

## UNIT-III

# Fundamentals of Electrical Machines



Lecture 17

Prepared By:

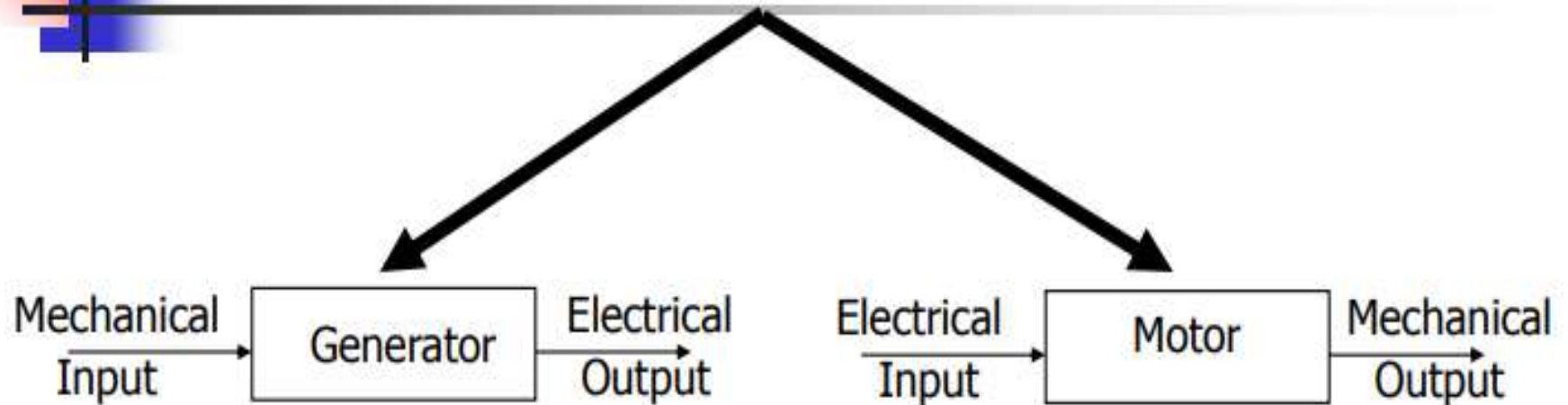
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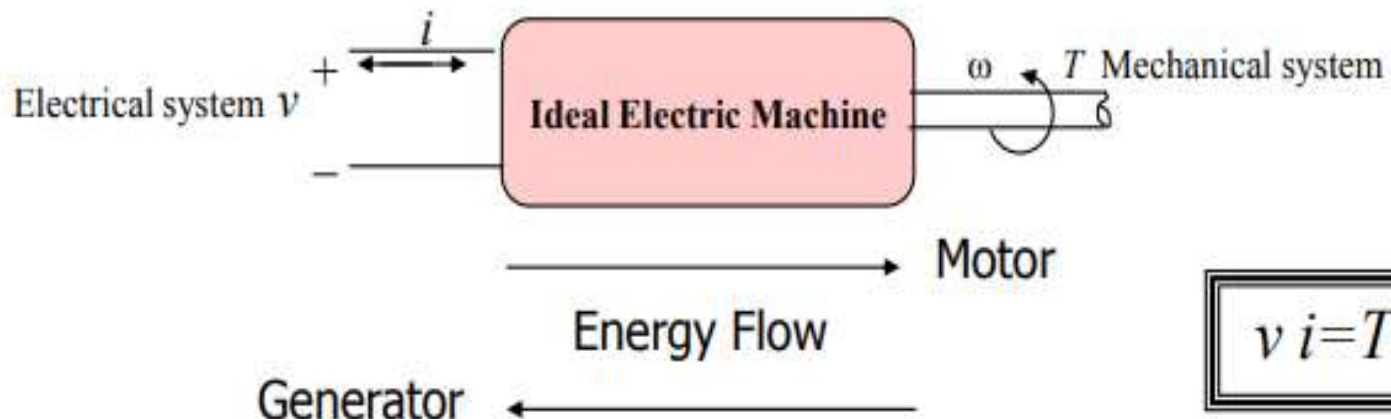
# What is an electric motor?

- An electric motor is an electromechanical device that converts electrical energy into mechanical energy.
- All electric motors operate through the interaction of magnetic fields and current-carrying conductors to generate force.

# Electric Machine

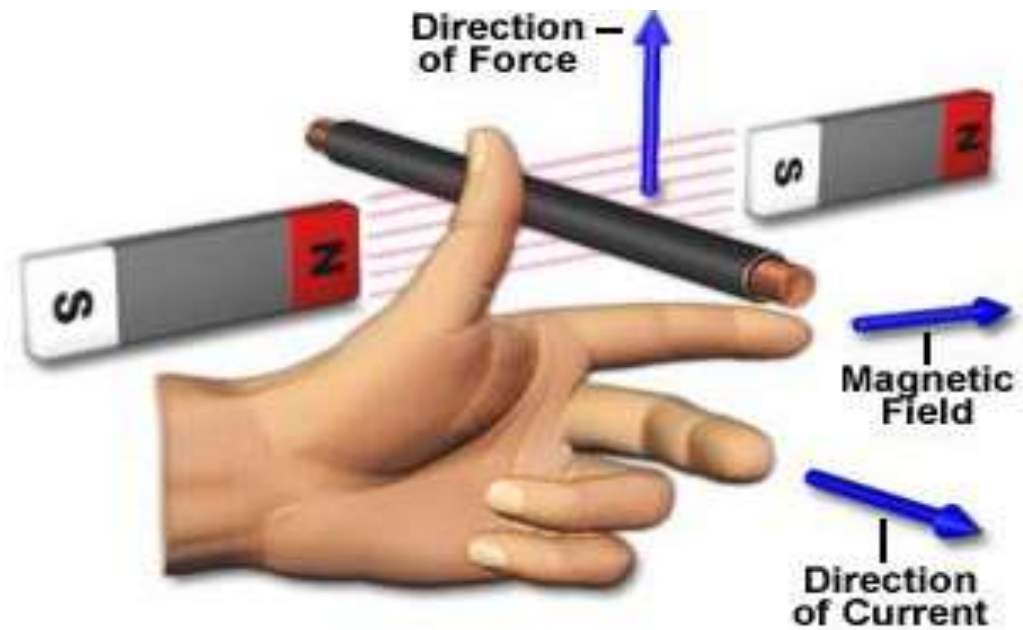


## Electromechanical Energy Conversion



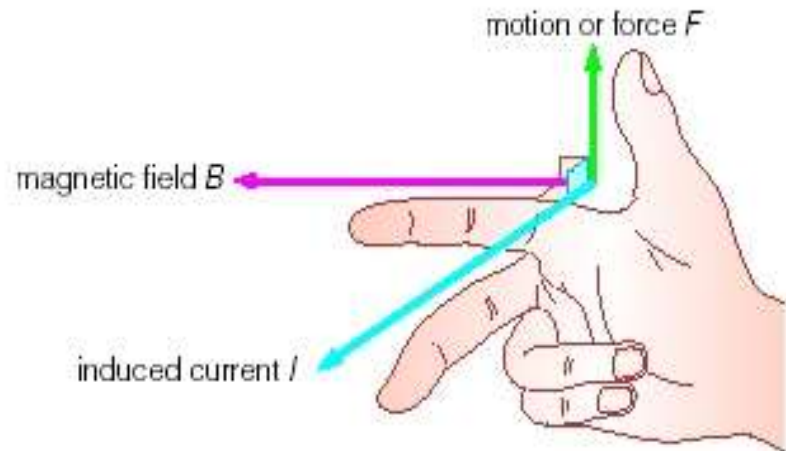
$$v i = T \omega$$

# Flemings left hand rule



- The direction of force exerted on the conductor is given by Fleming's Left Hand Rule.
- Thumb indicates the direction of force experienced by the conductor Index finger represents direction of magnetic field
- Middle finger indicates direction of current
- **This rule is used in motors.**

# Flemings Right hand rule

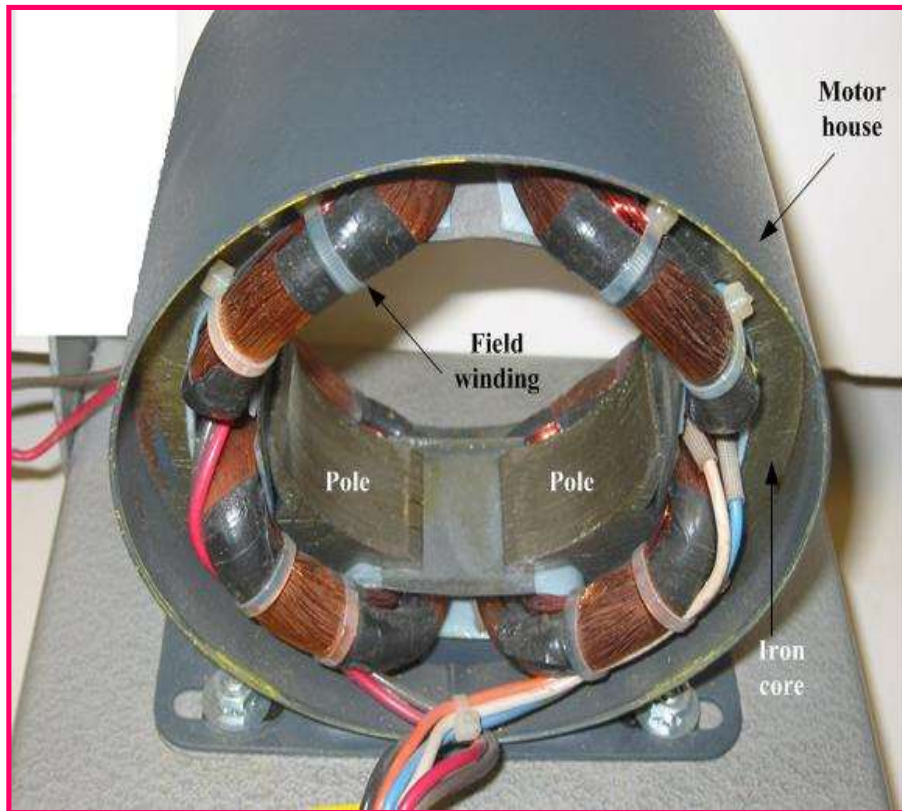


- When a current passes through a conductor, lines of magnetic force (flux) are generated around the conductor.
- The direction of the flux is dependent on the direction of the current flow. The magnetic field produced by the conductor is shown in Figure above.
- This can be found by using Right Hand Thumb Rule.
- **This rule states that If the thumb points in the direction of the current, then the curled fingers show the direction of the magnetic field.**

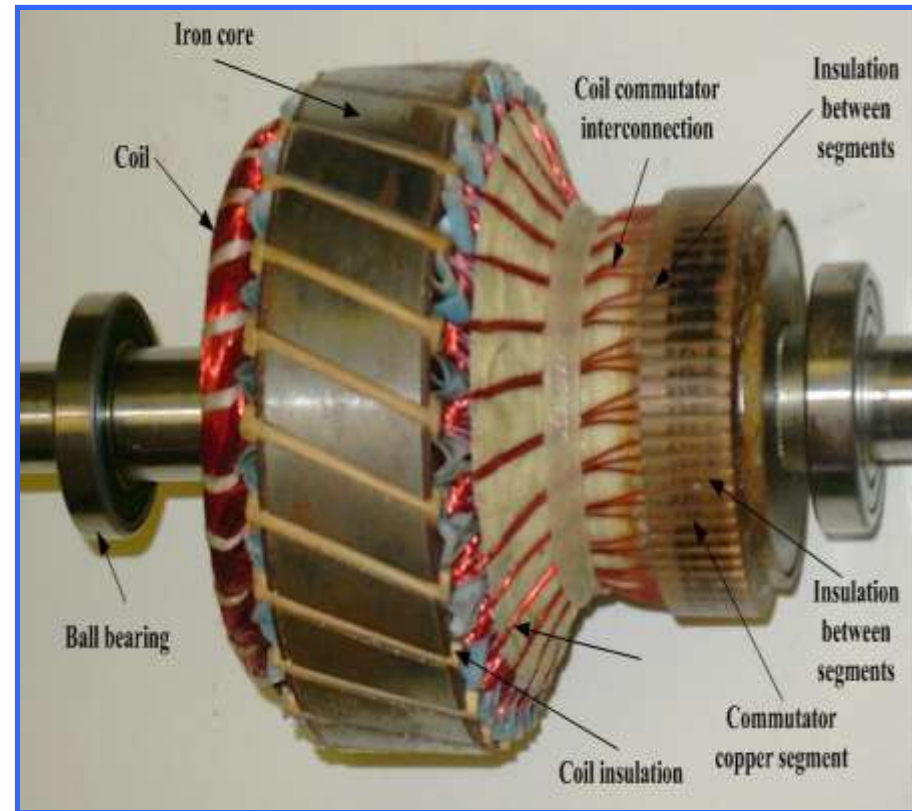
# Quick Quiz (Poll 1)

- Which of the following rule is used to determine the direction of rotation of D.C motor?
  - A. Coloumb's Law
  - B. Lenz's Law
  - C. Fleming's Right-hand Rule
  - D. Fleming's Left-hand Rule

# CONSTRUCTION OF DC MACHINES



DC motor stator

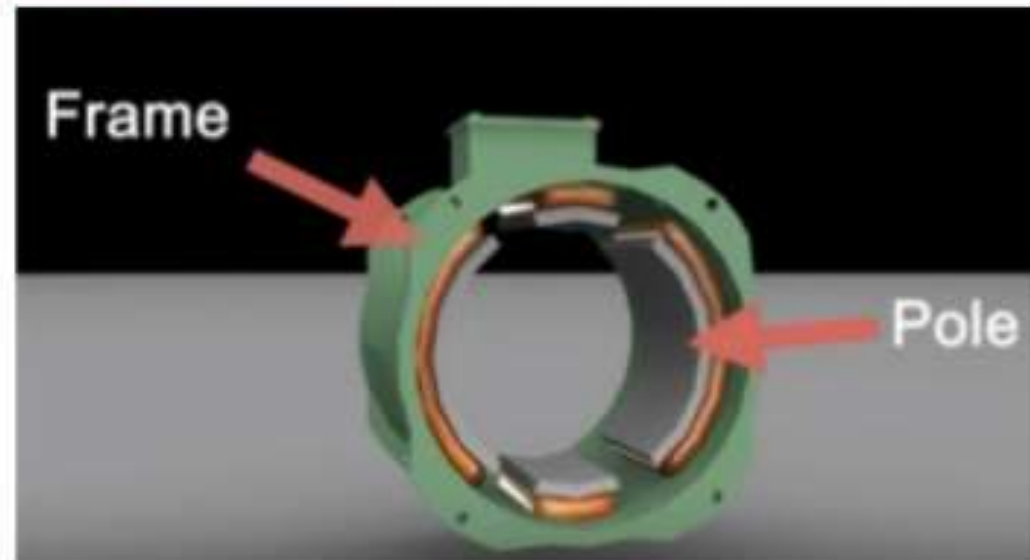
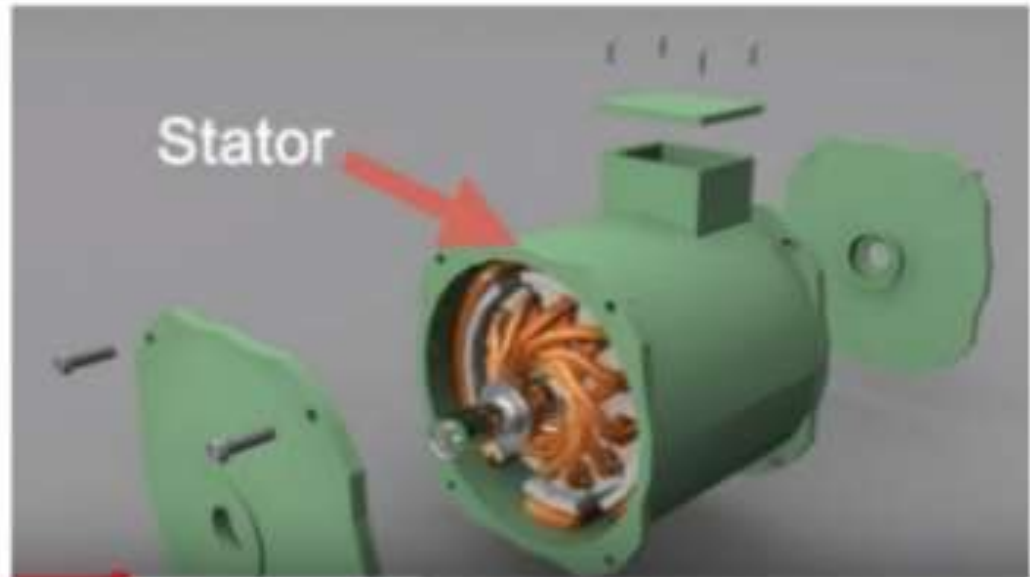


Rotor of a dc motor



## Construction

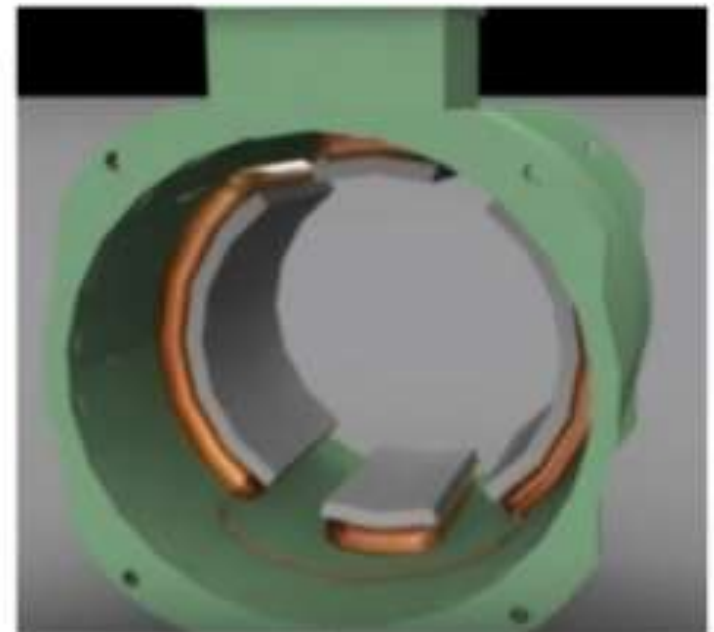
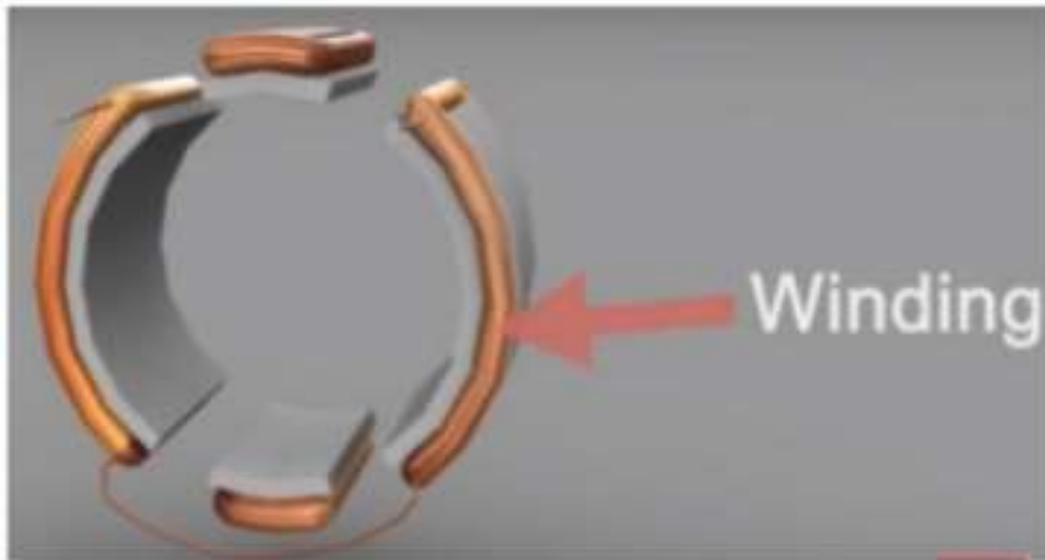
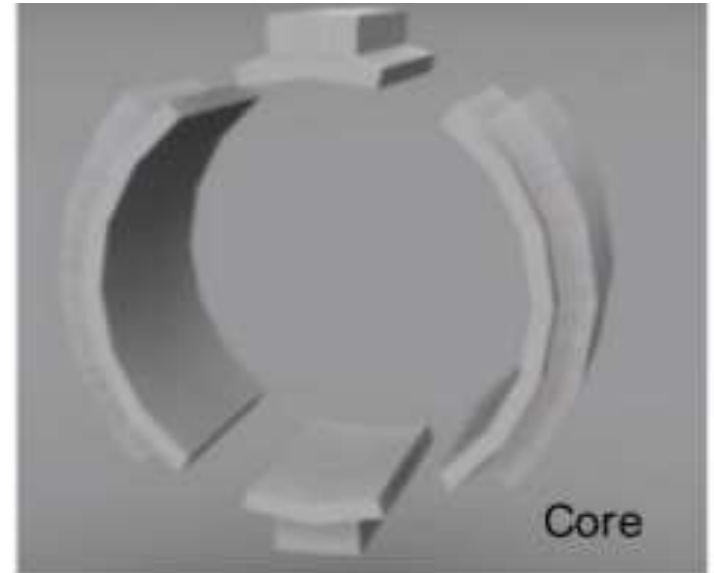
- The outer part of the motor is generally static, which is known as stator.
- Stator consist of a frame, and it contains "Pole Shoes" which are projected inward.





## Construction

- Core of these poles are made from silicon steel on which insulated copper wire is wound to make windings.
- These poles are bolted and fixed inside the frame.

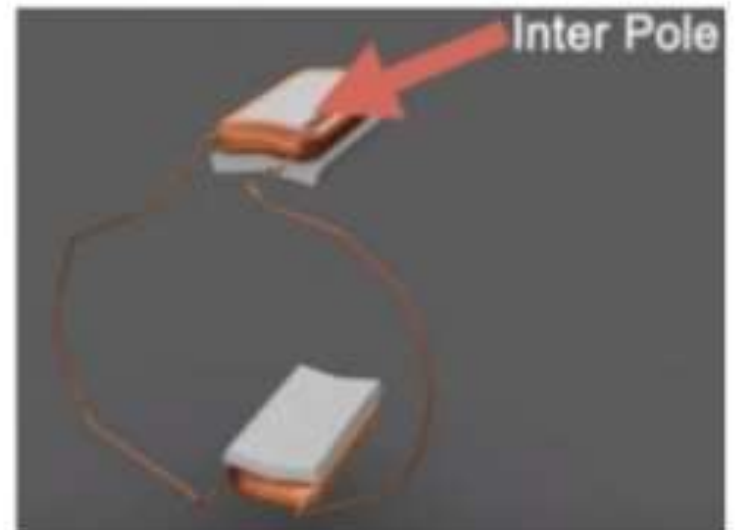
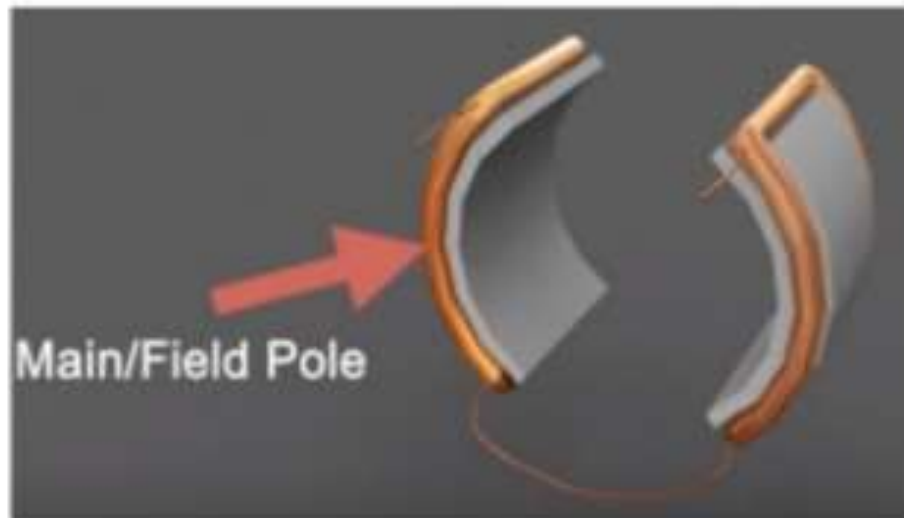
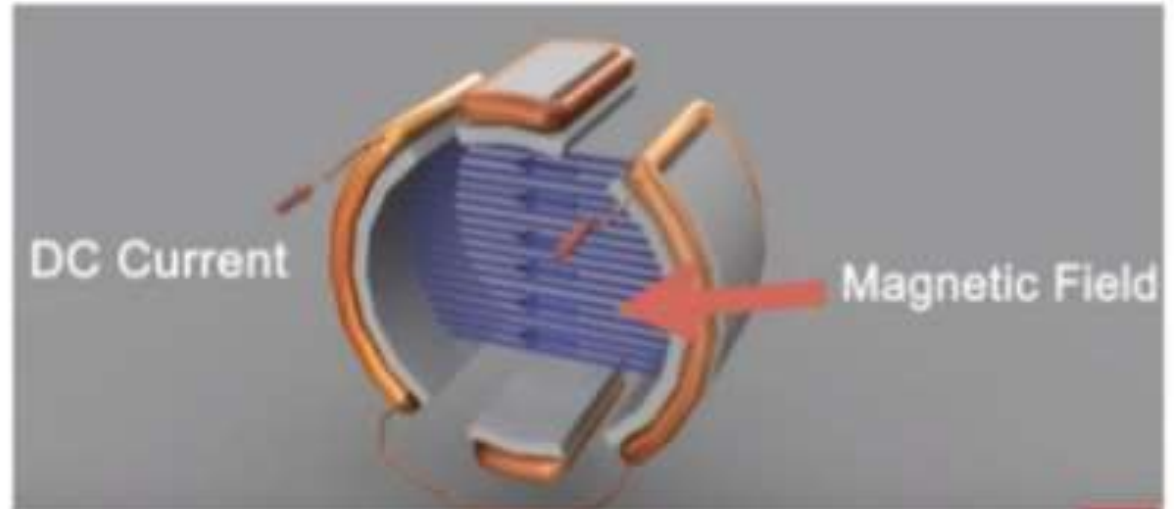


## Construction

- When DC current is passed through the windings it creates a static magnetic field.
- There are two types of pole in a DC machine.

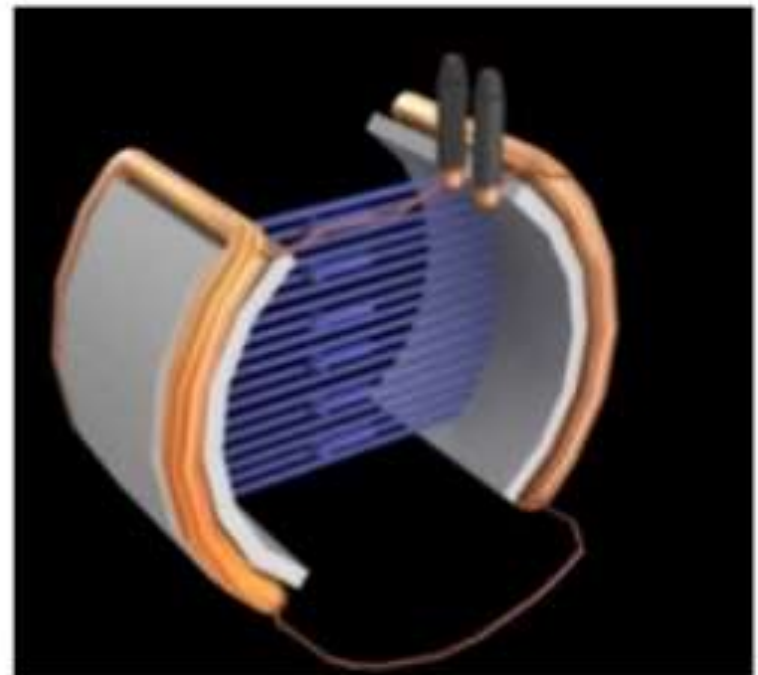
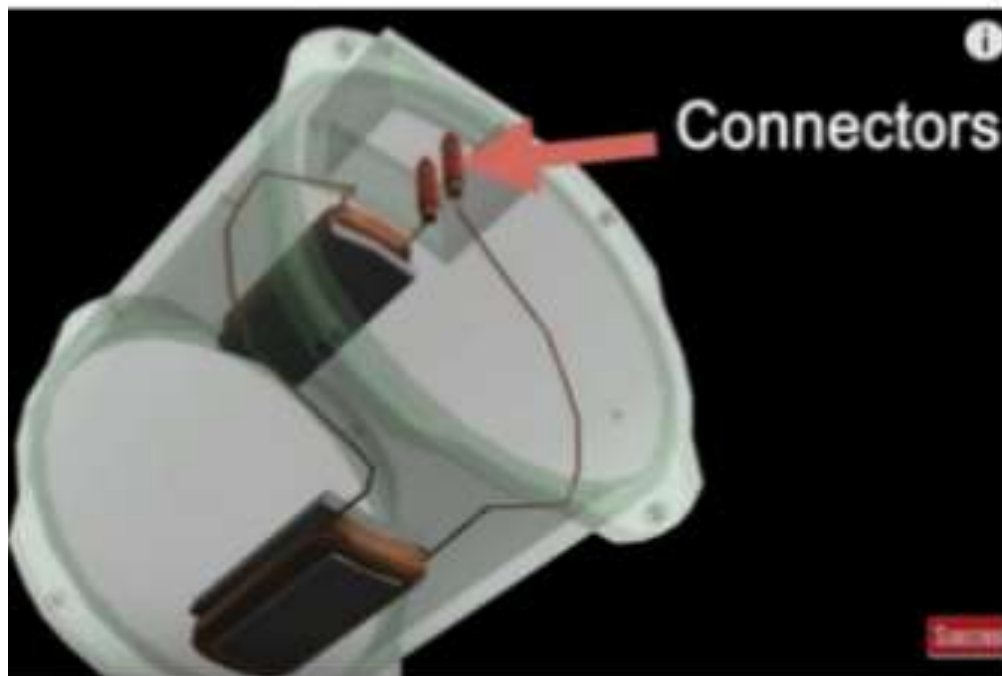
1. Main/ Field Pole

2. Inter Poles



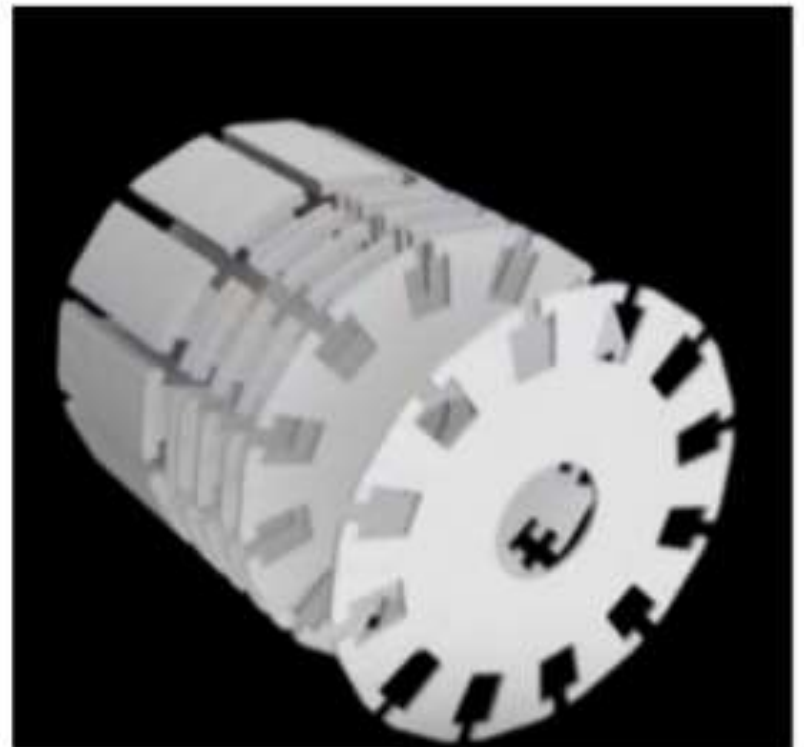
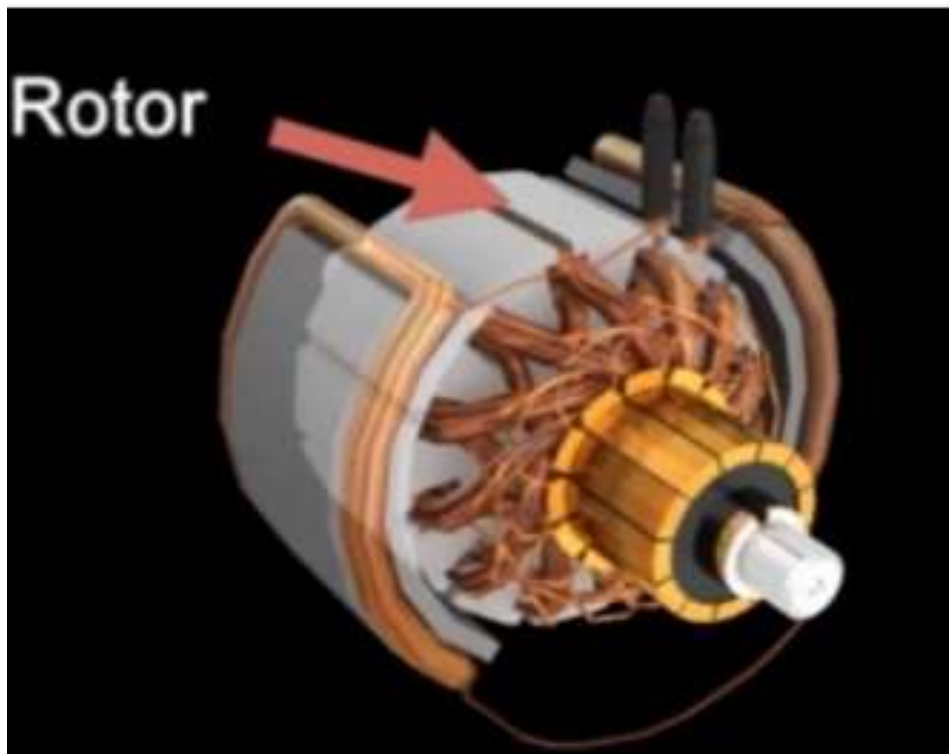
## Construction

- The connections of these poles are brought out through connectors in the terminal box, so that we can give electric supply to them and even do the check for the fault.
- Main poles create static magnetic field, when current is pass to its winding.



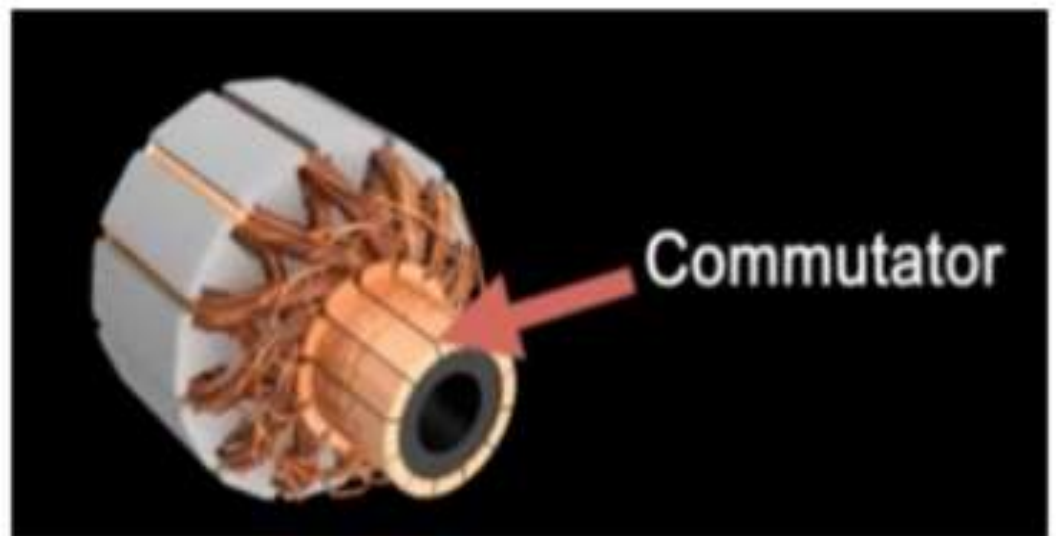
## Construction

- In this magnetic field rotating part of motor lies, known as Rotor or Armature which is made by number of stampings of highly permeable material i.e. silicon steel, which allows magnetic field to pass through it easily.



## Construction

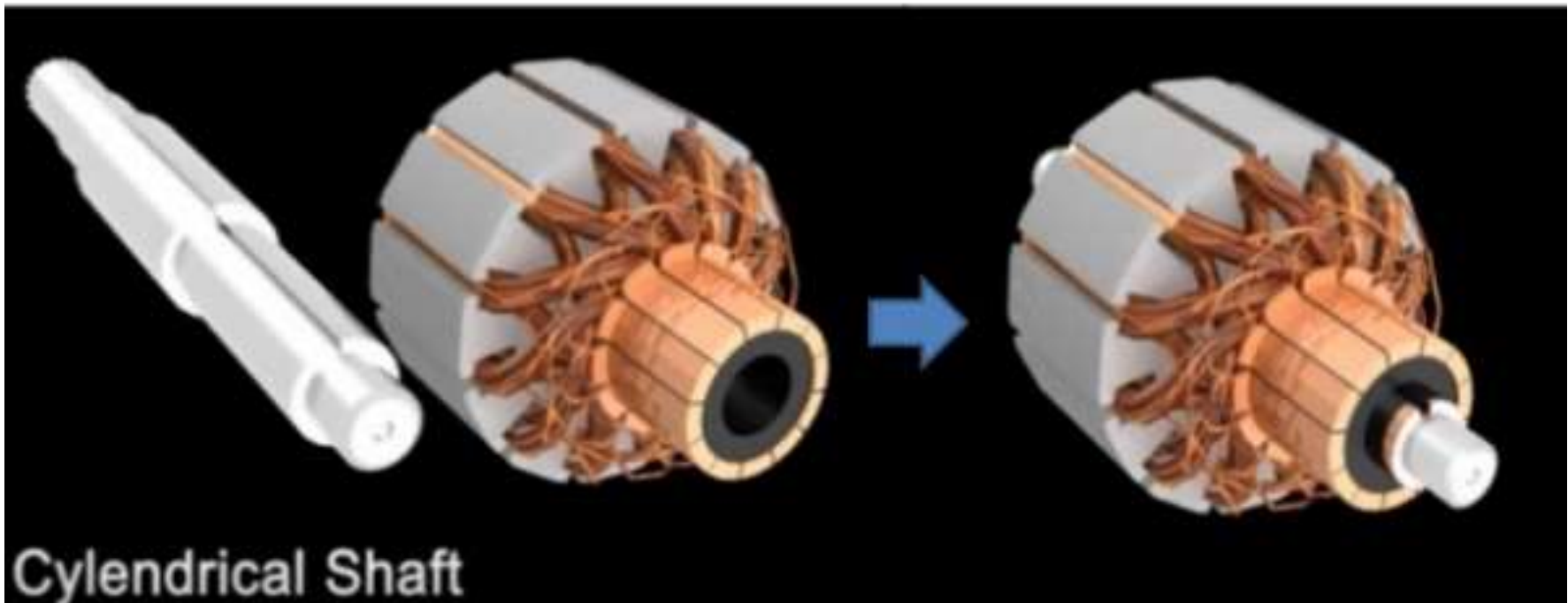
- Slots are cut on the outer periphery of rotor or we can say "armature", which receive coils/windings made up of copper conductor.
- Each coil gets connected to an external DC source by a pair of commutator segments arranged in the form of a Ring.





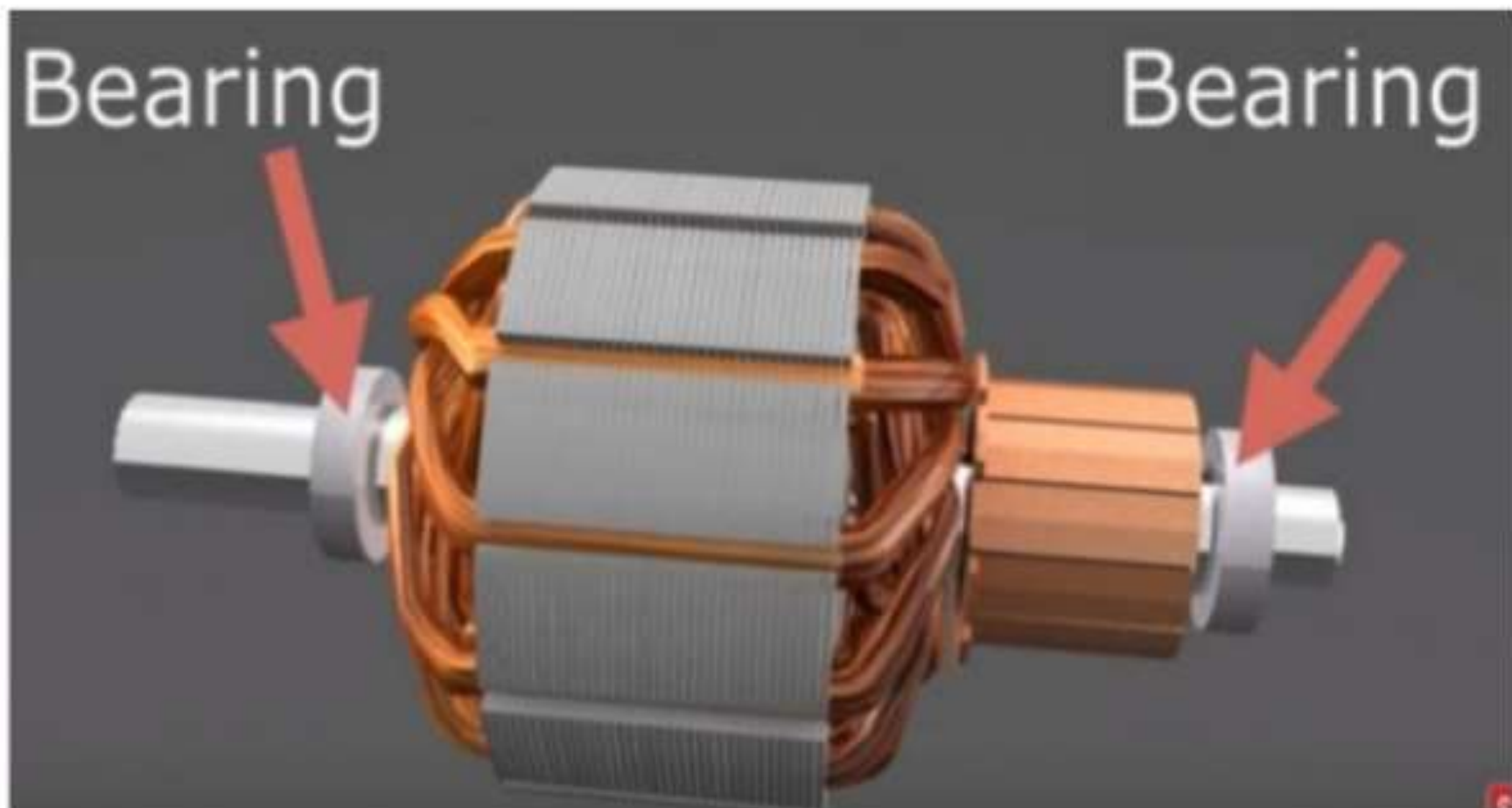
## Construction

- This complete assembly is housed over a cylindrical shaft made up of high quality steel.



## Construction

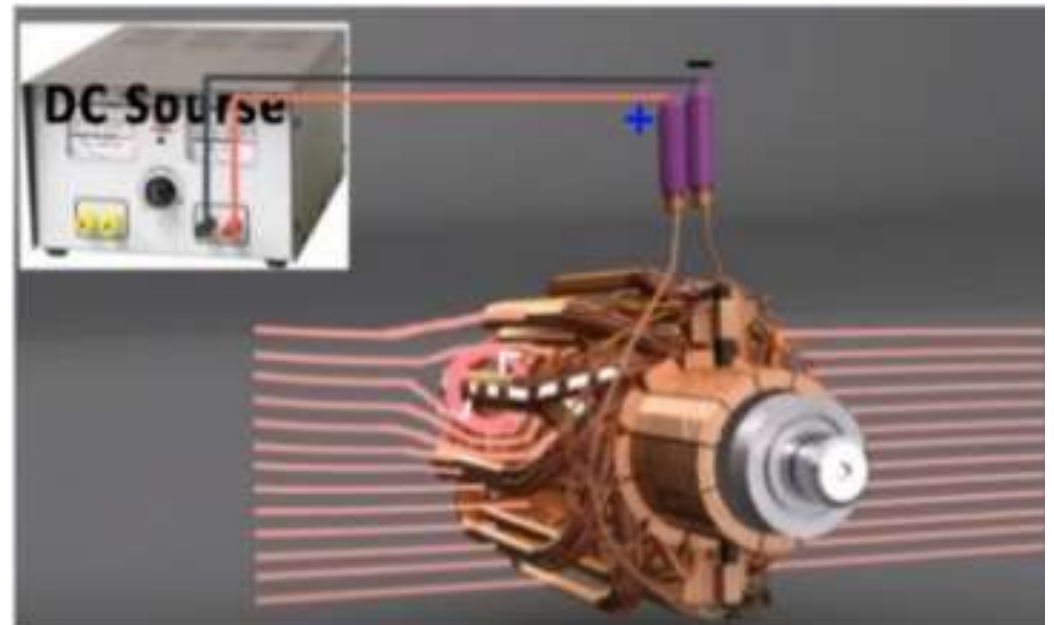
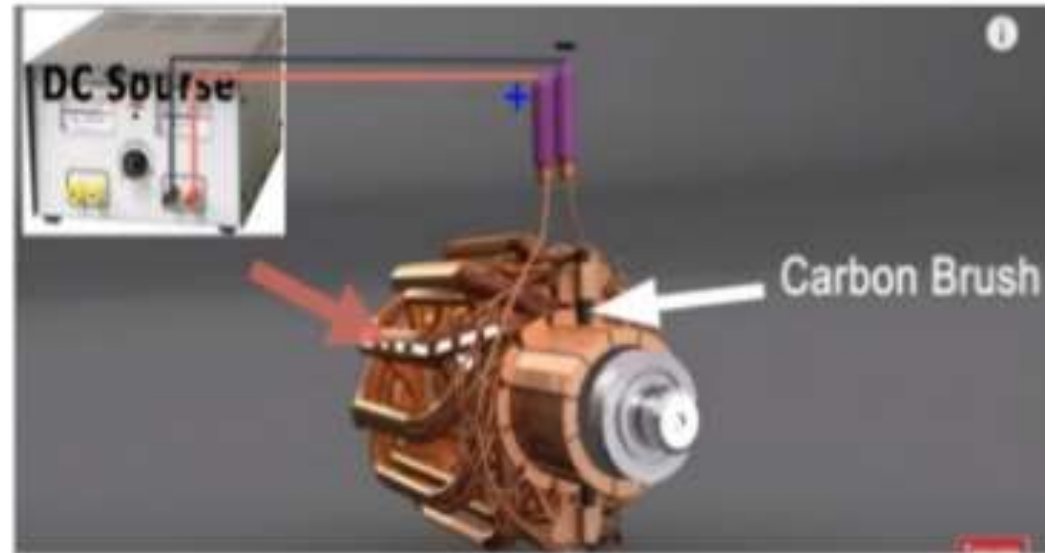
- Because of the bearings at both side of the shaft the rotor is capable of rotate between the field poles.



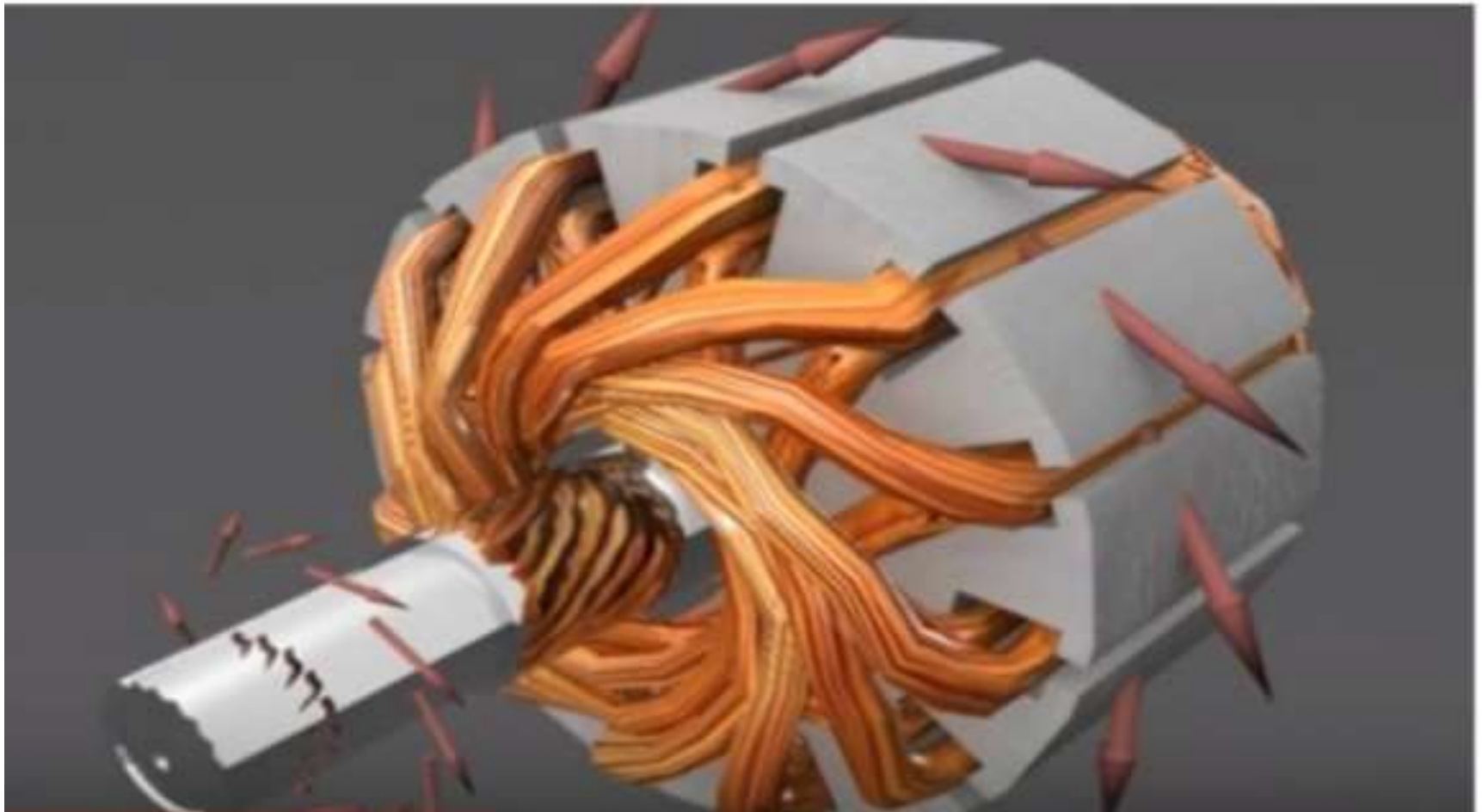


## Working

- When electric current is forced to pass through the rotor conductors by a set of carbon brushes through commutator segments, it creates their own magnetic field which tries to distort the magnetic field, created by the field pole.



- ins-
  - Due to interaction between two magnetic fields i.e magnetic field of main poles and the rotor conductors. Electromagnetic Forces act on the rotor conductors and these forces act tangentially on the rotor surface.
  - Therefore a torque is produced at the rotor shaft and the rotor rotates.



# Principle of operation

- When current carrying conductor is placed in a magnetic field, it experienced a force.
- In case of DC motor, the magnetic field is developed by the field current i.e. current flowing in field winding and armature winding plays the role of current carrying conductor
- So armature winding experienced a force and start rotating.

# Back EMF

- When the armature winding of a dc motor starts rotating in the magnetic flux produced by the field winding, it cuts the lines of magnetic flux.
- Hence according to the faraday's laws of electromagnetic induction, there will be an induced emf in the armature winding.
- As per the Lenz's law, this induced emf acts in opposite direction to the armature supply voltage. Hence this emf is called as the back emf and denoted by  $E_b$ .

$$E_b = \frac{NP\phi Z}{60 A}$$

# Quick Quiz (Poll 2)

- The efficiency of the DC motor at maximum power is
  - A. 90%
  - B. 100%
  - C. Around 80%
  - D. Less than 50%

# Quick Quiz (Poll 3)

- By looking at which particular part of the motor we can Identify a “**DC motor**”?

A Shaft

B Field winding

C Commutator

D Armature winding