Chapter six

Types of d-c generators

6.1 Introduction

There are different types of d-c generators in order to cover the demand in d-c power for different loads, and overcome some difficulties in volume, weight, and price of generators. The generators classified due to their excitation in that there are two main types, the self excited and the separately excited d-c gen.

6.2 Separately – Excited d-c Generator.

The field winding in this type excited from an isolated source of voltage, so the field circuit is separated and not affected by the armature circuit & load as shown in Fig.(6-1).

The generated emf for one conductor $\boldsymbol{e_c = p\,\Phi\,n}$,

Hence the total e.m.f (E) is $E = \frac{Z}{a} P \Phi \frac{n}{60}$ -------- (6-1)

Where

Z = total number of conductor.

a = number of parallel path in armature.

$\boldsymbol{I_f = V_f / R_f}$

$\boldsymbol{I_L = I_a}$

$\boldsymbol{V_t = E - I_a R_a}$

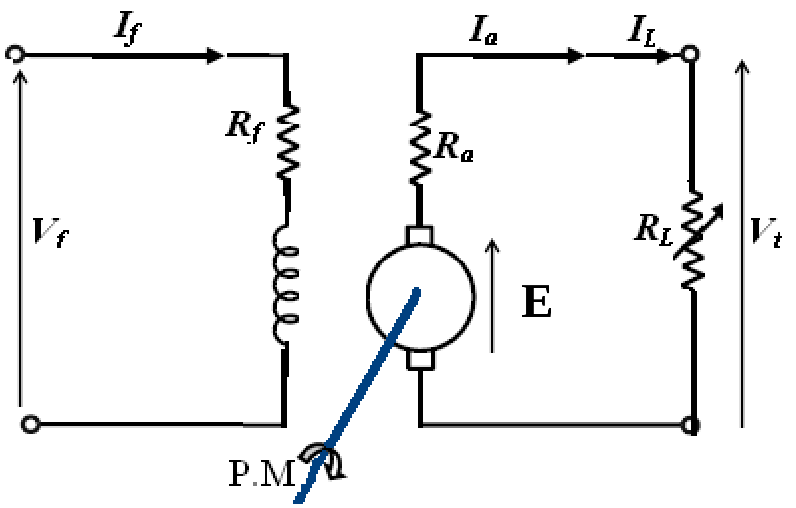


Fig.(6-1)

In eq'n (6-1) the parameter Z , a , & p are constants for each generator, while Φ & n are variables. The flux Φ is function to I_f (field current), and n (speed of rotor in ***r.p.s***) is determined by the prime mover. So the emf equation can be written as

$$E = k_e \Phi n \qquad \text{------------------(6.2)}$$

Where $K_e = \frac{Z}{a} P$

6.2.1 The Open -circuit characteristic (O.C.C.)

The relation between E and I_f at constant speed (n = const) when the load is open circuited ($R_L = \infty$) (the No-load condition) is called the open-circuit characteristic (O.C.C). The shape of this relation effected by the shape of the (***B-H)*** curve of the ferromagnetic material used to build the machine, as shown in fig. (6-2) so the terminal voltage of this type at no-load ($V_t = E$) determined by two factors (I_f & n) when n increased a parallel c/c's will be achieved as shown in fig (6-3)

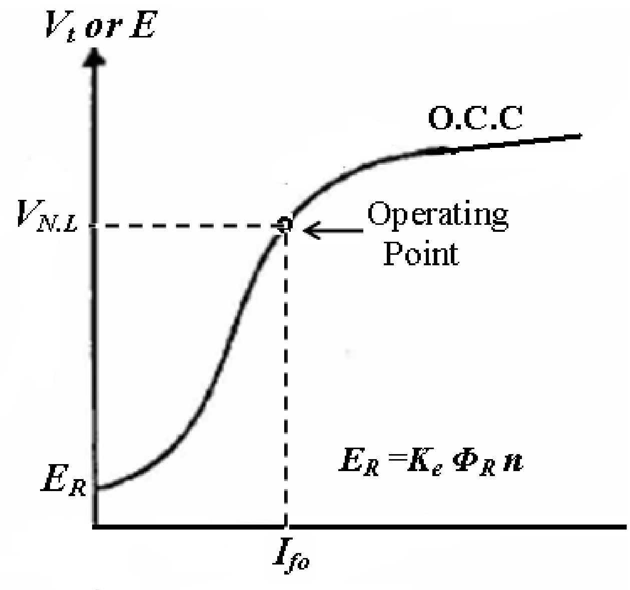


Fig.(6-2)

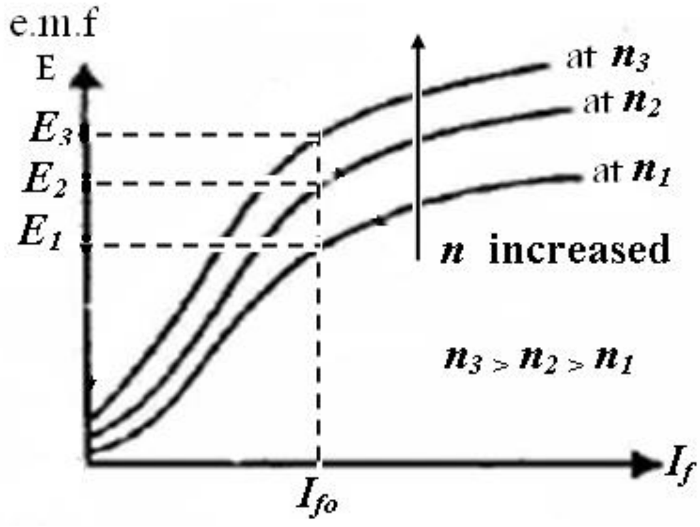


Fig.(6-3)

6. ***O.C.C for constant n*** **ıd c/c's)** ***O.C.C for variable n***

The external c/c is the relation between the terminal voltage & the load current.

In the circuit shown in fig. (6-1) & due to K.V.L.

$$V_t = E - I_a R_a \quad \text{----------- (6-3)}$$

Where $I_a = I_L$ in sep. excited d-c gen.

R_a = Armature resistance.

It is clear that eq'n (6-3) is a linear relation, so the load c/c's is a linear one as shown in fig. (6-4) which represents the external c/c's, showing that the terminal voltage will be decreased linearly. The factor representing this reduction is called the voltage regulation (***V.R.***) where

$$\%V.R. = \frac{V_{N.L} - V_{F.L}}{V_{N.L}} \times 100 \quad \text{----------(6-4)}$$

If the generator has no compensating winding so the external c/c's will not be very linear as shown in fig (6-4).

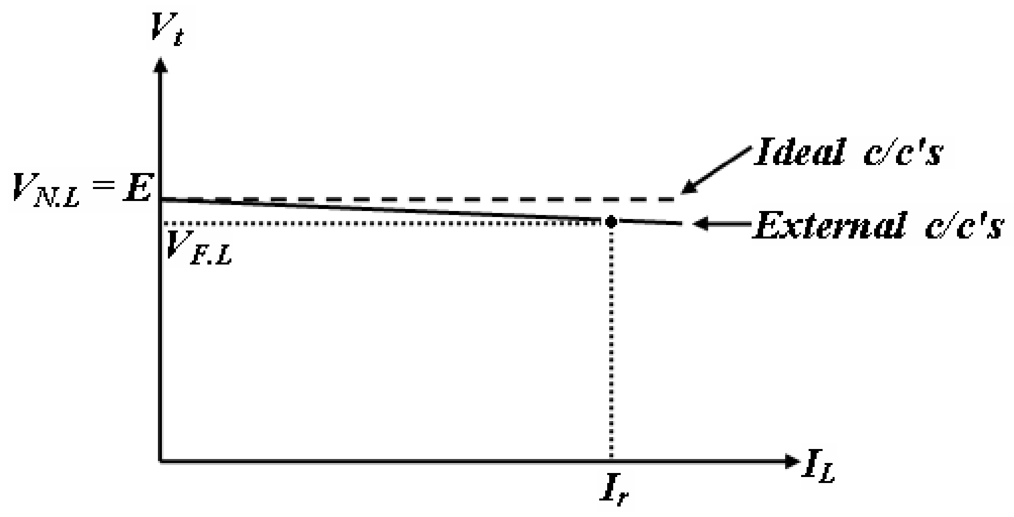


Fig.(6-4)

6.3 Self – Excited d-c generators

These generators fed their field winding by their generated voltage, so they don't need to external d-c voltage source. These types are

Self –excit
- Shunt
- Series
- Compound
  - long comp
    - Differential
    - Cumulative
  - Short comp
    - Differential
    - Cumulative

6.3.1 Shunt excited d-c generator

In this type the field winding connected in parallel (shunt) to the armature circuit as shown in fig. (6-5).

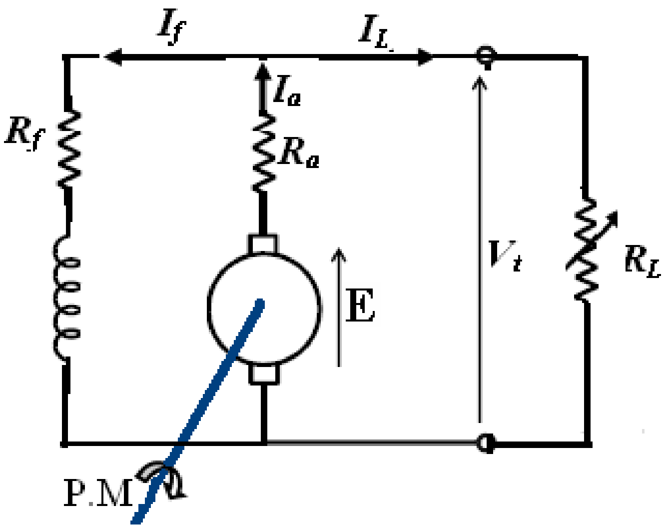


Fig.(6-5) shunt generator

In self-excited generated, the primary generated voltage depends on the residual flux in poles iron, but in shunt- gen. there are four conditions should be fulfilled in order to build-up the terminal voltage these are

1. Residual flux.
2. Polarity.
3. field Resistance < $R_{\mathbf{f\ critical}}$
4. Speed > $N_{\mathbf{critical}}$

The voltage will be increased gradually as shown in fig. (6-6)

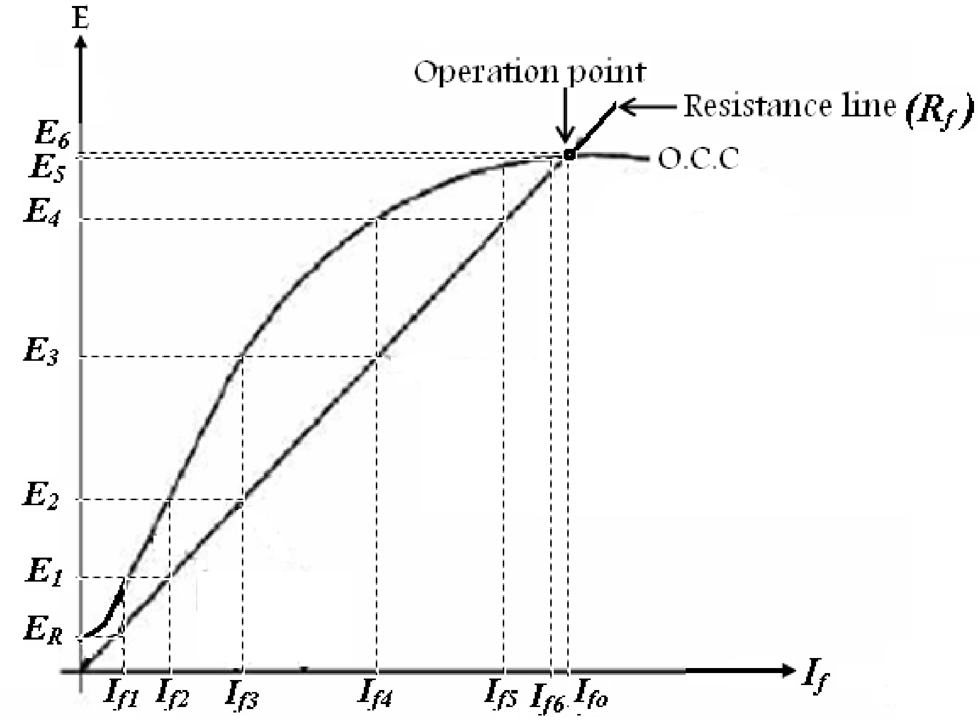


Fig.(6-6)steps of voltage build-up during starting of shunt generator

Fig. (6-6) represents the method of voltage build- up in steps, that when $\boldsymbol{I_f = 0}$ at starting and the prime mover starts up a small value of voltage $\boldsymbol{E_R}$ will be generated.

This value will initiate a low current $\boldsymbol{I_{f1}}$

$$I_{f1} = E_R / R_f \qquad (\text{Note: } R_L = \infty \quad \text{i.e o.c})$$

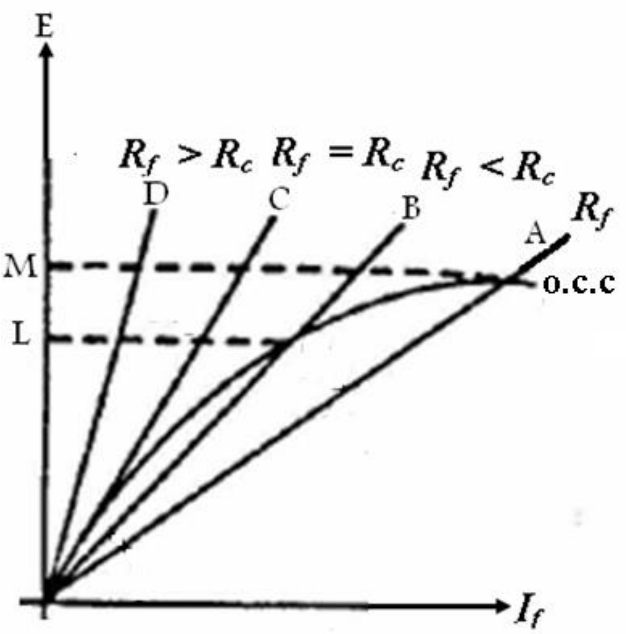
$\boldsymbol{I_{f1}}$ will increase the flux and generate E_1, … and so on until a balance will be reached at the operating point at which field current and no-load voltage will be sustained.

This methods shows the importance of the polarity of (field current, generated, voltage, direction of rotation, and the field coil terminals).

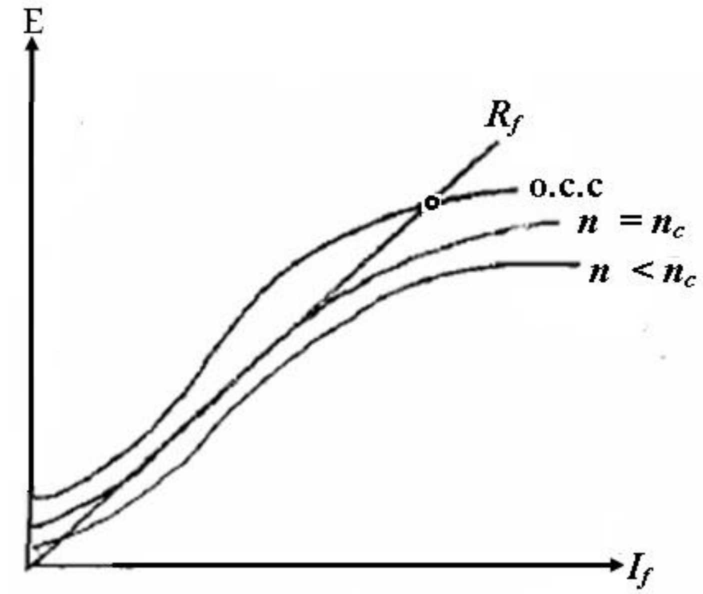
<u>The critical resistance</u> is (for constant speed) the value for field resistance in which the resistance line will be asymptotic to the linear part of the o.c.c..

<u>The critical speed</u> is (for constant field resistance) the value of speed, at which, the linear part of o.c.c. will be asymptotic to (or coincide with) the R_f line.

Fig.(6-7)



a- Critical resistance



b-Critical speed

When the load is connected to the generator fig. (6-5), the terminal voltage will obey the eq'n

$$V_t = E - I_a R_a$$

Which is the same formula used in separately -excited generator, but the difference here is in the fact that

$$V_f = V_t$$

Which lead to reduce V_f during loading and this will lead to reduce I_f and then Φ is reduce also. Since, $E = Ke\ \Phi\ n$, it will be reduce due to reduction in Φ. Hence the external c/c's will be no more linear as shown in fig. (6-8)

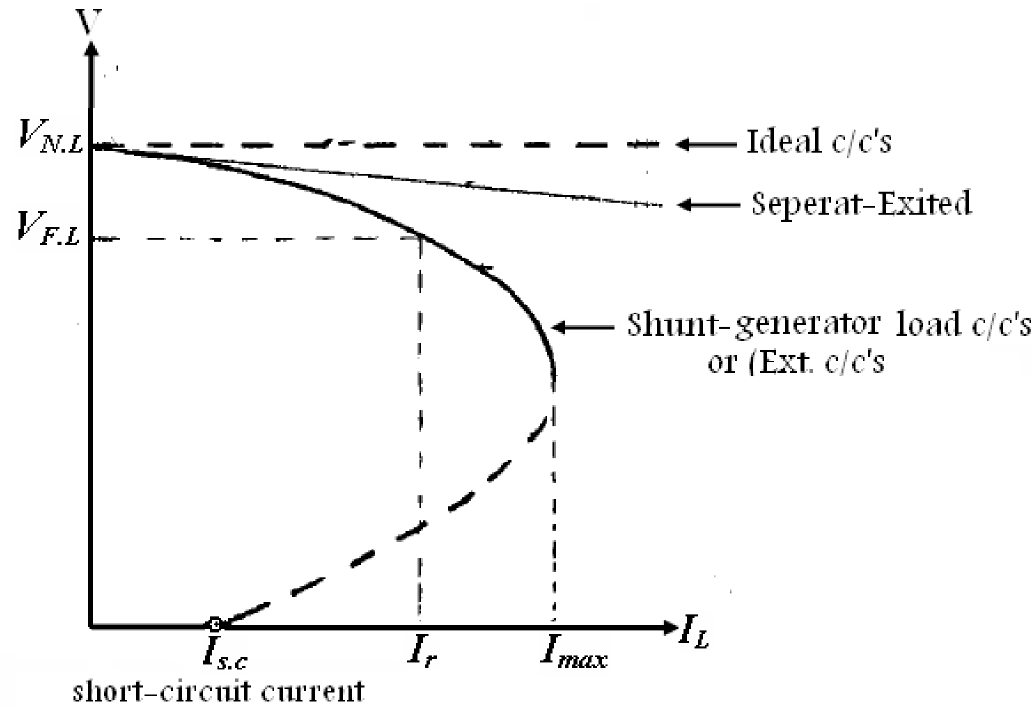


Fig.(6-8) External or load c/c's of shunt generator