

DC Motor	Induction Motor
- DC input voltage is given as input	- 3ϕ AC voltage
- DC voltage is supplied to rottatory part i.e. rotor	- AC voltage is supplied to stationary part i.e. stator
- flux is produced in yoke (DC flux)	- flux is produced in stator itself (AC flux)
	- Armature RYB will together forms one pole
- Outter pherephere	- Inner perephere

$\phi_R = \phi_m \sin\omega t$

$\phi_y = \phi_m \sin(\omega t - 120^\circ)$

$\phi_B = \phi_B \sin(\omega t - 240^\circ)$

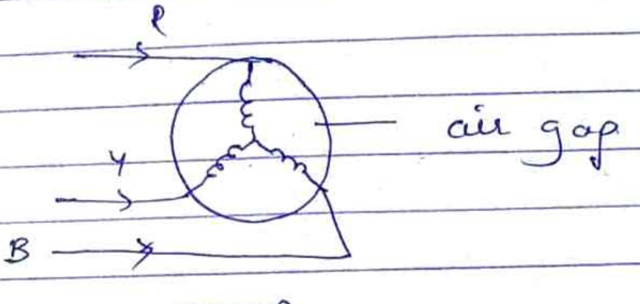
Stator - 3ϕ input voltage

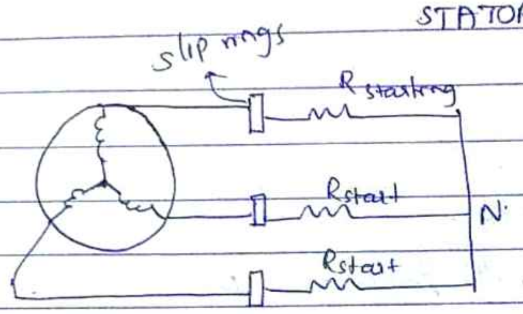
Rotor : SRIM : slip ring induction motor

SQIM Squirrel cage induction motor

SRIM:

The rotor is madeup of high silicon content steel stamping which are cut on the outer phuiphui

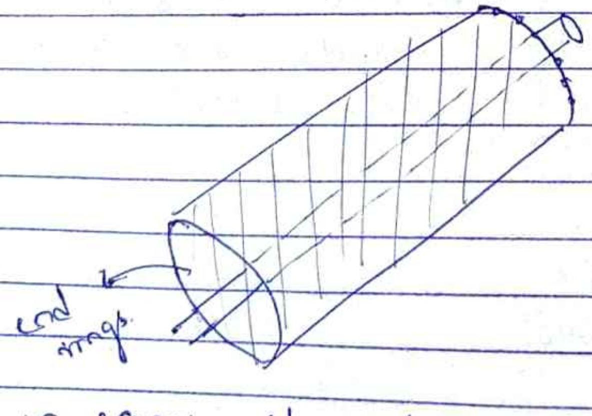




- func of Rstarting ~~is~~: It increases the starting torque
- during motor running condition slip rings slip on each other thereby disconnecting starting resistance
- These type of motors are used in high torque

SQIM

Thick copper plates are inserted in rotor slots and are permanently welded on to the end rings. It is used at constant speed application

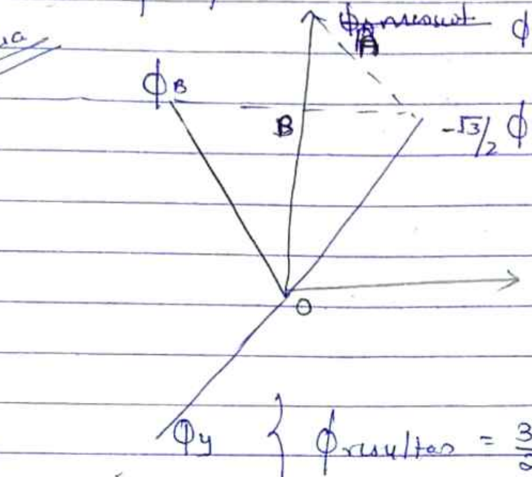


in SQIM, the rotor circuit comprises of thick Cu plate which are permanently welded on to end rings.

Explain how a rotating magnetic field (RMF) by phasor dia. taking two cases for ωt

- There is no provision to connect resistance to crt ckt
- It's outer pheriphery is cut into slots.

Phasor dia



ϕ resultant = OA
= 2OB
= $2\cos 30\ \frac{\sqrt{3}}{2}\phi_m$
= $\frac{\sqrt{3}}{2}\cdot\sqrt{3}\,\phi_m$
= $3/2\,\phi_m$.

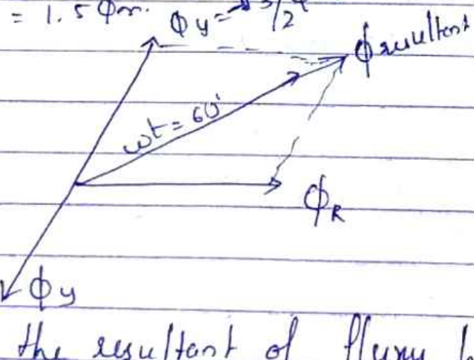
$\left\{ \phi_{resultan} = \frac{3}{2}\phi_m \right\}$

$\phi_{result} = 1.5\phi_m$
$\omega t = 0$.

i) $\omega t = 0$
$\phi_R = 0$
$\phi_y = \phi_m \sin(0-120^\circ) = -\sqrt{3}/2\,\phi_m$
$\phi_B = \phi_m \sin(0-240) = \sqrt{3}/2\,\phi_m$
$\phi_m = \phi_R - \phi_B$
$\phi_m =$

$\phi_{result} = 1.5\phi_m$

ii) $\omega t = 0$
$\phi_R = \phi_m \sin \omega t$
$\phi_R = \phi_m \sin 60^\circ = \sqrt{3}/2\,\phi_m$
$\phi_R = \phi_m \sin(-120)$
= $\phi_m \sin(60-120)$
= $-\sqrt{3}/2\,\phi_m$.
$\phi_B = \phi_m \sin(60-240)$
= $\phi_m \sin(-180)$
= 0.



- Hence the resultant of flux has a constant magnitude of $1.5\phi_m$ & is continously changing its direction
- which means a rotating magnetic field of speed is called as synchronous speed is established & is denoted by N_s.

Now, $N_s = \frac{120f}{P}$ ∴ f is frequency of 3ϕ supply voltage
P is no. of poles of induction motor

WORKING OF A 3ϕIM

i) 3ϕ supply is given to the stator windings which produces three phase fluxes, whose resultant is equal to 1.5ϕ_m & rotating at a speed called as synchronous speed.
given by $N_s = 120f/p$.

ii) This RMF cuts the rotor conductors thereby inducing emf in them.

iii) The rotor winding is a closed ckt, hence induced currents are set up. As a result each rotor conductor has its own magnetic field.

iv) The resultant effect of the two fields make the rotor ~~to at~~ a to rotate at a speed N

v) The rotor speed N is always less than N_s. (syncronous speed)
(Because
→ ~~The rotor sp~~ If $N = N_s$ then relative speed becomes zero, hence no induced emf in the rotor so the rotor stops rotating

This difference in speed ~~is~~ called as the slip speed
$= N_s - N$

$$s = \frac{N_s - N}{N_s}$$

$$\%\, slip = \frac{N_s - N}{N_s} \times 100$$

Slip is 1 at the instant of rotation $\because N = 0$.

N is 1 at start

Relation between f, f' and s.

f → supply frequency

f' → frequency of the rotor induced emf.

$f \propto N_s$ — ①

$f' \propto N_s - N$ — ②

$\frac{f'}{f} = \frac{N_s - N}{N_s} = s \rightarrow$ slip

$f' = sf$

Input to the induction motor : $P = \sqrt{3} V_L I_L \cos\phi$

$N_s = \frac{120 f}{P}$

$s = \frac{N_s - N}{N_s}$

$f' = sf$

⑥ $V = 440V$ $f = 50Hz$ $P = 4$

$p.f = 0.85$ $P = 10 \times 746$

$\cos\phi = 0.85$ $N = 1450$ rpm. $\eta = 90\%$

ii) $N_s = \frac{120 \times 50}{4} = 1500$

$s = \frac{1500 - 1450}{1500}$

$= 0.03333$

$s\% = 3.33\%$

iii) $f' = sf$

$f' = 0.03333 \times 50$

$= 1.666\ Hz$

$\eta = \frac{o/p}{i/p}$

$i/p = \frac{o/p}{\eta}$

$= \frac{7460}{0.90}$

$= 8288.88$

i)

$I_L = \frac{o/p}{V_L \sqrt{3} \cos\phi}$

$= \frac{7460}{440 \times \sqrt{3} \times 0.85}$

$= \frac{\cancel{7460}}{647.78} = \frac{8288.88}{647.78}$

$= 12.79A$