DC: Constructional features, D.C. Machine Introduction, equivalent circuit, emf equation, Principle of operation of D.C. generators and motors, speed controllation motor, flux control, ~~dcel~~ rheostatic control, voltage control, Ward-leonard system, speed controller series motor.

UNIT-3

DC Machine

-> The constructional features of DC Machine remains same for D.C. Motors as well as D.C. Generator

-> BUT the machine is differentiated based on the principle of operation.

M.E. -> electrical energy -> DC Generator

electrical energy -> ME -> D.C. Motor

The D.C. Machine consist of two parts
-> Static
-> Dynamic or rotatory.

DC Machines are characterised into
- Series
- Shunt
- compound

- Static - The immovable parts of the D.C. machines is known as static part.
- The movable part of D.C machine is known as Dynamic part.

Parts of D.C. machine

→ 1. Yoke
→ Poles
→ Pole shoe
→ Brush
→ Field winding
→ Armature winding
→ Commutator

1. Yoke - It is a stationary part of the D.C. machine. It is the outermost part of D.C. machine where, the whole of machine is placed.
   Field winding:

2. ~~Poles -~~

2. Armature! - Armature is the rotatory part of D.C. machines.

3. Poles - Poles are magnets that are present in D.C. machine.

4. ~~A~~ Pole shoe The part of the pole that is attached to the yoke is known as pole shoe.

5. Commutator - The part of the machine that converts A.C. to D.C. is known as Commutator.

6. Brush - Current is collected through the brushes and it is made up of carbon

→ The ~~chate~~ categorisation of D.C. machine is based upon the placement of field windings wrt armature.

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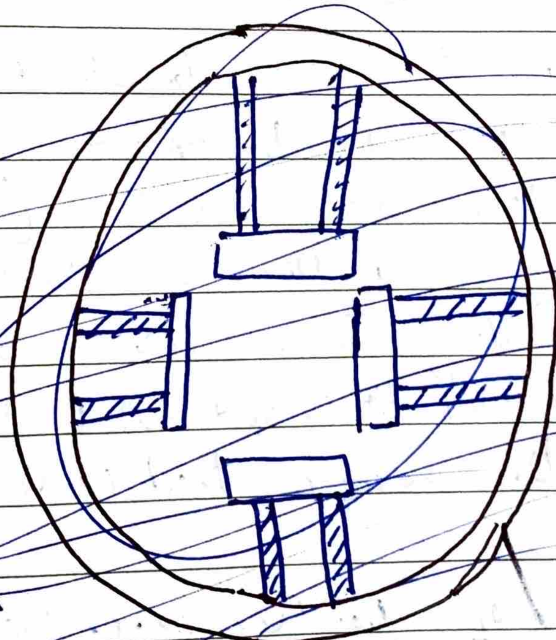
i) If the ~~machine~~ field winding is in series with the armature winding, it is known as D.C. series machine.

ii) If the field winding is in parallel or shunt with the armature winding it is known as D.C shunt machine

iii) If the the machine consist of both series and shunt winding it is known as D.C. compound machine

4 pole ~~a~~ D.C Machine



wire or windings are known as conductors

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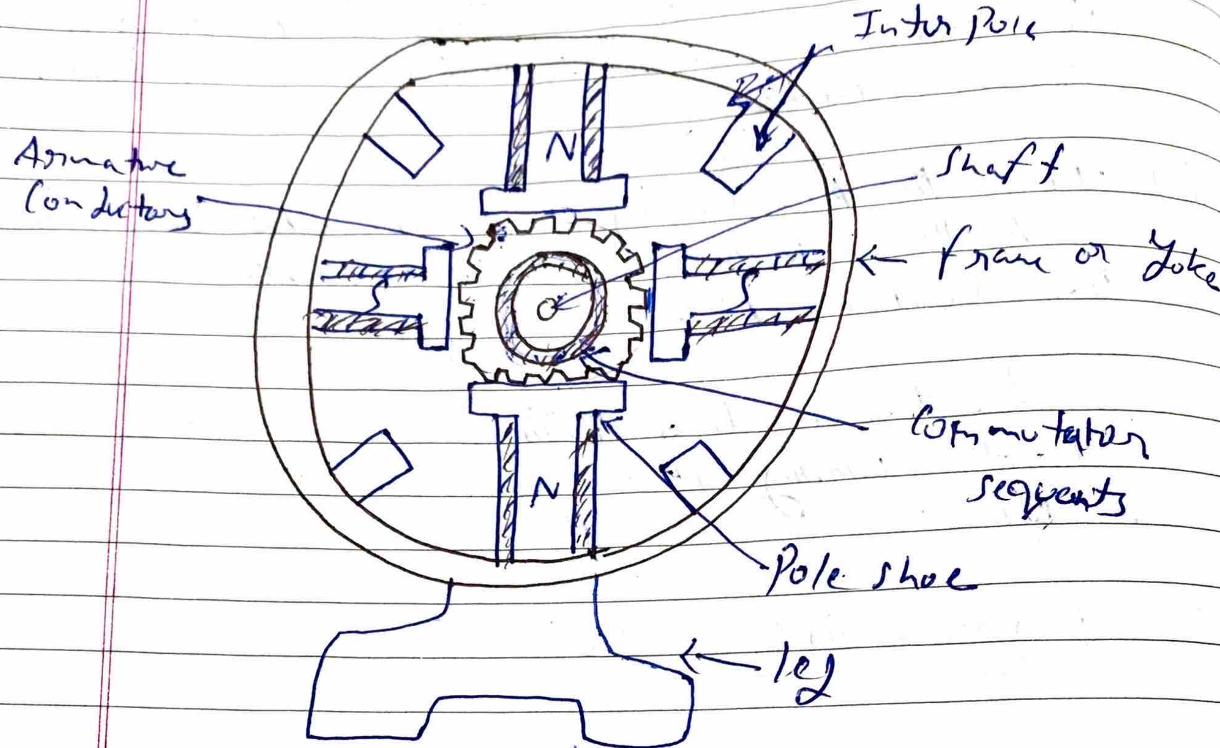


Q Discuss in brief the constructional features of D.C machine or Discuss in brief the constructional feature of D.C. Motors as [7.5 with diagram]
" " of D.C. Generator.

As i) D.C. Machines will always have even no. of poles
ii) Commutator is ~~used to convert A.C. to D.C. current~~ that part of D.C machine, that converts A.C. into D.C.
iii) Armature is moving part of D.C. machine
iv) Brushes are always made up of Carbon
v) The output voltage as per the design specifications is always less ~~gir~~ due to the phenomenon of armature reaction.
vi) Inter poles are used to reduce the effects of armature reaction i.e. to get the optimal voltage ~~as~~ as per the designed specifications

brush used for concentrating voltage

MNA Geometrical

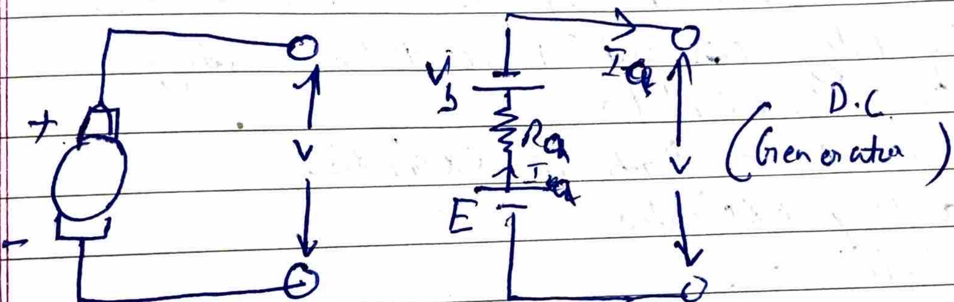
GNA → Gravitation Neutral Axis
Axis of machine

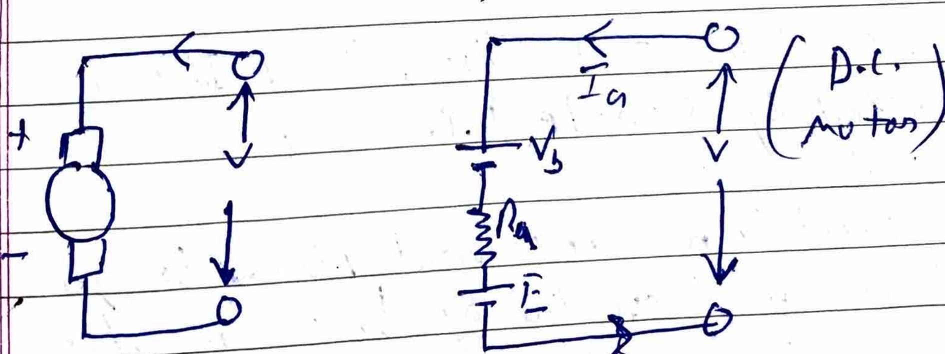
Q- What do you understand by Armature reaction. (demagnetisation of the machine but due to the affect of armature reaction also known demagnetisation, the output voltage obtained is not uniform.

viii) While solving the numerical you always consider the brush drop $V = IR$

GNA → Geometrical Neutral Axis (Axis of machine)
MNA → Magnetic Neutral Axis

Equivalent Ckt of DC machine





V_t → is the terminal voltage
E → Generated voltage
I_a → armature current.
V_b → voltage drop across brush

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~~$E = V - IR_a - V_b$~~

Note: 1. In case of motor ~~E_g~~ the generated voltage (E) is known as E_b (back emf)

2. Out put voltage is less than generated voltage

$$E = V + IR_a \pm V_b$$

Types of D.C. Machine

The magnetic flux produced in a d.c. machine produced by field coils carrying the ~~conductor~~ current
The production of magnetic flux in the machine by circulating current in the field winding is known as excitation
There are 2 - methods of excitation
1. Separately excitation
2. Self excitation.

Separate excitation - In this, the field coils are energized by separate D.C. source
Self excitation.
In self excitation, the current flowing through the field winding is supplied by the machine ~~itself~~ itself.

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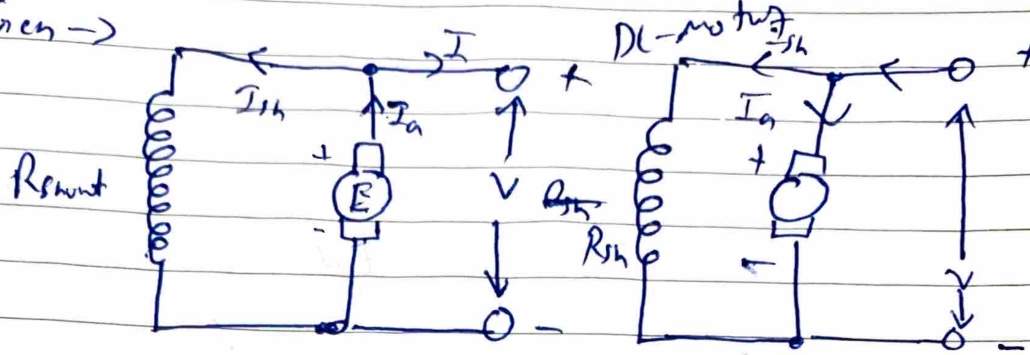
Shunt wound DC M/c



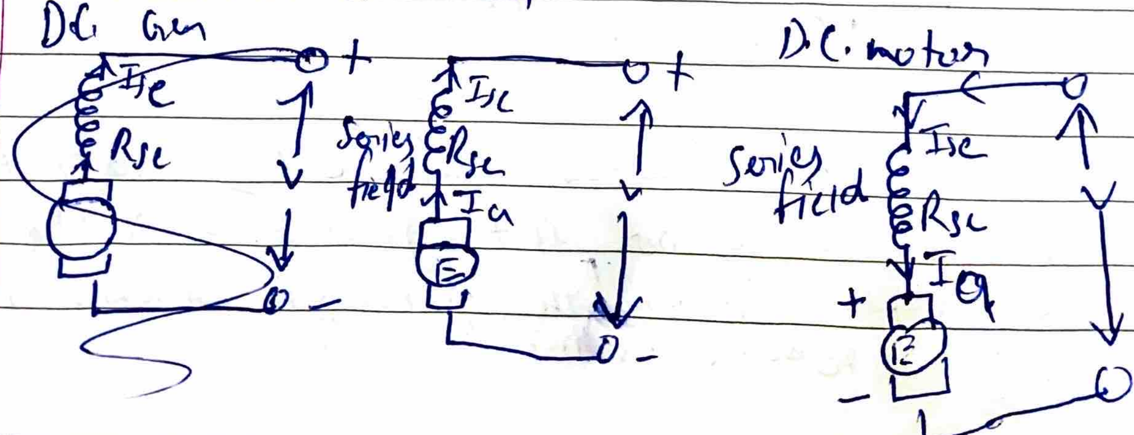
→ The machine in which the field coils are connected in parallel with the armature is called shunt machine

→ The shunt field receives the full output voltage of the generator or the supply voltage of the motor. It is made up of large no. of turns of fine wire carrying a small field current

Series wound DC m/c

→ A D.C. M/c in which the field coils are connected in series with the armature is called a series machine

→ The series field winding carries the armature current and since the armature current is large, the series field winding consists of few ~~tons~~ turns of wires of large crossectional area



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EMF Equation of DC M/c

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

In case of generator
E_g = Generated emf
In case of motor
E_b = back emf

$\phi \rightarrow$ Useful flux per pole (in weber)
$P \rightarrow$ Total no. of poles
$Z \rightarrow$ Total no. of conductors in the armature
$N \rightarrow$ Speed of rotation
$A \rightarrow$ No. of parallel paths through the armature between the brushes

Types of Winding

(i) Lap winding (ii) wave winding

(i) Lap winding: The ends of each armature coil are connected to adjacent segments on the ~~the~~ commutator.
* $\boxed{(A=P)}$

(ii) wave winding: The ends of each armature coil are connected to commutator segments some distance apart $\boxed{(A=2)}$ *

Q-1 An 8 pole lap ~~conductor~~ connected armature has 40 slots with 12 conductors per slot generates a voltage of 500 volts determine the speed of at which it is running, if the ~~mag~~ flux per pole is 50 mWb

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$P=8$ $Z = \cancel{40 \times 12}$ no. of slots $\times$ parallel paths $= 40 \times 12$
$V = 500V$, $\phi = 50 \times 10^{-3}$ wb
$N = ?$

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

$\cancel{= \frac{50 \times 10^{-3} \times 40 \times 12 \times 8}{60 \times 12} N =}$

$\cancel{N = E}$

$\cancel{500 = \frac{50 \times 10^{-3} \times 40 \times 12 \times 8}{60 \times 12}}$

$500 = \cancel{800 \times 10^{-3} N}$

$\cancel{\frac{500}{800} \times 10^{3}} = N$

$N = \frac{E \times 60}{\phi Z}$

$N = \frac{500 \times 60}{50 \times 10^{-3} \times 40 \times 12} = \cancel{\frac{5000\ 5 \times 10^4}{40}}$

$= \frac{50 \times 10^4}{5 \times 8} = \frac{10^4}{8} = \frac{500}{4} = \cancel{12}$ 125 rpm

$= 1.25 \times 10^3$
$= 1250$ rpm

Q-2 A 4 pole wave wound armature has 720 conductors and is rotated at 1000 rpm if the useful flux is 20 mwb, calculate the generated voltage

Q-3 A d.c. generator has an armature emf of 100 V when the useful flux per pole is 20 mwb and the speed is 800 rpm Calculate the generated emf with the following conditions (i) with the same flux and speed of 1000 rpm (ii) with the flux per pole of 24 mwb speed of 900 rpm

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Sol^n 2 $P = 8$, $Z = 720$, $\phi = 20 \times 10^{-3}$ wb
$N = 1000$ rpm, $A = 2$ (wave winding)

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

$$= \frac{20 \times 10^{-3} \times \cancel{720}^{12} \times 1000}{\cancel{60}} \times \frac{\cancel{4}^{2}}{\cancel{2}}$$

$$= 480 \text{ Volt}$$

Sol^n 3 $E = 100$
$\phi_1 = 20 \times 10^{-3}$ wb, $N_1 = 800$

$$100 = \frac{20 \times Z\, 80\cancel{0}}{6\cancel{0}} \times \frac{P}{A}$$

$$\frac{1\cancel{0}\cancel{0} \times 6 \times 10^{3}}{2\cancel{0} \times 8\cancel{0}} =$$

$$\frac{3}{8} = Z \times \frac{P}{A}$$

(i) $$E_{\phi} = \frac{\phi Z N}{60} \times \frac{P}{A}$$

$$= \frac{20 \times 10^{-3} \times 1000 \times 3}{60 \times 8} \times 10^{3}$$

$$= \frac{20}{60} \times \frac{3}{8} \times 10^{3} = \frac{10^{3}}{8} = 125 \text{ Volts}$$

(ii) $$E = \frac{\cancel{24}^{4} \times \cancel{900}^{150}}{\cancel{60}} \times \frac{3}{\cancel{8}_{2}} = 135\cancel{0} \text{ volts}$$