Lecture 4

Chapter 28

GENERATOR CHARACTERISTICS

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DC Generator Characteristics

28.1. Characteristics of D.C. Generators

Following are the three *most* important characteristics or curves of a d.c. generator :

1. No-load saturation Characteristic (E_0/I_f)

It is also known as Magnetic Characteristic or Open-circuit Characteristic (*O.C.C.*). It shows the relation between the no-load generated e.m.f. in armature, E_0 and the field or exciting current I_f at a given fixed speed. It is just the magnetisation curve for the material of the electromagnets. Its shape is practically the same for all generators whether separately-excited or self-excited.

2. Internal or Total Characteristic (E/I_a)

3. External Characteristic (V/I)

28.2. Separately-excited Generator

(a) (i) No-load Saturation Characteristic (E_0/I_f)

The arrangement for obtaining the necessary data to plot this curve is shown in Fig. 28.1. The exciting or field current I_f is obtained from an external independent d.c. source. It can be varied from zero upwards by a potentiometer and its value read by an ammeter A connected in the field circuit as shown.

Now, the voltage equation of a d.c. generator is, $E_g = \frac{\Phi ZN}{60} \times \left(\frac{P}{A}\right)$ volt

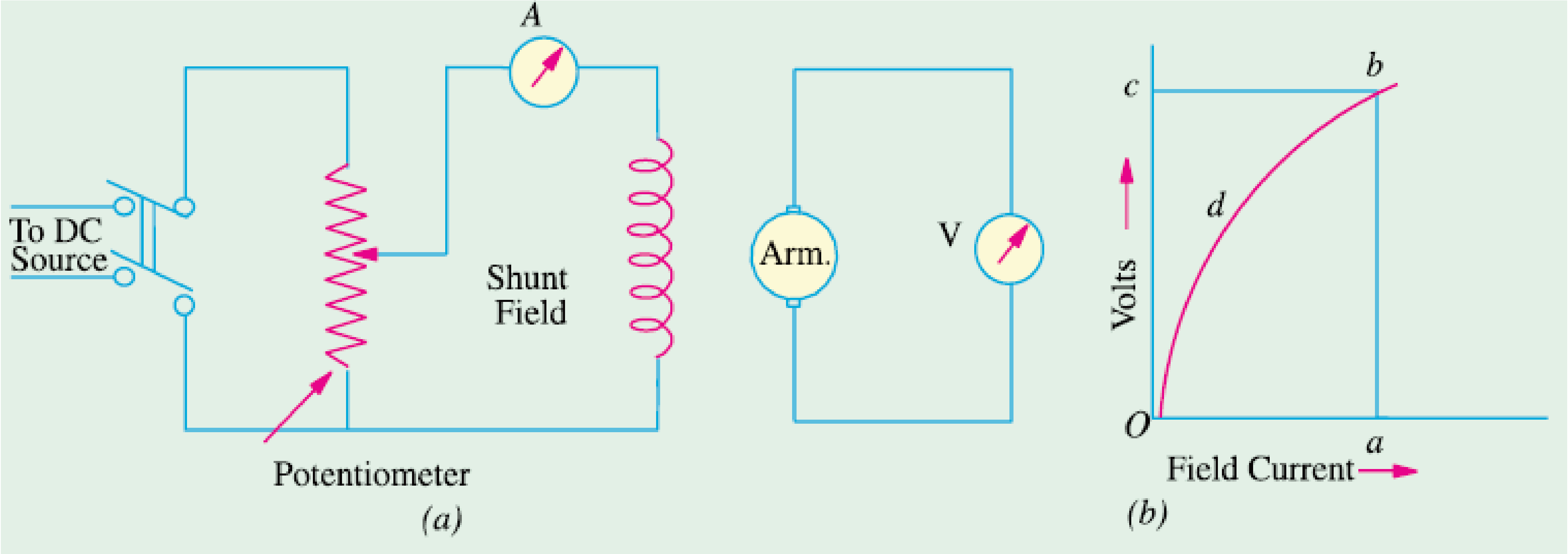

Fig. 28.1

Critical Resistance

Critical Resistance for Shunt Generator

Now, connect the field windings back to the armature and run the machine as a shunt generator. Due to residual magnetism in the poles, some e.m.f. and hence current, would be generated. This current while passing through the field coils will strengthen the magnetism of the poles (provided field coils are properly connected as regards polarity). This will increase the pole flux which will further increase the generated e.m.f. Increased e.m.f. means more current which further increases the flux and so on. This mutual reinforcement of e.m.f. and flux proceeds on till equilibrium is reached at some point like *P* (Fig. 28.6). The point lies on the resistance line *OA* of the field winding. Let *R* be the resistance of the field winding. Line *OA* is drawn such that its slope equals the field winding resistance *i.e.* every point on this curve is such that volt/ampere = *R*.

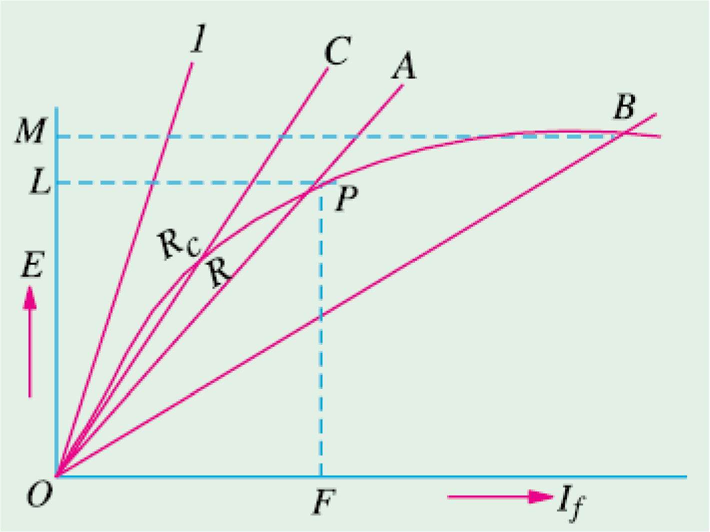

Fig. 28.6

The voltage *OL* corresponding to point *P* represents the maximum voltage to which the machine will build up with *R* as field resistance. *OB* represents smaller resistance and the corresponding voltage *OM* is slightly greater than *OL*. If field resistance is increased, then slope of the resistance line increased, and hence the maximum voltage to which the generator will build up at a given speed, decreases. If *R* is increased so much that the resistance line does not cut the *O.C.C.* at all (like *OT*), then obviously the machine will fail to excite *i.e.* there will be no 'build up' of the voltage. If the resistance line just lies along the slope, then with that value of field resistance, the machine will ***just*** excite. The value of the resistance represented by the tangent to the curve, is known as **critical resistance** R_c for a ***given speed***.

Example 28.4. *The following figures give the O.C.C. of a d.c. shunt generator at 300 r.p.m.*

Field amperes :	*0*	*2*	*3*	*4*	*5*	*6*	*7*
Armature volt :	*7.5*	*92*	*132*	*162*	*183*	*190*	*212*

Plot the O.C.C. for 375 r.p.m. and determine the voltage to which the machine will excite if field circuit resistance is 40 Ω.

(*a*) *What additional resistance would have to be inserted in the field circuit to reduce the voltage to 200 volts at 375 r.p.m.?*

(*b*) *Without this additional resistance, determine the load current supplied by the generator, when its terminal voltage is 200 V. Ignore armature reaction and assume speed to be constant. Armature resistance is 0.4 Ω.* **(Elect. Machines - I, South Gujarat Univ. 1986)**

Solution. The e.m.f. induced at 375 r.p.m. would be increased in the ratio 375/300 corresponding to different shunt field current values. A new table is given with the voltages multiplied by the above ratio.

Field amperes :	*0*	*2*	*3*	*4*	*5*	*6*	*7*
Armature volt :	*9.4*	*115*	*165*	*202.5*	*228.8*	*248.8*	*265*

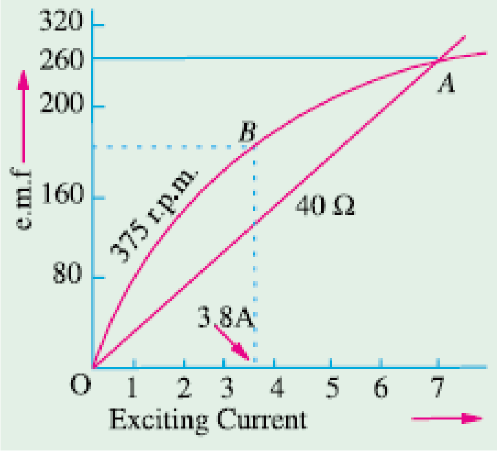

Fig. 28.11

The new *O.C.C.* at 375 r.p.m. is shown in Fig. 26.11. Line *OA* represents 40-Ω line.

The voltage corresponding to point *A* is 260 V. Hence machine will excite to 260 volt with 40 Ω shunt field resistance.

(*a*) From Fig. 28.11, it is clear that for exciting the generator to 200 V, exciting current should be 3.8 A.

∴ Field circuit resistance = 200/3.8 = 52.6 Ω

∴ Additional resistance required = 52.6 – 40 = **12.6 Ω**

(*b*) In this case, shunt field resistance = 40 Ω ...(as above)

Terminal voltage = 200 V ∴ Field current = 200/40 = 5 A

Generated e.m.f. for exciting current of 5 A = 228.8 V

For a generator $E = V + I_a R_a \therefore I_a R_a = E - V$ or $0.4\, I_a = 228.8 - 20 = 28.8$

∴ $I_a = 28.8/0.4 = 72$ A ∴ Load current $I = 72 - 5 =$ **67 A**

Voltage Regulation

28.11. Voltage Regulation

By voltage regulation of a generator is meant the change in its terminal voltage with the change in load current when it is running at a constant speed. If the change in voltage between no-load and full load is small, then the generator is said to have good regulation but if the change in voltage is large, then it has poor regulation. The ***voltage regulation of a d.c. generator is the change in voltage when the load is reduced from rated value to zero, expressed as percentage of the rated load voltage.***

If no-load voltage of a certain generator is 240 V and rated-load voltage is 220 V,

then, regn. = (240 – 220)/220 = 0.091 or 9.1 %

$$\boxed{\text{Regulation Percentage} = \frac{E_{\text{no-load}} - E_{\text{full-load}}}{E_{\text{full-load}}}(100\%)}$$