LECTURE NOTES ON

ELECTRICAL MACHINE

4^{TH} SEMESTER ETC

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Unit-1 : Electrical material

Electrical Material :-

The material which conduct electricity due to free electron when an electric potencial different is applied across than is called as electric material.

OHMS Law :-

At constant all physical quantity (tempretune, pressen,) in a close loop the current flowing through a conductor is directly perpostional to the potencial difference bet^n two end point at the conductor.

$V = I \times R$

ρ - Row

$I = \frac{V}{R}$

$V \propto I$ (in case Tempretune is constant)

$I \propto \frac{1}{R}$ ↓ ↑

$R = \rho \frac{L}{A}$

$A = \pi r^2$

$\rho = \frac{A \times R}{L}$

$\rho \rightarrow$ Resistivity

Properties & uses of different conducting material

(1) Low Resistivity :-

* Conductivity of a conductive material is inversely perpostional to Resistivity.
* So a conductive material should have low resistivity. so it will have better resistivity.

(2) Low tepretune coefficient :-

It means change of resistance which change in tempretune should below.

Ex:- In case of Hz sum of the resistance transmission line which are very long will increase. So more voltage drop and power loss occurd.

(3) Sufficient machanical strength :-

* In the case winding of transformer and over head line conductors use for transmission and distribution of electric Power. conductor are subjected to mechanical strength.

* There for to withstand mechanical stress the conductivity material should process sufficient mechanical strength.

(4) Ductility :-

* It is the Properties of material which a low drown out into a wire.

~~(5) Soil :-~~

* Conductor are required different size & shape. conductive material should be an above enable it self being drom into difference size & shape.

(5) Solderability :-

* Conductor have obtain to joinented. The joinent should have accure minimum constant resistance.

* So if the joint solider then minimum contanct registance.

(6) Resistance of corrosion :-

The conductive material should be such that if it is not corroded when it is use in outdoor atomsphere.

Application :-

* House wireing.
* Transmission & distribution. → ACR use conductor.

ACR → (Aluminium constant Resistivity).

* ACR conductor.
* Use in winding of electrical machine & transformer.
* Use for resistance welding electron.
* Use as filament in incandescent electrical heater.

Insulating materials :-

Those materials through which electricity does not flow are current electric insulating materials such as paper, plastic rubber mica wood etc.

Insulating material Properties & use of various insulating material :-

Properties :-

(i) visual properties.
(ii) Electrical Properties.
(iii) Mechanical Properties.
(iv) Chemical Properties.

(i) visual Properties :-

(a) appearance
(b) Colour.
(c) ~~cryst~~
(c) crystallinity.
(d) These count some extened twowards the customer selection of the insulating material.

Mechanical properties :-

(a) Density :-
Electrical insulator are use in the basic of volume & not weight.

Viscosity :-
* The viscosity is the resistance of a fluid (liquid or gas) to a change in shape or movement of neighbouring portions relative to one another.
* This Properties is important in case of liquid dielectric city uniform viscosity leads to uniform electrical

thermal properties

Moisture observation :-

Moisture water lowers the electrical resistance & also it dielectric strength.

* This may also result seling explain of material.

Electrical perpoties :-

(i) insulation Resistance :-

This is a properties by virtue of which a material resist flow of electric current it should be as high as possiable.

Dielectric strength :-

* Dielctric strength is defined as the electrical strength of an insulting material.

* It is a maximum potential gradient that the material can widthstand.

* If the operating voltage gradient increase the at a Particular voltage break down will occur & can s insulation Properties permanently.

Dia electric Constant :-

A Quantity measure the ability of a insulating material to store electrical energy in an electric field. for different measuring material capacitance is different.

$$C \propto \frac{A}{d}$$

$$C = E\frac{A}{D}$$

where, A = Area

d = distance betn two placed capacity

E = dielectric material.

Dielectric losses :-

* Insulator observe & obsorb electri energy and it reduce that energy in the form of Head it is know as dielectric losses.

* There is some electriclosses the electriclosse is called dielect-ric loss.

* So in this case the angel betn changing current & applied voltage is always less than 90°.

Chemical Properties :-

(1) Resistance to external :-

Insulating material should be resistance to oil or lequid, gas, fumes, Acid & Alkanis. The material should not go under oscillation & Hydrocies even under adverse condition.

Resistant to chemical in soil :- .

Effect of water :-

Water directly lower the electrical properties such as electrical resistance dielectric strength.

Uses :-

* Soild insulator :-

* The Application of insulating material are electrical rubber mats, Power & electronic system, cable & transmission lines etc.
* Use in welding machine, electric welding ovent etc.

Example :- Vaka · cotton, mica, paper, rubber, glass.

* use for widing of small magnet coil. (Armature winding, Chok, transfermer coil), X-Ray tube, ..

Lequid insulator :-

* Lequid insulater use in transfermer and oil circuit breaker where this help to disposal the heat generated by convetion.
* Exm :- silicon oil, mineral oil.

Gaseous insulator :-

* A dielectric gas, or insulating gas, is a dielectric material in gaseous state. its main purpose is to prevent or rapidly quench electric discharges.

Exm :- air, sulphur hexafluoride, nitrogen, SO_2, SO_4.

Various magnetic material & there uses :-

There are 3 types magnetic material.

(i) Paramagnetic materiail.
(ii) Diamagnetic material.
(iii) Ferromagnetic materiail.

(i) Paramagnetic materiail :-

The material which are not strongly attracted by magnetic material is known as Paramagnetic material.

Exm :- (i) Aluminium is not a magnetic material.
(ii) Magnesium :- tin,

* There are relative permability as small but positive. OR Just ~~gx~~ generator slidely than 1.

* For Exm :- The peramability aluminium is 1.00000065.
* Permability - magnetizes nan demagnetize.
* Such material are magnetize only when placed on supper strong magnetic field and at of the direaction of the magnetic field.

* When a strong magnetic field is appleied the permanent magnet dipoles orient them selves parallel to the applied magnetic field & give rise to the positive magnetizations.

* Since orientation of dipoles parallel to the applied magnetic field. the magnetization is very slow.

~~De~~

Demagnetic material :-

~~The material which are repelled by magnetic field, such as zinc, led~~

* When the diamagnetic material is placed on an external magnetic field, the material is weakly magnetised in such a way that it repels the extrenal field is known as demagnetic material.
* Example :- Copper, gold, antimony, silver, lead and hydrogen.

* The permability of the material is slidely less than 1.
* permanent magnet are absent its them.
* So very little OR no opplication electrical engineering.
* Exm:- The permability bismuth is (0.00083) (0.00083)

Ferro magnetic material :-

The which are strongly attracted by a magnetic is called ferro magnetic material.

Exm :- iron, Cobal, nikel, still

Application :-

* magnetic element present Harddics hence, to use computer to extra information.
* It is also use in food proccesing for separating smal metalic resources.

* Ferromagnetic materials commonly used for nonvoltage nonvolatile information storage in tapes, hard drives etc. They are also used for information-processing due to the interaction of electric current and ligh with magnetic order.

Date- 27.02.23

Unit-2	DC Generator	Unit-2

Machine :-

* The machine is the part of instrument which comparise a several part for doing a particular tax for utilising mechanical energy is called machine.

DC Generator :-

Generator is a electrical machine which convert mechanical energy to electrical energy. which work on the princeple of Faraday's Law of electro magnetic induction.

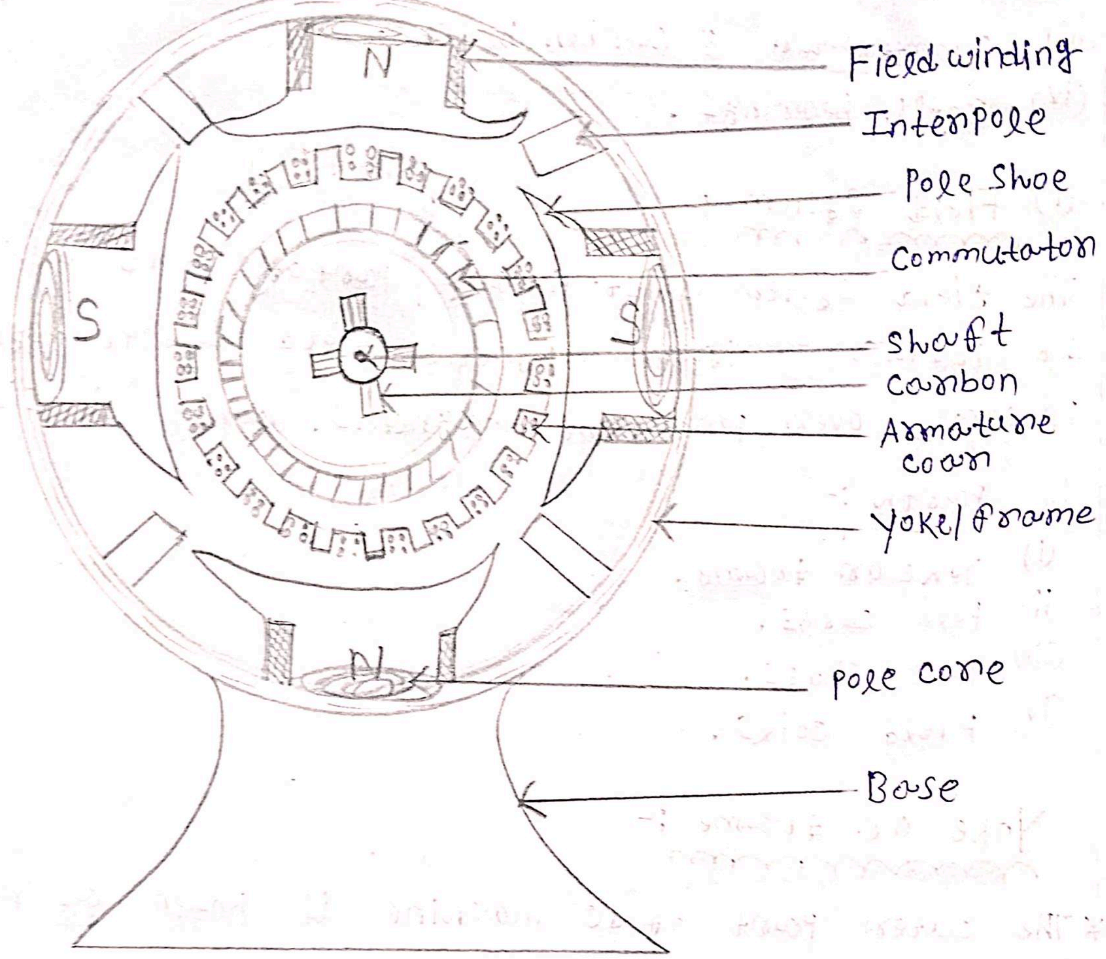
Faraday's Law :-

Whenever a conductor is placed in a varying magnetic field, an electromotive force is induced., if the conductor circuit is closed, a current in induced, which is called induced current".

Generator are 2 types :-

(i) AC Generator (ii) DC Generator.

DC Generator :-



* DC Generator is a Generator which convert machanical energy to dc voltage source.

* An electric generator based on the principle that, when even a current carrying conductor placed on the magnetic field flux is cut by the conductor & e.m.f is induced. which will cause a current to flow it's the conductor circuit is close.

* Direction of the induced emf is given by the framing Right hand Rules.

Construction of DC Generator :-

DC generator consist of 4 Parts

(i) Field system.

(ii) Armature circuit.

(iii) commutator & carbon brush.

(iv) Ball bearings.

(i) Field system :-

The field system is stationary part of a dc machine It produce uniform magnetic field. Electromagnets are preferred over permanent magnents. also Consist of 4 parth :-

(i) Yoke or frame.
(ii) pole cores.
(iii) Pole shoes.
(iv) Field coils.

Yoke or frame :-

* The outer part of dc machine is known as Yoke or frame.
* In small machine Yokes or made of cast iron but for largers machines rolled steels are used.

Yoke performs two purpoes :-

i* It provides mechanical straight & support for poles to be pivoted & protects to find flux./ To act as proteting cover for whole dc machine.

(ii) Pole cores :-

* pole cores are circular section and if used to cary the insulated field coils.
* pole cores are not laminated for small machine.
* But for large addvanced machines laminated steel sheets are used.
* The thickness of the lamination varioues from 1mm to 0.25 m.m.

(ii) Armature circuit.

(iii) Commutator & carbon brush.

(iv) Ball bearings.

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Relatance :-

It is propertity of a magnetic material which opposes the magnetic flux is know as relatance.

Pole Shoes /- poly Pole shoe :-

* Pole shoes support the field coils and serres two purposes.
* They spread the flux in the air gap.
* Reduces the air gap between star and rotor being larger in cross-section.
* The pole core / pole shoe are made of the cast steels The pole is laminated to reduce the loosses.
* The pole are such the following purpose.
(i) its support the fieldwinding.
(ii) They spered out the magnetic flux over are Armature most uniformly.
* It increase the cross section Area of the magnetic the relatance of the magnetic circuit at the resuelt part reduce.

Field coils :-

* The field coils or winding are made to copper wires or strips.
* The purpose of field coil is to provide the required mmf (flux) to induce the descrired potential difference.

* Filedwinding :-

Each pole core as work on more field winding placed over it. to produce a magnetic field.

* It is made on cupper wire.

* The coils are wonds on the former on it is placed around the pole core. when the direct current posses through the field winding, magnetic flux produce.

Armature circuit :-

* It is the rotating part of the DC machine the purpose of the armature is to roate the conductor inside the magnetic field.

* It consist of coils of insulated wireless wound around an iron core and emf is induced in it when rate of change of flux occurs due to rotation of the armature The armature core is made of high permeability silicon steel. Also they are laminated.

Commutator & carbon brush :-

Commutator acts as mechanical converter it converts AC to DC in case of dc generator & converts d.c to AC in case of dc motor. In a dc machine the armature e.m.f is alternating in nature also Commutator provides an electrical connection betn the rotating armature coils and station ay extranal circuit carbon brushes are made of carbon and its function is to collect current from the rotating commutator and suppy to the external load circuit. (in case of dc generator) (In case of dc motor) carbon brushes are used to gue suppy, to the rotating commutator. The brushes are hold under persssure on commutator by spring for smooth contact.

Ball bearings :-

Ball bearings are used to hold the rotor shaft with the static support. for small machine ball bearings are used in both ends of shaft. for large machine, roller bearings are used in both ends of shaft for large machanicse, roller bearings are used at the driving end.

Armature winding

* The solts of the Armature core whole insulated conductors that are connected a suitable manner this is known as Armature winding.
* The Armature winding is place where, coverssion power Mechanical power ⟷ Electrical Power
* Armature winding two types.

(i) Lap winding.

(ii) Wave winding.

(i) LAP winding :-

In Lap winding $a = P$ where,

a = Number of parallel path.

P = Number of ~~whole~~ pole

Wave winding :-

In wave winding $a = 2$ (a always 2).

Working Principle of DC Generator :-

* According to Faraday's law of E.M.F induction when conductor placed in a varying magnetic field & E.M.F induced in that conductor.

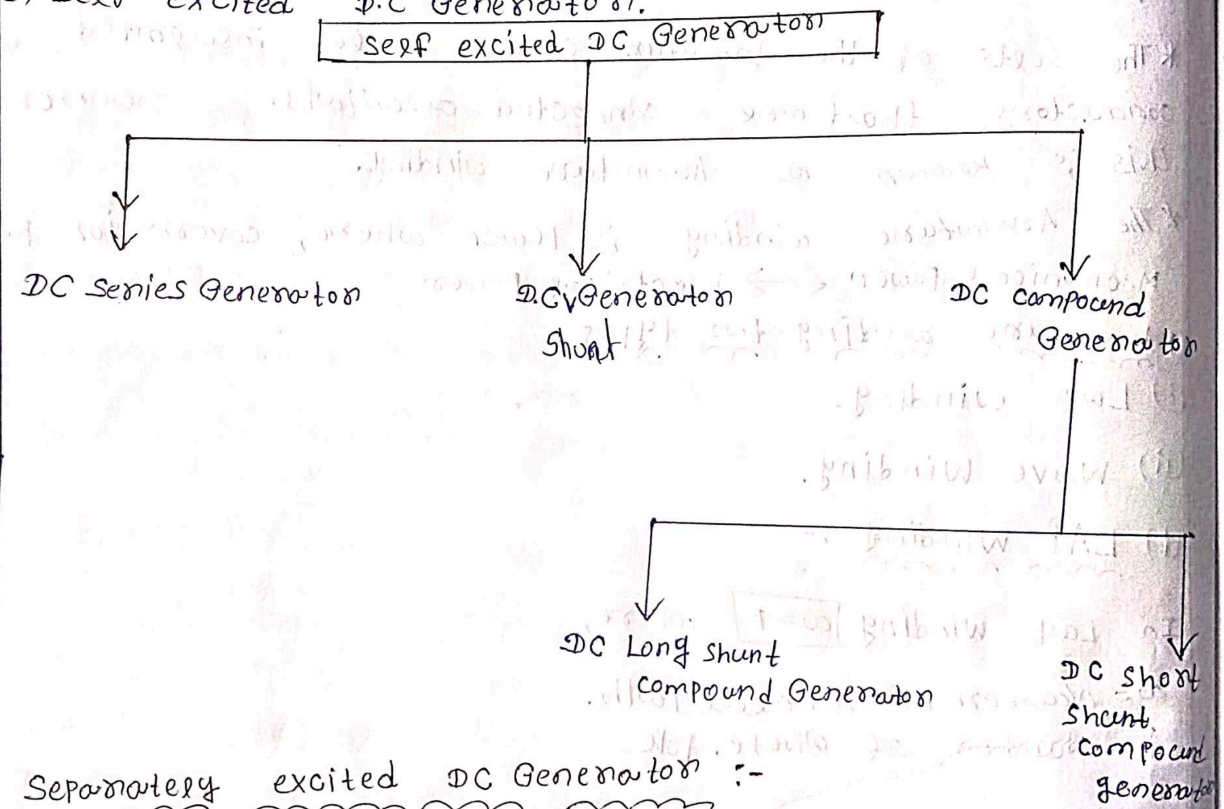
* ~~The magnitude~~

* The magnitude of induce of E.M.F can be calculation from of DC Generator.

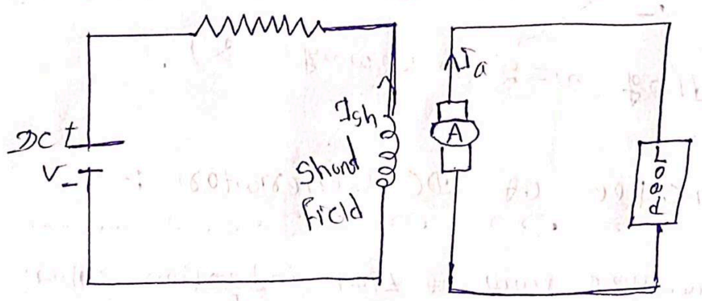
Application of DC Generator :-

Classification of DC Generator :-

(i) Separately excited D.C Generator.
(ii) Self excited D.C Generator.



Separately excited DC Generator :-



* A DC generator whose field magnet winding is supplied for on independent extranal dc source is separatelly excited DC generator.

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

where P = number of pole

E_g = Generate e.m.f

ϕ = magnetic flux.

N = speed

Z = number of conductor.

A = Number of power parallel path.

* Terminal Voltage $\boxed{V = e_g - I_a R_a}$ ($V = IR$)

$\boxed{V = IR}$

where,

I_a = Armature current.

R_a = Armature resistance.

$\boxed{E_g = V + I_a R_a}$ — given current / Resistance

Power developed :-

$$P = V \times R$$
$$P = E_g \times I_a$$

Power deliver to load :-

developed power – losses

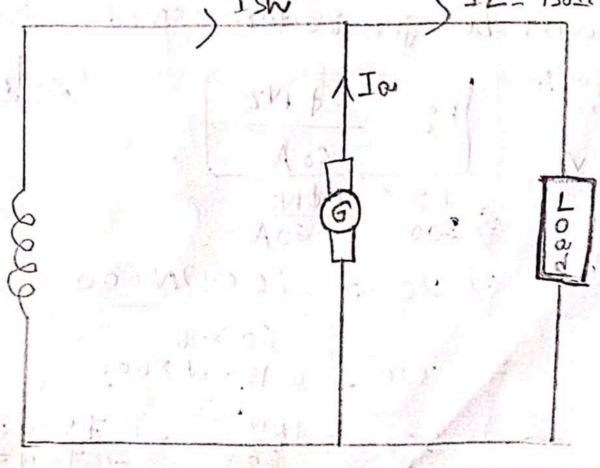
Date – 4.03.23

Problem No :-1

A shunt Generator delivers 450 Am at 230 V and the Resistance of the shunt field at the Armature are 50Ω & 0.03Ω Respectively. Calculate Generated e.m.f ?

Ans :-

Give data



I_L = 450 Am

R_a = 0.03 Ω

V = 230 V

R_{sh} = 50 Ω

$\boxed{E_g = V + I_a R_a}$

Find

$I_a = I_L + I_{sh}$

$\Rightarrow$ ~~$I_a - I_{sh}$~~

$I_{sh} = \frac{V}{R_{sh}} = \frac{230}{50} = 4.6$ Am

$I_a = I_L + I_{sh}$

$\Rightarrow I_a = 450 + 4.6$ ~~$= 451$~~

$= 454.6$ Am

$E_g = V + I_a R_a$

* $E_g = V + I_a R_a$

$E_g = 230 + 454.6 \times 0.03$

$= 243.63$ V

* $E_g = V + I_a R_a$

$\Rightarrow V = E_g - I_a R_a$

$\Rightarrow V = 243.63 - (454.6 \times 0.03)$

$\Rightarrow V = 229.992$ V (Ans)

Problem No :- 2 wave winding $A = 2$

(ii) $E_g = \frac{P\phi NZ}{60A}$

$\Rightarrow 300 = \frac{6(0.02) N \times 600}{60 \times 2}$

$\Rightarrow 300 = \frac{6(0.2) N600}{60 \times 2}$

$\Rightarrow 300 = \frac{0.12 \times N \times 600}{60 \times 2}$

$\Rightarrow 300 = \frac{72N}{120}$

$\Rightarrow 300 = 0.6N$

$\Rightarrow 0.6N = 300$

$\Rightarrow N = \frac{300}{0.6}$

$= 500$ R.P.M (Ans)

Problem No :- 2 :- Date - 06.03.23

A 6 Pole lap wonded Generator has 600 conductor, the flux per pole is 0.02 above (i) calcalated the speed are to which The Generator rungs to generate 300 V ?
(ii) What will be generator speed e.m.f with wave wonded ?

Given data :-

(i) $E_g = 300$ V

$Z = 600$

$\phi = 0.02$

$a = 6$

$P = 6$

$E_g = \frac{P\phi NZ}{60A}$

$E_g = \frac{P\phi NZ}{60A}$, ~~$E_g$~~ 300

$\Rightarrow 300 = \frac{6(0.02) N 600}{60 \times 6}$

$\Rightarrow 300 = \frac{0.12 \times N \times 600}{60 \times 6}$

$\Rightarrow 300 = \frac{72N}{360}$ $\Rightarrow 72N = 300 \times 360$ $\Rightarrow 72N = 108000$ $\Rightarrow N = \frac{108000}{72} = 1500$

So, $N = 1500$

Date - 09.03.23

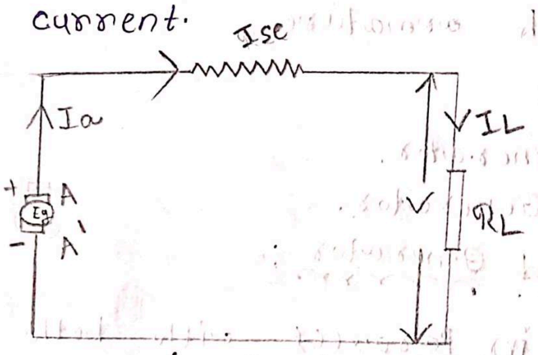
Self - excited :-

* A DC Generator whose field magnet winding is supplyed current for output of generator itself is called a self excited generator.

* There are 3 types exciting generator
(i) series Generator.
(ii) shunt Generator
(iii) Compound Generator.

(i) series Generator :-

In this generator field winding connected in series with Armature winding, so that whole Armature current flow through the field winding & series field winding & load current.



(series Generator)

$E_g = V + I_a R_a + I_{se} R_{se}$

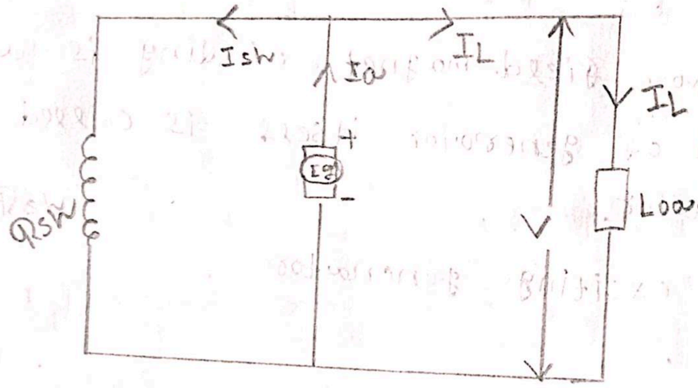
V = terminal Voltage

$I_a = I_{se} = I_L$
$V = E_g - I$

Shunt Generator :-

* Field winding is connected in parallel with armature winding. The shunt winding has many turns having high resistance has many turns having high resistance.

* Therefore only a armature current flows through shunt field is rest flows through load.



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

$I_a = I_L + I_{sh}$

$V = E_g - I_a R_a$

$I_a = I_L + I_{sh}$

$\Rightarrow I_{sh} = I_a - I_L$

$\Rightarrow I_L = I_a - I_{sh}$

Compound Generator :-

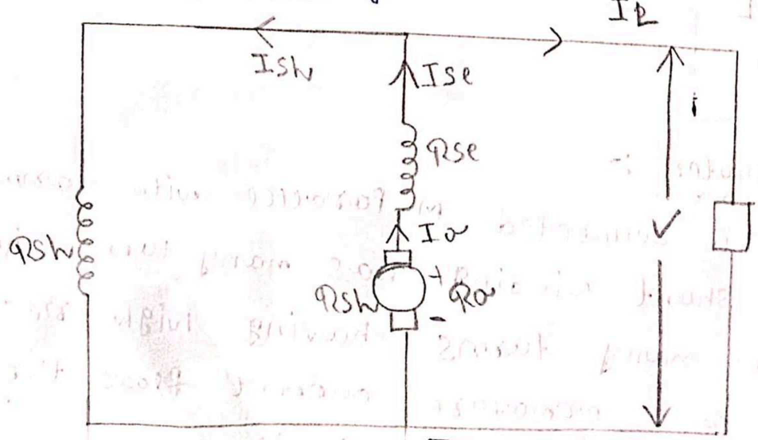
* In a compound generator there are two of field windings on each pole - one is in series with armature & other in parallel with armature.

* It is of 2 types :-

(i) Long Shunt compound Generator.
(ii) Short shunt compound Generator.

(i) Long shunt ~~Gen~~ compound Generator :-

* shunt filed winding is in parallel with both series field in Armature winding.



* Ise - Series current

* Long shunt current ~~Ish =~~

* $(P_d) = E_g \times I_a$
* $(P_L) = V \times I_a$

$I_{se} = I_a = I_L + I_{sh}$

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

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

$I_a = I_{se}$

$I_a = I_{sh} + I_L = I_{se}$

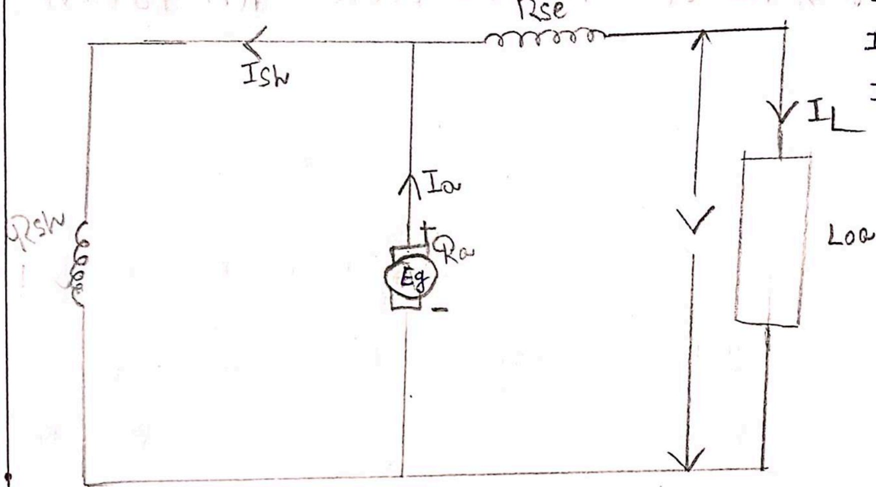
$E_g = V + I_a R_a + I_{se} R_{se}$

$\Rightarrow E_g - I_a R_a - I_{se} R_{se} = V$

$\Rightarrow E_g - I_a R_a - I_a R_{se} = V$

$\Rightarrow E_g - I_a(R_a + R_{se}) = V$

Short Shunt Comopound Generator :-



$I_{se} = I_L$

$I_a = I_{sh} + I_L$

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

$I_{se} = I_L$

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

$V = E_g - I_a R_a - I_{se} R_{se}$

* shunt field current $I_{sh} = \frac{V + I_{se} R_{se}}{R_{sh}}$
* pawlleel develope in Armature $(P_d) = E_g \times I_a$
* pawlleel deliver to load $(P_L) = V \times I_a$

E.M.F Equation of DC Generator :-

E.M.F = Electro motive force.

Let ϕ = flux/Pole in wb weber

Z = Total number of armature conductor

N = Speed of Armature in r.p.m.

P = number of pole.

E_g = E.m.f of Generator.

A = number of Power parallel path.

Flux

* flux cut by one conductor in one revolution of the Armature is $d\phi = P\phi$ in wb .
* Flux unit is weber .
* Time Taken to Complete one revolution $dt = \frac{60}{N}$ second

time

* e.m.f generate cut conductor $\frac{d\phi}{dt} = R = \frac{P\phi}{\frac{60}{N}}$

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

* e.m.f generator Eg = e.m.f per parallel path.

* E.M.f / conductor X No. of conductor series per parallel path.

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

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