# Chapter 26

# DC GENERATORS

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# Loss In DC Generator

## 26.35. Total Loss in a D.C. Generator

The various losses occurring in a generator can be sub-divided as follows :

**(*a*) Copper Losses**

(*i*) Armature copper loss = $I_a{}^2 R_a$

[**Note :** $E_g I_a$ is the power output from armature.]

where $R_a$ = resistance of armature and interpoles and series field winding etc.

This loss is about 30 to 40% of full-load losses.

(*ii*) Field copper loss. In the case of shunt generators, it is practically constant and $I_{sh}^2 R_{sh}$ (or $VI_{sh}$). In the case of series generator, it is = $I_{se}{}^2 R_{se}$ where $R_{se}$ is resistance of the series field winding.

This loss is about 20 to 30% of F.L. losses.

(*iii*) The loss due to brush contact resistance. It is usually included in the armature copper loss.

**(*b*) Magnetic Losses** (also known as iron or core losses),

(*i*) hysteresis loss, $W_h \propto B_{max}^{1.6} f$ and (*ii*) eddy current loss, $W_e \propto B_{max}^2 f^2$

These losses are practically constant for shunt and compound-wound generators, because in their case, field current is approximately constant.

Both these losses total up to about 20 to 30% of F.L. losses.

**(*c*) Mechanical Losses.** These consist of :

(*i*) friction loss at bearings and commutator.

(*ii*) air-friction or windage loss of rotating armature.

These are about 10 to 20% of F.L. Losses.

# Loss In DC Generator

- Total losses
  - Copper losses
    - Armature Cu loss
    - Shunt Cu loss
    - Series Cu loss
  - Iron losses
    - Hysteresis
    - Eddy current
  - Mechanical losses
    - Friction
    - Windage

## 26.36. Stray Losses

Usually, magnetic and mechanical losses are collectively known as ***Stray Losses***. These are also known as rotational losses for obvious reasons.

## 26.37. Constant or Standing Losses

As said above, field Cu loss is constant for shunt and compound generators. Hence, stray losses and shunt Cu loss are constant in their case. These losses are together known as standing or constant losses $W_c$.

Hence, for shunt and compound generators,

Total loss = armature copper loss + $W_c = I_a{}^2R_a + W_c = (I + I_{sh})^2R_a + W_c$.

Armature Cu loss $I_a{}^2R_a$ is known as variable loss because it varies with the load current.

Total loss = variable loss + constant losses $W_c$

# Condition for Maximum Efficiency

## 26.39. Condition for Maximum Efficiency

Generator output = $VI$

Generator input = output + losses

$$= VI + I_a^2 R_a + W_c = VI + (I + I_{sh})^2 R_a + W_c \qquad (\because I_a = I + I_{sh})$$

However, if $I_{sh}$ is negligible as compared to load current, then $I_a = I$ (approx.)

$$\therefore \qquad \eta = \frac{\text{output}}{\text{input}} = \frac{VI}{VI + I_a^2 R_a + W_c} = \frac{VI}{VI + I^2 R_a + W_c} \qquad (\because I_a = I)$$

$$= \frac{1}{1 + \left(\frac{IR_a}{V} + \frac{W_c}{VI}\right)}$$

Now, efficiency is maximum when denominator is minimum *i.e.* when

$$\frac{d}{dI}\left(\frac{IR_a}{V} + \frac{W_c}{VI}\right) = 0 \text{ or } \frac{R_a}{V} - \frac{W_c}{VI^2} = \quad \text{or} \quad I^2 R_a = W_c$$

Hence, generator efficiency is maximum when

**Variable loss = constant loss.**

The load current corresponding to maximum efficiency is given by the relation.

$$I^2 R_a = W_c \quad \text{or} \quad I = \sqrt{\frac{W_c}{R_a}}\,.$$