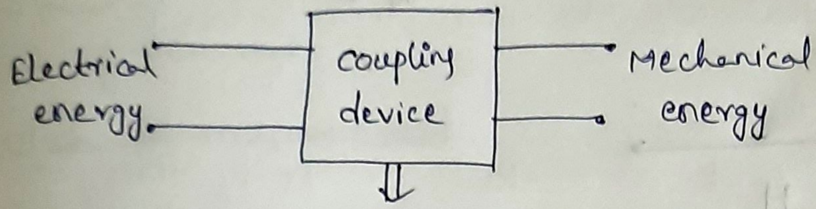
EMF :- is the force that causes electrons or current to flow in a closed circuit
↓
electromotive force

MMF :- magnetomotive force is the force which is produced, as current flow through the conductor coil. It is a driving force that causes flux to form in a magnetic field

→ When current flows through a conductor coil, a force known as MMF is created, which drives magnetic lines of flux.

05/01/23

Energy conversion:-



By nature in Electromagnetic

- Energy conversion devices:

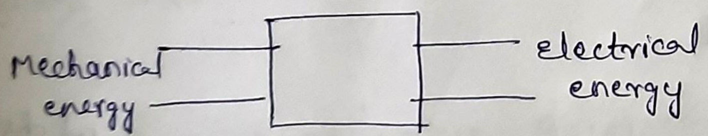
① Tranduser

② Force producing device

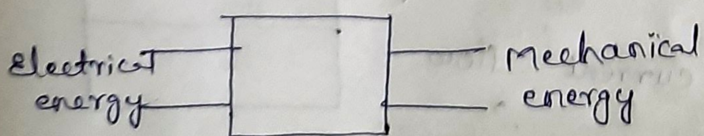
Ex. Relay, magnetic labulation

③ continuous energy ~~dissociation~~ conversion device:-

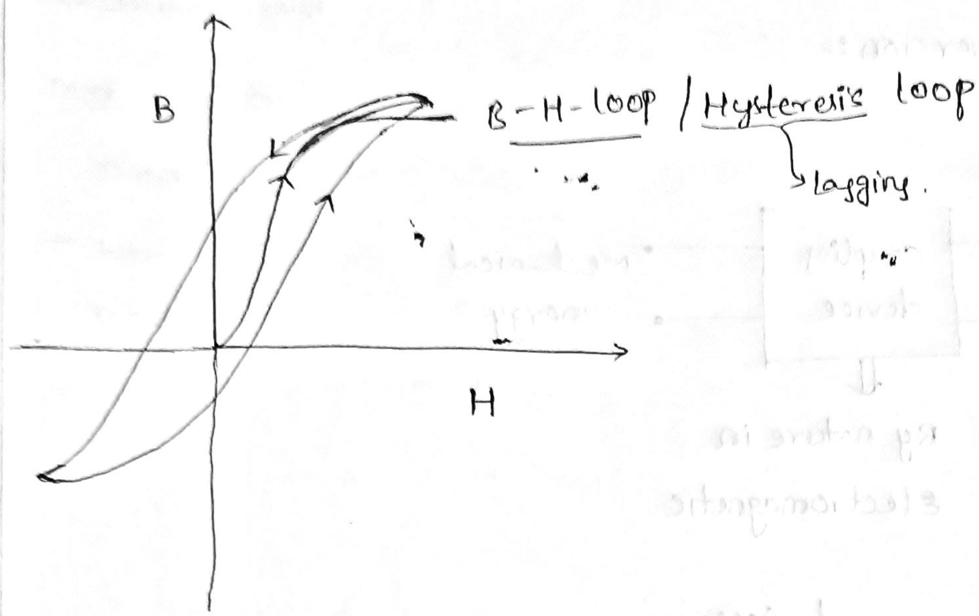
ⓐ Generator:-



ⓑ Motor:



→ Total mechanical energy = Electrical energy output + Energy loss + stored energy loss characteristics:-



$e \propto \frac{d\phi}{dt}$ if $e_1 \neq e_2$, potential difference exists

09/01/23

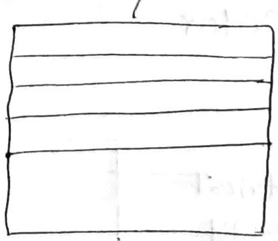
① Reduction of hysteresis loss:

$\propto$ area of hysteresis loop.

→ Ferromagnetic material → hysteresis loss is less

cast iron, cast steel

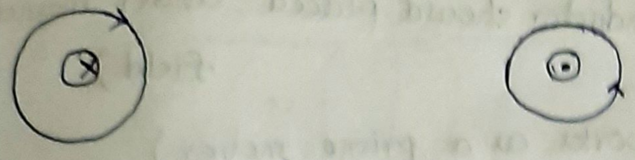
② Reduction of eddy current loss:



Due to laminated sheet resistivity inc then eddy current flow is decreases.

Cross & Dot Notation

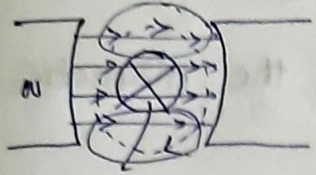
→ Current is away from observer we can use cross notation



cross → current

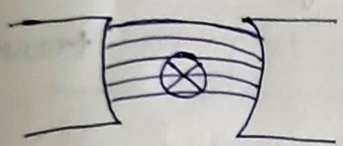
clockwise → magnetic field

* Direction of magnetic force:



At top both fields are in same direction so, they are additive in nature.

At bottom both are in opp. direction, so, they should cancel each other



direction of force is from higher magnetic field to lower magnetic field.

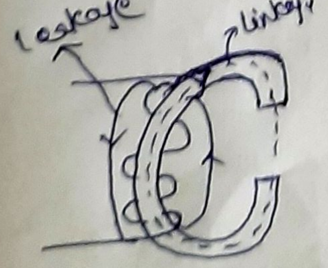
* Basic principle of voltage Generation:

→ Faraday law of magnetic induction:-

$$e \propto \frac{d\phi}{dt}$$

Flux → Linkage, Leakage

which → flux is not passing through conductor leakage



Basic requirement of voltage Generation:-

① Magnetic field

② conductor (but the conductor should placed under magnetic field)

③ prime mover (turbine works as a prime mover)

note:-

→ The magnetic field is constant or steady state but conductor is in motion then $\frac{d\phi}{dt}$ created

② The conductor is in static but the magnetic field itself changable in nature

→ A.C current

Statically induced emf / transformer

dynimacally induced emf / generator

$$e = -N\frac{d\phi}{dt}$$

$$e = Blu$$

① $\boxed{e \propto B}$ → flux density

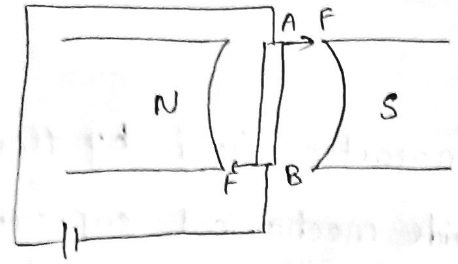
② $\boxed{e \propto L}$ → length of the conductor

③ $\boxed{e \propto u}$ → rotation/speed of conductor

Why voltage generation depends on rotation?

10/01/23

Basic principle of motor:-



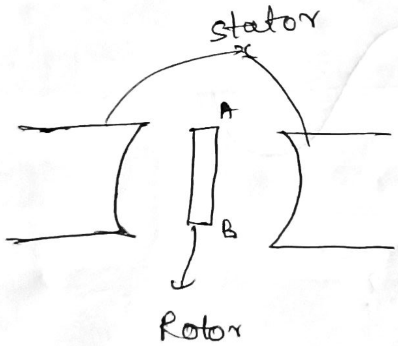
→ The nature of two force at end of conductor is parallel and opposite.

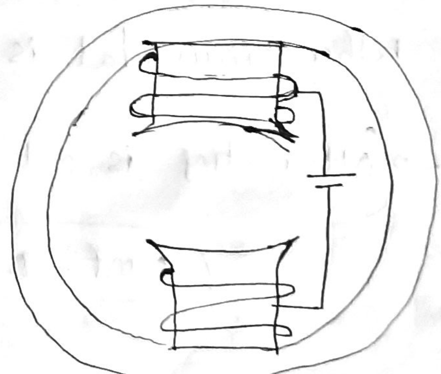
→ We have to apply voltage across conductor for electrical motor.

DC machines:-

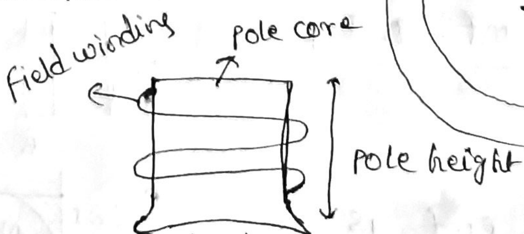
Construction

- Stator (static device)
- Rotor (Armature) (Rotational device)





Stator:- It is cylindrical in nature



(Where we wound the coil in magnet is pole core)

① Pole core:

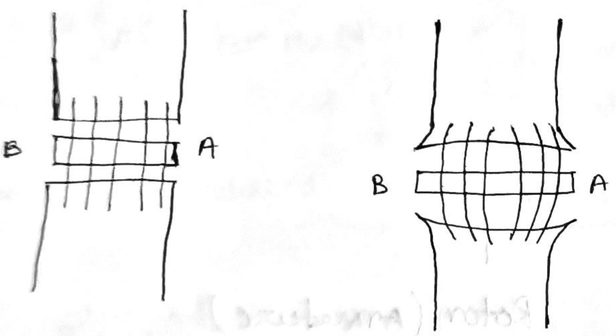
Function: To hold the ~~coil~~ field coil / winding.

② Field winding:

Function: to generate magnetic field by flowing current through it / ~~Provide mechanical support to the field winding~~.

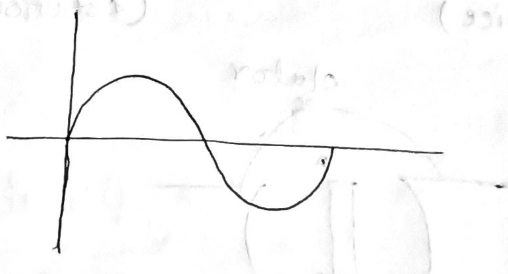
③ Pole shoe:

Function: to ~~permanently~~ mechanically hold the ~~pole~~ field coil / Provides mechanical support to the field windings.



Here length of conductor is more acc. to $\boxed{e = Blu}$

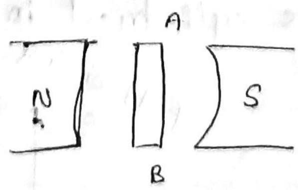
$\boxed{e = Blu}$



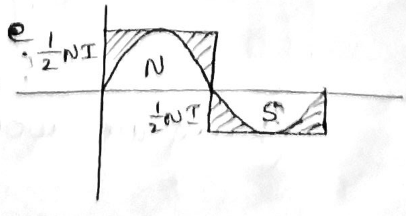
Why sinusoidal is important?

→ (Alternating is not always a sinusoidal)

$\boxed{mmf = NI}$



So, induced emf is rectangle in nature



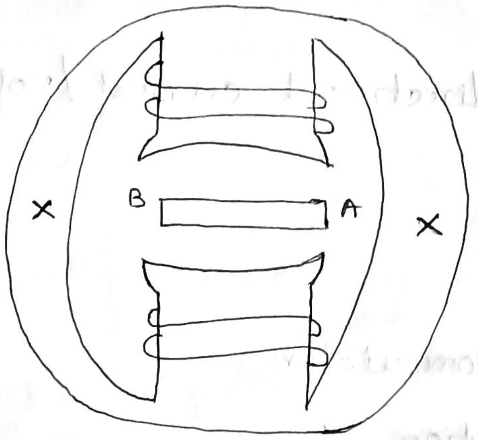
of rectangle ~~curve~~ wave form

* Fundamental ~~means where the~~ component is sinusoidal.

* As the extra space is less then we get more sinusoidal form.

12/01/23

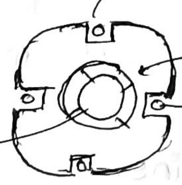
Armature:-



x → to provide continuous portion of magnetic field (yoke)

→ According to faraday's law, when we rotate the conductor induced emf is generated.

→ Rotor / Armature is cylindrical in shape



Parts of DC machine in details:-

① Yoke → outer part of the machine.

→ Provide internal support to magnetic structure.

→ It carries the magnetic flux produced by the poles.

② Pole core & Pole shoe:-

③ Field winding:-

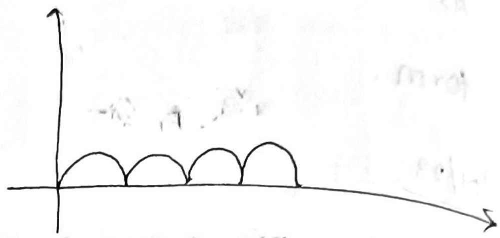
④ Armature core

DC – Unique direction

AC – to and fro motion

⑤ Armature winding.

⑥ commutator



DC voltage.

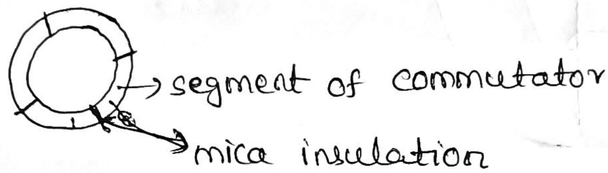
↓

AC to DC voltage

↳ hard drawn copper

→ it helps to make unidirectional current / voltage

⑦ brush & ball bearing



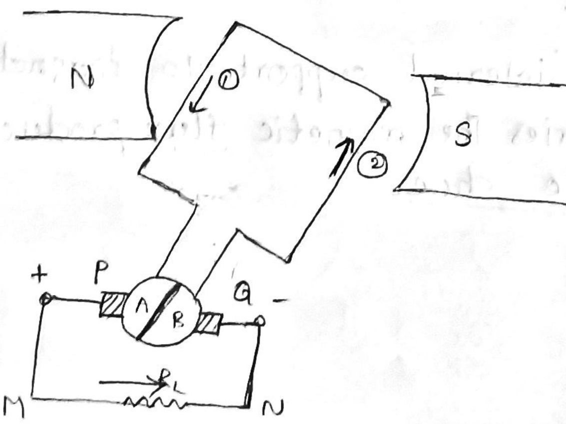
→ each and every armature coil connecte to segments of commutator.

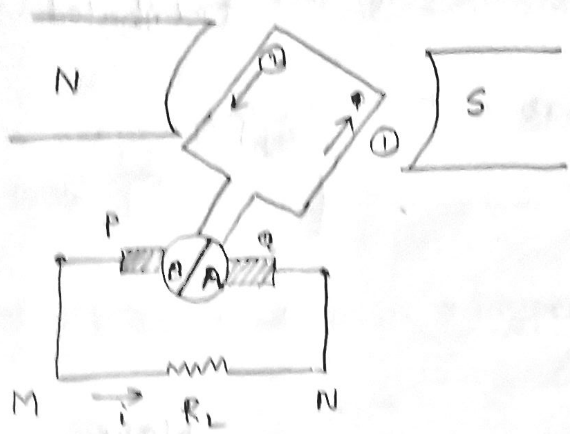
→ Brush helps us to collect current

↳ carbon or graphite are soft materials.

⑧ Shaft of the electrical machine:-

⊛ Function of the commutator:-



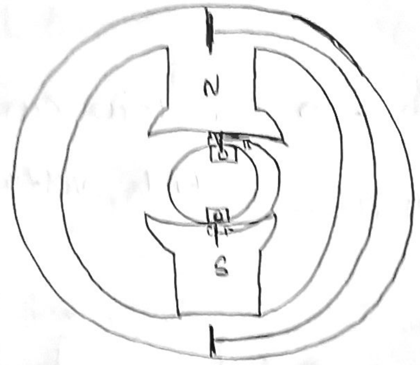


→ voltage induced is alternating in nature, so sinusoidal nature

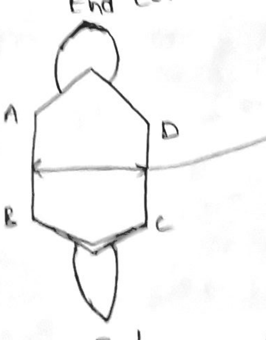
→ through external circuit unidirectional is flowing in both circuits.

16/10/21

<u>Pole pitch</u> :- The peripheral distance b/w consecutive poles.



<u>Coil</u>

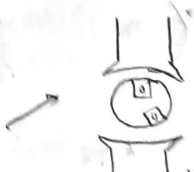


<u>coil span</u>:- pheripheral distance of two coil sides

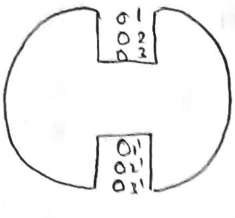
(mechanical angle is physical angle what we observed)

⊛ <u>Type of armature windings</u>:-

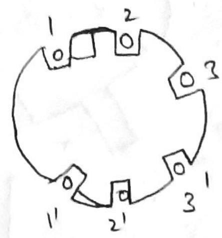
- Full pitch — coil span = pole pitch.
- short pitch — coil span < pole pitch



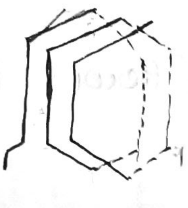
Concentrated



Distributed



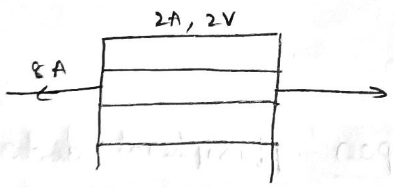
Lap winding



→ overlapping pattern

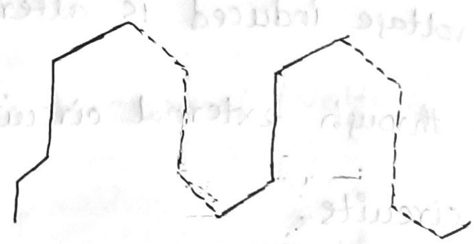
→ The no. of parallel path (A) = no. of pole (P)

→ ~~no of parallel path~~ is used for high current low voltage



→ requirement of brush is more

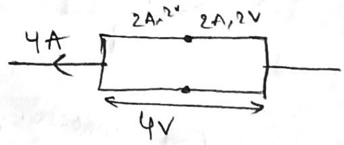
Wave



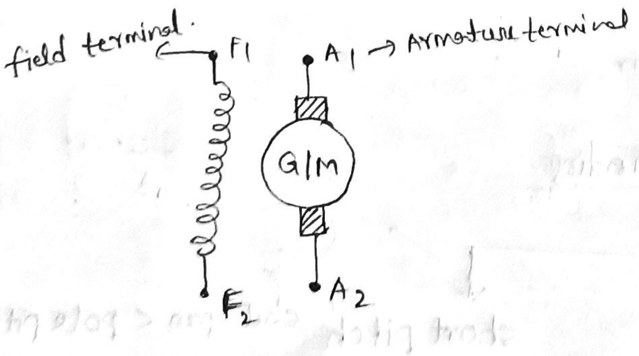
→ Wave pattern.

→ no. of parallel path = 2

→ for low current high voltage.



Symbol of electrical ~~instruments~~ machine.



Excitation:-

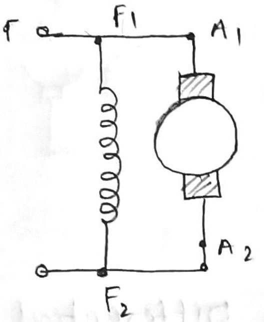
→ It is process to gernate magnetic field in electrical machines

→ According to excitation: 2 types of DC machine -

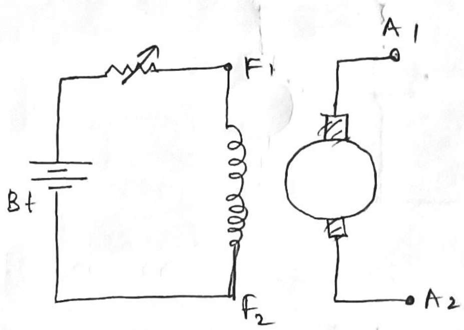
Type

- self excited
- separately excited

self excited



separately excited

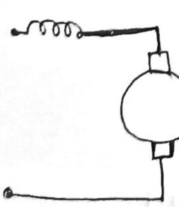


self excited	separately excited
→ field and armature are connected.	→ External voltage supply is required to generate magnetic field.
→ Nothing external supply is required.	
→ voltage drop is more with change of load.	→ less voltage drop.

Part of self exiced Type

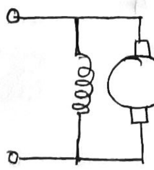
- Series
- shunt
- compound

Series



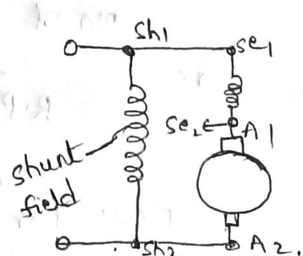
armature & field are in series

shunt



armature & field are in parallel

compound



some are in series and other are in parallel

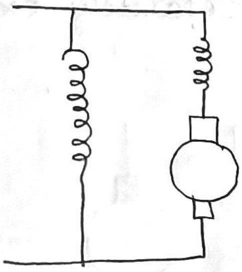
→ shunt field has more no. of turns.

→ more current flows in series field winding.

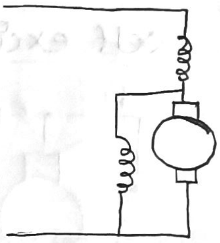
→ series field winding is thick

compound

Long compounded



Short compounded



Cumulative

If series field help shunt field.

Differential

If series field oppose the shunt field.

17/01/23

E.M.F equation of DC Generator:-

Let No. of pole = P

Flux / pole = ϕ

Total conductor = Z

No. of parallel path = A

R.P.M = N

r = radius of armature.

L = Length of the conductor.

Now, for one rotation, flux $= P\phi = d\phi$ (say)

time for one rotation $= \frac{60}{N}$ sec = dt (say)

(for $\frac{N}{60}$ rotation $= 1$ sec

1 rotation $= \frac{60}{N}$)

$\therefore$ Induced emf for one conductor $= \frac{d\phi}{dt}$

$$= \frac{P\phi}{\frac{60}{N}} = \frac{P\phi N}{60}$$

Now, effective conductor / parallel path $= Z/A$

$\therefore$ Induced e.m.f for Z no. of conductor, $\boxed{E = \frac{PN\phi}{60}\left(\frac{Z}{A}\right)}$

Derive equation using dependance factor

→ We know that, $e = Blv$

Now, flux density, $B = \frac{P\phi}{2\pi r l}$

And $v = \omega r = \frac{2\pi N r}{60}$

$$e = \frac{P\phi}{2\pi r l} \cdot l \cdot \frac{2\pi N r}{60}$$

$$= \frac{P\phi N}{60}$$

$$E = \frac{PN\phi}{60}\left(\frac{Z}{A}\right)$$

$$\therefore E_{Lap} = \frac{PN\phi}{60}\left(\frac{Z}{P}\right)$$

$$E_{Wave} = \frac{PN\phi}{60}\left(\frac{Z}{2}\right)$$

Again, $E = \frac{PN\phi}{60}\left(\frac{Z}{A}\right)$

$\therefore E = KN\phi$, where $K = \frac{PZ}{60A}$ = constant

$\Rightarrow$ $\boxed{\begin{array}{l} E \propto \phi \\ E \propto N \rightarrow \text{induced e.m.f practically depend on } N \end{array}}$

Now, $\frac{E_1}{E_2} = \frac{N_1\phi_1}{N_2\phi_2}$

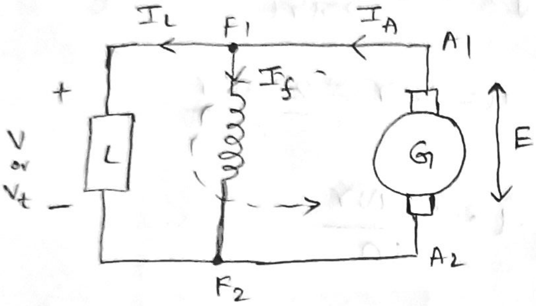
But If $\phi_1 = \phi_2 = \phi = \text{const}$

$$\therefore \frac{E_1}{E_2} = \frac{N_1}{N_2}$$

Again $\because \phi_1 \propto I_{f_1}$ & $\phi_2 \propto I_{f_2}$

$$\therefore \frac{E_1}{E_2} = \frac{N_1 I_{f_1}}{N_2 I_{f_2}}$$

◎ Some other equations of generator:-



$\boxed{I_A = I_L + I_f} \rightarrow ①$

or

$I_a = I_l + I_f$

Now, Let $R_A = R_a$ = Armature resistance

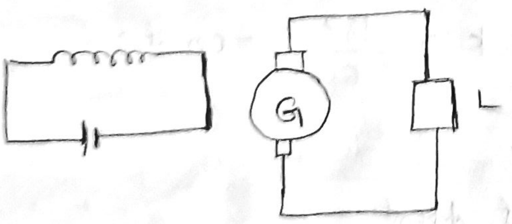
$R_F = R_f$ = Field resistance

KVL, $E - I_a R_a - V = 0$

$\Rightarrow \boxed{E = V + I_a R_a} \rightarrow ②$

Again, $\boxed{V = I_f R_f}$

◎

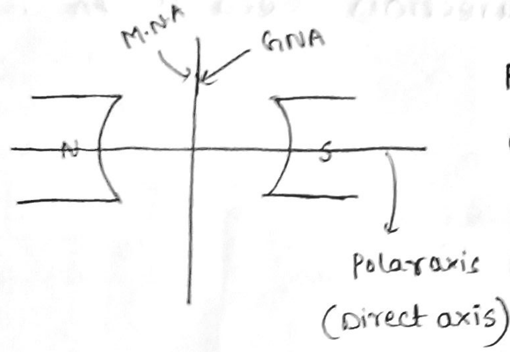


$\boxed{I_a = I_L}$

Armature reaction:-

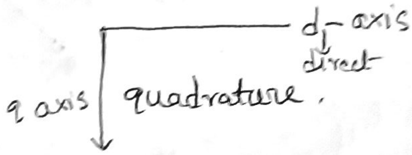
→ In generator two magnetic fields are developed one is stator and other is armature core

→ The interaction b/w main magnetic field and armature magnetic field is called armature reaction.

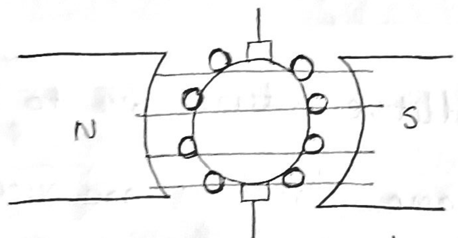


MNA → magnetic neutral axis

GNA → Geometric neutral axis



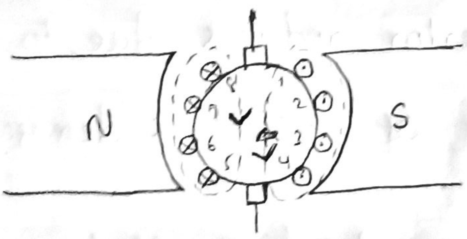
Case-I:- When the field gets excitation only.



→ ϕ_m (direction of main magnetic field) N to S

→ F_m
↓
magnetomotive force.

Case-II:- When the armature gets excitation only.



ϕ_A → belongs to MNA

(direction of flux is along ↓)

Case-III: When the both field and armature gets excitation.

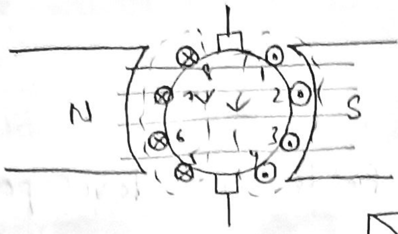
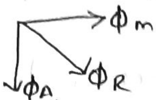


fig-3



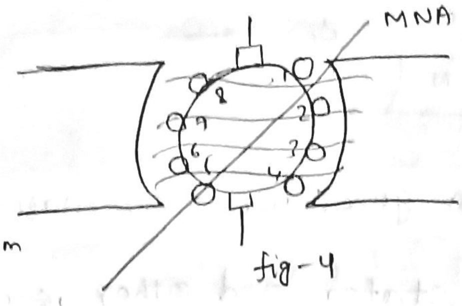


fig-4

→ Due to change in shape of magnetic field MNA changes and 1 an 5 are changes from ⊗ to ⊙ and ⊙ to ⊗.

→ Now, ϕ_A also changes the direction because ϕ_A is always along MNA

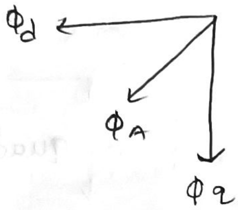


fig-5

→ The shape of magnetic field change due to armature reaction.

→ In fig-3, left upside get additive nature due to main field and armature field are in same direction and vice versa.

→ ϕ_d always opposes main flux ϕ_m, so ϕ_m reduces.

→ As $E \propto \phi$, induced emf also reduces.

→ Voltage generation of generator reduces due to armature reaction, and the name of effect is demagnetization.

→ Effect of ϕ_q is cross magnetisation effect.

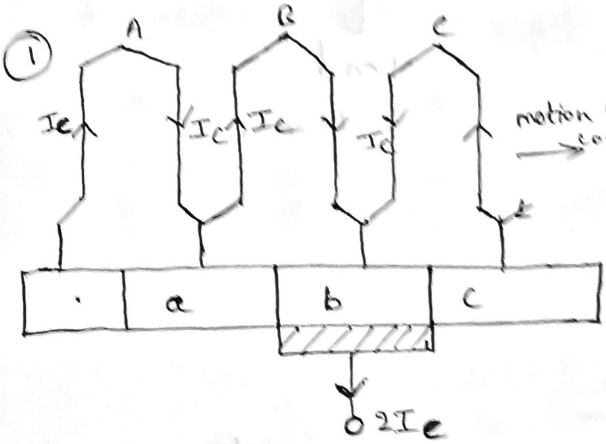
④ Effect of Armature reaction

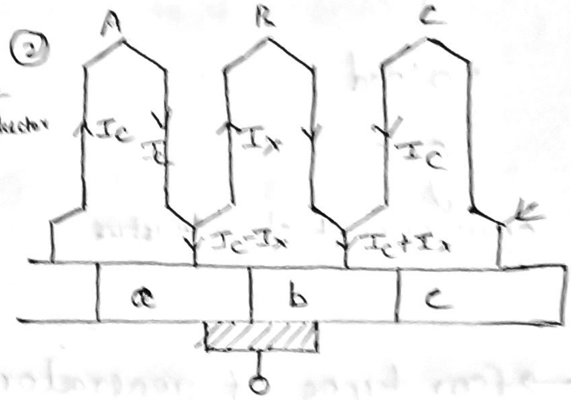
① Demagnetisation effect : it reduces voltage.

② Cross magnetisation effect :
↓
sparking is coming

(23/01/23)

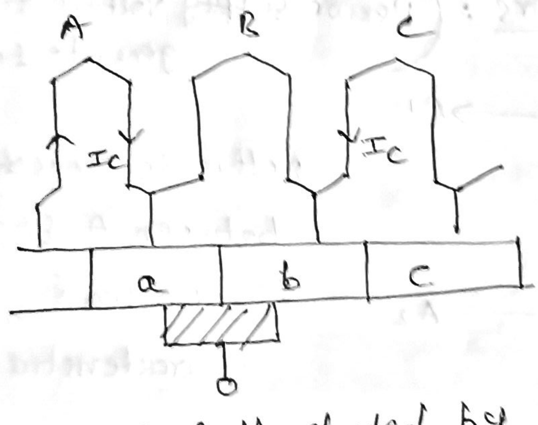
④ commutation phenomenon :- → process of reversal of ~~armature~~ current of armature conductor.

①


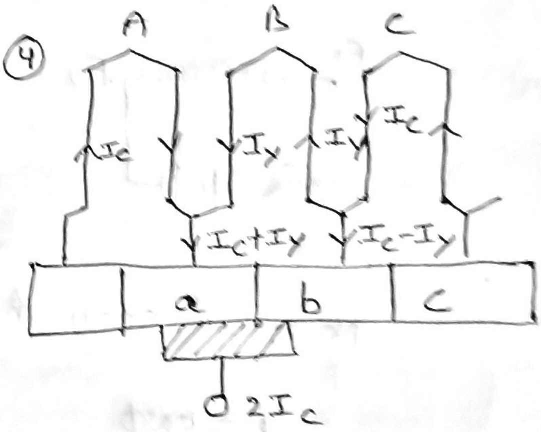
②


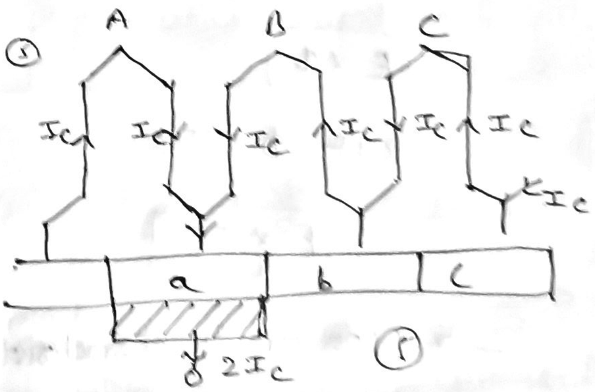
$= I_c - I_x + I_c + I_x$

$= 2I_c$

③


coil B perfectly shorted by brush so no current pass through ~~co~~ 'B'

④


⑤


→ sparking occurs due to commutation process and it leads to damage commutator.

→ To ~~better~~ improve the commutation problem of DC machine :-

(1) Resistance commutation

(2) voltage commutation.

(3) compensating winding

(*) Characteristics of DC Generator:-

No load

OCC

↓

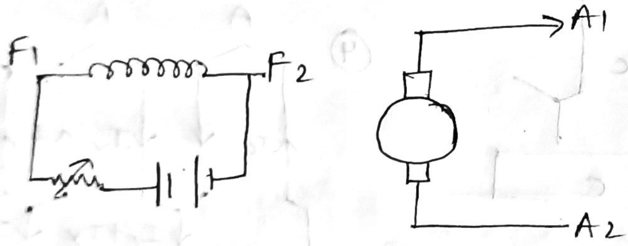
open circuit characteristics

Load

external

→ four types of generators:-

(1) seperately excited generators :- (Here we ~~supply~~ apply voltage to generate field.)



Nothing is connected between A_1 & A_2 so, No load characteristics.

Now, we know that,

$$E = KN\phi$$

$$\boxed{E \propto \phi}$$

But $\phi \propto I_f$

$$\therefore \boxed{E \propto I_f}$$

→ Open circuit characteristics

case - I :-

If $I_f = 0$

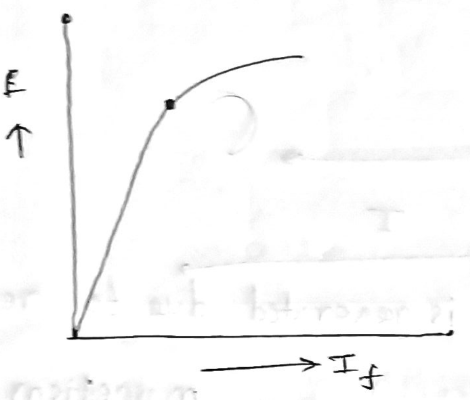
$\therefore$ Induced emf $E = 0$

case - II :- If I_f increases

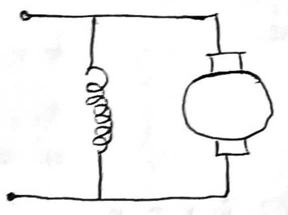
$\Rightarrow$ E also increases

$\rightarrow$ linear characteristic between E & I_f

Note :- ~~After~~ some time field get saturated & there is no possible to further increase the emf.



① Shunt generator :-



We know that,

$E = KN\phi$

For constant N,

$E \propto \phi$

But $\phi \propto I_f$

$\therefore E \propto I_f$

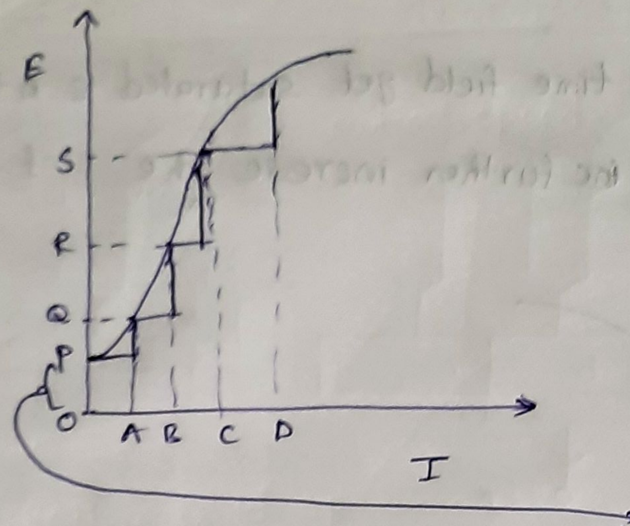
If $I_f = 0$

$\rightarrow$ with I_f '0' & emf '0' cannot build up generate any voltage

Note :- Generator has ~~resdu~~ residual magnetism, due to this initially some voltage is generated ~~is~~, so if $I_f = 0$, emf has some value.

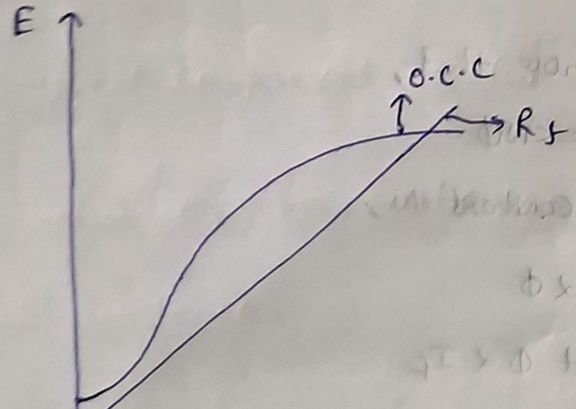
case - II :-

Due to small voltage generated i.e. 20 V, current flows through armature conductor. As the field winding is connected to conductor, some current also flows throw field winding.



→ For $0 \rightarrow I_f$, OP voltage is generated due to residual magnetism.

24/01/23



$\therefore E = V + I_a R_a$

$\therefore V = E - I_a R_a$

But at No-load $I_a \simeq 0$ very less

$\therefore I_a R_a = 0$

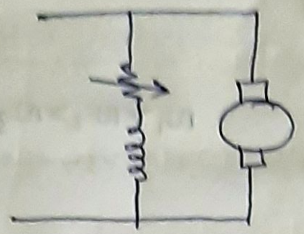
$V = E$

$= I_f R_f$

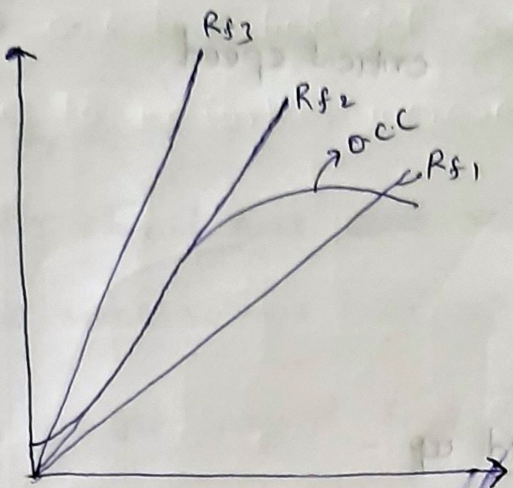
$\Rightarrow \boxed{R_f = \frac{E}{I_f}}$

→ Conclusion :- for particular generator, we can observe the R_f curve is under OCC from graph.

② If we want to inc field resistance we have to connect exerternal resistor series with field ~~ci~~ winding.



After Inc:



$R_{f1} < R_{f2} < R_{f3}$

$R_{f3} > R_{f2} > R_{f1}$

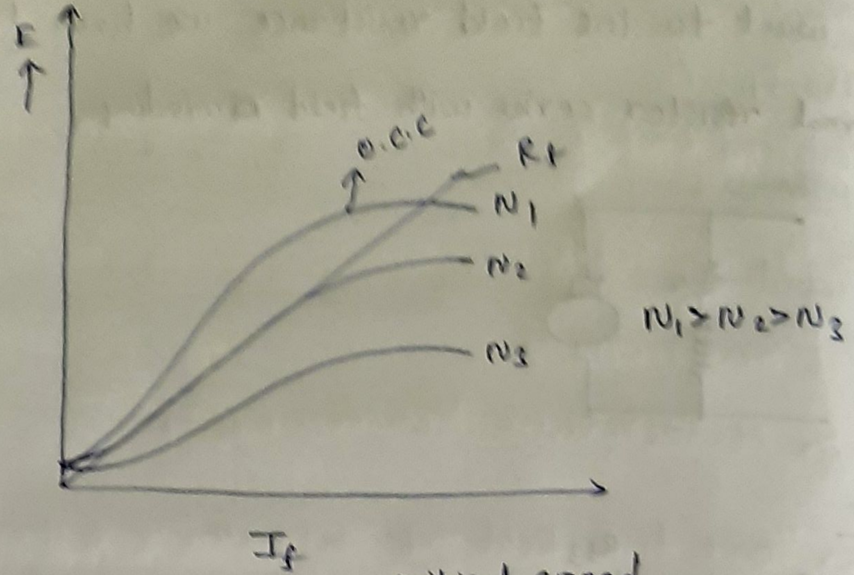
(No O.CC, no emf, so no voltage build up)

→ If there is no residual magnetism, generator can't build up any voltage.

→ upto R_{f2}, generator can build up voltage.

→ The max value of field resistance upto which generator can build up voltage is R_{f2} critical field resistance (i.e. R_{f2})

→ After R_{f2}, there was no OCC characteristics.



critical speed.

conditionas of voltage build up--

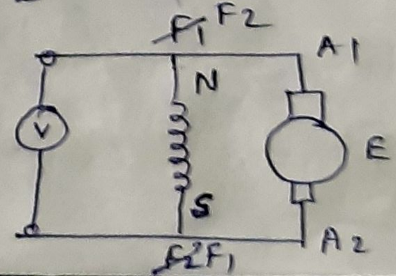
→ There must be residual magnetism

→ for seperately excited generator residual magnetism may or may not be present & for self excited or shunt generator it must be

→ The value of R_f for particular generator less than critical field resistance.

→ The value

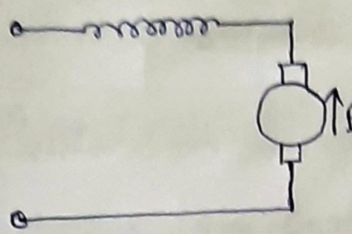
→ The polarity of field and rotation of armature must be in proper sequence.



we ~~cannot~~ connect F_2 & A_1 then voltage generates but no F_1 & A_1

(Note) :- (4th point) If voltage is not generated we can change the polarity

③ series generator:-



$E = KN\phi$

$E \propto \phi$

$\phi \propto I_f$

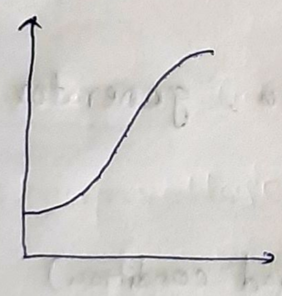
$\therefore E \propto I_f$

case - I :- $I_f = 0$

→ generator should have some residual magnetism, so there is some voltage build up.

→ Initial we get induced emf due to residual magnetism, as circuit is open, no current will flow & there is no magnetic field generation, so no voltage build up.

→ so this is considered as self excited generator.



④ compound generator:-

→ compound generator OCC is same as shunt generator.

30/1/23

Load → how much ampere current we have to draw.

Load characteristics of DC Generator:-

Load means current

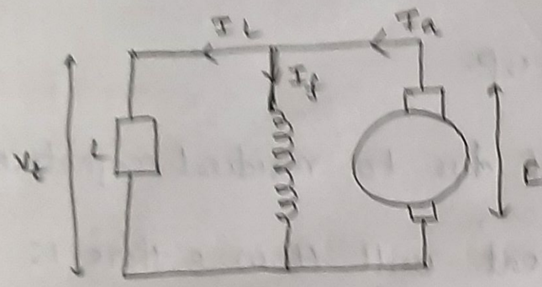
$E = V_t + I_a R_a$ ↓ terminal voltage

↓ $\boxed{V_t \ V_s \ I_L}$

$\Rightarrow \boxed{V_t = E - I_a R_a}$

→ ~~The change of the load~~

Shunt generator:-



we know that

$E = V_t + I_a R_a$

$V_t = E - I_a R_a$

Case-I :- At no-load condition. generator is open circuit condition.

$I_L = I_a - I_f$ (At load condition)

→ At no-load condition, generator complete voltage build up process.

→ If $I_a \uparrow$ $I_f \uparrow$

→ When I_f is max then as $I_L \uparrow$ then $I_a \uparrow$

→ At no-load, the generator only deliver only field current

As $I_L = 0$

$\Rightarrow I_a \approx 0$

$\left[I_L = I_a - I_f \ \text{min} \right.$
then $\left. \boxed{I_L \propto I_a} \right]$

$V_t = E - \underbrace{I_a R_a}_{0}$

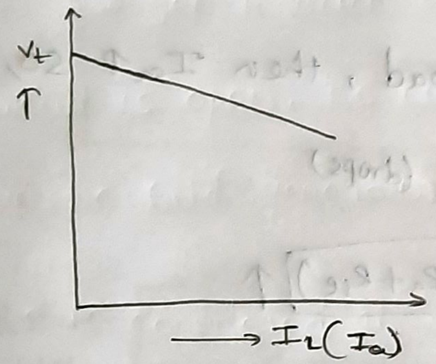
$\boxed{V_t = E}$

→ At 'o' I_a, the ~~curre~~ curve start at maximum induced emf

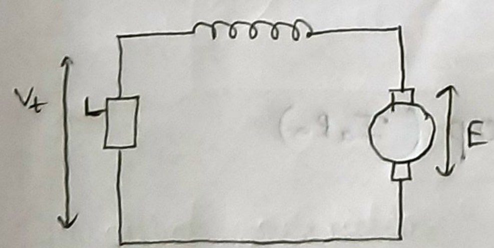
→ case II :- when load is ↑ I_a ↑

so, $V_t = E - (I_a R_a) \uparrow$

$V_t \downarrow$



* series generator:-



$I_a = I_L = I_f$

$E = V_t + I_a R_a + I_{se} R_{se}$

$= V_t + I_a (R_a + R_{se})$

$\Rightarrow \boxed{V_t = E - I_a (R_a + R_{se})}$

At no load,

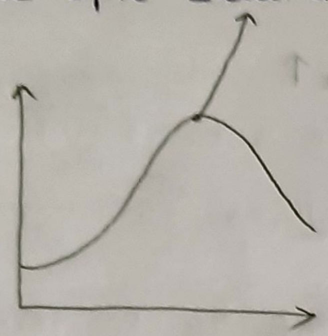
→ In series generator, voltage build up process is not complete.

→ (and it is build by residual magnetism and it is small)

case-II when we connect load try to ↑ the I_a, due to flow I_a, the generator field gets excitation current.

→ Now field of generator increases, emf also inc

→ emf is inc upto saturation point



→ After sat-point we inc load, then I_a↑ so, induced emf decreases. and V_t dec (drops)

$$\text{As, } \underset{\substack{\downarrow \\ \text{decreases.}}}{V_t} = E - \boxed{I_a(R_a + R_{se})} \uparrow$$

⊛ Causes of voltage drop:-

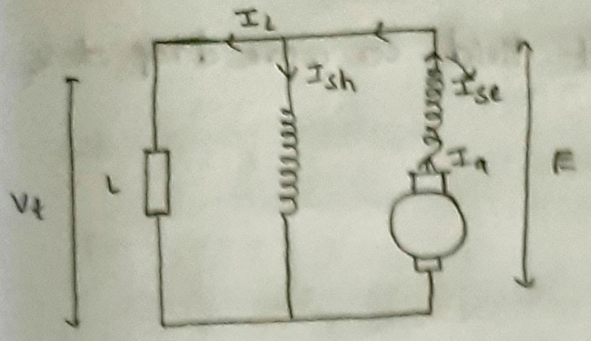
→ Due to armature voltage drop (I_aR_a)

→ Due to brush contact drop

→ Due to armature reaction (due to demagnetisation effect) (main field dec)

→ Due to decrement in field current for the above three effect.

Compound Generator:-



$E = V_t + I_a R_a + I_a R_{se}$

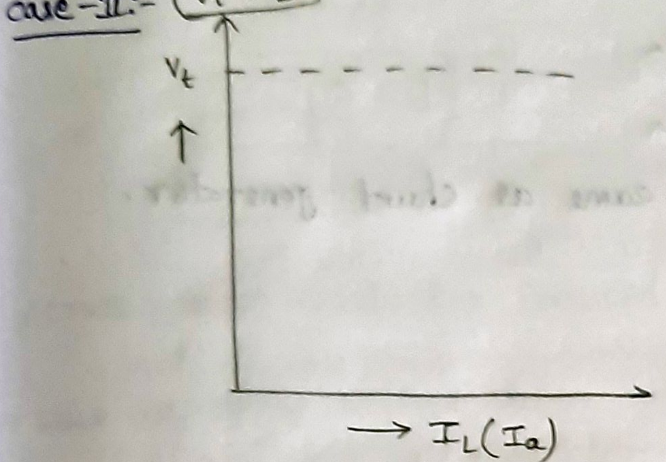
$= V_t + I_a(R_a + R_{se})$

$\Rightarrow V_t = E - I_a(R_a + R_{se})$

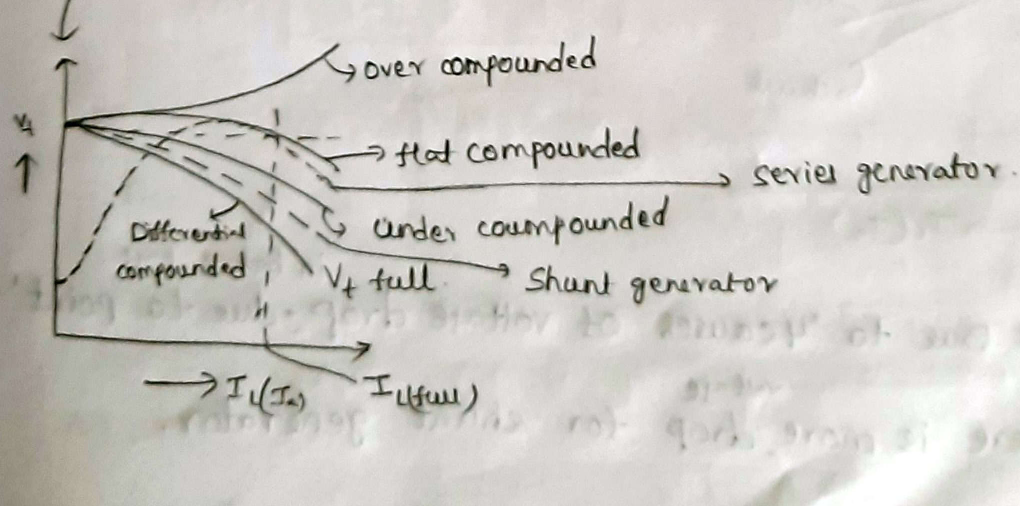
Here $I_a = I_{se}$

case-I:- similar analysis as like shunt generator.

case-II:- $\boxed{V_t = E}$



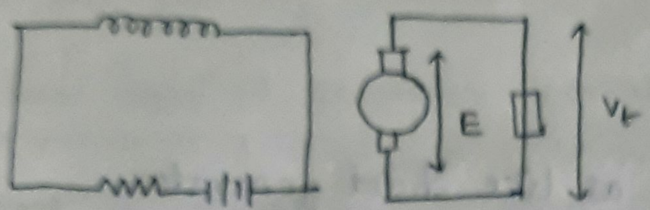
① cumulative (series field helps shunt field)
- → over compoundd → resultant magnetic field ↑ so emf ↑
- → flat compounded → no load voltage and full load is same
- → under compounded.



② Differential compounded :-

→ series field oppose the shunt field, so more drop of V_t.

seperately excited generator:

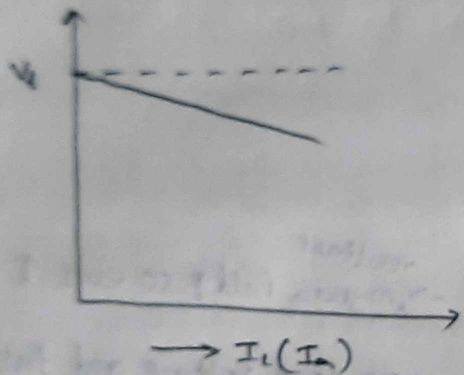


$I_a = I_L$

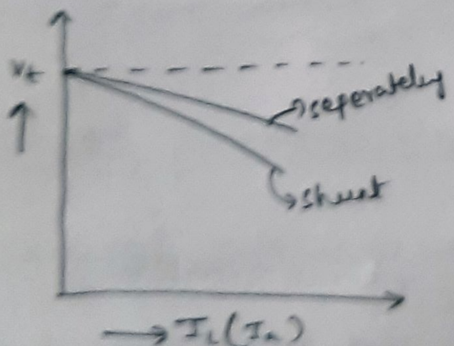
$V_t = E - I_a R_a$

$= E - I_L R_a$

→ no load characteristics same as shunt generator.



→

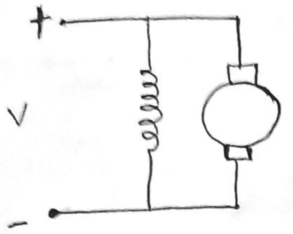


→ ~~sepe~~ Due to '4' causes of voltage drop : due to point '4' in before page.

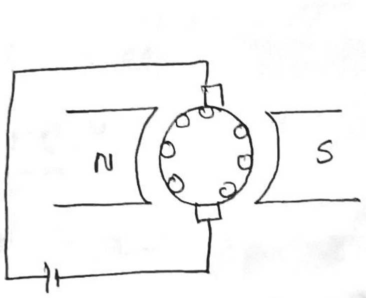
there is more voltage drop for shunt generator.

* DC Motor:-

For generator we should supply load voltage an in motor we apply voltage.



* Back emf:- induced emf across rotor opposes supply voltage



$$E_b = KN\phi$$
$$= \frac{PN\phi}{60}\left(\frac{Z}{A}\right)$$

In motor conductor rotates itself due to force

Across rotor conductor induced emf is generated.

→ When we apply voltage rotor rotates

* Torque equation of DC Motor:-

Let E_b = back emf

I_a = Armature current

ω = angular speed

τ = developed torque

$$P_{mechanic\ develop} = \tau\omega$$

$$P_{electrical\ develop} = E_b I_a.$$

As $P_{m\text{-}develop} = P_{e\text{-}develop}$

$$\tau\omega = E_b I_a$$

$$\Rightarrow \tau = \frac{E_b I_a}{\omega} = \frac{PN\phi}{60}\left(\frac{Z}{A}\right)\cdot I_a \frac{60}{2\pi N}$$

$$\tau = \frac{PZ}{2\pi A} \cdot \phi I_a$$

$$\tau = K_t \phi I_a, \text{ where } K_t = \frac{PZ}{2\pi A}$$

$$= \text{constant}$$

$\Rightarrow$ ① $\tau \propto \phi$

② $\tau \propto I_a$.

Home work:-

$F = Bli$ → i = current/conductor

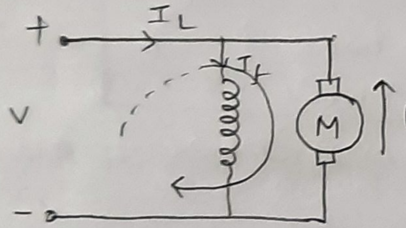
Z is total conductor

$\tau = F \times r$ → radius of armature

02/02/23

Some other equations of DC motor:-

shunt motor:



$I_L = I_a + I_f$

$$\boxed{I_a = I_L - I_f} \rightarrow ①$$

for motor

I_L is load/supply/line current

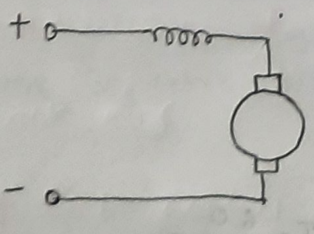
KVL

$V = I_a R_a + E$

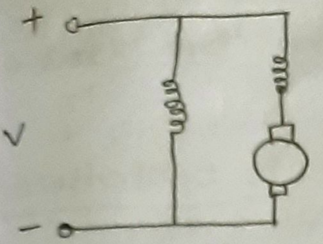
$$\boxed{E = V - I_a R_a} \rightarrow ②$$

$$\boxed{V = I_f R_f} \rightarrow ③$$

④ series motor:-



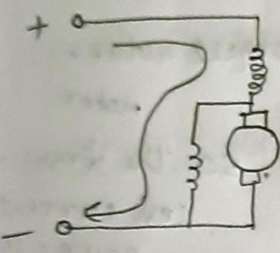
$E = V - I_a R_a - I_f R_f$



$E = V - I_a R_a - I_{se} R_{se}$

$I_{se} = I_a.$

$V = I_f R_f$



$I_L = I_{se}$

$V = I_{se} R_{se} + I_{sh} R_{sh}$

① ~~seperately excited~~

② <u>speed</u> <u>epuetion</u>:-

$\therefore E_b = V - I_a R_a \rightarrow ①$

But $E_b = KN\phi$

$KN\phi = V - I_a R_a$

$$\boxed{N = \frac{V - I_a R_a}{K\phi}}$$

speed of the motor implies that ⇒

→ It depends on supply voltage

→ " $I_a R_a$ drop

→ " flux of the motor.

③ From ①

Armature current, $\boxed{I_a = \frac{V - E_b}{R_a}}$

① Importance of back emf of motor:-

we know that, $I_a = \frac{V - E_b}{R_a}$ → ①

Case-I: At No-load condition, motor running freely.

→ load torque always opposes the rotation of ~~morque~~ motor.

→ Motor draw driving torque at no-load. so the motor draw very less current from armature (power source)

$T_d = K_a \phi I_a$ → constant → armature current come from voltage source

→ When rotating we have to conider friction loss.

→ Generation of back emf is nearly equal to supply voltage at no Load condition.

→ Here armature current is zero then torque decreases.

Case-II: Load ↑ speed of the motor decrease, so back emf also decreases. as ($E_b \propto N$) According to ① I_a ↑

→ Motor will draw more current from supply

Case-III: After full Load, we dec the load of motor, the speed will increase. As $E_b \propto N$, back emf also increases, so acc. to ① I_a ↓

→ How much amount of I will draw from supply by motor depends on back emf.

→ Back emf control the armature current as per load inc or dec.

→ Back emf work as governor for dc motor.

Characteristics of DC motor:-

① Torque Vs Armature current (τ Vs I_a)

② speed Vs Armature current (N Vs I_a)

③ speed Vs Torque (N Vs τ)

* DC shunt motor:-

① τ Vs I_a

we know that $\tau = k_t \phi I_a$

∴ for const, ϕ $\tau \propto I_a$.

case(i):- At no load condition:-

$I_a \approx 0$ as discussed before page.

$\tau \to 0$

we will start from origin

case(ii):- As load of motor ↑ due to speed ↓ back emf ↓

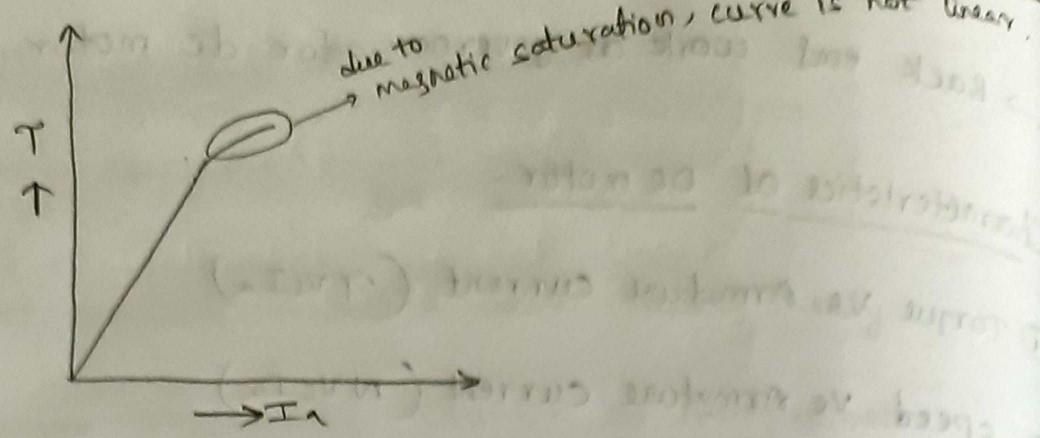
I_a ↑

↓

τ also ↑

so characteristic are linear

case(iii):- Due to increament of load, armature mmf more so effect of armature reaction is ~~permanent~~ prominent, so resultant flux is reduced. τ also decreasing in nature



→ when we apply full load there will be mechanical or electrical break down.

② N Vs I_a

we know that $N = \dfrac{V - I_a R_a}{k\phi}$

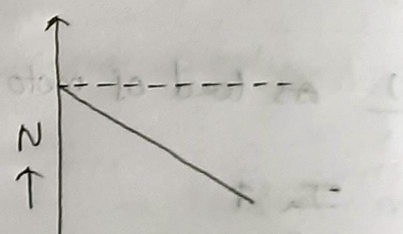
Case-I:- At no-load.

As $I_a \approx 0 \Rightarrow I_a R_a = 0$

$\therefore \quad N = \dfrac{V}{k\phi}$ → max speed at no load.

Case-II: Load ↑ I_a↑

As $I_a R_a$↑ N↓

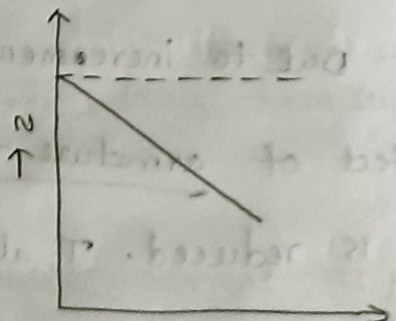


③ N Vs T

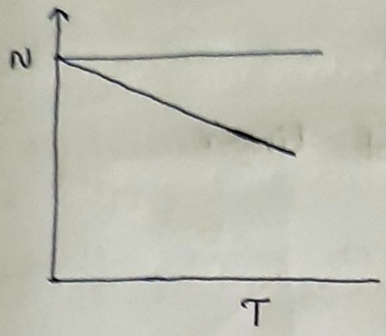
$T = k_t \phi I_a$

$I_a = \dfrac{T}{k_t\phi}$

$N = \dfrac{V - \dfrac{T R_a}{k_t\phi}}{k\phi}$



06/03/23



$T = 0$ means no load

→ without the torque the system cannot be rotate.

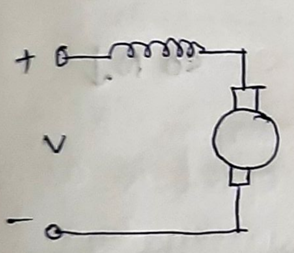
→ Here due to developed torque (T_d) the system will rotate

→ so how much load apply will ~~said~~ decide the speed.

→ we maintain const speed.

Series motor:-

① T vs I_a:



$T = k_t \phi I_a$.

$I_a = I_f = I_L$.

$\phi \propto I_f$

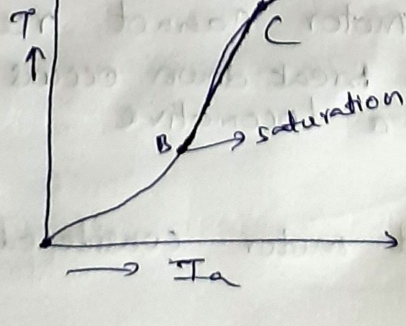
$\therefore T = k_{t_1} I_f I_a$.

$= k_t I_a^2$.

$\therefore \boxed{T \propto I_a^2}$

Case (i):- At no-load condition,

$I_a = 0$



{ upto OB ⇒ $T \propto I_a^2$ }
{ after OB → $T \propto I_a$ }
(linear B to C)

Case- When we ↑ load I_a ↑

As $T \propto I_a^2$

the characteristics are not linear.

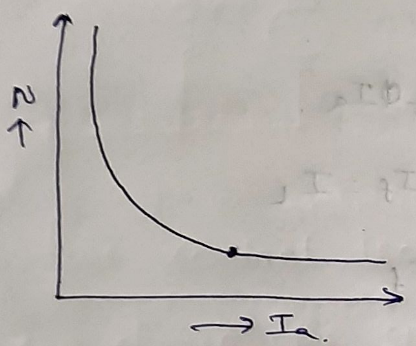
(II) N Vs I_a

$$N = \frac{V - I_a R_a}{K\phi}$$

$$N = \frac{V - I_a R_a}{k_1 I_f}$$

$$\boxed{N = \frac{V - I_a R_a}{k_1 I_a}}$$

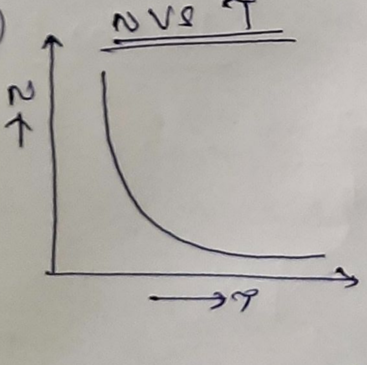
(i) At no-load, $I_a = 0$, $\boxed{N = \infty}$



(ii) After load ↑, I_a ↑

so N ↓

(III) N Vs T



→ The series motor cannot run at no-load condition. And mechanical break down occurs.

→ It use as a locomotive.

* Justify shunt motor considered as constant speed

* Why series motor is used as traction device?

→ In locomotive there is not chance of making no load condition and motors mechanically couple.

→ At strating motor draw 5-10% times of max current

→ so starting torque is more in series motor compared to shunt.

* Why belt pulley is dangerous to run series motor?

→ Due to edging effect, if the belt breakes, then no load the speed increas it may cause mechanic break down.

* Method of speed control:-

$$N = \frac{V - I_a R_a}{K\phi}$$

① By changing the voltage supply.

② By chaning I_a, or armature voltage

③ By changing the I_f.

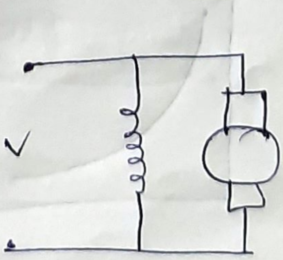
① supply voltage is always constant. that's why it is not able to control speed of motor.

Shunt motor:

Armature control method:-

(supply voltage & I_f makes constant)

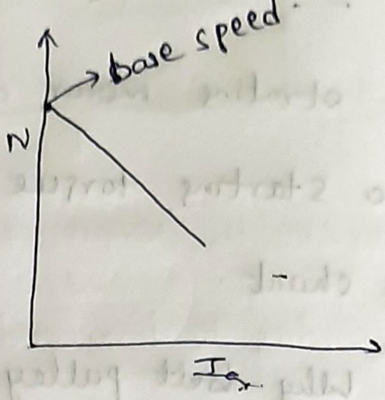
$$N = \frac{V - I_a R_a}{K\phi}$$

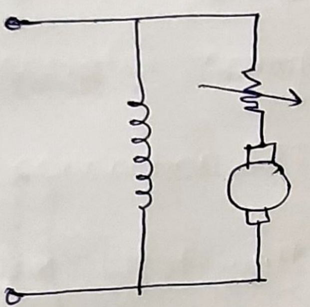


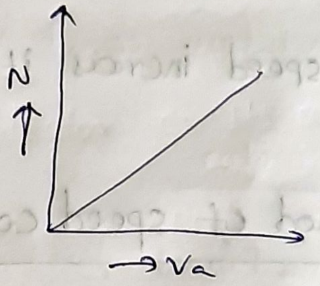
Armature resistance / armature current

Case - I :- At no-load, $I_a = 0$

→ to change I_a we have to change resistance of armature circuit, so we connect externally rheostat to armature circuit. so, I_a decreases.





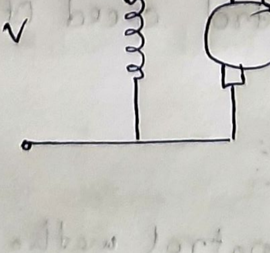


→ By armature control technique speed is always decreases.

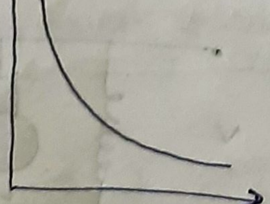
→ so we can change the speed below the base speed.

Field control -

$$N = \frac{V - I_a R_a}{K\phi}$$



$$N \propto \frac{1}{\phi}$$

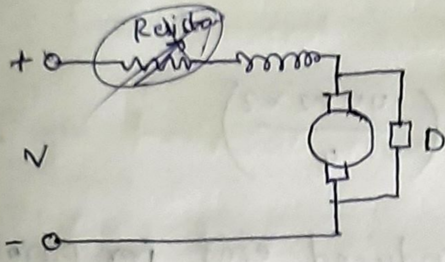


By changing the field current i.e., some external resistance to be added in series with field.

→ By field control technique speed, ~~is~~ ~~[illegible]~~ we can change the speed above the base speed.

* speed control for DC series motor:-

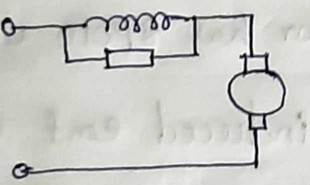
① Armature control:



$$N = \frac{\overset{\nearrow \text{const}}{V} - I_a R_a}{K\phi}$$

At const ϕ, as $I_a R_a$ changes, speed changes

② Field control method:



Field diverter circuit is nothing but which has a variable resistance.

→ By connecting field diverter circuit parallel we can change only field current

Imp

(Q: How many methods are there to control speed of DC motor)

(Q: What is field diverter circuit)

Problems:-

Ex-1: A 4 pole DC machines has 144 slot in the armature with 2 coil side per slot, ~~on~~ each coil has 2 turn. The flux per pole is 20 mwb, the armature is lap wound and it rotates at 720rpm. Determine the induced emf.

Sol: We know that,

$$E = \frac{PN\phi}{60}\left(\frac{Z}{A}\right)$$

$P = 4$ $\quad Z = 144 \times 2 \times 2$

$N = 720$

$\phi = 20 \times 10^{-2}$ wb

$A = P = 4$

$$\Rightarrow \quad E = \frac{4 \times 720 \times 20 \times 10^{-3}}{60}\left(\frac{144 \times 2 \times 2}{4}\right)$$

$= 138.24V \rightarrow$ Induced emf ~~per~~ per parellel Path

② A DC generator carry 600 conductor on its armature with Lap connection. The generator has 8pole with 0.06wb useful flux. What will be the induced emf at its terminal if it is rotate at 1000rpm? Also determine the speed at which it should be driven to induced the same voltage with wave connection

$$600 = \frac{8 \times \cancel{1000}\,N \times 0.06}{60}\left(\frac{\cancel{600}\,300}{2}\right)$$

$$N = \frac{600}{40 \times 0.06}$$

$$\boxed{N = 250\ rpm}$$

(3) A DC machine running at 750rpm has an induced emf of 200V. Calculate

(i) the speed at which induced emf will be 250 V

(ii) The % inc in main field flux for an induced emf of 250V at speed of 700rpm

(i) $\boxed{\frac{E_1}{E_2} = \frac{N_1}{N_2}}$

$\frac{200}{250} = \frac{750}{x}$

$\boxed{x = 937.5 rpm}$

(ii) $\frac{E_1}{E_2} = \frac{N_1 \Phi_1}{N_2 \Phi_2}$

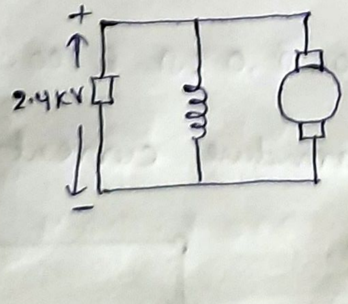
$\frac{200}{250} = \frac{750\Phi_1}{700\Phi_3}$?

$\frac{Q_3}{Q_1} = \frac{75}{70} \times \frac{250}{200}$

$\frac{Q_3}{Q_1} = 1.34$

(4) A 4 pole shunt generator with lap connected armature has field and ~~resistance~~ armature resistance are 50Ω & 0.1Ω respectively. The generator is supplying a load of 2.4KW at 100V. Calculate the armature current, current in its conductor & generated emf.

Sol:



$I_a = I_L + I_f$

$= \frac{2.4 \times 10^3}{100} + \frac{100}{50}$

$= 240 + 2 = 242$

$E = V + I_a R_a$

$E = 100 + 242(0.1)$

$= 100 + 24.2$

$= 124.2$

(4) current in its conductor $(I_c) = \frac{I_a}{A} = \frac{242}{4} = 60.5$

(5) The armature of a 4pole DC shunt generator has 378 wave connected. The armature and shunt winding resistance 1Ω & 100Ω respective. The flux per pole is 0.02Wb. If a load resistance of 10Ω is connected across the armature terminal and generator is driving at 1000 rpm, the power absorbed by the load Calculate

$$E = \frac{PN\phi}{60}\left(\frac{Z}{A}\right)$$

$$E = V + I_aR_a$$

$$E = \frac{4\times1000\times0.02}{60}\left(\frac{378}{2}\right)$$

$$252 = V + \left(\frac{V}{100} + \frac{V}{10}\right)$$

$$E = 252 \qquad V = IR$$

$$252 = V + \left(\frac{V+10V}{100}\right)$$

$$252 = V + \frac{11V}{100}$$

$$P = I_LV$$

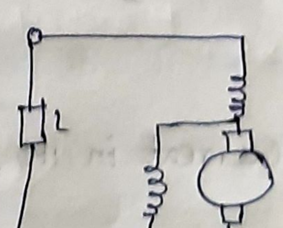
$$25200 = 111V$$

$$P = \frac{227.02}{10} \times 227.02$$

$$\boxed{V = 227.02}$$

$$\boxed{P = 5.153\,KW}$$

(6) A short shunt ~~DC~~ compound Generator deliver a load ~~of~~ current of 30Amp & 220 volt, The resistance of armature, sieries field and shunt field are 0.05Ω, 0.3Ω & 200Ω respectively. Calculate induced emf & armature current. Allow 1volt per brush contact drop.



$E = V_t + I_a(R_a + R_{se}) +$ brush contact drop $\cancel{I_a = I_{se}}$

$\cancel{I_a + I}$

$I_a = I_L + I_{sh}$ $V = IR$

$E = V + I_aR_a +$ brus contact drop

$I_a = 30 + \frac{229}{200}$

$E = 220 + 31.14 \times 0.05 + 2 + I_{se}R_{ce}$.

$= 30 + 1.1$

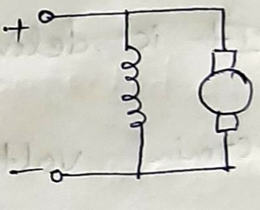
$\cancel{223.56}$

$= 232.56$

$= 31.14$

(7) The armature shunt 4pole lap. wind DC Generator is 0.05 Ω & 25 Ω respectively. If the armature contain 500 conductor. find the speed of motor when it take 120A from a DC main of 100V supply. flux per pole is 2×10^{-2} wb

sol:- $N = \frac{V - I_aR_a}{}$



$E = \frac{P N \phi}{60}\left(\frac{Z}{A}\right)$

$E = V - I_aR_a$.

$94 = \frac{4 \times N \times 2 \times 10^{-2}}{60}\left(\frac{500}{4}\right)$

$E = 100 - 116 \times 0.05$

$= 94.2$

$N = \frac{94.2 \times 60}{10}$

$I_a = I_L - I_f$

$= 120 - \frac{100}{25}$

$\boxed{N = 565.2}$

$= 116$

(T)

8. The electromagnetic torque = 80Nm for I_a of 30A

15A? what is emf at a speed of 900 rpm

for I_a ~~of~~ 15A?

$$\frac{80}{x} = \frac{30}{15}$$

$x = 40$

→ $E = KN\phi$ $T\omega = E_b I_a$

$$\frac{E_1}{E_2} = \frac{N_1}{N_2}\frac{\phi_1}{\phi_2}$$

$$\Rightarrow 40 \times \frac{2\pi \times 900}{60} = E_b \times 15$$

$$\Rightarrow E_b = \frac{40 \times 2\pi \times 900}{60 \times 15}$$

$$\boxed{E_b = 251.32}$$

9. The armature resistance of 220V DC Generator is 0.4Ω

It is delivering a load of 4 kW at a rated

terminal voltage. Now the machine operated as a

motor and draw the same current at same V_t.

In this if flux/pole ↑ by 10%. what will be

the ratio speed from generator to motor,

$E = KN\phi$

$$E_2 = \frac{10}{100} \times E_1$$

$$\boxed{\frac{\phi_2}{\phi_1} = 1.1}$$

$E = V + I_a R_a$

$= 220 + 18.18 \times 0.4$

$$\boxed{E = 227.272}$$

$4kW = V \times I_L$ (220)

$4000 = 220 \times I_L$

$$\boxed{I_L = 18.18}$$

$E = V - I_a R_a$

$E = 220 - 18.18 \times 0.4$

172.728

$$\frac{229.272}{172.728} = 1\cancel{0} \times \frac{N_1}{N_2}$$

$$\frac{N_1}{N_2} = 0.13.$$

(16) A DC shunt motor run at 1000rpm at 220V supply. It armature & R_f are 0.5Ω & 100Ω. & the total current taken from supply is 26A. It is desirve to reduce the speed to 750rpm keeping armature & field current same. What resistance should be inserted in armature circuit. (Ans:- 2.18Ω)

$$\boxed{\frac{E_G}{E_m} = \frac{N_1\phi_1}{N_2\phi_2} = \frac{N_a\phi_a}{N_m\phi_m}}$$

$I_a = I_L - I_f$

$= 26 - \frac{220}{100}$

$= 26 - 2.2$

$= 23.8 \times 0.5$

$$N = \frac{V - I_a R_a}{K\phi}$$

$$1000 = \frac{220 - \cancel{23}.11.9}{K_1\phi}$$

$$K\phi = \frac{208.1}{1000}$$

$$750 = \frac{220 - 23.8\times x}{208.1} \times 1000$$

$$\frac{750}{1000} \times 208.1 = 220 - 23.8x.$$

(11) ~~Fie~~ ~~If~~ R_f & R_a of a 240V DC shunt motor is 120 Ω

& 0.1. It draw 24A at rated Vol with speed 1000rpm

. ~~I~~Find value of additional Resis in armature circuit to

reduce the speed to 800rpm. when

(i) The load Torque ∝ N

(ii) The load torque ~~varies~~ ∝ N^2

$\boxed{\text{Ans } 3.434\,\Omega}$

$E = V \mp I_a R_a$.

~~240~~

$E = V -$

$$\frac{T_1}{I_2} = \frac{N_1}{N_2}$$

$$\frac{\phi_1 I_1}{\phi_2 I_2} = \frac{N_1}{N_2}.$$

(17) Field & armature resistance of DC ~~shunt~~ series motor is 0.2Ω & 0.3Ω. Motor run at 500 rpm and draw current at 49 Amp. If the load torque $\propto N^2$. Determine the value of external resistance with series with armature for the motor to run at 450rpm. Assume linear magnetization.

i.e, $\phi_1 = \phi_2$

$\boxed{\text{Ans } 3.117\Omega}$