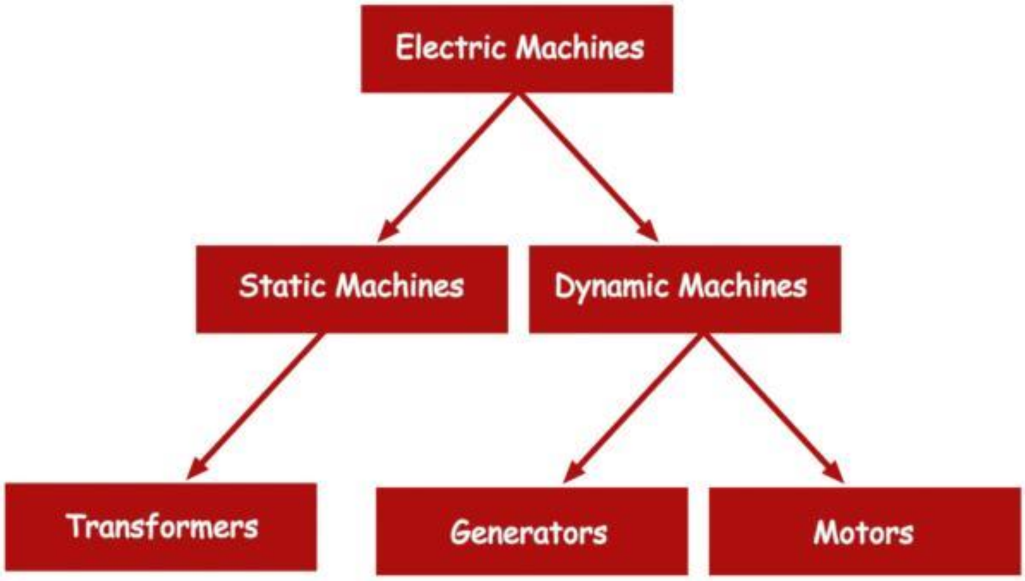
Electrical Machines

Introduction: Electrical machine may be a motor or a generator.

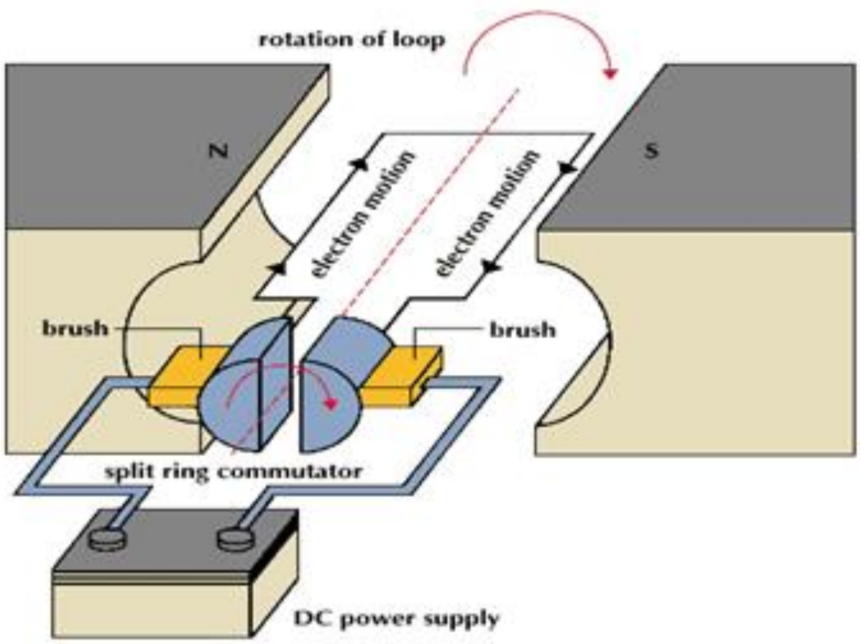
In motor: The input is electrical power and output is mechanical power.

In generator: The input is mechanical power and output is electrical power



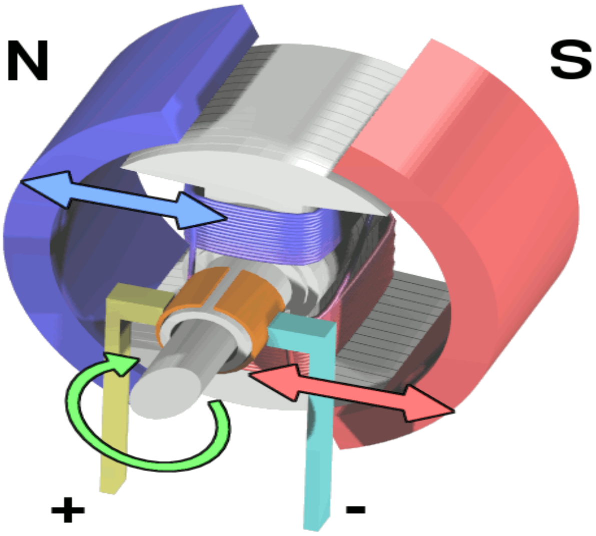
Further, machines may be DC operated or AC operated.

DC Motor:



- Stationary permanent magnets form the stator field.
- Torque is produced by the principle that when a current carrying conductor placed in a magnetic field experiences a force, and this forces provide the required torque.
- The motor rotates on basis of Fleming's left hand rule.

DC Generator:



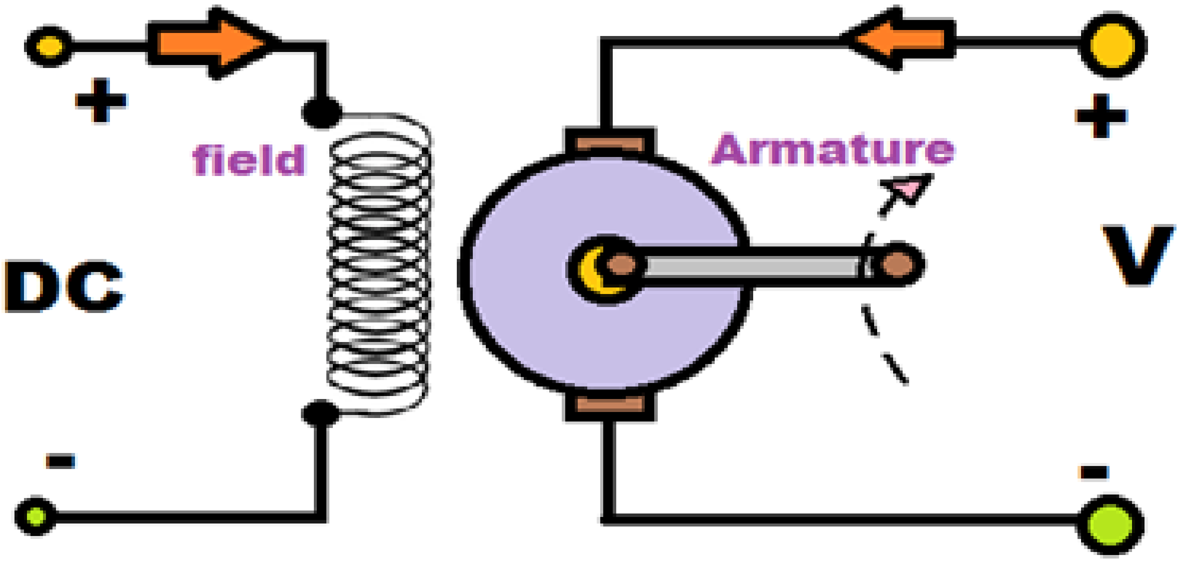
- Stationary permanent magnets form the stator field.
- The principle of generator is based on faraday's law of electromagnetic induction.
- When a conductor is rotated within a magnetic field, it cuts the magnetic field. Thus, according to faradays principle whenever flux cutting action takes place an EMF is induced across the conductor coils.

Classification of DC Motor:

DC motor are classified based on the excitation given to the field winding as

- ✓ Separately excited DC motor
- ✓ Self excited DC motor
  - ❖ Shunt wound DC motor
  - ❖ Series wound DC motor
  - ❖ Compound wound DC motor
    - Short shunt compound
    - Long shunt compound

Separately excited DC Motor:

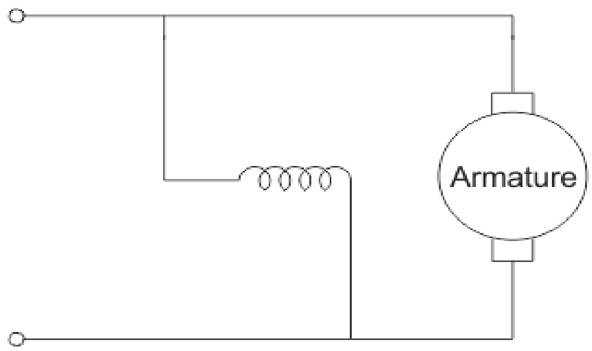


In this, the armature and field windings of a separately excited DC motor is fed with separate D.C. power source.

Shunt wound DC Motor:

A **DC shunt motor** the armature and field windings are connected in parallel.

Thus, armature and field windings are exposed to the same supply voltage.



Shunt Excited DC Motor

The supply current in case of the **shunt wound DC motor** is split up into 2 parts. I_a, flowing through the armature winding of resistance R_a and I_{sh} flowing through the field winding of resistance R_{sh}. The voltage across both windings remains the same.

From there we can write

$$I_{total} = I_a + I_{sh}$$

$$Where\ I_{sh} = \frac{E}{R_{sh}}$$

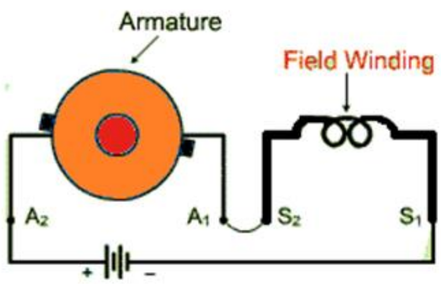
$$or,\ I_a = I_{total} - I_{sh} = \frac{E}{R_a}$$

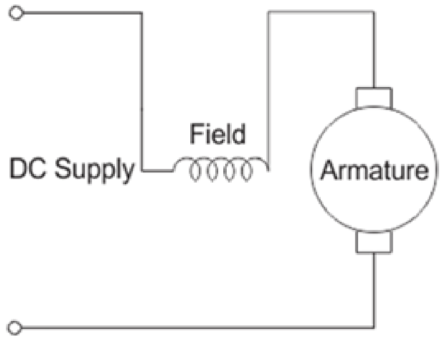
Thus we put this value of armature current Ia to get general voltage equation of a DC shunt motor.

$$E = E_b + I_a R_a$$

$$Or \ E = E_b + (I_{total} - I_{sh}) R_a$$

Series Wound DC Motor:



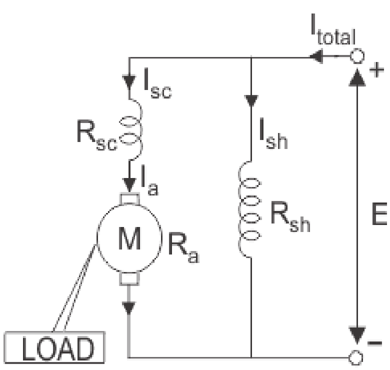


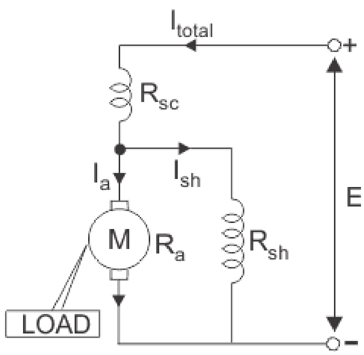
The field winding is connected in series to the armature winding. Thus the field winding are exposed to the entire armature current unlike in the case of a shunt motor. The motor speed varies as a non-linear function of load torque and armature current. This motor is used when high starting torque is desirable.

Moreover, series motor should never be started at no load. Because if there is no load then the current in starting is very less, the counter- emf produced by the field winding is also weak, and so the armature turn fast to produce sufficient counter-EMF to balance the supply voltage. Thus, motor can be damaged due to over speed.

Compound Wound DC Motor

In this, both the series field coils and shunt field coils are connected to the armature winding as shown in the figure below.





- A compound DC motor connects the armature and fields windings in a shunt and a series combination to give it characteristics of both a shunt and a series DC motor.
- This motor is used when both a high starting torque and good speed regulation is needed.
- The motor can also be connected in two arrangements: cumulatively or differentially.
- Cumulative compound motors connect the series field to aid the shunt field, which provides higher starting torque but less speed regulation.
- In Differential compound DC motors the flux due to the shunt field winding diminishes the effect of the main series winding. Thus, the net flux produced in this case is lesser than the original flux and hence does not find much of a practical application.