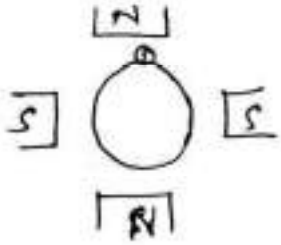
<UNIT-4>

< Electrical Machine >

Que-1> Drive the Expression for e.m.f equation of D.C. Generator.

Ans.>



Let ϕ → flux per pole
N → Speed of ~~armature~~ Generator in R.P.M.
Z → Total no of Conductor
P → no of Pole of Generator

* Flux cut by 1 Conductor in one revolution = $P\phi$
* Flux Cut by Conductor in one Second = $P\phi \times N/60$
" now flux cut by Conductor in one Second is actually a average value of Induced e.m.f. because

$$e = \frac{d\phi}{dt} \quad \text{So average value is} \quad e = \frac{\Delta\phi}{\Delta t}$$

+ average value of Induced e.m.f per Conductor = $P\phi \times N/60$

now no. of Conductor in Series is given by

$$Z^* = \frac{Z}{A} \quad \text{where A} \rightarrow \text{no of parallel Path}$$

+ Total Induced e.m.f. is given by $E = \phi P \times N/60 \times Z^*$

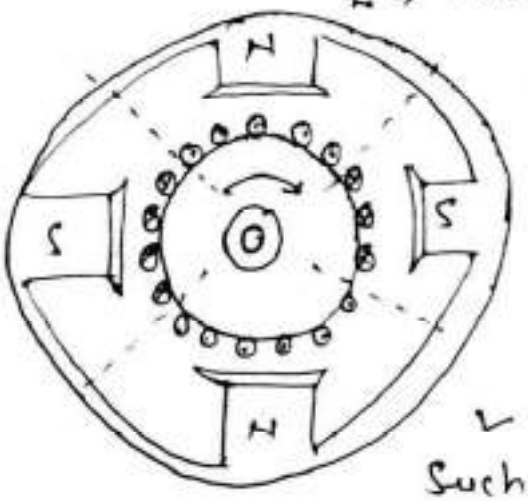
$$\boxed{E = \frac{\phi Z N P}{60 A}}$$

A = 2 for wave winding
A = P for lape winding

Ans.2> Explain working principal of D.C. Motor >

Ans.> D.C. Motor is based on the principal that when a current carrying conductor placed in a magnetic field Force is Experienced by the conductor and magnitude of Force is given by $\boxed{F = BIL}$

where B → magnetic field strength
I → current in Conductor
L → length of conductor



* When Motor is connected to D.C. Supply ~~current~~ Current start to flow in Rotor Conductor through Commutator & Commutator Preform following Perpose.

↳ "It convert D.C current into A.C. Such that Conductor under different pole have current in opposite direction. So by Flemings left hand rule ~~Force~~ in all Conductor must in same direction and unidirectional Torque is produced and motor start to run in particular direction"

↳ also when particular Conductor come Influence of one pole to another pole the direction of current in it is reversed and Motor Continue to run in particular Direction.

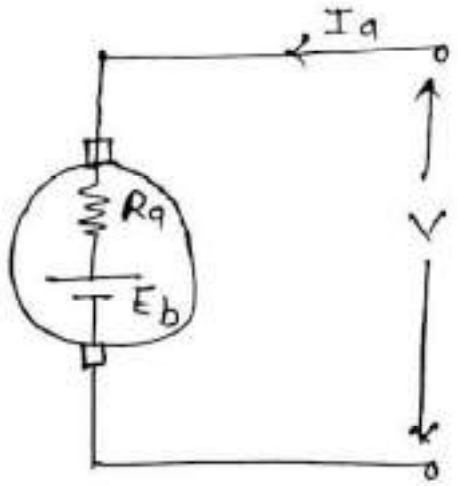
Ans 3> What is back e.m.f.?

Ans.> When Rotor Conductor Continue to run due To Motor action flux linkage with the Conductor is change so e.m.f. is Induced in the Conductor as like generator. this Induced e.m.f. apport the supply Voltage and is known as back e.m.f.

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

Qus.4> What is the Physical Significance of back e.m.f.

Ans.>



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

$V = E_b + I_a R_a$

$I_a = \frac{V - E_b}{R_a}$

* Without back e.m.f. the speed of D.C. motor is undefined because there is no opposing factor to supply.

* Also back e.m.f. is responsible for producing variable Torque in motor according to applied load. So motor becomes self regulating.

* as the load is increases Motor reduce its speed so that E_b decreases and Torque increases.

Qus.5> Drive the Torque equation of D.C. Motor.

Ans> let Motor is Running with speed N R.P.M. and Producing a Torque of T then

Power developed in Motor = $T\omega$

$= T \frac{2\pi N}{60}$ Watt

Now this Mechanical Power is equivalent to electrical power in armature ($E_b I_a$)

So

$$T \times \frac{2\pi N}{60} = E_b I_a$$

$$T = \frac{E_b I_a 60}{2\pi N} \quad \text{---(i)}$$

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

Putting the Value of E_b in eq. (i')

$$T = 0.159 \phi Z P \frac{I_a}{A} \quad \text{Newton-meter}$$

$$\boxed{T \propto \phi I_a}$$

Ques. 6> A 4 pole lap wound armature has 144 slots with two coil sides per slot each coil having two turns if flux per pole is 20 m Wb and speed of armature is 720 RPM find Induced Voltage.

Ans. > Z = total slots × no of coil sides per slot × no of turn in each coil

$= 144 \times 2 \times 2$

$Z = 576$

$$E = \frac{\phi Z N P}{60 A} = \frac{20 \times 10^{-3} \text{ Wb} \times 576 \times 720 \times 4}{60 \times 4}$$

$\boxed{E = 138.24 \text{ V}}$ Ans.

Ques. 7> What is slip. Drive the expression for Rotor frequency in term of supply Frequency.

Ans. > The difference between Stator Field and Rotor speed is known as slip and denoted by s

$\boxed{S = \frac{N_s - N}{N_s}}$ * It is expressed as fraction of Synchronous speed.

* When Rotor is stationary the Supply frequency and Rotor frequency is same. $\boxed{f = \frac{N_s P}{120}}$

but when Rotor start Rotating in the direction of Field Relative speed b/w Rotor & Stator Decreases so frequency also decreases

$$f' = \frac{(N_s - N)P}{120f}$$

$$= \frac{N_s - N}{N_s} \times \frac{N_s P}{120f}$$

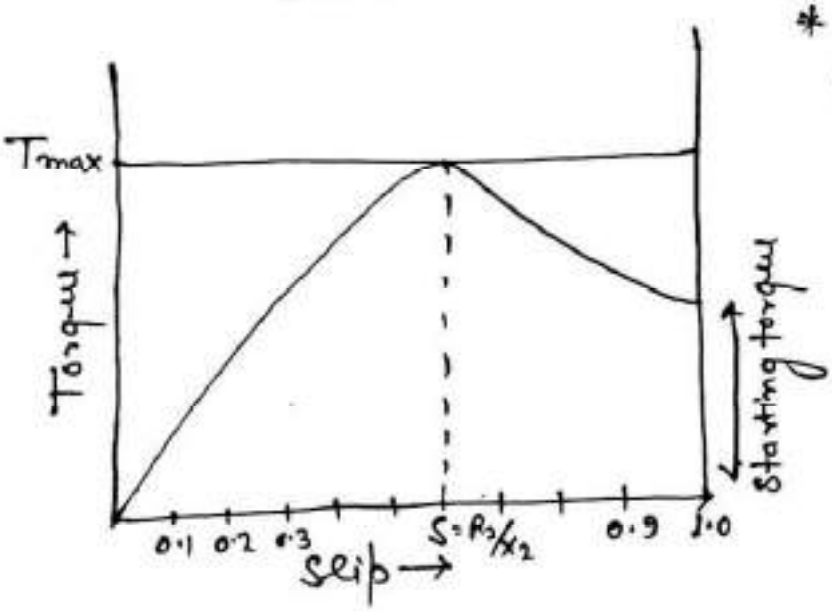
$$f' = S \times f \qquad \boxed{S = \frac{N_s - N}{N_s}}$$

$$\boxed{f' = SF}$$

Ques·8> "Explain Torque slip characteristics of three Phase Induction Motor."

Ans·> as we know Torque of Three phase Induction Motor is given by

$$\boxed{T = \frac{KS R_2 E_2^2}{R_2^2 + S^2 X_2^2}}$$



* for starting slip is very small S. we can neglect the S^2 Term and

$$\boxed{T \propto S}$$

and curve is straight line on increasing the slip Torque is also increases upto its become maximum at $\boxed{S = R_2/X_2}$

* after Max. torque if we further increases the slip now slip is sufficient so we can not neglect the S^2 term and

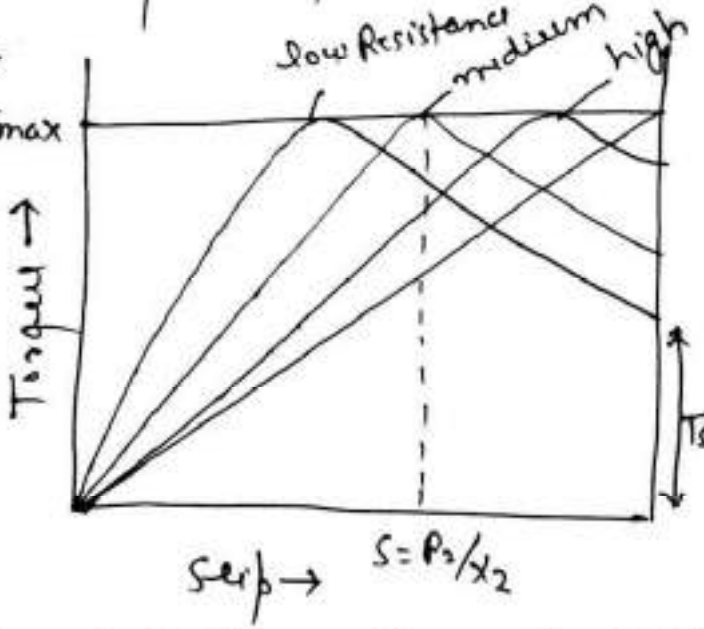
$$\boxed{T \propto 1/S}$$

Now Increasing slip further Torque start decreasing and curve is Rectangular hyperbola.

* If we further Increase the slip Motor eventually stop and at this point Torque is equal To starting Torque.

Ans.9> Explain the effect of Rotor Resistance on Torque slip characteristics.

Ans.>



* as we Increase the Resistance the value of slip at which max torque occurs is also Increases So curve shift towards Right as shown in figure.

$$T_{max} = \frac{K E_2^2}{2 X_2}$$

which is Independent of slip so Tmax Remains unchanged on changing the Resistance of Rotor.

Ans.10> A 3phase 4-pole 50 Hz. Induction motor is running at 1455 r.p.m. find the slip.

Ans.> $N_s = 120f/p = \frac{120 \times 50}{4} = 1500$ r.p.M.

actual speed $N = 1455$

$$\text{Slip}(S) = \frac{N_s - N}{N_s} = \frac{1500 - 1455}{1500} = .03$$

$$\% S = .03 \times 100$$

$$\boxed{\% S = 3\%}$$

Que-11> A 3phase, 4-Pole Induction motor connected to 3ϕ, 400V, 50Hz. ac. supply. Calculate.

(i) Synchronous speed

(ii) Rotor speed at 4% slip

(iii) Rotor frequency when rotor speed is 600 r.p.m.

(iv) Rotor Induced e.m.f. when Rotor to stator turn ratio is 2:1 and stator is star connected and rotor speed is 600 r.p.m.

Ans.> (i) $N_S = \frac{120f}{P} = \frac{120 \times 50}{4} = 1500$ r.p.m.

(ii) $\frac{N_S - N}{N_S} \times 100 = 4$

$\frac{1500 - N}{1500} = .04 \Rightarrow N = 1440$ r.p.m.

(iii) $N = 600 \qquad S = \frac{1500 - 600}{1500} = 0.6$

$f' = Sf = 50 \times 0.6 = 3$ Hz.

(iii) $V_1 = 400/\sqrt{3} \qquad \frac{V_2}{V_1} = \frac{2}{1} \qquad V_2 = \frac{800}{\sqrt{3}}$

$V_2' = SV_2$

for $N = 600$

$S = 0.6$

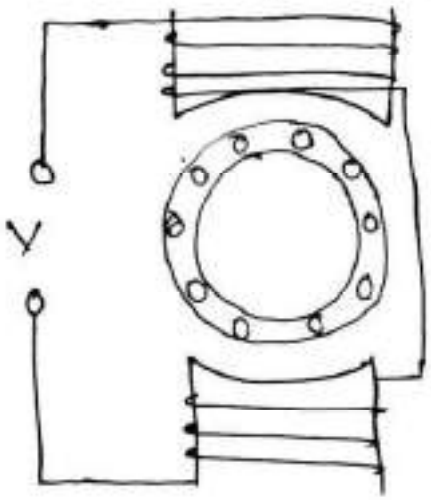
$V_2' = SV_2$

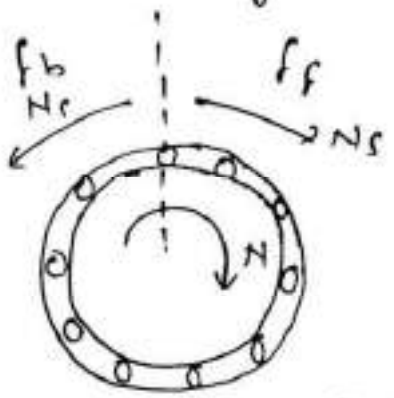
$= 0.6 \times 800/\sqrt{3}$

$\boxed{V_2' = 48/\sqrt{3}\ V}$ Ans.

Que.12> Explain operating principal of Single phase Induction Motor. also explain why it is not Selfstating.

Ans.> The operation of Single phase Induction motor can be explain by "Double revolving Field" Theory.





Double revolving field theory

* When we give Singe phase Seppley to motor pulsating Magnetic field is produced this pulsating magnetic field can be resolved into two Rotating Magnetic field of half its amplitude and Rotating in apposite direction with synchronous speed.
* when Rotor is stationary both field produce equal and apposite Torque so Net torque is zero and motor is not self starting.
* now if we rotate rotor in particular lets in forword direction with speed N such that $N \approx N_s$

↳ slip due to forword field $S_f = \frac{N_s - N}{N_s} = S$

↳ slip due to back ward field $S_b = \frac{N_s - (-N)}{N_s} = \frac{2N_s - (N_s - N)}{N_s}$

$$\boxed{S_b = 2 - S}$$

* Now because $2 - S >> S$

So current in conductor due to back ward field is very high so magnetic field produce in rotor Conductor due to back ward field is also high and it Completely finish the back ward field due to which only forward

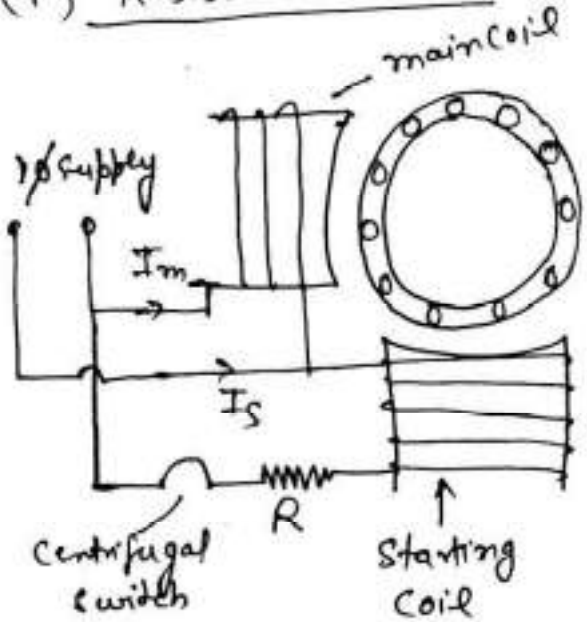
field remains and motor behave as like Three phase Induction motor and continue to run in Forward Direction.

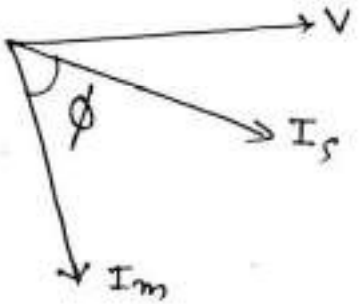
Que 13> Explain starting Method of single phase Induction Motor. why it is not self starting.

Ans.> as we know there is No Torque in single phase Induction motor at starting due to pulsating field. So we produce Rotating Magnetic field at starting with the help of Auxiliary coil and at motor attend sufficient speed for proper operation we remove auxiliary coil with the help of Centrifugal Switch. In Starting Method we try to develope phase difference b/w main coil and auxiliary coil near about (90° – 50°)

(i) Resistance start Singe phase Induction motor
(ii) Capacitor start Singe phase Induction motor
(iii) Capacitor start Capacitor run singe phase Induction motor
(iv) permanet capacitor Singe phase Induction motor

(i) Resistance start>





+ "Due to heavy resistor in starting coil a phase difference is developed b/w main coil and auxiliary coil. which is not 90° but Sufficient to develope a Magnetic field (Rotating) which is capable for starting the low power Singe phase Induction motor."

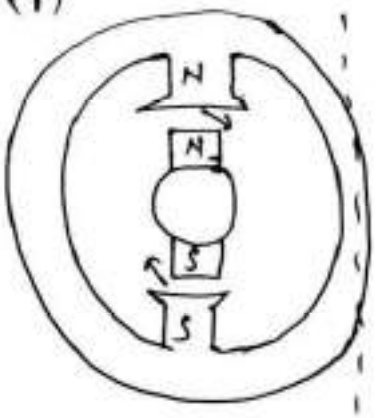
Q.4) 14 > Explain operating Principal of Synchronous Motor. the Draw V-curve. Why it is not self starting.

Ans.> Let Consider 3ϕ 2 pole Synchronous Machine ie Three phase Synchronous Motor Stator windings are Connected to 3ϕ A.C. Supply by Rotor windings are Connected to D.C. Supply.

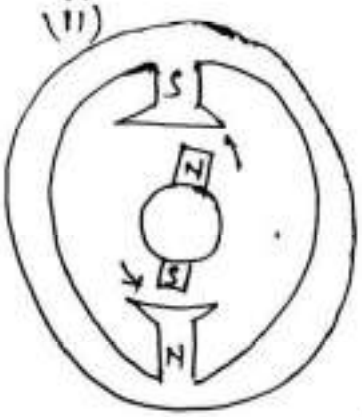
↳ So Rotor pole Remains unchanged due to D.C. Supply.

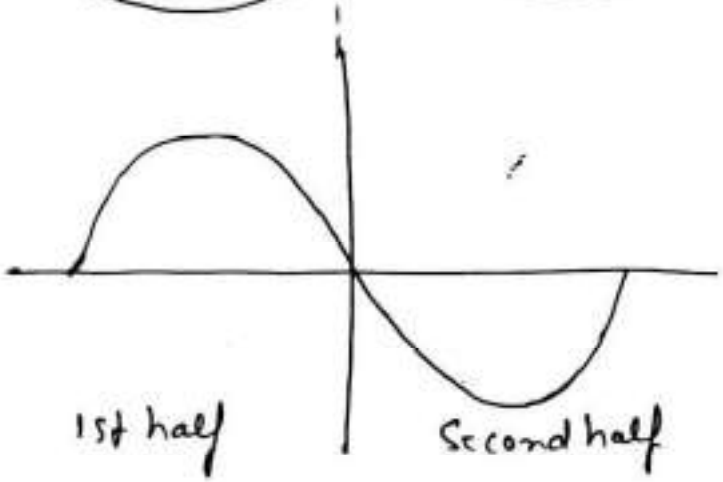
↳ Stator pole change after each half Cycle or half Time period N pole become S & S pole becomes N pole.

(i)



(ii)





* let condition(i) where North pole of stator repal North pole of Rotor So Torque ie divelped in cloch wise direction and motor try to rotate in thi direction
* but after half time period Stator North pole becomes South by Rotor Pole remains unchanged and Stator South pole attract the Rotor North pole hence Torque produced in anti clockwise Direction
* hence Torque ie pulsating and motor Doe not rotate in any direction and it is not self starting.

(iii)

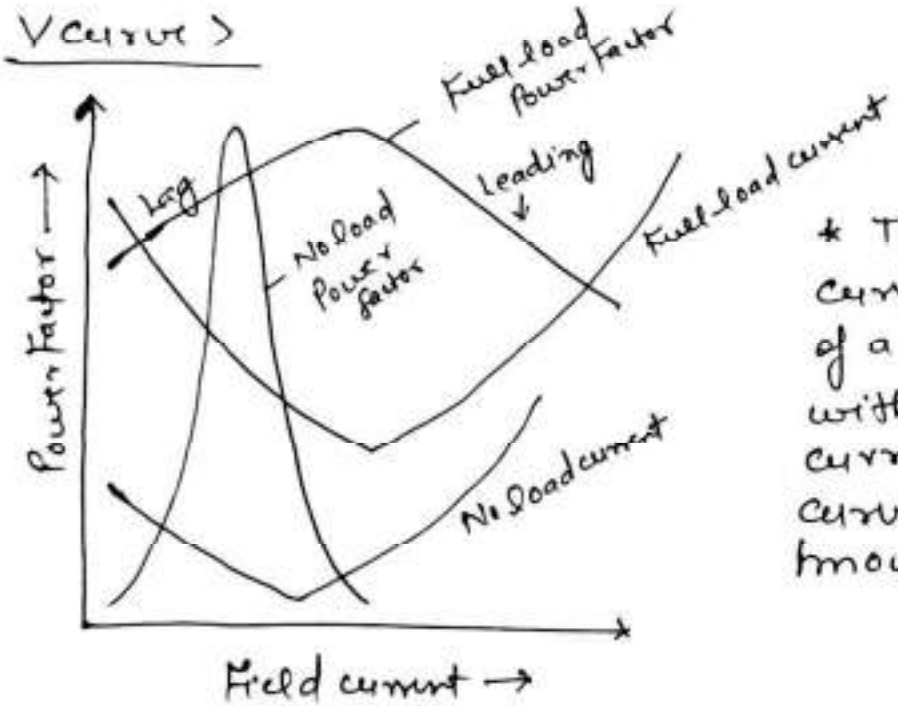
Now if Rotate the Rotor with speed So that in half time Period ie comes from influence of one stator pole to adjacent Stator pole and Now the Torque ie same as like figure(i) unidirectional Torque ie produced and Motor start to Rotate in clockwise Direction.

· So Required speed is calculated by →

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

known as synchronous speed

V Curve >



* The Variation between current and Power Factor of a synchronous Motor with Variation of Field current is Represented by curve these curve are known as V-curve

Que·15> Explain application of D.C. Motor.

Ans.> (i) D.C. Series Motor > It is Variable speed motor and develope very high Toorque at low speed. It has very high starting Torque therefor used in hoist, Cranes, Trolley cars, conveyors, electric locomotive, elevator, etc.

(ii) D.C. Shunt Motor > It is Constant speed Motor and has medium starting Torque and therefor used for Constant speed application like Centrifugal pump, reciprocating pump, Fans, blowers, Conveyors, woodworking Machines, Machine tools, etc.

(III) Compound Wound Motor's > Rarely used due to Poor Torque characteristics. It is basically used in machine which is subjected to sudden applications of heavy load like rolling mills, Punching & Shearing Machine, lifts, mine hoists etc.

Que·16> Explain application of Single phase Induction Motor and Three phase Synchronous Motor.

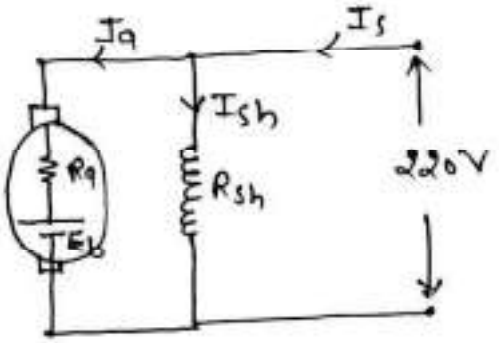
Ans·> (i) Three phase Synchronous Motor → It is Constant Speed Motor hence used in -

- Power house and Substations for Improving the Power Factor
- Regulate the Voltage at the end of Transmission line
- fans, blowers, dc generator, line shafts, Constant speed application.

(ii) Single phase Induction Motor > low load application like, home appliances like fan, Washing Machine, Mixy juicer, etc.

Que·17> A 220V D.C. Shunt Motor have 4 pole and take a line current of 3A at no load while running at 1500 r.p.m. determine the speed when motor take line current of 50A. armature field and armature resistance are 400Ω and 0.2Ω respectively.

Ans·>



Case(i) → $I_s = I_a + I_{sh}$

$$I_{sh} = \frac{220}{400} = 0.55A$$

$$I_{a_0} = 3 - 0.55 = 2.45A$$

$$E_b = V - I_a R_a$$

$$= 220 - (2.45 \times 0.2)$$

$$E_{b_0} = 219.51V$$

Case(ii) $I_s = 50A$

$$I_{a_1} = 50 - 0.55 = 49.45A$$

$$E_{b_1} = 210.11V = V - I_{a_1} R_a = 220 - (49.45 \times 0.2)$$

$$= 210.11V.$$

$$N_f = N_0 \times \frac{E_{b_1}}{E_{b_0}} = 1500 * \frac{210.11}{219.51} = 1436 \text{ r.p.m}$$