D.C. Generators & Motors

1. Machine

Static machine
- stationary
- eg: transformers

Imp. **REM**
rotational Electrical machine

Linearly operating machine
linear motion pe output provide

REM →
- **Motor** → AC, DC
- **Generator** → AC, DC

* [All the machines work on electromechanical conversion of energy]

Motor: Electrical energy ⇒ Mechanical energy

Generator: Mechanical energy ⇒ Electrical energy

DC Machines advantages

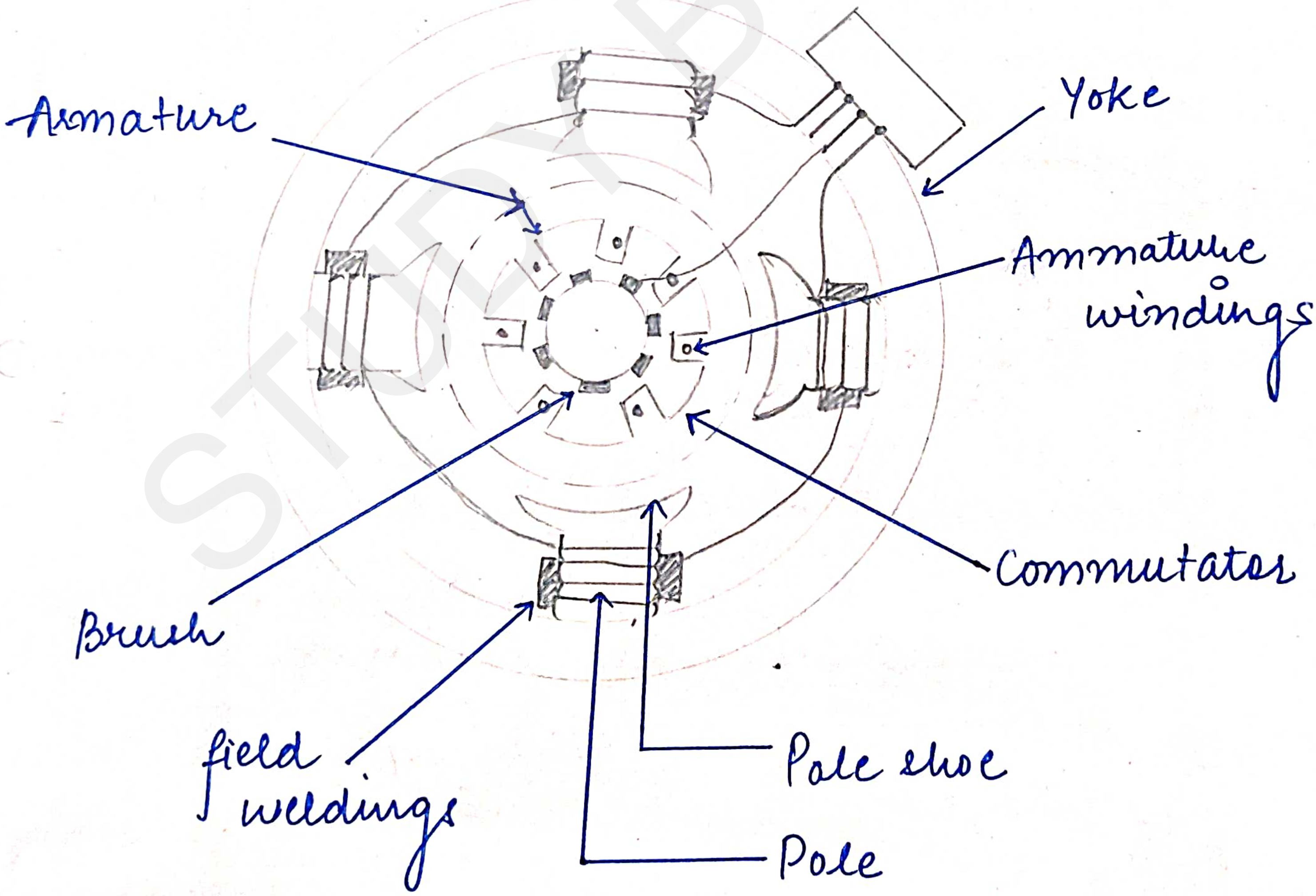
1. lower speed - can provide higher τ (torque)
2. Less complexity
3. Easy designs
4. Higher power range isn't required.

CONSTRUCTION

The DC Generator & motor have the same general construction.

5 principle components -

1. field system
2. armature core
3. armature winding
4. commutator
5. Brushes

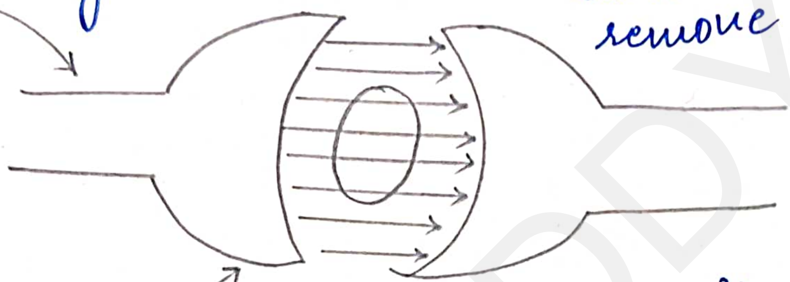


Components -

1. **Yoke** - protection from extreme condition
   - low reluctance path
   - strong

2. **Pole** -

laminated sheets to remove eddy currents.



3. **Pole shoes**

to distribute magnetic field uniformly

4. **field windings** - produce uniform mag. field. within which the armature rotates.

5. **Armature core** - rotates b/w the field poles.
   - stacked w soft iron laminations.

↳ to protect from eddy currents.
↳ easy path to magnetic flux.

6. **Commutator** - mechanical rectifier which converts alternating voltage → direct voltage across the brushes.

   - made of copper segments insulated from each other by mica sheets.

7. **Brushes** - ensure electrical connections b/w rotating commutator and ext. load circuit.

Brushes have -ve & +ve polarities.

Faraday's Law - predicts the relation b/w magnetic & electric field.

Electromagnetic Induction - relative motion b/w conductor and a mag. field emf is produced

$$\mathcal{E} = -\frac{N d\phi}{dt}$$

Lenz law

- States that the magnitude of induced emf will be equal to the amount of mag field linked with the conductor coil.

$$\text{Emf induced} = \frac{\text{Rate of change of flux}}{\text{Time}}$$

EMF Equation -

Let us assume,

ϕ = flux per pole in Wb

Z = total no. of armature conductors

P = no. of poles

A = no. of parallel paths — $A = 2$ (wave winded syst), $A = P$ (lap winded syst)

N = speed of armature in r.p.m.

E_g = Emf of generator.

- flux linked by one conductor in one revolution of armature $= P\phi = d\phi$
- Time taken per revolution $= 60/N$ second
- emf generator/conductor $= \frac{\text{change of flux}}{\text{Time}} = \frac{P\phi}{60/N}$

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

- E_g (parallel path emf) $= \frac{P\phi N}{60} \times \frac{Z}{A}$ — no. of conductors in series per parallel path.

Working of DC Machines

1. The field magnets are excited developing alternate N & S poles.
2. The armature conductors carry eddy currents

conductors under N polarity → flow in same direction

conductors under S polarity → flow in opposite direction

- Since the Armature is carrying current, and placed in mag field, MECHANICAL FORCE acts on it.

Applying fleming's left hand rule, it is clear that force on each conductor is tending to rotate the armature in anticlockwise dir.

when the conductor moves from one side of the brush to another,

- the current gets reversed & at the same time it comes under influence of next pole which is of OPPOSITE POLARITY.

Consequently the direction of force on conductor remains the same.

Back Emf

When armature of DC motor rotates under the influence of torque, magnetic field is produced and hence emf is induced.

The induced Emf acts in opposite direction to applied ~~force~~ voltage (Lenz Law) & is known as back or counter Emf

* The back emf: $E_b = \frac{P \phi Z N}{60 A}$ is always lesser than applied V.

Net voltage across armature circuit $= V - E_b$

If Ra : Resistance of armature then, $\boxed{I = \frac{V - E_b}{R_a}}$ (ohm's law)

If the speed of motor is high then $E_b = \frac{P \phi Z N}{60 A}$ is large and then less armature current will be drawn.

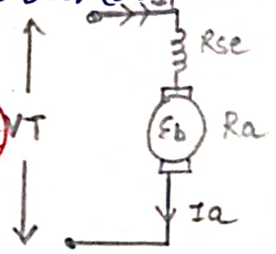
Significance of back Emf:

- enables DC motor to become self regulating machine.
- draw as much armature current as required to develop torque.
- based on Lenz law.

Classification of DC Motors

- Permanent Magnet
- Seperately Excited
- Self excited DC Motors (Important)
  - Series wound DC motor
  - Shunt wound DC motor
  - compound wound DC motor
    - long shunt compound
    - short shunt compound

1. **Series Wound DC motor** – field windings are connected in series w the armature
   - It is designed w fewer no. of Turns as compared to shunt wound motors.
   - Small no. of turns
   - thick wire (can take huge current)
   - low resistance
   - develops strong mag field (larger torque)



due to large torque, the machine can get unbalanced and thus we need to control it.

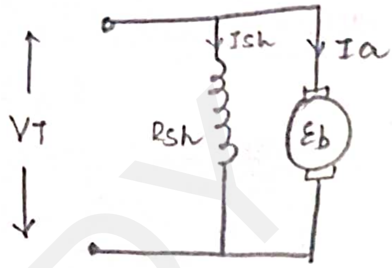
Speed control in DC series motor –

- flux control
- Armature resistance control method

★ Applications –
- Drill machine
- sewing machine
- winch machine

2. DC Shunt Motor

- in which field windings are connected in parallel with the armature.
- the current through the shunt field winding is not same as the armature current
- Relatively large no. of turns.
- produce necessary mmf
- current is relatively small as compared to armature current



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

I_{sh} = Current in shunt

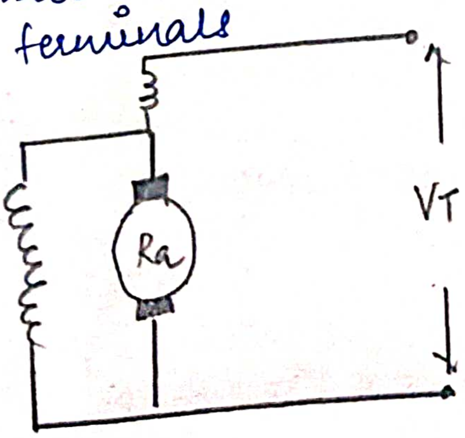
- high resistance is provided
- armature current is high
  ↳ because load ↑ and speed ↓ because of back emf.

Application -
1. Reciprocator pumps
2. lathe machines
3. conveyer belts at airports

3. Compound wound Motor

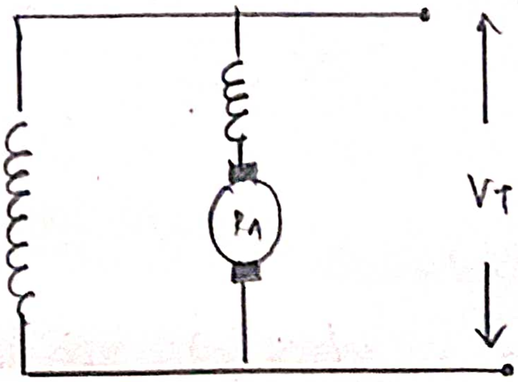
Short shunt connection

when shunt wound windings are directly connected across armature terminals



long shunt connection

when shunt winding is connected that it shunts the series combination of armature and series field.



Need of Speed Control in DC Motors

- for controlling operation of apparatus.
- for higher efficiency requirement.
- for better performance.
- Reliability.

Speed control → Flux control method, Armature control, Voltage control

$N \propto \frac{E_b}{\phi}$

$$N = K\frac{(V - I_a R)}{\phi}$$

$R = R_a$ (shunt motor)

$R = R_a + R_s$ (series motor)

1. Flux control –

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

$N \propto \frac{1}{\phi}$ [inversely]

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

- If flux is increased then speed can get reduced.
- Current increases then flux decreases.

advantages	disadvantages
• Easy & convinient	• limit to maximum speed.
• less power is wasted	• only speed higher than normal can be obtained.
• control is independant.	• it should never be opened.
• inexpensive	

2. **Armature control method**

- done by inserting a variable Resistance Rc in series with armature. (controller resistance)
- Due to voltage drop in controller resistance, the back Emf is produced.
- can only provide speed below normal speed.

Disadvantages

- a large amount of power is req and wasted.
- the speed varies widely with load since the speed depends on voltage drop.
- the output & efficiency of motor are reduced.
- poor speed regulation.

3. **Voltage Controller** -

- It avoids the disadvantages of poor speed regulation and low efficiency as in armature control method.
- It is quite expensive
- This method of speed control is employed for large size motors where effenciency is of great importance.

Advantages

> can be adjusted through a wide range.
> back emf. sends current through the generator armature, establishing dynamic braking.

Speed Control of DC Motor

1. Flux Control Method -

- a variable resistance is connected in parallel to series field windings.
- $\uparrow N \propto \frac{1}{\phi \downarrow}$ $\uparrow I_a \propto \frac{1}{\phi \downarrow}$
- easy & convinient
- less power is wasted in shunt due to low value of shunt current.
- control is independant of load.

2. Armature Control Method -

- armature control is a closed loop system.
- offers more accuracy.
- Speed control in both the directions.
- Torque remains same & constant

IMPORTANT!!

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AC Motor & Generators -

works on the same principle as D.C
just learn D.C.
↳ works on sinosudal waveform
because it is easy to generate and easy to analyse mathematically

↳ essa sir ne bola hai!!