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UNIT 2
PERFORMANCE OF DC GENERATOR

ARMATURE REACTION:

The effect of magnetic flux produced by the current flowing in the armature winding of a DC generator on the main flux of the field system is called armature reaction.

Or

The effect of armature flux over the distribution of main flux is called as armature reaction.

Or

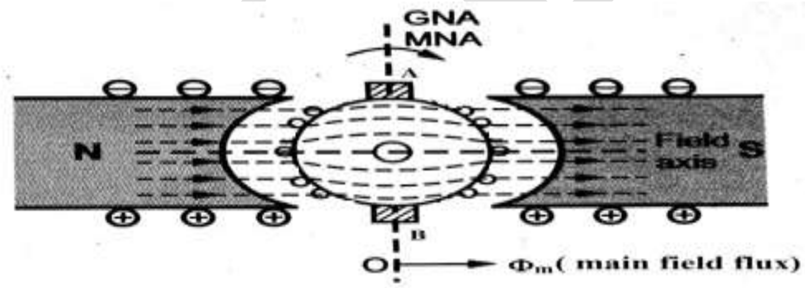
The effect of armature flux on main field flux.

Armature reaction leads to (produces) two effects.

- Cross magnetisation.
- De-magnetisation.

Consider a 2-pole machine having an armature with 10 conductors.

Case 1: Consider only the field flux:

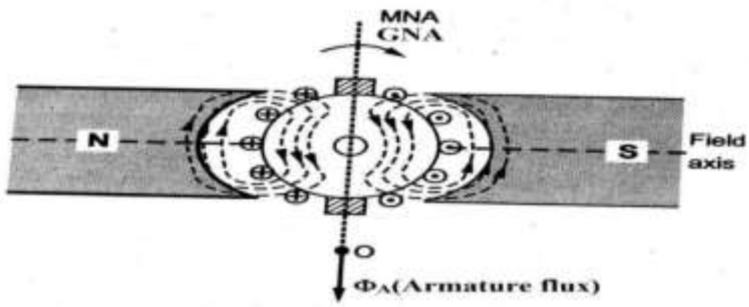


GNA:(Geometrical neutral axis):
Axis which bisects the angle between two centres of the adjacent poles is called GNA. It is perpendicular to the stator field axis.

MNA:(Magnetic neutral axis):
Axis at which armature conductor move parallel to the flux lines is called MNA. In this plane fluxes are absent and induced EMF is zero.
It is perpendicular to the magnetic flux lines. Brushes are always placed along MNA because reversal of currents in the armature conductors takes place along the axis.

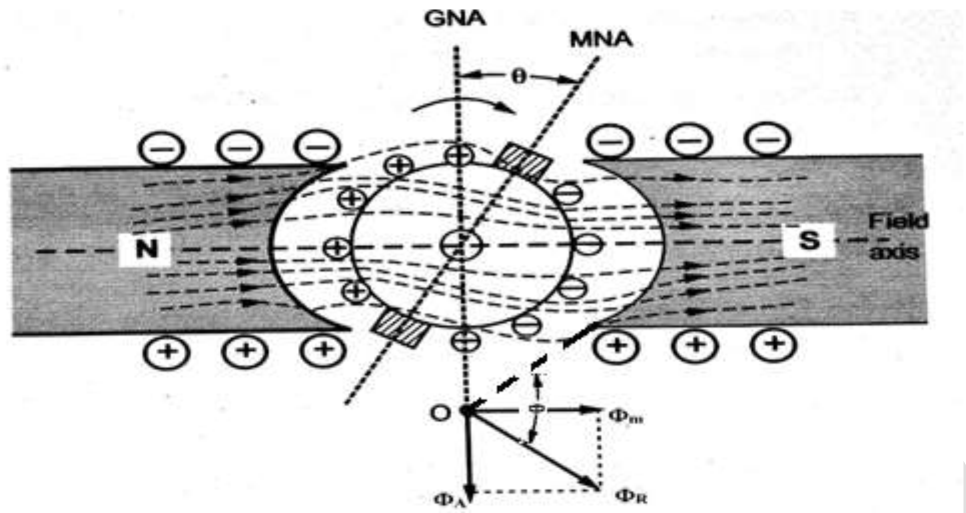
- Consider only field flux in the No-load condition of generator.
- The flux lines move from North Pole to South Pole without flux cutting from armature winding.
- In the No-load condition of generator magnetic neutral axis and geometrical neutral axis is in same plane. In this condition induced EMF in the generator is zero.
- The main flux move from North (N) pole to South (S) pole is shown in the above figure. Denoted as Φ_m.
- The brushes A & B is always in the magnetic neutral axis.

Case 2: Consider only the armature flux:



- Consider only the armature flux in the load condition of generator.
- Using main field fluxes, armature winding's produces own magnetic fluxes around the conductor.
- Both the fluxes under N & S is down word direction.
- Direction of induced EMF is decided by Flaming's right-hand rule. Under North Pole fluxes is inward and under South Pole flux is outward.

<u>Case 3:</u> consider both field flux and armature flux:



- Both the fluxes (field and armature flux) are reacted and to form resultant flux (Φ_R).
- Above figure shows the armature reaction on magnetic field (effect of armature flux on main field flux).

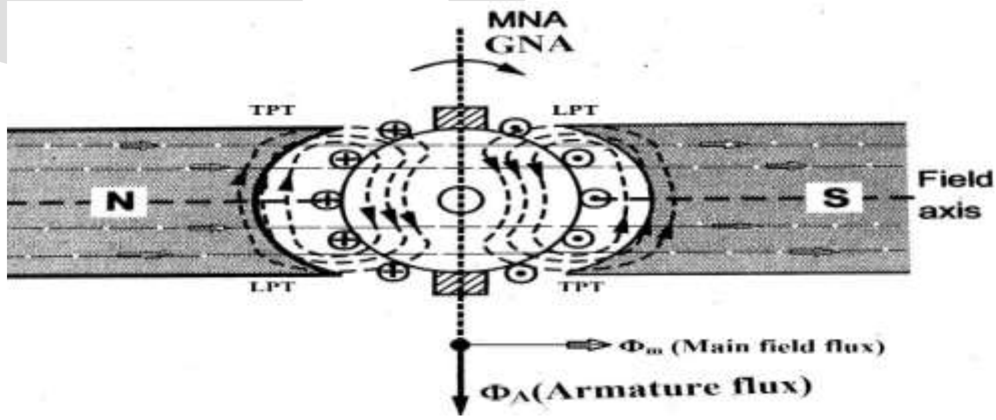
<u>CROSS MAGNETISATION and DE-MAGNETISING EFFECT:</u>

<u>CROSS MAGNETISATION:</u>

- The main field gets distorted from armature field is known as cross magnetisation.

  Or

  Distortion of the main field flux along the air gap periphery called as cross magnetizing effect.
- Cross magnetizing leads to sparking in the brushes.
- Change in the flux-density distribution in the air gap of a generator caused by armature reaction.
- In the ON load condition of a generator, the armature reaction occur in the generator.

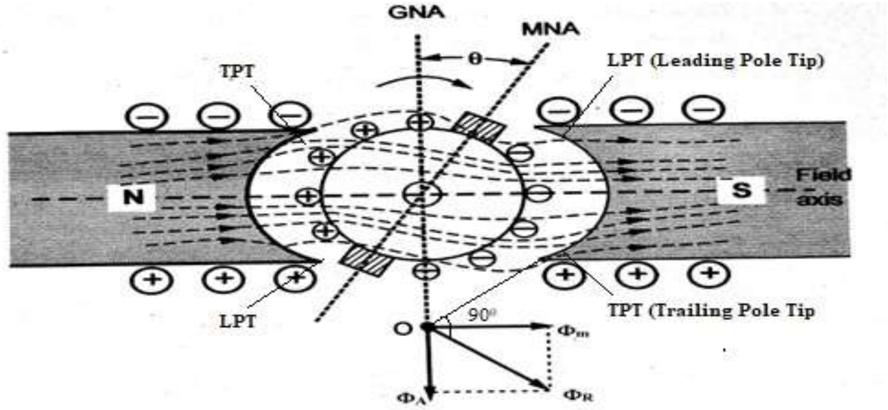


- **<u>CONSIDER NORTH POLE:</u>**

  In the trailing pole tip region, the magnetic fluxes from field coil and armature combined together to form strong magnetic field. (Both the fluxes are in the same direction). In the leading pole tip region both the magnetic fluxes are in opposite direction and weak magnetic field generated.

  The armature fluxes cross the main field flux is known as cross-magnetisation.

- **CONSIDER SOUTH POLE:**
  In leading pole tip region flux distribution is weak due to the opposite flux region.
  In trailing pole tip region flux distribution is strong due to the same flux region.
- In cross-magnetising effect magnetic neutral axis slightly shifted to in the direction of rotation. New MNA is produced due to the armature action with an angle of Φ.
- Across the trailing pole tip (TPT) magnetic flux strength is very high.



DE-MAGNETISING EFFECT:

- The process of removing magnetic property from the magnet is called “demagnetisation”.

  Or

  Net reduction in the main flux called as demagnetizing effect.
- The demagnetisation of DC generator is the effect of armature reaction.
- The Armature reaction is the effect of armature fluxes over the field fluxes. The armature Fluxes always opposes the field fluxes.
- Terminal voltage across the conductor is $V_t = E-(I_aR_a)$. As the armature reaction increases the terminal voltage decreases.

EFFECTS OF ARMATURE REACTION:

- Armature reaction will reduce the generated EMF, due to the decrease in value of flux per pole.
- Iron losses across the teeth of the pole is high in load condition.
- Maximum fluxes across the trailing pole tip produces in rushing (large) of current in commutator, due to this spark’s generated.
- The armature reaction shifts brush axis from GNA and it produces distortion in the generation of power.

REMEDIES TO ARMATURE REACTION EFFECT:

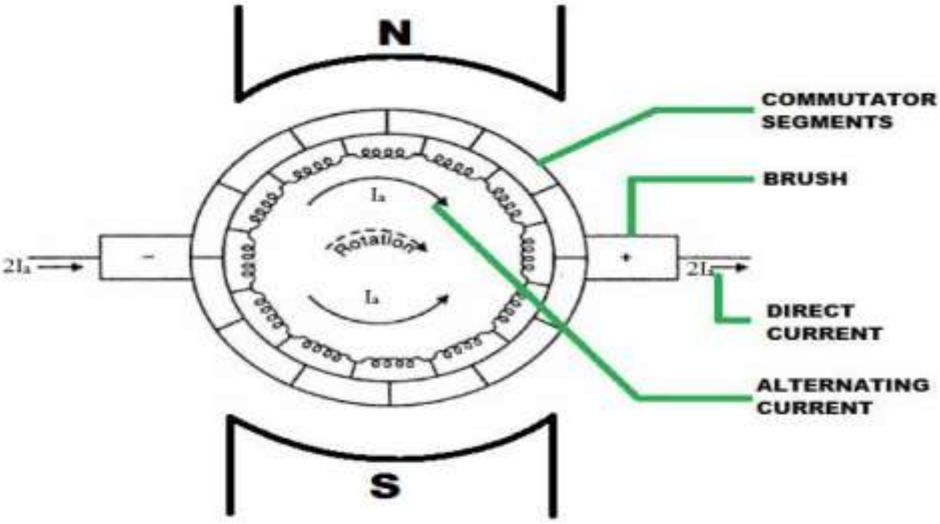
- Armature reaction effect can be minimized by connecting of compensating winding in the main-pole faces.
- Inter poles (external poles) is connected in between the main poles.
- In small machines armature reaction effect can be minimized by shifting of Corban brushes.
- By increasing length of air gap.
- Armature reaction effect can be minimized by making a high lamination across leading and trailing pole tip.

COMMUTATION:

Process of converting generated alternating current into direct current after going through the commutator segments and the stationary brushes.

Or

The reversal of current in the armature winding by means of commutator segment bar & carbon brushes provided is known as commutation process.



- Armature winding wound on armature slots.
- Let us consider commutator is moving from left to right and brushes will move from right to left. The current flowing in the armature conductor is armature current (I_a).
- Pictorial representation of commutation in DC generator is shown in below five cases.

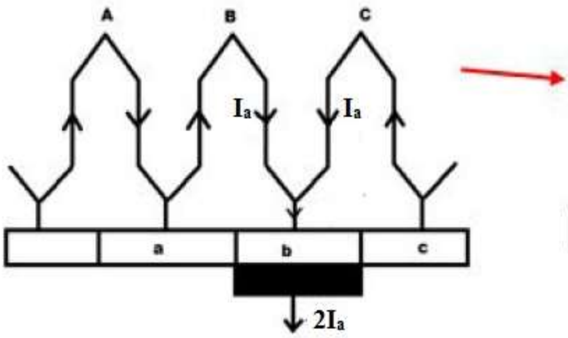


FIG- 1

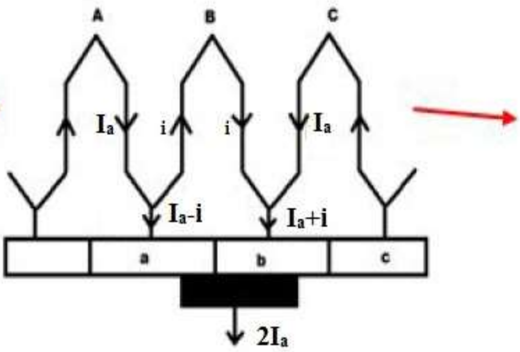


FIG- 2

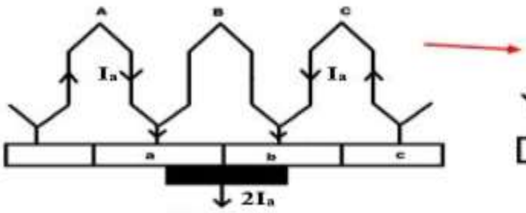


FIG- 3

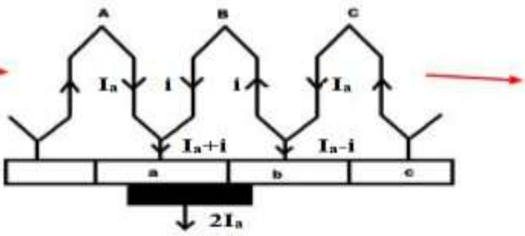


FIG- 4

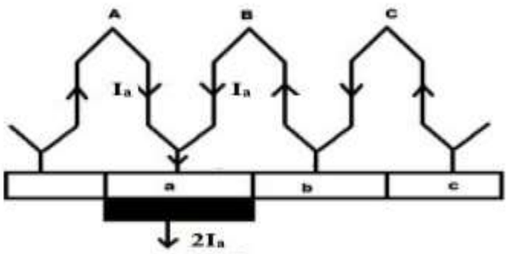


FIG- 5

Case 1: At the first position, the brush is connected to the commutator bar "b" as shown in figure (1). Then the total current transmit by the commutator bar "b" into the brush is $2I_a$.

Case 2: When the armature starts to move right side, then the small portion of brush comes to contact with bar "a". Then the armature current flows through in two paths. The total output current ($2I_a$) collected by the brush remain same as shown in figure (2).

Case 3: Armature again to move right side, then the position of brush is equally divided into two commutator bar's a and b. The total output current remains same as shown in figure (3).

Case 4: Armature again to move right side, then the small portion of brush comes to contact with bar "b". Then the armature current flows through in two paths. The total current remains same as shown in figure (4).

Case 5: Armature again to move right side, exactly whole brush is connected to the commutator bar "a" as shown in figure (5) and current ($2I_a$) remains same.

- In all the above five cases direction of current in DC generator is in one direction. The commutator converts alternating current into direct current and output taken across brushes (+ ve and – ve).
- High resistance of contactor and brushes are used for minimizing of sparks across the commutator and brushes.

REASON FOR POOR COMMUATATION:

- Poor mechanical condition of brushes like vibration of brushes.
- Over loading.
- Short circuited main field coils.
- Opening (break-up) of armature coil.
- Wrong size selection of brushes.
- Brushes are not in proper position.
- In correct spacing of brushes.
- Poor brush contacts.
- Rough or burned commutator.

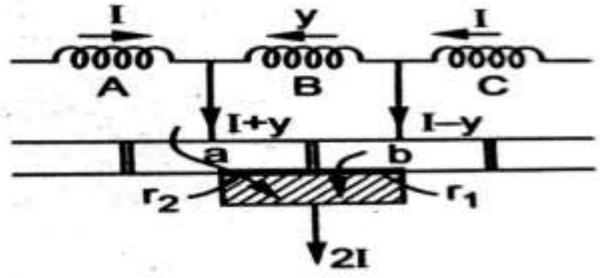
METHODS OF IMPROVING COMMUTATION:

Commutation can be improved by the following methods,

1) Resistance commutation.
2) EMF commutation.

1) Resistance commutation:

- The connection of high electrical resistance brushes for getting spark less commutation is called resistance commutation.
- In resistance commutation, the low resistance copper brushes are replaced by high resistance carbon brushes.



- In the above figure, the current I from coil C when passing through commutator segment 'b' has two parallel paths. One is straight from 'b' to brush and other is through short circuited coil B to segment 'a' and then brush.

- When carbon brushes having high resistance, then current I through coil C will select the second path, as resistance r_1 of first path will be increasing due to decrease in contact area of ‘b’ with brush and resistance r_2 of second path will be decreasing due to increase in contact area of ‘a’ with brush.
- Resistance commutation minimizes the inrushing of current across the commutator segment and brushes.
- Advantage is reducing the sparking and disadvantage is voltage drop occurs in resistance commutation.

2) **<u>EMF commutation:</u>**

The reactance voltage (self-induced EMF in the coil) is neutralised by producing a reversing EMF in the short-circuited coil under commutation is called EMF commutation.
The reversing EMF may be produced in two ways.

i. By shifting the position of brushes.
ii. By using commutating poles.

Reactance voltage: The voltage rises in the short-circuited coil due to inductive property of the coil. Which opposes the current reversal in it during the commutation period. The reactance voltage produced by the coil due to it’s inductive property.

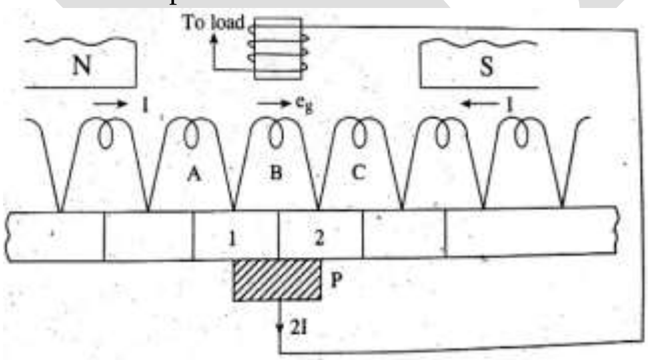
i. <u>By shifting the position of brushes:</u>

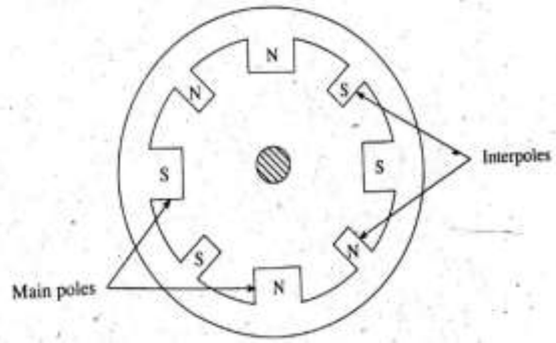
- If the brushes are shifted forward or backward depending on generator or motor, a little beyond to magnetic neutral axis. This will neutralize the reactance voltage, which will help to flowing of current in between commutator and brushes.
- This method reduces the sparking at brushes and is suitable for the machines operating at constant load.

ii. <u>By using commutating poles (interpoles):</u>

Interpoles are small pole pieces connected between the main field poles used to reduce armature reaction.
Interpoles are connected in series with the armature. Interpole windings are wound with few turns of large wire similar to series field winding.

- By inserting commutation poles (auxiliary poles) in between the two main poles. The flux generated by the inter-pole is proportional to the armature current.
- Interpole winding produces its own flux & it neutralises the armature reaction.
- This inter-pole is sufficient to reduced armature reaction and it helps to commutation processes.





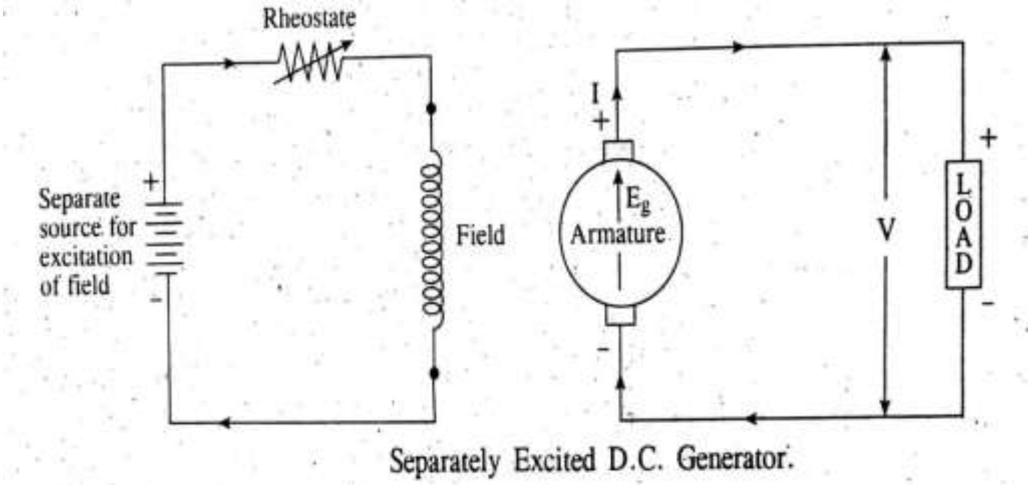
<u>CHARACTERISTICS OF DC GENERATOR:</u>

- The characteristics of DC generators are the relation between the loads, excitation and terminals voltage through graph.
- Three important characteristics of DC generators are

1) Magnetisation or No-load or open-circuit characteristics of DC generator (Generating voltage or No-load voltage V/S field current)
2) Internal characteristics:(Generated voltage V/S load current)
3) External characteristics or load characteristics:(Terminal voltage V/S load current)

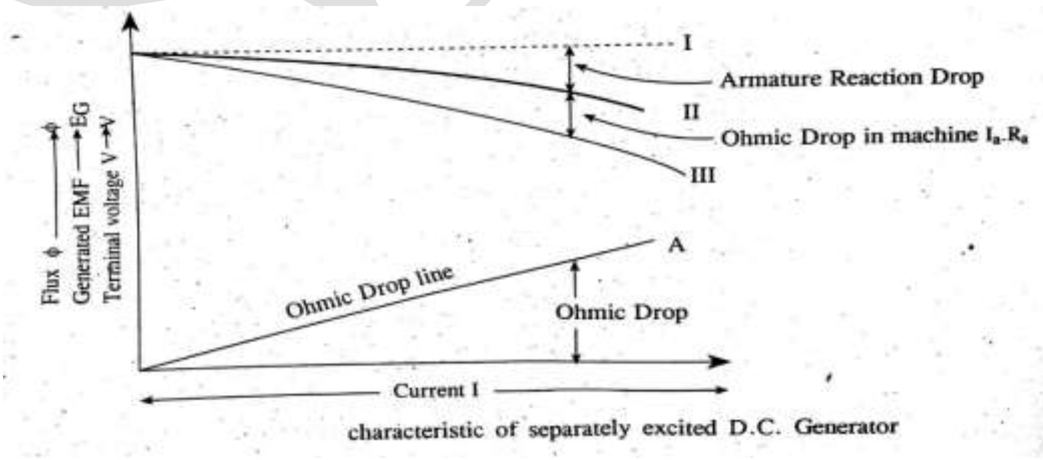
CHARACTERISTICS OF SEPARATELY EXCITED DC GENERATOR:

- DC generator field winding are energised from external source of DC current is called separately excited DC generator.



Separately Excited D.C. Generator.

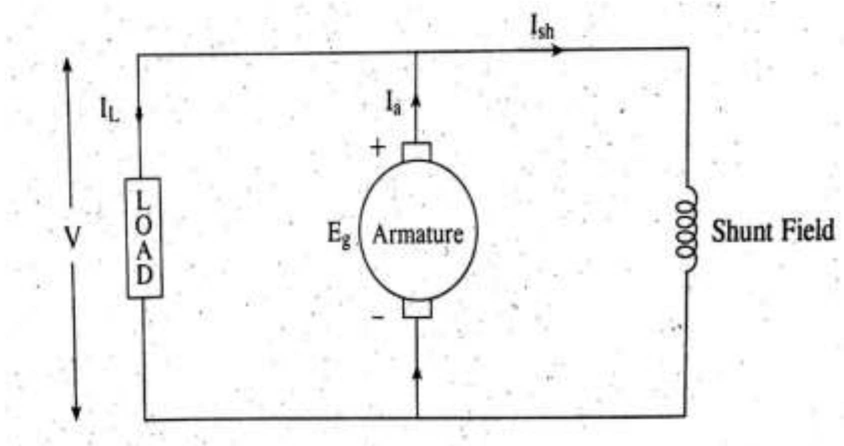
- The separately excited DC generator on loaded condition is shown in above fig.
- The field windings are excited by separate DC source. Since exciting current independent on load or armature current.
- The curve is drawn between flux per pole (ϕ) and load current (I_L), keeping field current constant and neglecting armature reaction in No-load condition. A straight line parallel to X-axis is obtained as indicated by curve-I is called open circuit characteristics or No-load characteristics of separately excited DC generator.
- Internal characteristics curve represents the relation between the generated voltage (E_g) & the load current (I_L). Due to the armature reaction, flux in the machine slightly reduces, due to this induced (generated) EMF also decreases and as indicated by curve-II is called internal characteristics of separately excited DC generator.
- External characteristics curve represents the relation between the terminal voltage (V) & the load current (I_L). The terminal voltage on load, the load current increases and terminal voltage slightly decreases as shown in the curve-III is called external characteristics or load characteristics of separately excited DC generator.
- Due to ohmic drop in machine some amount of voltage losses occur in DC machine.



characteristic of separately excited D.C. Generator

CHARACTERISTICS OF SHUNT WOUND DC GENERATOR:

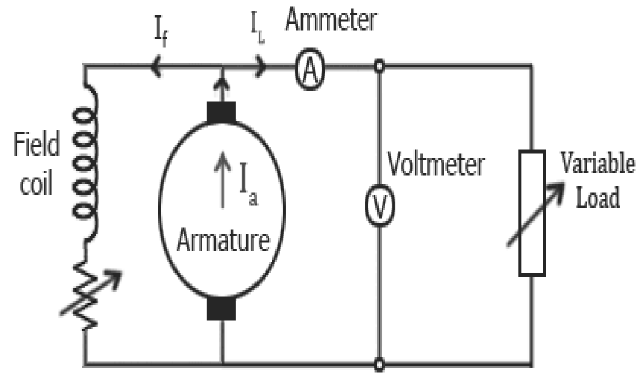
The field windings are connected in parallel with armature conductor is called shunt wound DC generator.

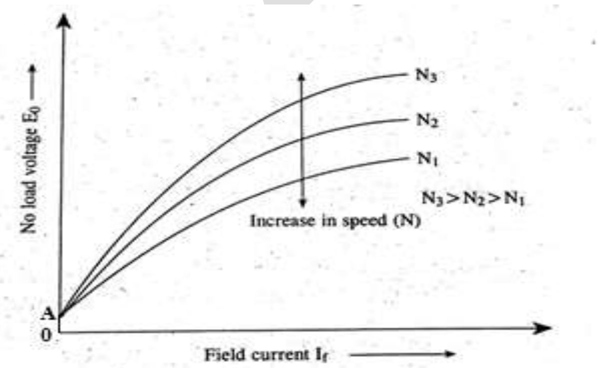


Characteristics of shunt wound DC generators are, OCC or magnetization characteristics, internal characteristics & external characteristics.

1) **MAGNETIZATION or OCC OF SHUNT WOUND DC GENERATOR:**

- Open circuit characteristics is also known as magnetic characteristics or No-load saturation characteristics. This characteristic shows the relation between generated emf at no load (E_0) and the field current (I_f) at a given fixed speed.
- The data for OCC curve is obtained by operating the generator at no load and keeping a constant speed. field current is gradually increased and the corresponding terminal voltage is recorded.
- The connection arrangement to obtain OCC curve is as shown in the figure below.

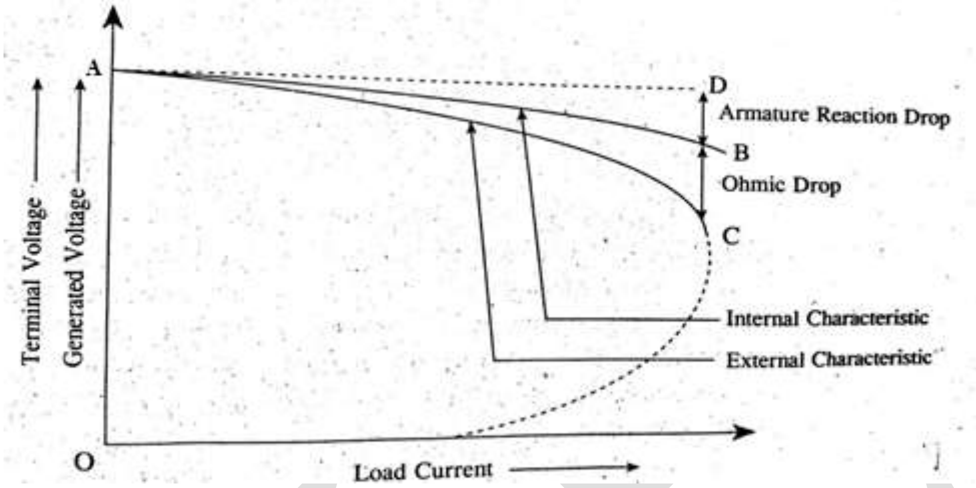




- From the EMF equation of DC generator, we know that $E_g \alpha \Phi$. Hence, the generated emf should be directly proportional to field flux.
- A small initial induced emf in the generator is due to the existence of some residual magnetism in the field poles.
- This initially induced emf aid the existing residual flux, and hence, increasing the overall field flux and induced emf also increases.
- Due to residual magnetism, the curves start from a point “A” slightly up from the origin “o”.
- However, as flux density increases, the poles get saturated and the flux becomes constant and induced emf also constant.

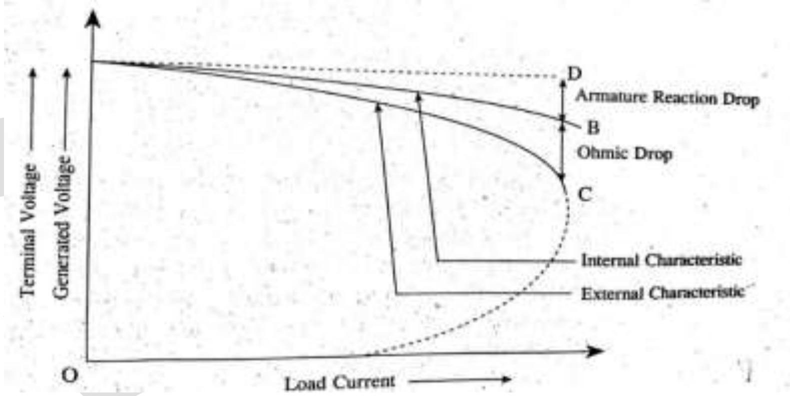
2) **INTERNAL CHARACTERISTIC OF SHUNT WOUND DC GENERATOR:**

- The internal characteristic curve represents the relation between the generated voltage (E_g) and the load current (I_L).
- When the generator is loaded, then the generated voltage is decreased due to armature reaction.
- Generated voltage will be lower than the EMF generated at No-load.
- In the below figure AD curve is No-load voltage curve and AB is the internal characteristics curve.



3) **EXTERNAL CHARACTERISTIC OF SHUNT WOUND DC GENERATOR:**

- The external characteristics curve represents the relation between the terminal voltage (V) and the load current (I_L).
- The terminal voltage drops due to 1. Armature reaction. 2. Armature resistance. 3. Reduced I_{sh} due to the armature reaction & resistance.
- When the generator is loaded, then the generated voltage is decreased due to armature reaction. Generated voltage will be lower than the EMF generated at No-load.
- In the below figure AD curve is No-load voltage curve, AB is the internal characteristics curve & AC is the external characteristics curve.

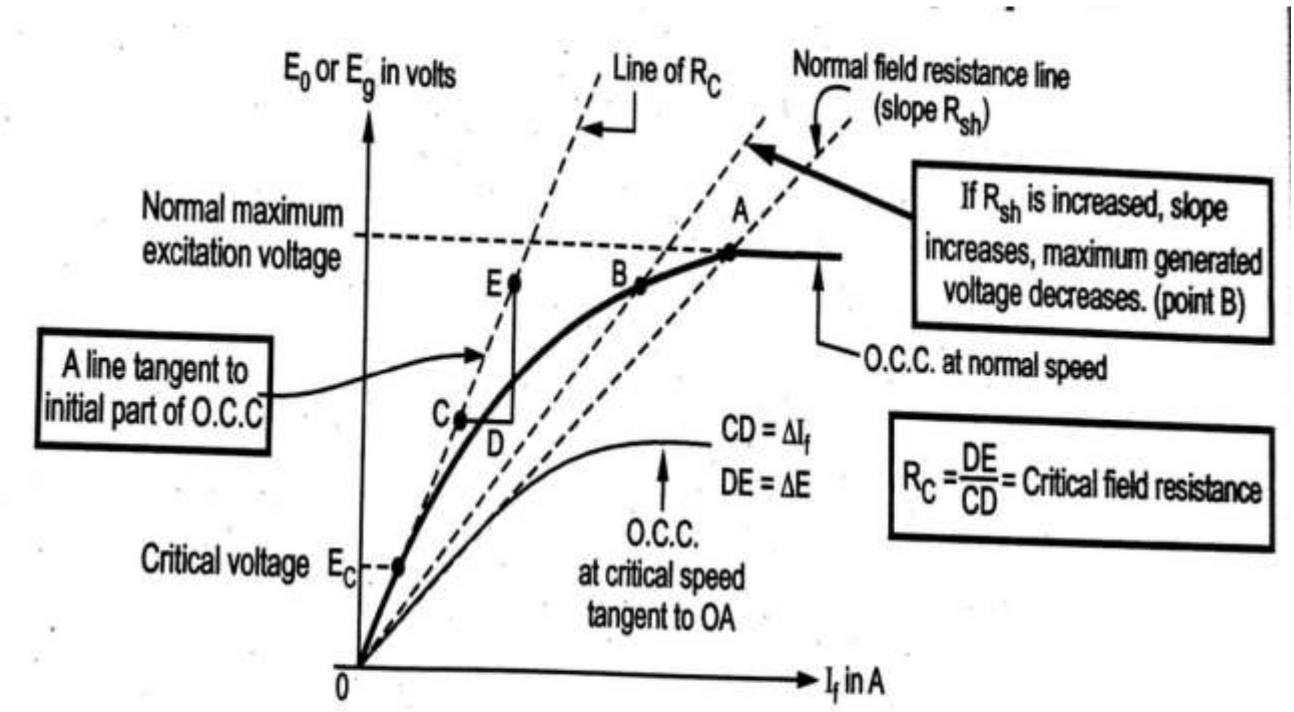


- Due to voltage drop in the armature winding, the terminal voltage across the load is lesser than the generated voltage.
- Terminal voltage (V) = $E_g - I_a R_a$

  $V = E_g - (I_L + I_{sh}) Ra$
- When load current (I_L) increases, then terminal voltage decreases.

CRITICAL FIELD RESISTANCE IN DC SHUNT GENERATOR:

- The maximum field resistance at which the shunt generator gets excite (turn ON) is called critical field resistance.
- The shunt generator will build up voltage only if field circuit resistance is less than critical field resistance.
- Consider the open circuit characteristics of a DC shunt generator is shown in the below figure.
- The below figure shows that generator voltage builds in step till point A.
- The dotted line indicates the field resistances in different resistance value.

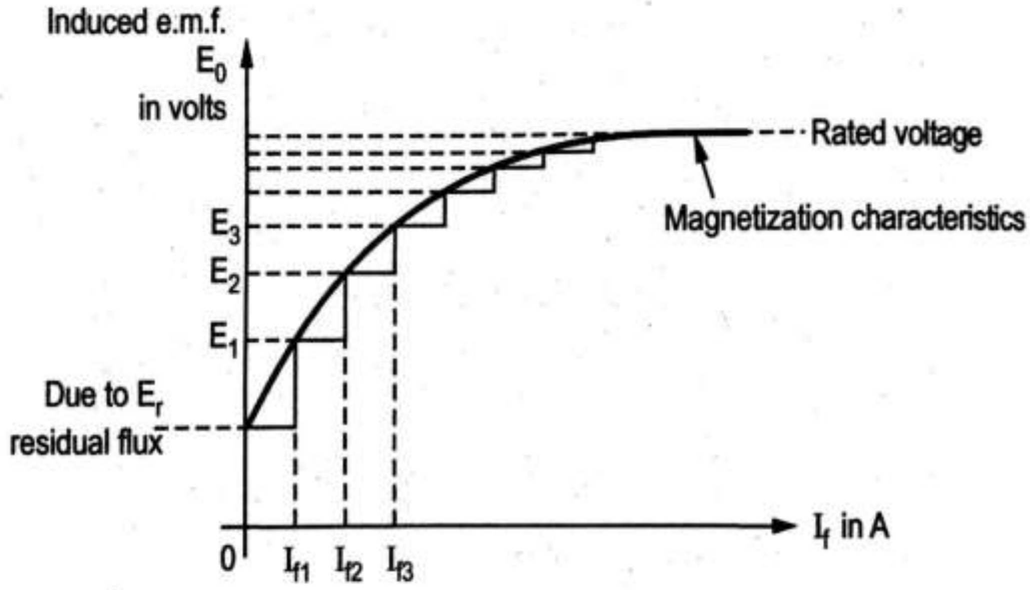


- The point of intersection of field resistance line with the open circuit characteristics (OCC) is point A. voltage corresponding to point A is the maximum voltage it can generated.
- If the slope of field resistance line is reduced by decreasing the field resistance, the generator induces the voltage higher than that corresponding to point A.
- Similarly, if the slope of field resistance line is increased by increasing the field resistance (Point B), the generator induces the voltage lesser than that corresponding to point A.
- The field circuit (winding) resistance is more than critical resistance at start, then induced EMF fail to drive current through field circuit.
- Critical resistance is the slope of the critical resistance line.

$$\boxed{R_C = \frac{\Delta E}{\Delta I_f} = \frac{DE}{CD} = \tan\theta}$$

VOLAGE BUILD-UP OF A SHUNT WOUND DC GENEATOR:

- The greater (large) number of generator's used as a self-excited field winding. Its field core having some amount of residual magnetic property.
- When armature rotates, conductors cut this small residual flux to produce the EMF.
- Generated small EMF drives small current through field winding, now field current (I_f) produces more flux which is greater than residual flux. Hence more EMF gets induced.
- This process is continuing till reaching of rated voltage building-up inside the generator.



- First the small induced EMF generated (E_r) due to residual magnetic flux. Small induced EMF start to drive small current (I_{f1}) through field winding.
- Field winding produces large fluxes with compared to residual flux. Using this large flux armature winding induces large emf (E_1) with compared to E_r.
- The process continuous up to generation of rated voltage.

CONDITIONS FOR VOLTAGE BUILD-UP OF A SHUNT WOUND DC GENERATOR:

1. Residual magnetism must be present (The field winding should have residual magnetic field).
2. The field winding connection should be in proper direction. (Because, the wrong connections can produce flux in opposite direction to residual flux and may cancel it).
3. Field resistance must be less than the critical resistance.
4. The generator must be driven in proper direction by the prime mover.

REASONS FOR FAILURE OF SELF-EXCITED SHUNT GENERATOR TO BUILD-UP VOLTAGES:

1. **No residual magnetism of field:** Rotating armature will not induce any voltage when there is no field present in the field poles.
   After a long period of using of generator the residual magnetism not produces, to overcome it to use separately excitation to production of rated induced EMF.
2. **Field connection reversed:** Induced voltage in the armature will always try to oppose the direction of field & hence voltage will not increase.
3. **Field resistance is more than the critical resistance:** Too high field resistance will prevent the flow of required field current to raise the armature field voltage further.
4. **Open field connection:** When there is no current in the field. So, armature voltage will not build-up.
5. **The speed of rotation may not be equal to rated speed.**

LOSSES IN A DC MACHINE (DC MOTOR and DC GENERATOR):

Losses in a DC machine are classified into three groups, they are

1) Copper losses.
2) Iron or core losses.
3) Mechanical losses.

1) Copper losses:

- The power wasted in the form of I^2R loss due to the resistances of the windings.
- The copper losses are proportional to the square of the current flowing through the windings.
- Copper losses in DC machine can be classified in to three types, they are
  Armature copper losses = $I_a^2R_a$
  Series field copper losses = $I_{se}^2R_{se}$
  Shunt field copper losses = $I_{sh}^2R_{sh}$
- In a compound DC machine, both shunt and series field copper losses are present.

Joule's heating Law:
Joule's first law: The heat produced by current in a conductor is directly proportional to the square of the current, the resistance of the conductor and the time for which the current exists.

2) Iron or core losses:(Magnetic losses)

The power wasted in the form of hysteresis & eddy current losses in an electromagnetic apparatus.

Hysteresis loss:

Hysteresis loss occur in DC machine due to the reversal of magnetization of the armature core. When the armature core passes under one pair of poles, it undergoes one complete cycle of magnetic reversal. Molecular magnets reverse constantly within the armature core, it produces heat loss.

Hysteresis loss $P_h = \eta B^{1.6}_{max} fV$ ……….. Watts

Where,
η = Hysteresis co-efficient.
B_{max} = Maximum flux Density in armature winding.
F = Frequency of magnetic reversals.
= NP/120 (N is in RPM)
V = Volume of armature core in m^3

Hysteresis loss is mainly depending upon the flux density and volume of core.

Eddy current loss:

When the armature core rotates in the magnetic field, due to this EMF is generated in the armature winding and large current flow's in the armature core with low resistance of the core, this current is known as eddy current and power loss due to this current is known as eddy current loss.

Eddy Current loss $(P_e) = K_e B_m^2 f^2 t^2 v$………watts

Where, ke = constant
B_m = Maximum flux density in wb/m^2
T = Thickness of lamination in m
V = Volume of core in m^3

Note: Constant (**Ke**) depend upon the resistance of core and system of unit used

3) Mechanical losses:

Mechanical losses are caused by movement of the motor. This include the friction in the motor bearings, friction between the brushes & the commutator.

Constant and variable losses:

Constant losses: Losses in a DC generator that stay constant at all loads are referred to as constant losses. They are iron losses, mechanical losses and shunt field losses.

Variable losses: Losses in a DC generator that differ with load are referred to as variable losses. They are Copper loss in armature winding (I^2Ra), Copper loss in series field winding ($I_{se}^2R_{se}$).

Total losses = Constant losses + Variable losses

Efficiency of a dc generator:

Efficiency is defined as the ratio of output power to the input power.

$$\%\eta = \frac{\text{output power}}{\text{input power}} \times 100$$

$$\%\eta_G = \frac{\text{output power}}{\text{output power + losses}} \times 100$$

Ratio of output electrical power generated to the input mechanical power given to the generator is known as efficiency of a DC generator.

Condition for maximum efficiency:

The efficiency of a DC generator is maximum when the constant losses are equal to variable losses.

Let, V is the output voltage, I_L is the load current of the generator, then

Output power = VI_L

Input power = output power + losses

= VI_L + (constant losses + variable losses)

= $VI_L + W_C + I_a^2R_a$

$I_a = I_L + I_{sh}$, (I_{sh} is very small hence neglect it)

Input power = $VI_L + W_C + I_L^2R_a$

Efficiency = $\frac{output\ power}{input\ power}$ = $VI_L / (VI_L + W_C + I_L^2R_a)$

$\eta = VI_L / (VI_L\,(1 + (I_LR_a / V) + (W_C / VI_L))$

The efficiency is high when the denominator value is low. Now consider denominator value to differential with respect to I_L.

$$\frac{d[1+ (ILRa / V) + (WC / VIL)}{dIL} = 0$$

$0 + (R_a / V) - (W_c / VI_L^2) = 0$

$R_a / V = W_c / VI_L^2$

$$\boxed{W_c = I_L^2 R_a}$$

Above equation shows the maximum efficiency in the generation in the time of constant losses is equal to the variable losses.

Voltage regulation:

Voltage regulation is defined as amount of output voltage drops as load is added from no-load to full-load.

Ratio of voltage difference between No-load & Full-load voltages of a generator with respect to its Full-load voltage is called voltage regulation of generator.

Voltage regulation is expressed in the following formula.

$$\boxed{\%\text{ voltage regulation} = ((V_{NL} - V_{FL}) / V_{FL}) \times 100}$$

V_{NL} = NO load voltage.

V_{FL} = FULL load or rated voltage

Lesser the regulation, the performance of the generator is good.

Voltage regulation determines the ability of the generator to provide the constant voltage for different load.

Importance of Efficiency and Regulation:

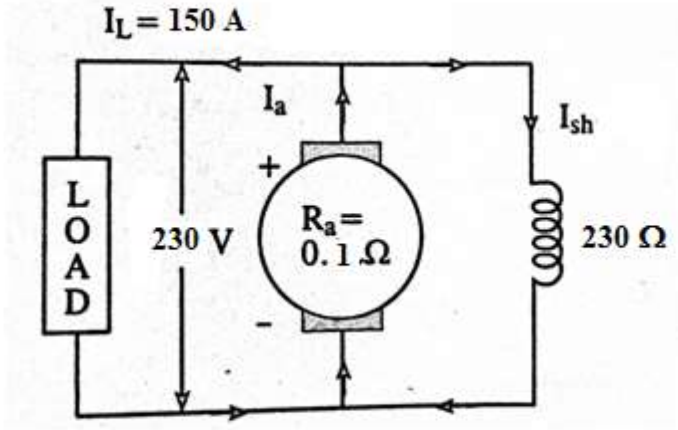
- The efficiency indicates how effectively mechanical input power is converted to electrical output power.
- Higher the efficiency of a machine means losses is less.
- The generator is used to supply voltage to the load; hence voltage regulation must be minimum.
- Lesser regulation is always preferred, as indicates that no change in terminal voltage.
- Lesser the regulation and higher the efficiency, it indicates the better performance of the DC generator.

UNIT-2

1) A 230 V shunt generator has a full load current of 150 A. its armature resistance is 0.1 Ω and field resistance is 230 Ω. The stray losses are 1500 W. Determine the efficiency of the generator.

Given:

$V=230$ V, $I_L=150$ A, $R_a=0.1\ \Omega$, $R_{sh}=230\ \Omega$, Stray losses=1500 w, $\eta_g=?$



$$\eta_g = \frac{\text{Output power}}{\text{Output power} + \text{Losses}}$$

Output power = $VI_L = 230 \times 150 = 34500$ watts.

$I_a = I_{sh} + I_L$

$I_{sh} = \frac{V}{R_{sh}} = \frac{230}{230} = 1$ A.

$I_a = I_{sh} + I_L = 1 + 150 = 151$ A.

Armature copper loss = $I_a^2 R_a = (151)^2 \times 0.1 = 2280.1$ watts

Shunt field copper loss = $I_{sh}^2 R_{sh} = (1)^2 \times 230 = 230$ watts

Total copper loss = Armature copper loss + Shunt field copper loss

= 2280.1 + 230

Total copper loss = 2510.1 watts.

Total loss=Total copper loss+Stray losses = 2510.1 + 1500 = 4010.1 watts

$$\%\eta_g = \frac{\text{Output power}}{\text{Output power} + \text{Total Loss}} \times 100$$

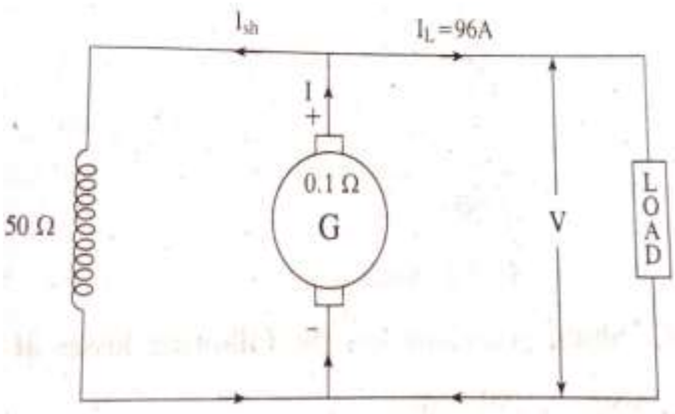
$$= \frac{34500}{34500+4010.1} \times 100$$

$\%\eta_g = 89.58\ \%$

2) A shunt generator supplies 96 Amp at a terminal voltage of 200 volts. The armature and shunt field resistance are 0.1 Ω and 50 Ω respectively. The iron and frictional losses are 2500 W. find (i) EMF generated (ii) copper losses (iii) commercial efficiency.

<u>Given:</u>

I_L=96 A, V=200 V, R_a=0.1 Ω, R_{sh}=50 Ω, Iron & friction losses (Stray losses) = 2500 w.



(i) $E_g = V + I_a R_a$

$I_a = I_L + I_{sh} = 96 + \frac{V}{R_{sh}} = 96 + \frac{200}{50} = 96 + 4 = 100$ A. $\{I_{sh} = \frac{V}{R_{sh}} = \frac{200}{50} = 4$ A$\}$

$E_g = 200 + (100 \times 0.1)$

$E_g = 210$ V.

(ii) Armature copper loss = $I_a^2 R_a = (100)^2 \times 0.1 = 1000$ watts.

Shunt copper loss = $I_{sh}^2 R_{sh} = 4^2 \times 50 = 800$ watts.

Total copper loss = Armature copper loss + Shunt copper loss

= 1000 + 800

Total copper loss = 1800 watts

(iii) Total losses = Stray losses + copper losses

= 2500 + 1800

Total losses = 4300 watts.

Output power = $VI_L = 200 \times 96 = 19200$ watts

Input power = Output power + losses = 19200+4300 = 23500 watts

$\%\eta = \frac{\text{Output power}}{\text{Input power}} \times 100$

$= \frac{19200}{23500} \times 100$

$\eta = 81.7\ \%$

3) A 10 KW DC shunt generator has the following losses at full load:
Mechanical losses = 290 watts
Iron losses = 420 watts
Shunt cu losses = 120 watts
Armature cu losses = 595 watts
Calculate the efficiency at i) No-load ii) 25% of full-load.

<u>Given:</u>

P=10 KW=10000 watts, Mechanical losses = 290 watts,
Iron losses = 420 watts, Shunt cu losses = 120 watts,
Armature cu losses = 595 watts

(i) At No-load,

The stray losses remain constant at No-load or at any other load.

Stray losses = Mechanical losses + Iron losses = 290+420 = 710 w

Total losses at No-load = Stray losses + Shunt Cu losses
= 710 + 120

Total losses at No-load = 830 watts.

The efficiency at No-load is zero because there is no output.

(ii) At 25 % of full-load.

Constant losses = 830 watts.

Armature Cu loss = n^2 × Full load Cu loss = $(\frac{1}{4})^2 \times 595 = 37.18$ w

Total losses = Constant losses + Armature Cu loss = 830+37.18

Total losses = 867.18 watts

Output power = $\frac{1}{4} \times 10000 = 2500$ watts

Input power = Output power + Losses =2500+867.18 = 3367.18 w

$\%\eta = \frac{Output\ power}{Input\ power} \times 100 = \frac{2500}{3367.18} \times 100$

η=74.24 %

4) A 75 KW shunt generator is operated at 230 V. The stray losses are 1810 watts and shunt field circuit draws 5.35 Amp. The armature circuit has a resistance of 0.035 Ω and brush drop is 2.2 V. calculate i) Total losses ii) Output of prime-mover iii) Efficiency at rated load.

<u>Given:</u>

P=75 KW =75000 watts, V=230 V, Stray losses =1810 watts, I_{sh}=5.35 A

R_a=0.035 Ω, Brush drop = 2.2 V.

i)

Load current = $I_L = \frac{P}{V} = \frac{75000}{230}$ = 326.086 A.

Armature current = $I_a = I_L + I_{sh}$ = 326.086 + 5.35 = 331.436 A.

Armature copper loss = $I_a^2 R_a = (331.436)^2 \times 0.035$ = 3844.743 watts.

Shunt copper loss = $I_{sh}^2 R_{sh} = VI_{sh} = 230 \times 5.35$ = 1230.5 watts.

Brush power loss = Brush drop × I_a = 2.2 × 331.436 = 729.159 watts.

Total losses = Stray losses + Armature copper loss + Shunt copper loss + Brush power loss

Total losses = 1810+3844.743+1230.5+729.159 = 7614.402 watts

ii)

Output of prime mover = Output power + Total losses = 75000+7614.402

Output of prime mover = 82614.402 watts.

iii)

$\%\eta = \frac{Output\ power}{Input\ power} \times 100 = \frac{75000}{82614.402} \times 100$

η = 90.78 %

5) A 10 KW, 250 V, DC 6 pole shunt generator runs at 1000 rpm. When delivering full-load. The armature has 534 lap-connected conductors. Full load copper losses are 0.64 KW. The total brush drop is 1 volt. Determine the flux/pole neglect shunt current.

<u>Given:</u>

P=10 KW = 10000, V=250 V, P=6, N=1000 rpm, Z=534,

Armature Copper loss = 0.64 KW = 640 watts, Brush drop = 1 V, ϕ=?.

When shunt current is neglected, then there is no shunt copper losses. The copper loss occurring in armature only.

$I=I_a= \frac{P}{V} = \frac{10000}{250} = 40$ A.

Armature copper loss = $I_a^2R_a$

$R_a = \frac{\text{Armature copper loss}}{Ia^2} = \frac{0.64 \times 10^3}{40^2} = 0.4\ \Omega$

$E_g = V + I_aR_a +$ Brush drop $= 250 + (40\times0.4) + 1 = 267$ V.

$E_g=\frac{\phi PNZ}{60A}$

$\phi = \frac{E_g 60A}{PNZ} = \frac{267\times60\times6}{6\times1000\times534} = 0.03$ weber. (30 mwb).