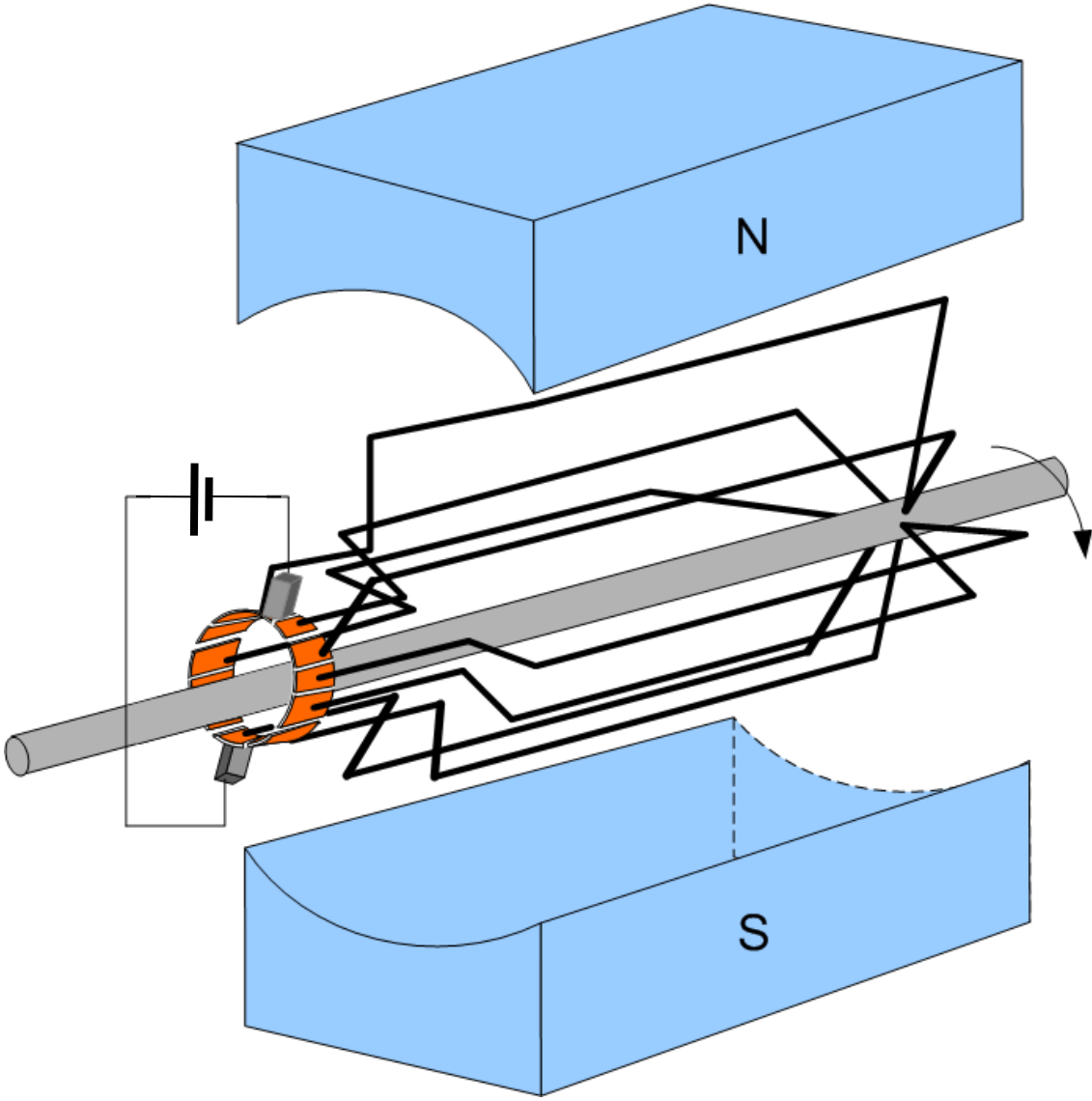
Day 33
DC Machine Construction

DC Machine

Basic Construction

- Pair of semi-circular shaped magnets (field system or the poles) in stator
- The coils are mounted on shaft in the rotor (armature)
- A split copper ring (commutator) is permanently connected to the coil ends
- Two static conducting brushes (graphite) touch the rings
- A fixed DC voltage is supplied to the armature coils through the brush and commutator



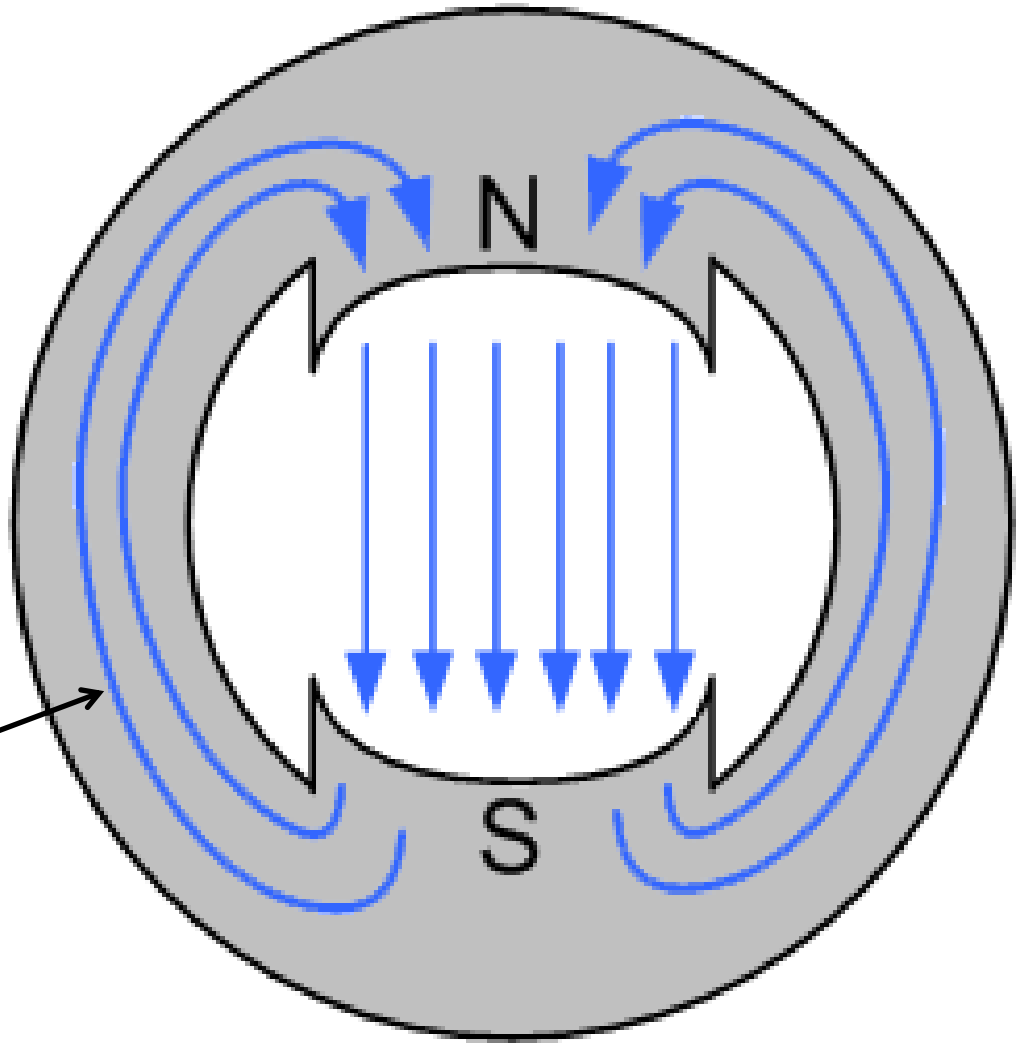
Construction of DC Machine

- A DC machine (generator or motor) consists of two main constructional parts:
  - A stationary part called the **stator**
  - A rotating part called the **rotor**

- The stator is designed mainly for producing the magnetic flux
- The rotor is the inner part of the machine that has coils
- Rotor is also called the **armature** where mechanical energy is converted into electrical energy (generator) or electrical energy is converted into mechanical energy (motor)
- The stator and rotor parts are separated from each other by a small **air-gap**

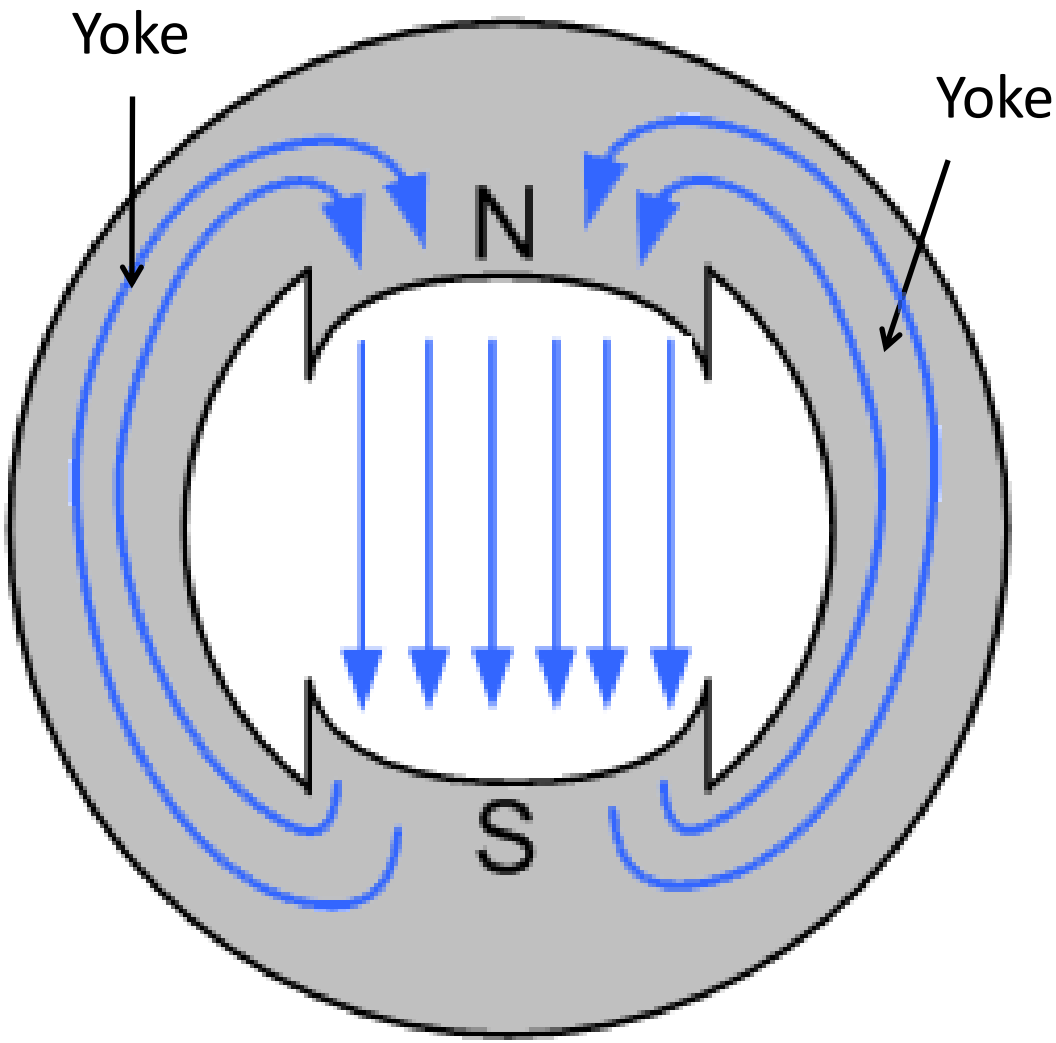
Basic components of stator

- Minimum two poles
- Flux goes from N to S
- But how will it return from S to N?
- We need a complete magnetic path
- So, a thick iron cylindrical ring is used outside
- This is called **YOKE**
- Yoke provides a **low reluctance return path** for the flux lines



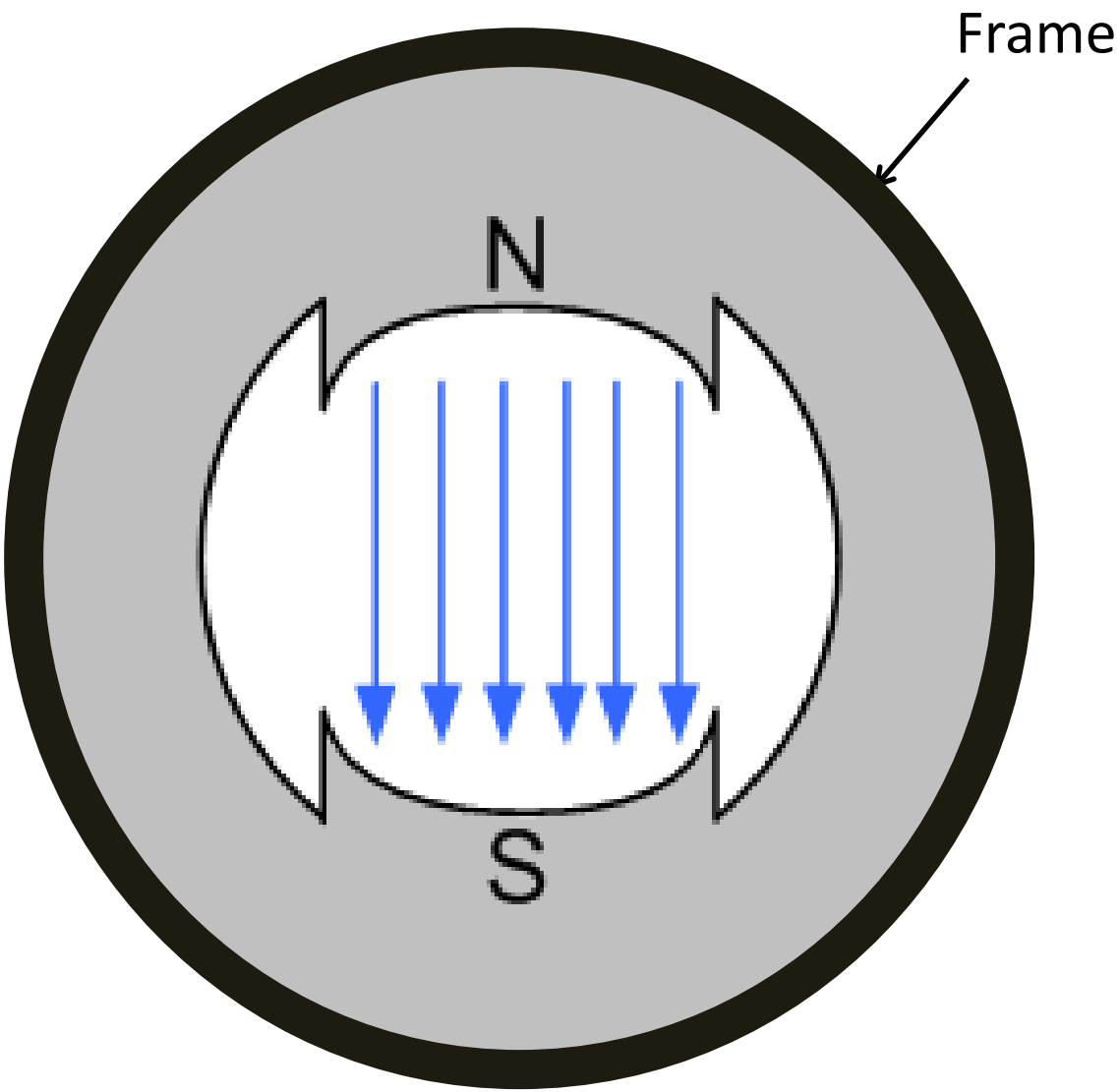
Yoke

- Yoke provides a low reluctance **return path** for the flux lines
- Yoke provides support to the poles
- Poles are bolted to the yoke
- Yoke material should be good quality (high permeability) iron or steel that will allow easy flow of flux through it



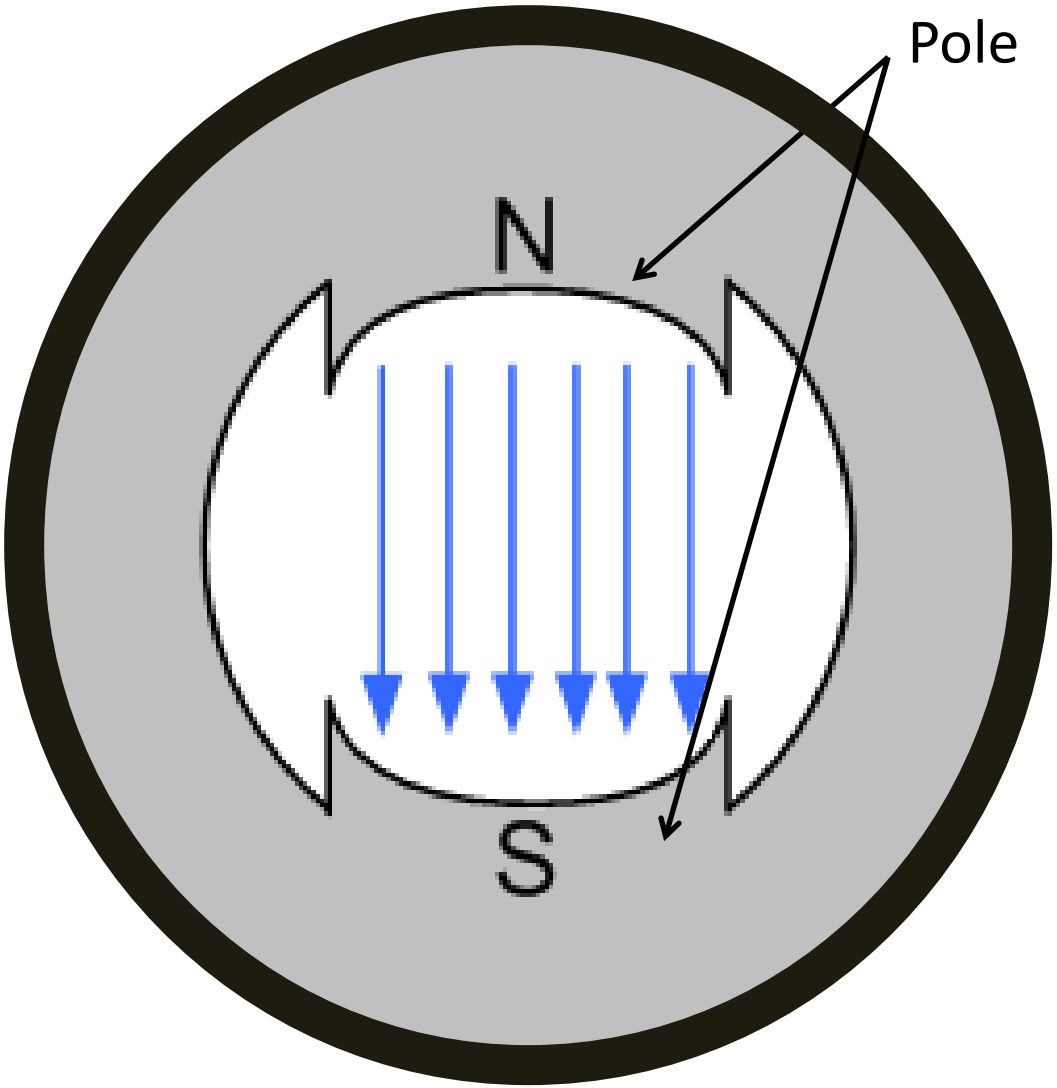
Frame

- Frame of a DC machine is the outer cylindrical part that encloses all internal parts of the machine
- Frame is usually made of cast iron
- The main function of frame is to protect the internal parts from outside
- and hold static parts (stator) of the machine



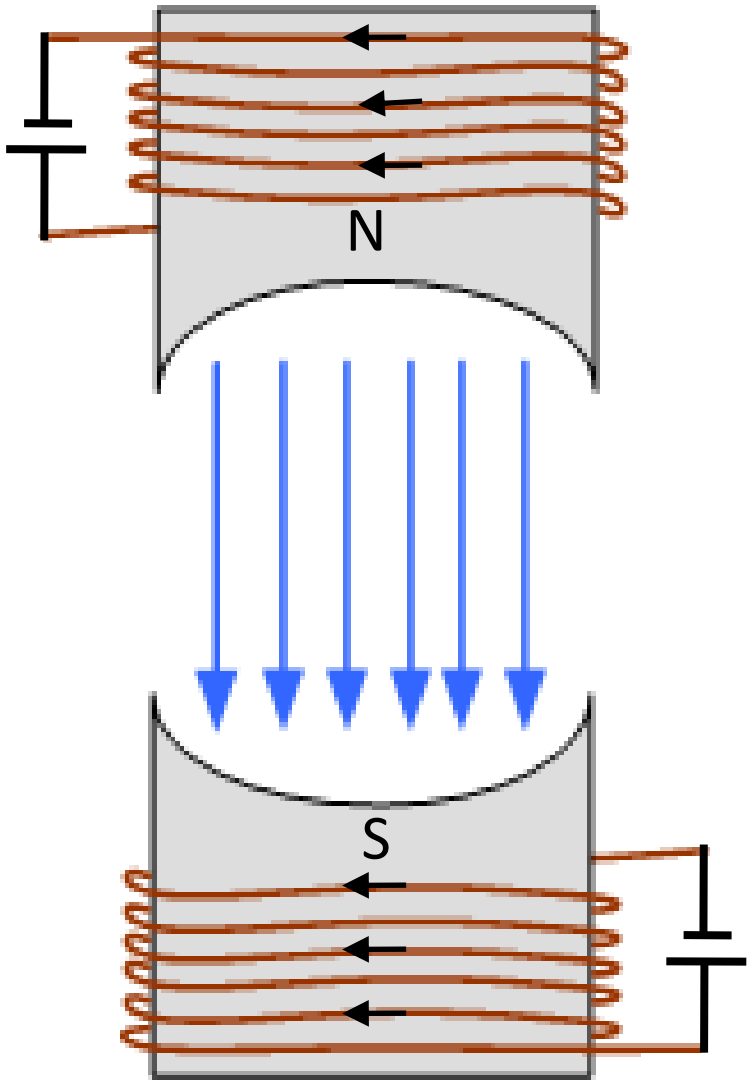
Main poles

- Function of main poles in a DC machine is to create the working magnetic flux
- For small DC machines, permanent magnets may be used as the poles
- For larger machines, however, electromagnets are used since permanents magnets are expensive

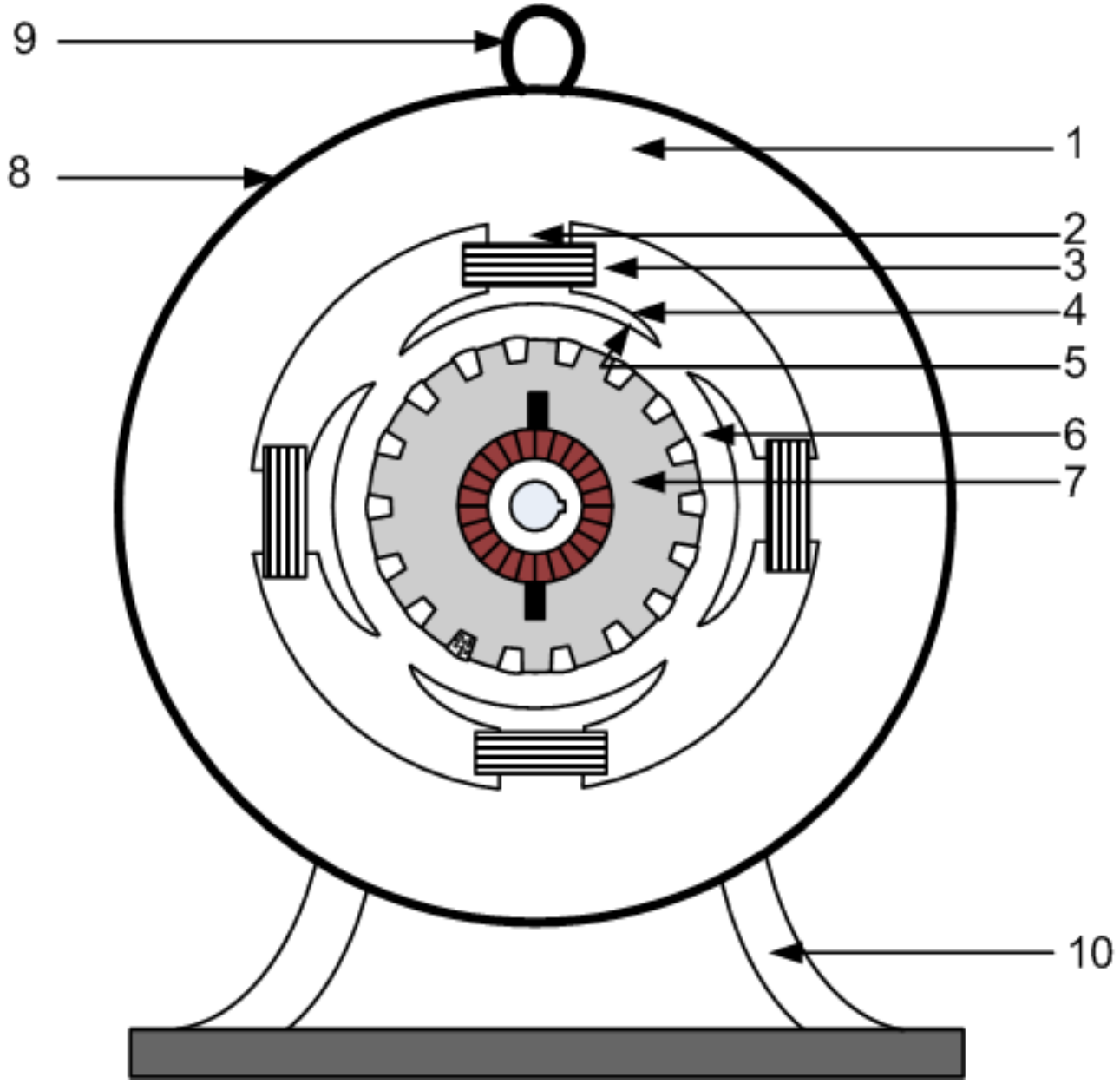


Electromagnets as poles

- Coils are placed on poles
- DC current passed through coils
- Diametrically opposite poles have opposite MMF direction
- So, they produce opposite poles

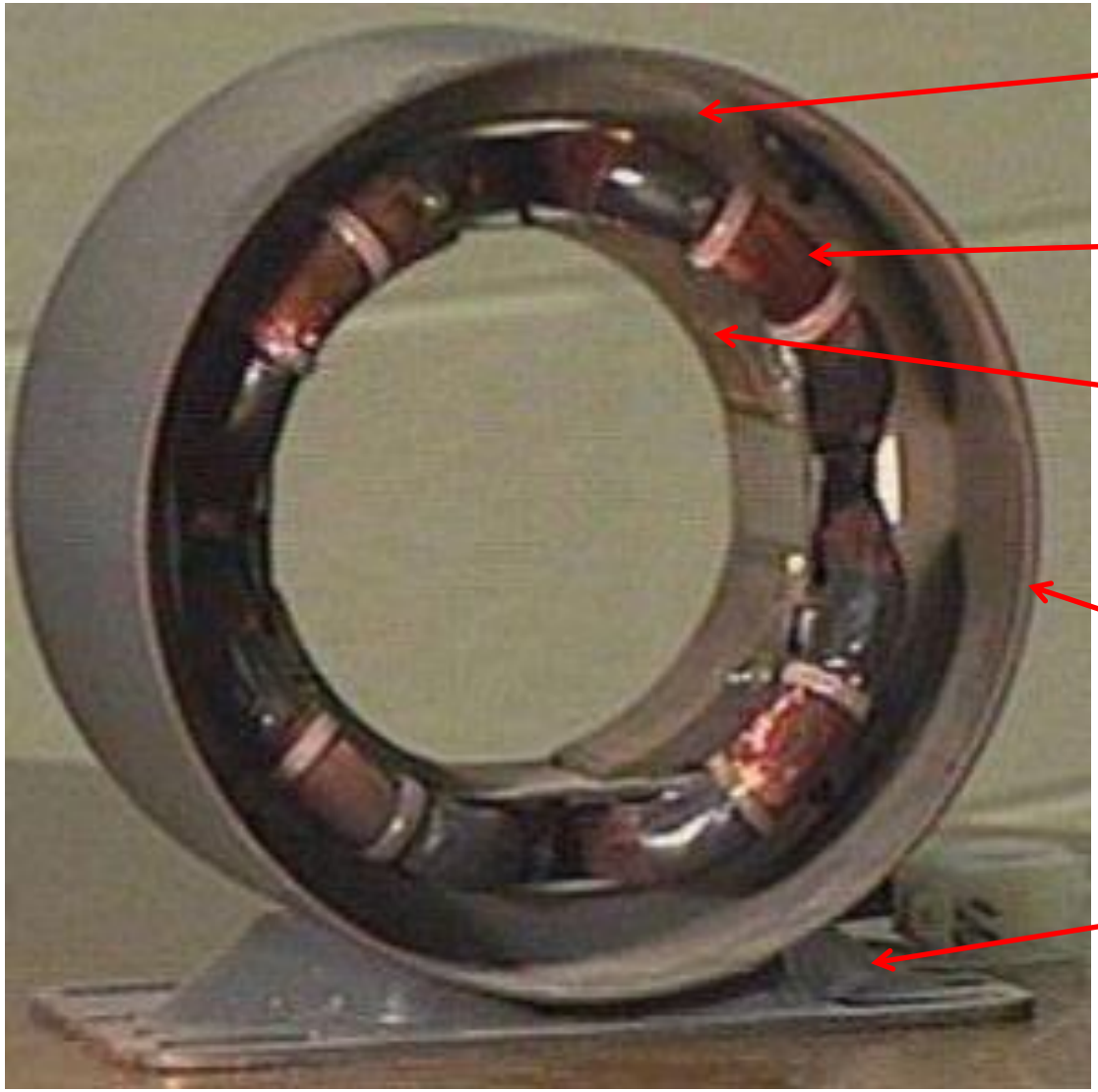


Cross section – 4 pole DC machine



1. Yoke
2. Pole core
3. Pole winding
4. Pole shoe
5. Pole face
6. Air-gap
7. Armature
8. Frame
9. Lifting pin/lug
10. Foot

Photograph - stator



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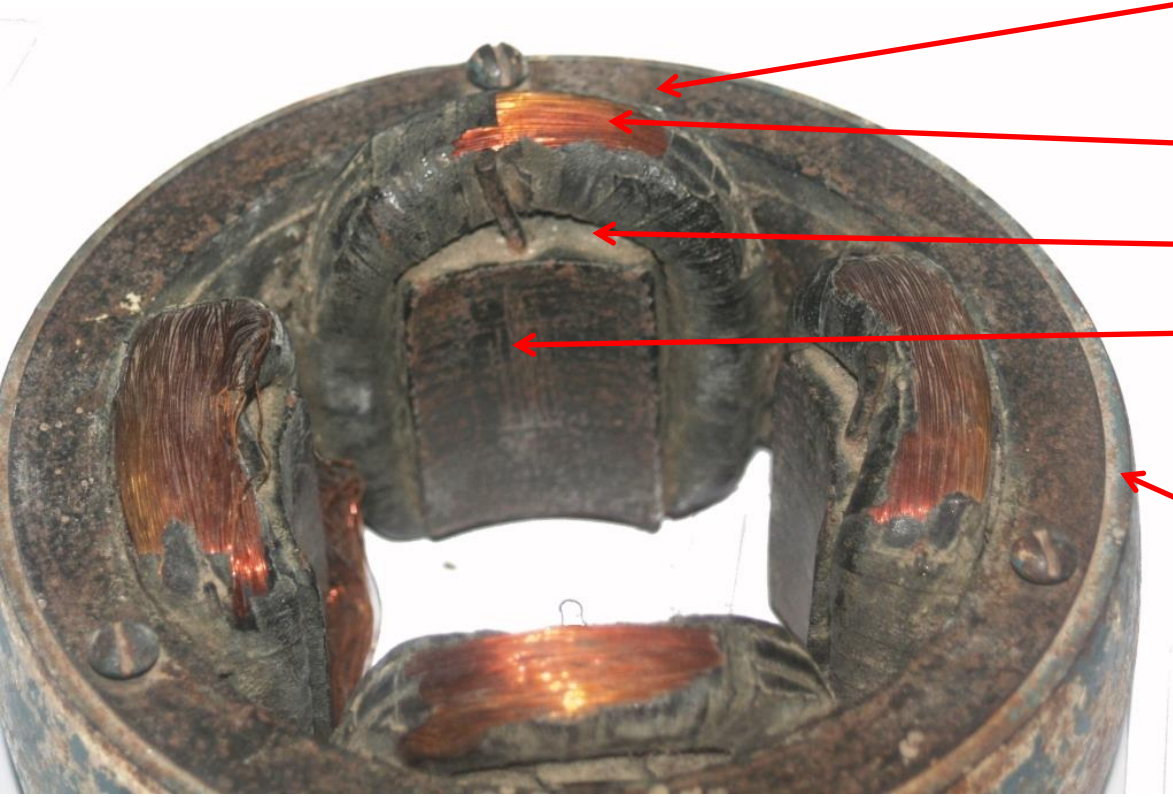

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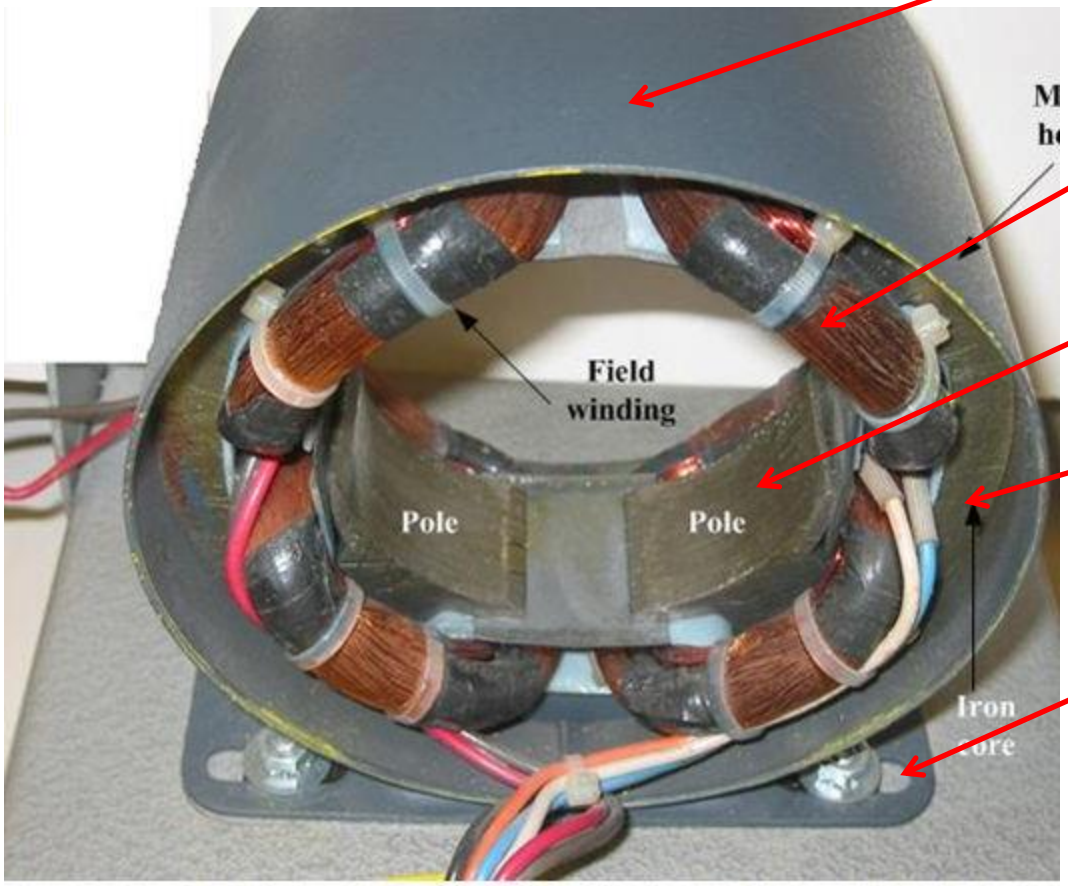


Frame

Pole winding

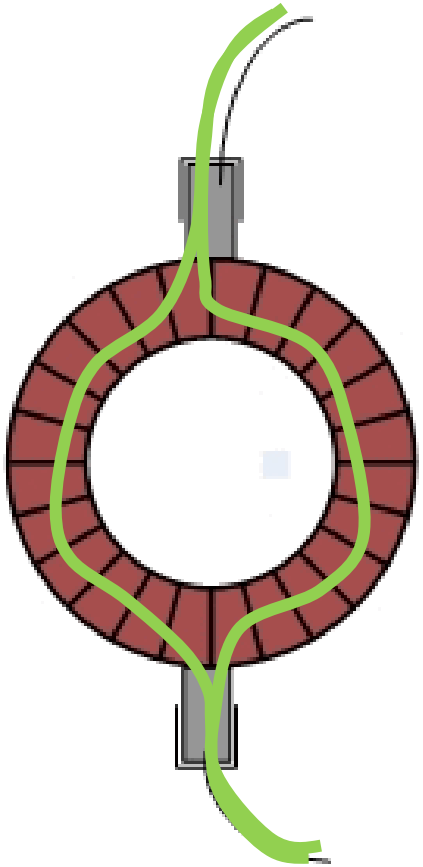
Pole face

Yoke

Foot

Brush

- Brushes are fixed in the brush holder in the stator
- Commutator rotate at high speed
- Brush make contact on the surface of commutator
- Current flows through the brush-commutator contact area



Brush

- **Desirable properties**
  - Carry current – conductor
  - Less friction with rotating commutator
  - Quickly dissipate away the heat developed due to friction
  - Conductivity should not be hampered due to heating
  - Slippery, so that reduce friction with rotating commutator

Brush

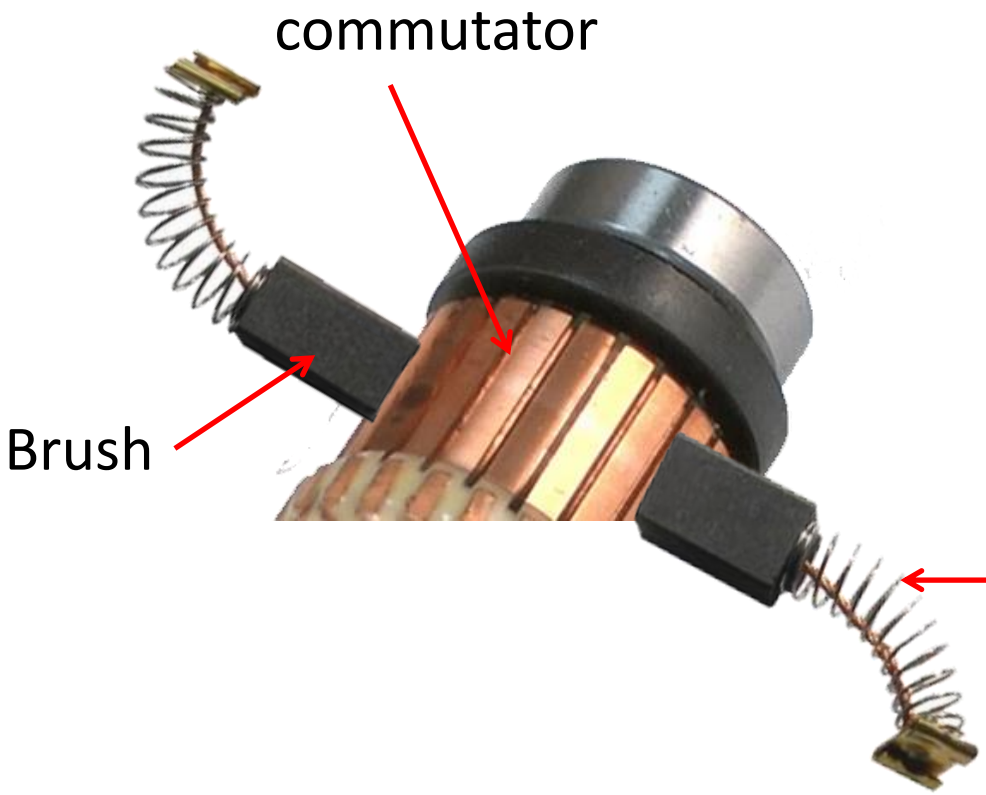
- **Brush material**
  - The various type of brush materials are carbon, electro-graphite, copper-graphite, etc.
  - Carbon brushes are used for very small machines
  - Most commonly used brush material is **electro-graphite**
    - In electro-graphite materials, the carbon is converted into graphite by heat treatment at a temperature of 2500°C.
  - Electro-graphite material has the properties of high thermal and electrical conductivity and is additionally very resistant to burning

Brush

- **Why brushes in DC machine are made of graphite?**
  - Graphite is a good conductor of electricity
  - coefficient of friction between graphite (brush) and copper (commutator) is very less
  - The temperature coefficient of resistance of graphite is negative
    - This has the advantage that even if large current and friction can heat up the brushes, its resistance will not rise during operation
  - Graphite has a ‘self-lubricating’ property that further reduces friction between brush and commutator surface
  - Melting point of graphite is extremely high (> 3,000°C)

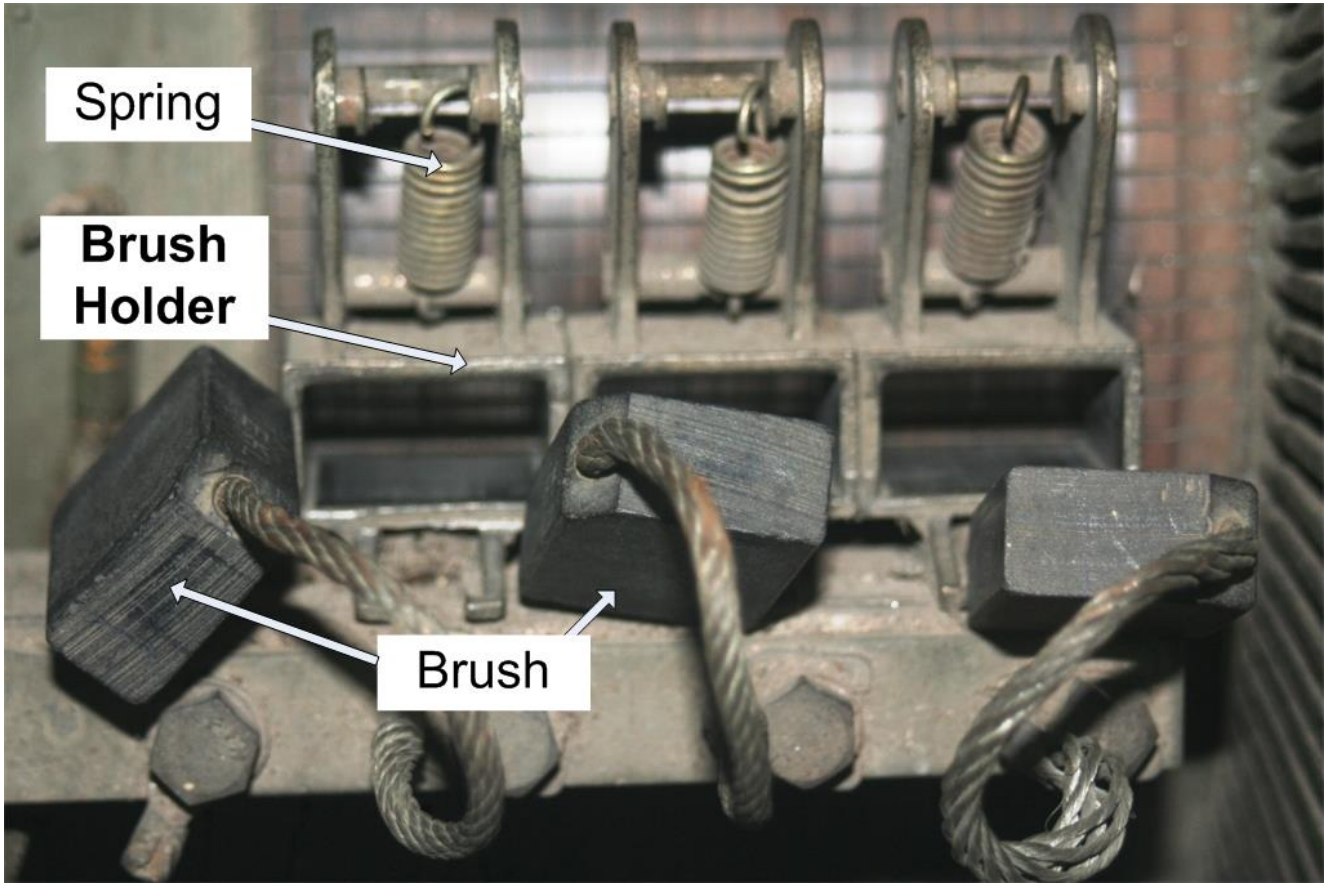
Brush holder

- Brushes are to be fitted over the commutator
- Commutator rotate, but brushes remain stationary
- Connection of armature coils to external circuit through brushes



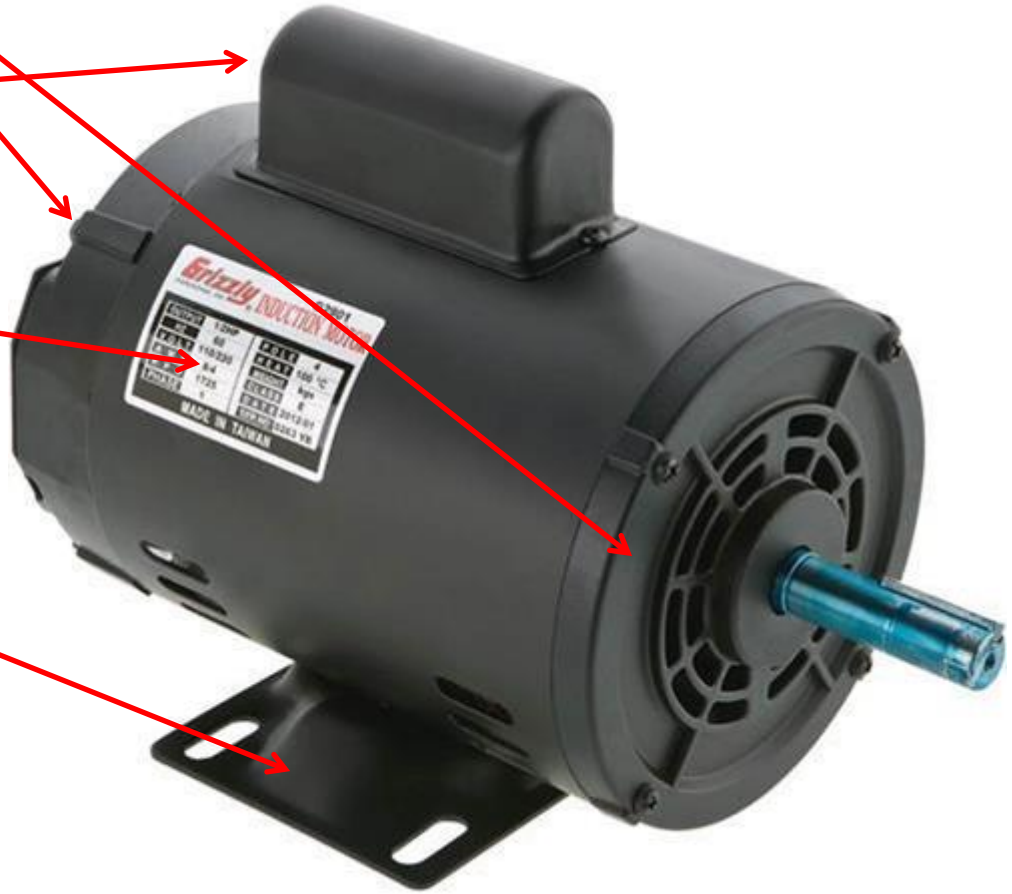
- Brushes are pressed over commutator by spring pressure
- Brush holders hold the brush and springs

Brush holder



Other components of stator

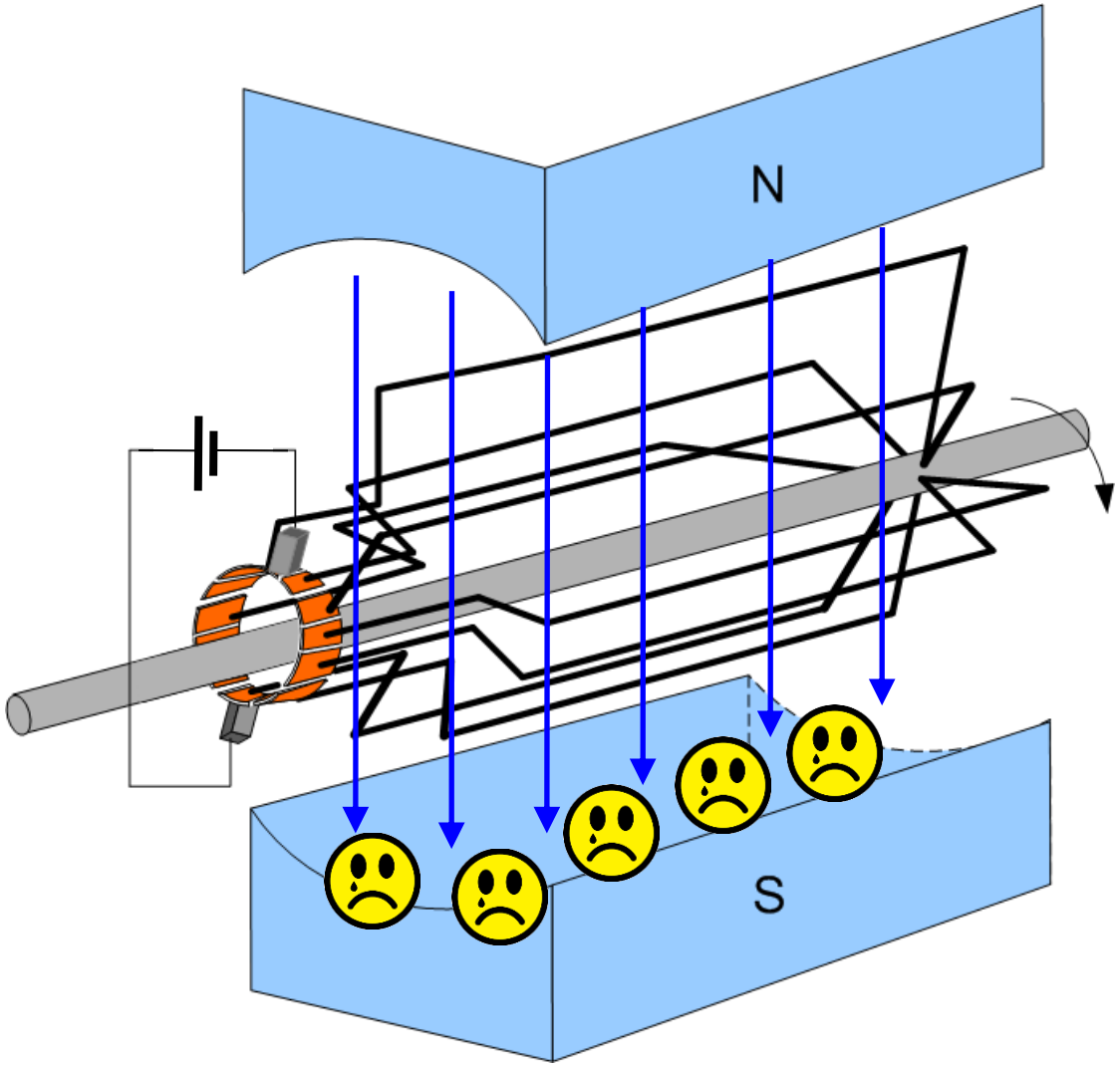
- End bracket
- Terminal box
- Name plate
- Foot



Rotating parts

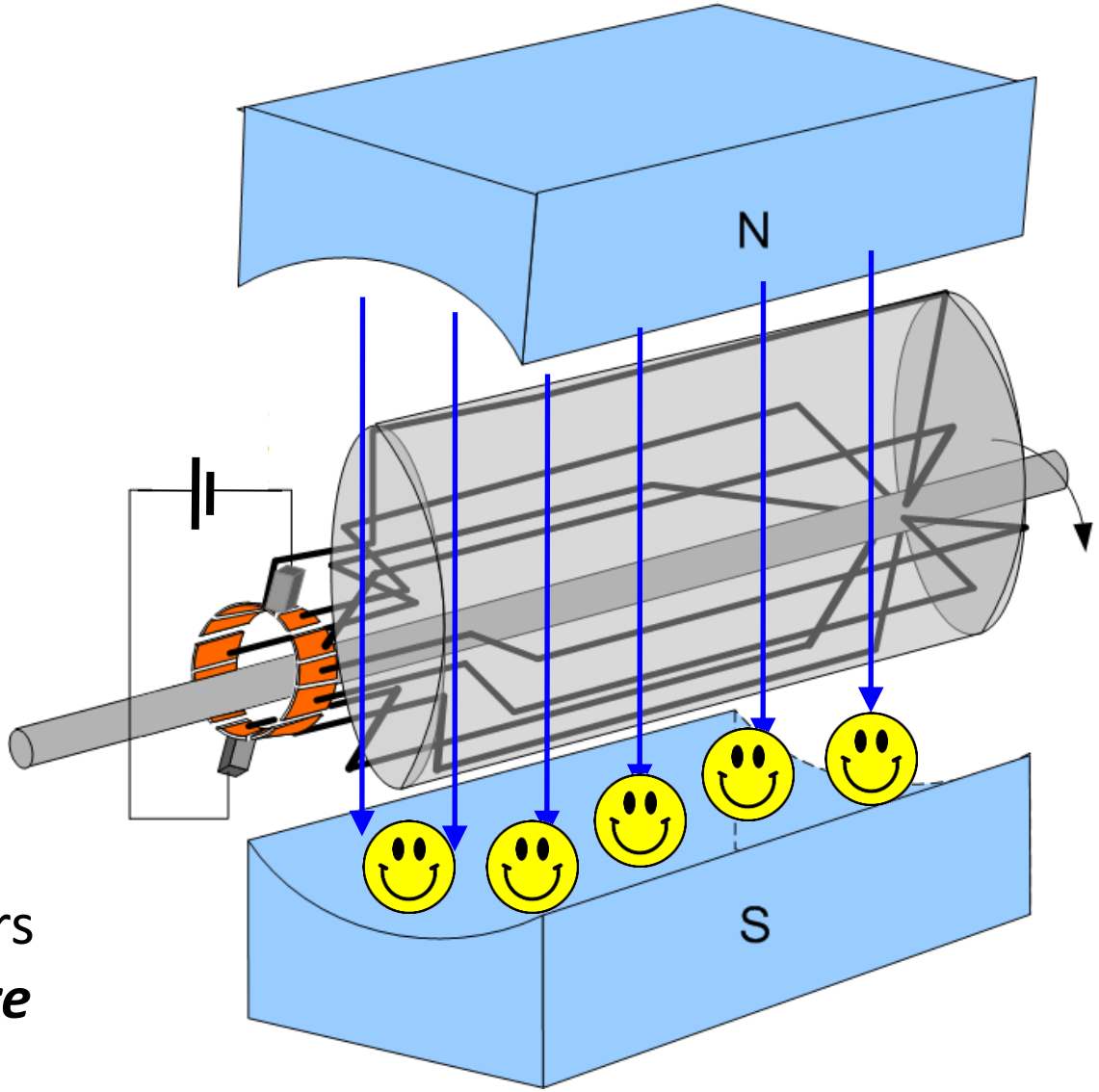
- **Armature**
- **Commutator**
- **Shaft**
- **Bearing**

- For operation of the machine, flux lines must cut the rotor coils
- But the copper coils when placed in air, flux does not like to pass
- Because air is non-magnetic and copper is diamagnetic



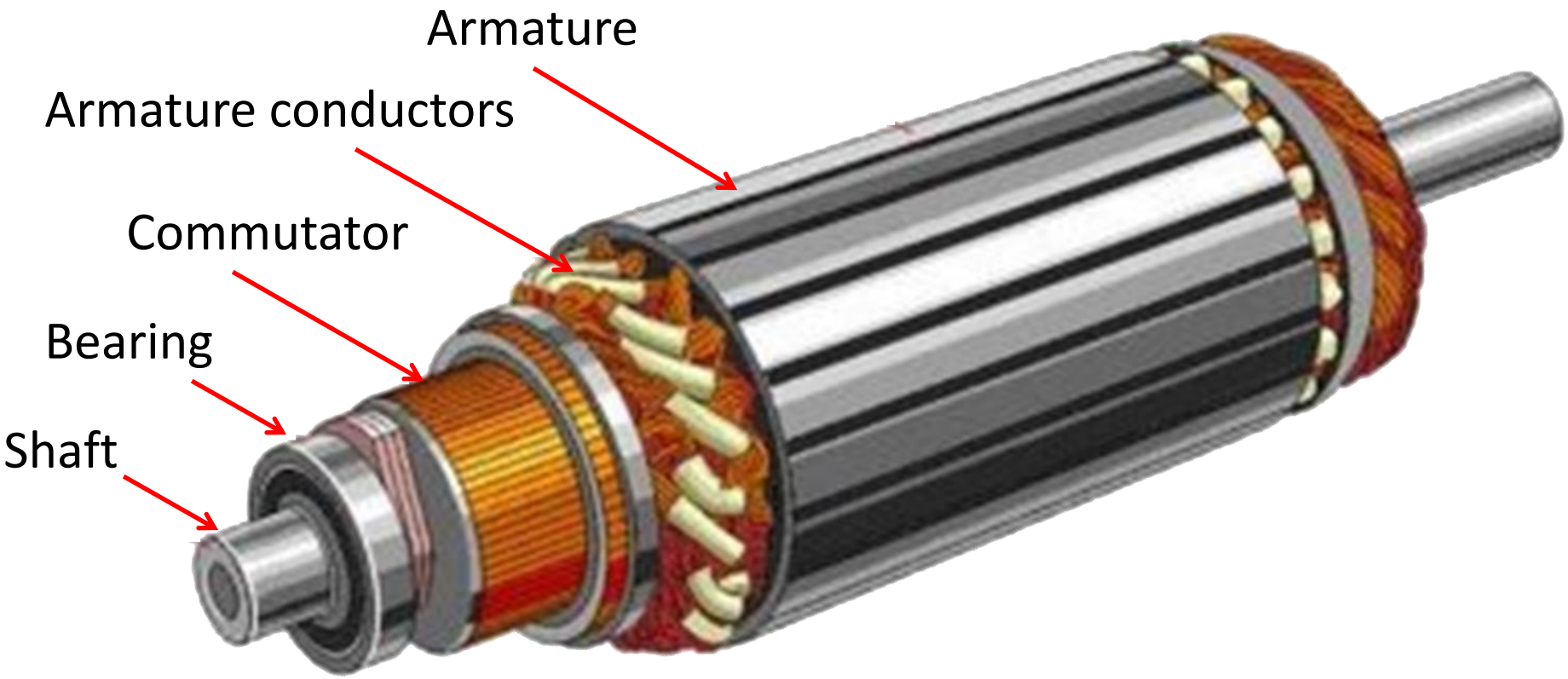
Armature

- So, make the rotor with an iron cylinder
- Hide the coils inside the iron cylinder
- Flux lines will be attracted by the iron cylinder
- In the process, flux lines also will cut the copper coils also
- That iron cylinder along with conductors is called the ***armature***



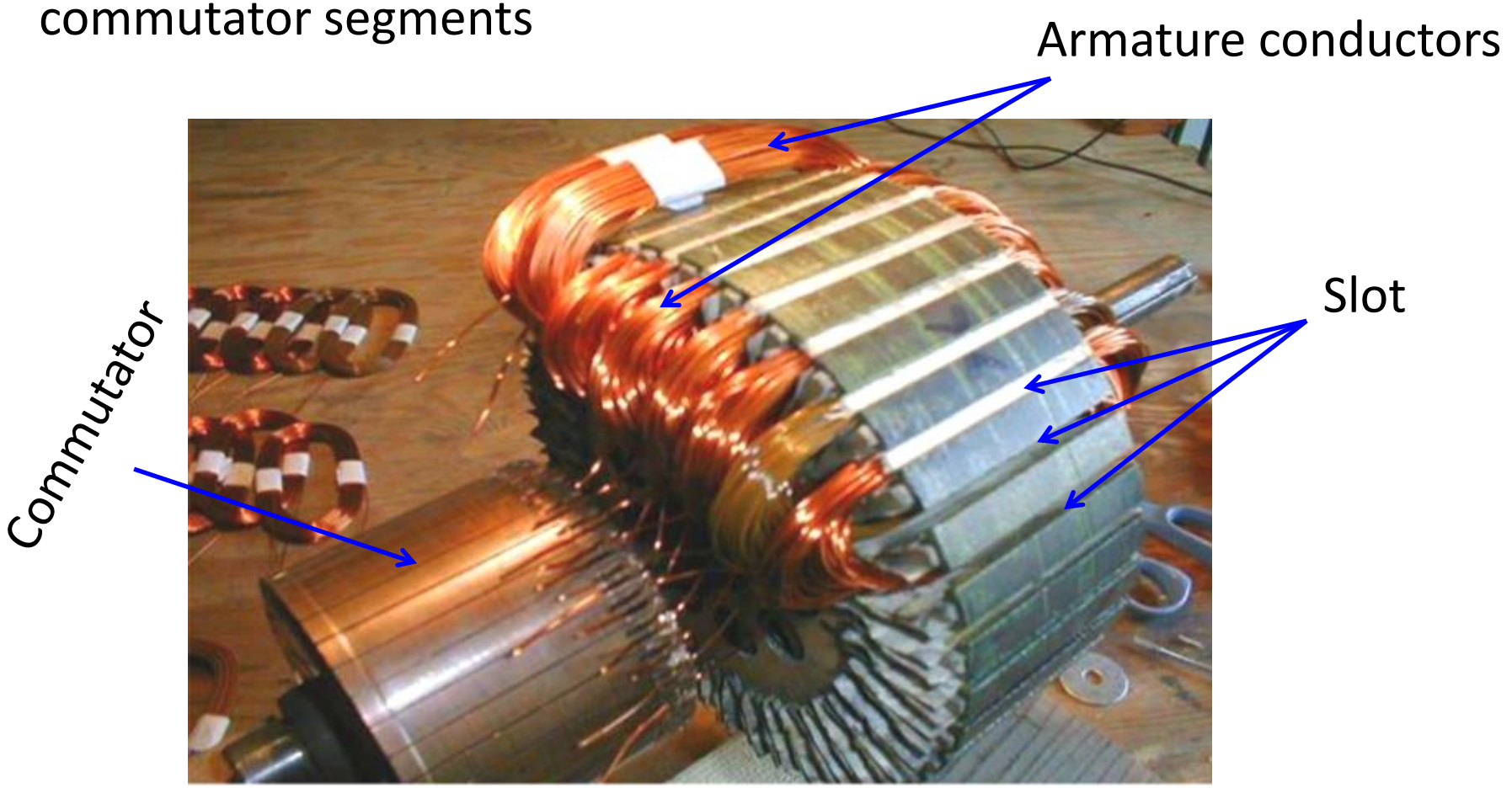
Armature

- Armature is the rotating part of a DC machine which is placed in the cylindrical space between poles of the stator
- The armature body is fixed to the shaft and the shaft is supported by bearings at the two ends



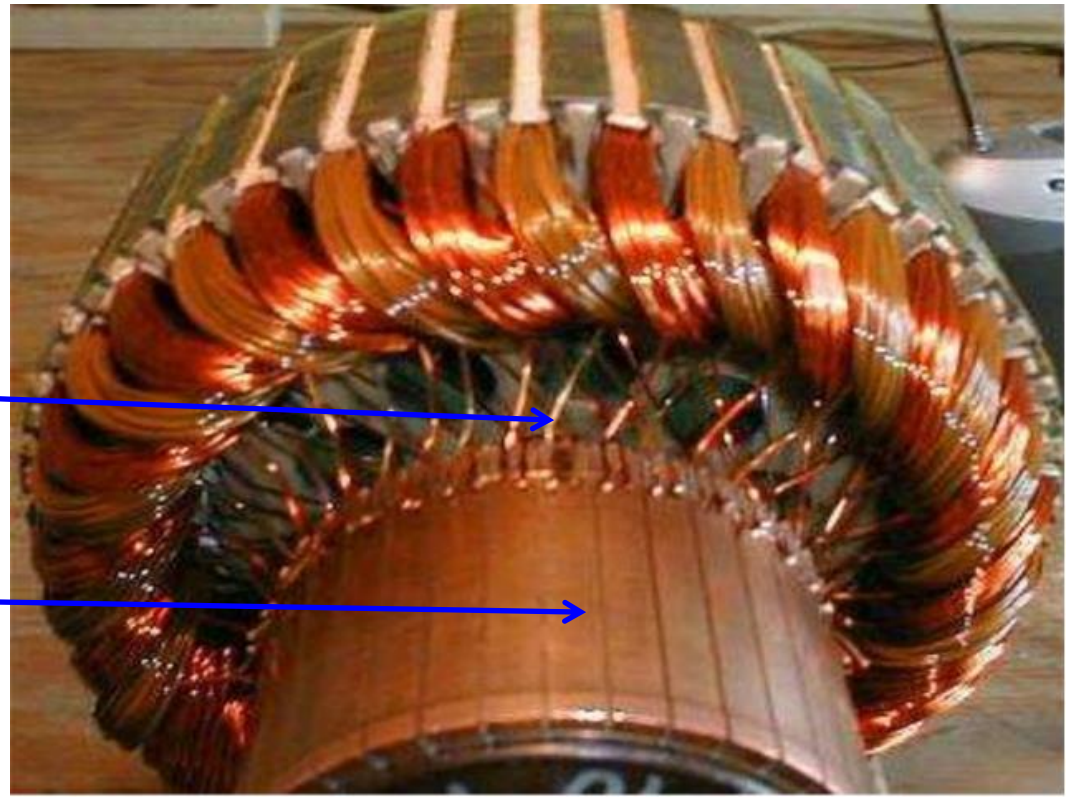
Armature

- Conductors are placed inside slots (grooves) provided on surface of the armature
- One end of the conductors is welded (soldered) to the commutator segments



Commutator

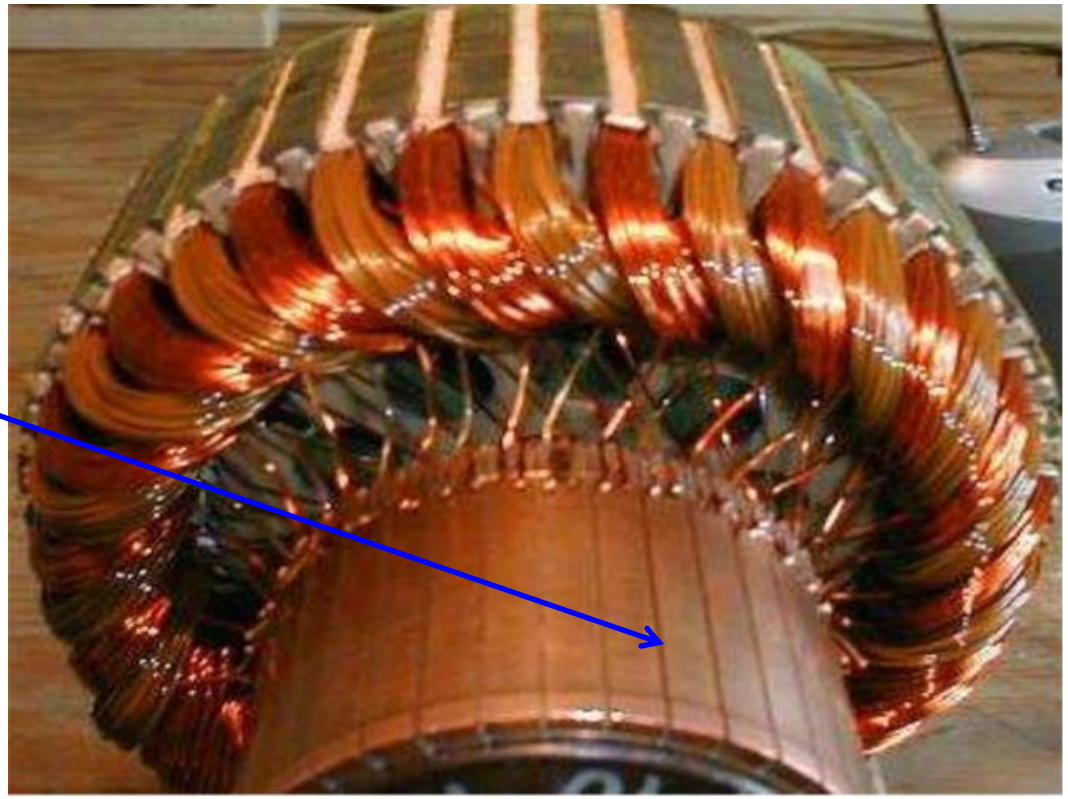
- Commutator segments are made from copper and are placed on the front side of armature
- All the armature coils are connected to the commutator segments
- As the armature rotates, the commutator also rotates along with it



Commutator

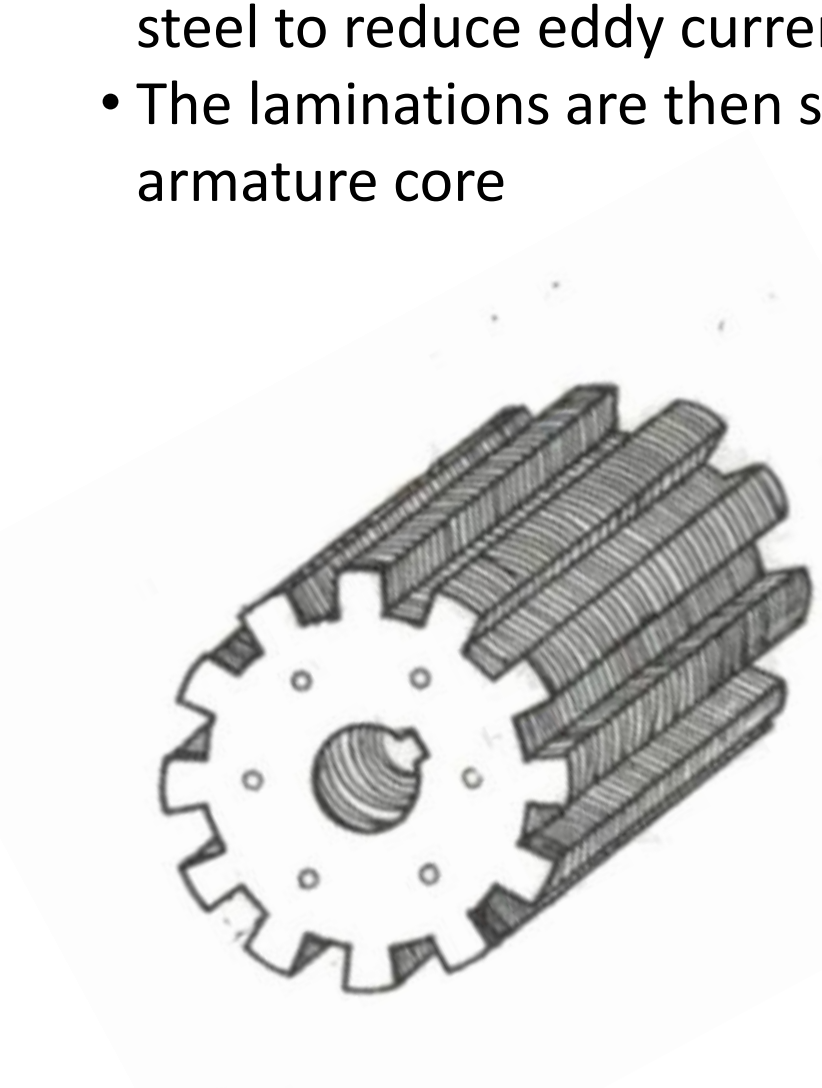
- Each individual commutator segments is **insulated** from each other by *thin* **mica sheets**
  - Mica is a good insulator
  - Mica can withstand large amount of heat for a long time

Thin sheets of mica
Placed between
segments as insulation

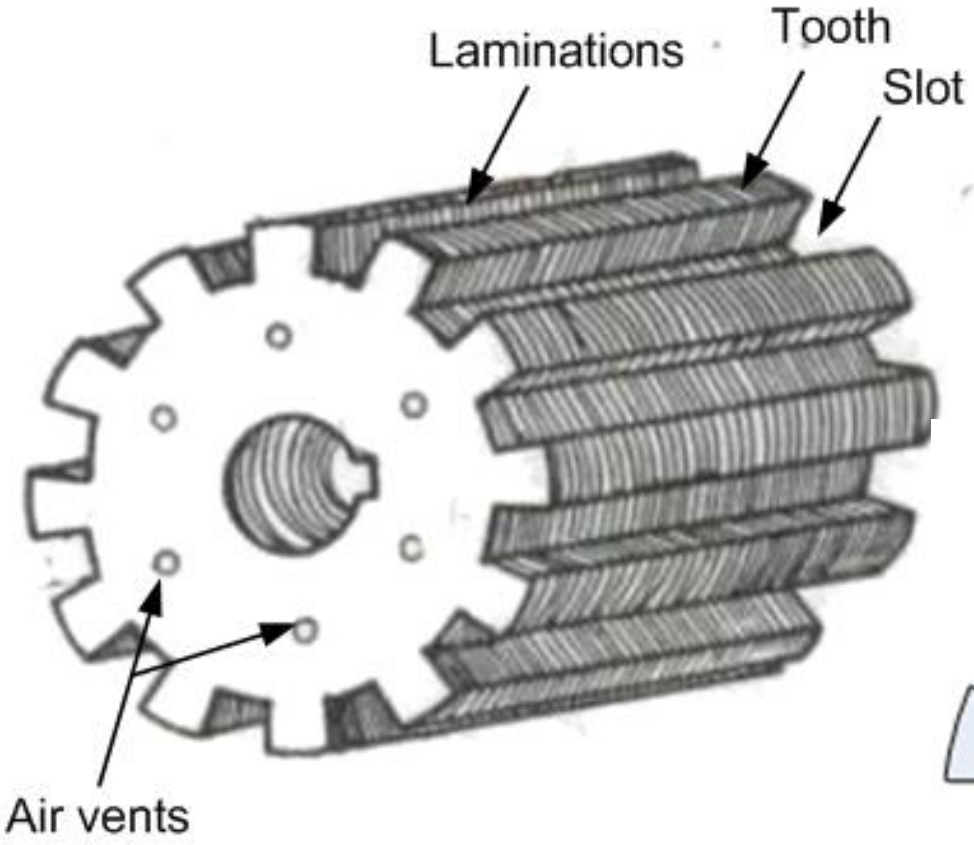


Armature

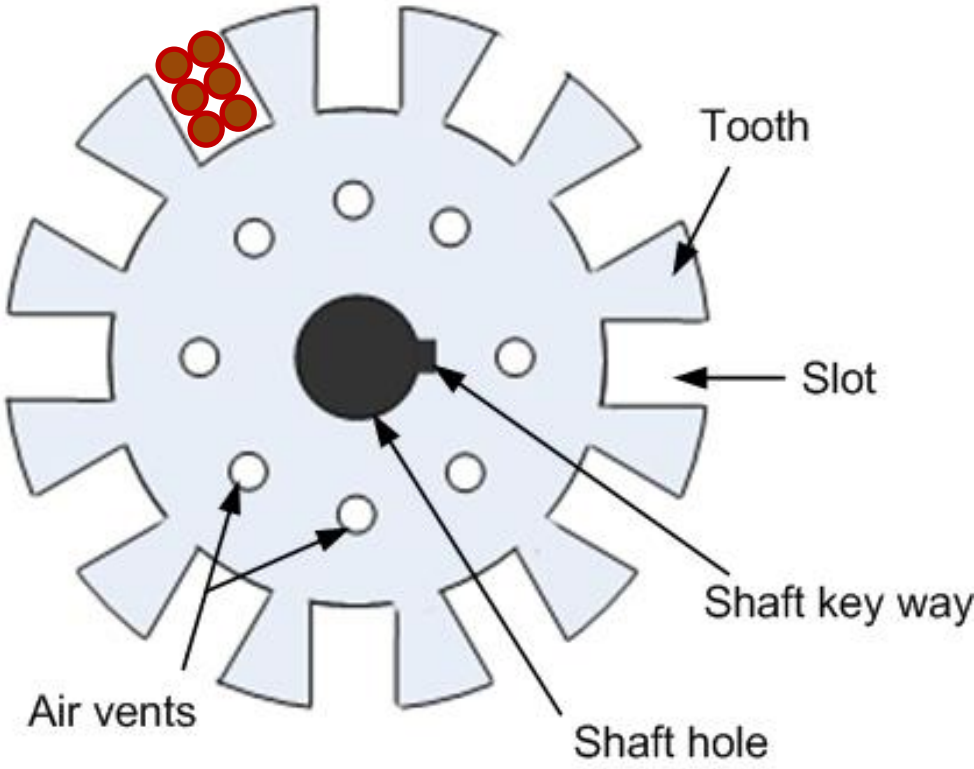
- Armature body is made using thin ***laminations*** (0.3–0.5 mm) of ***insulated*** steel sheets instead of a solid cylindrical block of steel to reduce eddy current loss
- The laminations are then stacked together to build the armature core



Armature laminations



- Tooth is the iron part between two slots
- Armature conductors are placed in the slots



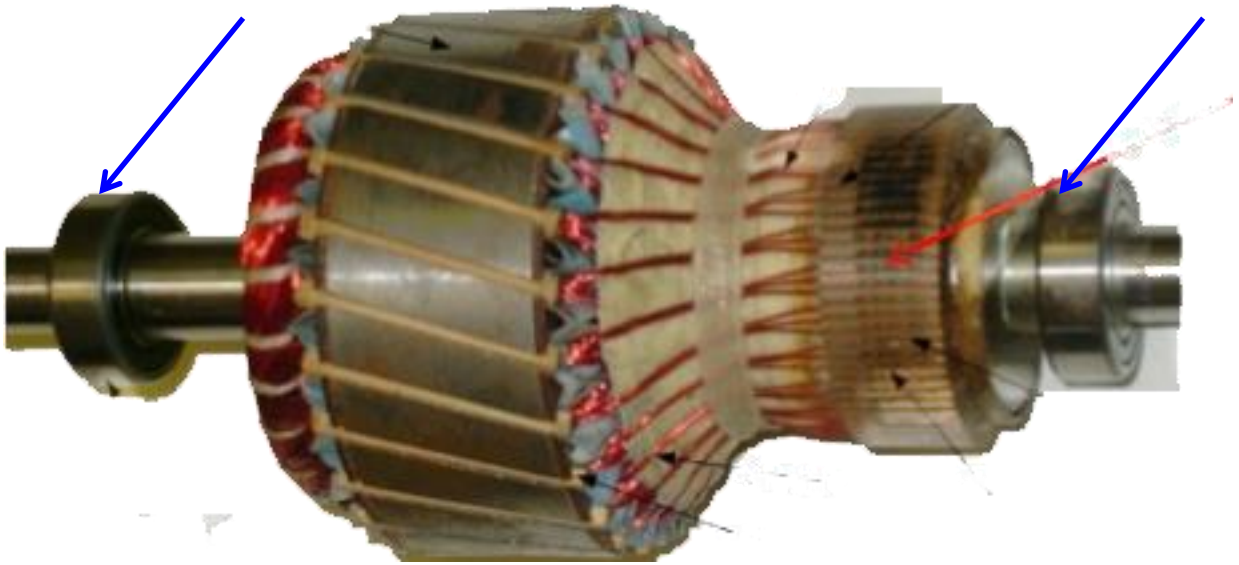
Bearings

- Enable free rotation of the rotor with least friction
- Supports weight of the rotating parts
- Bearings are fitted at both ends of the shaft
- Generally ball bearings are used
- Roller bearings are used for larger machines

Ball bearing

Bearing

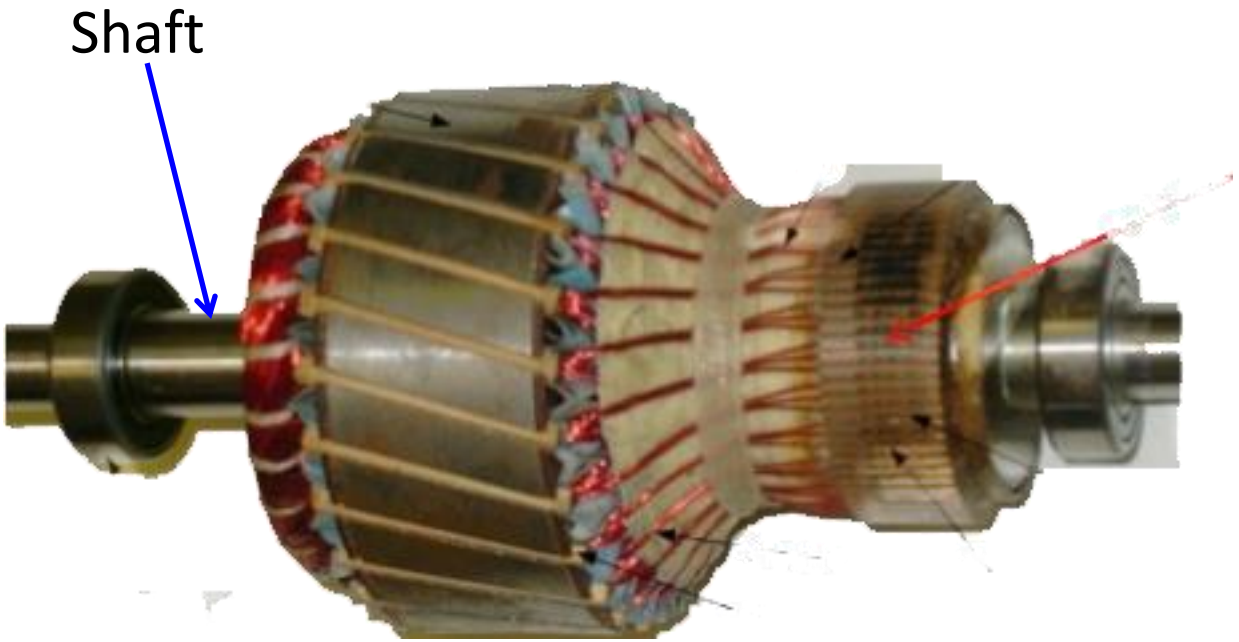
Bearing



Roller bearing

Shaft

- Armature, commutator, bearings fitted to the central shaft
- Supports weight of the rotating parts
- Should be very strong
- Should not bend
- Ordinary shafts are made of mild steel
- When high strength is required, an alloy steel such as nickel, nickel-chromium or chromium-vanadium steel is used



Summary

- Stator of a DC machine
  - Frame
  - Yoke
  - Pole
  - Lifting pin, foot, name plate, end bracket
  - Brush holder
- Rotor of a DC machine
  - Armature
  - Commutator
  - Shaft
- Interface between stator and rotor
  - Brushes
  - Bearings
  - Air gap

Assignment Activity

Part		Material
Frame		
Yoke		
Pole	Pole core	
	Pole winding	
Armature body		
Armature coils		
Commutator		
Shaft		
Brush		
Bearing		
Air gap		