Ministry of Higher Education and Scientific Research
Al-Mustaqbal University
College of Engineering and Engineering Technologies
Department of Electrical Engineering Technologies

Lecture 1

Basic Construction of Electrical Machines

Second stage

DC Machine

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Outcomes

By the end of this lecture, students will be able to:

1. Define what an electrical machine is and its importance..
2. Identify all major components of electrical machines.
3. Explain the function and construction of each part.
4. Describe how energy conversion occurs inside the machine.

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1. Introduction

An **electrical machine** is a device that converts **energy from one form to another**:

- **Generator:** Converts **mechanical energy → electrical energy**.
- **Motor:** Converts **electrical energy → mechanical energy**.

These machines operate based on **Faraday's Law of Electromagnetic Induction**, which states: Whenever a conductor cuts the magnetic flux, an electromotive force (EMF) is induced in it.

Equation:

$$\textbf{E.M.F} = -\,\mathbf{N}\,\frac{d\Phi}{dt}$$

where:

- e = induced EMF electric motive force (volts)
- N = number of turns
- ϕ = magnetic flux (Weber)

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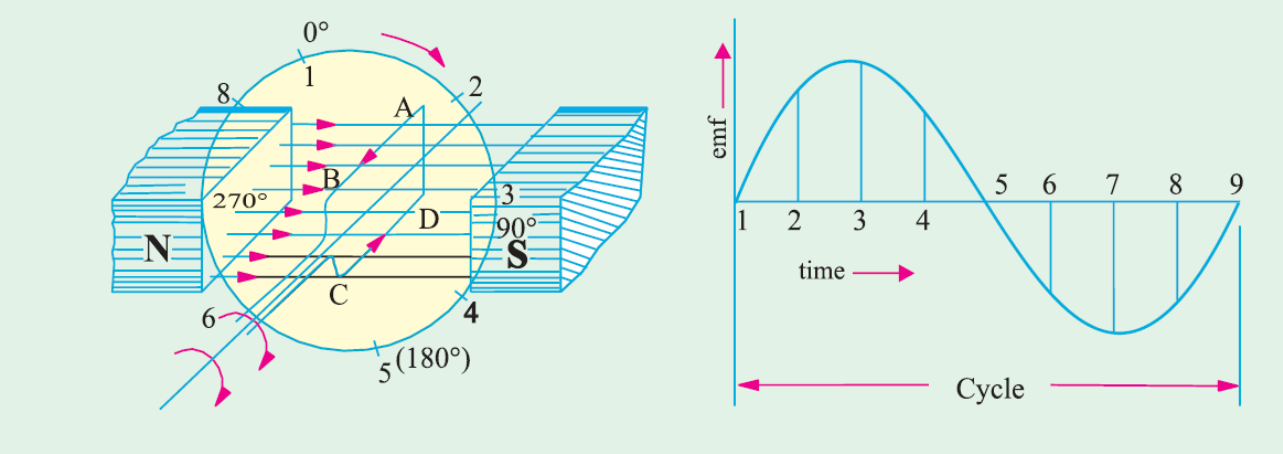
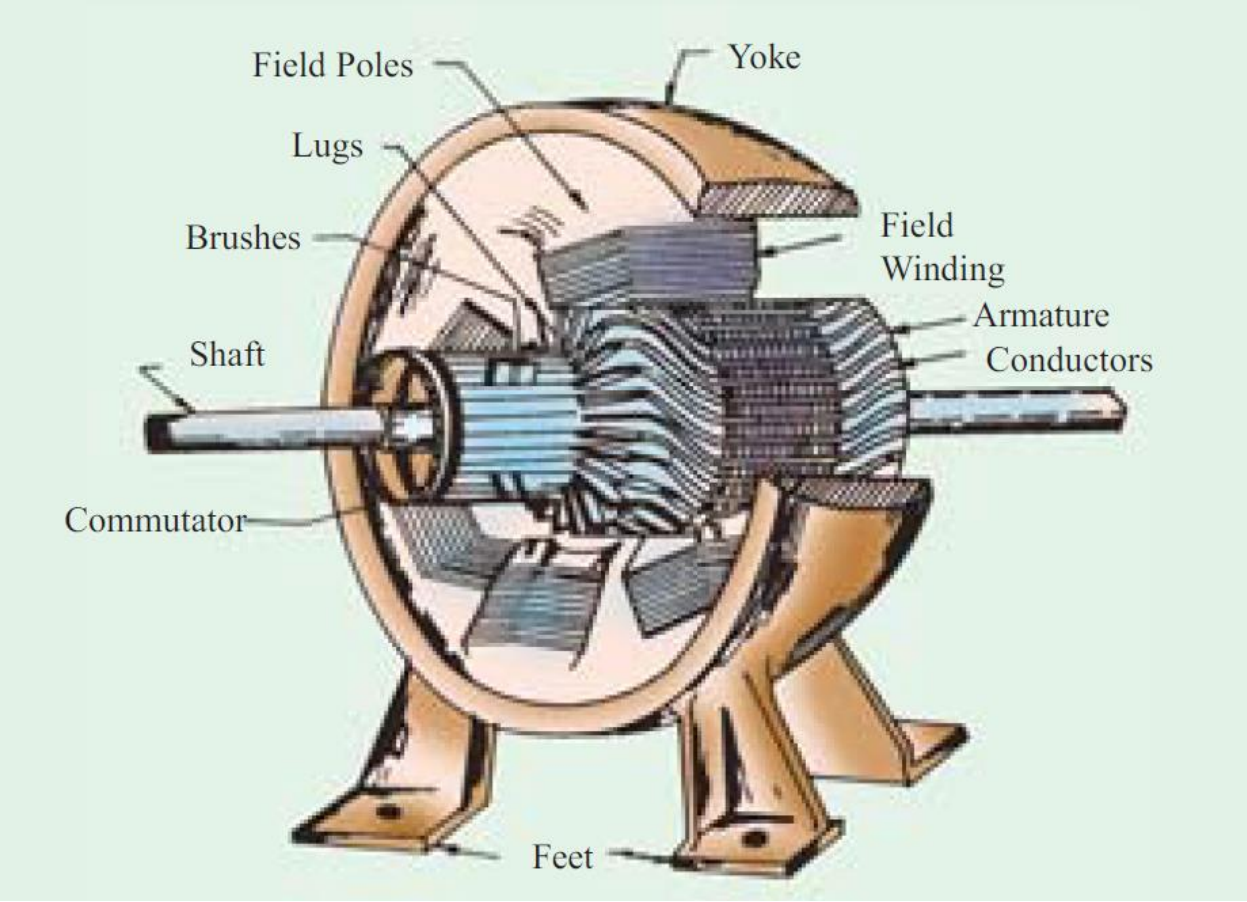
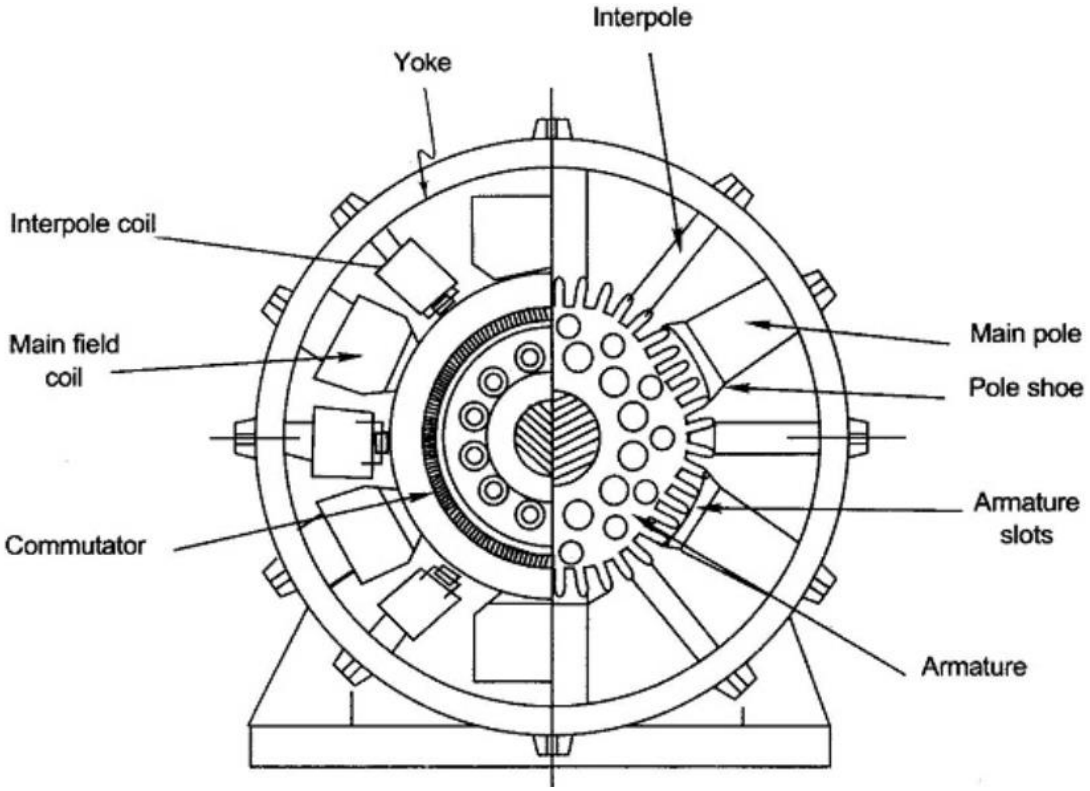


2. Major Parts of Electrical Machines

All electrical machines (whether DC or AC) have **two main parts**:





A. Stator (Stationary Part)

The **stator** is the stationary part of the machine.
It performs the following main functions:

- Provides **mechanical support**.
- Carries the **magnetic field system**.
- Protects the internal components.

Construction:

- Made of **cast iron** or **steel frame** for strength.
- Contains **field poles** and **field windings** in DC machines,

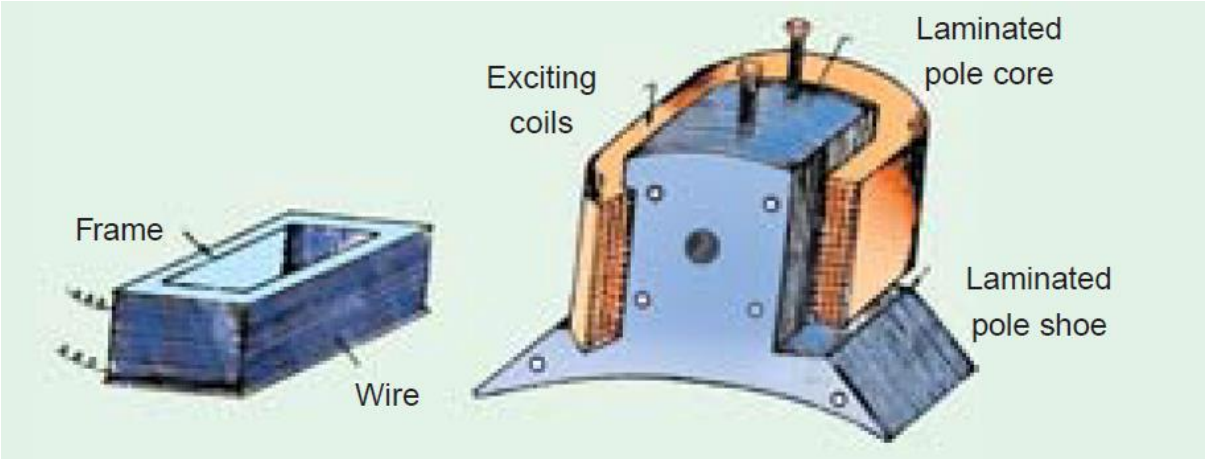
In DC machines:

- The field system creates the main magnetic field.
- Poles are bolted to the inner surface of the frame.
- Each pole has:
    - **Pole core** – made of laminated steel.

- **Pole shoe** – spreads magnetic flux evenly.
- **Field winding** – copper wire wound around the pole core.

Stator of DC machine)

- Frame (Yoke)
- Field poles
- Field windings
- Air gap



B. Rotor (Rotating Part)

The **rotor** (or armature) rotates inside the stator.
It is mounted on a **shaft** supported by **bearings**.

Construction:

- **Armature core:** Cylindrical, made of laminated soft iron to reduce eddy current loss.
- **Armature winding:** Conductors placed in slots on the armature core where EMF is induced (in generators) or current flows (in motors).

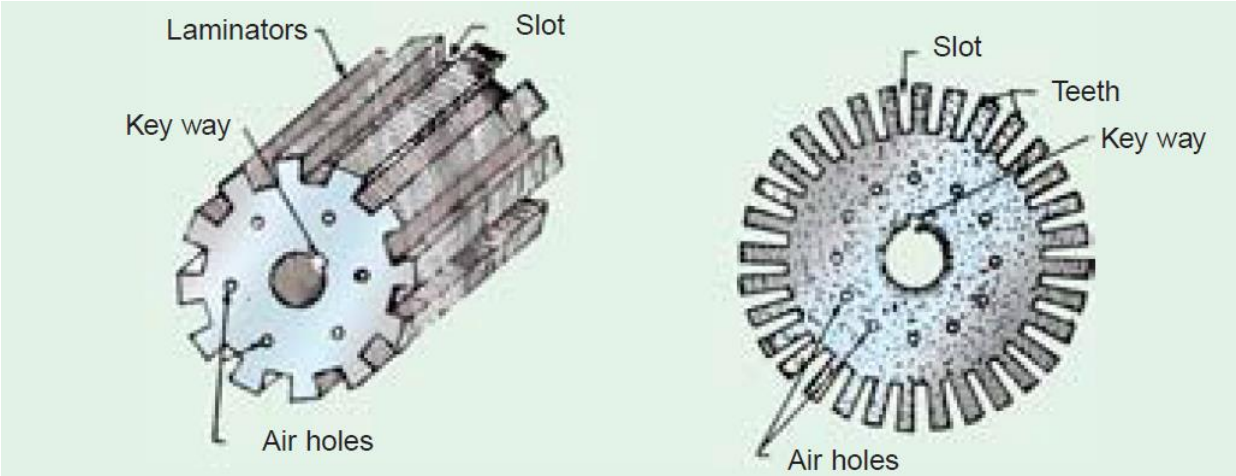
Function:

- In a generator → produces voltage.

- In a motor → produces torque.

Rotor construction

- Armature core
- Armature slots
- Windings
- Shaft
- Bearings



3. Auxiliary Components

1. Air Gap

- Small space between stator and rotor (0.2–1 mm).
- Ensures smooth rotation and magnetic coupling.
- A smaller air gap increases magnetic flux density and machine efficiency.

2. Bearings

- Support the rotating shaft.
- Reduce friction and allow smooth motion.
- Usually made of **ball bearings** or **roller bearings**.


Bearing

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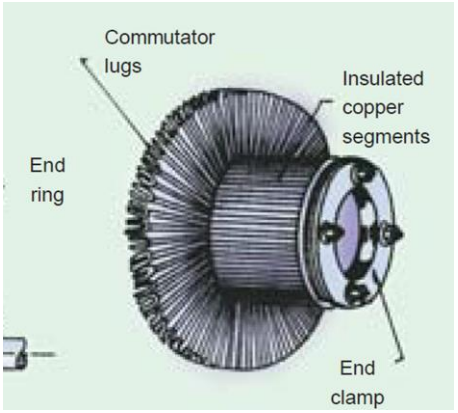
3. Shaft

- Transfers mechanical power between machine and load or prime mover.
- Made of **high-strength steel**.

4. Commutator (in DC Machines Only)

- Mechanical rectifier that converts **AC induced EMF → DC output**.
- Consists of **copper segments** insulated by **mica**.
- Mounted on the rotor shaft.
- Connected to the armature windings.



3: Commutator and Brushes arrangement)

Show:

- Armature winding
- Commutator segments
- Carbon brushes
- External circuit connection

5. Brushes

- Maintain electrical contact between the **commutator** and **external circuit**.
- Made of **carbon** to reduce wear and friction.
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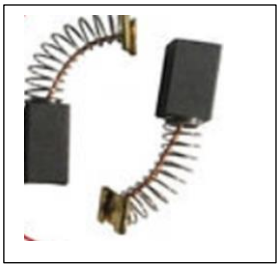

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4. Magnetic Circuit of the Machine

The **magnetic circuit** allows the magnetic flux to flow through the machine and link with the armature windings.

5. Losses in Electrical Machines (Briefly)

1. **Copper Losses (I^2R loss)** – in windings.
2. **Iron Losses** – hysteresis and eddy current losses in the core.
3. **Mechanical Losses** – due to friction and windage.

6. Construction Materials Summary

Component	Material	Purpose
Frame	**Cast iron**	**Mechanical protection**
Field poles	**Laminated steel**	**Magnetic path**
Windings	**Copper**	**Carry current**
Armature core	**Laminated soft iron**	**Reduce eddy currents**
Commutator	**Copper with mica insulation**	**Convert AC to DC**
Brushes	**Carbon or graphite**	**Electrical contact**

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7. Diagram of a Complete DC Machine

- Yoke (frame)
- Field poles
- Armature core
- Armature winding
- Commutator
- Brushes
- Air gap
- Shaft and bearings

8. Working Principle Recap

- **Generator:** Motion → Magnetic field → Induced voltage.
- **Motor:** Voltage → Current → Magnetic field → Motion.

Both rely on:

- **Faraday's Law** (EMF induction).
- **Lorentz Force Law** (motion due to magnetic field).

9. Summary Table

Machine Part	Type	Function
Stator	**Stationary**	**Houses magnetic field system**
Rotor	**Rotating**	**Produces or receives electrical power**
Commutator	**Rotating**	**Converts AC to DC**
Brushes	**Stationary**	**Connects external circuit**
Air Gap	**—**	**Magnetic coupling**
Shaft	**—**	**Transfers mechanical power**

10. Discussion Questions

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1. Why are the armature cores laminated?
2. What is the function of the commutator?
3. What will happen if the air gap increases too much?
4. How does energy conversion differ between generator and motor

Thank you

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