NARSIMHA REDDY
ENGINEERING COLLEGE
An Autonomous Institution| Affiliated to JNTUH | Approved by AICTE
Accredited by NBA & NAAC with 'A' Grade

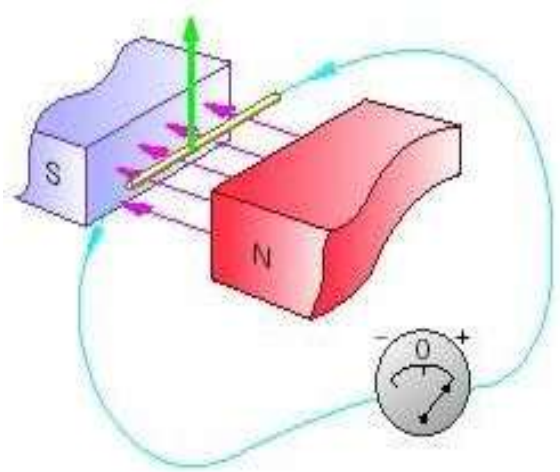
UNIT-1
DC Generator

DC Generator

Mechanical energy is converted to electrical energy

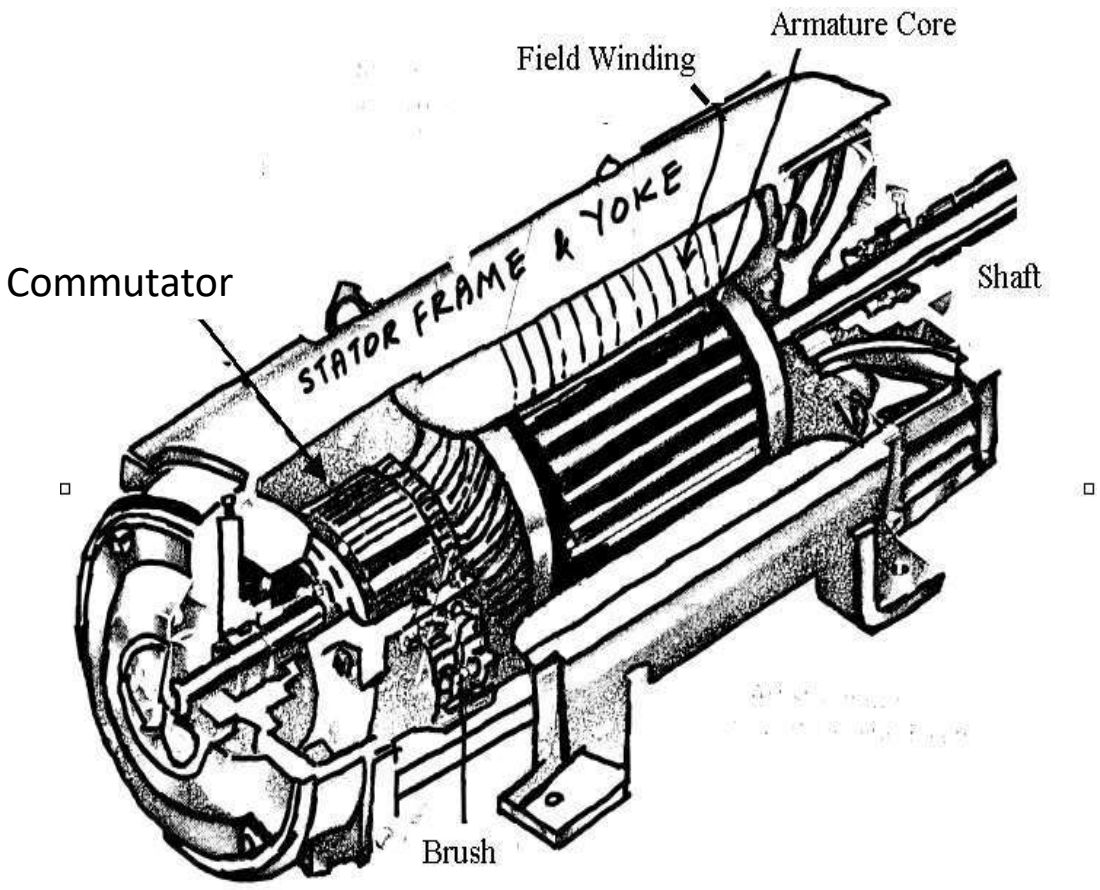
Three requirements are essential

1. Conductors
2. Magnetic field
3. Mechanical energy

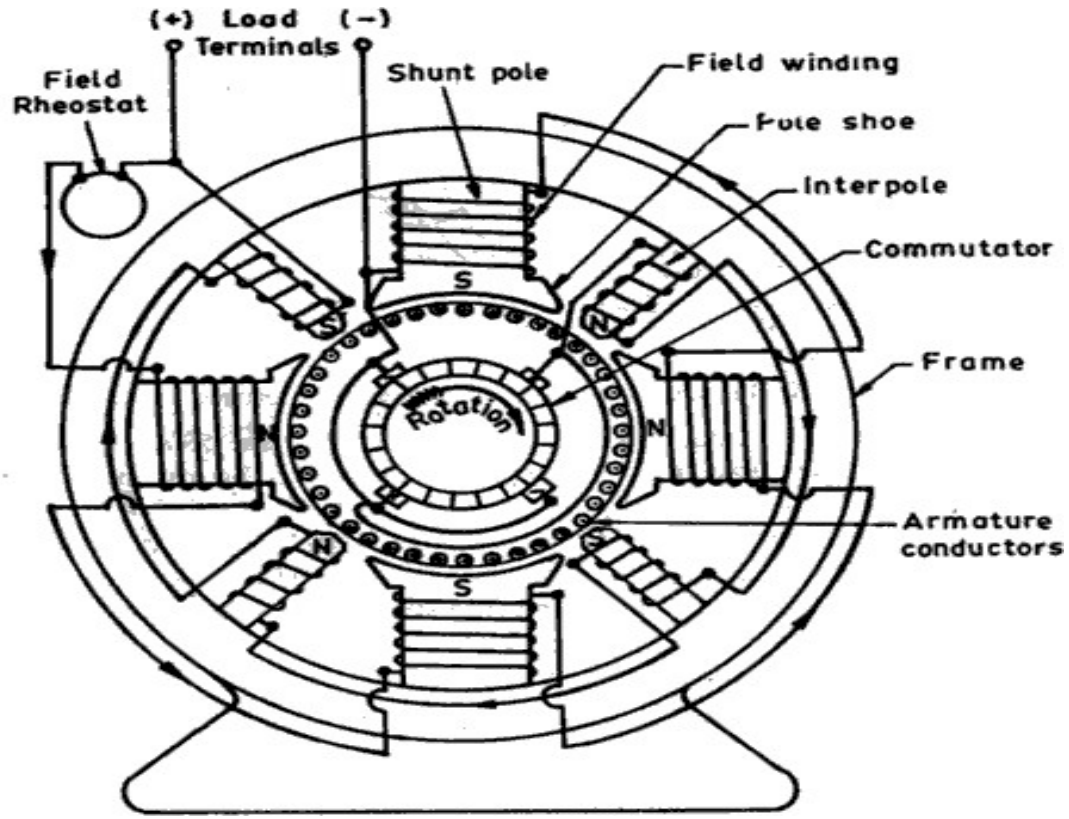


How it works??

- A generator works on the principles of Faraday's law of electromagnetic induction
- Whenever a conductor is moved in the magnetic field , an emf is induced and the magnitude of the induced emf is directly proportional to the rate of change of flux linkage.
- This emf causes a current flow if the conductor circuit is closed .

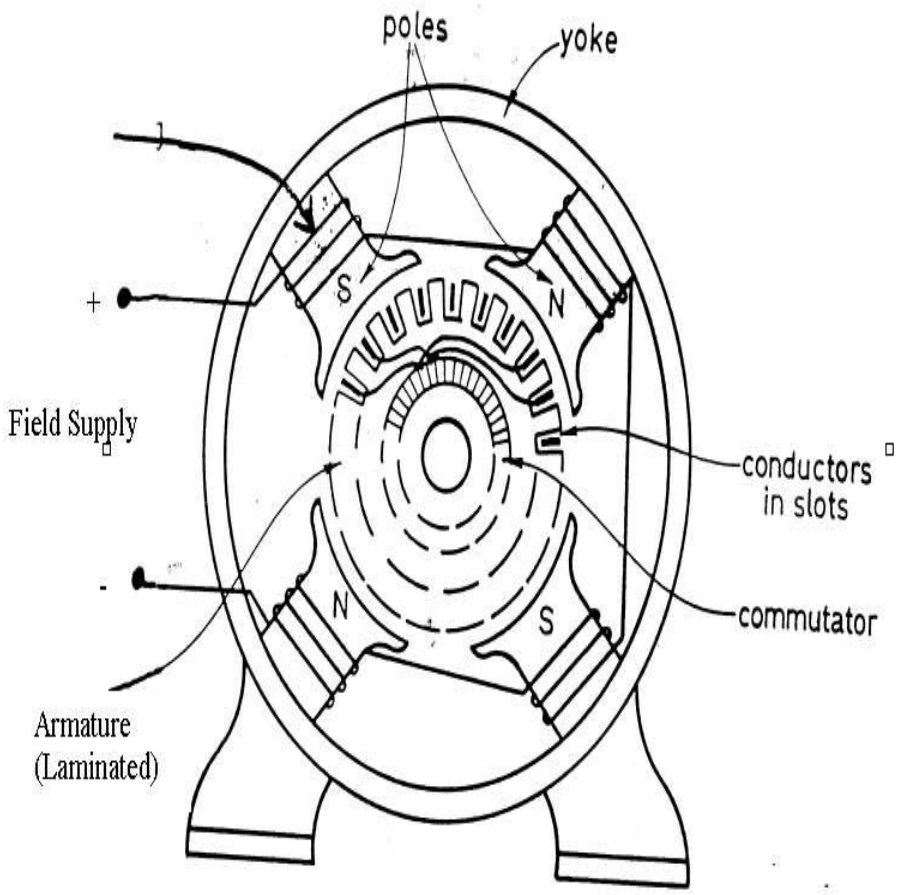

Armature Core
Field Winding
STATOR FRAME & YOKE
Commutator
Shaft
Brush

Sectional View

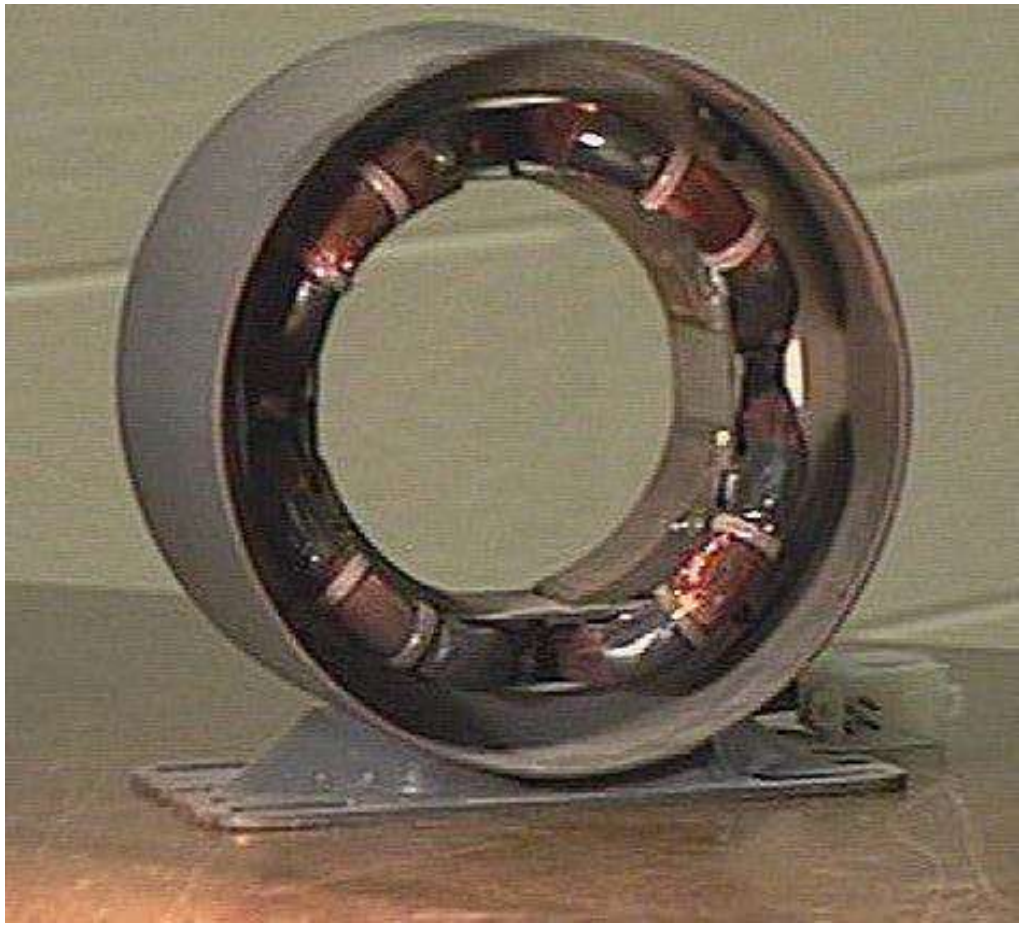


Construction

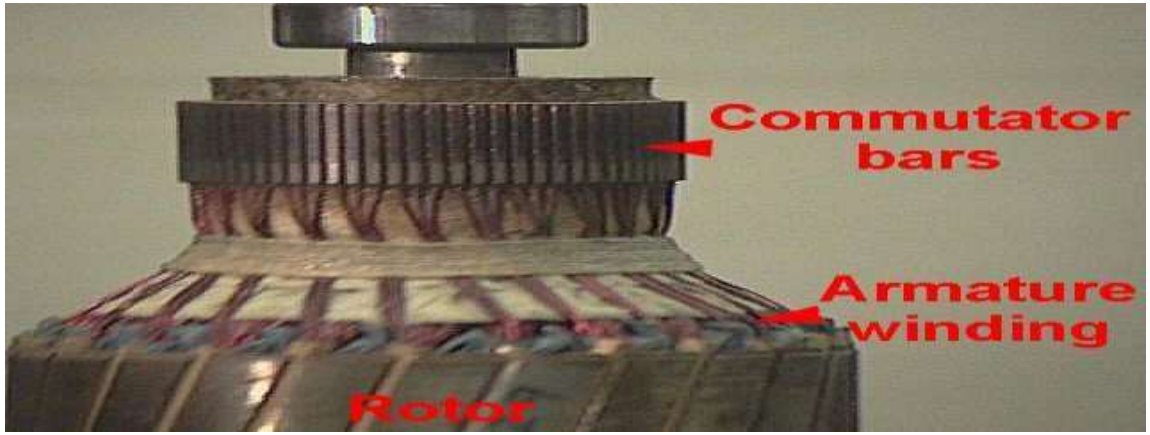
- Field system
- Armature core
- Armature winding
- Commutator
- Brushes



Field winding



Rotor and rotor winding



Armature winding

There are 2 types of winding

Lap winding

- A = P

- The armature windings are divided into no. of sections equal to the no of poles

Lap and Wave winding

Wave winding

- A = 2

- It is used in low current output and high voltage.

- 2 brushes

How field works

- It is for uniform magnetic field within which the armature rotates.
- Electromagnets are preferred in comparison with permanent magnets
- They are cheap , smaller in size , produce greater magnetic effect and
- Field strength can be varied

Field System Components

- Yoke
- Pole cores
- Pole shoes
- Field coils

Armature core

- The armature core is cylindrical
- High permeability silicon steel stampings
- Impregnated
- Lamination is to reduce the eddy current loss

Commutator

- Connect with external circuit
- Converts ac into unidirectional current
- Cylindrical in shape
- Made of wedge shaped copper segments
- Segments are insulated from each other
- Each commutator segment is connected to armature conductors by means of a cu strip called riser.
- No of segments equal to no of coils

Brush (Carbon)

- Carbon brushes are used in DC machines because they are soft materials
- It does not generate spikes when they contact commutator
- To deliver the current thro armature
- Carbon is used for brushes because it has negative temperature coefficient of resistance
- Self lubricating , takes its shape , improving area of contact

Brush rock and Holder

EMF equation

Let,

- Ø= flux per pole in weber
- Z = Total number of conductor
- P = Number of poles
- A = Number of parallel paths
- N =armature speed in rpm

- Eg = emf generated in any on of the parallel path

- Flux cut by 1 conductor in 1 revolution = P * ϕ
- Flux cut by 1 conductor in 60 sec = P ϕ N /60
- Avg emf generated in 1 conductor = PϕN/60
- Number of conductors in each parallel path = Z /A

$$Eg = P\phi NZ/60A$$

Types of DC Generator

DC generators are generally classified according to their method of excitation .

- Separately excited DC generator
- Self excited D C generator

Sub Classification

- Series wound generator
- Shunt wound generator
- Compound wound generator
  - Short shunt & Long shunt
  - Cumulatively compound

  &

  Differentially compound

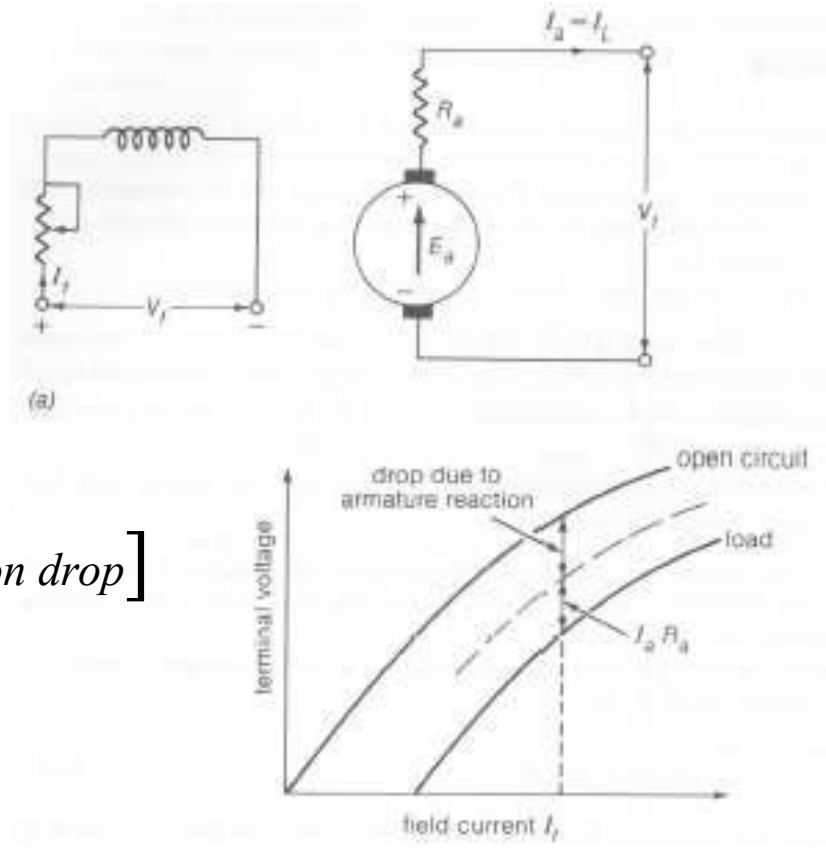
Characteristics

- No load saturation characteristic (Eo/If)
- Internal or Total characteristic (E/ Ia)
- External characteristic (V/I)

DC Generator Characteristics

The terminal voltage of a dc generator is given by

$$V_t = E_a - I_a R_a$$
$$= \left[f\left(I_f, \omega_m\right) - Armature\ reaction\ drop \right]$$
$$- I_a R_a$$



Open-circuit and load characteristics

DC Generator Characteristics

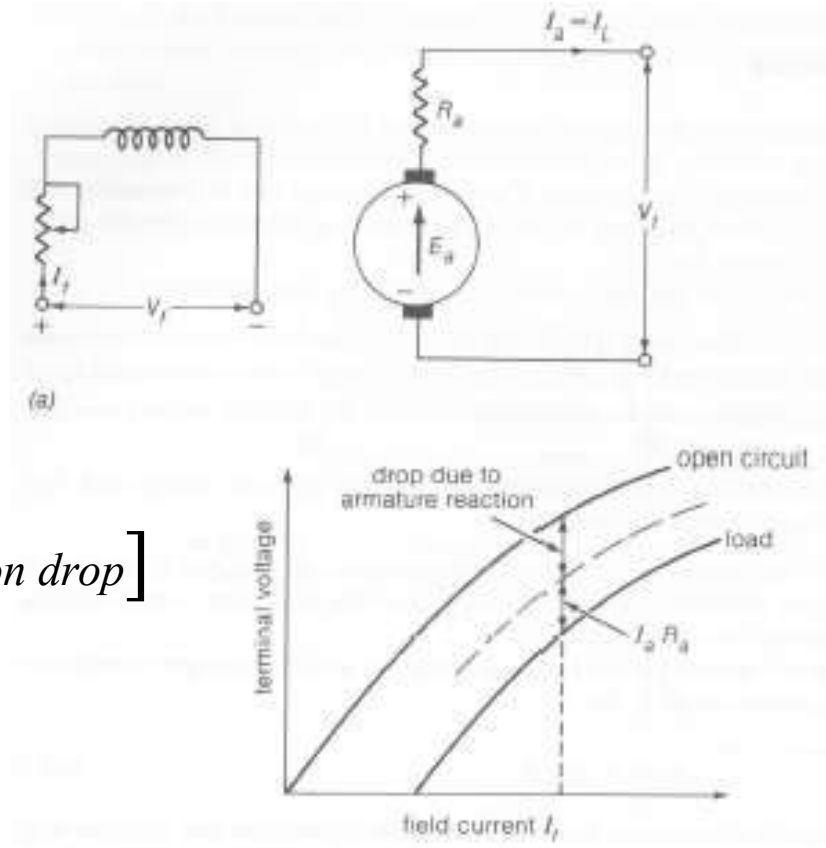
In general, three characteristics specify the steady-state performance of a DC generators:

1. Open-circuit characteristics: generated voltage versus field current at constant speed.
2. External characteristic: terminal voltage versus load current at constant speed.
3. Load characteristic: terminal voltage versus field current at constant armature current and speed.

DC Generator Characteristics

The terminal voltage of a dc generator is given by

$$V_t = E_a - I_a R_a$$
$$= \left[f\left(I_f, \omega_m\right) - Armature\ reaction\ drop \right]$$
$$- I_a R_a$$

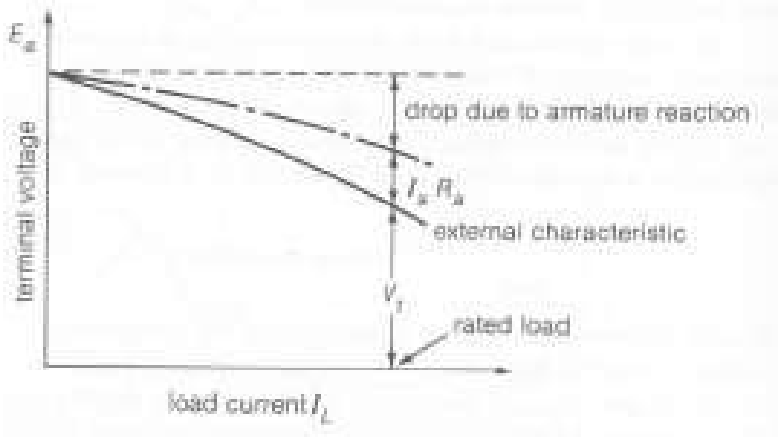


Open-circuit and load characteristics

DC Generator Characteristics

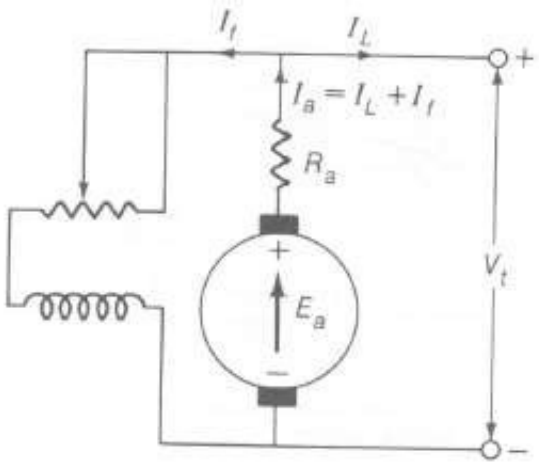
It can be seen from the external characteristics that the terminal voltage falls slightly as the load current increases. *Voltage regulation* is defined as the percentage change in terminal voltage when full load is removed, so that from the external characteristics,

$$Voltage\ regulation = \frac{E_a - V_t}{V_t} \times 100$$



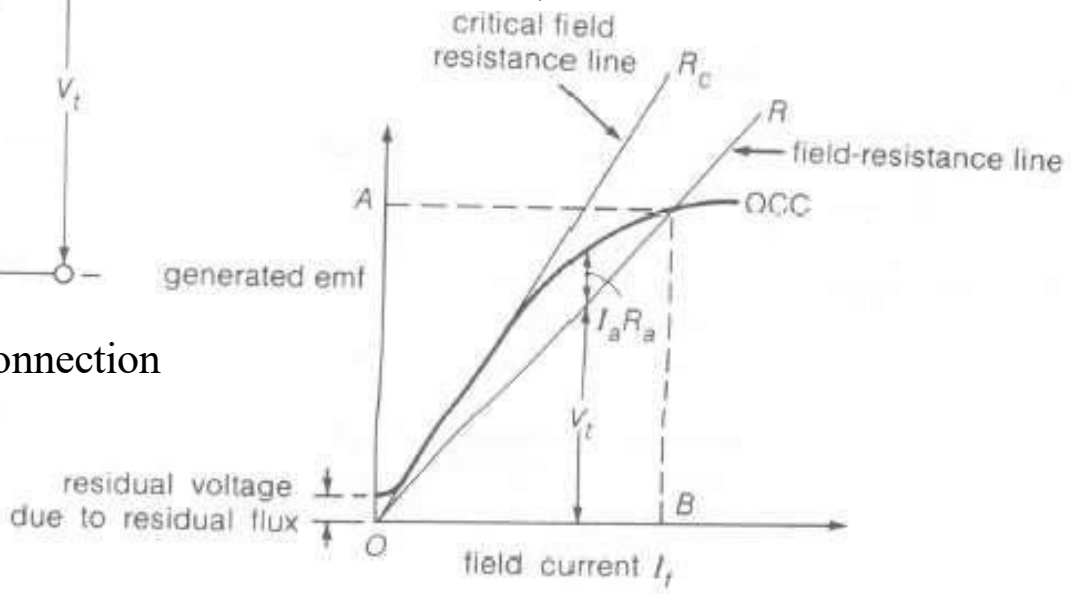
External characteristics

Self-Excited DC Shunt Generator



Schematic diagram of connection

Maximum permissible value of the field resistance if the terminal voltage has to build up.



Open-circuit characteristic

Critical field resistance

For appreciable generation of emf, the field resistance must be always less certain resistance, that resistance is called as the critical resistance of the machine .

General terms used in Armature reaction

Magnetic neutral axis :

It is perpendicular to the lines of force between the two opposite adjacent poles.

Leading pole Tip (LPT) :

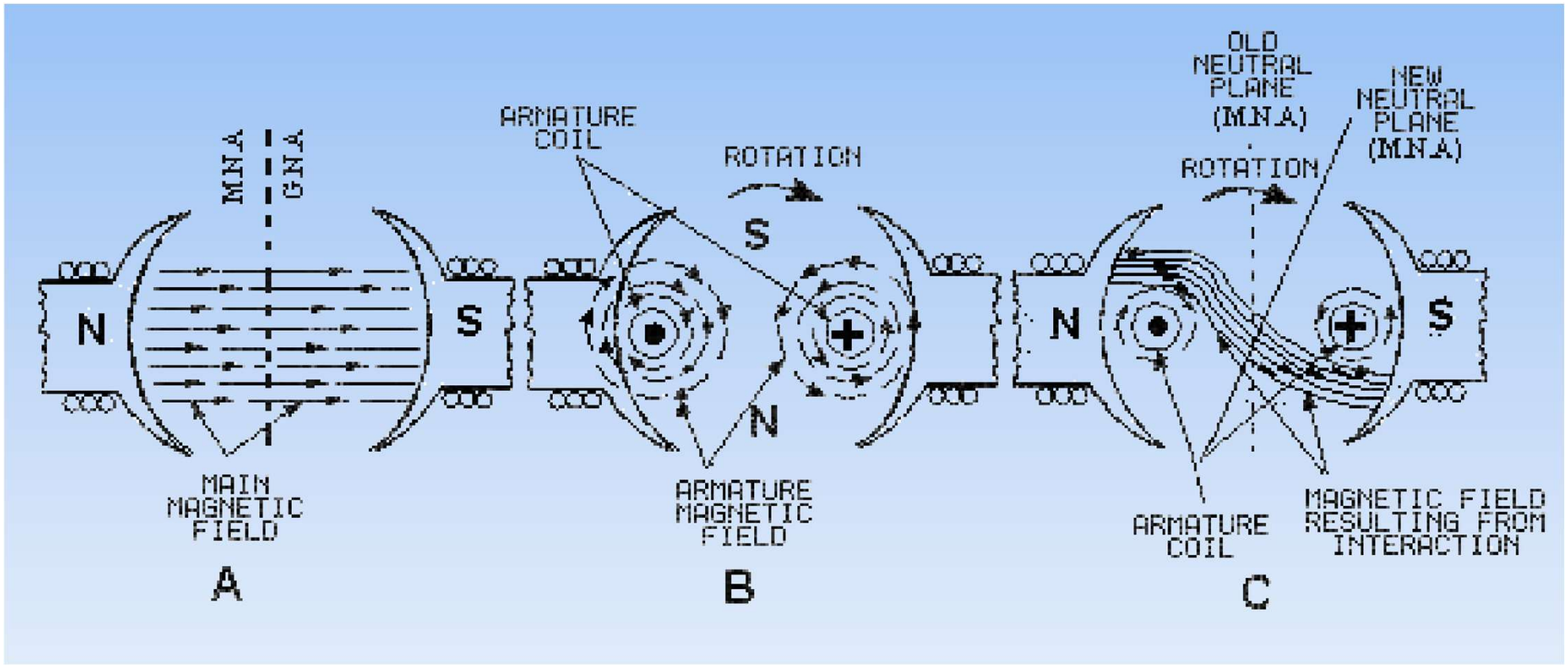
It is the end of the pole which first comes in contact with the armature.

Trailing pole tip :

It is the end of the pole which comes in contact later with the armature.

Armature Reaction

Interaction of Main field flux with Armature field flux



Effects of Armature Reaction

- It decreases the efficiency of the machine
- It produces sparking at the brushes
- It produces a demagnetizing effect on the main poles
- It reduces the emf induced
- Self excited generators some times fail to build up emf

Armature reaction remedies

1. Brushes must be shifted to the new position of the MNA
2. Extra turns in the field winding
3. Slots are made on the tips to increase the reluctance
4. The laminated cores of the shoe are staggered
5. In big machines the compensating winding at pole shoes produces a flux which just opposes the armature mmf flux automatically.

Commutation

- ✓ The change in direction of current takes place when the conductors are along the brush axis .
- ✓ During this reverse process brushes short circuit that coil and undergone commutation
- ✓ Due to this sparking is produced and the brushes will be damaged and also causes voltage dropping.

Losses in DC Generators

1. Copper losses or variable losses
2. Stray losses or constant losses

Stray losses : consist of (a) iron losses or core losses and (b) windage and friction losses .

Iron losses : occurs in the core of the machine due to change of magnetic flux in the core . Consist of hysteresis loss and eddy current loss.

Hysteresis loss depends upon the frequency ,

Flux density , volume and type of the core .

Hysteresis loss depends upon the frequency ,

Flux density , volume and type of the core .

Eddy current losses : directly proportional to the flux density , frequency , thickness of the lamination .

Windage and friction losses are constant due to the opposition of wind and friction .