Module 4 : Electrical Machines 4 Hrs

Principle of operation, construction and applications of DC machines, transformers, induction motors, synchronous generators, stepper motor, Brushless DC (BLDC) motor

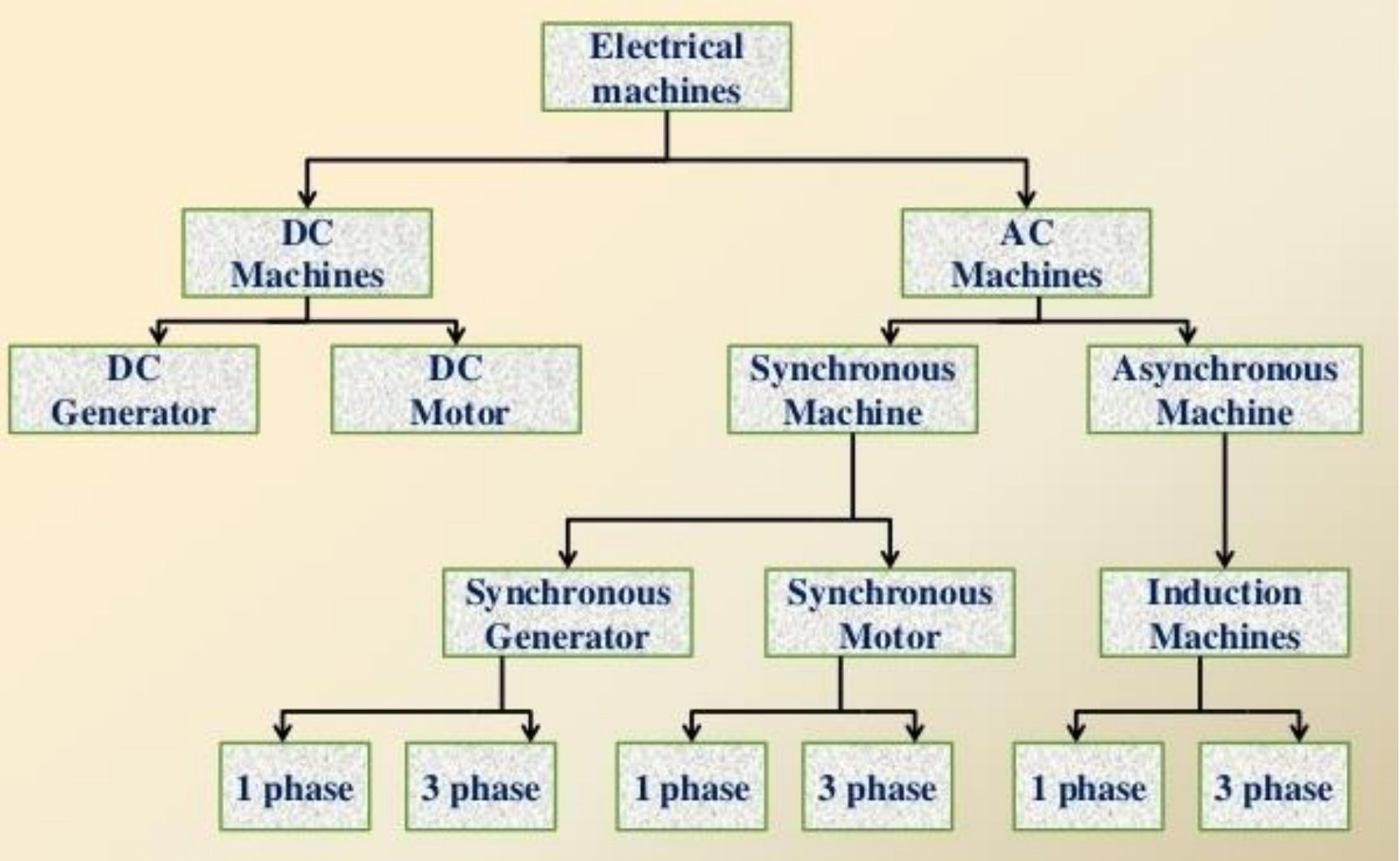
Course Outcome (CO2)

Analyze the parameters of magnetically coupled circuits (module 3) and compare various types of electrical machines (module 4)

Electrical Machines

- Electrical machine converts energy from one form to another form
- **Generator** – It converts mechanical energy into electrical energy
- **Motor** – It converts electrical energy into mechanical energy
- Two types of machines
  - AC machines
  - DC machines

Classification of electrical machines



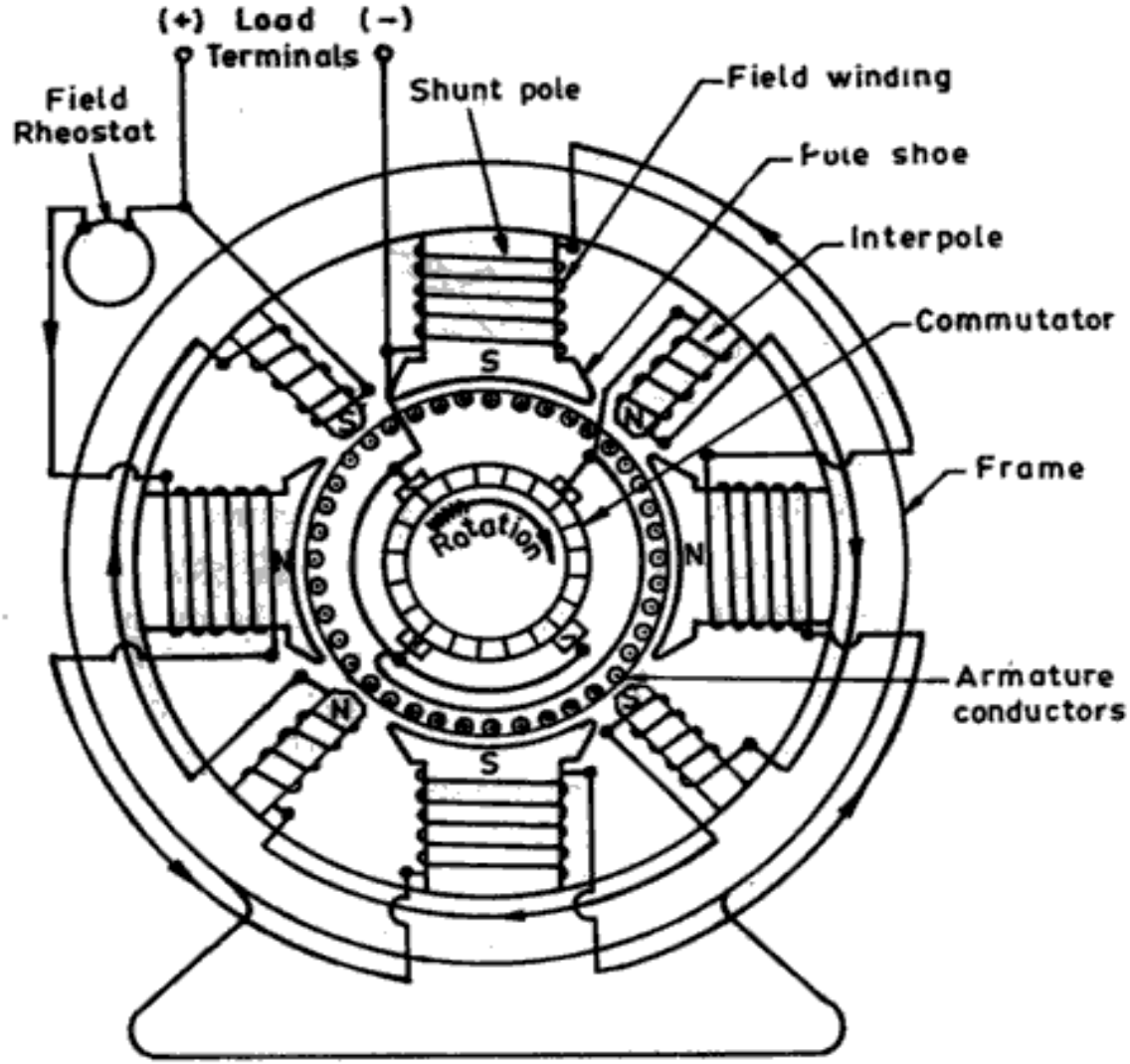
Parts of a machine

- DC machines and AC synchronous machines
  - Armature and field
  - Low rating machines – field is stationary
  - High rating machines – Armature is stationary

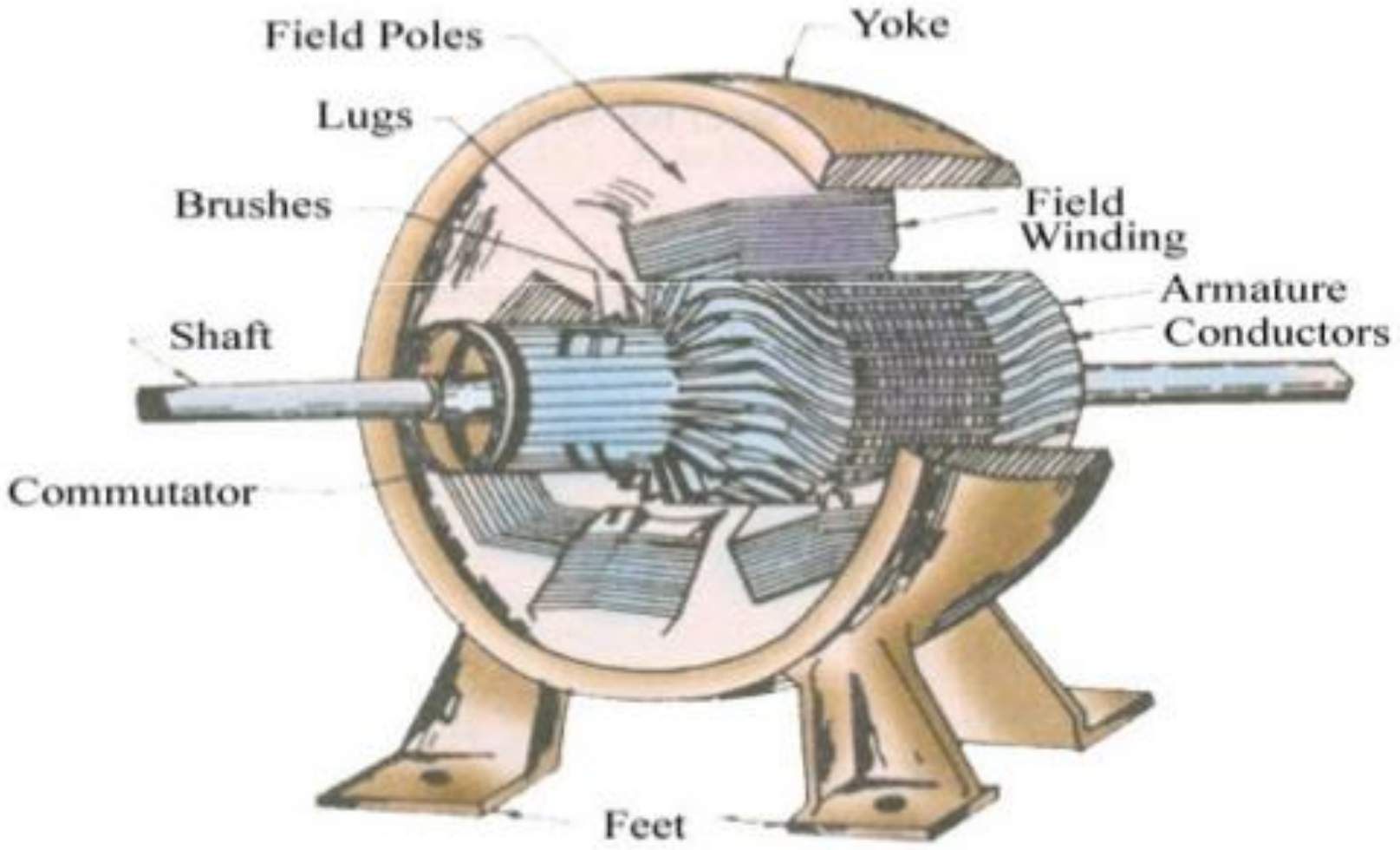
- Stator and rotor – AC induction machines (Asynchronous)

Parts of a DC generator

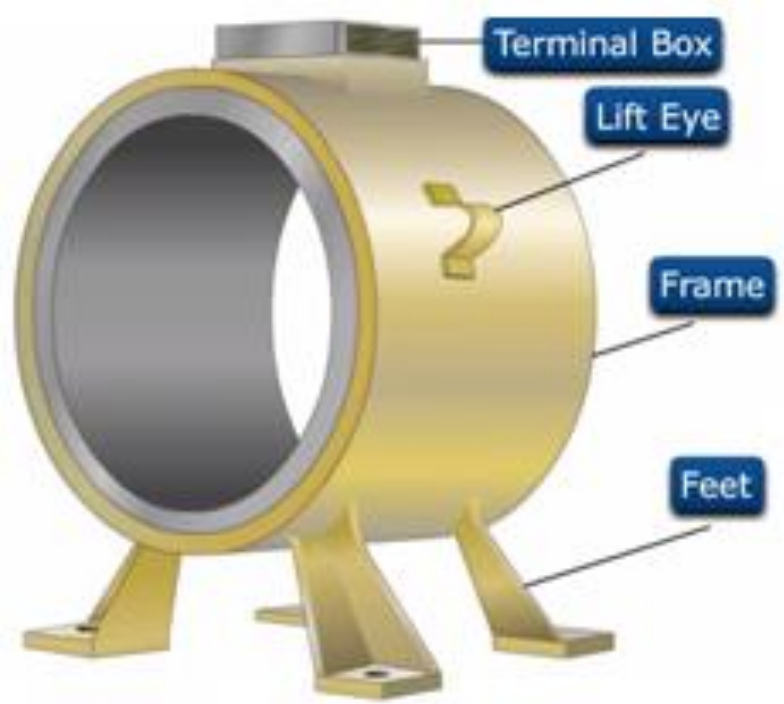
- Stator – Yoke, field system and brushes
- Rotor - Armature and commutator



Constructional diagram

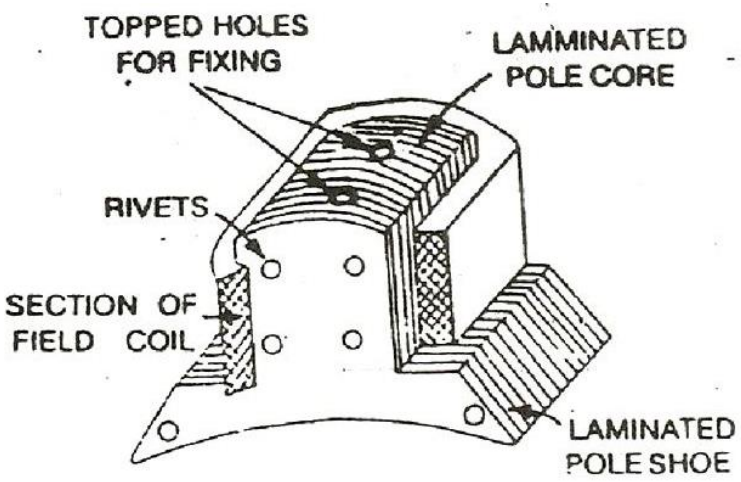


- Yoke – outermost metal part of the machine
  - Provides mechanical support for the poles
  - Carries the magnetic flux produced by the poles
  - Protects all the inner parts from mechanical damage
  - Made of cast iron, cast steel or rolled steel



Field system

- Main field poles and field winding
- Field poles of made of laminations of magnetic material to reduce eddy current loss
- Pole face is in the form of horse shoe for uniform flux distribution



Field system

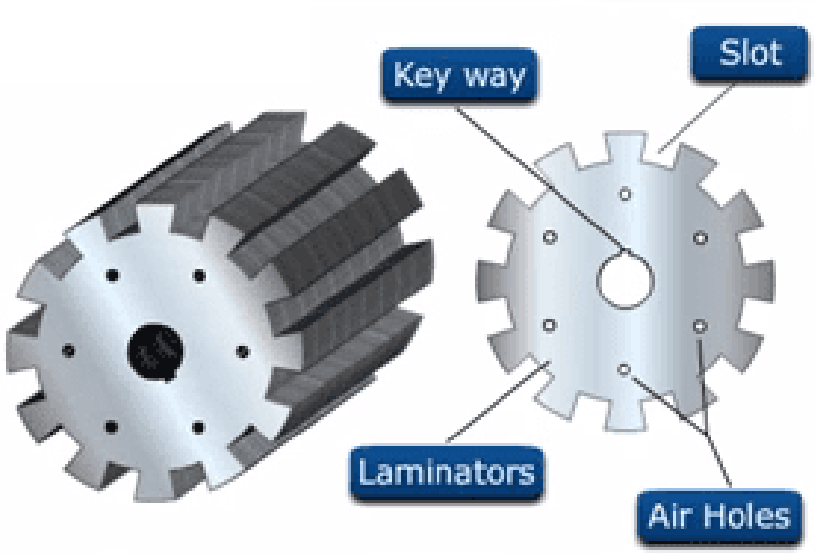
- Field winding is placed over each pole and are connected in series
- Alternative poles act as north and south when DC current passes through it.
- Practical DC machines have

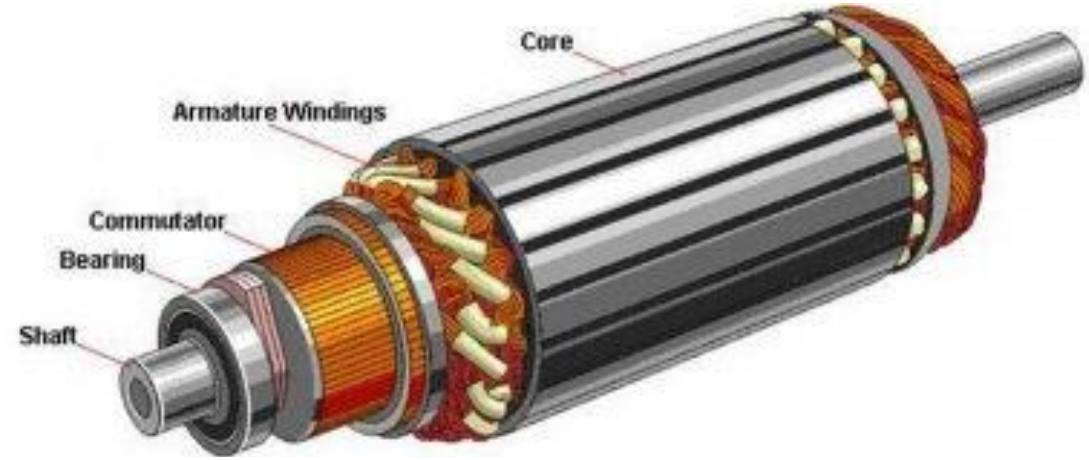
air gaps from 0.5 mm to

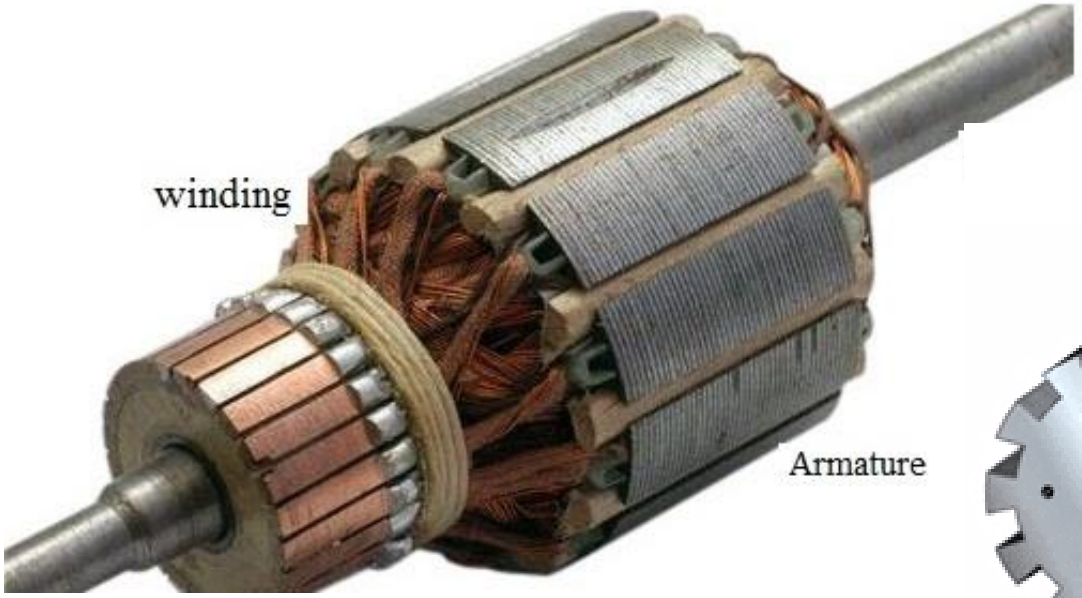
1.5 mm

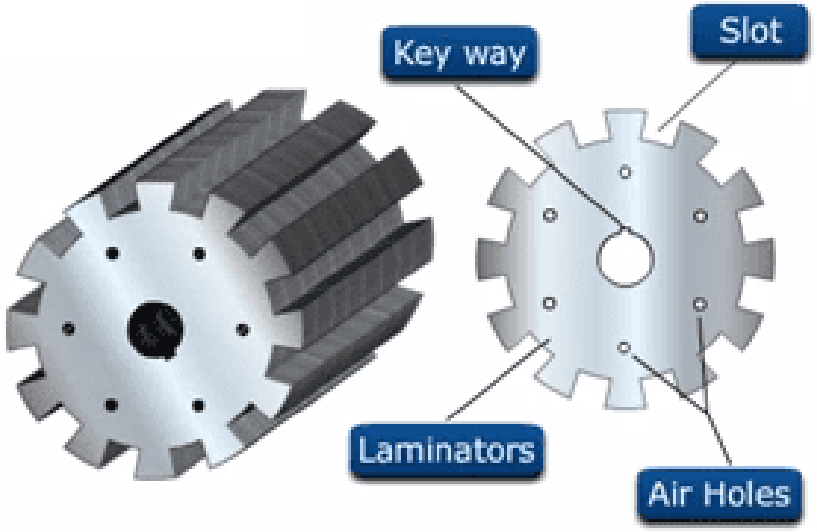
Armature

- In the form of laminated slotted drum
- Slots are provided over the entire periphery of the armature
- Conductors are placed in the slots
- conductors are connected to the commutator at the front end.



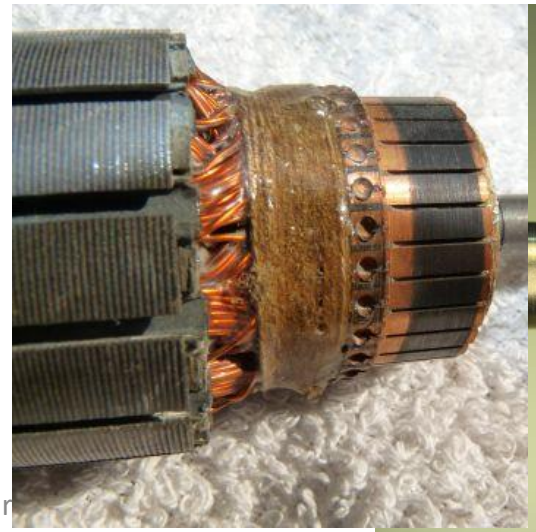

Core
Armature Windings
Commutator
Bearing
Shaft

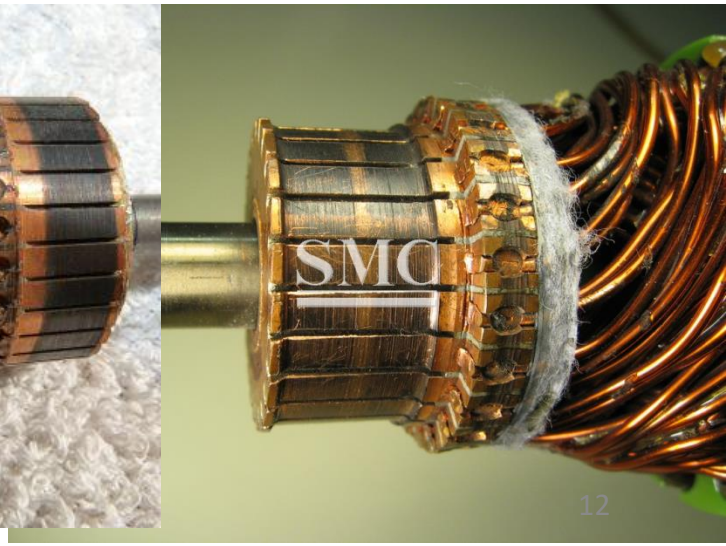

winding
Armature

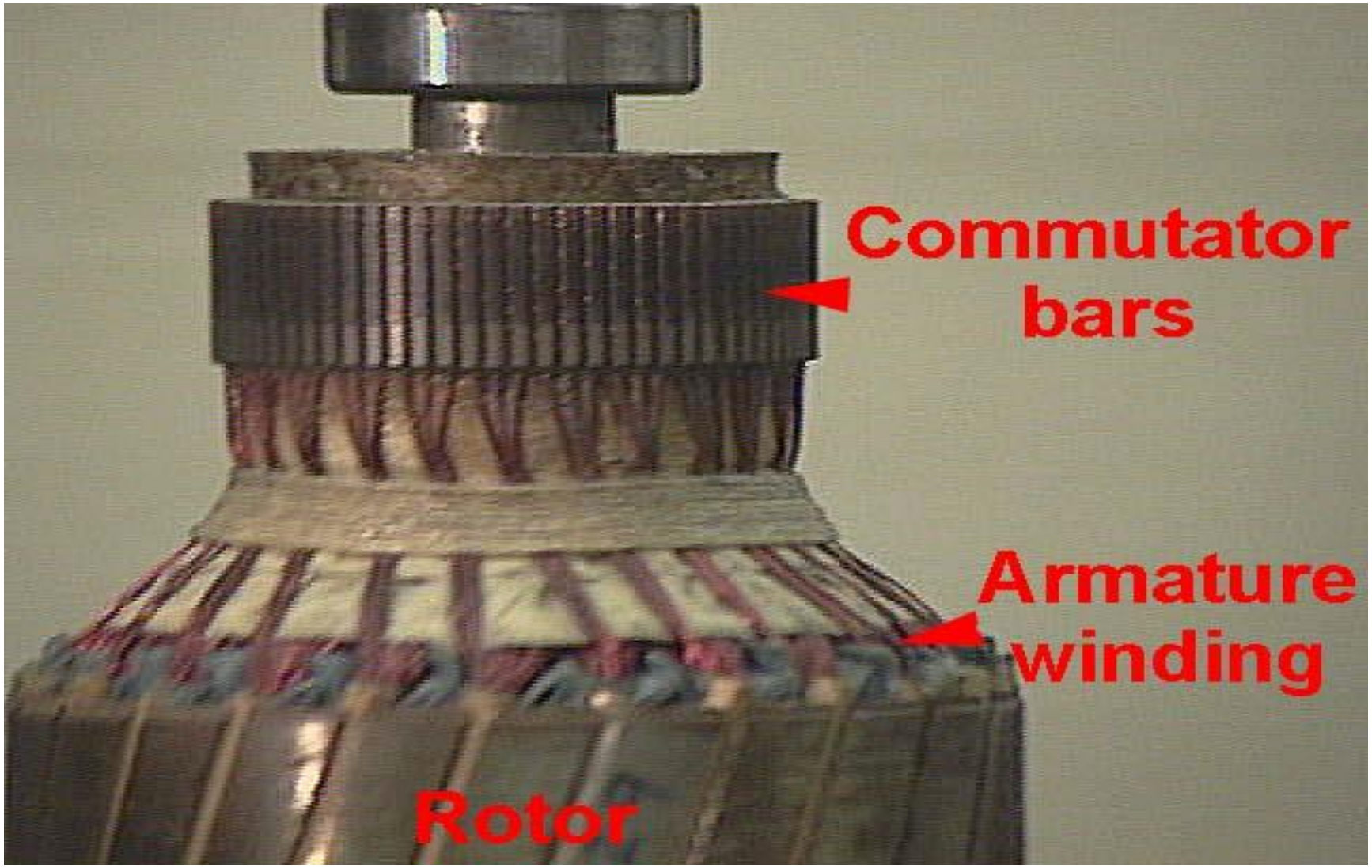

Key way
Slot
Laminators
Air Holes

Commutator

- Less diameter than armature
- No. of segments is equal to no. of slots in armature
- There is an electrical insulation between every pair of segments by mica sheets
- Brushes always touch the rotating commutator segments
- Converts ac into dc

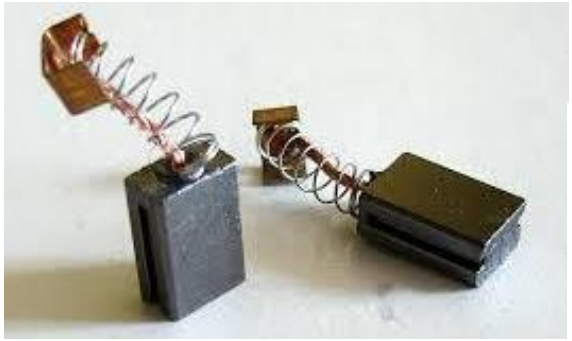


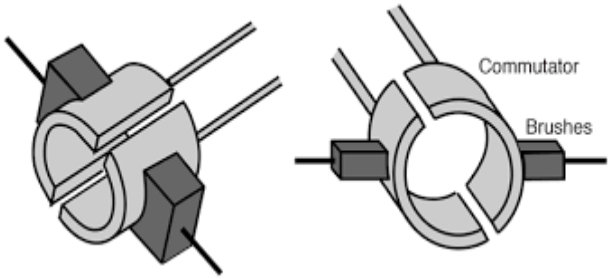



Commutator bars
Armature winding
Rotor

Brushes

- A set of brushes made of carbon or graphite are fixed
- They are in gentle touch with the rotating commutator
- Brushes are used to tap the generated electrical energy



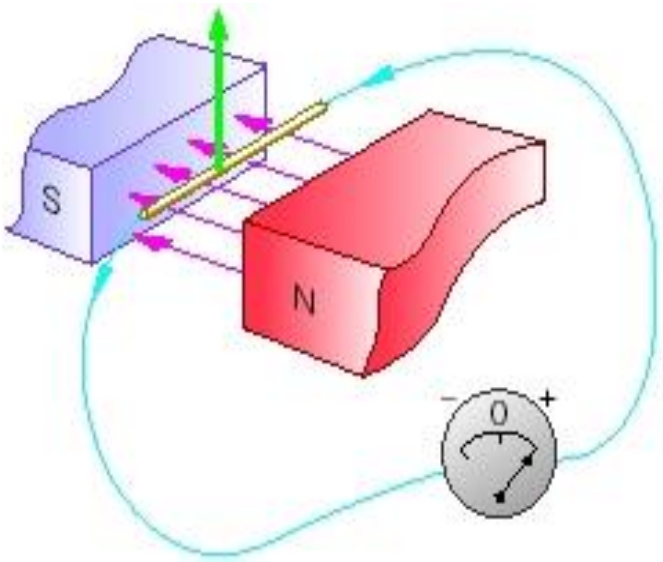


Other parts

- Front end cover
- Rear end cover
- Cooling fan
- Terminal box

DC generator

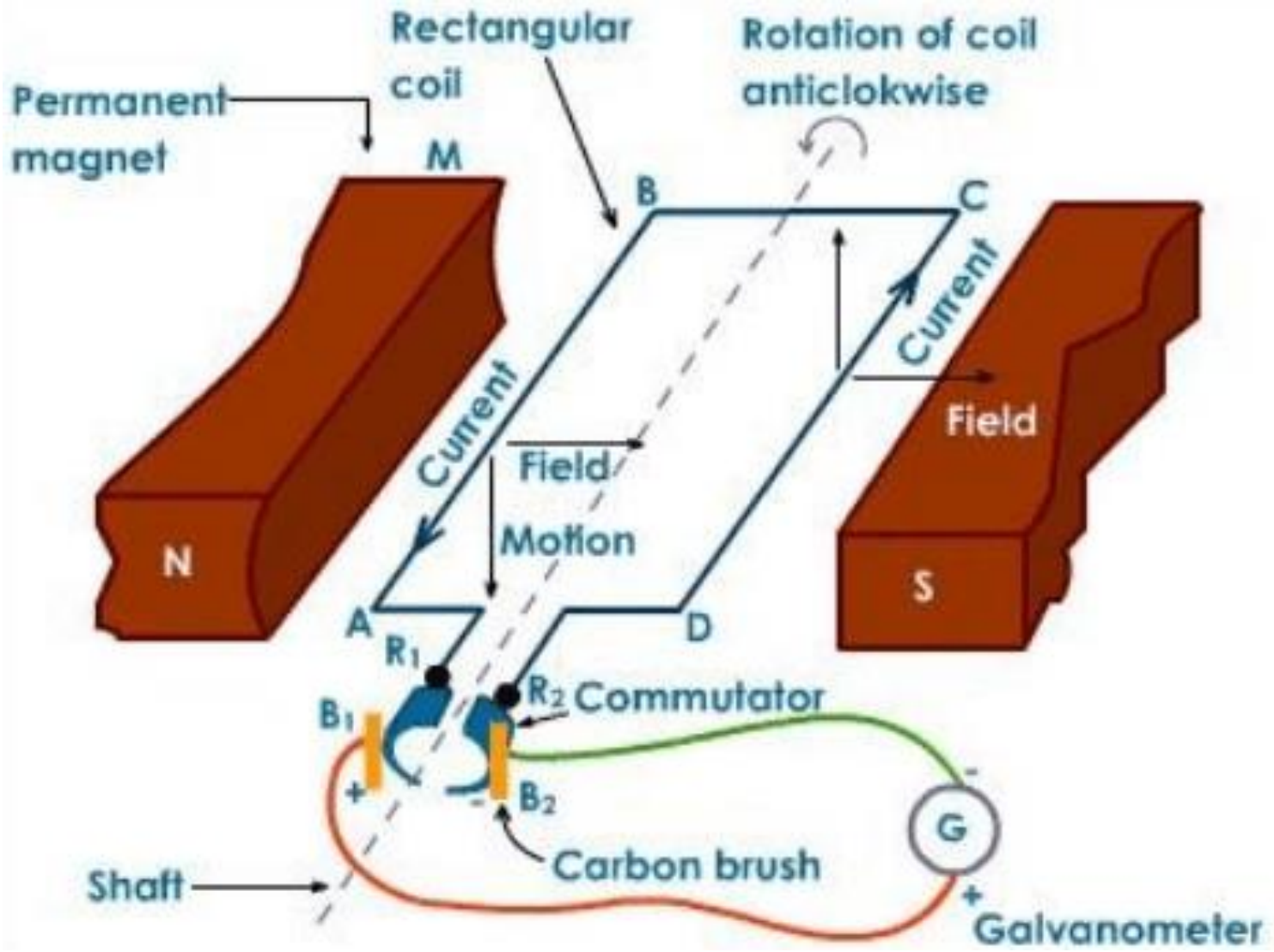
- Generator is a dynamic machine in which mechanical energy is converted into electrical energy.
- It operates on the principle of Faraday's law of electromagnetic induction
- Basic requirements:
  - Steady magnetic field
  - Conductors
  - Relative motion (mechanical)

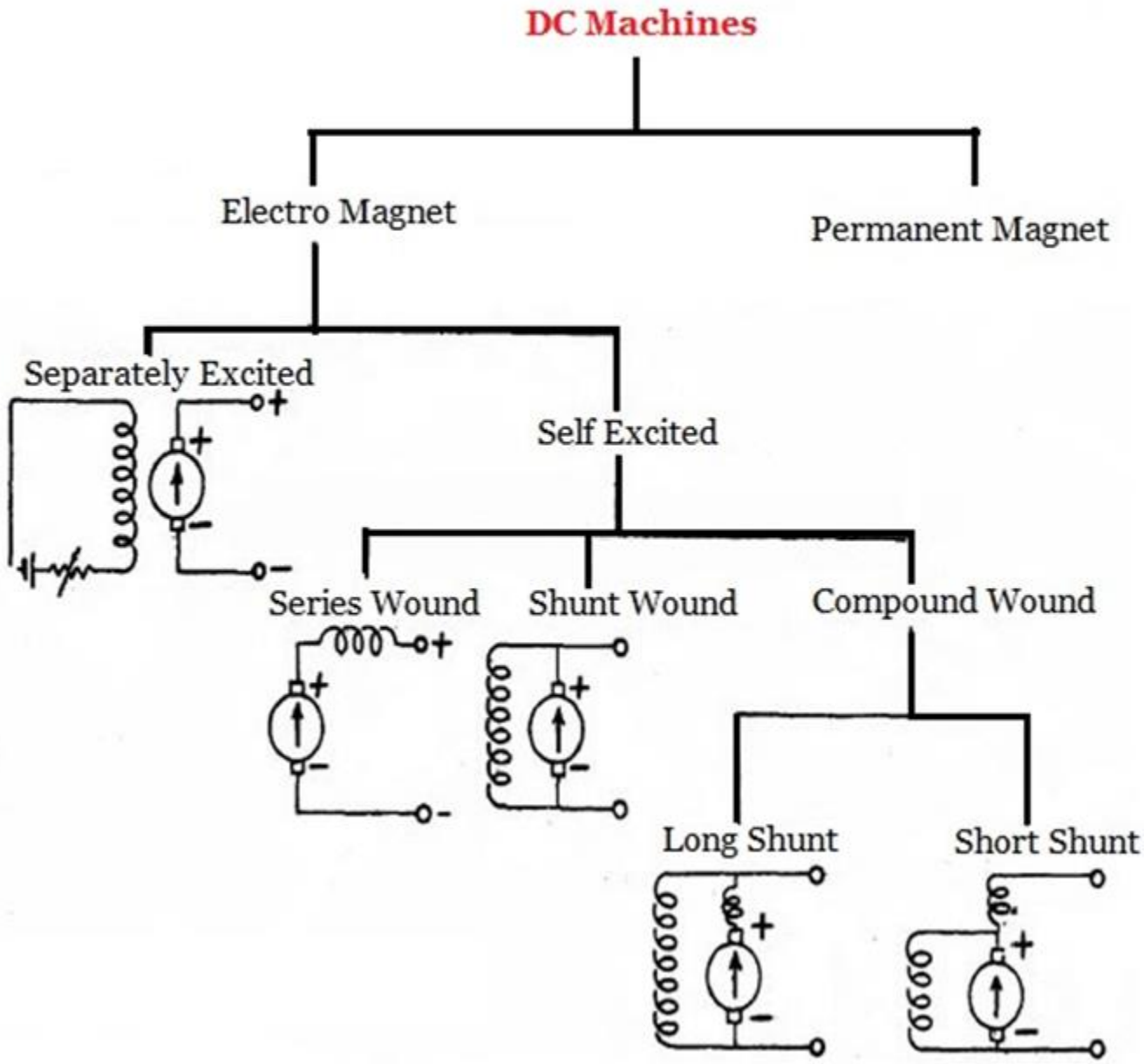


Working principle

- A generator works on the principles of Faraday's law of electromagnetic induction
- Whenever a conductor is moved in the magnetic field, it cuts the flux and an emf is induced
- 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 .

Working principle




DC Machines
Electro Magnet
Permanent Magnet
Separately Excited
Self Excited
Series Wound
Shunt Wound
Compound Wound
Long Shunt
Short Shunt

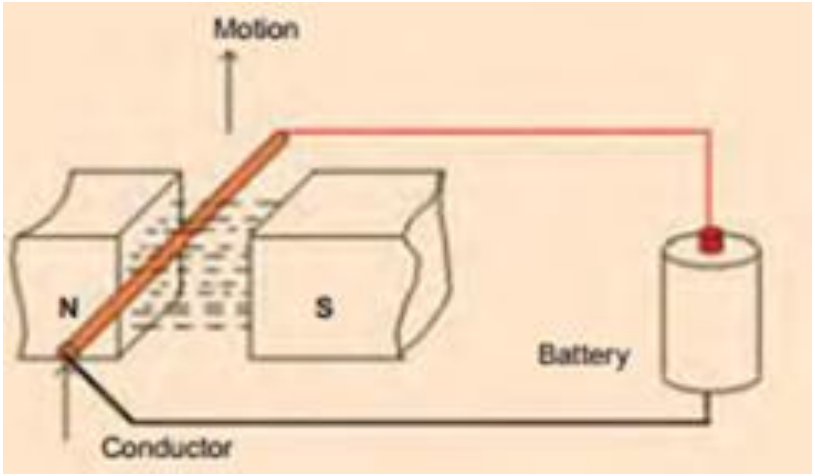
Motor principle

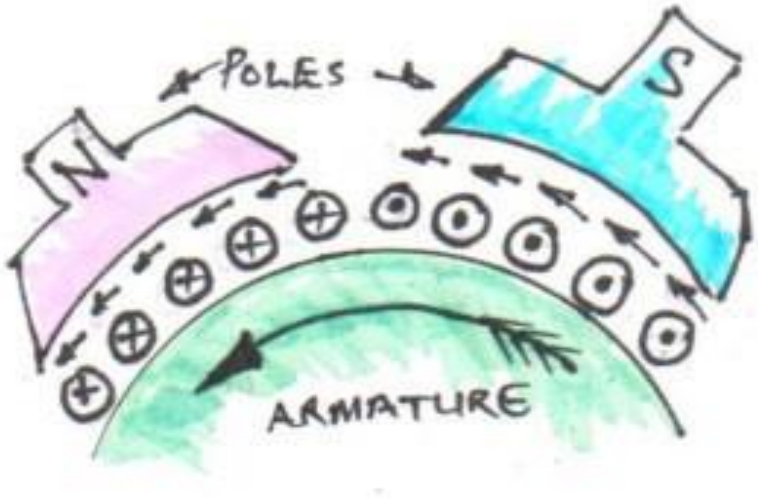
Electric motor is a machine which converts electrical energy into mechanical energy.

When a current carrying conductor is placed in a magnetic field, it experiences a mechanical force whose direction is given by Fleming's left hand rule.

$F = BIl\ N$

Working principle





When the field magnets of a dc motor are excited and its armature conductors are supplied with current from the supply mains, they experience a force tending to rotate the armature.

Back emf

- When the motor armature rotates, the conductors cut the flux.
- In accordance with the law of electromagnetic induction, emf is induced in the armature.
- The induced emf opposes the cause producing it i.e. the applied voltage.
- It is called as back emf or counter emf.
- Voltage equation: $V = E_b + I_a R_a$

Applications

Shunt Generators:

a. in electro plating

b. for battery recharging

c. as exciters for AC generators.

Series Generators :

A. As boosters

B. As lighting arc lamps