

### *D.C. Machines:*

Syllabus: Working principle of D.C. Machine as a generator and a motor. Types, constructional features and Types of armature windings. Emf equation of generator, relation between induced Emf and terminal voltage with an enumeration of brush contact drop and drop due to armature reaction. Operation of D.C. motor, back Emf and its significance, torque equation. Types of D.C. motors, characteristics and applications. Necessity of a starter for D.C. motor.

### Introduction:

- The converters which are used to continuously translate an electrical input to a mechanical output or vice versa are called as DC machines.
- If the conversion is from mechanical to electrical energy then it is called as DC Generator and if the conversion is from electrical to mechanical energy then it is called as DC Motor.

### Working principle of D.C. Machine as a generator and a motor:

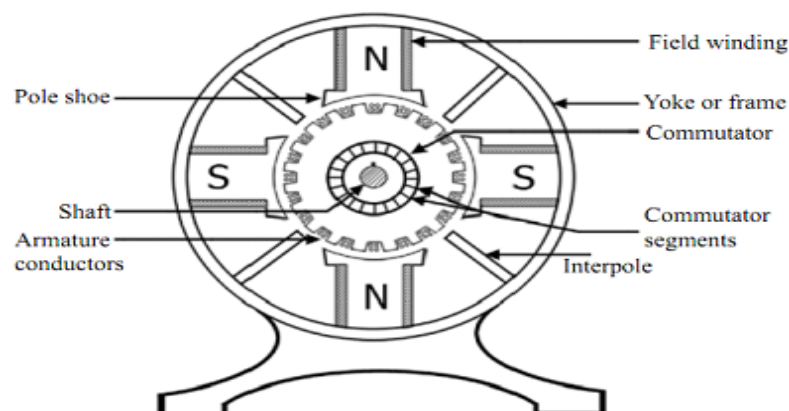
Working principle of D.C. Machine as a generator:

- Whenever a coil is rotated in a magnetic field an Emf will be induced in this coil and is given by  $e = B \cdot l \cdot v \cdot \sin \theta$  volts/coil side where, B=The flux density in Tesla, l=the active length of the coil side in meters v=the velocity with which the coil is moved in meters/sec and  $\theta$  is the angle between the direction of the flux and the direction of rotation of the coil side.
- The direction of the induced voltage can be ascertained by applying **Fleming's right hand rule**.

Working principle of D.C. Machine as a motor:

- Whenever a current coil is placed under a magnetic field the coil experiences a mechanical force, and is given by  $F = B \cdot I \cdot l \cdot \sin \theta$  Newton/coil side where, I is the current through the coil.
- Applying **Fleming's left hand rule**, we note torque  $T_e$  will be produced in the counter clockwise direction causing the rotor to move in the same direction.

### Construction of DC Machine:



Salient parts of a D.C. Machine are:

- (i) Field system (poles)
- (ii) Coil arrangement (armature)
- (iii) Commutator
- (iv) Brushes
- (v) Yoke

**Yoke:**

- i) It serves the purpose of outermost cover of the D.C. machine. So that the insulating materials get protected from harmful atmospheric elements like moisture, dust and various gases like  $SO_2$ , acidic fumes etc.
- ii) It provides mechanical support to the poles.
- iii) It forms a part of the magnetic circuit. It provides a path of low reluctance for magnetic flux.

**Poles:**

Each pole is divided into two parts a) pole core and b) pole shoe

- Pole core basically carries a field winding which is necessary to produce the flux.
- It directs the flux produced through air gap to armature core, to the next pole.
- Pole shoe enlarges the area of a pole core to provide a larger area across the flux, which is necessary to produce a larger induced emf. To achieve this, pole shoe has given a particular shape.

**Field winding [F1-F2]:**

- The field winding is wound on the pole core with a definite direction.
- To carry current due to which pole core on which the winding placed behave as an electromagnet, producing necessary flux. As it helps in producing the magnetic field i.e. exciting the pole as electromagnet it is called Field winding or Exciting winding.

**Armature:**

- It is further divided into two parts namely,
  - I) Armature core and
  - II) Armature winding
- Armature core is cylindrical in shape mounted on the shaft. It consists of slots on its periphery and the air ducts to permit the air flow through armature which serves cooling purpose.

**Commutator:**

- The basic nature of Emf induced in the armature conductors is alternating.
- This needs rectifications in case of D.C. generator which is possible by device called commutator.

## DC Motors:

### Operation of a DC motor:

- When a DC machine is loaded as a motor, the rotor conductors carry current.
- These conductors lie in the magnetic field of the air gap.
- Thus, each conductor experiences a force.
- The conductors lie near the surface of the rotor at a common radius from its centre
- Hence, a torque is produced around the circumference of the rotor, and the rotor starts rotating.

### Back Emf and its Significance:

- When the armature of a D.C. motor rotates under the influence of the driving torque, the armature conductors move through the magnetic field and hence an emf is induced in them.
- The induced emf acts in opposite direction to the applied voltage  $V$  (Lenz's law) and is known as back emf.
- Back EMF always acts to reduce the changing magnetic field through the coils. It does so by generating a voltage which opposes the supply voltage, thus reducing the current.

### Significance:

- The presence of back emf makes the d.c. motor a self-regulating machine i.e., it makes the motor to draw as much armature current as is just sufficient to develop the torque required by the load.
- Back emf in a D.C. motor regulates the flow of armature current i.e., it automatically changes the armature current to meet the load requirement.

### Types of DC Motors:

Motors are classified into 3 types: a) DC Shunt motor.

b) DC Series motor.

c) DC Compound motor.

#### a) DC Shunt motor:

- In shunt wound motor the field winding is connected in parallel with armature.
- The current through the shunt field winding is not the same as the armature current.