Behavioral Objectives

1- list the types of DC generators.

2-mathematical equations of the 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 behavior of a d.c. generator on load depends upon the method of field excitation adopted.

i) Separately Excited D.C. Generators

A 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 ($E_g = P\,\phi\,Z\,N/60\,A$). 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

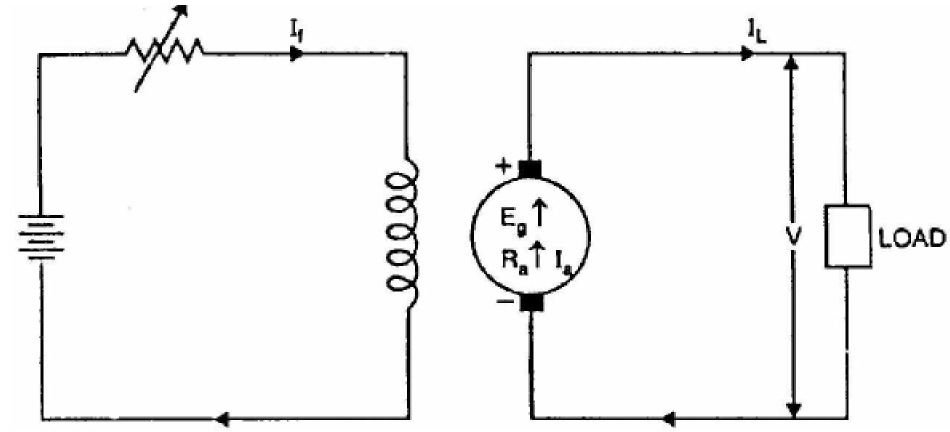

Fig. (1.32)

Armature current, $I_a = I_L$

Terminal voltage, $V = E_g - I_a * R_a$

Electric power developed = $E_g * I_a$

Power delivered to load = $E_g I_a - I_a^2 R_a = I_a (E_g - I_a R_a) = V I_a$

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

(i) 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, $V = E_g - I(Ra + R_{se})$

Power developed in armature = $E_a * I_a$

Power delivered to load

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

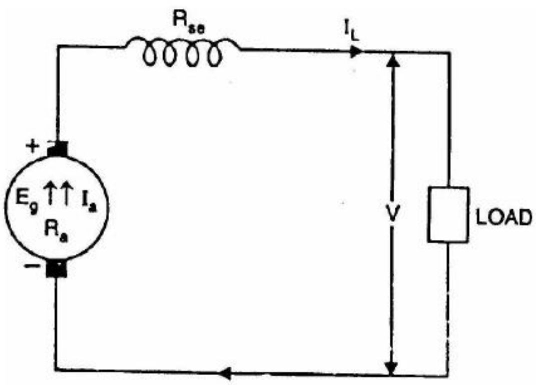

Fig. (1.33)

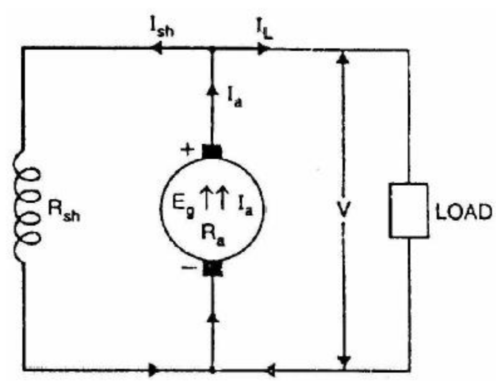

Fig. (1.34)

(ii) 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, $V = E_g - I_a * R_a$

Power developed in armature = $E_a * I_a$

Power delivered to load = **v** ∗ **I_l**

(iii) 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)].

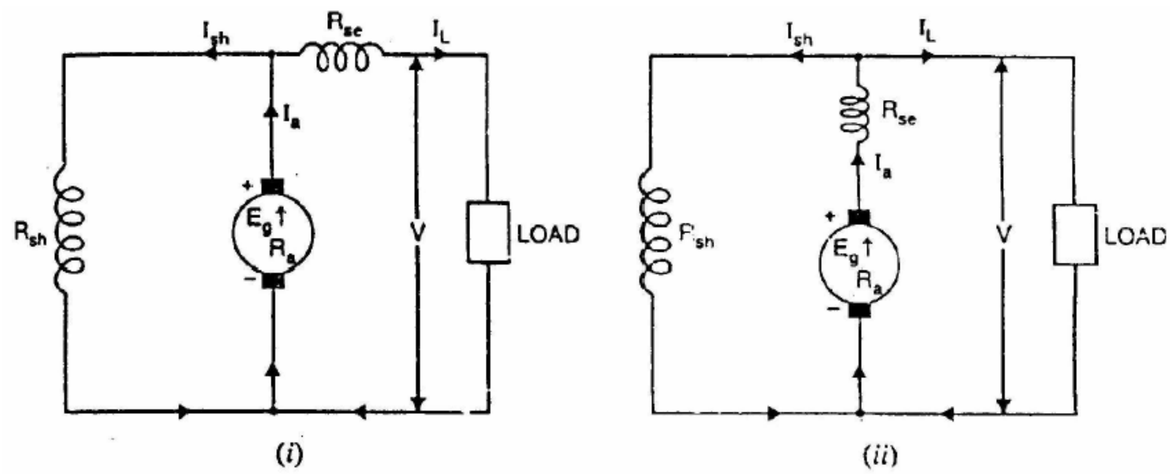

Fig. (1.35)

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 = $E_g I_a$

Power delivered to load = VI_L

Brush Contact Drop

It is the voltage drop over the brush contact resistance when current flows. Obviously, its value will depend upon the amount of current flowing and the value of contact resistance. This drop is generally small.

0.5 V for metal-graphite brushes.

2.0 V for carbon brushes.

Example 1 *A shunt generator delivers 450 A at 230 V and the resistance of the shunt field and armature are 50 Ω and 0.03 Ω respectively. Calculate the generated e.m.f.*

Solution. Generator circuit is shown in Fig. 26.46.

Current through shunt field winding is

$$I_{sh} = 230/50 = 4.6 \text{ A}$$

Load current $I = 450$ A

$\therefore$ Armature current $I_a = I + I_{sh}$

$$= 450 + 4.6 = 454.6 \text{ A}$$

Armature voltage drop

$$I_a R_a = 454.6 \times 0.03 = \mathbf{13.6\ V}$$

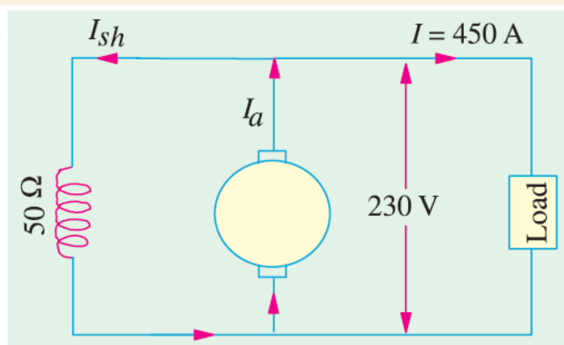

Fig. 26.46

Now E_g = terminal voltage + armature drop

$$= V + I_a R_a$$

$\therefore$ e.m.f. generated in the armature

$$E_g = 230 + 13.6 = \mathbf{243.6\ V}$$

Example 2 *A short-shunt compound generator delivers a load current of 30 A at 220 V, and has armature, series-field and shunt-field resistances of 0.05 Ω, 0.30 Ω and 200 Ω respectively. Calculate the induced e.m.f. and the armature current. Allow 1.0 V per brush for contact drop.*

(AMIE Sec. B. Elect. Machines 1991)

Solution. Generator circuit diagram is shown in Fig. 26.48.

Voltage drop in series winding = 30 × 0.3 = 9 V

Voltage across shunt winding = 220 + 9 = 229 V

$$I_{sh} = 229/200 = 1.145 \text{ A}$$

$$I_a = 30 + 1.145 = 31.145 \text{ A}$$

$$I_aR_a = 31.145 \times 0.05 = 1.56 \text{ V}$$

$$\text{Brush drop} = 2 \times 1 = 2 \text{ V}$$

$$E_g = V + \text{series drop} + \text{brush drop} + I_aR_a$$

$$= 220 + 9 + 2 + 1.56 = 232.56 \text{ V}$$

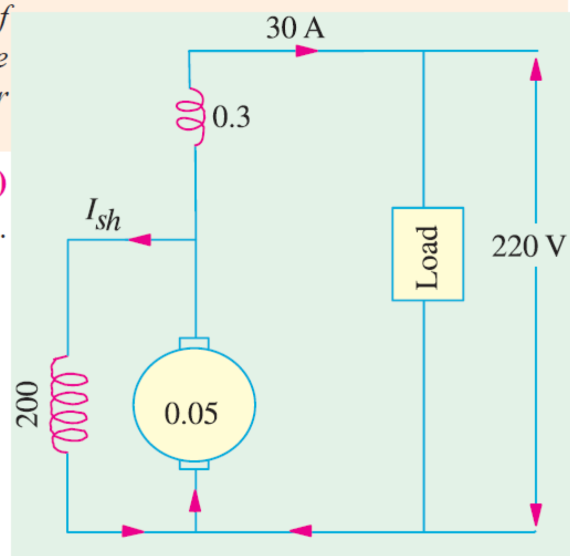

Fig. 26.48

Example 3 *A long-shunt compound generator delivers a load current of 50 A at 500 V and has armature, series field and shunt field resistances of 0.05 Ω, 0.03 Ω and 250 Ω respectively. Calculate the generated voltage and the armature current. Allow 1 V per brush for contact drop.*

(Elect. Science 1, Allahabad Univ. 1992)

Solution. Generator circuit is shown in Fig. 26.47.

$$I_{sh} = 500/250 = 2 \text{ A}$$

Current through armature and series winding is

$$= 50 + 2 = 52 \text{ A}$$

Voltage drop on series field winding

$$= 52 \times 0.03 = 1.56 \text{ V}$$

Armature voltage drop

$$I_aR_a = 52 \times 0.05 = 2.6 \text{ V}$$

Drop at brushes = 2 × 1 = 2 V

Now, $E_g = V + I_aR_a + \text{series drop} + \text{brush drop}$

$$= 500 + 2.6 + 1.56 + 2 = \textbf{506.16 V}$$

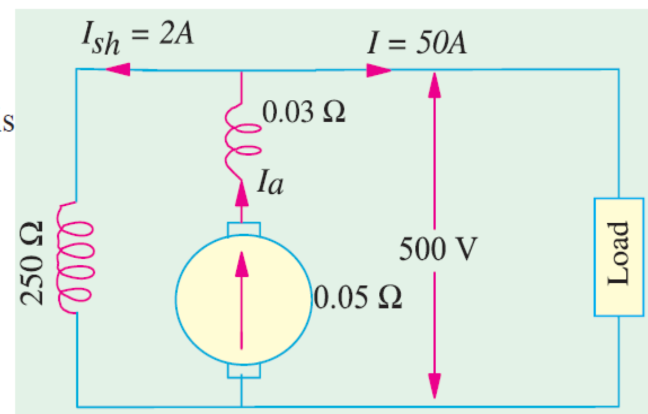

Fig. 26.47

Example 4 *The following information is given for a 300-kW, 600-V, long-shunt compound generator : Shunt field resistance = 75 Ω, armature resistance including brush resistance = 0.03 Ω, commutating field winding resistance = 0.011 Ω, series field resistance = 0.012 Ω, divertor resistance = 0.036 Ω. When the machine is delivering full load, calculate the voltage and power generated by the armature.*

(Elect. Engg-II, Pune Univ. Nov. 1989)

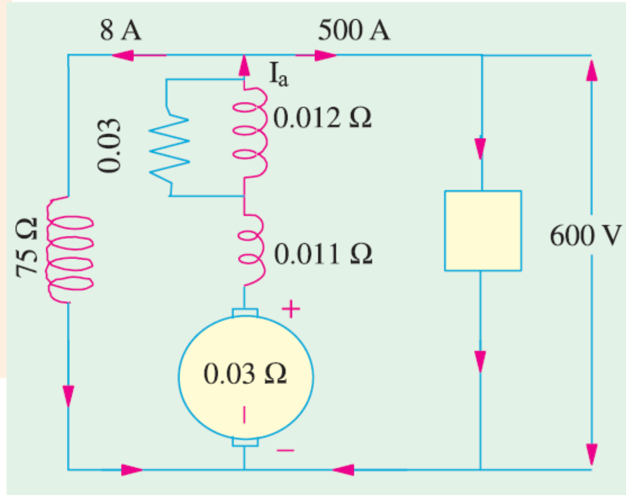

Fig. 26.50

Solution. Power output = 300,000 W

Output current = 300,000/600

= 500 A

I_{sh} = 600/75 = 8 A,

I_a = 500 + 8 = 508 A

Since the series field resistance and divertor resistance are in parallel (Fig. 26.50) their combined resistance is

$$= \frac{0.012 \times 0.036}{0.048} = 0.009\ \Omega$$

Total armature circuit resistance

$$= 0.03 - 0.011 + 0.009 = 0.05\ \Omega$$

Voltage drop = 508 × 0.05 = 25.4 V

Voltage generated by armature

$$= 600 + 25.4 = 625.4\ \text{V}$$

Power generated = 625.4 × 508 = 317,700

W = **317.7 kW**

Homework

1 *In a long-shunt compound generator, the terminal voltage is 230 V when generator delivers 150 A. Determine* ***(i)*** *induced e.m.f.* ***(ii)*** *total power generated and* ***(iii)*** *distribution of this power. Given that shunt field, series field, divertor and armature resistance are 92 Ω, 0.015 Ω, 0.03 Ω and 0.032 Ω respectively.*

2 What are the Type of dc generator ?