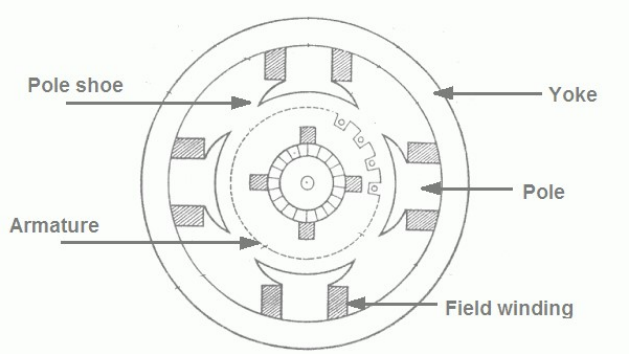
Construction and working principal of DC Motor

A DC motor is any of a class of rotary electrical motors that converts direct current electrical energy into mechanical energy. A DC motor or a DC machine consists of two windings namely field winding and armature winding. The field winding is stationary and armature winding can rotate. The field winding produces a magnetic flux in the air gap between the armature and field windings and the armature is placed in this magnetic field.

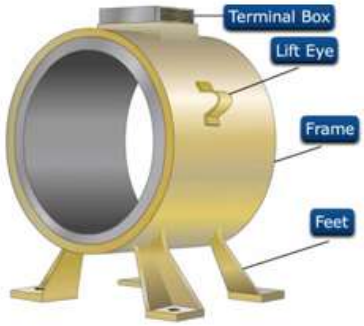


Construction of a DC Motor

The main parts used in the construction of a DC motor are the yoke, poles, field winding, commutator, carbon brushes bearings etc. A brief description of the various parts is as follows:

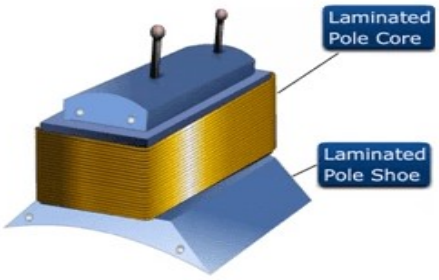
1.Yoke

The yoke acts as the outer cover of a DC motor and it is also known as the frame. The yoke is an iron body, made up of low reluctance magnetic material such as cast iron, silicon steel, rolled steel etc. Yoke serve two purposes, firstly it provides mechanical protection to the outer parts of the machine secondly it provides low reluctance path for the magnetic flux.



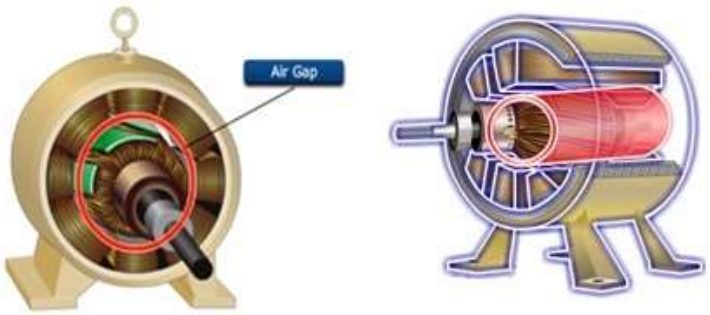
2. Poles and Pole Shoe

The pole and pole shoe are fixed on the yoke by bolts. These are made of thin cast steel or wrought iron laminations which are riveted together. Poles produce the magnetic flux when the field winding is excited. Pole shoe is an extended part of a pole. Due to its shape, the pole area is enlarged and more flux can pass through the air gap to the armature.



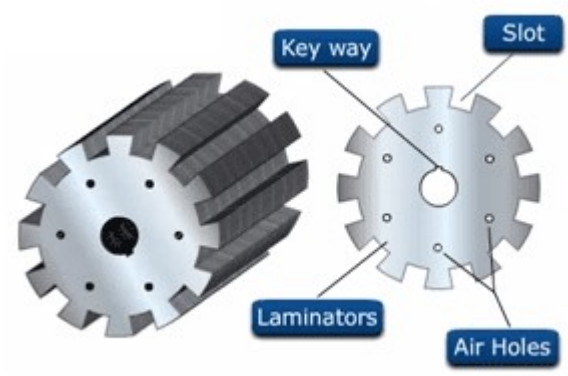
3.Field Winding

The coils around the poles are known as field (or exciting) coils and are connected in series to form the field winding. Copper wire is used for the construction of field coils. When the DC current is passed through the field windings, it magnetizes poles which produce magnetic flux.



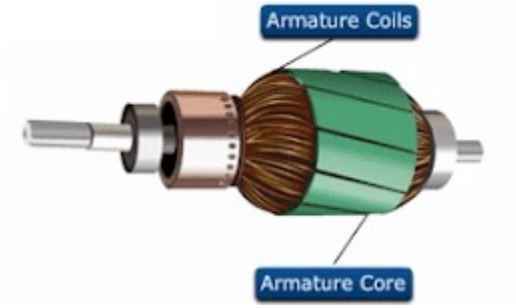
4. Armature Core

It is a cylindrical drum and keyed to the rotating shaft. A large number of slots are made all over its periphery, which accommodates the armature winding. Low reluctance, high permeability material such as cast iron and cast steel are used for armature core.
The laminated construction is used to produce the armature core to minimize the eddy current losses. The air holes are also provided on the armature core for the air circulation which helps in cooling the motor.



5. Armature Winding

The armature winding plays very important role in the construction of a DC motor because the conversion of power takes place in armature winding. On the basis of connections, there are two types of armature windings name.



a. Lap winding
b. Wave Winding

Lap Winding

In lap winding the armature conductors are divided into P groups. All the conductors in a group are connected in series and all such groups are connected in parallel. For a lap winding the number of parallel paths (A) is equal to the number of poles (P).

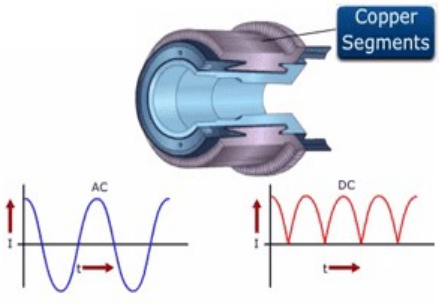
Due to the existence of a large number of parallel paths, the lap wound armature is capable of supplying larger load currents, therefore, lap winding is used for low voltage high current DC motors.

WaveWinding

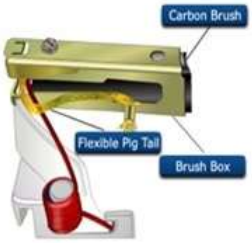
In wave winding, all the conductors are connected in series to form a single closed circuit. This closed circuit is tapped at various points. The two carbon brushes touch two diametrically opposite tappings. For wave winding the number of parallel paths is equal to two irrespective of the number of poles. The wave winding is useful for high voltage low current motors.

6.Commutator

It is a mounted on the shaft. It is made up of a large number of wedge-shaped segments of hard drawn copper, insulated from each other by a thin layer of mica. The commutator connects the rotating armature conductor to the stationary external circuit through carbon brushes. It converts alternating torque into unidirectional torque produced in the armature.



7. Carbon Brushes



The current is conducted from voltage source to armature by the carbon brushes which are held against the surface of commutator by springs. They are made of high-grade carbon steel and are rectangular in shape.

8. Bearings

The ball or roller bearings are fitted in the end housings. The friction between stationary and rotating parts of the motor is reduced by bearing. Mostly high carbon steel is used for making the bearings as it is very hard material.

WORKING PRINCIPLE OF DC MOTOR

A machine that converts DC electrical power into mechanical power is known as a Direct Current motor.

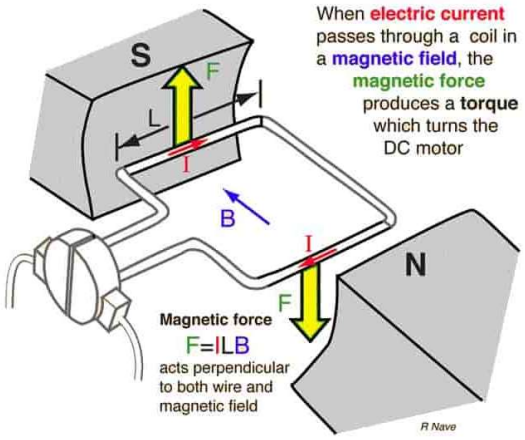
DC motor working is based on the principle that when a current carrying conductor is placed in a magnetic field, the conductor experiences a mechanical force.

The direction of this force is given by Fleming's left-hand rule and magnitude is given by;

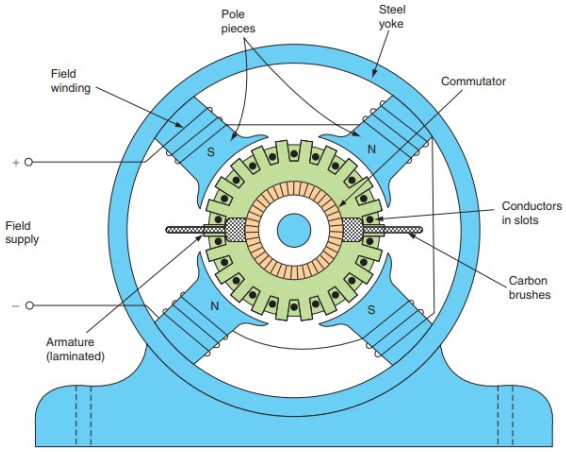
F = BIL Newtons

According to Fleming's left-hand rule when an electric current passes through a coil in a magnetic field, the magnetic force produces a torque that turns the DC motor.

The direction of this force is perpendicular to both the wire and the magnetic field.



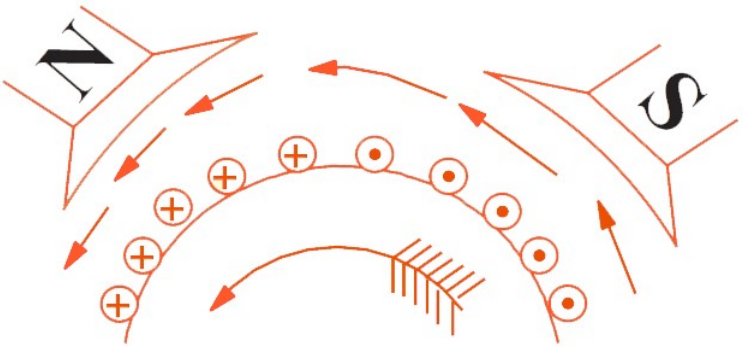
Basically, there is no constructional difference between a DC motor and a DC generator. The same DC machine can be run as a generator or motor.



Consider a part of a multipolar DC motor as shown in the figure below. When the terminals of the motor are connected to an external source of DC supply:

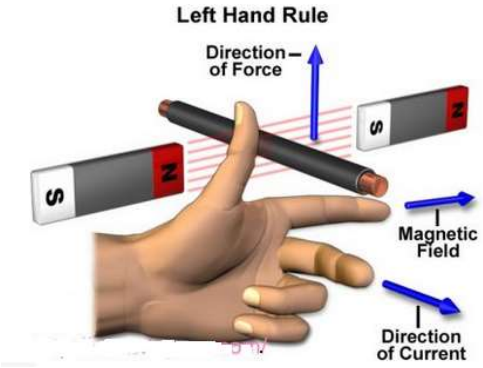
- the field magnets are excited developing alternate North and South poles

- the armature conductors carry currents.



Part of a Multi-polar DC Motor

All conductors under North-pole carry currents in one direction while all the conductors under South-pole carry currents in the opposite direction.
The armature conductors under N-pole carry currents into the plane of the paper (denoted as ⊗ in the figure). And the conductors under S-pole carry currents out of the plane of the paper (denoted as ⊙ in the figure).
Since each armature conductor is carrying current and is placed in the magnetic field, a mechanical force acts on it.
On applying Fleming's left-hand rule, it is clear that force on each conductor is tending to rotate the armature in the anticlockwise direction. All these forces add together to produce a driving torque which sets the armature rotates.



When the conductor moves from one side of a brush to the other, the current in that conductor is reversed. At the same time, it comes under the influence of the next pole which is of opposite polarity. Consequently, the direction of the force on the conductor remains the same.
It should be noted that the function of a commutator in the motor is the same as in a generator. By reversing current in each conductor as it passes from one pole to another, it helps to develop a continuous and unidirectional torque.