Unit 2

D.C.Machine

D.C Machine Construction

A cross-section of a 4-pole dc machine is shown in. Only the main components of the machine have been identified and are discussed below.

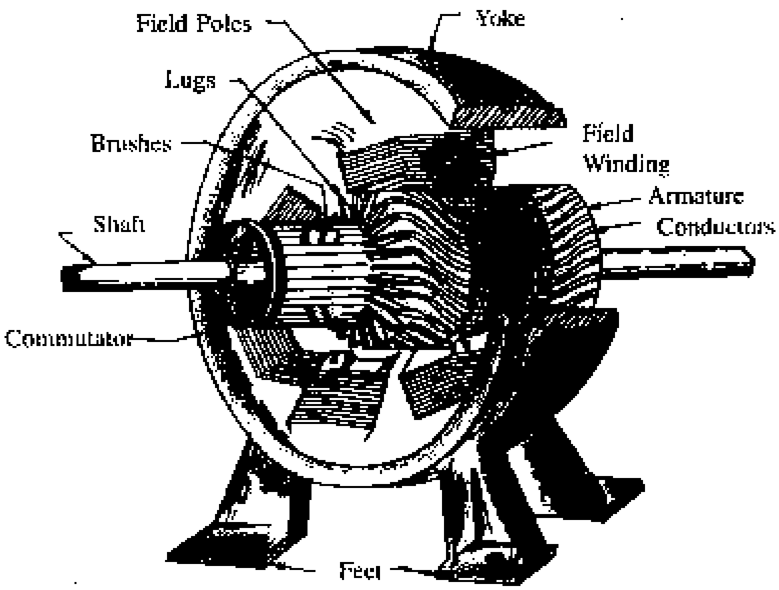


Fig 2.1

Stator

The stator of a dc machine provides the mechanical support for the machine and consists of the **yoke** and the **poles** (or field poles). The yoke serves the basic function of providing a highly permeable path for the magnetic flux. The poles are mounted inside the yoke and are properly designed to accommodate the field windings.

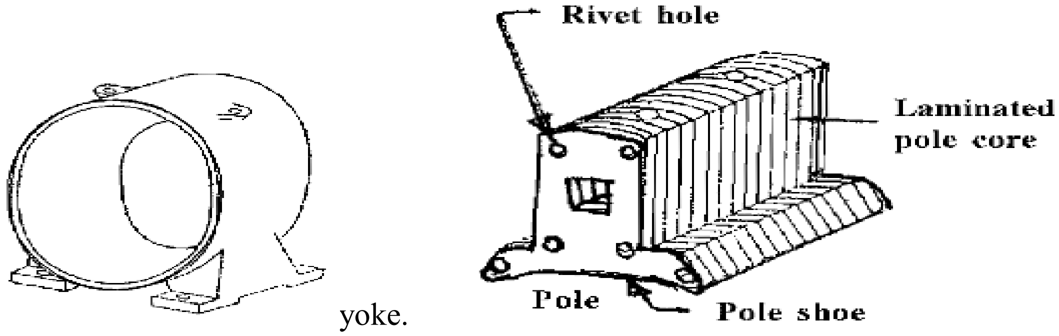

yoke.

Fig 2.2

Field Winding

The field coils are wound on the poles in such a way that the poles alternate in their polarity. There are two types of field windings-a **shunt field winding** and a **series field winding.**

Armature

The rotating part of a dc machine, which is shrouded by the fixed poles on the stator, is called the armature. The effective length of the armature is usually the same as that of the pole. Circular in cross-section, it is made of thin, highly permeable, and electrically insulated steel laminations that are stacked together and rigidly mounted on the shaft.

Commutator

The commutator is made of wedge-shaped, hard-drawn copper segments as shown in Fig 2.3 It is also rigidly mounted on the shaft as depicted in Fig 2.3. The copper segments are insulated from one another by sheets of mica.

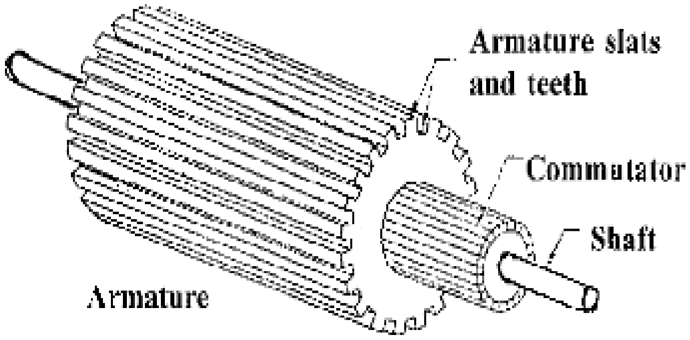


Fig 2.3

Brushes

Brushes are held in a fixed position on the commutator by means of brush holders. An adjustable spring inside the brush holder exerts a constant pressure on the brush.

Armature Windings

As mentioned in the previous section, the outer periphery of the armature has a plurality of slots into which the coils are either placed or wound. The armature slots are usually insulated. The maximum emf is induced in a full-pitch coil, that is, when the distance between the two sides of a coil is 180" electrical. A full-pitch coil, in other words, implies that when one side is under the center of a south pole, the other side must be under the center of the adjacent north pole.

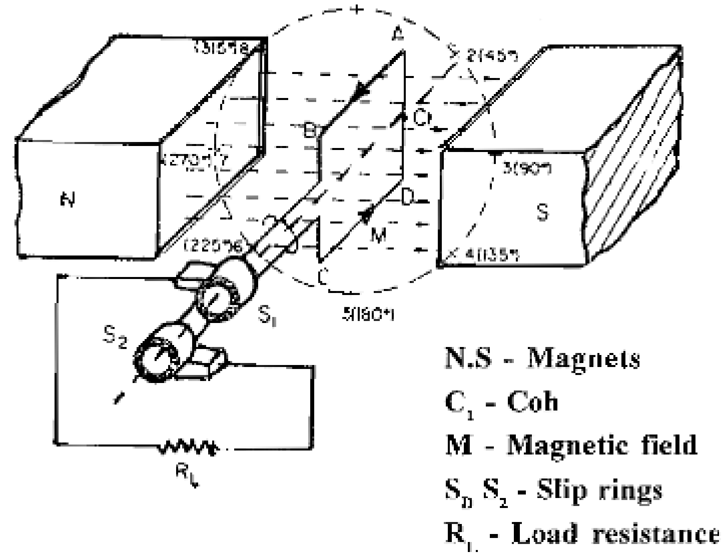
Lap Winding

In a lap-wound machine the two ends of a coil are connected to adjacent commutator segments. In the lap winding, the two ends of a coil are connected to adjacent commutator segments .

Wave Winding

The wave winding differs from the lap winding only in the way the coils are connected to the commutator segments. In the wave winding, the two ends of **a** coil are connected to those segments of the commutatorthat are **360"** electrical apart (2-pole pitches).This is done to ensure that the entire winding closes onto itself only once.

Induced Emf Equation



N.S - Magnets

C_1 - Coh

M - Magnetic field

S_1 S_2 - Slip rings

R_L - Load resistance

Fig 2.5

E.M.F. Equation of D.C. Generator:-

The e.m.f. generated in a direct current generator is proportional to the speed rotation of the armature, total number of armature conductors, total flux available in the field and the type of winding adopted in the armature.

Let, P = No. of poles.

Ø = flux per pole, in webers.

Z – total no. of conductors in the armature (number of slots in the armature x number of conductors per slot).

N = Speed of rotation of armature in r.p.m.

A = No. of parallel paths in armature

Eg = e.m.f. induced in any parallel path is armature.

The EMF Equation of D.C. generator (Eg) = $\frac{\text{Ø}zn}{60} \times \frac{P}{A}$ volts

Where, A = P in case of lap wound generator,

A = 2 in case of wave wound generator.

Armature Reaction

When there is no current in the armature winding (a no-load condition), the flux produced by the field winding is uniformly distributed over the pole faces as shown in Figure 2.6 for a 2-pole dc machine. The induced emf in a coil that lies in the neutral plane, a plane perpendicular to the field-winding flux, is zero. This, therefore, is the neutral position under no load where the brushes must be positioned for proper commutation. The armature flux distribution due to the armature mmf is also shown in the figure below.

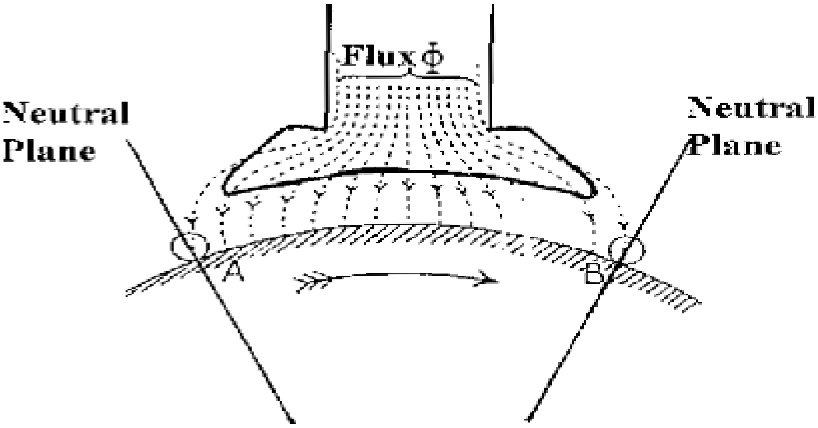


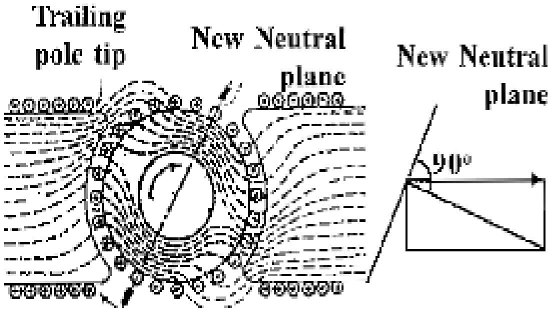
Fig 2.6

The flux distribution due to the field winding is suppressed in order to highlight the flux distribution due to the armature mmf. Note that the magnetic axis of the armature flux (the quadrature, or q-axis) is perpendicular to the magnetic axis of the field-winding flux (direct, or d-axis). Since both fluxes exist at the same time when the armature is loaded, the resultant flux is distorted . The armature flux has weakened the flux in one-half of the pole and has strengthened it in the other half. The armature current has, therefore, displaced the magnetic-field axis of the resultant flux in the direction of rotation of the generator. **As** the neutral plane is perpendicular to the resultant field, it has also advanced. The effect of the armature mmf upon the field distribution is called the **armature reaction.**The armature reaction has a demagnetizing effect on the machine. The reduction in the flux due to armature reaction suggests a substantial loss in the applied mmf per pole of the machine. In large machines, the armature reaction may have a devastating effect on the machine's performance under full load. Therefore, techniques must be developed to counteract its demagnetization effect. Some of the measures that are being used to combat armature reaction are summarized below:

The brushes may be advanced from their neutral position at no load (geometrical \neutral axis) to the new neutral plane under load. This measure is the least expensive. However, it is useful only for constant-load generators .Interpoles, or commutating poles as they are sometimes called, are narrow poles that may be located in the interpolar region centered along the mechanical neutral axis of the generator.

The interpole windings are permanently connected in series with the armature to make them effective for varying loads. The interpoles produce flux that opposes the flux due to the armature mmf. When the interpole is properly designed, the net flux along the geometric neutral axis can be brought to zero for any load. Because the interpole winding carries armature current, we need only a few turns of comparativelyheavy wire to provide the necessary interpole mmf.

Another method to nullify the effect of armature reaction is to make use of compensating windings. These windings, which also carry the armature current, are placed in the shallow slots cut in the pole faces

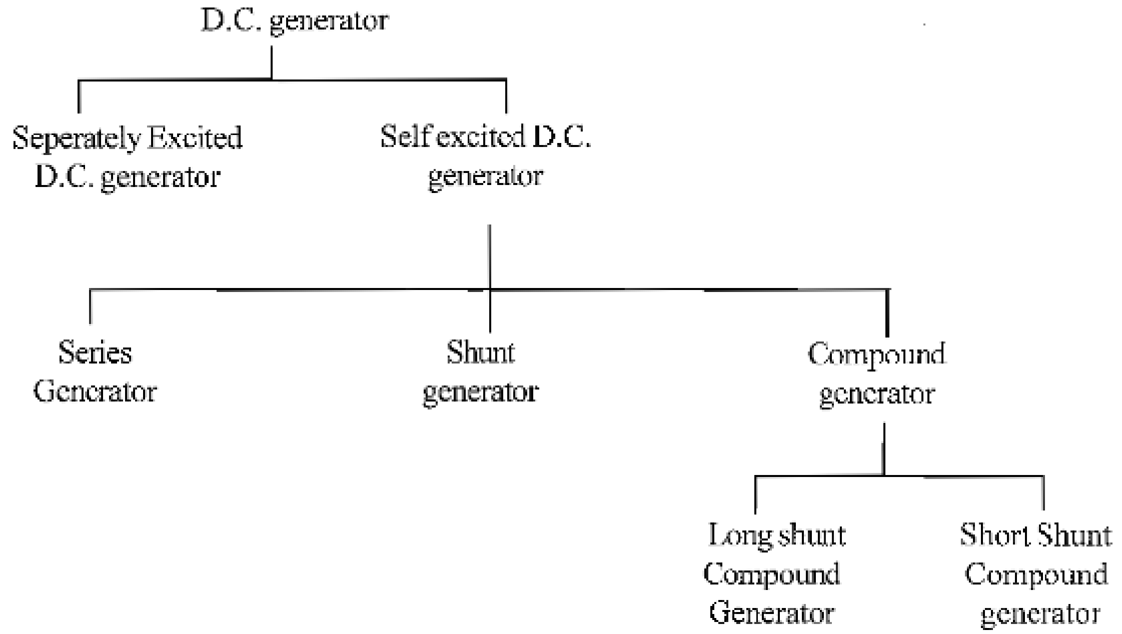


Commutation

For the successful operation of a dc machine, the induced emf in each conductor under a pole must have the same polarity. If the armature winding is carrying current, the current in each conductor under a pole must be directed in the same direction. It implies that as the conductor moves from one pole to the next, there must be a reversal of the current in that conductor. The conductor and thereby the coil in which the current reversal is taking place are said to be commutating. The process of reversal of current in a commutating coil is known as commutation.

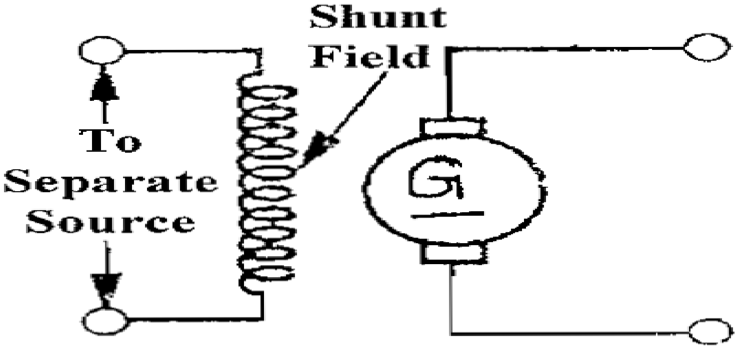
Types of D.C. Generators:

D.C. Generators are classified according to the manner in which their field windings are connected. The process of giving D.C. voltage to the field winding for producing magnetic field is called field excitation. The generators are classified as follows:



A Separately Excited DC Generator

As the name suggests, a separately excited dc generator requires an independent dc external source for the field winding and for this reason is used primarily in (a) laboratory and commercial testing and (b) special regulation sets. The externalsource can be another dc generator, a controlled or uncontrolled rectifier, or simply a battery.The equivalent circuit representation under steady-state condition of a separately excited dc generator is given in Figure 5.19. The steady-state condition implies that no appreciable change occurs in either the armature current or the armature speed for a given load. In other words, there is essentially no change in the mechanical energy or the magnetic energy of the system.



The Internal Characteristic

Under no load, the armature current is equal to the field current, which is usuallya small fraction of the load current. Therefore, the terminal voltage under no-load*V,,* is nearly equal to the induced emf E, owing to the negligible *l,R,* drop. As

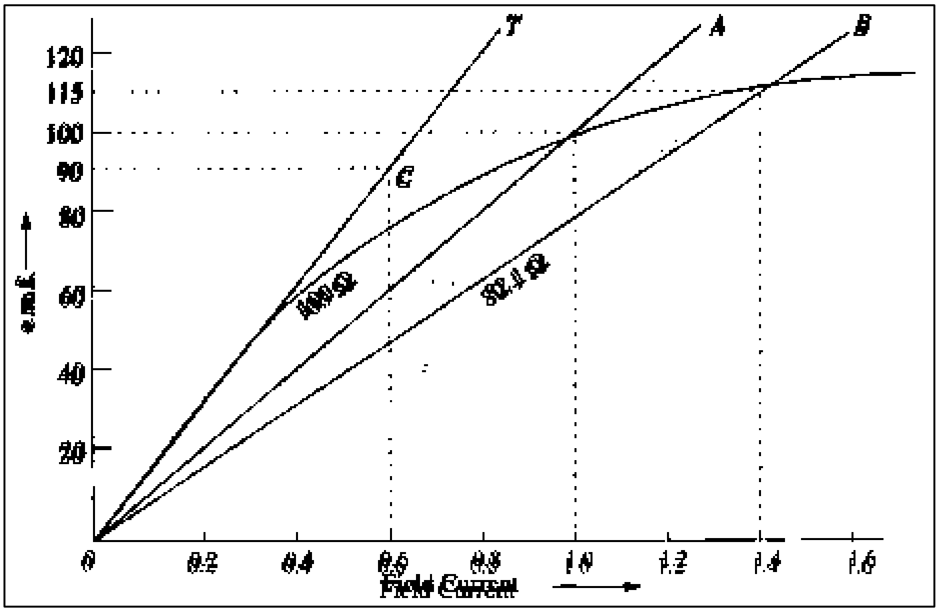
the load current increases, the terminal voltage decreases for the following

reasons:

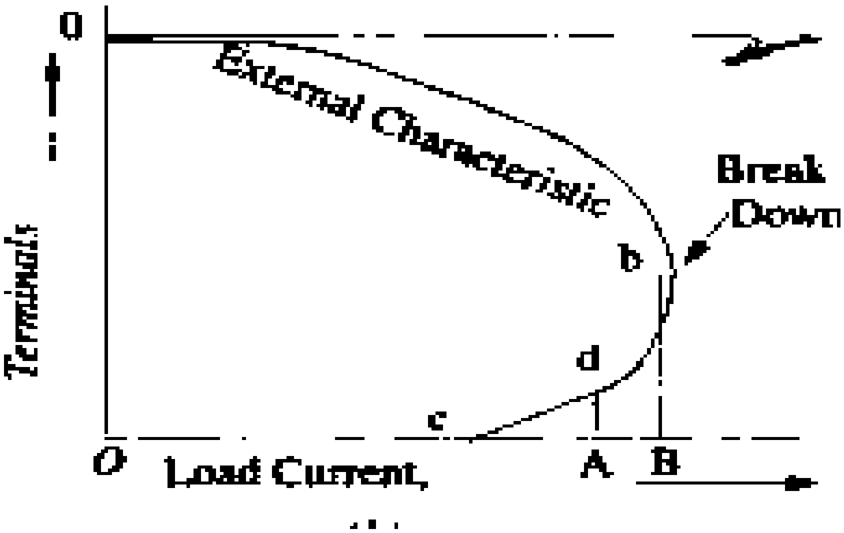
1.The increase in *l,R,* drop

2.The demagnetization effect of the armature reaction

3.The decrease in the field current due to the drop in the induced emf region.



The External Characteristic


0
External Characteristic
Break
Down
Terminals
b
d
c
O
Load Current,
A
B