DIRECT CURRENT MACHINES:

DC generator:

An electrical generator is a rotating machine which converts mechanical energy into electrical energy. This energy conversion is based on the principle of electromagnetic Induction. According to Faraday's law of electromagnetic induction, whenever a conductor is moved in a magnetic field, dynamically induced emf is produced in the conductor.

When an external load is connected to the conductor the induced emf causes a current to flow in the load. Thus the mechanical energy which is given in the form of motion the conductor is converted into electrical energy. Large number of conductors are used to obtain greater emf and the rotating conductor assembly is called an armature.

Parts of a DC Generator:

1. Magnetic frame or yoke.
2. Poles, interlopes, windings, pole shoes.
3. Armature
4. Commutator
5. Brushes, bearings and shaft

Emf Induced in a DC Generator:

Eg= $\frac{\phi\,\mathrm{zn}}{60}\,\frac{p}{a}\ Volts$

ϕ = flux per pole in wb

p = number of poles

Z = total number of conductors in the armature

A = number of parallel paths

N = speed of rotation in rpm

For lap wound armatures, A = P

Wave wound armatures A = 2

Types of DC Generators:

According to their methods of field excitation

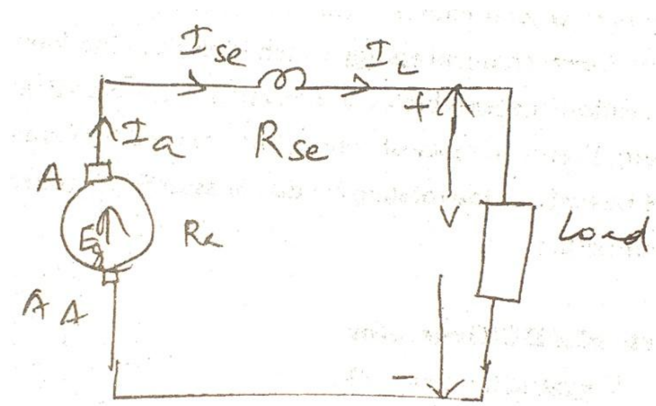
1) Separately excited
2) Self excited

Self excited DC Generators:

Depending upon how the field winding is connected to the armature,

1. Series Generator
2. Shunt Generator
3. Compound Generator

Series Generator:

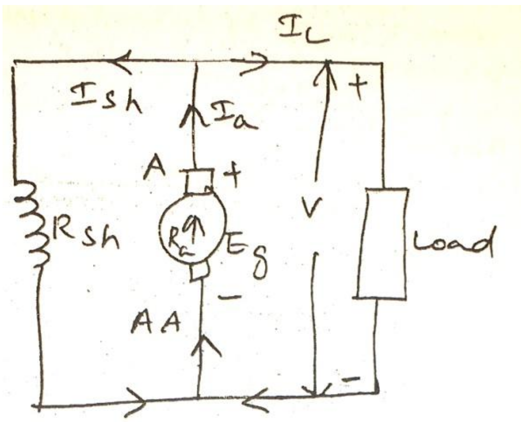


$I_a = I_{se} = I_L$

$E_g = V + I_aR_a + I_aR_{se} + V_{brush}$

Power developed in the armature = $E_g I_a$
Power delivered to load = VI_a
Power delivered to load = VI_c

Shunt Generator:



Terminal voltage $V = E_g – I_a R_a$
Shunt field current $I_{sh} = \frac{V}{R_{sh}}$
Armature current $I_a = I_L + I_{sh}$
Power developed by armature = $E_g I_a$
Power delivered to load = VI_L

Compound Generator:

Consists of both shunt field and series field windings. Depending upon the shunt field and series field connections, compound generator can be classified as,

1. Long shunt compound generator
2. Short shunt compound generator

Applications of DC Generators:

1. Shunt generator are used for supplying nearly constant loads. They are used for battery charging, for supplying the fields of synchronous machines and separately excited DC machines.
2. Since the O/P voltage of a series generator increases with load, series generators are ideal for use as boosters for1 adding a voltage to the transmission line to compensate for the line drop.
3. Compound generators maintain better voltage regulation and hence find use where constancy of voltage is required. Eg. for a self contained generator unit.

DC Motors:

While a DC generator converts mechanical energy in the form of rotation of the conductor (armature) into electrical energy, a motor does the opposite. The input to a DC motor is electrical and the 0/P is mechanical rotation or torque. The fundamental principles and construction of the DC motors are identical with DC generators which have the same type of excitation.

Principle of Operation:

Whenever current carrying conductor is placed in a magnetic field, the conductor experiences a force tending to move it.

Back emf:

According to Lenz's Law, the direction of the emf opposes the supply voltage, in a DC motor. The back emf is given by

$E_b = \frac{\phi ZN}{60} \times \frac{P}{A}$ volts

Armature current, $I_a = \frac{V - E_6}{R_a}$ Amps

• When the DC motor is operating on no –load condition,

$E_b \cong V$

Voltage Equation of DC Motor:

$V = E_b + I_a R_a$

Power relationship of DC Motor:

Power developed in armature is maximum when the back emf is equal to half of the input voltage.

i.e. $E_b = \frac{V}{2}$

Types of DC Motors:

i) Separately excited

ii) Self excited

a) Series motor

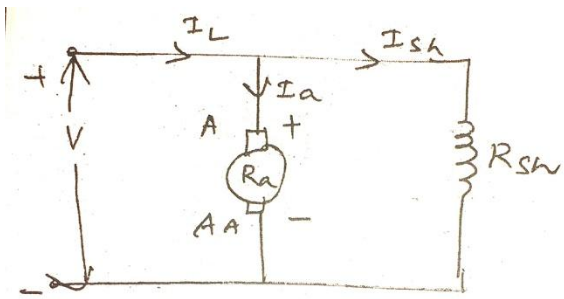
b) Shunt motor

c) Compound motor

a) Long shunt

b) Short shunt

DC Shunt Motor:



$I_L = I_a + I_{sh}$

$I_{sh} = \frac{V}{R_{sh}}$

$V = E_o + I_a R_a + V_{brush}$

In shunt motor,

$\phi \; \alpha \; I_{sh}$

DC compound Motor:

a) Long shunt compound motor

$I_a = I_{se}$

$V = E_b + I_a (R_a + R_{se}) + V_{brush}$

b) Short Shunt compound motor

$I_{se} = I_L$

$V_{sh} = E_b + I_a R_a + V_{brush}$

$I_{sh} = \frac{V - I_L R_{se}}{R_{sh}}$

Torque equation:

Torque is nothing but turning or twisting force about an axis.

$T_a = 0.159\phi \, I_a \frac{PZ}{A}$ N-m

$\therefore T \; \alpha \; \phi \, I_a$

Speed and Torque equation:

$N = \frac{K(V - I_a R_a)}{\phi}$

$\therefore N \alpha \frac{V - I_a R_a}{\phi}$

or $N \; \alpha \; \frac{E_b}{\phi}$

Also $7 \; \alpha \; \phi I_a$

For DC shunt motor,

ϕ is constant

$\therefore T \; \alpha \; \phi I_a$ becomes

$T \; \phi \; I_a$ – Shunt motor

For DC series motor,

$\phi \; \alpha \; I_a$

$\therefore T \; \alpha \; I_a^2 \longrightarrow$ series motor

Applications of DC Motors:

DC shunt motors are used where the speed has to remain rarely constant with load and where high starting torque is not required. Thus shunt motors may be used for driving centrifugal pumps and light machine tools, wood working machines, lathe etc.

Series motors are used where the load is directly attached to the shaft or through a gear arrangement and where there is no danger of the load being thrown off. Series motors are ideal for use in electric trains, where the self-weight of the train acts as load and for cranes, hoists, fans, blowers, conveyers lifts etc, where the starting torque requirement is high.

Compound motors are used for driving heavy machine tools for intermittent loads shears, punching machines, etc.