26/02/201

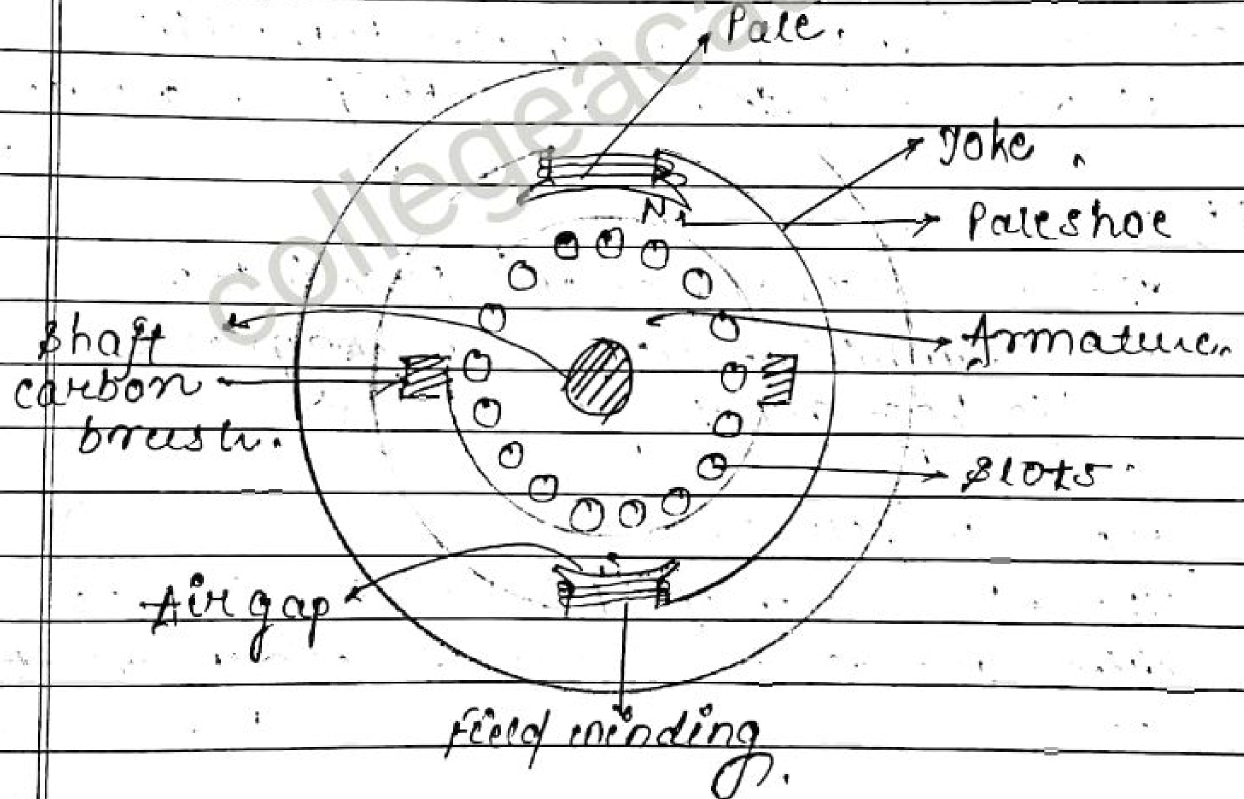
UNIT-04
Rotating Machine

Motor:	Generator
(1) EE $\rightarrow$ $\boxed{motor}$ $\rightarrow$ ME	M.E $\rightarrow$ $\boxed{generator}$ $\rightarrow$ EE.
(2) Basic working principle of Motor: $f = BIL\sin\theta$. where, f = force B = flux density L = length of conductor I = current. θ = Angular displacement.	(2) Basic working principle of generator $E = Blv\sin\theta$. where, E = generated emf B = magnetic flux D. L = length of conductor v = velocity.
(3.) When a current carrying conductor placed in a magnetic field, A force is experienced by the conductor, Hence conductor starts moving.	(3.) when a conductor rotates in a magnetic field, an emf is induced in the conductor due to rate of change of flux.
(4.) Fleming's left hand rule is applicable to denote the direction of force.	(5.) Fleming's right hand rule is applicable to denote the direction of induced emf or current.

Classification of Induced EMF:-

Induced EMF

- Statically Induced EMF (X-mer EMF).
  - Self induced EMF
  - mutually Induced EMF.
- Dynamically induced EMF (Rotating Machine)



27/02/19 -

DC Machines:-

- Stator (stationary Part)
  consists of:
  1) Yoke or magnetic frame.
  2) field Poles & field coils
- Rotor (moving Part)
  consists of:
  1) Armature
  2) commutator

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Yoke or Magnetic frame :-

(1) This is made up of cast Iron.
(2) Acts as protective covering for machine Parts.
(3) It Provides mechanical support to the different Parts of machine.
(4) Provides Path to the magnetic Flux.

Field Poles :-

(1) Field Poles are fixed to the magnetic frame by bolts.
(2) Poles produces the magnetic flux which is to be cut by the rotating armature.

(3) Pole shoe :-

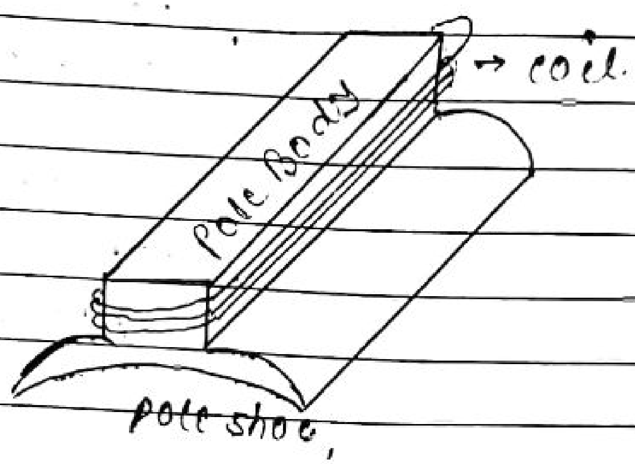
This is used to spread out flux in the air gap which reduces the magnetic leakage and fringing.

Pole Body / Pole core :-

This is made up of Thin laminations of silicon steel which reduces the eddy current loss.

Field coils :-

It is made up of copper. Exciting current through these coils produce magnetic field in the whole pole body.



Rotor

commutator.

Armature.

Armature core

Armature Winding

Armature core	Armature winding
(i) Made of laminated silicon steel.	Armature winding are the interconnection of conductors.
(2) cylindrical in shape	conductors made up of copper.
(3.) consists of slots and teeth on its periphery. and also have air holes for cooling purpose.	(3.) These are placed in the slots on armature Phoriphery.
(4) Armature winding is placed in it Hence rotates them in magnetic field.	(4.) An Emf is induced in these conductor when rotates in magnetic field case of

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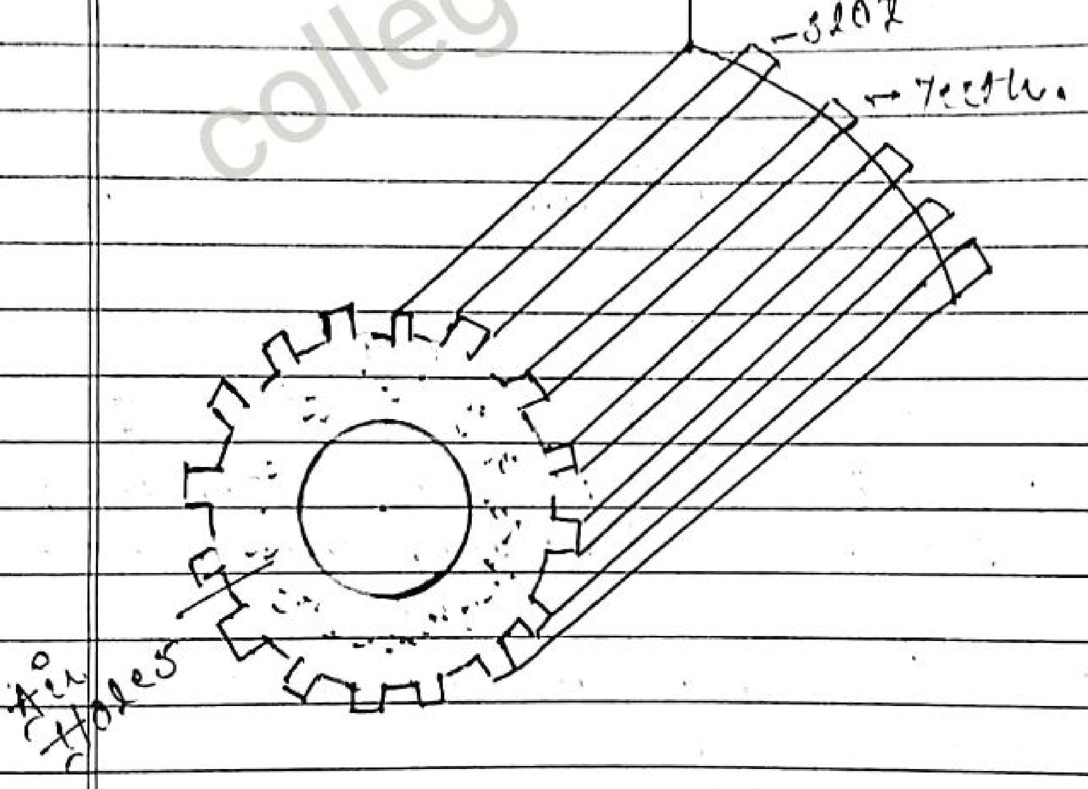
(6)	Provide the path of very low	Current is supplied to the Armature winding in case of motor. so that electrical Energy converts into mechanical Energy.



Commutator :-

(i) Commutator is cylindrically shape and placed at one end of Armature.

(2.) Made up of hard drawn copper segments seperated by mica insulations.

(3.) Generator case :- It converts generated AC into DC.

(4.) Motor case :- convert DC supply into AC.

(5.) Carbon Brush :-

(i) Brush are stationary and resting on the surface of commutator.

(ii) The function of carbon brush is to collect current the current from commutator. It is made of carbon.

(6. ~~iii~~) Shaft :- It is generally made up of alloy of carbon. It provides support to rotating parts.

(7.) Ball Bearing :-

This is generally made up of cast iron. It is used to reduce friction loses.

Classification of DC generator :-

- DC generator
  - Separately excited DC generator
  - Self excited DC generator
    - DC compound generator
      - Long shunt
      - short shunt
    - DC shunt generator
    - DC series generator
- D.C motor :- *

DC Motor :-

- separately excited
- self excited
  - DC series motor
  - DC shunt motor
  - DC compound motor

05/03/19 -

Methods of Excitations

To give the DC supply to field winding of DC machine is known as excitation.

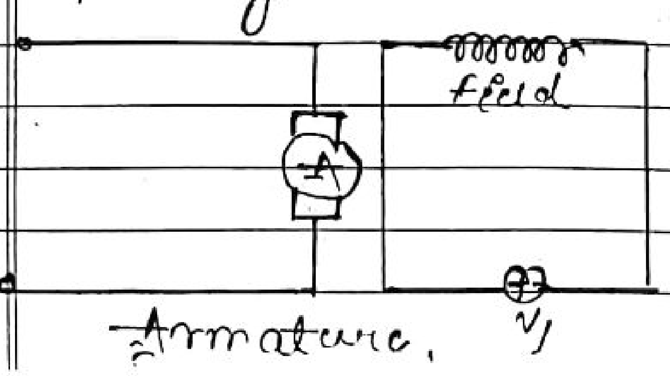
Permanent magnets can also be used for producing field, but their use is limited to very small DC Machines.

There are two methods of excitations.

(1) separate Excitation
(2) self Excitation.

→ (1) Separate Excitation :-

In this case, field winding is excited by using separate DC source and there is no connections between the field and Armature winding. This winding has several thin wire turns. DC machine which uses this method for excitation is known as separately excited DC machine.



(2) Self Excitation →

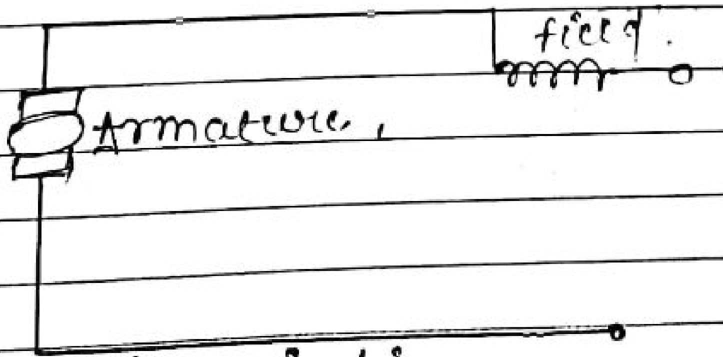
In case of seperately excited Machine, an extra DC source is required. If Armature is used for excitation of field winding and no other source is required for this purpose then the method is known as self excitation and the machine is known as self Excited Machine.

The necessary condition for self Excitation is that machine poles must have some residual magnetism. so that some initial voltage can be generated in Armature of Machine.

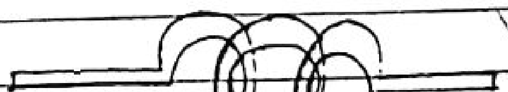
Types of self Excitation :-

(i) Series Excitation :-

This is also known as current controlled field Excitation. Since field winding carries full Armature current (load current) Here field winding is connected in series with Armature winding. This type of field winding has few no. of turns of thick wire for keeping the resistance as low as possible since it carries full load current, drop and loss (I^2R) should be low.



Series Excitation.

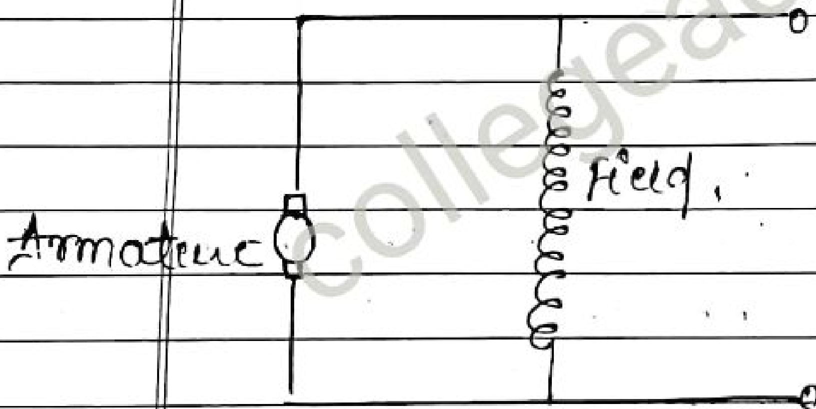


Field winding with thick and less turns.

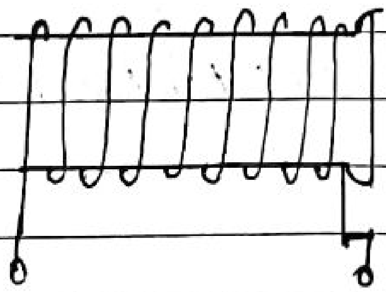
Shunt Excitation -

This is also known as voltage controlled field Excitation since voltage across field winding is equal to the Armature Terminal voltage.

Since the field winding is connected to parallel to the armature winding and it carries very small percentage of Armature current as its Resistance must be as high as possible. which can be achieved by making field winding with large and very thin turns.



Shunt Excitation



field winding with very thin and large no. of Turns.

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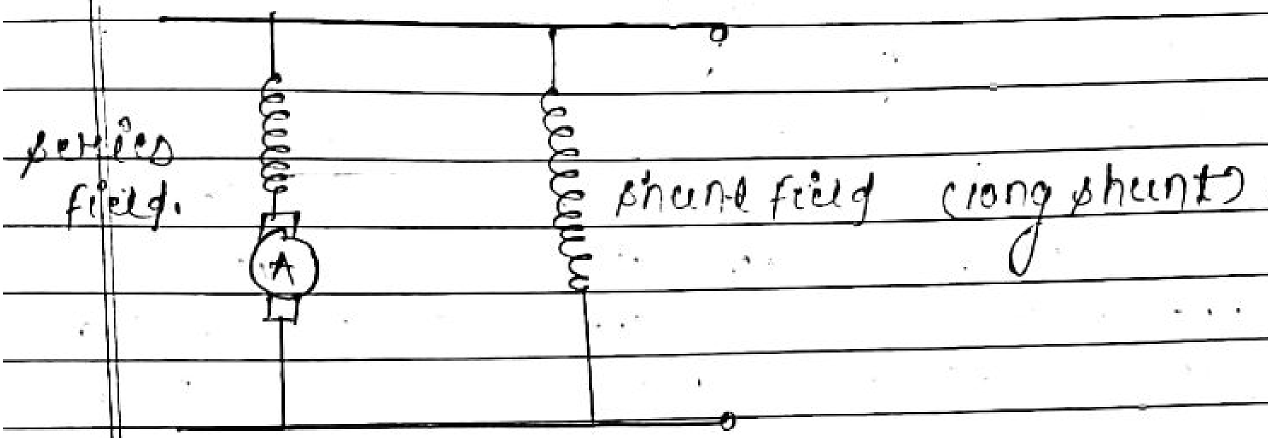
Compound Excitation:-

In this type of Excitation both series and field winding are used. It may be further classified as.

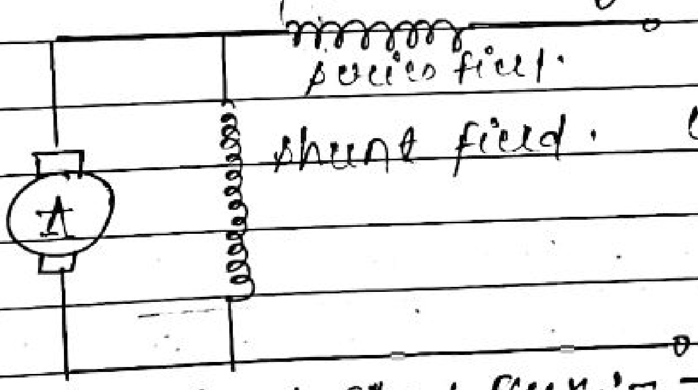
(I) Long shunt:-

The shunt field winding is connect across the ~~wire~~ line Terminals.



(II) shot shunt:-

In this case the shunt field winding is connect across the ~~Armature~~ only.



On the Basic of field flux:-

(i) cumulatively compound DC Machine-

of the series field flux supports the shunt field flux and resultant air gap flux per pole is increased then the machine is call. cumulatively compound DC Machines.

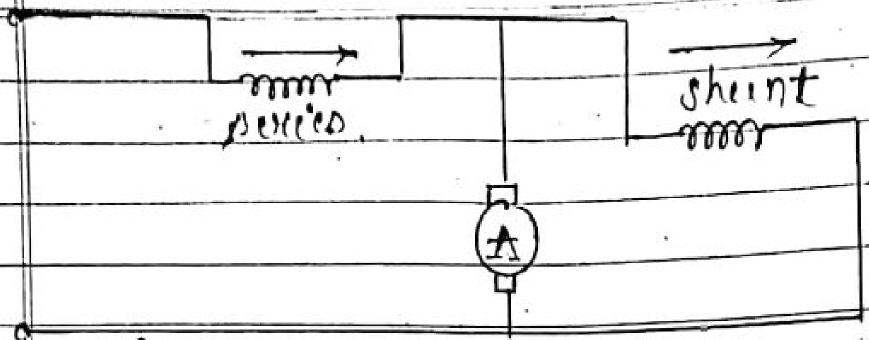
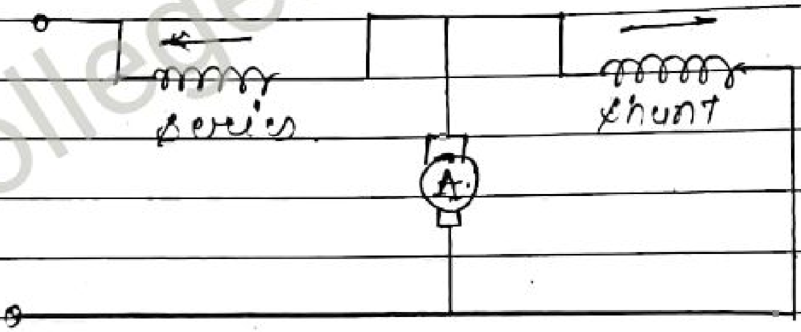


Fig: cumulatively compound DC Machine

Differentially Compound DC Machine –
In this machine connections of series & shunt fields are such that their flux opposes to each other. Hence the resultant air gap flux decreases. This kind of machine is called as Differentially compound DC machine.

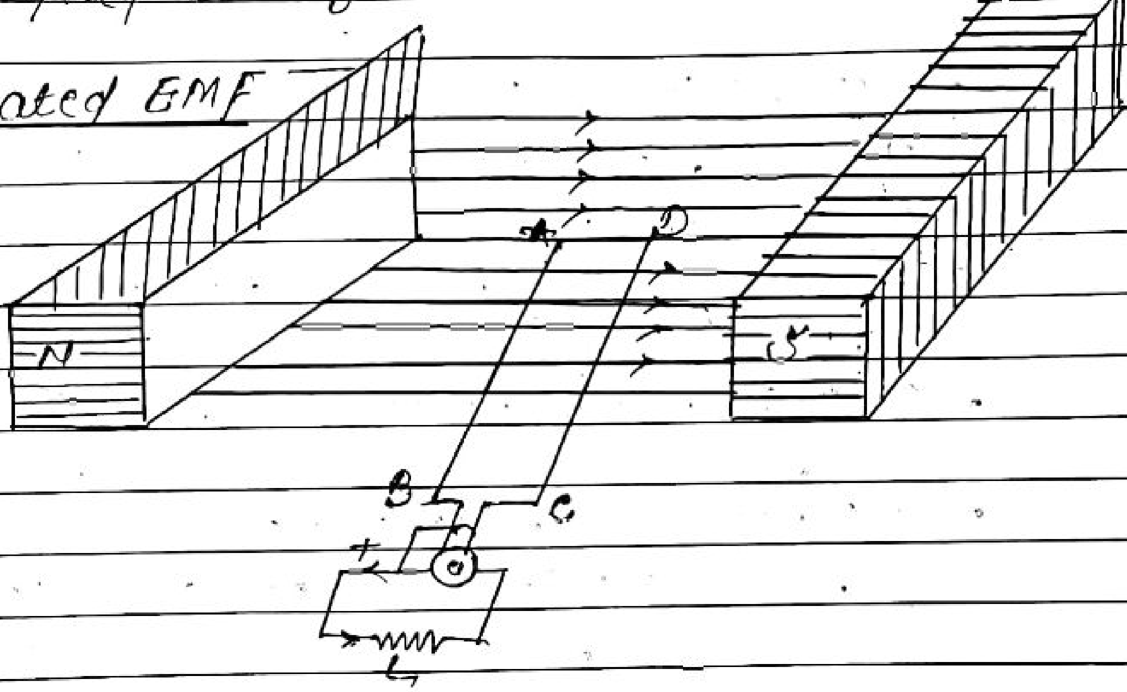


DC Generator – (EMF Equation):
DC generator takes mechanical input (through the prime mover or another motor) and it gives the electrical output to the external circuit (load). This mechanical input is given to the shaft of the generator. The field circuit is excited by DC and then emf is induced in the armature circuit. This emf is of alternating nature which is converted in DC by using commutator.

Generator Principle :-

When the conductor is moving in the uniform magnetic field then EMF is induced in the conductor because it cut the magnetic lines of forces A/C to Faraday's law of Electromagnetic induction. The polarity of this emf is decided by Fleming's Right hand Rule. This is known as Generator principle. The required field flux (magnetic field) is produced either by the permanent magnet (in small machine) or by field windings.

Generated EMF



8/03/19 :- The Diagram shows the simple principle of generator action when coil ABCD rotates in the uniform magnetic field created by permanent magnet. then A/C to Faraday's law of EMF, an alternating EMF is induce in the coil. by using slip rings and carbon brushes this emf. is converted into direct voltage and then feed to the external circuit (Load)

Let E_g is the generated EMF in the Armature

A/c to Faraday's Law of EMI

$$E_g = \frac{d\phi}{dt}$$

ϕ = Flux Per Pole

Z = Total no. of conductors.

N = ~~No. of~~ ~~rr~~ speed of Armature (rpm)

A = No. of Parallel Path

P = No. of Poles

- Flux cut by one conductor in one revolution of the armature i.e $d\phi = P\phi$ wb
- Time taken to complete one revolution of armature i.e $dt = \frac{60}{N}$ second
- emf Generated Per conductor $\frac{d\phi}{dt} = \frac{P\phi}{60/N}$
- emf generated by Generator
  = emf generated per conductor $\times$ no. of conductors in series/Parll. Path

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

$$E_g = \frac{Z\phi NP}{60A}$$

Date / /
Page No.

DC MOTOR

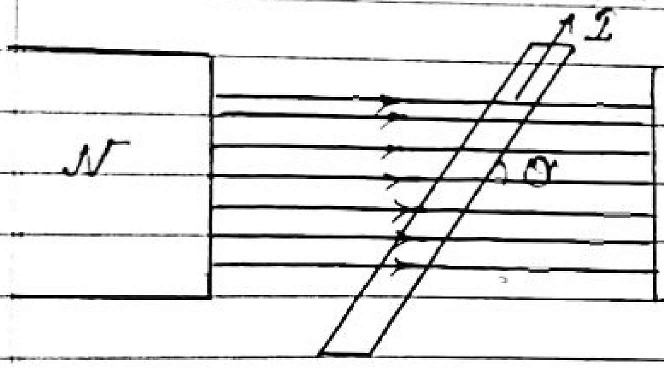
DC Motor takes electrical input and gives mechanical output at rotor shaft. construction of DC Motor is similar to DC Generator.

Motor Principle –

when a current carrying conductor is placed in uniform magnetic field then it experiences a force then the direction of force is given by Fleming's left hand rule. if conductor is free to rotate then it starts moving in the direction of force.

$F = BIl\sin\theta$.

where B = flux density in wb/m^2.
I → current in Amperes
l → length of the conductor in meters
θ → ∠ between field and conductor.



In DC Motor the magnetic field is produced by the direct current in field winding and rotor is assumed to be equivalent to the current carrying conductor when electrical input is given to it.

Back EMF: –

When rotor rotates in DC motor then armature conductors cut the field flux.

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Hence due to Faraday's law of EMI an Emf is induced in them as incase of DC Generator. The Polarity of this induced Emf is such that it opposes the applied voltage V in the Armature circuit. This Emf is known as counter emf or Back emf. Its expression is same as that of the generated emf of DC generator.

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

$$\boxed{\text{Also, } E_b = V - I_a r_a}$$

where, V = Applied voltage in armature circuit

now, multiply the eq. by I_a current

$$\boxed{E_b I_a = V I_a - I_a^2 r_a}$$

Here, $E_b I_a$ = Electrical equivalent of mechanical Power developed in the rotor (This is the Power required to overcome the opposition due to E_b)

$V I_a$ = Total Electrical input.

$I_a^2 r_a$ = copper loss in Armature circuit.

09/03/19
12/03/19

Losses in DC Machines :-

- core loss
  - Eddy current loss
  - Hysteresis loss
- copper loss
  - $I_a^2 r_a$
  - $I_f^2 r_f$
- Mechanical loss
  - windage loss
  - friction loss

Core loss :- (Iron loss)

These losses takes place in the armature core of DC Machine. These are of two types :-

(1) Eddy current loss
(2) Hysteresis loss } → "from Transformer".

Copper losses (ohmic losses) :-

These loses takes place in the conducting path - (Armature and field winding) of DC Machines.

(a) Field copper loss $= I_f^2 r_f$

This loss is about 20-30% of full load loss (Total loss).

(b) Armature copper loss $= I_a^2 r_a$

This is about 30-40% of full load loss. It is variable loss in the DC Machine.

Mechanical loss :-
(Rotational loss) :-

These loses takes place due to rotation of armature in the DC Machine :-

(a) windage loss - These loses takes place due to friction caused by air

(b) Friction loss → These lo[ss] takes place at the bearing and commutator. These are about 10-20% of full load loss.

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Efficiency of DC Machines :-

(a) Generator Efficiency :-

i) Overall Efficiency $\eta = \dfrac{\text{output in watts at the load circuit}}{\text{Mechanical i/p at rotor shaft}} \times 100\%$

(ii) Electrical Efficiency :-

$\eta_e = \dfrac{\text{output in watt to load ckt}}{\text{Total power generated at armature in watts}} \times 100\%$

(iii) Mechanical Efficiency :-

$\eta_m = \dfrac{\text{Total power generated at armature in watts}}{\text{Mech. i/p at rotor shaft}} \times 100\%$

overall efficiency $(\eta) = \eta_e \times \eta_m$

$\eta = \dfrac{\text{output}}{\text{output} + \text{loss}} \times 100\%$

$= \dfrac{VI_L}{VI_L + P_C + P_{oh}} \times 100\%$

Motor Efficiency :-

1) overall efficiency $= \dfrac{\text{Net o/p of the motor (shaft power in kW)}}{\text{motor i/p } VI \times 10^{-3}} \times 100$

Electrical efficiency :-

$\dfrac{\text{Driving power in Armature}}{\text{Motor i/p}} = \dfrac{E_b I_a}{VI}$

(3) Mechanical efficiency

$$= \frac{\text{net output of the Motor}}{\text{Driving power of Armature}} \times 100$$

$$= \frac{\text{shaft power in kw}}{E_b I_a \times 10^{-3}}$$

DC Machines Applications :-

Generator :-

(1) shunt generators :- (constant terminal voltage characteristics).

1) used for power supply
2) For lighting purpose
3) battery charging.

(2) Series Generator :- (rising characteristics).

used as a booster in certain types of distribution systems, particularly in railway services.

(3) Compound Generator :-

cumulatively compound generator.
(adjustable characteristics under voltage drop)

1). for power supply
2). da motor device.
3). For lamp roads.
4) for heavy power services like electric Railways.

(4) differentially compound Generator :-
(dropping characteristics).

1) For arc welding
2) Type of generator where large voltage drop is

(3) Mechanical efficiency

$$= \frac{\text{net output of the Motor}}{\text{Driving power of Armature}} \times 100$$

$$= \frac{\text{shaft power in kW}}{E_b I_a \times 10^{-3}}$$

DC Machines Applications :-

Generator :-

(1) shunt generators :- (constant terminal voltage characteristics).

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cumulatively compound generator.
(adjustable characteristics under voltage drop)
1). for power supply
2). dc motor device.
3). for camp roads.
4) for heavy power services like electric Railways.

(4.) differentially compound Generator :-
(droping characteristics).
1) for arc welding
2) Type of generator where large voltage drop is

desirable with increase in current.

MOTOR :-

(1) Shunt Motor :- (const. speed characteristics)
1) For driving lathe machine
2) Machine tools.
3) centrifugal & Reciprocating pumps.
4) fans and blowers.

(2) Series Motor :- (variable speed charac.)
1) • electric Traction & locomotives.
2) • cranes, hoists and conveyers.
3) • Trolley cars.

(3) Compound motor —
(variable & adjustable speed characteristics) :-
1) rolling mills, ice machine, printing presses and air compressor
2) elevators.
3) conveyers.

Numericals :-

Q.1: calculate the Generated emf. in a wave bound DC generator having 6 poles, running at 1500 rpm. with 430 conductors. Let the flux per pole is 0.4 wb.

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

Lap winding, $A = P$
wave winding, $A = 2$.

$$E_g = \frac{\phi N P}{60}$$

$E_g = 12900$

$E_g = 4300$

$Z = 430$
$N = 1200$ rpm.
$P = 6$
$A = 2$
$\phi = 0.4$ wb.

Q:02:-) The power to a 230 v DC shunt motor is 8·477 kw. The field resistance 230 Ω and armature resistance is 0·28 Ω; find out input current; Armature current and back emf.

$P = 8 \cdot 477\,kw = 8477\,w$.

$V = 230\,v$.

$I_{sh} = \frac{V}{R_{sh}}$

$I_{sh} = \frac{230}{230\Omega}$.

$\boxed{I_{sh} = 1A}$

Input current (I_L)

$I_L = P/V$.

$I_L = \frac{8477}{230} = 36 \cdot 86\,A$

Armature current $I_a = I_L - I_{sh}$

$= 36 \cdot 86 - 1$

$I_a = 35 \cdot 86\,A$.

Back emf :-

$E_b = V - I_a r_a$

$= 230 - (35 \cdot 86)\,0 \cdot 28$

$= 220$

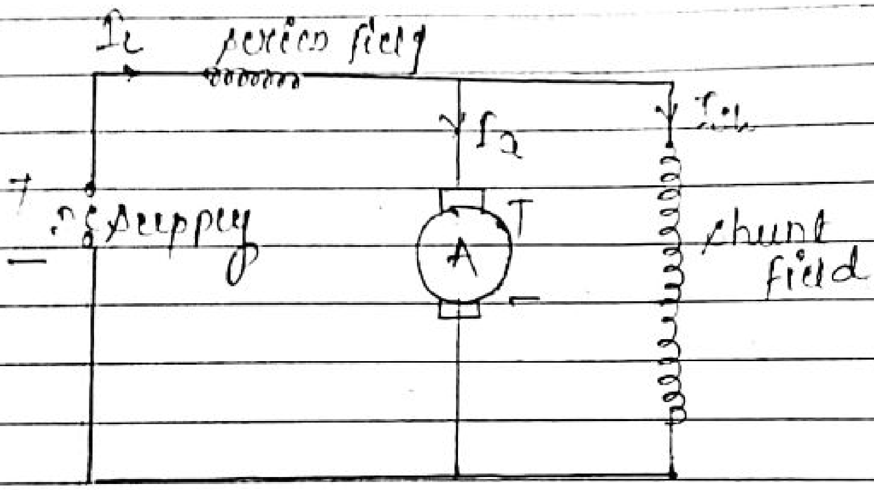
Q(03) :- A 250V DC shunt motor takes 30A current while running at full load. The resistance of armature and field windings are 0·1 Ω and 200 Ω respectively. Determine the back emf generated in the motor when it runs on full load.

Classification of DC Motor :-

2. Compound wound DC Motors :-

A compound wound DC motor has both series as well as shunt field coils. This is generally classified as two types. Cumulative compound and differential compound.

Cumulative compound wound motor :-
This is the one in which the field windings are connected in such a way that the direction of flow of current is same in both of the field windings. In this type of motor the flux due to series field winding supports the flux due to shunt field winding. Hence Resultant flux increases.



Differentially Compound wound motor :-
In this type of motor the field windings are connected in such a way that the direction of flow of current is opposite to each other in the series f w and shunt field w. Hence the flux produced by series field winding opp

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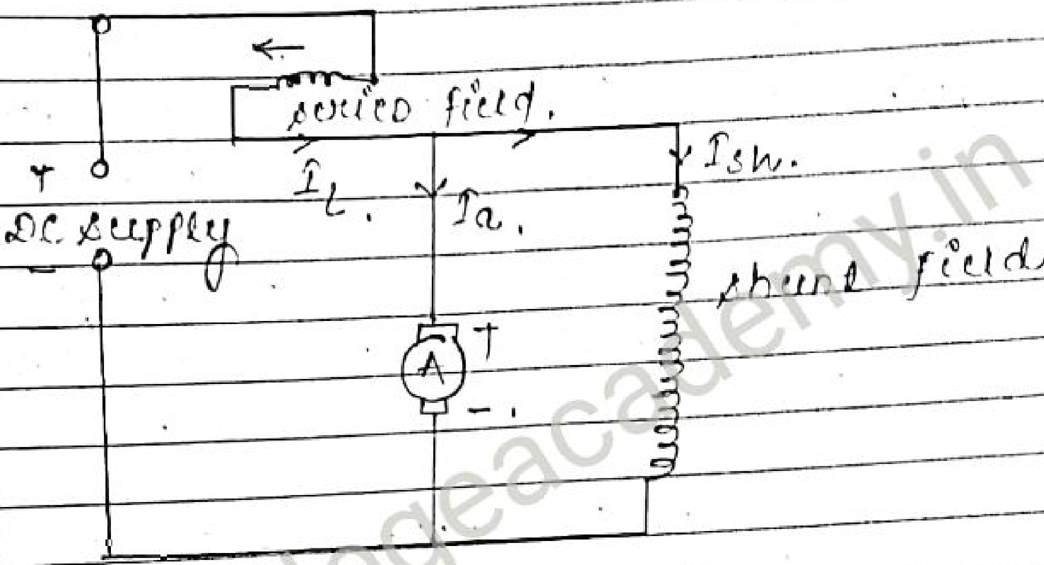
To flux Produced by.
Hence Resultant flux in air gap gets reduced.



3-φ Induction Motor :

(i) The Polyphase induction motors is most widely used motors. Almost more than 90% of the mechanical Power in the induction is provided by 3-φ induction Motors.

(2) The reasons are its low cost, simple construction absence of commutator, good operating characteristics and Robust construction. Reasonably good power factors high efficiency and good speed regulation.

An induction motor of medium size may have an efficiency as high as 90% & Power factor of 0.89. Substa . a C

Speed motors with shunt charact. a very small % of speed drop from no load to Full load

The physical size of such motor for given output rating is relatively small as compare to other types of motor.

- This motor is single excited machine equipped with both field and armature windings. In such machines the field (stator) winding is connected to an AC supply and there is no electrical connection from the armature (Rotor) to any source of supply.

Currents are mainly flows in the a (rotor) conductors by induction which interacts with the produced magnetic field winding & thereby produces a net unidirectional torque such motors are also called asynchronous motor as they run at a speed other than the synchronous speed of the rotating field developed by the stator current.

Holi vaccations → 20/03/19 – 25/03/19

#1:- classification of DC Motor:-

① Permanent Magnet Motor

It consists of an armature and one or several permanent magnets encircling the armature field coils are ~~vertically~~ not usually not required, however some of these motors have coils wound on poles: if they exist they are useful only for recharging the magnet in the event when they loose their strength.

(2.) Seperately excited DC Motor :-

These motors have field coils similar to those of a shunt wound machine but the armature and field coils are get supply from different supply source.

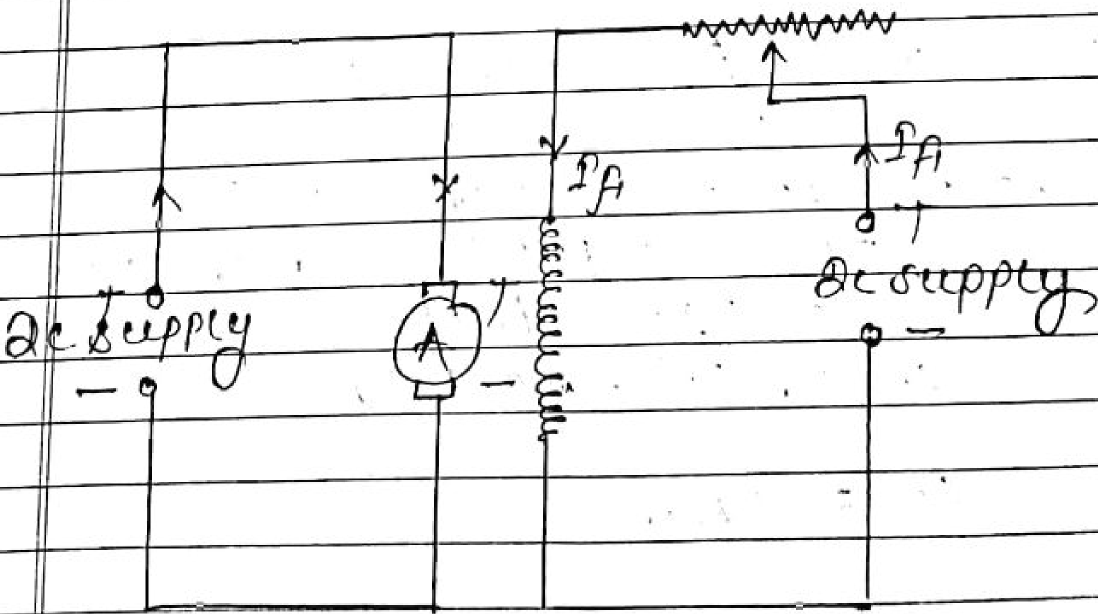
In a seperately excity DC motor; Armature current I_a = line current $I_L = I$

Back emf $\Rightarrow E_b = V - I_a r_a$
$= V - I r_a$

Power drawn from supply (P) = VI.

mechanical power developed

(Pm) = (Power input to armature) − (Power loss to armature).

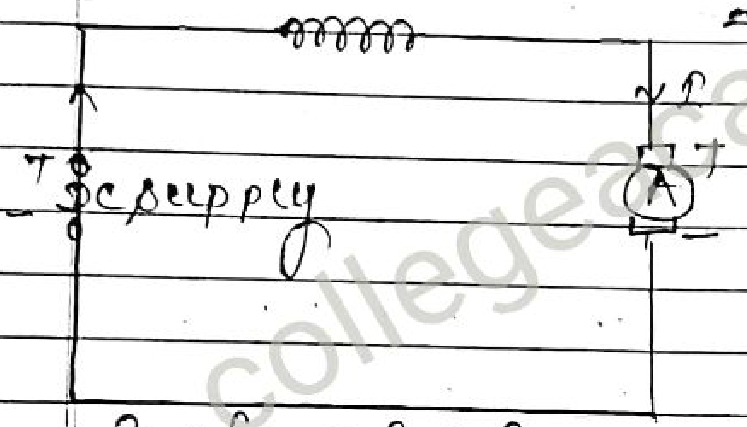


$P_m = VI - I^2 R_a$
$= I(V - I R_a) = E_b I$

Series wound DC Motor :-

In this case the field winding is connected in series with the armature hence carried full load current. To maintain resistance as low as possible. It is required to have small no. of turns of thick wire for field winding to maintain voltage drop as well as power losses.

Armature current I_a = series field current (I_{se})
= line current (I_L)
$= I$



$I_a = I_{se} = I_L = I$.

Back emf developed ;
$$E_b = V - I(R_a + R_{se})$$

Power drawn from supply ;
$$P = VI$$

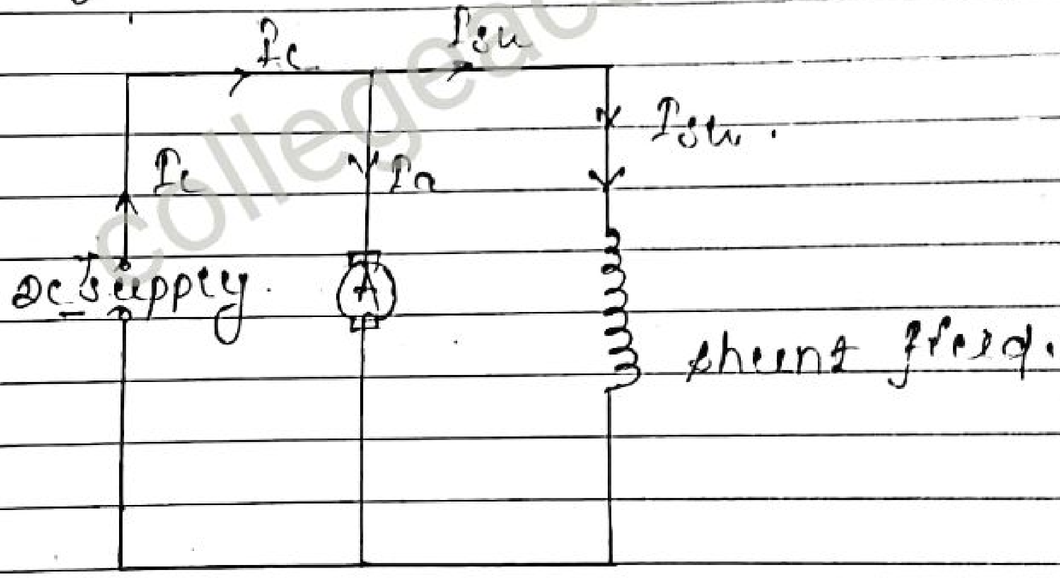
mechanical Power developed (P_m)
= Power input - armature losses.
$$P_m = VI - I^2(R_a + R_{sh})$$
$$P_m = I(V - I(R_a + R_{sh}))$$

$$P_m = E_b I.$$

(4). Shunt wound DC Motor :-

As the name suggest, in this case the field winding is connected in parallel with armature winding. The field winding consists of a large no. of ~~turns~~ then wire so as to maintain large resistance, since the field current is much less than armature current, sometimes as low as 5%.

The current supplied to the motor is divided into two path, one current flows through the armature and another current flows through the shunt field.



Input line current $I_L = I_a + I_{sh}$,
where I_a = armature current.
I_{sh} = shunt field current $= \frac{V}{R_{sh}}$

where V = supply voltage,
R_{sh} is the shunt field resistance.
Back emf developed. $E_b = V - I_a r_a$.
Power drawn from the supply(P) = $V I_L$.

Mechanical Power developed
= Power input − losses in armature &
shunt field.

$$P_m = VI_L - VI_{sh} - I_a^2 R_a$$
$$= V(I_L - I_{sh}) - I_a^2 R_a$$
$$= VI_a - I_a^2 R_a$$
$$= I_a(V - I_a R_a)$$
$$= E_b I_a.$$

Hour 2

7/03/2019

AC Motors :-

- Synchronous Motor
- Induction Motor.

Synchronous Machine :-

Synchronous Machine is an AC Machine in which at steady state rotation of shaft is synchronised with the frequency of supply current.

NOTE :- The synchronous motor & Induction motors are most-widely used of AC motors. The difference b/w them is that the synchronous motor rotates in the exact synchronism with the line Frequency.

Apparent power — VA (volt Ampere)

DC → motor = BIL sin θ
→ generator = BLU sin θ.

DC
- Stator (field wdg.)
- Rotor (Armature winding).

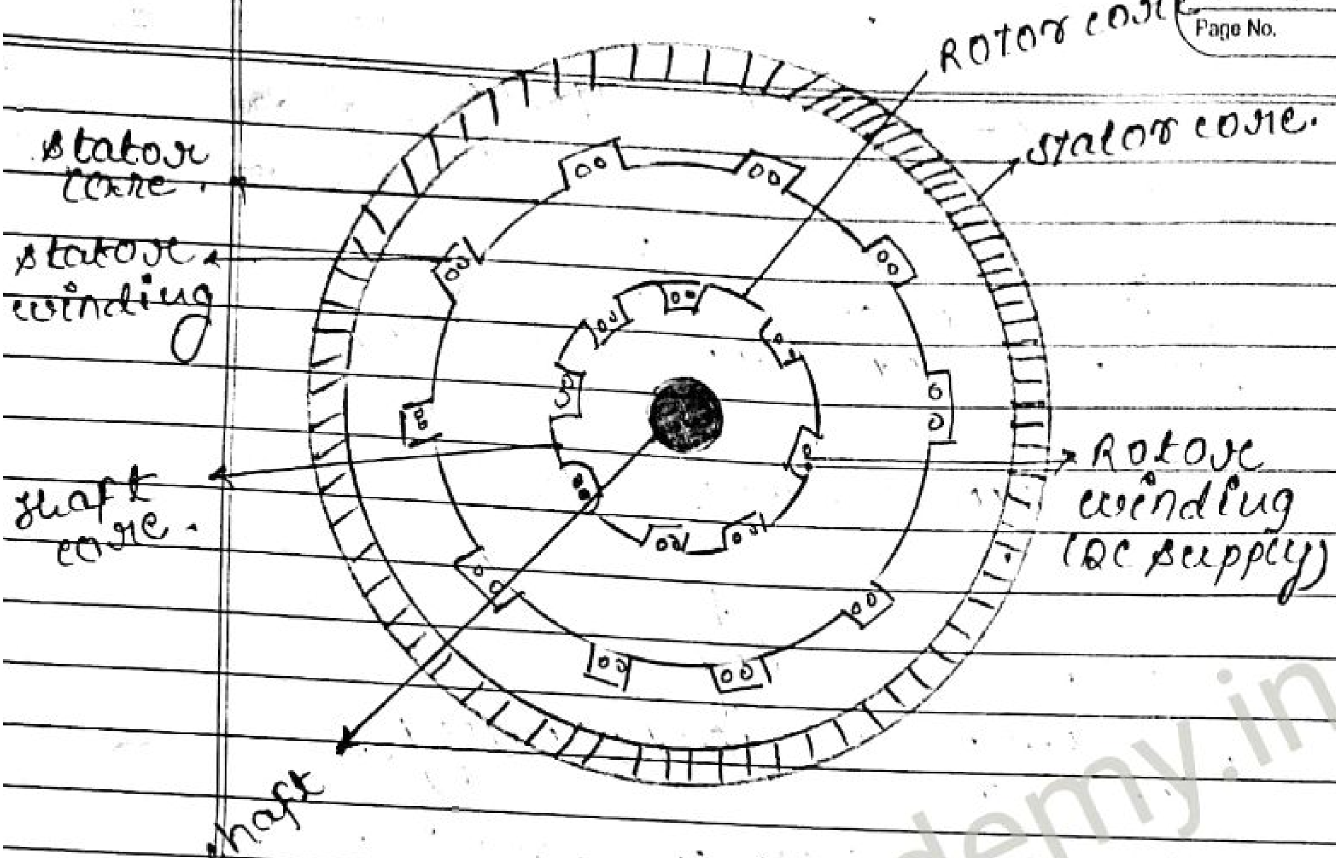
AC (synchronous)
- Stator → Armature winding
- Rotor → field winding

Classification of synchronous Machine —
- Alternator or (500 MVA). generator
- Synchronous motor (doubly Excited).

(1) small size alternators are not economical. It is usually of large size that produces 500 MVA (megavolt Ampere).

(2) Similar to the alternators synchronous motors are also of large size, for small motor application, induction motors are best.

Constructional features of Synchronous Machine:-



Stator consists of stator frame, Stator core and stator 3-phase windings. This is the stationary Part of Machine.

Stator Frame :-

usually This is madeup of cast iron. This Provides mechanical strength to the stator core.

Stator core :-

usually made up of Laminated silicon doped steel. slots are provided on its inner periphery for housing of Three Phase windings.

Armature windings are placed on the stator. it supplies AC Power incase of Generator and it consumes AC Power in case of motor.

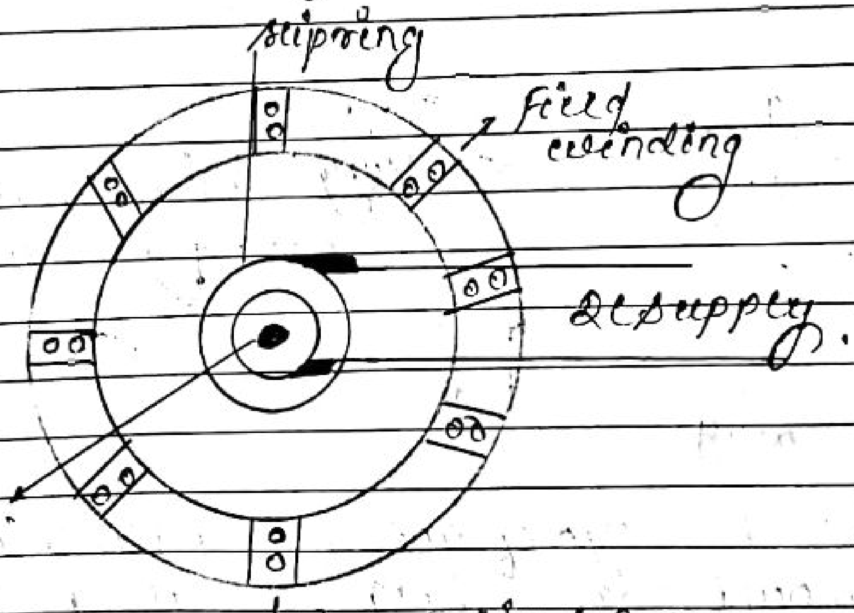
Note:- In this machine field winding is placed on rotor & usually excited by DC source.

Rotor:-
This is the rotating part of machine & carries field winding which is excited by DC supply source through the two slip rings (in place of commutator).

types of Rotor:
↳ cylindrical pole type rotor (non-salient)
↳ salient pole type rotor

28/03/2019 -

(1) Cylindrical Pole Type Rotor:-



Non-salient Pole.

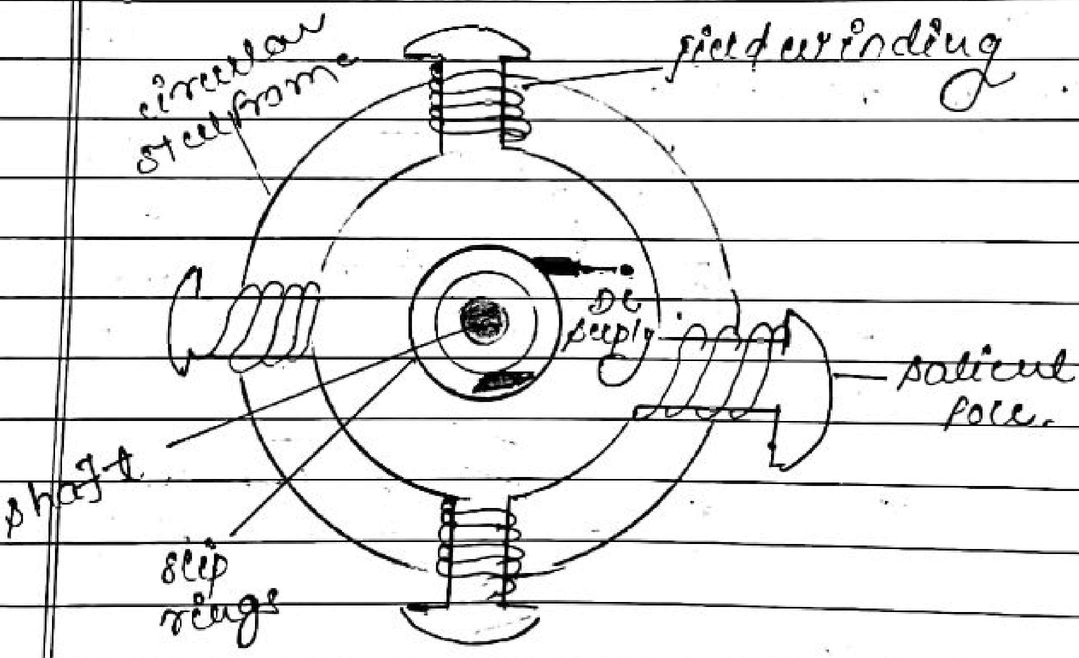
(1) As its name suggest this type of rotor is cylindrical in shape.
(2) Long cylindrical rotor have no. of slots on its

outer periphery.
(2) Field winding are placed in these slots which are connected in series with the slip rings.

(3) slip rings are energized by the DC source by means of carbon brushes

(4) This type of rotor provides uniform air Gap blw the rotor & stator.

(2) Salient Pole Type Rotor :-



(1) In this type of rotor projecting poles are mounted on a large circular steel frame which is fixed to the sharp by means of Bolts.

(2) Individual Field Pole windings are Connected in series in such a way that when the field windings are energized by DC

source. The adjacent poles have opposite polarities.

(3) This type of rotor provides non-uniform air gap between rotor & stator.

Synchronous Generator :- / Alternator :-

(1) In the case of synchronous generator stator have armature windings.

(2) Rotor have field winding which is excited by DC source by means of carbon brush on the slip rings.

(3) Armature winding consists of three coils for three phase alternator. The conductors are parallel to the shaft in the armature windings.

(4) The rotor of alternator has to be rotated at constant speed by source of mechanical power connected to the shaft.

Synchronous Motor :-

1) An alternator can be run as synchronous motor.

(2) The synchronous motor is doubly excited since it requires double excitation in both rotor & stator windings.

(3) The stator windings (Armature winding) are connected to the 3-ϕ AC source. This 3-ϕ supply connected to stator winding produces

rotating field at air gap. The speed of this field depending upon the supply frequency & no. of poles.

$N_s = \frac{120f}{P}$ where N_s = speed of the stator
f → frequency of supply
P – no. of poles.

(4.) DC supply is connected to the rotor windings by means of carbon brushes. Hence the field winding gets excited & produces magnetic field.

Merits of synchronous Machine :-

1) or p.f power factor improvement.
2.) Speed is constant & independent of load.
3.) operates at higher efficiency.
4.) This machine is mechanically better than induction motor.

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Demerits of synchronous machine :-
(i) This machine required seperate DC source for excitation of field winding.

(ii) variable speed control is not possible.
(3.) The cost per kilo watt o/p is higher.
(4.) This motor is not self st and hence require some arrangement for starting.
(5.) whenever it gets overloaded machine falls

out of synchronism and may cause tripping of Pole system
(Tripping - automatically shutdown).

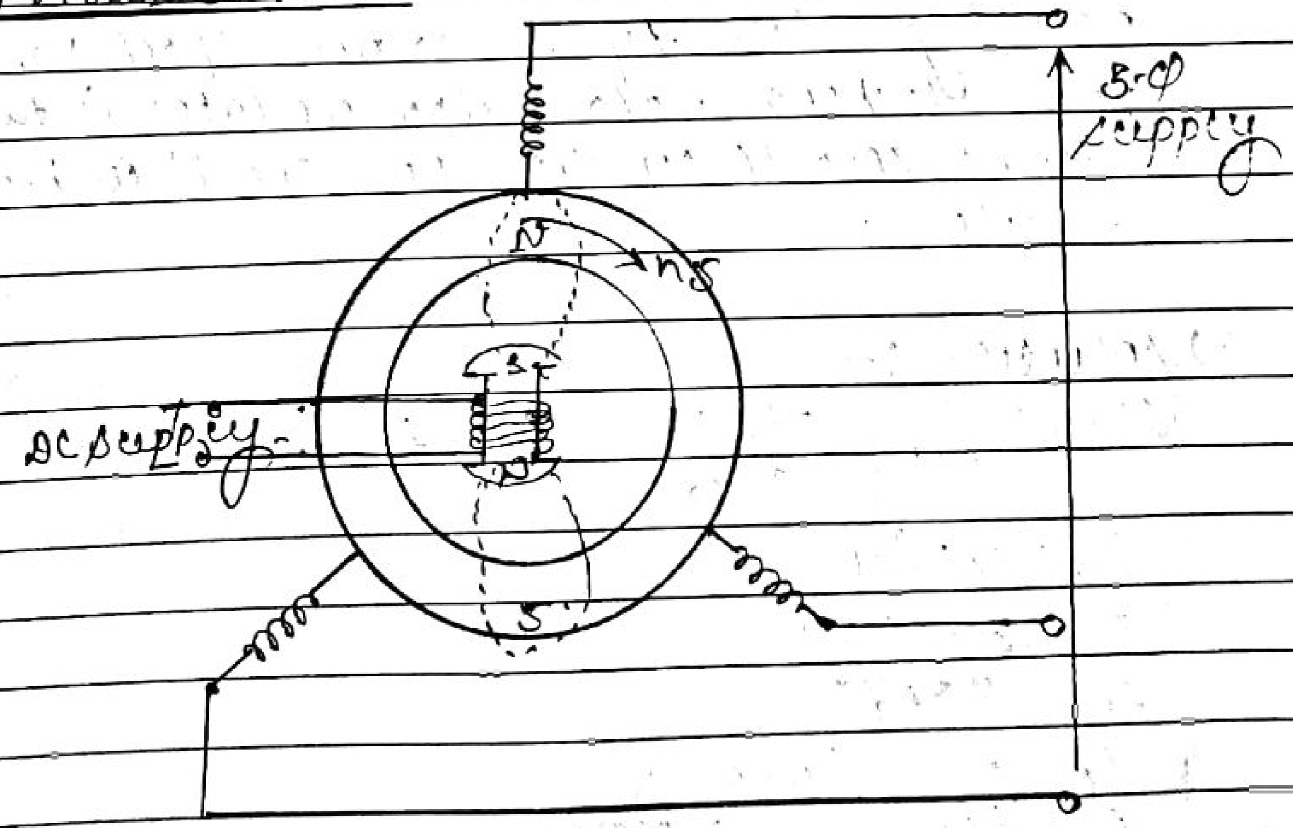
Synchronous Motor (working) :-

In synchronous motor field winding is excited by DC source whereas its armature winding is energised by 3-ϕ AC supply. constructional features are similar for both Alternator & synchronous Motor.

Synchronous motor has constant speed and it runs only at synchronous speed ie $N_S = \frac{2f}{P}$ rps.

corresponding to supply frequency :-

Principle :-



(1) synchronous motor isn't self starting motor for running the motor. Motor is driven by means of prime mover or an another motor upto the speed near synchronous speed.

(2) when 3-φ supply is given to the armature, it produces the synchronously rotating field in the air gap.

(3) The DC supply is given to the rotor which magnetise the rotor so when the rotor is rotate with the help of prime mover upto the speed near synchronous speed, rotor poles are locked with the stator poles.

(4) Since the stator poles (stator) are rotating with synchronous speed so, due to locking rotor also rotates in the same speed (synchronous speed) in the same direction.

Q(03) solution:-

$\left[I_{sh} = \frac{V}{R_{sh}}\right] = \frac{250}{200} = 1.25A$

$I_a = I_L - I_{sh}$

$I_a = 30 - 1.25$

$I_a = 28.75$

$E_b = 250 - I_a R_a$

$E_b = 250 - 28.75 \times 0.1$

$= 247.125$

Q(04):-

$P = 9630$

$V = 230\ V$

$R_{sh} = 0.5\Omega$

$R_a = 100\Omega$

$I_{sh} = ?$

$I_L = ?$

$I_a = ?$

$E_b = ?$

sol:- $I_L = P/V = \frac{9630}{230} = \boxed{41.86}$

$I_{sh} = \frac{V}{R_{sh}} = \frac{230}{0.5} = \boxed{460}$

$I_a = I_L - I_{sh} = 41.86 - 460 = \boxed{-418.14}$

$E_b = V - I_a R_a = 230 - (100 \times -418.14)$

$= 230 + 41814$

$E_b = \boxed{42044}$

01.04.2020-

Basic Principle of Alternator (synchronous generator):-

(1) AC generators or alternators operates on the same fundamental principle of electromagnetic induction as DC generators.

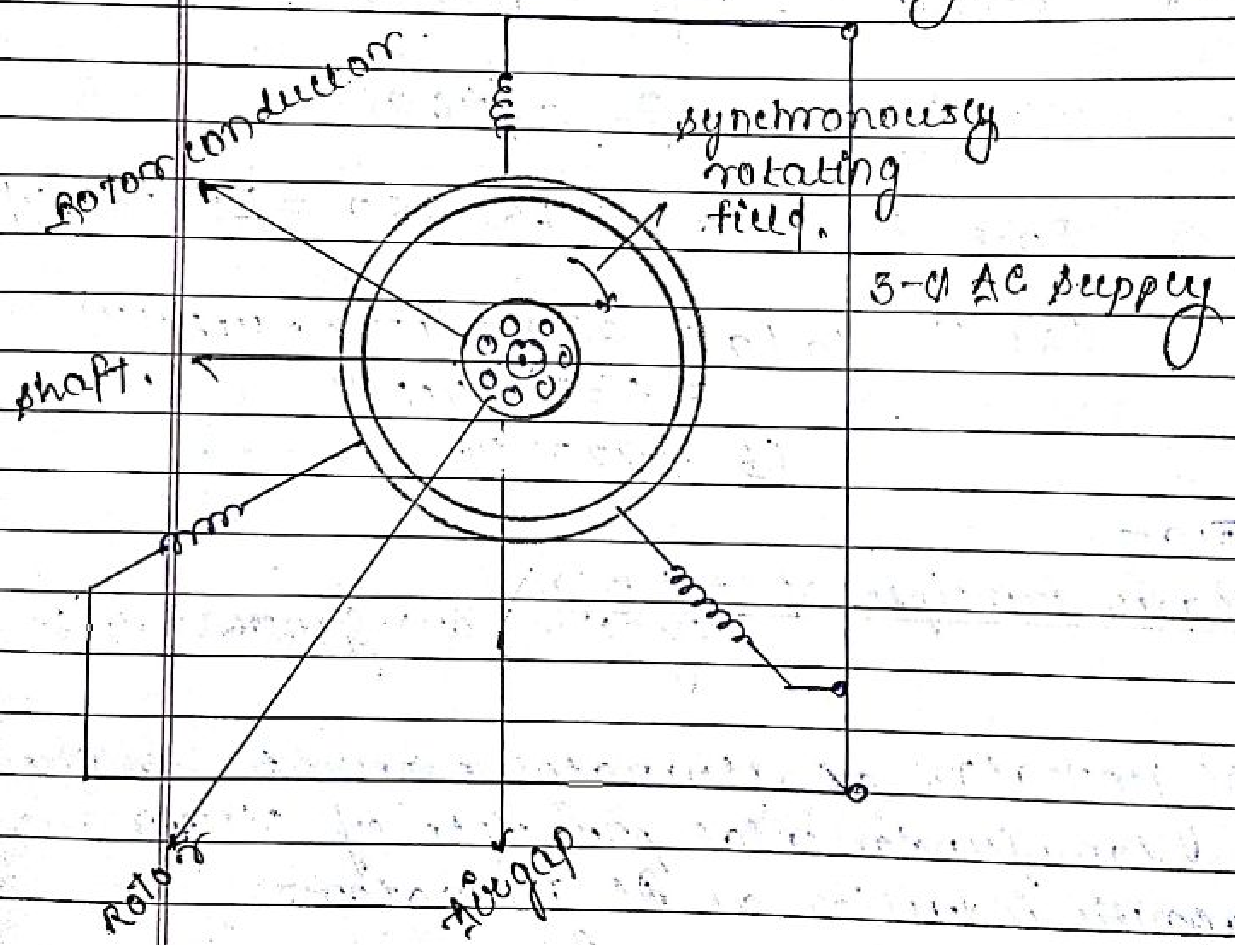
(2) They also consist of an armature winding placed on the stator & a magnetic field.

(3) But there is a difference b/w the two as in case of DC generators the armature rotates &

field system is stationary but the arrangement of alternator is just reverse of it.

(4) In their case standard construction consists of armature winding mounted on a stationary element called as stator & the field winding is placed on the rotating element called as rotor.

3-ϕ Induction motor (working Principle) :-



(i) Induction motor works on the principle of ~~mutual~~ mutual induction. (Transformer action). The induction motor is singly excited machine.

which converts the electrical energy at the stator to the mechanical o/p on the rotor shaft.

(2) when the 3-ϕ stator winding are excited by 3-ϕ AC supply, it produces the rotating flux in the air gap. This flux is cut by short circuit rotor conductors.

(3) So Faraday's law of Electromagnetic induction emf is induced in the rotor circuit. Since rotor circuit is short circuit ∴ Large current starts flowing in it.

(4) The induced rotor current produces its own flux in air gap due to interaction of rotor & stator produced flux, a torque is developed. This torque is responsible for rotation of rotor. In this way electrical energy is converted into Mechanical energy.

(5) The induced emf in the rotor circuit has the same frequency as that of supply and the polarity is such that it can opposes that cause a/c to Lenz law. In this case the cause for induced emf is the relative motion b/w the rotating air gap flux.

(6) For reducing this relative motion b/w stator field & rotor circuit rotor starts rotating in similar direction i.e field or it tries to follow the synchronously rotating field.

In case of induction motor rotor

cannot achieve the synchronous speed because if rotor attends this speed, there will be no relative motion b/w the field & rotor circuit so emf will be induced in the rotor a/c to faraday's law of electromagnetic induction because of the absence of induced of induced current & the torque will be zero and rotor stops immediately. so the induction motor always runs at the speed lower than the synchronous speed

02.04.19 -

Construction of 3-ϕ Induction Motor :-

Stator

Rotor

Squirrel cage Rotor

wound Rotor (or)

slipping type Induction Motor.

Stator :-

(1) The stator has laminated core in order to reduce the eddy current loss.

(2) It has slots in its inner periphery to accomodate 3-ϕ distributed winding

(3.) These stator windings are connected to the 3-ϕ energy system. to set up the synchronously rotating field in the air gap.

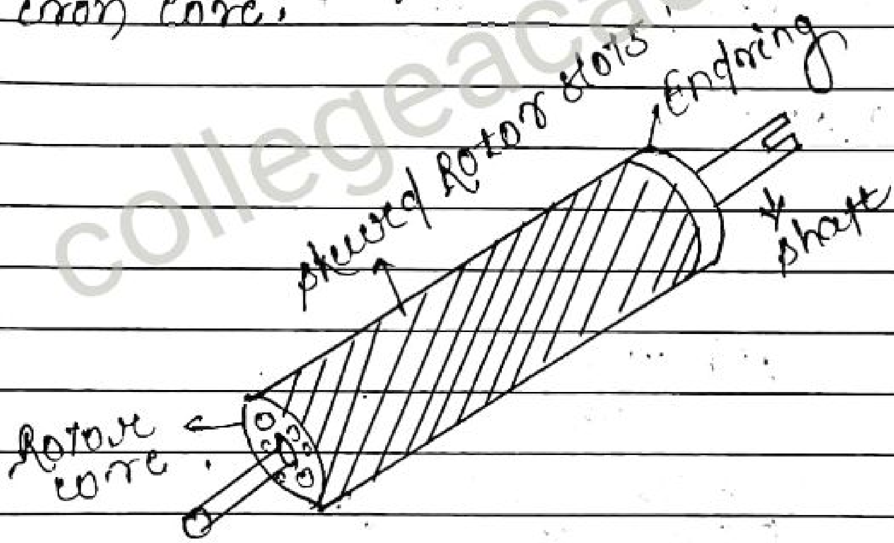
ROTOR :-

on the basic of rotor construction 3-φ induction motor is classify as-

i) squirrel cage Rotor :-

a) In this type of rotor, rotor does not have the windings distributed in the slots. which has uninsulated copper or aluminium bars which are short circuit at the endrings.

b) These bars are placed in the slots on laminated iron core.



(c) For the rating lower the 50kW, rotor core is normally squirrel cage type.

Advantages :-

1) it is more economical.

2) construction is simple.

3) Less supervision and maintainance is required.

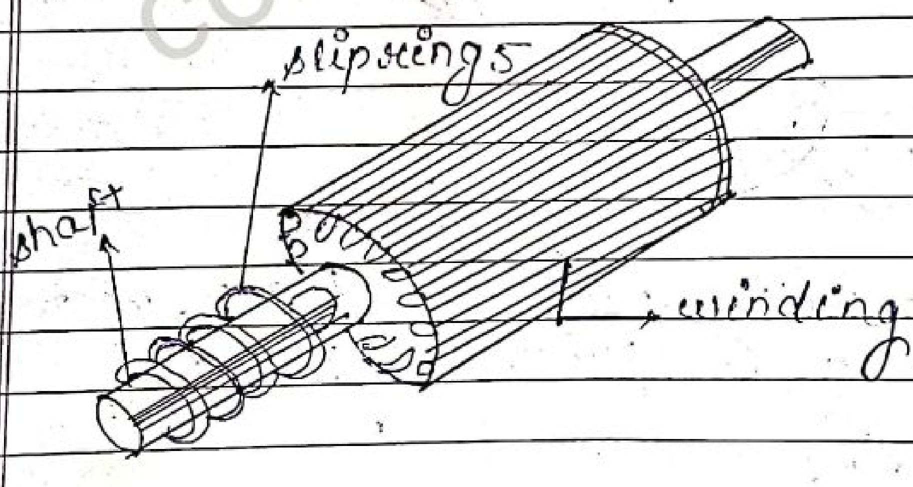
4) No slipring & extra resistance required.

Disadvantages:-

(1) The induction motor requires high starting torque and low starting current. The starting torque is directly ∝ to the rotor resistance. Since in case of cage motor the bars are short circuited at the end. so there is no provision of high resistance and also extra resistance cannot be inserted in the circuit.

(2) Starting characteristics is poor as compare to wound rotor type motor.

Wound Rotor:-



(1) The construction of this rotor is similar to the stator that means it has 3-ϕ distributed windings accomodate in the slots provided on it outer periphery.

(2) These windings are normally star connected. The outer terminals of this windings are

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Page No.

Connected to the insulated slip rings placed on the shaft.

(3.) The brushes are rest on this, the whole arrangmt. includes the external star connected rehostat (variable resistance).

03.04.19 –

Advantages of wound motor:-

(i) Since there is a provision of providing extra resistance the starting torque can improve to large extend and the starting torque can be reduced to very low value.

Disadvantage :-

1) Construction is complicated and more costly as compared to squirrel cage motor. It requires extra supervision & maintainance.
2) More frictional losses at slipring and brushes.

Air Gap :-

This is provided b/w rotor and stator structure. This must be as small as possible in order to reduce the losses and magnetic leakage flux.
Air gap should be uniform. The resultant magnetic field due to stator & rotor current is setup in the air gap which causes the rotation of rotor.

FRAME :-

- Frame is the outermost part of the machine which is made up of closed grained alloy of cast iron & it is used for giving the mechanical strength to the stator.

SHAFT :-

Rotor is mounted on the shaft by using ball bearing and rollers. also the mech. load is connected to the shaft. In case of bound rotors s

Cooling fans:-

The efficient working of induction motor which requires the adequate cooling arrangement. This can be achived by providing mechanical rotor shaft.

Slip and slip speed:-

As we have discuss the rotor runs at the speed lower than the synchronous speed is maximum possible speed. For given no. of poles.

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

f = supply frequency

P = no. of poles.

or $$N_s = \frac{2f}{P} \text{ rps}$$

Slip:-

Slip is that factor by which rotor speed is less than synchronous speed. It is a always express in % of synchronous speed.

$$S = \frac{N_s - N_r}{N_s} \times 100$$

where N_S = synchronous speed in rpm.
N_r = Rotor speed in rpm

slip speed is:
slip × synchronous speed
$= N_S - N_r$ (rpm).
$= n_S - n_r$ (rps).

Slip Torque Characteristics: Of induction motor: