Electromechanical Energy Conversion

Electromechanical energy conversion is one device which is convert energy one form to another form. electromechanical device converts electrical energy into mechanical energy and vice versa. Energy conversation take place through the medium of electric field or magnetic field.

Electromechanical energy conversion devices with magnetic field as the coupling medium between electrical and mechanical systems are more common in commercial application. the energy storing capacity of the magnetic field is much greater about 25,000 greater than the electric field.
electromechanical energy conversion is a reversible process except for the losses in the system.
Here we use word reversible that means the energy can be transfer back and forward between mechanical and electrical system. during the process of energy conversion, some of the energy is converted into heat and it lost from the system.

Electromechanical energy conversion devices may categorize in Various parts as under: -

1. The first category of devices, involving small motion, processes only low-energy signals from electrical to mechanical or vice versa. These are microphones, gramophone pick-ups, loudspeakers and low-signal transducers.
2. The second category consists of force or torque-producing devices with limited mechanical motion. These are electromagnets, relays, moving-iron instruments etc.
3. The third category includes continuous energy conversion devices like motors and generators these are used for bulk energy conversion and utilization.

Principal of energy conversion: -

Its state that the energy cannot be created or destroyed. it can only be converted from one form to the another form of energy.
If we consider electric Generator then its convert mechanical energy into electrical energy
If we consider electric **Motor** then its convert electrical energy into mechanical energy.

Electromechanical energy conversion system has basically divided in three parts,

1. Mechanical system
2. Field coupling system
3. Electrical system

Principal of energy conversion is based on below equations.

Energy transfer equation for generator action can be written as,
Mechanical energy input = electrical energy output + losses in field + total energy losses

Energy transfer equation for motoring action can be written as,
Electrical energy input = mechanical energy output + stored energy by filed + total energy losses

During the energy conversation there are occur some **Losses**, which are following as,

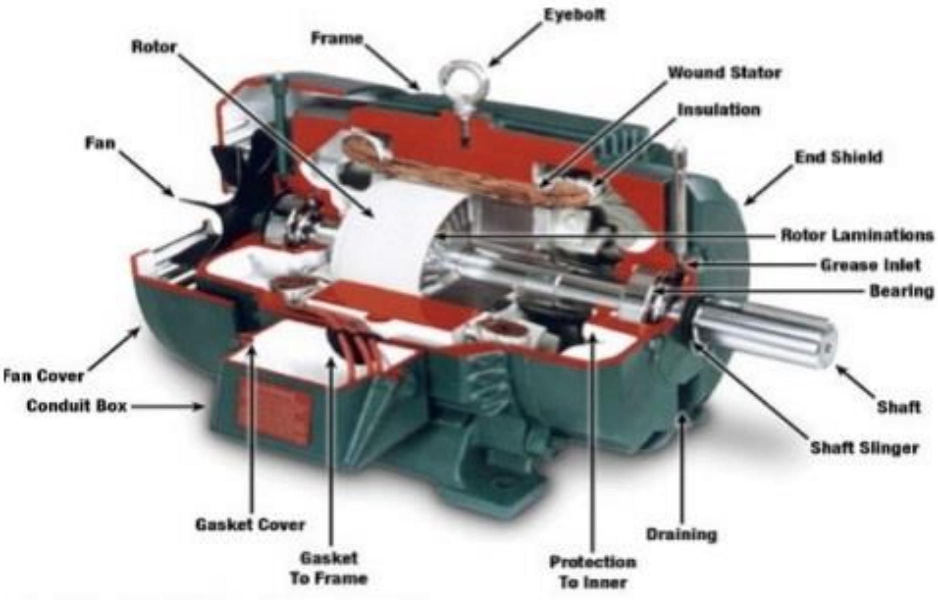
- Core losses or iron losses
- Electrical losses or copper losses
- Mechanical losses
  This all losses are called energy losses,
  Energy losses equation can be written as,

Electrical energy input – copper loss = (mechanical energy output + mechanical losses) + (core losses + energy stored in core)

DC Machines

The DC machine can be classified into two types namely DC motors **as well as DC** generators. Most of the DC machines are equivalent to AC machines because they include AC currents as well as AC voltages in them. The output of the DC machine is DC output because they convert AC voltage to DC voltage. The conversion of this mechanism is known as the commutator; thus, these machines are also named as commutating machines. DC machine is most frequently used for a motor. The main benefits of this machine include torque regulation as well as easy speed. The **applications of the DC machine** are limited to trains, mills, and mines. As examples, underground subway cars, as well as trolleys, may utilize DC motors. In the past, automobiles were designed with DC dynamos for charging their batteries.

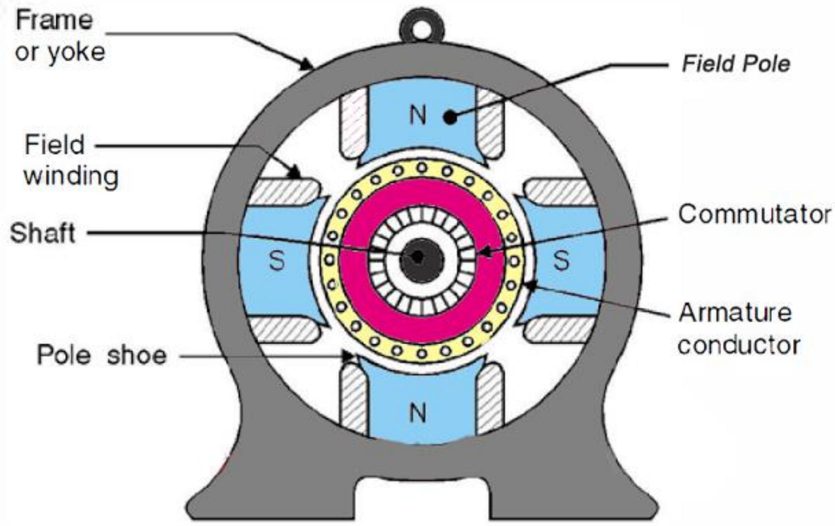
Working Principle:
A DC machine is an electromechanical energy alteration device. The **working principle of a DC machine** is when electric current flows through a coil within a magnetic field, and then the magnetic force generates a torque which rotates the dc motor. The DC machines are classified into two types such as DC generator as well as DC motor. The main function of the DC generator is to convert mechanical power to DC electrical power, whereas a DC motor converts DC power to mechanical power. The **AC motor** is frequently used in the industrial applications for altering electrical energy to mechanical energy. However, a DC motor is applicable where the good speed regulation & ample range of speeds are necessary like in electric-transaction systems.



DC Machine

Construction of DC Machine

The construction of DC machine can be done using some of the essential parts like Yoke, Pole core & pole shoes, Pole coil & field coil, Armature core, Armature winding otherwise conductor, commutator, brushes & bearings. Some of the **parts of the DC machine** is discussed below.



Construction of DC Machine

Yoke

Another name of a yoke is the frame. The main function of the yoke in the machine is to offer mechanical support intended for poles and protects the entire machine from the moisture, dust, etc. The materials used in the yoke are designed with cast iron, cast steel otherwise rolled steel.

Pole and Pole Core

The pole of the DC machine is an electromagnet and the field winding is winding among pole. Whenever field winding is energized then the pole gives magnetic flux. The materials used for this are cast steel, cast iron otherwise pole core. It can be built with the annealed steel laminations for reducing the power drop because of the eddy currents.

Pole Shoe

Pole shoe in DC machine is an extensive part as well as enlarge the region of the pole. Because of this region, flux can be spread out within the air-gap as well as extra flux can be passed through the air space toward armature. The materials used to build pole shoe is cast iron otherwise cast steed, and also used annealed steel lamination to reduce the loss of power because of eddy currents.

Field Windings

In this, the windings are wounded in the region of pole core & named as field coil. Whenever current is supplied through field winding then it electromagnetics the poles which generate required flux. The material used for field windings is copper.

Armature Core

Armature core includes the huge number of slots within its edge. Armature conductor is located in these slots. It provides the low-reluctance path toward the flux generated with field winding. The materials used in this core are permeability low-reluctance materials like iron otherwise cast. The lamination is used to decrease the loss because of the eddy current.

Armature Winding

The armature winding can be formed by interconnecting the armature conductor. Whenever an armature winding is turned with the help of prime mover then the voltage, as well as magnetic flux, gets induced within it. This winding is allied to an exterior circuit. The materials used for this winding are conducting material like copper.

Commutator

The main function of the commutator in the DC machine is to collect the current from the armature conductor as well as supplies the current to the load using brushes. And provides uni-directional torque for DC-motor. The commutator can be built with a huge number of segments in the edge form of hard drawn copper. The Segments in the commutator are protected from thin mica layer.

Brushes

Brushes in the DC machine gather the current from commutator and supplies it to exterior load. Brushes wear with time to inspect frequently. The materials used in brushes are graphite otherwise carbon which is in rectangular form.

Types of DC Machines

The excitation of the DC machine is classified into two types namely separate excitation, as well as self-excitation. In separate excitation type of dc machine, the field coils are activated with a separate DC source. In self-excitation type of dc machine, the flow of current throughout the field-winding is supplied with the machine. The principal kinds of DC machine are classified into four types which include the following.

- Separately excited DC machine
- Shunt wound/shunt machine.
- Series wound/series machine.
- Compound wound / compound machine.

Separately Excited DC Machine

In Separately Excited DC Machine, a separate DC source is utilized for activating the field coils.

Shunt Wound DC Machine

In Shunt wound DC Machines, the field coils are allied in parallel through **the armature**. As the shunt field gets the complete o/p voltage of a generator otherwise a motor supply voltage, it is normally made of a huge number of twists of fine wire with a small field current carrying.

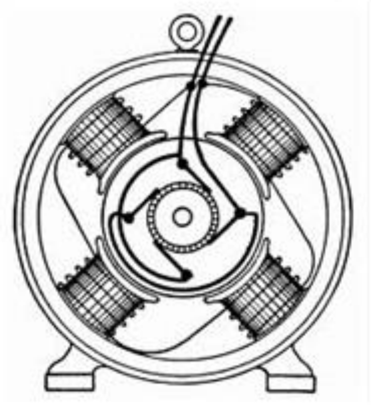
Series Wound DC Machine

In series wound D.C. Machines, the field coils are allied in series through the armature. As series field winding gets the armature current, as well as the armature current is huge, due to this the series field winding includes few twists of wire of big cross-sectional region.

Compound Wound DC Machine

A compound machine includes both the series as well as shunt fields. The two windings are carried-out with every machine pole. The series winding of the machine includes few twists of a huge cross-sectional region, as well as the shunt windings, include several fine wire twists. The connection of the compound machine can be done in two ways. If the shunt-field is allied in parallel by the armature only, then the machine can be named as the 'short shunt compound machine' & if the shunt-field is allied in parallel by both the armature as well as series field, then the machine is named as the 'long shunt compound machine'.

EMF Equation of a Generator



EMF Equation of a Generator

Let φ =flux/pole in weber.

Z=total number of armature conductors = No. of slots * No.of conductors/slot.

P = No. of poles.

A = No. of parallel paths in armature.

N = armature rotation in rpm.

E = EMF induced in any parallel path in armature.

Generated EMF = e.m.f. generated in one of the parallel paths.

Average EMF generated/conductor = ($d\varphi/dt$) volt.

Now, flux cut/conductor in one revolution, $d\varphi = (\varphi*P)$ web.

Number of revolution per second = N/60;

Then, time for one revolution, dt = 60/N second.

Hence according to Faraday's laws of electromagnetic induction,

EMF generated/conductor= $(d\varphi/dt) = (\varphi ZPN/120)$ Volt.

For a wave-wound generator

No. of parallel paths is 2

No. of conductors (in series) in one path = Z/2

For a lap-wound generator

No. of parallel paths = P

No. of conductors (in series) in one path = Z/P

Then, EMF generated/path = $[(\varphi PN/60)*(Z/P)] = (\varphi ZN/60)$ Volt.

In general, generated EMF = $[(\varphi PN/60)*(Z/A)]= (\varphi ZPN/60A)$ Volt

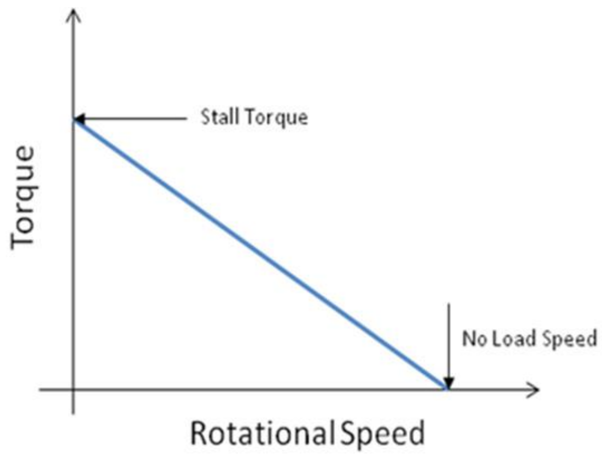
Where A=2 for wave-winding.

A= P for lap-winding.

Torque Equation of motor

Understanding the torque equation and the relationship between speed and torque is an important part of selecting and operating a DC motor.

DC motors are relatively simple machines: when the load on the motor is constant, speed is proportional to supply voltage. And when supply voltage is constant, speed is inversely proportional to the load on the motor. This second relationship—between speed and load (or torque)—is typically shown on the motor’s torque-speed curve.



The inverse relationship between speed and torque means that an increase in the load (torque) on the motor will cause a decrease in speed. This can be demonstrated by the DC motor torque equation:

$$T = \frac{V - \omega \cdot k}{R} \cdot k$$

Where:
T = motor torque
V = supply voltage
ω = rotational speed
k = motor constant
R = resistance

Of course, the motor constant (k) doesn't change, and resistance (R) in the motor windings is constant. Therefore, when supply voltage (V) is constant, torque (T) is inversely proportional to speed (ω).

Rearranging for speed, we can see the same inverse relationship to torque:

$$\omega = \frac{V}{k} - \frac{T}{k^2} \cdot R$$

The inverse relationship means that the torque-speed curve is a descending line, with a negative slope. The torque-speed curve begins at the crossing of the Y axis, where torque is maximum, and speed is zero. This is the stall torque—the maximum torque when the motor is running at nominal voltage. The curve slopes downward until it intersects the X axis—that is, zero torque and maximum speed. This point is known as the no-load speed—the speed when running at nominal voltage and zero load.

Because the torque-speed curve is a straight line, it's simple to find the torque that the motor can produce at a given speed, or conversely, to find the motor's speed for a given load (torque) on the shaft. Recall the equation for a straight line:

$$y = m \cdot x + b$$

Where,
y = value of y axis variable, to be determined
m = slope of the line; change in y divided by change in x
x = value of x axis variable, given
b = y intercept; point at which the line crosses the y axis

Using this equation for the torque-speed curve, we can find the motor's torque at a given speed. In this case, the variables in the line equation represent the following:

y = torque to be determined
m = change in torque divided by change in speed
x = given speed
b = stall torque (value where the line crosses the y axis)
The line equation can also be rearranged to find the motor's speed at a given torque:

$$x = \frac{y - b}{m}$$

<u>EMF Equation of DC Machine</u>

The **DC machine e.m.f** can be defined as when the armature in the dc machine rotates, the voltage can be generated within the coils. In a generator, the e.m.f of rotation can be called the generated emf, and Er=Eg. In the motor, the emf of rotation can be called as counter or back emf, and Er=Eb.
Let,
Φ is the useful flux for every pole within Weber's
P is the total number of poles
z is the total number of conductors within the armature
n is the rotation speed for an armature in the revolution for each second
A is the no. of parallel lane throughout the armature among the opposite polarity brushes.
Z/A is the no. of armature conductor within series for each parallel lane
As the flux for each pole is 'Φ', every conductor slashes a flux 'PΦ' within a single revolution.

The voltage produced for each conductor = flux slash for each revolution in WB / Time taken for a single revolution within seconds

As 'n' revolutions are completed within a single second and 1 revolution will be completed within a 1/n second. Thus, the time for a single armature revolution is a 1/n sec.

The standard value of produced voltage for each conductor

$$p\,\Phi/1/n = np\,\Phi \text{ volts}$$

The voltage produced (E) can be decided with the no. of armature conductors within series I any single lane among the brushes thus, the whole voltage produced

E = standard voltage for each conductor x no. of conductors within series for each lane

$$E = n.P.\Phi \times Z/A$$

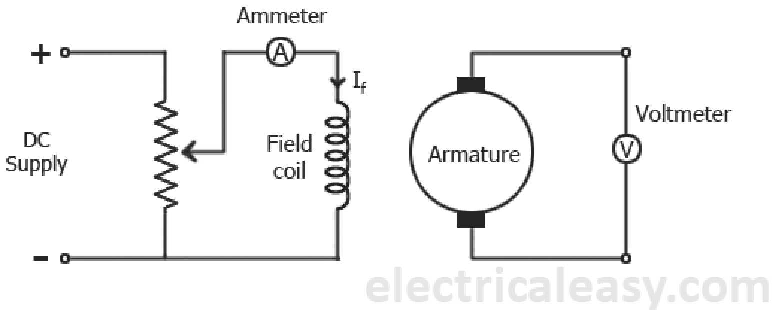
The above equation is the e.m.f. the equation of the DC machine.

<u>Characteristics of DC Generator</u>

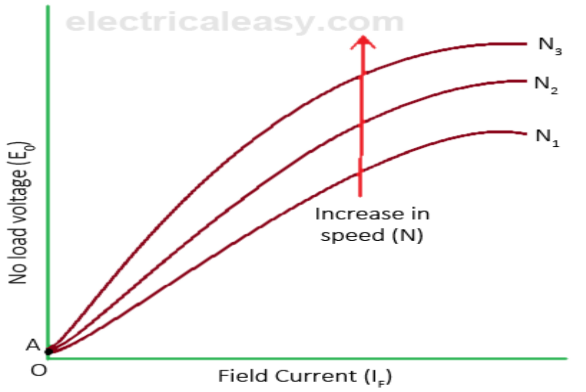
Generally, following three characteristics of DC generators are taken into considerations: (i) Open Circuit Characteristic (O.C.C.), (ii) Internal or Total Characteristic and (iii) External Characteristic. These **characteristics of DC generators** are explained below.

1. Open Circuit Characteristic (O.C.C.) (E_0/I_f)
Open circuit characteristic is also known as **magnetic characteristic** or **no-load saturation characteristic**. This characteristic shows the relation between generated emf at no load (E_0) and the field current (I_f) at a given fixed speed. The O.C.C. curve is just the magnetization curve and it is practically similar for all type of generators. The data for O.C.C. curve is

obtained by operating the generator at no load and keeping a constant speed. Field current is gradually increased, and the corresponding terminal voltage is recorded. The connection arrangement to obtain O.C.C. curve is as shown in the figure below. For shunt or series excited generators, the field winding is disconnected from the machine and connected across an external supply.



Now, from the [emf equation of dc generator](), we know that Eg = kϕ. Hence, the generated emf should be directly proportional to field flux (and hence, also directly proportional to the field current). However, even when the field current is zero, some amount of emf is generated (represented by OA in the figure below). This initially induced emf is since there exists some residual magnetism in the field poles. Due to the residual magnetism, a small initial emf is induced in the armature. This initially induced emf aids the existing residual flux, and hence, increasing the overall field flux. This consequently increases the induced emf. Thus, O.C.C. follows a straight line. However, as the flux density increases, the poles get saturated and the ϕ becomes practically constant. Thus, even we increase the I_f further, ϕ remains constant and hence, Eg also remains constant. Hence, the O.C.C. curve looks like the B-H characteristic.



Open Circuit Characteristic (O.C.C.)

The above figure shows a typical no-load saturation curve or open circuit characteristics for all types of DC generators.

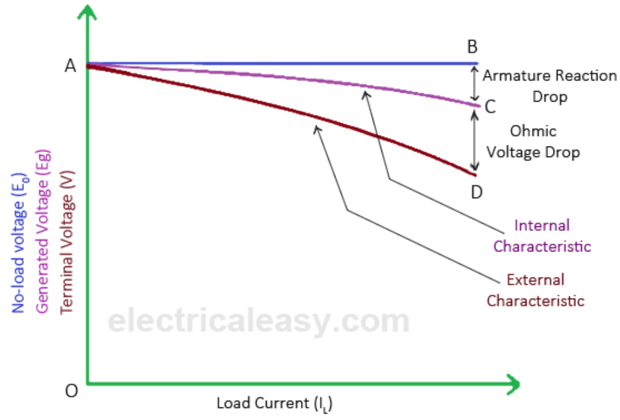
2. Internal or Total Characteristic (E/I_a)
An internal characteristic curve shows the relation between the on-load generated emf (Eg) and the armature current (I_a). The on-load generated emf Eg is always less than E_0 due to the [armature reaction](). Eg can be determined by subtracting the drop due to demagnetizing effect of armature reaction from no-load voltage E_0. Therefore, internal characteristic curve lies below the O.C.C. curve.

3. External Characteristic (V/I_L)
An external characteristic curve shows the relation between terminal voltage (V) and the load current (I_L). Terminal voltage V is less than the generated emf Eg due to voltage drop in the armature circuit. Therefore, external characteristic curve lies below the internal characteristic

curve. External characteristics are very important to determine the suitability of a generator for a given purpose. Therefore, this type of characteristic is sometimes also called as **performance characteristic** or **load characteristic**.

Internal and external characteristic curves are shown below for each type of generator.

Characteristics of Separately Excited DC Generator

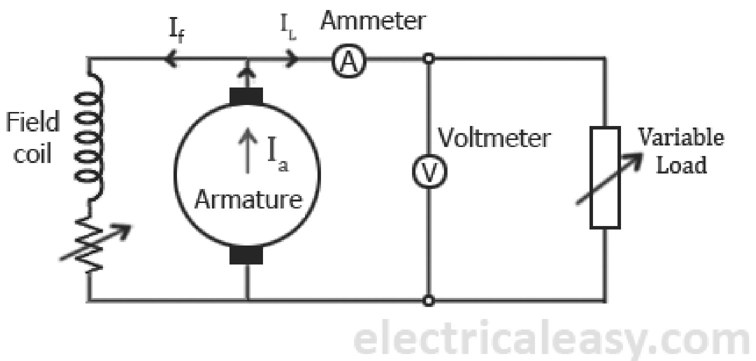


Characteristics of separately excited DC generator

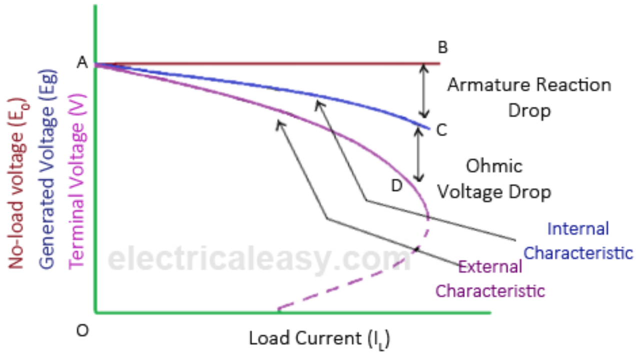
If there is no armature reaction and armature voltage drop, the voltage will remain constant for any load current. Thus, the straight-line AB in above figure represents the no-load voltage vs. load current I_L. Due to the demagnetizing effect of armature reaction, the on-load generated emf is less than the no-load voltage. The curve AC represents the on-load generated emf Eg vs. load current I_L i.e. internal characteristic (as $I_a = I_L$ for a separately excited dc generator). Also, the terminal voltage is lesser due to ohmic drop occurring in the armature and brushes. The curve AD represents the terminal voltage vs. load current i.e. external characteristic.

Characteristics of DC Shunt Generator

To determine the internal and external load characteristics of a DC shunt generator the machine can build up its voltage before applying any external load. To build up voltage of a shunt generator, the generator is driven at the rated speed by a prime mover. Initial voltage is induced due to residual magnetism in the field poles. The generator builds up its voltage as explained by the O.C.C. curve. When the generator has built up the voltage, it is gradually loaded with resistive load and readings are taken at suitable intervals. Connection arrangement is as shown in the figure below.



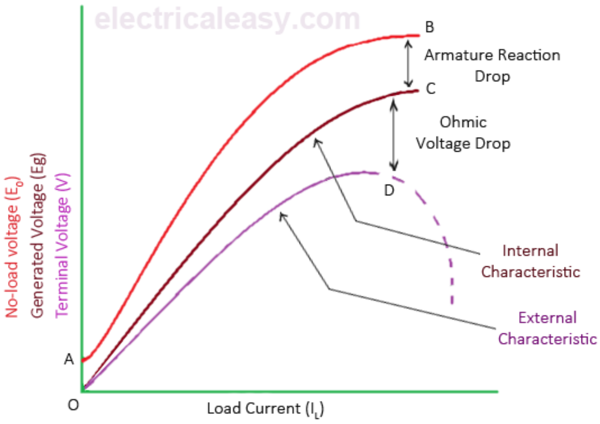
Unlike, separately excited DC generator, here, $I_L \neq I_a$. For a shunt generator, $I_a = I_L + I_f$. Hence, the internal characteristic can be easily transmitted to Eg vs. I_L by subtracting the correct value of I_f from I_a.



Characteristics of DC shunt generator

During a normal running condition, when load resistance is decreased, the load current increases. But, as we go on decreasing the load resistance, terminal voltage also falls. So, load resistance can be decreased up to a certain limit, after which the terminal voltage drastically decreases due to excessive armature reaction at very high armature current and increased I^2R losses. Hence, beyond this limit any further decrease in load resistance results in decreasing load current. Consequently, the external characteristic curve turns back as shown by dotted line.

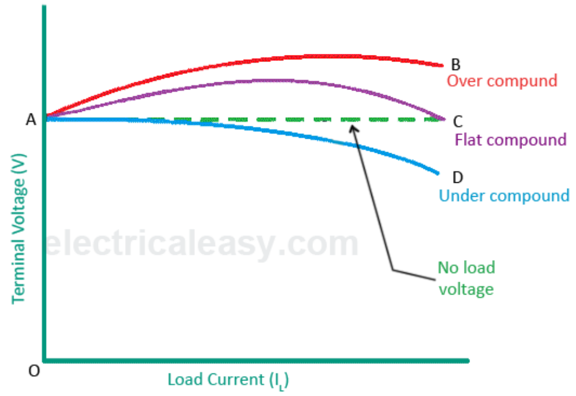
Characteristics of DC Series Generator



Characteristics of DC series generator

The curve AB in above figure identical to open circuit characteristic (O.C.C.) curve. This is because in DC series generators field winding is connected in series with armature and load. Hence, here load current is similar to field current (i.e. $I_L=I_f$). The curve OC and OD represent internal and external characteristic respectively. In a DC series generator, terminal voltage increases with the load current. This is because, as the load current increases, field current also increases. However, beyond a certain limit, terminal voltage starts decreasing with increase in load. This is due to excessive demagnetizing effects of the armature reaction.

Characteristics of DC Compound Generator



External characteristic of DC compound generator

The above figure shows the external characteristics of DC compound generators. If series winding amp-turns are adjusted so that, increase in load current causes increase in terminal voltage then the generator is called to be over compounded. The external characteristic for over compounded generator is shown by the curve AB in above figure.
If series winding amp-turns are adjusted so that, the terminal voltage remains constant even the load current is increased, then the generator is called to be flat compounded. The external characteristic for a flat compounded generator is shown by the curve AC.
If the series winding has lesser number of turns than that would be required to be flat compounded, then the generator is called to be under compounded. The external characteristics for an under compounded generator are shown by the curve AD.

Applications of DC Generators

There are various types of DC generators available for several types of services. The **applications of these DC generators** based on their characteristic are discussed below:
Applications of Separately Excited DC Generators

This type of DC generators are generally more expensive than self-excited DC generators because of their requirement of separate excitation source. Because of that their applications are restricted. They are generally used where the use of self-excited generators is unsatisfactory.

1. Because of their ability of giving wide range of voltage output, they are generally used for testing purpose in the laboratories.
2. Separately excited generators operate in a stable condition with any variation in field excitation. Because of this property they are used as supply source of DC motors, whose speeds are to be controlled for various applications. Example- Ward Leonard Systems of speed control.

Applications of Shunt Wound DC Generators

The application of shunt generators is very much restricted for its dropping voltage characteristic. They are used to supply power to the apparatus situated very close to its position. These type of DC generators generally give constant terminal voltage for small distance operation with the help of field regulators from no load to full load.

1. They are used for general lighting.
2. They are used to charge battery because they can be made to give constant output voltage.
3. They are used for giving the excitation to the alternators.

4. They are also used for small power supply (such as a portable generator).

Applications of Series-Wound DC Generators

These types of generators are restricted for the use of power supply because of their increasing terminal voltage characteristic with the increase in load current from no load to full load. We can clearly see this characteristic from the characteristic curve of series wound generator. They give constant current in the dropping portion of the characteristic curve. For this property they can be used as constant current source and employed for various applications.

1. They are used for supplying field excitation current in DC locomotives for regenerative breaking.
2. This types of generators are used as boosters to compensate the voltage drop in the feeder in various types of distribution systems such as railway service.
3. In series arc lightening this type of generators are mainly used.

Applications of Compound Wound DC Generators

Among various types of DC generators, the compound wound DC generators are most widely used because of its compensating property. Depending upon number of series field turns, the cumulatively compounded generators may be over compounded, flat compounded and under compounded. We can get desired terminal voltage by compensating the drop due to armature reaction and ohmic drop in the in the line. Such generators have various applications.

1. Cumulative compound wound generators are generally used for lighting, power supply purpose and for heavy power services because of their constant voltage property. They are mainly made over compounded.
2. Cumulative compound wound generators are also used for driving a motor.
3. For small distance operation, such as power supply for hotels, offices, homes and lodges, the flat compounded generators are generally used.
4. The differential compound wound generators, because of their large demagnetization armature reaction, are used for arc welding where huge voltage drop and constant current is required.

Characteristics of DC Motors

Generally, three characteristic curves are considered important for DC motors which are, (i) Torque vs. armature current, (ii) Speed vs. armature current and (iii) Speed vs. torque. These are explained below for each type of DC motor. These characteristics are determined by keeping the following two relations in mind.

$\mathbf{T_a \propto \phi . I_a}$ and $\mathbf{N \propto E_b/\phi}$

These above equations can be studied at - emf and torque equation of dc machine. For a DC motor, magnitude of the back emf is given by the same emf equation of a dc generator i.e. $E_b = P\phi NZ / 60A$. For a machine, P, Z and A are constant, therefore, $N \propto E_b/\phi$

Characteristics of DC Series Motors

Torque Vs. Armature Current (T_a-I_a)

This characteristic is also known as **electrical characteristic**. We know that torque is directly proportional to the product of armature current and field flux, $T_a \propto \phi . I_a$. In DC series motors, field winding is connected in series with the armature, i.e. $I_a = I_f$. Therefore, before magnetic saturation of the field, flux ϕ is directly proportional to Ia. Hence, before magnetic saturation Ta α Ia^2. Therefore, the Ta-Ia curve is parabola for smaller values of Ia.

After magnetic saturation of the field poles, flux ϕ is independent of armature current Ia. Therefore, the torque varies proportionally to Ia only, $T \propto$ Ia.Therefore, after magnetic saturation, Ta-Ia curve becomes a straight line.

The shaft torque (Tsh) is less than armature torque (Ta) due to stray losses. Hence, the curve Tsh vs Ia lies slightly lower.
In DC series motors, (prior to magnetic saturation) torque increases as the square of armature current, these motors are used where high starting torque is required.

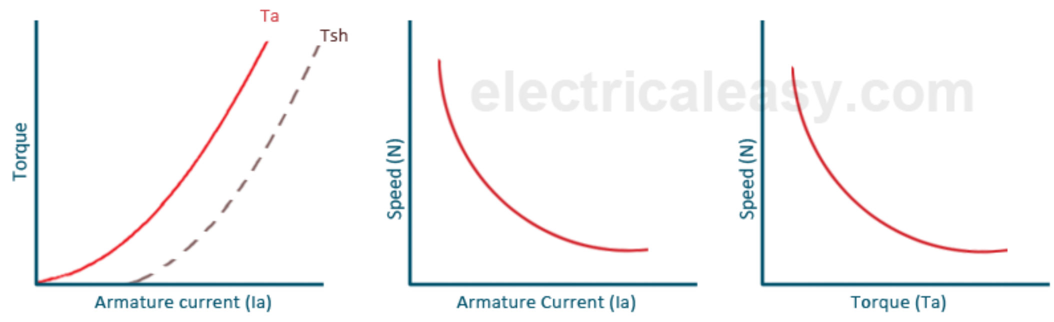
Speed Vs. Armature Current (N-Ia)

We know the relation, $N \propto E_b/\phi$
For small load current (and hence for small armature current) change in back emf Eb is small and it may be neglected. Hence, for small currents speed is inversely proportional to ϕ. As we know, flux is directly proportional to Ia, speed is inversely proportional to Ia. Therefore, when armature current is very small the speed becomes dangerously high. That is **why a series motor should never be started without some mechanical load**.

But, at heavy loads, armature current Ia is large. And hence, speed is low which results in decreased back emf Eb. Due to decreased Eb, more armature current is allowed.

Speed Vs. Torque (N-Ta)

This characteristic is also called as **mechanical characteristic**. From the above two **characteristics of DC series motor**, it can be found that when speed is high, torque is low and vice versa.



Characteristics of DC series motor

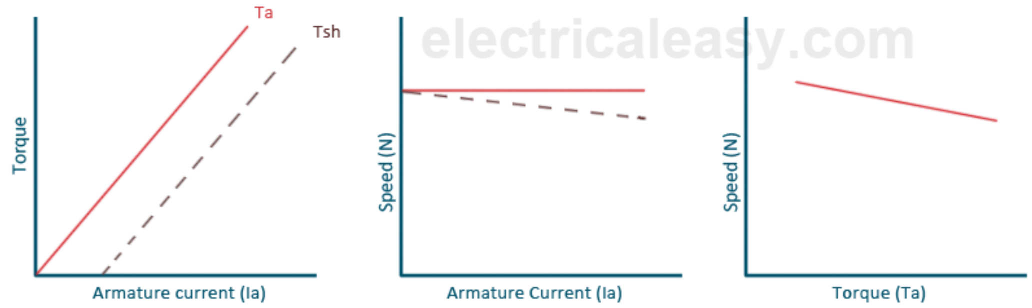
Characteristics of DC Shunt Motors

Torque Vs. Armature Current (Ta-Ia)

In case of DC shunt motors, we can assume the field flux ϕ to be constant. Though at heavy loads, ϕ decreases in a small amount due to increased armature reaction. As we are neglecting the change in the flux ϕ, we can say that torque is proportional to armature current. Hence, the Ta-Ia characteristic for a dc shunt motor will be a straight line through the origin.
Since heavy starting load needs heavy starting current, **shunt motor should never be started on a heavy load**.

Speed Vs. Armature Current (N-Ia)

As flux ϕ is assumed to be constant, we can say N ∝ Eb. But, as back emf is also almost constant, the speed should remain constant. But practically, ϕ as well as Eb decreases with increase in load. Back emf Eb decreases slightly more than ϕ, therefore, the speed decreases slightly. Generally, the speed decreases only by 5 to 15% of full load speed. Therefore, **a shunt motor can be assumed as a constant speed motor**. In speed vs. armature current characteristic in the following figure, the straight horizontal line represents the ideal characteristic and the actual characteristic is shown by the dotted line.



Characteristics of DC shunt motor

Characteristics of DC Compound Motor

DC compound motors have both series as well as shunt winding. In a compound motor, if series and shunt windings are connected such that series flux is in direction as that of the shunt flux then the motor is said to be cumulatively compounded. And if the series flux is opposite to the direction of the shunt flux, then the motor is said to be differentially compounded. Characteristics of both these compound motors are explained below.

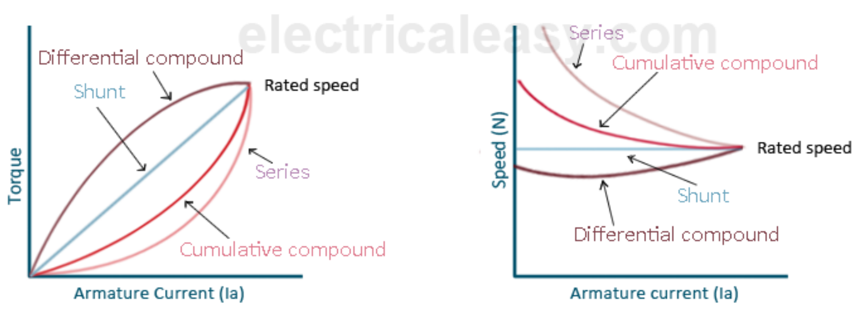
(a) Cumulative compound motor

Cumulative compound motors are used where series characteristics are required but the load is likely to be removed completely. Series winding takes care of the heavy load, whereas the shunt winding prevents the motor from running at dangerously high speed when the load is suddenly removed. These motors have generally employed a flywheel, where sudden and temporary loads are applied like in rolling mills.

(b) Differential compound motor

Since in differential field motors, series flux opposes shunt flux, the total flux decreases with increase in load. Due to this, the speed remains almost constant or even it may increase slightly with increase in load ($N \propto E_b/\phi$). Differential compound motors are not commonly used, but they find limited applications in experimental and research work.

Applications of DC



Characteristics of DC compound motor

Applications of DC Motors

Different Types of DC Motors with Their Applications:

- Type 1: DC Shunt Motor:

Applications of DC Shunt Motor: Reciprocating pump Centrifugal pump Machine Tools Blower and Fan Lathe Constant speed line shaft, etc...

Type 2: DC Series Motor:

Applications of DC Series Motor: Electric Traction Trolley Car Crane, Hoist Conveyor, etc...

Type 3: DC Cumulative Compound Motor:

Applications of DC Cumulative Compound Motor: Elevator, Conveyor Heavy Planer Rolling Machine Air Compressor Shearing and Punching Machine Intermittent High Torque Load, etc...

Type 4: DC Differential Compound Motor:

Applications of DC Differential Compound Motor: Light Load For Constant Speed Drive, e.g. Paper Mill Drive, etc...