WELCOME TO MY PRESENTATION

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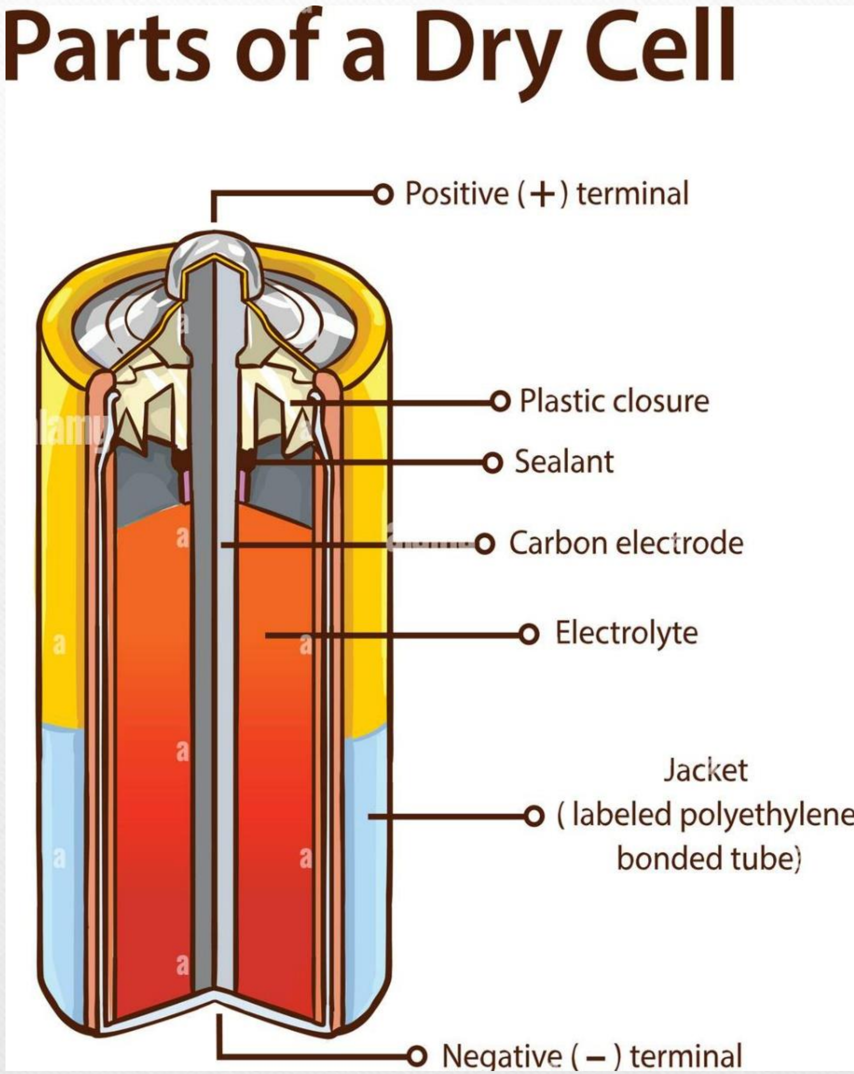
Subject Name: D.C Machine

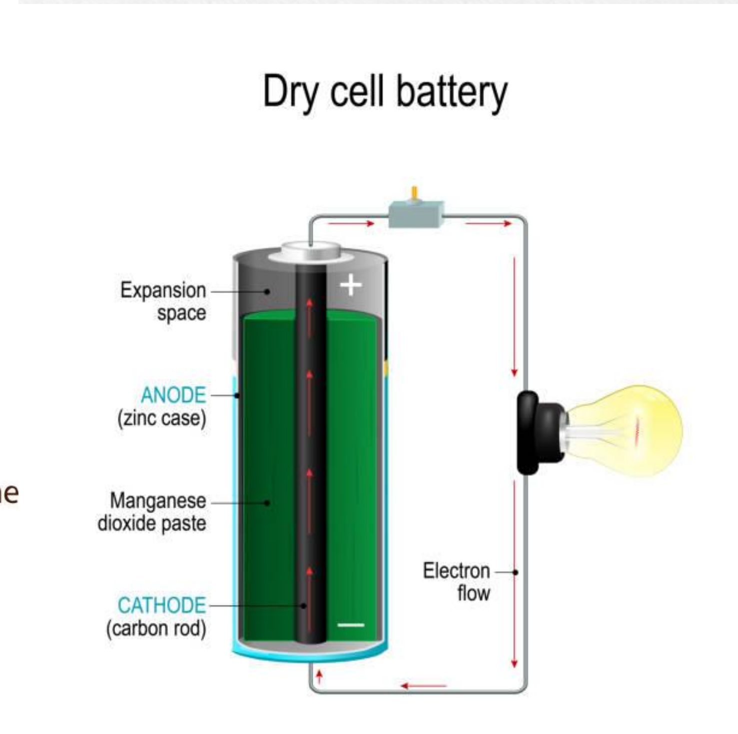
Subject Code: 26742

Cell and Battery

- A **battery** is a source of electric power consisting of one or more electrochemical cells with external connections[1] for powering electrical devices. When a battery is supplying power, its positive terminal is the cathode and its negative terminal is the anode.[2] The terminal marked negative is the source of electrons that will flow through an external electric circuit to the positive terminal. When a battery is connected to an external electric load, a redox reaction converts high-energy reactants to lower-energy products, and the free-energy difference is delivered to the external circuit as electrical energy. Historically the term "battery" specifically referred to a device composed of multiple cells; however, the usage has evolved to include devices composed of a single cell.[3]


Parts of a Dry Cell
Positive (+) terminal
Plastic closure
Sealant
Carbon electrode
Electrolyte
Jacket
(labeled polyethylene
bonded tube)
Negative (–) terminal

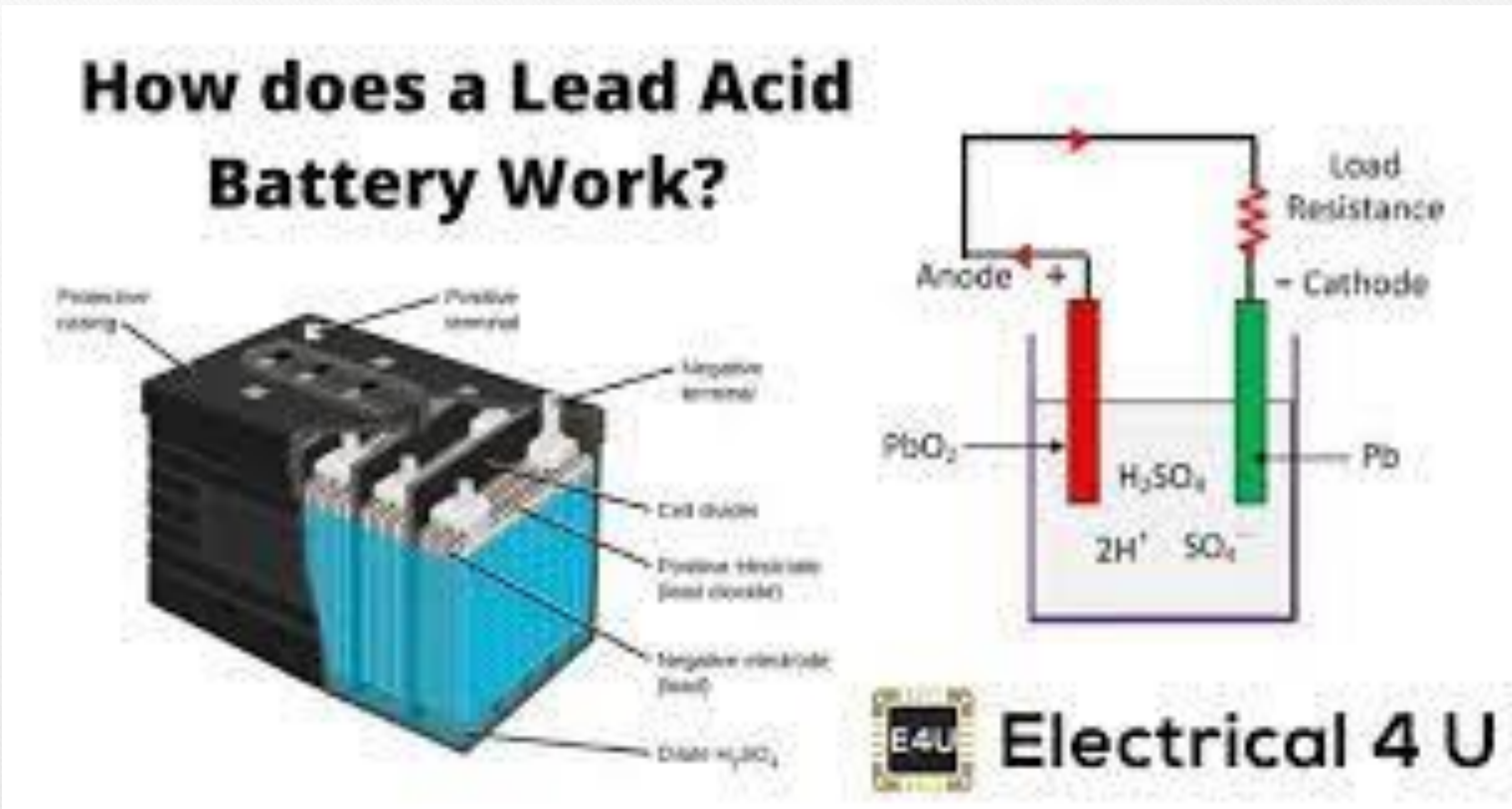

DURACELL
ALKALINE BATTERY
DURACELL
ALKALINE BATTERY


Dry cell battery
Expansion space
ANODE
(zinc case)
Manganese dioxide paste
CATHODE
(carbon rod)
Electron flow
+
–

LEAD ACID CELL BATTERY

- The lead–acid battery consists of two electrodes submerged in an electrolyte of sulfuric acid. The positive electrode is made of grains of metallic lead oxide, while the negative electrode is attached to a grid of metallic lead. Lead–acid batteries are classified into two types: flooded and valve-regulated.

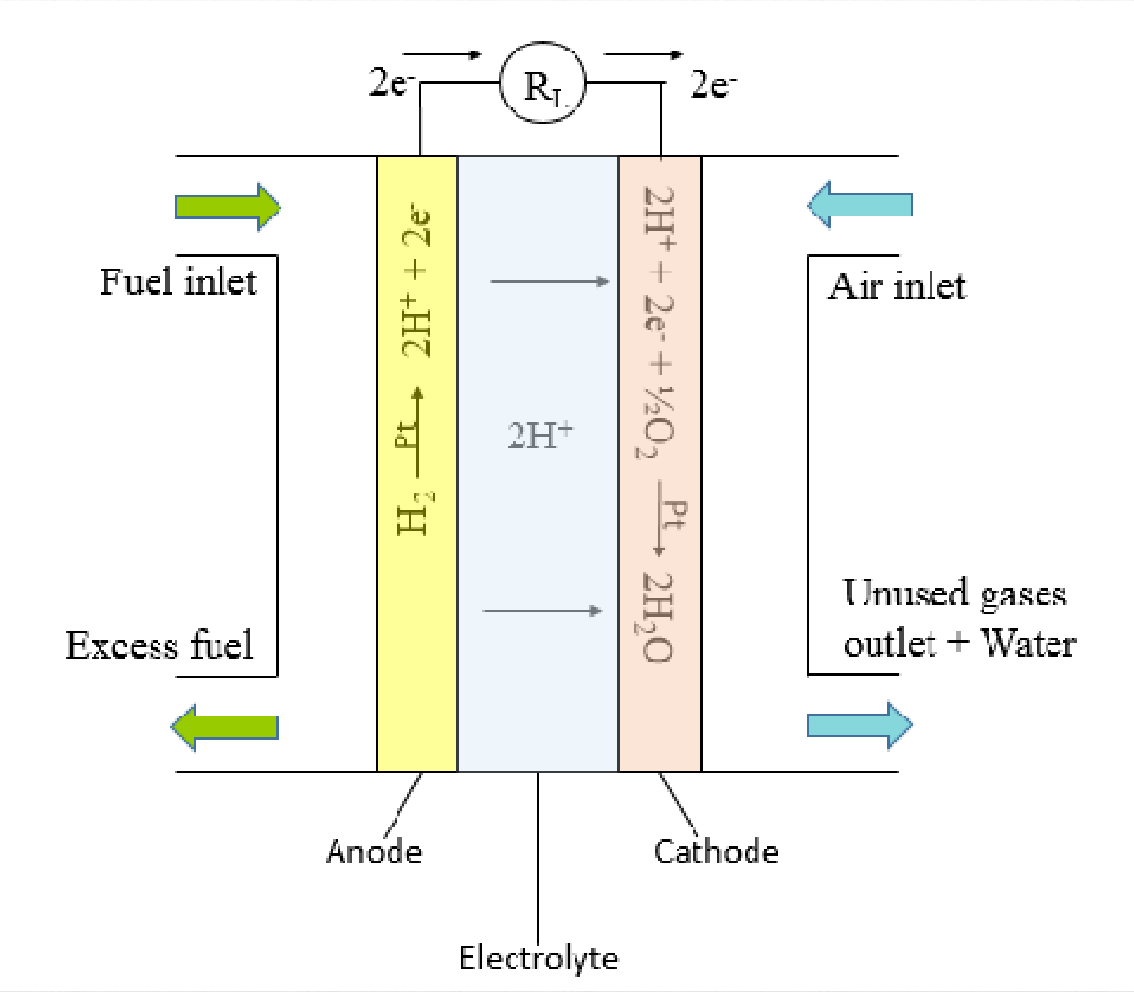
LEAD ACID CELL BATTERY



Fuel Cell

- Fuel cells require a continuous input of fuel and an oxidizing agent (generally oxygen) in order to sustain the reactions that generate the electricity. Therefore, these cells can constantly generate electricity until the supply of fuel and oxygen is cut off.
- Despite being invented in the year 1838, fuel cells began commercial use only a century later when they were used by NASA to power space capsules and satellites. Today, these devices are used as the primary or secondary source of power for many facilities including industries, commercial buildings, and residential buildings.
- A fuel cell is similar to electrochemical cells, which consists of a cathode, an anode, and an electrolyte. In these cells, the electrolyte enables the movement of the protons.

Fuel Cell



2e-
R_L
2e-
Fuel inlet
Excess fuel
H2 —Pt→ 2H+ + 2e-
2H+
2H+ + 2e- + ½O2 —Pt→ 2H2O
Air inlet
Unused gases outlet + Water
Anode
Cathode
Electrolyte

Working principle of fuel cell

- A fuel, such as hydrogen, is fed to the anode, and air is fed to the cathode. In a hydrogen fuel cell, a catalyst at the anode separates hydrogen molecules into protons and electrons, which take different paths to the cathode. The electrons go through an external circuit, creating a flow of electricity.

DC MACHINE

A DC Machine is an electro-mechanical energy conversion device. There are two types of DC machines; one is the DC generator, and another one is known as DC motor. A DC generator converts mechanical power (ωT) into DC electrical power (EI), whereas, a DC motor converts d.c electrical power into mechanical power. The AC motor is invariably applied in the industry for conversion of electrical power into mechanical power, but at the places where the wide range of speeds and good speed regulation is required, like in electric traction system, a DC motor is used. The construction of the dc motor and generator is nearly the same. The generator is employed in a very protected way. Hence there is an open construction type.

But the motor is used in the location where they are exposed to dust and moisture, and hence it requires enclosures for example dirt proof, fireproof, etc. according to requirement.

Although the battery is an important source of DC electric power, it can only supply limited power to any machines.

There are some applications where large quantities of DC power are required, such as electroplating, electrolysis, etc. Hence, at such places, DC generators are used to deliver power.

Classifications Of DC Machines

1. DC Motors
2. DC Generators

D.C. Generators

- Introduction

- Although a far greater percentage of the electrical machines in service are a.c. machines, the d.c. machines are of considerable industrial importance. The principal advantage of the d.c. machine, particularly the d.c. motor, is that it provides a fine control of speed. Such an advantage is not claimed by any a.c. motor. However, d.c. generators are not as common as they used to be, because direct current, when required, is mainly obtained from an a.c. supply by the use of rectifiers. Nevertheless, an understanding of d.c. generator is important because it represents a logical introduction to the behaviour of d.c. motors. Indeed many d.c. motors in industry actually operate as d.c. generators for a brief period. In this chapter, we shall deal with various aspects of d.c. generators.

Generator Principle

- An electric generator is a machine that converts mechanical energy into electrical energy. An electric generator is based on the principle that whenever flux is cut by a conductor, an e.m.f. is induced which will cause a current to flow if the conductor circuit is closed. The direction of induced e.m.f. (and hence current) is given by Fleming's right hand rule. Therefore, the essential components of a generator are: (a) a magnetic field (b) conductor or a group of conductors (c) motion of conductor w.r.t. magnetic field.

E.M.F. Equation of a D.C. Generator

We shall now derive an expression for the e.m.f. generated in a d.c. generator.

Let ϕ = flux/pole in Wb

Z = total number of armature conductors

P = number of poles

A = number of parallel paths = 2 ... for wave winding

= P ... for lap winding

N = speed of armature in r.p.m.

E_g = e.m.f. of the generator = e.m.f./parallel path

Flux cut by one conductor in one revolution of the armature,

$$d\phi = P\phi \text{ webers}$$

Time taken to complete one revolution,

$$dt = 60/N \text{ second}$$

$$\text{e.m.f generated/conductor} = \frac{d\phi}{dt} = \frac{P\phi}{60/N} = \frac{P\phi N}{60} \text{ volts}$$

e.m.f. of generator,

$$E_g = \text{e.m.f. per parallel path}$$

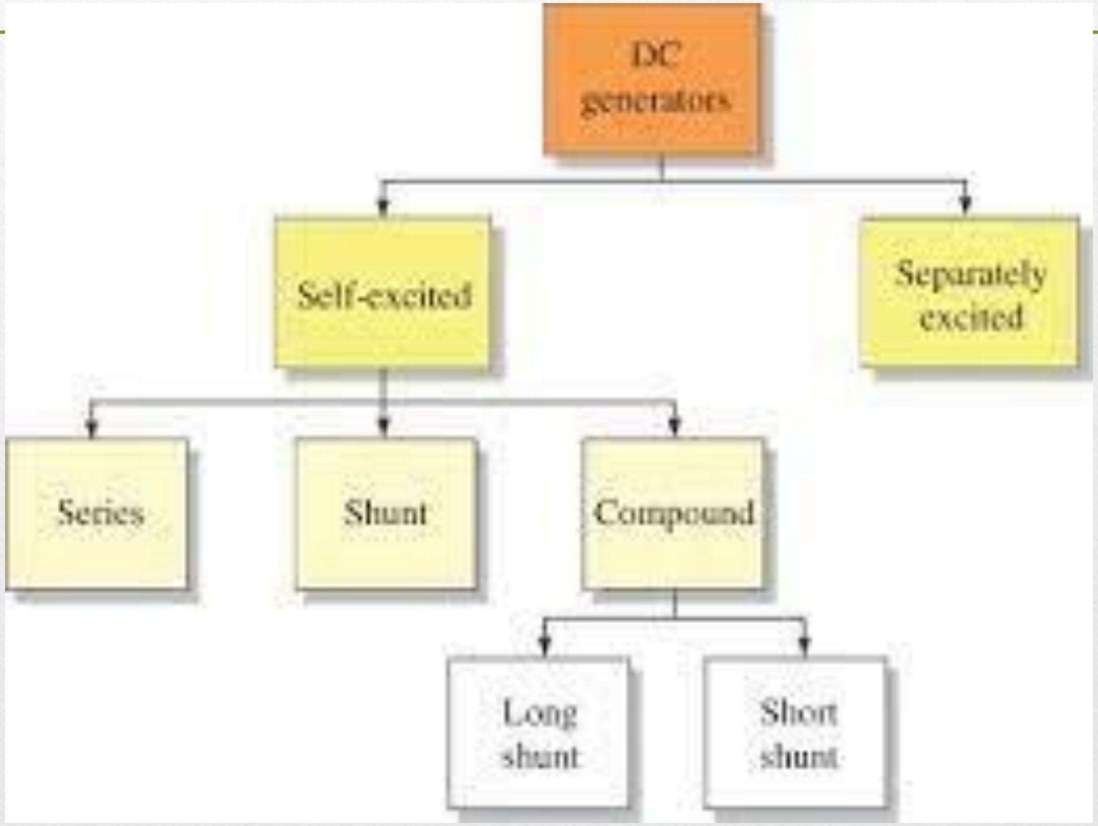
$$= (\text{e.m.f/conductor}) \times \text{No. of conductors in series per parallel path}$$

$$= \frac{P\phi N}{60} \times \frac{Z}{A}$$

$$\therefore \quad E_g = \frac{P\phi ZN}{60A}$$

where $A = 2$ for-wave winding

CLASSIFICATION OF DC GENERATOR



Types of D.C. Generators

- The magnetic field in a d.c. generator is normally produced by electromagnets rather than permanent magnets. Generators are generally classified according to their methods of field excitation. On this basis, d.c. generators are divided into the following two classes:

(i) Separately excited d.c. generators

(ii) Self-excited d.c. generators

The behaviour of a d.c. generator on load depends upon the method of field excitation adopted.

Separately Excited D.C. Generators

D.C. generator whose field magnet winding is supplied from an independent external d.c. source (e.g., a battery etc.) is called a separately excited generator. Fig. (1.32) shows the connections of a separately excited generator. The voltage output depends upon the speed of rotation of armature and the field current (Eg = Pf ZN/60 A). The greater the speed and field current, greater is the generated e.m.f. It may be noted that separately excited d.c. generators are rarely used in practice. The d.c. generators are normally of self-excited type.

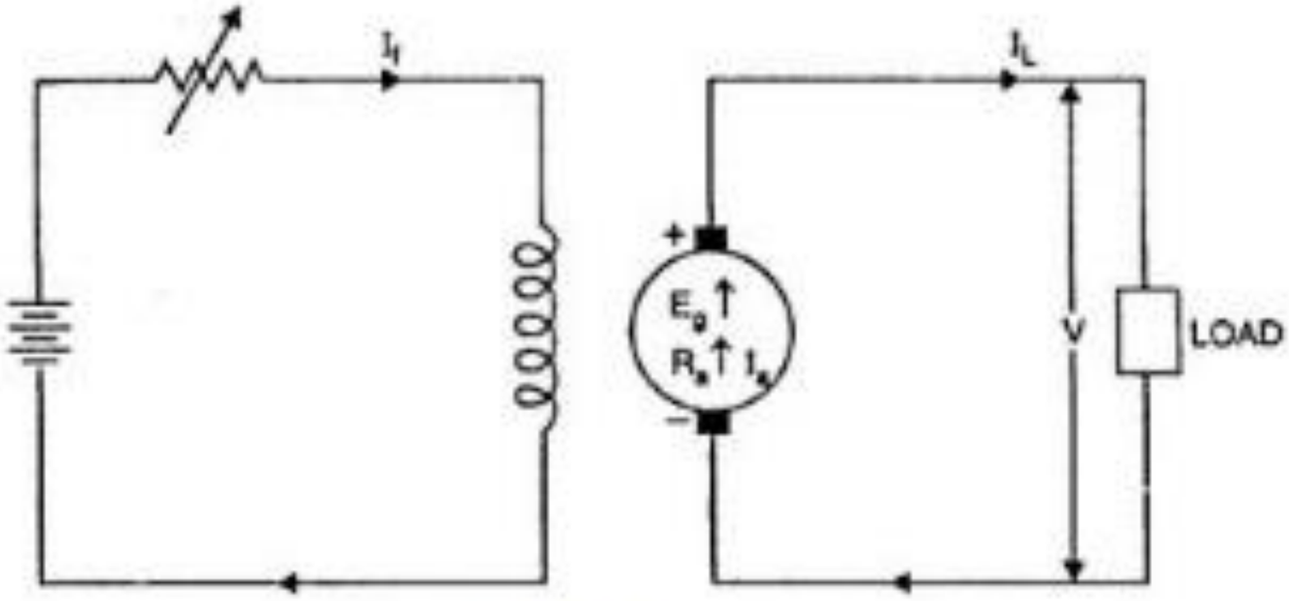


Fig. (1.32)

Armature current, $I_a = I_L$

Terminal voltage, $V = E_g - I_aR_a$

Electric power developed = E_gI_a

Power delivered to load = $E_gI_a - I_a^2R_a = I_a(E_g - I_aR_a) = VI_a$

Self-Excited D.C. Generators

- A d.c. generator whose field magnet winding is supplied current from the output of the generator itself is called a self-excited generator. There are three types of self-excited generators depending upon the manner in which the field winding is connected to the armature, namely;
- (i) Series generator;
- (ii) Shunt generator;
- (iii) Compound generator

Series generator

- In a series wound generator, the field winding is connected in series with armature winding so that whole armature current flows through the field winding as well as the load. Fig. (1.33) shows the connections of a series wound generator. Since the field winding carries the whole of load current, it has a few turns of thick wire having low resistance. Series generators are rarely used except for special purposes e.g., as boosters.

Armature current, $I_a = I_{se} = I_L = I(say)$

Terminal voltage, $V = E_G - I(R_a + R_{se})$

Power developed in armature $= E_g I_a$

Power delivered to load

$$= E_g I_a - I_a^2 (R_a + R_{se}) = I_a [E_g - I_a (R_a - R_{se})] = VI_a \text{ or } VI_L$$

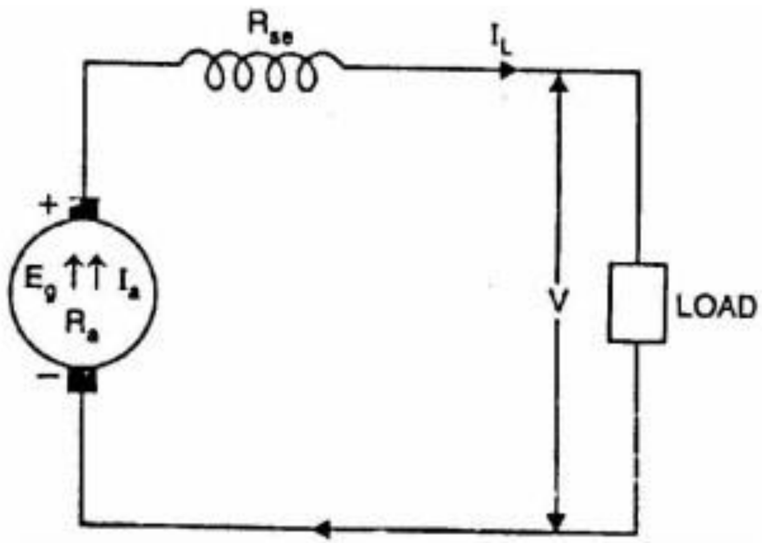


Fig. (1.33)

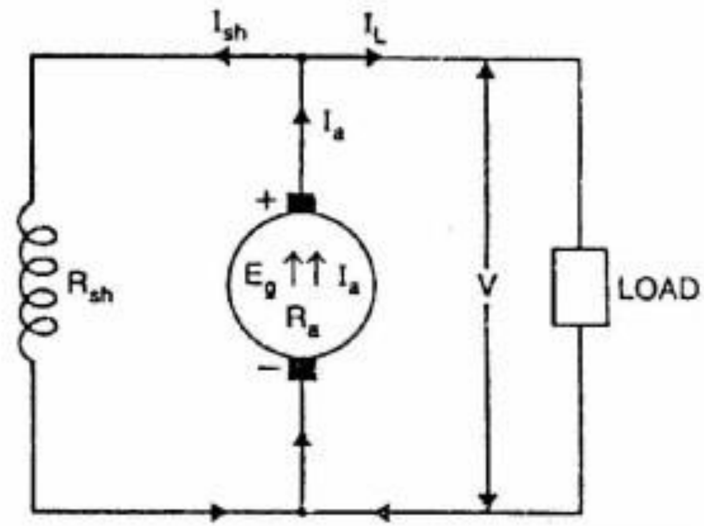


Fig. (1.34)

Shunt generator

- In a shunt generator, the field winding is connected in parallel with the armature winding so that terminal voltage of the generator is applied across it. The shunt field winding has many turns of fine wire having high resistance. Therefore, only a part of armature current flows through shunt field winding and the rest flows through the load. Fig. (1.34) shows the connections of a shunt-wound generator.

- Shunt field current, $I_{sh} = V/R_{sh}$
- Armature current, $I_a = I_L + I_{sh}$
- Terminal voltage, $V = E_g - I_aR_a$
- Power developed in armature $= E_gI_a$
- Power delivered to load $= VI_L$

Compound generator

- In a compound-wound generator, there are two sets of field windings on each pole—one is in series and the other in parallel with the armature. A compound wound generator may be: (a) Short Shunt in which only shunt field winding is in parallel with the armature winding [See Fig. 1.35 (i)]. (b) Long Shunt in which shunt field winding is in parallel with both series field and armature winding [See Fig. 1.35 (ii)].

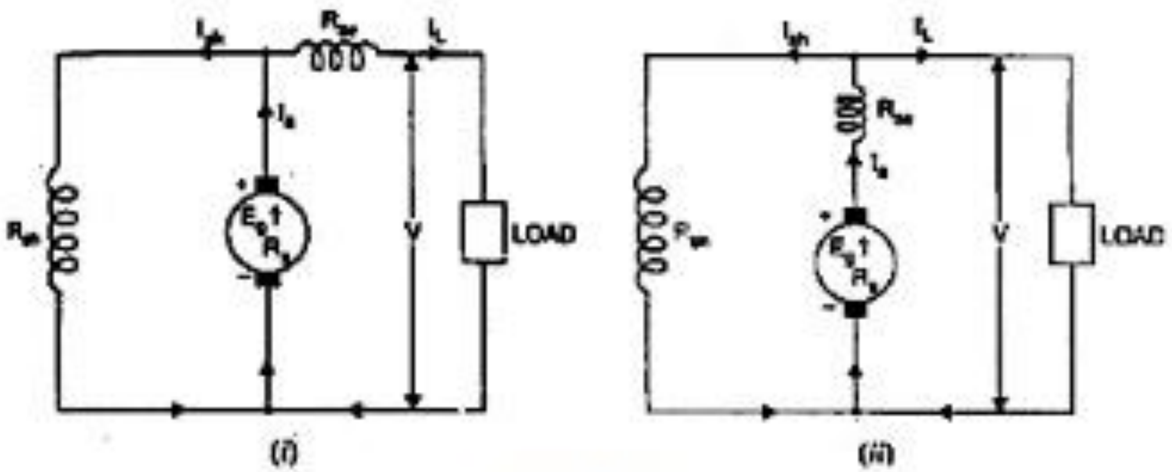


Fig. (1.35)

Short shunt

Series field current, $I_{se} = I_L$

Shunt field current, $I_{sh} = \dfrac{V + I_{se}R_{se}}{R_{sh}}$

Terminal voltage, $V = E_g - I_aR_a - I_{se}R_{se}$

Power developed in armature $= E_gI_a$

Power delivered to load $= VI_L$

Long shunt

Series field current, $I_{se} = I_a = I_L + I_{sh}$

Shunt field current, $I_{sh} = V/R_{sh}$

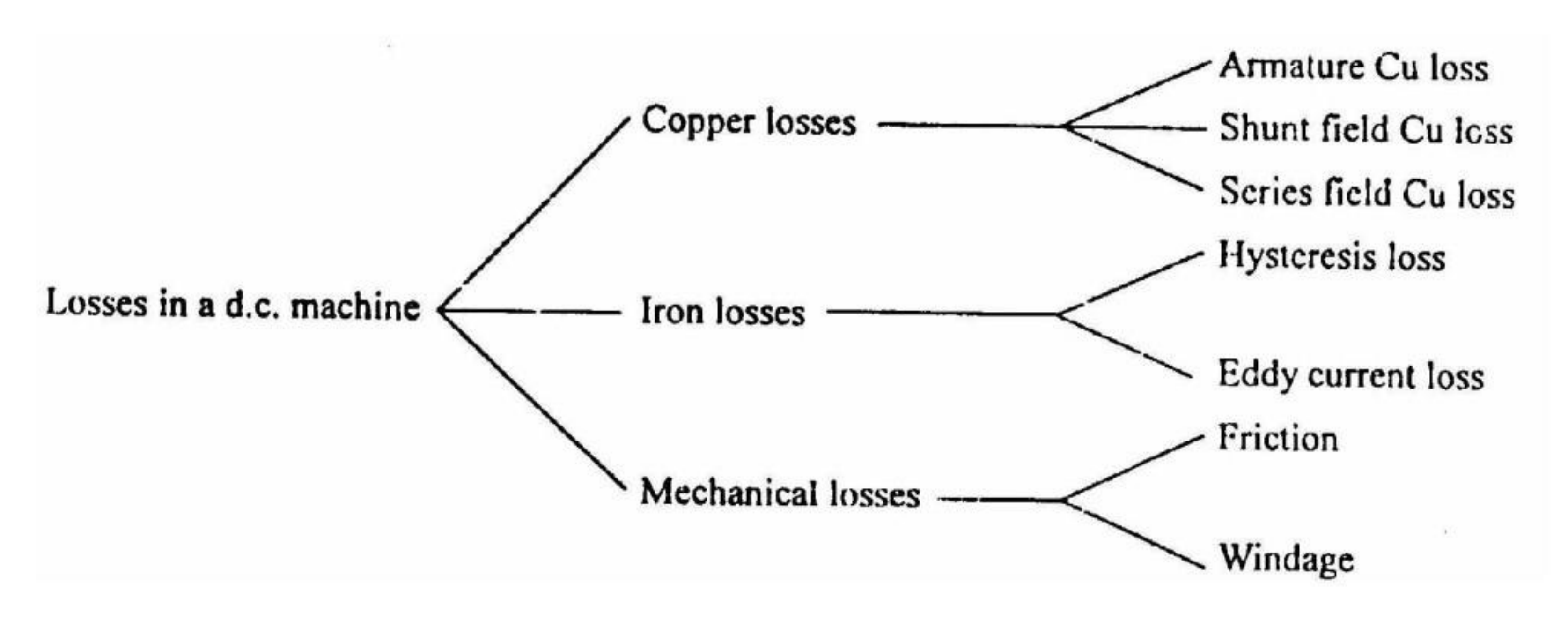
Terminal voltage, $V = E_g - I_a(R_a + R_{se})$

Power developed in armature $= E_gI_a$

Power delivered to load $= VI_L$

Losses in a D.C. Machine

- The losses in a d.c. machine (generator or motor) may be divided into three classes viz (i) copper losses (ii) iron or core losses and (iii) mechanical losses. All these losses appear as heat and thus raise the temperature of the machine. They also lower the efficiency of the machine.


Losses in a d.c. machine
Copper losses
Iron losses
Mechanical losses
Armature Cu loss
Shunt field Cu loss
Series field Cu loss
Hysteresis loss
Eddy current loss
Friction
Windage

Power Stages

- The various power stages in a d.c. generator are represented diagrammatically in Fig. (1.39).
- A - B = Iron and friction losses
- B - C = Copper losses

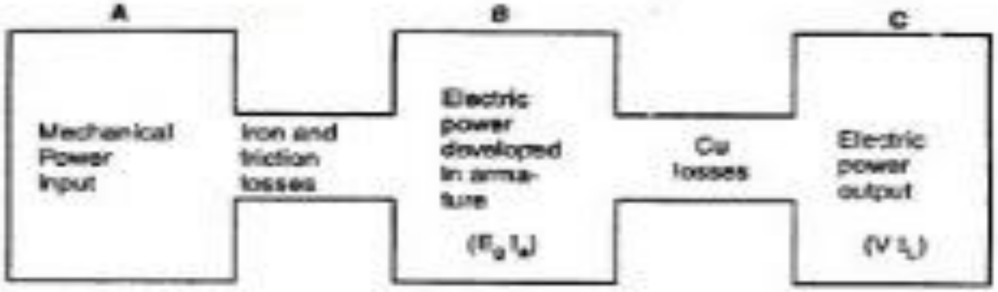


Fig. (1.39)

(i) Mechanical efficiency

$$\eta_m = \frac{B}{A} = \frac{E_g I_a}{\text{Mechanical power input}}$$

(ii) Electrical efficiency

$$\eta_e = \frac{C}{B} = \frac{V\,I_L}{E_g\,I_a}$$

(iii) Commercial or overall efficiency

$$\eta_c = \frac{C}{A} = \frac{V\,I_L}{\text{Mechanical power input}}$$

Clearly $\eta_c = \eta_m \times \eta_e$

Unless otherwise stated, commercial efficiency is always understood.

Now, commercial efficiency, $\eta_c = \frac{C}{A} = \frac{\text{output}}{\text{input}} = \frac{\text{input} - \text{losses}}{\text{input}}$

D.C. Motor

D.C. motor is a machine which converts d.c. electric energy into mechanical energy. Its action is based on the principle that when a current-carrying conductor is placed in a magnetic field, it experiences a mechanical force whose direction is given by Fleming's Left-hand Rule and whose magnitude is given by F=BIL Newton.

Constructionally , there is no basic difference between a d.c. generator and a d.c. motor. In fact, the same d.c. machine can be used interchangeably as a generator or as a motor.

Classification of D.C. Motor:

(a) Shunt motor (b) Series motor © Compound motor

D.C. Shunt motor

- V_s= Supply voltage, E_b = Back e.m.f, I_s = Supply current,
- I_a = Armature current, R_a = Armature resistance, I_{sh} = Shunt field current, R_{sh} = Shunt field resistance, V_{brush} =Total brush drop. So, voltage equation, $V_s = E_b + I_a R_a + V_{brush}$
- $E_b = V_s – I_a R_a - V_{brush}$, $E_b = (\Phi ZNP)/60A$.
- $I_{sh} = V_s / R_{sh}$, $I_s = I_a + I_{sh}$,
- Power developed in the armature = $E_b I_a$ watts.

D.C. Series motor

- V_s= Supply voltage, E_b = Back e.m.f, I_s = Supply current, Here, $I_s = I_{se} = I_a$
- I_a = Armature current, R_a = Armature resistance, I_{se} = Series field current, R_{se} = Series field resistance, V_{brush} =Total brush drop. So, voltage equation, $V_s = E_b + I_a R_a + I_{se} R_{se} + V_{brush}$ $=E_b + I_a (R_a + R_{se}) + V_{brush}$
- $E_b = V_s – I_a (R_a + R_{se}) - V_{brush}$, E_b = (ΦZNP)/60A.
- $I_s = I_a = I_{se}$,
- Power developed in the armature = $E_b I_a$ watts.

D.C. Compound motor(long shunt comp.)

- V_s= Supply voltage, E_b = Back e.m.f, I_s = Supply current,
- I_a = Armature current, R_a = Armature resistance, I_{sh} = Shunt field current, R_{sh} = Shunt field resistance, I_{se} =Series field current, R_{se} =Series field resistance, V_{brush} =Total brush drop. So, voltage equation, $V_s = E_b + I_a (R_a + R_{se}) + V_{brush}$
- $E_b = V_s - I_a (R_a + R_{se}) - V_{brush}$, $E_b = (\Phi ZNP)/60A$.
- $I_{sh} = V_s / R_{sh}$, $I_s = I_a + I_{sh}$, Here, $I_a = I_{se}$
- Power developed in the armature = $E_b I_a$ watts.

D.C. Compound motor(Short shunt comp.)

- V_s= Supply voltage, E_b = Back e.m.f, I_s = Supply current,
- I_a = Armature current, R_a = Armature resistance, I_{sh} = Shunt field current, R_{sh} = Shunt field resistance, I_{se} =Series field current, R_{se} =Series field resistance, V_{brush} =Total brush drop. So, voltage equation, $V_s = E_b + I_a R_a + I_s R_{se} + V_{brush}$
- $E_b = V_s – I_a R_a - I_s R_{se} - V_{brush}$, $E_b = (\Phi ZNP)/60A$.
- $I_{sh} = (V_s – I_s R_{se}) / R_{sh}$, $I_s = I_a + I_{sh}$, Here, $I_s = I_{se}$
- Power developed in the armature = $E_b I_a$ watts.

Back e.m.f equation of d.c. motor:

- When the motor armature rotates, the conductors also rotate and hence cut flux. In accordance with the laws of electromagnetic induction, e.m.f. is induced in them whose direction, as found by Fleming's Right-hand Rule, is in opposition to the applied voltage. Because of its opposing direction, it is referred to as counter e.m.f. or back e.m.f. E_b . The rotating armature generating the back e.m.f. E_b is like a battery of e.m.f. E_b put across a supply mains of V volts. Obviously, V has to drive I_a against the opposition of E_b . The power required to overcome this opposition is E_bI_a .
Here, $I_a = (V - E_b)/R_a$.

Torque equation of d.c. motor:

- Consider a pulley of radius r metre acted upon by a circumferential force of F Newton which causes it to rotate at N r.p.s.
- Then torque, T=F*r N-m . Work done by this force in one revolution = Force* distance = F*$2\pi r\ Joule$. Power developed =
- (F*$2\pi r * N$) joule/second =(F*r)*$2\pi N\ \ Watt$.
- Here, $2\pi N = Angular\ velocity\ (\omega)\ rad./second$
- and F*r= Torque(T)

So power developed, $P = T\omega$ Watt.$= T*2\pi N$ Watt.

- Armature Torque of a d.c. Motor: Let T_a be the torque developed by the armature of motor running at N r.p.s. If T_a is in N-m, then power developed in armature = $T_a * 2\pi N$ Watt.
- We also know that electrical power converted into mechanical power in the armature = $E_b I_a$ Watt. So we can write,
- $T_a*2\pi N = E_b I_a$. We also know , $E_b = (\Phi ZNP)/A$
- $T_a *2\pi N = (\Phi ZNP)/A * I_a$
- $T_a = \frac{1}{2\pi} . \Phi Z I_a . (\frac{P}{A})$ N-m $= 0.159 . \Phi Z I_a . (\frac{P}{A})$ N-m
- Here $T_a \propto \Phi I_a$.

For series motor: Φ is directly proportional to I_a (before saturation). $\therefore T_a \propto I_a^2$

- For shunt motor: Φ is practically constant,
- Hence, $T_a \propto I_a$.

Shaft torque: The torque which is available for doing useful work is known as shaft torque T_{sh} .It is so called because it is available at the shaft.

- The motor output = $T_{sh} \times 2\pi N$ Watt. T_{sh} = Shaft
- Torque in N-m and N in r.p.s.
- $T_{sh} = \frac{output\ in\ watts}{2\pi N}$ N-m Here, N in r.p.s.
- $T_{sh} = \frac{output\ in\ watts}{2\pi N/60}$ N-m Here, N in r.p.m. = $9.55\ \frac{output}{N}$ N-m
- The difference(T_a - T_{sh}) is known as lost torque and is due to iron and friction losses of the motor.

Problem: Determine developed torque and shaft torque of 220V. 4-pole series motor with 800 conductors wave-connected supplying a load of 8.2 kw by taking 45A from mains. The flux per pole is 25 mWb and its armature resistance is 0.6Ω .

- **Solution:** Developed torque = Gross torque = Armature torque
- Here, Output =8.2KW = 8200 W, Φ = 25 mWb = 0.025 Wb. Z = 800
- P = 4 I_a = 45 Amp. A = 2
- $T_a = 0.159\Phi Z I_a\,(P/A) = 0.159\times25\times10^{-3}\times800\times45\times(4/2) = 286.2$ N-m Ans.
- $E_b = V - I_a R_a = 220 - 45\times0.6 = 193$ V
- $E_b = (\Phi ZNP)/A \quad \therefore N = (E_b A)/(\Phi ZP) = (193\times2)/(0.025\times800\times4) = 4.825$ r.p.s.
- T_{sh} =Output/$2\pi N$ = 8200/(2×3.14×4.825) = 270.61 N-m Ans.

Problem: A 220-V d.c. shunt motor runs at 500 r.p.m. when the current is 50A. Calculate the speed if the torque is doubled. Given that $R_a = 0.2\ \Omega$.

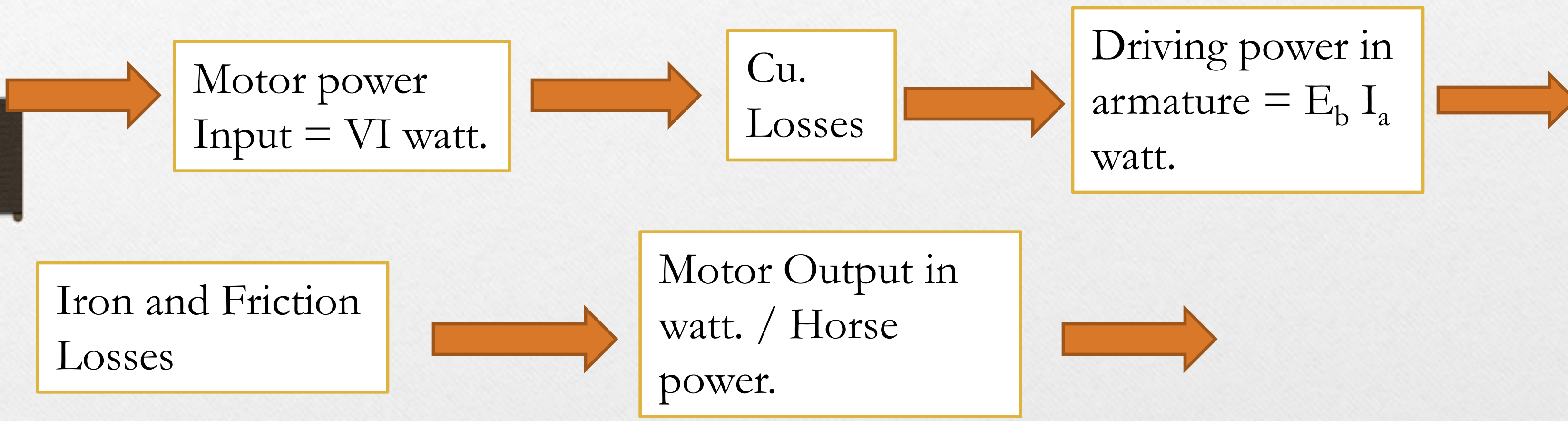
- We know for shunt motor $T_a \propto \Phi I_a$ Since Φ is constant $\therefore T_a \propto I_a$
- $\therefore T_{a1} \propto I_{a1}$ And $T_{a2} \propto I_{a2}$ $\therefore$ $T_{a2} / T_{a1} = I_{a2} / I_{a1}$
- $2 = I_{a2} / 50$ $\therefore I_{a2} = 100A$
- Again, $N_2 / N_1 = E_{b2} / E_{b1}$ Since Φ remains constant.
- $E_{b1} = V - I_{a1} R_a = 220 - (50 \times 0.2) = 210\ V$
- $E_{b2} = V - (I_{a2} R_a) = 220 - (100 \times 0.2) = 200\ V$
- $\therefore N_2 = (200 \times 500)/210 = 476$ r.p.m. Ans.

Speed control of d.c. motor:

- Factors controlling motor speed:

- We know, $E_b = V - I_a R_a$ $N = (V - I_a R_a) A / (\Phi ZP)$, Here
- Z,P,A are constant . So, $N = K (V - I_a R_a) / \Phi$.
- $N \propto (V - I_a R_a)/\Phi$ OR, $N \propto E_b / \Phi$
- It is obvious that the speed can be controlled by varying -
- (i) Flux/ pole ,Φ (Flux control)
- (ii) Resistance R_a of armature circuit (Rheostatic control)
- (iii) Applied voltage ,V (Voltage control

Power stages of d.c. motor:



Problem: A 220 d.c. shunt motor has an armature resistance of 0.2 ohm and field resistance of 110 ohm. The motor draws 5A at 1500 r.p.m. at no load. Calculate the speed and shaft torque if the motor draws 52A at rated voltage.

- **Solution:** Here, $I_{sh} = 220/110 = 2A$; $I_{a1} = 5 – 2 = 3A$; $I = 52 - 2 = 50A$. So, $E_{b1} = 220 - 3\times 0.2 = 219.4V$; $E_{b2} = 220 - 50\times0.2 = 210V$. $N_2/1500 = 210/219.4 = 1436$ r.p.m. Because $\Phi_1 = \Phi_2$
- For finding the shaft torque, we will find the motor output when it draws a current of 52A . First we will use the no-load data for finding the constant losses of the motor. No load motor input = 220×5=1100 watt. No load armature cu. Loss = $3^2 \times 0.2 = 1.8$ watt. Constant losses of the motor = 1100 – 1.8 =1098.2 W. When loaded arm. Cu. Losses = $50^2 \times 0.2 = 500$ W
- Total motor losses = 1098.2 + 500 = 1598.2 W
- Motor input on load = 220× 52 = 11440 W. Motor output on load = 11440 – 1598.2 = 9841.8 W. $T_{sh} = 9.55\times$ Motor output/N = 9.55× 9841.8/1436 = 65.5 N-m Ans.

Problem: A 500V d.c. shunt motor takes a current of 5A on no-load . The resistances of the armature and shunt field circuit are 0.22 ohm and 250 ohm respectively . Find (a) the efficiency when loaded and taking current of 100A (b) the percentage change of speed .

- **Solution:** No-load condition: $I_{sh} = 500/250 = 2A$; $I_{ao} = 5 - 2 = 3A$; $E_{bo} = 500 - (3\times 0.22) = 499.34V$; armature cu. Loss $= 3^2\times 0.22 = 1.98W$
- Motor input $= 500\times 5 = 2500$ W ; Constant losses $= 2500 - 1.98 = 2498.2$ W
- Load condition: Motor current = 100A ; $I_a = 100 - 2 = 98A$;
- $E_b = 500 - 98\times 0.22 = 478.44V$; Armature cu. Loss $= 98^2\times 0.22 = 2110$ W
- Total losses $= 2110 + 2498.2 = 4608.2$ W ; Motor input $= 500\times 100 = 50000W$
- Motor output $= 50000 - 4608.2 = 45391.8$ W. Motor $\eta = 45391.8/50000 = 0.908 = 90.8\%$ Ans. $N/N_0 = E_b / E_{b0} = 478.44/499.34$
- $(N - N_0)/N_0 = (478.44 - 499.34)/499.34 = -0.0418 = -4.18\%$ Ans.

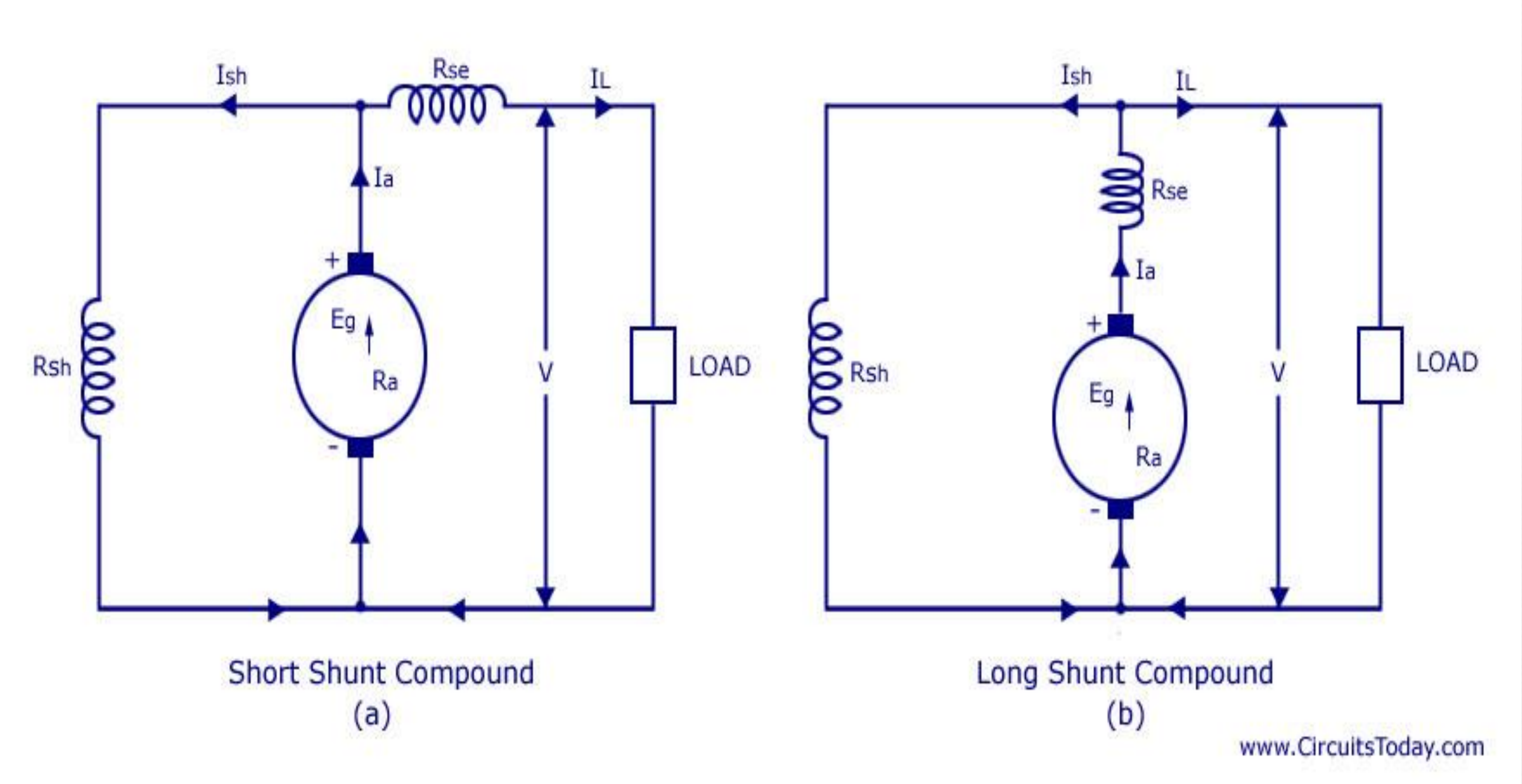
Induction Motor: In a.c. motor, the rotor does not receive electric power by conduction but by induction in exactly the same way as the secondary of a two winding transformer receives its power from the primary. That is why such motors are known as induction motors. In fact , an induction motor can be treated as a rotating transformer i.e. one in which primary winding is stationary but the secondary is free to rotate.

- Advantages: (i) It has very simple and extremely rugged, almost unbreakable construction.
- (ii) Its cost is low and it is very reliable.
- (iii) It has sufficiently high efficiency.
- (iv) It requires minimum of maintenance.
- (v) Its starting arrangement is simple
- Disadvantages: (i) Its speed cannot be varied without sacrificing some of its efficiency.
- (ii) Just like a d.c. shunt motor , its speed decreases with increase in load .
- (iii) Its starting torque is somewhat inferior to that of a d.c. shunt motor .

Problem solve on dc generator

Problem no-01: A short shunt compound generator supplies 200A at 100V.The resistance of armature, series field & shunt field windings are 0.4, 0.3 and 60 ohms respectively. Find the emf generated. Also find the emf generated if same machine is connected as a long-shunt machine.

Figures



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Short Shunt Compound
(a)
Long Shunt Compound
(b)
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Solution: For short-shunt connection: Here, Generator terminal voltage=Vt =100V, series field current, Ise = I_L = 200A, Armature terminal voltage, V_a=Vt + Ise Rse = 100 + 200 * 0.03 = 106V , Shunt field current, Ish = 106/60 = 1.767amp , Armature current, Ia = I_L + Ish = 200 + 1.767 =201.767amp , Armature induced emf Vg = Va + IaRa = 106 + 201.767* 0.04 = **114.07volts.** (Ans.)

For **Long- shunt connection:** Shunt field current, Ish = 100 /60 = 1.667amp , Armature current, Ia =I_L + Ish = 200 + 1.667 = 201.667amp. Armature induced emf, Vg = Vt + Ia(Ra + Rse) = 100 + 201.667(0.04 + 0.03) = **114.12volts** (Ans.)

Problem no-02

A 4-pole, lap-wound, d.c. shunt generator has a useful flux per pole of 0.07wb. The armature winding consists of 220 turns each of 0.004 ohm resistance. Calculate the terminal voltage when running at 900 r.p.m. if the armature current is 50amps.

Solution: Here, Z=220*2=440; N=900 r.p.m; Φ=0.07wb; P=A=4

Vg=(ΦZNP)/(60A)=(0.07*440*900*4)/(60*4)= 462 volts. Total resistance of 220 turns(440 conductors)=220* 0.004= 0.88 ohm. Resistance of each path=0.88/4=0.22 ohm. Armature resistance Ra= 0.22/4=0.055 ohm. So armature voltage drop = IaRa = 50*0.055 = 2.75 volts. Now terminal voltage, Vt = Vg – IaRa = 462 – 2.75 = 459.25 volts.

The total losses in a d.c. generator

- (a) Copper losses: i) Armature copper loss (I^2 a Ra)
- ii) Shunt field copper loss(I^2_{sh} $R_{sh)}$
- iii) Series field copper loss(I^2_{se} R_{sh})
- (b) Iron losses: i) Hysteresis loss($W \propto B^{1.6}_{max}$ f)
- ii) Eddy current loss($W_e \propto B^2_{max}$ f^2)
- (c) Mechanical losses: i) Friction loss
- i) Windage loss

Stray losses: Magnetic /Iron and Mechanical losses are collectively known as stray losses. These are also known as rotational losses.

- **Constant or standing losses** : Shunt field copper loss, Magnetic/iron losses and Mechanical losses are collectively known as Constant or Standing losses (W_c) .

Efficiencies of a D.C. generator:

- Mechanical Efficiency, η_m = B/A= EgIa/(Mechanical Power Input)

Electrical Efficiency, η_e = C/B = VI/EgIa

Overall or Commercial Efficiency, η_c = C/A

$\eta_c = \eta_m * \eta_e$

Problem on-03

- A shunt generator delivers 195 A at terminal voltage of 250 V. The armature resistance and shunt field resistance are 0.02 Ω and 50 Ω respectively. The iron and friction losses equal 950 W. FIND
- (a) E.M.F generated (b) Cu losses
- (c) output of the prime motor
- (d) commercial, mechanical and electrical efficiencies

Solution

- (a) $Ish = V_{sh} / R_{sh} = 250 / 50 = 5A$, $I_a = I_L + I_{sh} = 195 + 5 = 200A$

Armature voltage drop = $IaRa = 200 \times 0.02 = 4V$

Generated e.m.f, $Eg = V_L + Ia\ Ra = 250 + 4 = 254V$

- (b) Armature Cu loss = $Ia^2R_a = 200^2 \times 0.02 = 800\ W$

Shunt Cu loss = $V_{sh} . I_{sh} = 250 \times 5 = 1250W$

TOTAL Cu loss = 1250+800 = 2050W

- (c) Stray losses=950W ;Total losses=2050+950=3000W

Output = 250×195 = 48750W ; Input = 48750+3000 = 51750W

Output prime mover = 51750W

- (d) Generator input = 51750W ; Stray losses=950W

Electrical power production in armature = 51750-950 = 50800W

$\eta_{m} =$ (50800/51750)×100 = 98.2%

Electrical or Cu losses= 2050W

η_e= {48750/(48750+2050)}×100 = 95.9%

And η_c = (48750/51750)×100 = 94.2%

Prob.-4: A short shunt compound d.c. Generator supplies a current of 100A at a voltage 220V. If the resistance of the shunt field is 50 ohm, of the series field 0.025ohm, of the armature 0.05ohm, the total brush drop is 2V and the iron and friction losses amount to 1KW, find (a) the generated e.m.f. (b) the copper losses © the prime-mover output (d) the generator efficiency. Ans. (a) 229.7V (b) 1.995KW ©24.99KW (d) 88%

Prob.-5 A 110V shunt generatorhas a full-load current of 100A , shunt field resistance of 55 ohm and constant losses of 500W . If full-load efficiency is 88% , find armature resistance, copper losses and efficiencies

Thank You for Watching My Presentation