3- Generated E.M.F. or E.M.F. Equation of a Generator

Let Φ = flux/pole in weber

Z = total number of armature conductors = No. of slots × No. of conductors/slot

P = No. of generator poles

A = No. of parallel paths in armature

N = armature rotation in revolutions per minute (r.p.m.)

E = e.m.f. induced in any parallel path in armature

Generated e.m.f. Eg = e.m.f. generated in any one of the parallel paths i.e. E.

Average e.m.f. generated/conductor $= \frac{d\emptyset}{dt}\ volt\ (\because n = 1)$

Now, flux cut/conductor in one revolution dΦ = ΦP Wb

No. of revolutions/second = N/60 ∴ Time for one revolution, dt = 60/N second

Hence, according to Faraday's Laws of Electromagnetic Induction:

E.M.F. generated/conductor= $\frac{d\emptyset}{dt} = \frac{\emptyset PN}{60}\ volts$

For a simplex wave-wound generator

No. of parallel paths = 2

No. of conductors (in series) in one path = Z/2

$$\therefore E.M.F_{generated}/_{path} = \frac{\emptyset PN}{60} \times \frac{Z}{2} = \frac{\emptyset ZNP}{120}\ volt$$

For a simplex lap-wound generator

No. of parallel paths = P

No. of conductors (in series) in one path = Z/P

$$\therefore E.M.F_{generated}/_{path} = \frac{\emptyset PN}{60} \times \frac{Z}{P} = \frac{\emptyset ZN}{60}\ volt$$

In General

$$\therefore \boldsymbol{E.M.F_{generated} = \frac{\emptyset ZN}{60} \times \left\{\frac{P}{A}\right\} volt}$$

Where: A = 2-for simplex wave-winding

= P-for simplex lap-winding

Example 1. A four-pole generator, having wave-wound armature winding has 51 slots, each slot containing 20 conductors. What will be the voltage generated in the machine when driven at 1500 rpm assuming the flux per pole to be 7.0 mWb?

Solution:

$$E_g = \frac{\Phi Z N}{60}\left(\frac{P}{A}\right) \text{volts}$$

Here, $\Phi = 7 \times 10^{-3}$ Wb, $Z = 51 \times 20 = 1020$, $A = 2$, $N = 1500$ r.p.m.

$$\therefore \quad E_g = \frac{7 \times 10^{-3} \times 1020 \times 1500}{60}\left(\frac{4}{2}\right) = \mathbf{178.5\ V}$$

Example 2. An 8-pole d.c. shunt generator with 778 wave-connected armature conductors and running at 500 r.p.m. supplies a load of 12.5 Ω resistance at terminal voltage of 50 V. The armature resistance is 0.24 Ω and the field resistance is 250 Ω. Find the armature current, the induced e.m.f. and the flux per pole.

Solution:

The circuit is shown in Fig. 9

Load current = $V/R = 250/12.5 = 20$ A

Shunt current = $250/250 = 1$ A

Armature current = $20 + 1 =$ **21 A**

Induced e.m.f. = $250 + (21 \times 0.24) =$ **255.04 V**

Now, $$E_g = \frac{\Phi Z N}{60} \times \left(\frac{P}{A}\right)$$

$$\therefore \quad 255.04 = \frac{\Phi \times 778 \times 500}{60}\left(\frac{8}{2}\right)$$

$$\therefore \quad \Phi = \mathbf{9.83\ mwb}$$

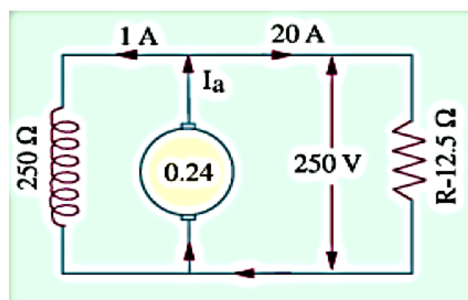

Figure 9

Example 3. A 4-pole lap-connected armature of a d.c. shunt generator is required to supply the loads connected in parallel:

(1) 5 kW Geyser at 250 V, and

(2) 2.5 kW Lighting load also at 250 V.

The Generator has an armature resistance of 0.2 ohm and a field resistance of 250 ohms. The armature has 120 conductors in the slots and runs at 1000 rpm. Allowing 1 V per brush for contact drops and neglecting friction, find:

(1) Flux per pole, (2) Armature-current per parallel path.

Solution:

Geyser current = 5000/250 = 20 A

Current for Lighting = 2500/250 = 10 A

Total current = 30 A

Field Current for Generator = 1 A

Hence, Armature Current = 31 A

Armature resistance drop = $31 \times 0.2 = 6.2$ volts

Generated e.m.f. = $250 + 6.2 + 2 = 258.2$ V,

since $E = V_t + I_a r_a$ + Total brush contact drop

For a 4-pole lap-connected armature,

Number of parallel paths = number of poles = 4

(1) The flux per pole is obtained from the emf equation

$$258.2 = [\phi Z N/60] \times (p/a)$$

$$= [\phi \times 120 \times 1000/60] \times (4/4)$$

$$= 2000\,\phi$$

$$\phi = 129.1 \text{ mWb}$$

(2) Armature current per parallel path = 31/4 = 7.75 A.