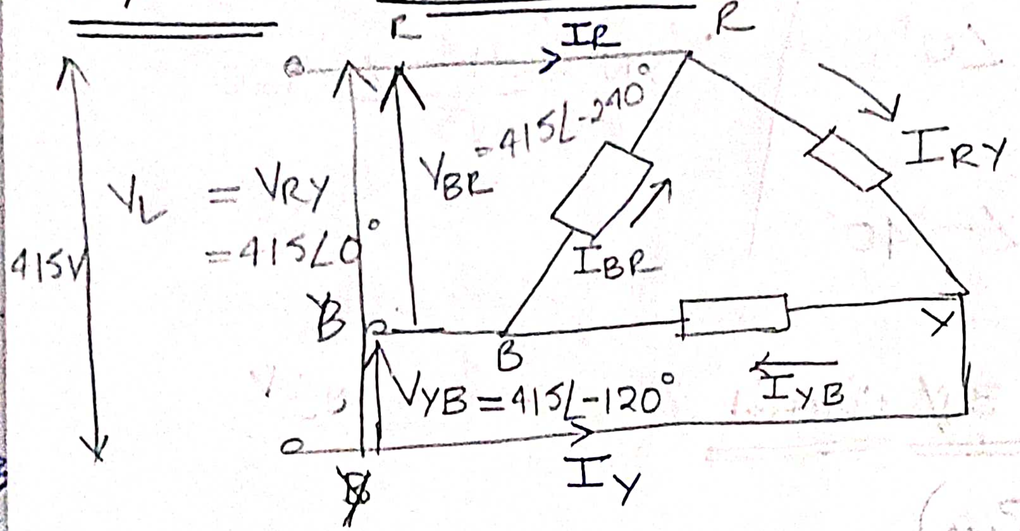
* All phases will have equal voltages i.e. balanced circuit.

* 3ϕ DELTA CONNECTION:



at R

$$I_R + I_{BR} = I_{RY}$$

$$I_R = \cancel{415}\, I_{RY} - I_{BR}$$

$$= \frac{415}{5}\angle 0^\circ - \frac{415}{5}\angle -240^\circ$$

$$= \sqrt{3} \times 83 \angle -30^\circ$$

29/07/2022

* DC GENERATOR:

→ Generator: Mechanical Energy to Electrical energy.

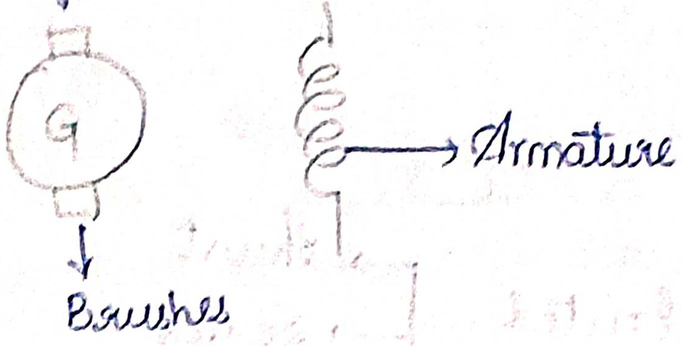
* Faraday's Law of electromagnetic induction:

Whenever flux linkage is present emf is generated.

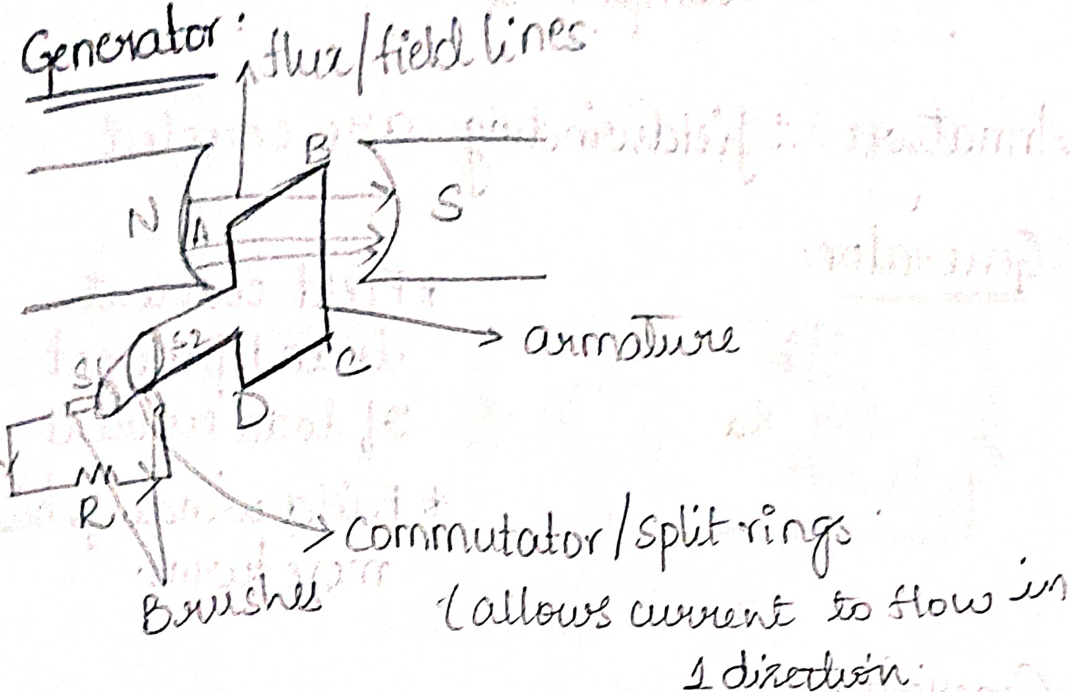
Conductor System: Armature

Field System: Flux system (field)

Electromagnets:



* DC Generator:



→ TYPES OF GENERATOR:

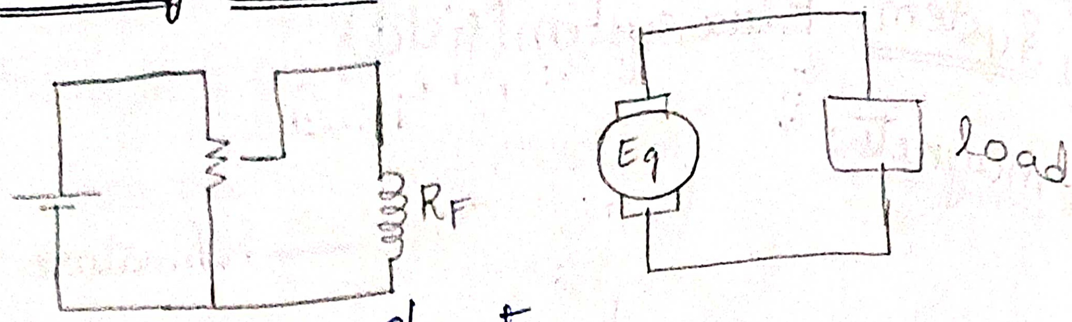
- Separately Exited
- Self Excited.

Giving energy to field winding : exciting

→ **Separately Excited:** Giving energy from separate source.

→ **Self Excited** : Giving energy through self.

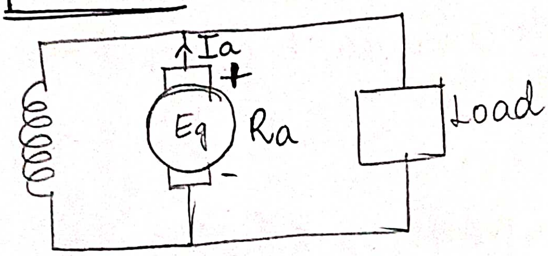
→ Separately Excited:



Self Excited: → Shunt
→ Series
→ Compound.

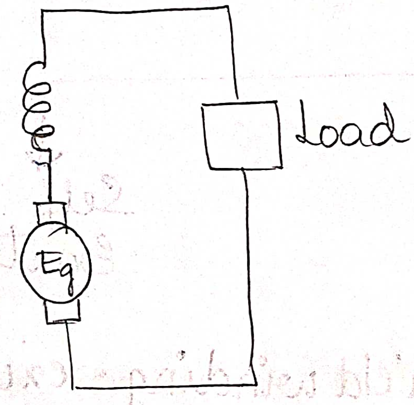
SHUNT: Armature & fieldwinding are coupled.

→ Shunt Generator:



* Field current is independent of load current.
* Field windings has more turns.

→ Series Generator:

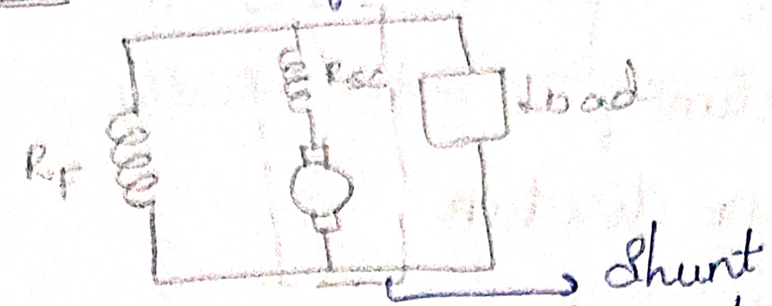


* Load will decide the DC current.
* Field winding has less turns of very thick wire.

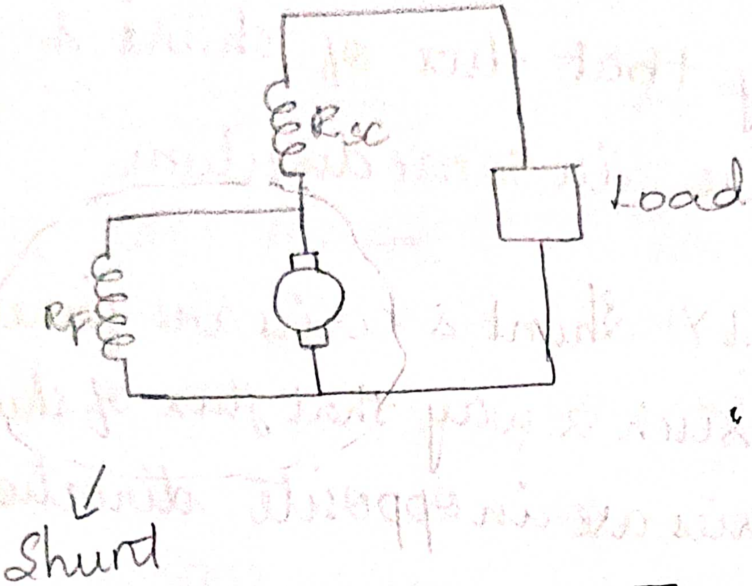
→ Compound Generator: → Long Shunt
→ Short Shunt.

Combination of Series + shunt = compound.

→ **LONG SHUNT**: Connecting series to shunt



→ **SHORT SHUNT**: Connecting shunt to series



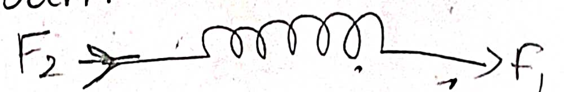
GENERATORS

- Separately Excited
- Self-Excited
  - Series
  - Shunt
  - Compound
    - Long Shunt
    - Short Shunt
    - Cumulatively
    - Differentially

* **Compound:** → Cumulatively
→ Differentially

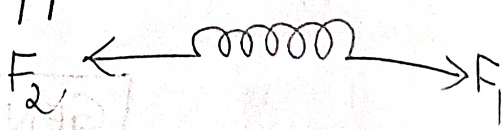
based on dim. of winding flux direction changes.

→ **CUMULATIVELY:** Shunt & series are joined in such a way that flux of shunt & flux of series are in same direction.



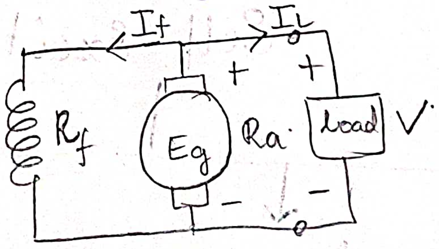
BEE

→ **DIFFERENTIALLY:** Shunt & series are joined/connected in such a way that flux of shunt and flux of series are in opposite direction



30/07/2022

* **SHUNT GENERATOR:**



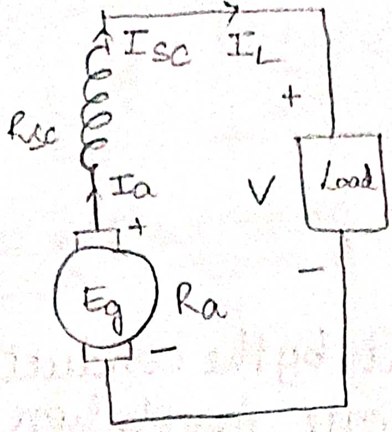
$$I_a = I_f + I_L$$

$$\boxed{I_f = \frac{V}{R_f}}$$

$$E_g - I_a R_a - V = 0$$

$$\boxed{E_g - \underbrace{I_a R_a}_{\text{Brush drop}} = V}$$

* **SERIES GENERATOR:**



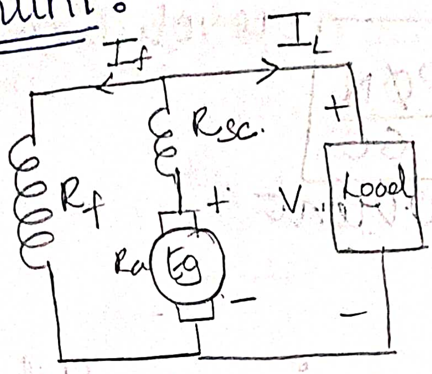
$$I_a = I_{sc} = I_L$$

$$E_g - I_a R_a - I_a R_{sc} - V = 0$$

$$\boxed{V = E_g - I_a R_a - I_a R_{sc}}$$

↓ Brush drop.

* Long Shunt:



$$\boxed{I_f = \frac{V}{R_f}}$$

$$I_a = I_{sc}$$

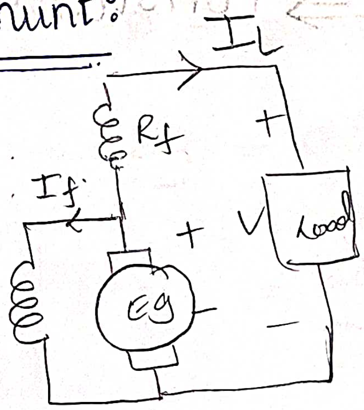
$$I_a = I_f + I_L$$

$$E_g - I_a R_a - I_a R_{sc} - V = 0$$

$$\boxed{V = E_g - I_a R_a - I_a R_{sc}}$$

↓ Brush drop.

* Short Shunt:



$$I_L = I_{sc}$$

$$E_g - I_a R_a - I_L R_{sc} - V = 0$$

$$\boxed{V = E_g - I_a R_a - I_L R_{sc}}$$

↓ Brush Drop.

* EMF equation of a DC generator:

ϕ = Flux/Pole in wb.

P = No. of poles

Z = total no. of conductors in armature

N = Speed of armature in rpm.

$A =$ No. of parallel paths.

Emf of conductor / Emf induced $= \frac{d\phi}{dt}$

$= \frac{\text{Flux cut by the conductor in one revolution}}{\text{Time taken for one revolution}}$

$$\boxed{e = \frac{d\phi}{dt} = \frac{P\phi N}{60}}$$

No. of parallel paths $\propto$ current.

Lap windings: $A = P \Rightarrow$ i.e. parallel paths depends on poles.

Wave windings: $A = 2 \Rightarrow$ constant.

ex:

100 conductors

Lap: $P = A = 4$

$\frac{100}{4} = 25$ conductors sets are connected in series to source and all 4 paths are parallel

$V = 25V$

Wave: $A = 2$

$\frac{100}{2} = 50$ conductors

$\boxed{V = 50V}$

$$\boxed{E_g = \frac{P\phi N}{60} \times \frac{Z}{A} = \frac{\phi Z N}{60} \times \frac{P}{A}}$$

for lap winding :

$$\boxed{E_g = \frac{\phi Z N P}{60A}}$$

for wave winding : $A = 2$

$$\boxed{E_g = \frac{\phi Z N P}{120}}$$

* $P = 4 \quad A = 2, \quad Z = 720 \quad N = 1000\ rev/min$

$\phi = 20mWb$

$$n = \frac{100\cancel{0}}{6\cancel{0}} = \frac{50}{3}$$

$$\phi = 20 \times 10^{-3}\ wb$$

$$E_g = \frac{\phi Z N P}{120}$$

$$= \frac{20 \times \cancel{10^{-3}} \times \overset{6}{\cancel{72}\cancel{0}} \times \cancel{1000} \times 4}{\cancel{12}\cancel{0}}$$

$$= 480\ V$$

* $P = 8 \quad Z = 12$ per slot $\quad \phi = 50 \times 10^{-3} \quad E_g = 300V$

40 slots

total no. of conductors $= 12 \times 40$

$= 480$

$$E_g = \frac{\phi Z N P}{60A}$$

$$\cancel{500 = \frac{50\times10^{-2}\times12\times N\times8}{60\times8}}$$

$\cancel{N = 21}$

$$\overset{10}{\cancel{500}} = \cancel{50}\times10^{-3}\times\overset{8}{\cancel{480}}\,N\times\cancel{8} \over \cancel{60}\times\cancel{8}$$

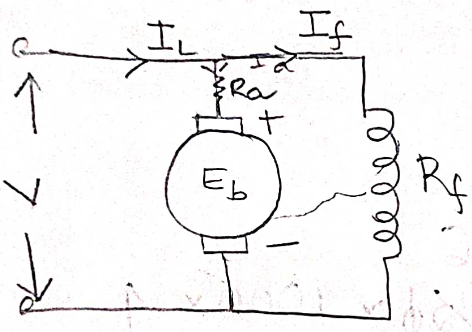
$$N = \frac{10^4}{8} = \frac{\overset{2500}{\cancel{10000}}}{\cancel{8}_{2}} = 1250\,rpm$$

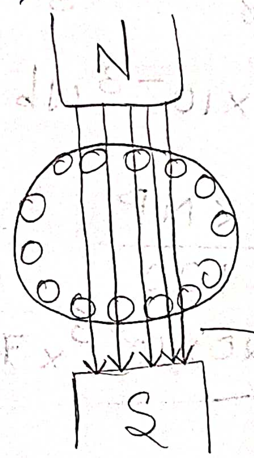
BEE

03/08/2022

* DC MOTOR:

Whenever we place a current carrying conductor in a magnetic field; there is a force developed.





armature flux → conductor flux

field flux → actual flux

→ current carrying conductors

⊙ → inward

⊗ → outward

Interaction b/w armature & field flux

$I_L = I_a + I_f$

$V = I_aR_a + \boxed{E_b}$ → back emf: opposes the source voltage

$$\boxed{V - I_aR_a - E_b = 0}$$

SHUNT MOTOR:

$$\boxed{E_b = V - I_aR_a}$$

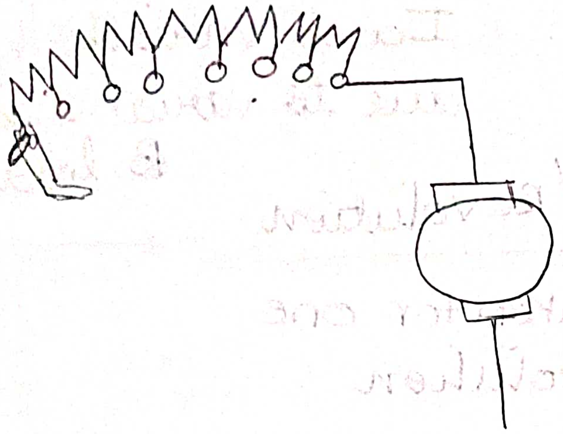
$$\boxed{I_a = \frac{V - E_b}{R_a}}$$

$$\boxed{E_b = \frac{\phi Z N}{60} \times \frac{P}{A}}$$

* $\boxed{E_b \text{ controls the current } I_a}$

If $E_b = 0$; $N = 0$

$$\boxed{I_a = \frac{V}{R_a}}$$



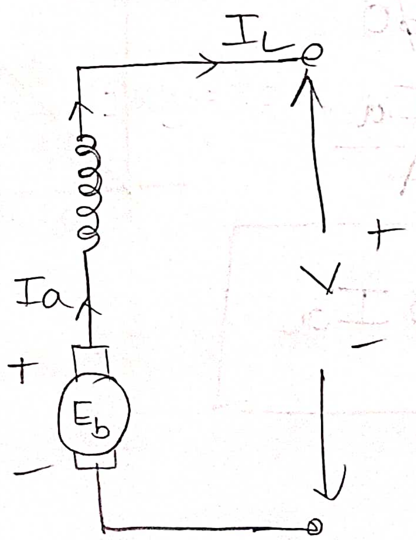
Starter is used to limit the starting current.

$$I_a = \frac{V - E_b}{R_a}.$$

* We need to limit the starting current to avoid the damage to the circuit

* Also at the beginning $E_b = 0$
∴ current I_a is very high; to control this current; starter is used $\boxed{I_a = \frac{V}{R_a}}$

* SERIES MOTOR:



$I_L = I_{sc} = I_a$.

$E_b - I_aR_a - V = 0$

$$\boxed{E_b = I_aR_a + V}$$

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

$$\cancel{500 = \frac{50\times10^{-3}\times 12\times N\times 8}{60\times 8}}$$

$$\cancel{N = Z}$$

$$\overset{10}{\cancel{500}} = \frac{\cancel{50}\times10^{-3}\times \overset{8}{\cancel{480}}\, N\times\cancel{8}}{\cancel{60}\times\cancel{8}}$$

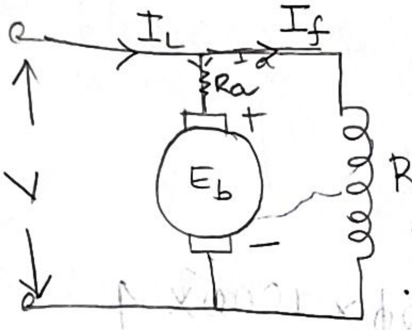
$$N = \frac{10^4}{8} = \frac{\overset{2500}{\cancel{10000}}}{\underset{2}{\cancel{8}}} = \underline{1250\,\text{rpm}}$$

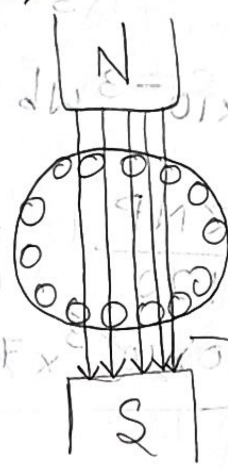
BEE

03/08/2022

* DC MOTOR:

Whenever we place a current carrying conductor in a magnetic field, there is a force developed.





armature flux → conductor flux

field flux → actual flux

→ current carrying conductors

Interaction b/w armature & field flux

⊙ → inward

⊗ → outward

$I_L = I_a + I_f$

$V = I_aR_a + \boxed{E_b}$ → back emf: opposes the source voltage

$$\boxed{V - I_aR_a - E_b = 0}$$

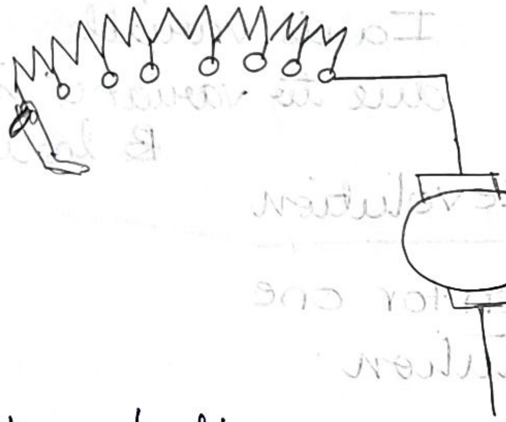
SHUNT MOTOR: $\boxed{E_b = V - I_aR_a}$ $\boxed{I_a = \frac{V - E_b}{R_a}}$

$$\boxed{E_b = \frac{\phi Z N}{60} \times \frac{P}{A}}$$

* E_b controls the current I_a

If $E_b = 0$; $N = 0$

$$\boxed{I_a = \frac{V}{R_a}}$$



Starter is used to limit the starting current.

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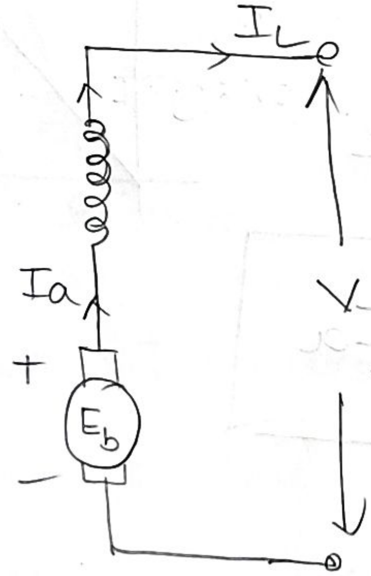
∴ current I_a is very high; to control this current; starter is used

$$\boxed{I_a = \frac{V}{R_a}}$$

* SERIES MOTOR:



$$I_L = I_{sc} = I_a$$

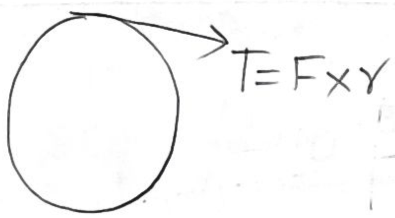
$$E_b - I_a R_a - V = 0$$

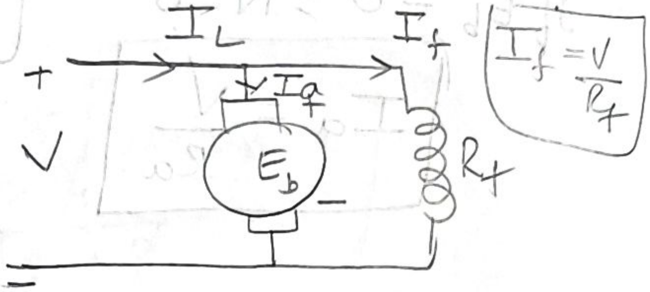
$$\boxed{E_b = I_a R_a + V}$$

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

06/08/2022

* TORQUE IN DC MOTOR:





$$\boxed{P_m = E_b I_a}$$

I_a is variable due to variance in load.

$$\text{Power} = \frac{\text{Workdone / Revolution}}{\text{Time taken for one revolution}}$$

$$= \frac{(F \times 2\pi r)/1}{60/N} = (Fr)\frac{2\pi N}{60}$$

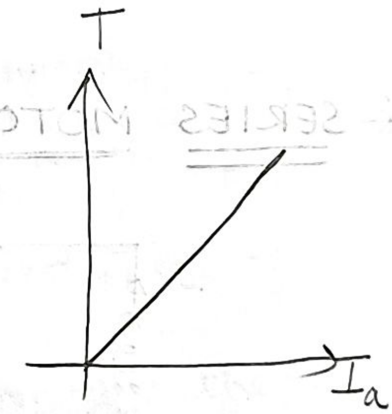
$$= Fr \cdot 2\pi f = (Fr)\,\omega$$

$$\boxed{P = T\omega}$$

$$E_b I_a = T\omega$$

$$\frac{P\phi \cancel{N}}{\cancel{60}} \times \frac{Z}{A} I_a = T \cdot \frac{2\pi \cancel{N}}{\cancel{60}}$$

$$T = \frac{P\phi Z I_a}{2\pi A}$$



$$\boxed{T = \frac{ZP}{2\pi A}\phi I_a}$$

$$T \propto I_a$$

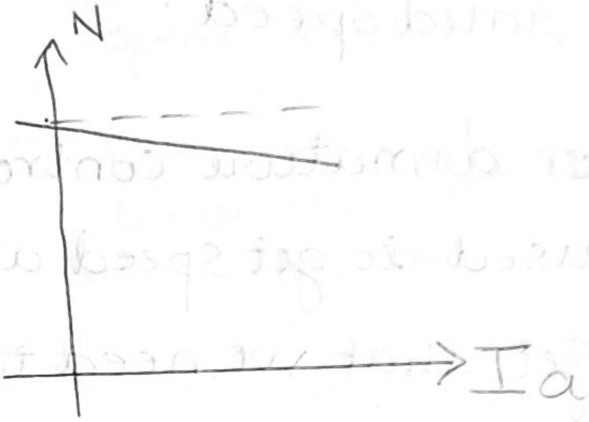
$$E_b = \frac{\phi Z N}{60} \times \frac{P}{A}$$

$$\boxed{N \propto \frac{E_b}{\phi}}$$

ϕ varies with I_f

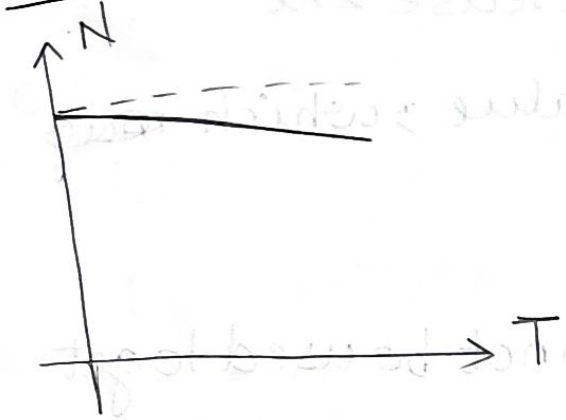
$N \rightarrow$ varies.

$$E_b = V - I_a R_a$$



$$N \propto V - I_a R_a$$

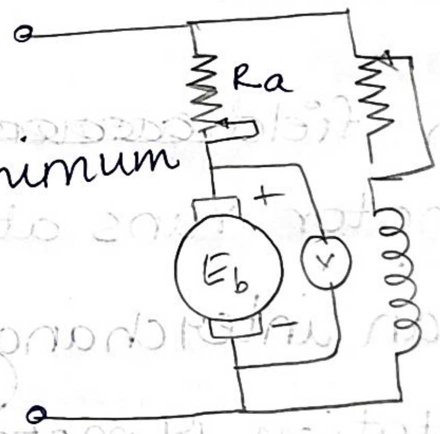
N v/s T



* Speed control of DC shunt motor (or) Separately excited DC Motor.

- We need start the circuit with a minimum speed

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



V_a can be varied with armature resistance

R_a at max and R_f is max to start the circuit with min speed.

→ When the rated voltage and ~~rated~~ field current are applied; we get the rated speed.

~~for~~ Armature control method cannot be used to get speed above rated value. ~~&~~ To get that we need to increase the resistance over rated value; which ~~may~~ will damage the circuit.

Field control method cannot be used to get speed below rated value. To get that we need to increase the resistance over rated value.

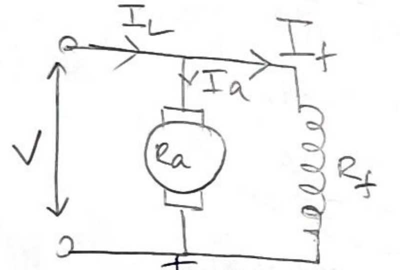
* When field ~~current~~ windings are opened the motor runs at a very high speed
* We can interchange the direction of the rotation of motor by either interchanging the armature (or) field polarities

10|08|2022

* $V = 250V$

$R_a = 0.12\Omega$ $R_f = 100\Omega$

$I_L = 80A$



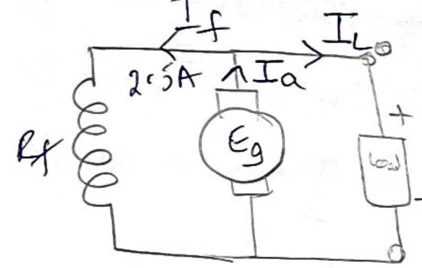
$I_f = \frac{V}{R_f}$

$= 2.5A$

$\underline{I_a = 77.5A}$

$\frac{\text{Speed as generator}}{\text{Speed as motor}} = ?$

flux in a shunt motor is constant due to constant V & I



$I_a = 80 + 2.5$

$\underline{= 82.5A}$

Motor: $N_M \propto E_b$

Generator: $N_g \propto E_g$.

$E_b = V - I_a R_a$

$= 250 - 77.5 \times 0.12$

$= 240.7V$

$E_g = V + I_a R_a$

$= 250 + 82.5 \times 0.12$

$= 259.9V$

$$\frac{N_g}{N_b} = \frac{259.9}{240.7} = \underline{\underline{1.08}}$$

* $V = 200V$ $R_a = 0.4\Omega$ $I_a = 2A \longrightarrow$ no load current

$\left.\begin{array}{l} I_a = 50A \\ N = 1200rpm \end{array}\right\} \longrightarrow$ Loaded conditions.

$E_0 = V - I_a R_a = 200 - 2 \times 0.4$

$= 200 - 0.8$

$= 199.2V$

$E_1 = V - I_{a_1} R_a = 200 - 50 \times 0.4$

$= 200 - 20 = 180V$

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

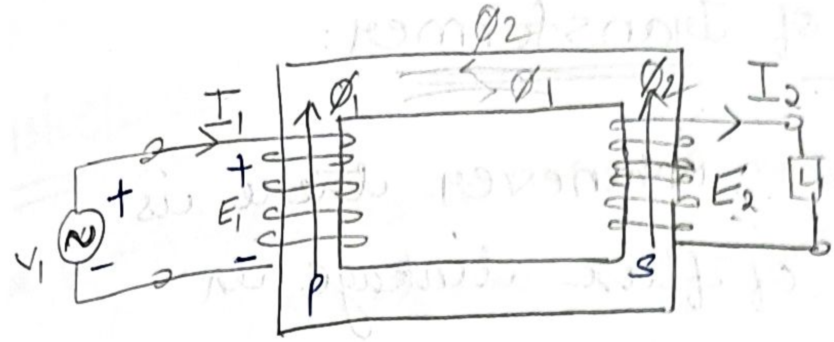
$$\frac{N_1}{N_o} = \frac{E_d}{E_o}$$

$$N_o = \frac{1200 \times 199.2}{180}$$

$$= \underline{1328 \text{ rpm}}$$

10/08/2022

TRANSFORMERS



E_1 = Self induced emf

∵ emf is induced due to the source :

The transformer just step up or down the voltage ; but total power on either side remains same $\boxed{V_1 I_1 = V_2 I_2}$

Due to the flux developed in primary coil there is a flux developed in secondary coil ; $\boxed{E_2 = \text{Mutually induced emf}}$

Principle: Faraday's Law of Electromagnetic Induction.

E_1 is time dependent/ varying voltage.

Lenz Law: Effect should oppose the cause.

- Constant flux machine.
- Whenever; there is no load; the reduction in initial flux ϕ_1 due to ϕ_2; therefore, the source supplies a flux ϕ_2' equal to ϕ_2 but opposite in direction.

∴ Therefore, the overall flux in the

transformer is ϕ_1

* EMF equation of Transformer:

By Faraday's law ; whenever there is a rate of change of flux linkage in a conductor ; there is emf induced.

$$\text{Avg emf/turn} = E_{avg}/\text{turn} = \frac{d\phi}{dt}$$

$$= \frac{\phi_m - 0}{\frac{1}{4f}}$$

$$\boxed{E_{avg}/\text{turn} = 4f\phi_m}$$

$$K_f = \frac{\text{Rms value}}{\text{Avg value}} = 1.11$$

$$\text{Rms value} = E_{rms}/\text{turn} = 4f\phi_m(1.11)$$

$$\boxed{E_{rms}/\text{turn} = 4.44 f\phi_m}$$

$$\boxed{\begin{aligned} E_1 &= 4.44 f\phi_m N_1 \\ E_2 &= 4.44 f\phi_m N_2 \end{aligned}}$$

* Transformer Ratio (K) $= \frac{E_2}{E_1} = \frac{N_2}{N_1}$

$K > 1 \rightarrow$ Step-Up Transformer
$K < 1 \rightarrow$ Step-Down Transform

$K = 1 \longrightarrow$ Isolation Transformer.

13/08/2022

* $E_1 = 3300V$ $E_2 = 250V$. $A = 125 cm^2$ $f = 50 Hz$.

$N_2 = 70$ $= 125 \times 10^{-4} m^2$

max.

$$B_m = \frac{\phi_m}{A} = \frac{E_2}{4.44 f N_2 A}$$

$$= \frac{250}{4.44 \times 50 \times 70 \times 125 \times 10^{-4}}$$

$$= \boxed{1.289 T}$$

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

$$N_1 = \frac{330\cancel{0}}{25\cancel{0}} \times 70$$

$= 924$.

* $N_1 = 800$ $N_2 = 200$ $V_{ac} = E_1 = 100V$.

$E_2 = ?$

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

$$= \frac{100 \times 200}{800} = 25V.$$

$$\text{Volts per turn} = \frac{V_1}{N_1} = \frac{100}{800} = 0.125.$$

Volts per turn $= \frac{V_2}{N_2} = 0.125$.

* Ideal transformer:

Properties:

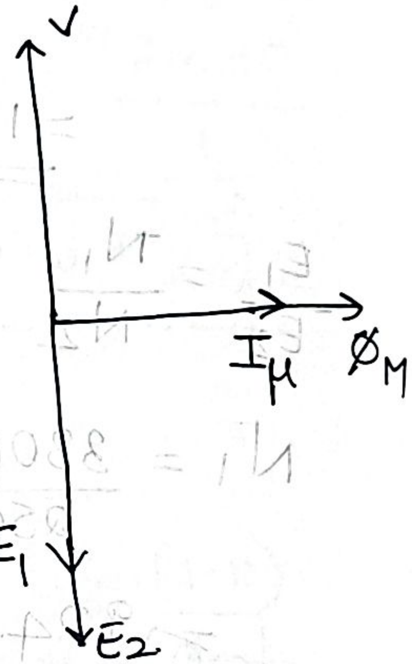
1) $\mu = \infty$: ability ~~so~~ to produce flux with a min MMF (magnetomotive force)

2) Copper loss (I^2R) is neglected.

3) $R_1 = 0$; $R_2 = 0$ $\Rightarrow$ purely inductive.

4) No ~~of~~ leakage flux

5) core loss $= 0$.



* $$\boxed{\frac{E_2}{E_1} = \frac{I_1}{I_2} = \frac{N_2}{N_1}}$$

17/08/2022

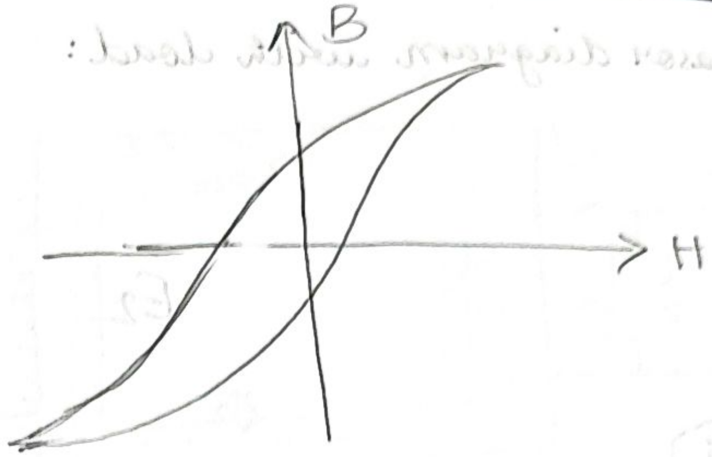
~~* Magnetising & demag~~

* Magnetic reversal : magnetising & demagnetising of core : Heat loss developed due mechanical vibrations ~~these~~ is called HYSTERESIS LOSS.

If the area of the loop is max. losses are more and vice versa

By using a proper material ~~for~~ we

can reduce the Hysteresis loss.



H → Magnetic field density

B → Magnetic flux density

EDDY CURRENT LOSSES:

- Heat developed due to the eddy current developed in the core (∵ closed circuit) will cause eddy current losses.
  ⇒ I^2R loss.
- Losses can be reduced using thin laminated core.

* Ideal transformer with no load but having core loss:

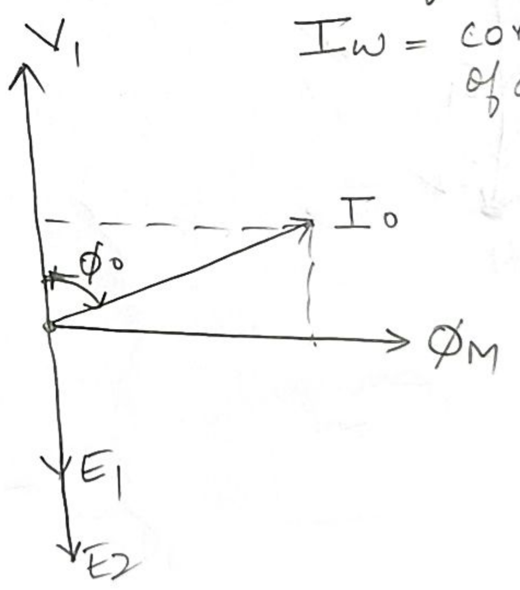
I_μ = Magnetising loss component of current

I_w = core loss component of current

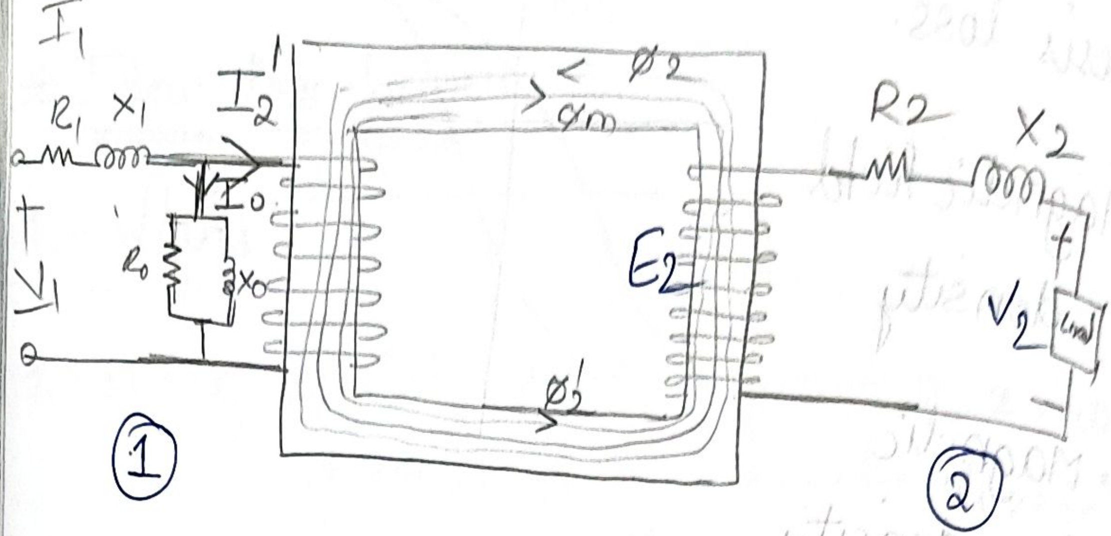
Phasor diagram:

$I_0 = \sqrt{I_w^2 + I_M^2}$

= No load ~~core loss~~ current.



*Phasor diagram with load:



Flux linking in the same coil : flux leakage

1

$V_1 = E_1 + I_1(R + jX_1)$

$V_2 + I_2(R + jX_2) = E_2$

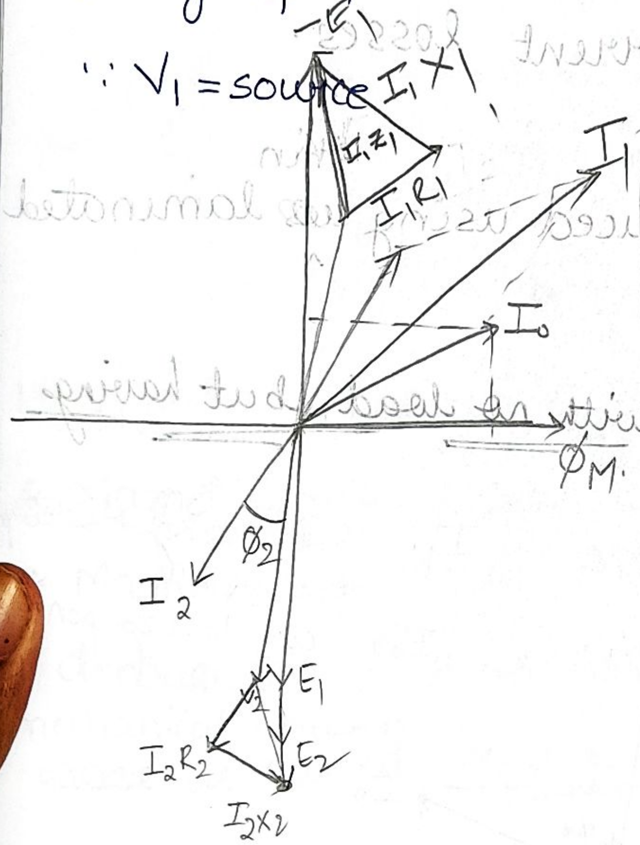
~~E_1~~ lags ~~E_1~~ V_1

V_2 lags E_2

~~E_2 lags V_2~~

$\because V_1 =$ source

$E_2 =$ source



Loads

UPF : R

Lagging : RL

Leading : RC