1

ELECTRICAL MACHINES 2010

[1] What's the Electricity?

It's a type of Energy can do works.

[2] What are the applications of Electricity? Give some Examples?

Electricity is very important for our life so that it's used in

i) For Transport (Metro)
ii) For industry
iii)

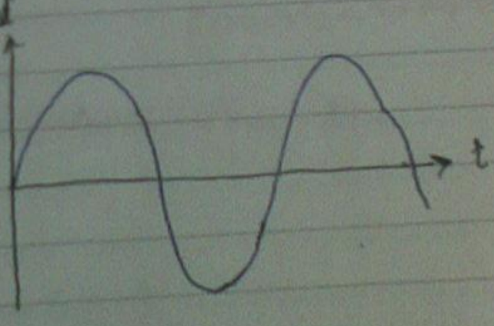
[3] When Electricity discovered?

Electricity discovered from 400 years.

[4] What are the different types of Electricity "Electrical Energy"?

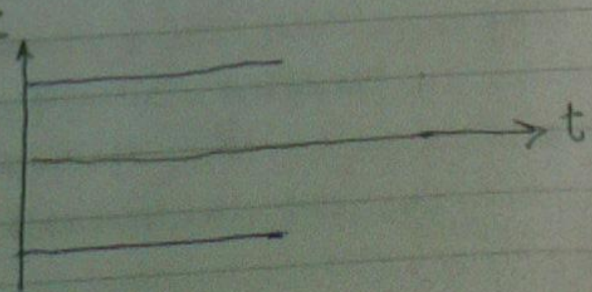
i- Alternating current (AC)

Current's Alternating with time.



ii- Direct current (DC)

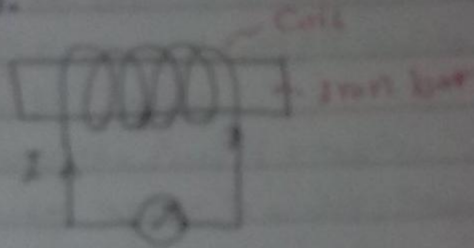
current's constant with time.



[5] What are the factors required to generat (Produce) Electricity?

[i] Magnatic Energy " Magnet "

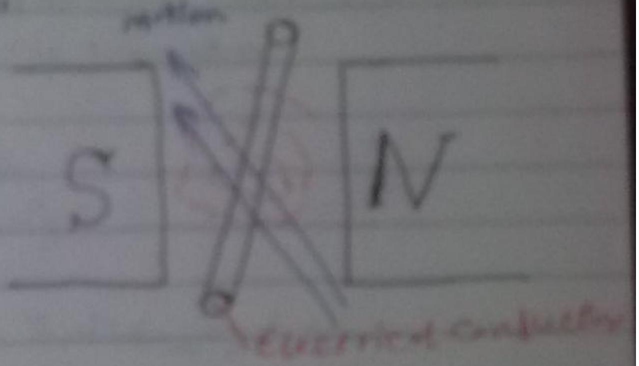
- a) Natural Magnet
  1) There are types of rocks content on magnetic field this Rock called " Magnetic Rocks "
  2) Have constant Energy (Power)
- b) Artificial Magnet. (Electrical magnet)
  1) When current pass through ~~coil of iron~~ coils, it'll generat magnetic field.
  2) Have variable Energy



[ii] Mechanical Energy "Motion"

The most contripiuting source

أهم مصدر هو في انتاج الكهرباء



[iii] Electrical conductors.

[6] What are the different types of materials from the electricity point of view?

i) Conducting materials (Fe - Al - Cu -)

- Metallic materials تسمح بمرور التيار الكهربي بسهولة خلالها

ii) Insulating materials (Wood - plastic - Rubber)

لا تسمح بمرور الكهرباء بسهولة

iii) Semi conducting materials (Germanium, Silicon)

7 What are the different sources of Energy used to produce electricity?

A) Conventional sources — مصادر تقليدية

1) Water Power (Energy):-

- Natural — Falls — الشلالات
- Artificial — Dams — السدود

Where the potential energy is used to drive the water turbines to move and rotate the rotor (Shaft) of the generator

2) Fuel Energy:-

- Solid (Wood, Coke) High Calorific Value
- Liquid (Petroleum, Solar, Benzene) medium Calorific value
- Gas (Natural Gas) Low Calorific value

where the Heat produced from burning the fuel is used to Add Heat to burning (Boiler) to change water to water steam with High presure. to drive and move the Steam Turbine to rotate the rotor (Shaft) of the Generator

3) Atomic (Nuclar) Energy.
(Platinum - Uranium)

B) Un conventional Sources — مصادر غير تقليدية

1) Solar Energy — الطاقة الشمسية

2) Wind Energy — طاقة الرياح

3) Wave Energy — طاقة الأمواج

4) Tie Energy — طاقة المد والجزر

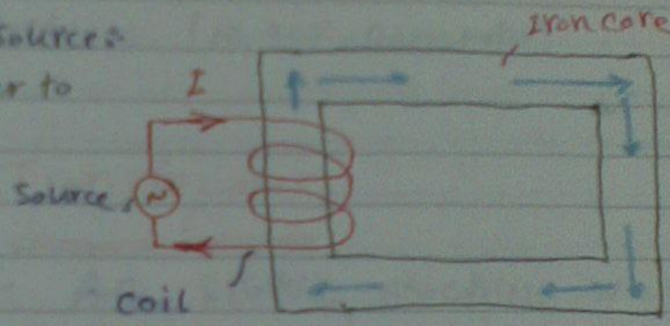
8 What are the effects of an electrical current passing through a conductor?

1) Heat effect. ($= I^2 . R$ watt), where, I is the current passing through conductor (A) and R is the resistance (Ω)

2) Magnetic Field.
Magnetic field generated around and along the conductor when current pass through it
شدة المجال المغناطيسي تعتمد على قيمة التيار المار في الملف

9 What are the main parts of magnetic circuit? and what's the function of each part?

1- Electrical power source:-
Give Electrical power to the circuit
(volt - current)



2- Coil:-
To convert the electrical power to magnetic power

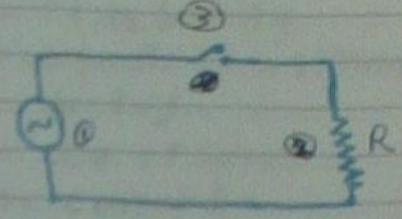
3- Iron Core:-
To Transport and control the magnetic energy produced.

10 Why all the cores of different types of machine are made from Iron?
- Why all the electrical Machines have an Iron Core?

The Iron core has a very low resistance for pass a magnetic flow. Less the Air

11 What are the main parts (elements) of Electrical circuit?

1- Source of Current
2- Load [Resistance - Inductance - Capacitance].
3- Switch



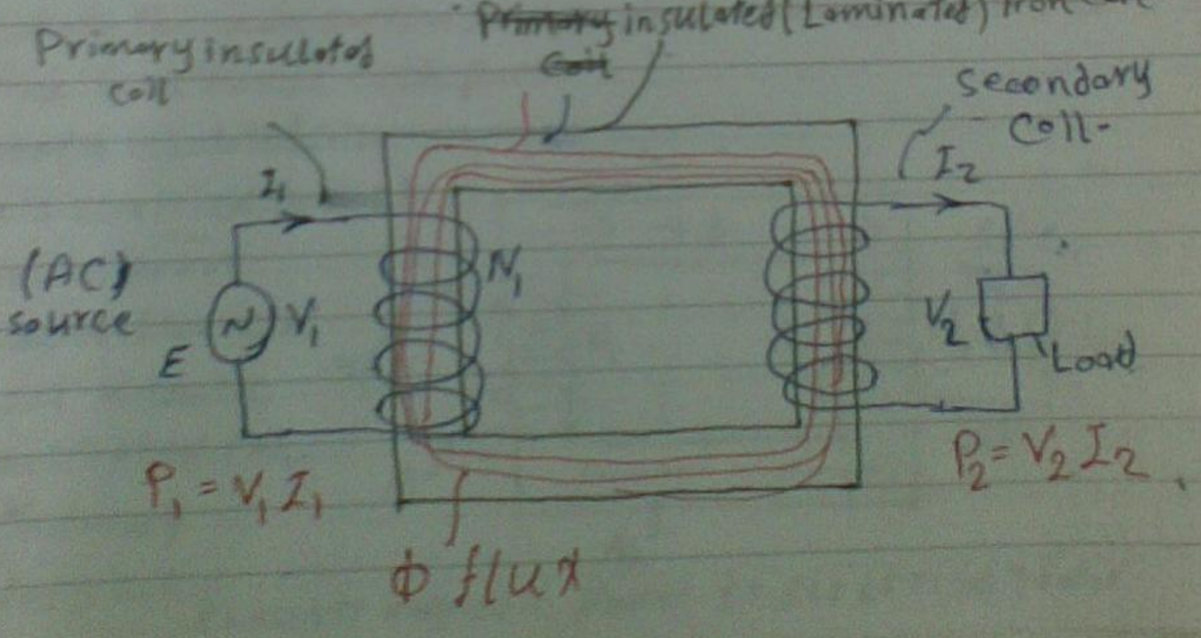
12 What are the different types of electrical Machines?

A) According to the type of power:
1) AC Machines 2) DC Machines

B) According to the type of motion
1) static machines (Transformer)
2) Dynamic Machines (motor, Generator)

Transformer

- Transformer It's AC - Static Machine which transforms electric power from one Alternating circuit to another without change in frequency.



If $N_2 > N_1 \Rightarrow V_2 > V_1$
Step up transformer
$a > 1$

If
$N_2 < N_1 \Rightarrow V_2 < V_1$
Step down transformer
$a < 1$

$$a = \frac{N_2}{N_1}$$

Φ :- Flux field
B :- Flux density
H :- magnetic field strength
V :- Voltage
N :- No. of turns
I :- current
$\frac{V}{N}$:- Voltage per turn
a :- Transformation ratio

$$\frac{V_1}{N_1} = \frac{V_2}{N_2}$$

- إذا كان المحول رافع للجهد فإنه يعطي تيار منخفض
- إذا كان المحول خافض للجهد فإنه يعطي تيار عالي

$\uparrow\downarrow N_1 V_2 \uparrow\downarrow = \downarrow\uparrow N_2 V_1 \downarrow\uparrow$

$$\frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{I_2}{I_1}$$

$\because P_1 = V_1 I_1 \quad , \quad P_2 = V_2 I_2$

For ideal transformer $P_1 = P_2 \Rightarrow V_1 I_1 = V_2 I_2$

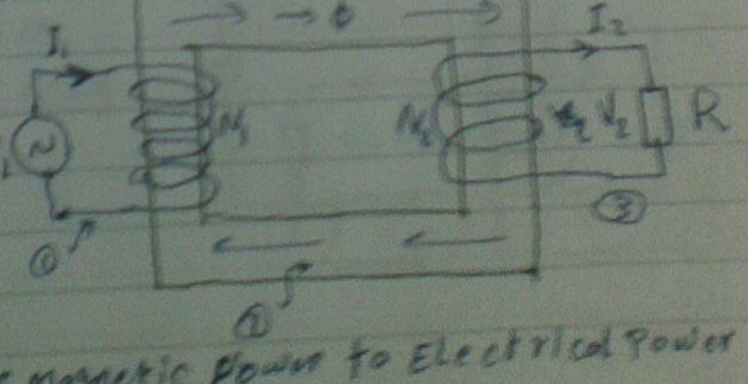
$$\frac{V_1}{V_2} = \frac{I_2}{I_1}$$

$$\Rightarrow a = \frac{N_2}{N_1} = \frac{V_2}{V_1} = \frac{I_1}{I_2}$$

13 What are the main parts of single phase transformer? what's the function of each parts?

1- primary insulated coil
converts Electrical power to Magnetic power

2- Insulated Iron core
Transport magnetic field and control the magnetic energy

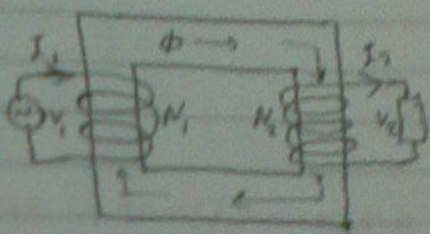


3- Secondary coil converts magnetic power to Electrical power

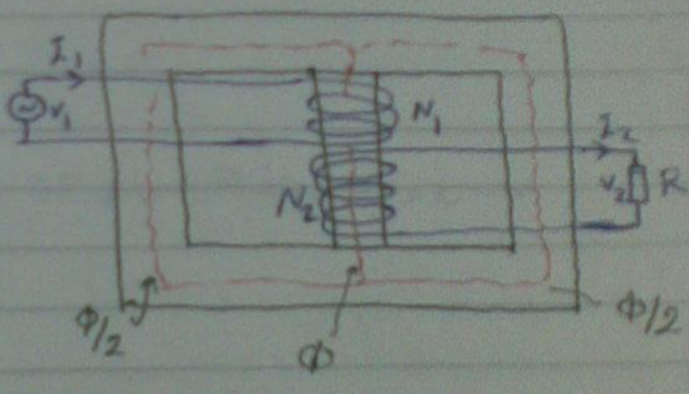
14 What are the different types of transformer?

a) According to Voltage :-
1- Step-up transformer
2- step-down transformer

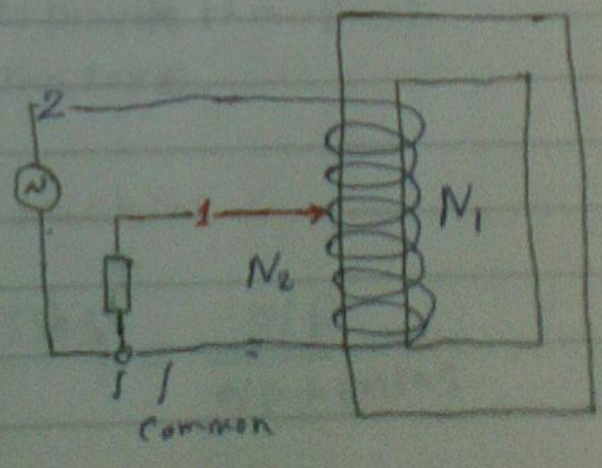
b) According to Construction
1- Core type transformer :-
The magnetic flux take long time to transform primary to secondary coil. because two coils at different core
- High iron losses
- Low efficiency



2- Shell type transformers :-
All magnetic flux cutting the secondary coil in quick time because the two coils in the same core
- Low losses
- High efficiency



3- Auto transformer
Consist of one coil only
- High efficiency
- Low volumetric size
- used in small power only



c) According to No. of phases :-

1- single phase transformer

2- Three- phase transformer

d) According to rating of power :-

1- very Large power transformer

2- Large power transformer

3- medium power transformer

4- Distribution power transformer

5- Electronic power transformer

15 What are the different types of losses in transformer and how to Reduce them?

1-) Copper Losses (Heat Losses) :-

$Cu.losses = H.losses = I_1^2 R_1 + I_2^2 R_2$

2) Iron Losses

a) Residual Losses

عند مرور الفيض المغناطيسي في الـ (core) فإن جزء منها يتبقى فيه

b) ED current

To Reduce Losses :-

1) select Material has a low resistance.

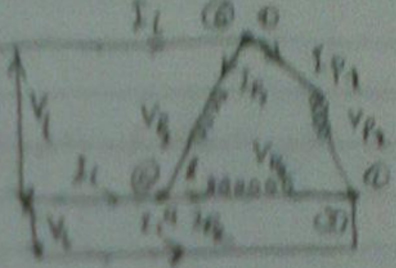
2) Add silicon to Iron to provide through of magnetic field on Iron core.

16 efficiency on any machine :-

$$\eta = \frac{o/p}{i/p} = \frac{i/p - losses}{i/p} = \frac{o/p}{o/p + losses}$$

17 With the help of Simple line diagram show the different methods of Connection of 3-Phase System?
write the equation of 3-Phase System?
- with the help of simple diagrams show the different connections of 3-phase transformer?

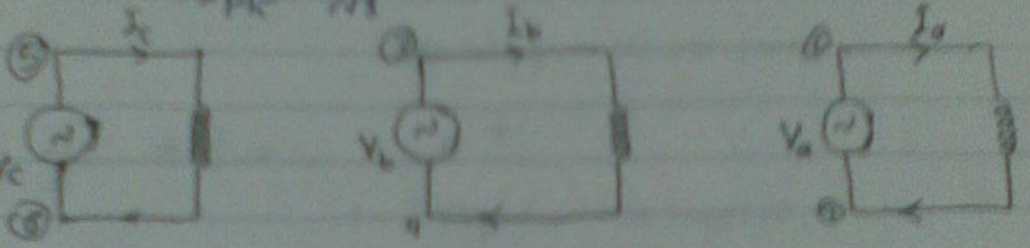
I) Delta Connection (Δ)



$V_L = V_{ph}$

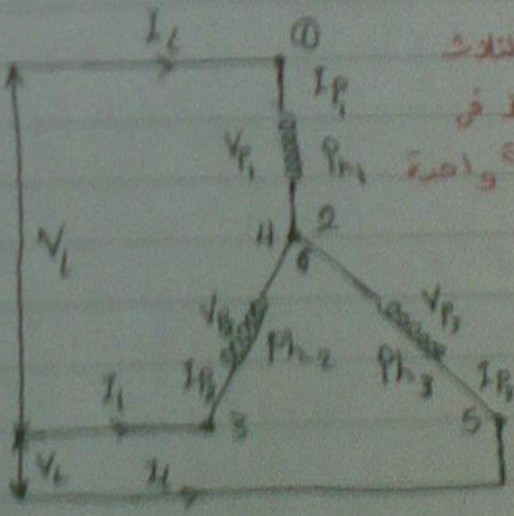
$I_L = \sqrt{3}\, I_{ph} = 1.73\, I_{ph}$

$I_{ph} = I_L / \sqrt{3}$



$P_{3\text{-}ph} = 3 V_{ph} I_{ph} = 3 V_L \cdot \frac{I_L}{\sqrt{3}} = \sqrt{3}\, V_L I_L$

II) Star connection (Y)



نجمع الثلاث نقاط في نقطة واحدة

$I_L = I_{ph}$

$V_L = \sqrt{3}\, V_{ph}$

$P_{3\text{-}ph} = \sqrt{3}\, V_L I_L$

* مميزات Star connection

1) تعطي قيمتين للجهد
2) لو زاد التيار في أي وجه يسير ولا يسبب مشكلة

(18) What are the basic operation of Electrical Motor?

[19] What are the different types of electrical motors give Some Applection?

1- DC Motor:-

~~Sing~~ Single phase Motor.

2- AC Motor:-

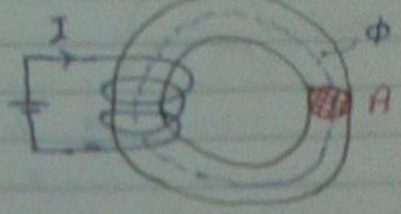
1- Single phase motor.

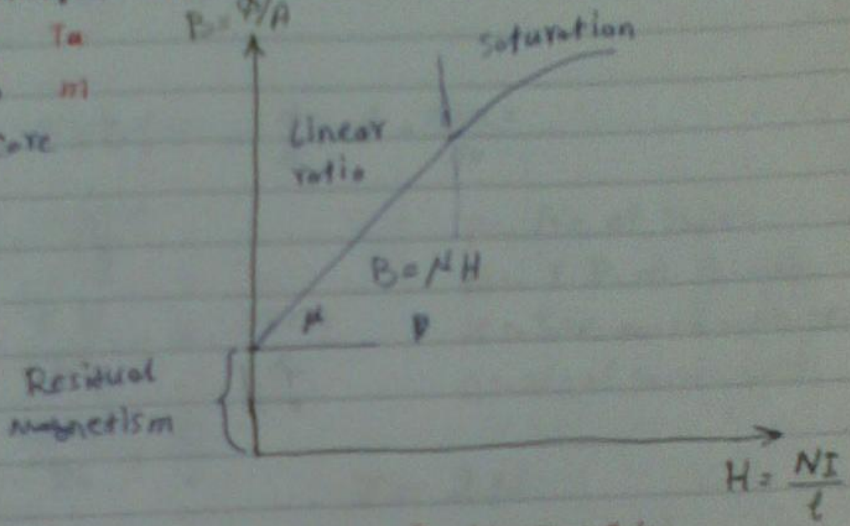
2- 3phas Motor.

DC Machines

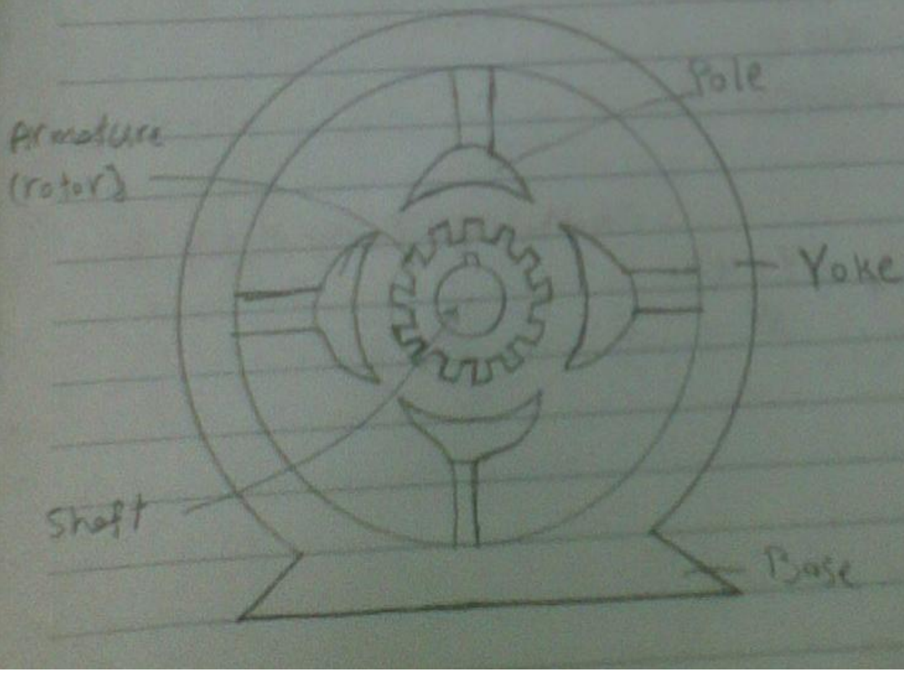
Φ :- flux Weber (Wb)
A :- Cross section area m^2
I :- Current A
B :- flux density tesla Wb/m^2
μ :- Permeability
H :- Magnetic field strength AT/m
N :- No. of turns T
l :- length of coil m
V :- Velocity of core

$e = BlV$

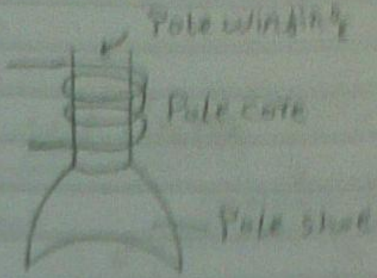




B.H Curve



*** Function of Pole Shoe**



١- تثبيت الملفات
٢- هي جزء من الدائرة المغناطيسية
٣- تجعل المغناطيسية ذات شدة ثابتة ومنتظمة

*** Function of Frame (Yoke)**

١- تثبيت أجزاء الماكينة
٢- هو جزء من الدائرة المغناطيسية
٣- يحمي الأجزاء الداخلية للماكينة

*** Armature :-**

$$e = B l V = \frac{\phi}{A} * l * \frac{2\pi n r}{60}$$

$$A = \frac{2\pi r l}{P}$$

$$\therefore e = \frac{\phi P}{2\pi r l} * l * \frac{2\pi r n}{60}$$

$$e = \frac{\phi n P}{60} * \frac{Z}{a}$$

$$E_g = \frac{Z \phi n P}{60 a}$$

P :- No. of Poles
n :- r.p.m Speed.
Z :- Total no. of conductors
a :- No. of parallel paths

$$Z = 2N$$

* طرق لف الملفات

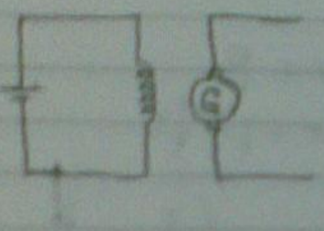
~~1)~~
1) Lap $a = P$
2) Wave $a = 2$

*** Voltage Regulation**

$$\frac{E_g - V_t}{V_t} * 100\%$$

Types of Generator

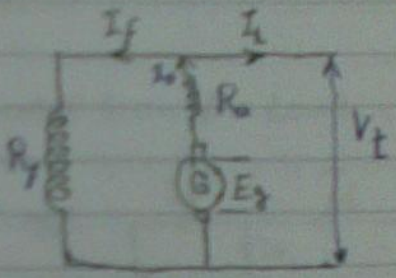
- Separately excited
- Self excited
  - Series
  - Shunt
  - Compouned
    - Short Shunt
    - Long Shunt



Shunt ≡ Parallel

★ Shunt ≡ Parallel

I_f ⇒ Field current.
I_a ⇒ Armature current.
I_L ⇒ Load current.
R_a ⇒ Armature winding Resistance.
R_f ⇒ Field winding resistance.
V_t ⇒ Termenal Voltage.
E_g ⇒ E.M.F.



P_{in} ⇒ Input power
P_o ⇒ output power

$I_a = I_f + I_L$

$V = I R$

$I_f = \frac{V_t}{R_f}$, $V_t = E_g - I_a R_a$

$P_{in} = E_g I_a + W$ $\quad$ $P_o = V_t I_L$

★ Generator efficiency :-

$$\eta = \frac{P_o}{P_{in}} * 100\% = \frac{P_o}{P_o + loss} * 100\% = \frac{P_{in} - loss}{P_{in}}$$

$Losses = P_a + P_f + W$ — stray losses

$P_a = I_a^2 R_a$ $\quad$ $P_f = I_f^2 R_f$

How to get max. efficiency :- η_{max}

Const. loss = Variable losses

$$P_f + W = P_a$$

$$I_f^2 R_f + W = I_a^2 R_a$$

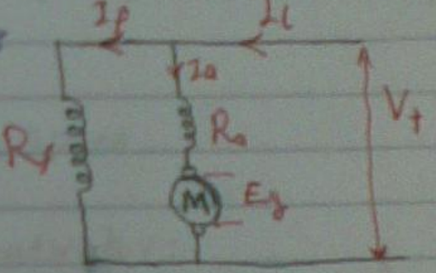
$$I_a)_{\eta_{max}} = \sqrt{\frac{P_f + W}{R_a}}$$

How to get stray losses :- (W) :-

By running any machine as a motor & on No Load.

For Motor

$$P_{out} = E_g I_a - W \quad (P_{out} \to 0) \Rightarrow$$



$$E_g I_a = W$$

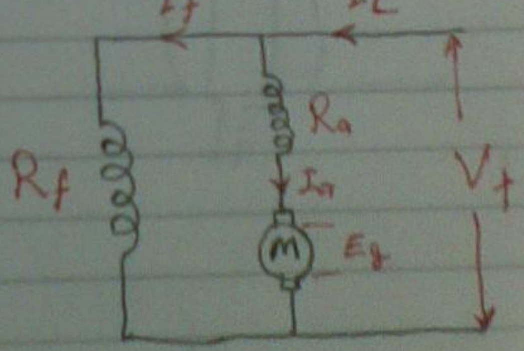
$$P_{in} = V_t I_L$$

DC-Motor

$$I_a = I_L - I_f$$

$$E_g I_a - W = P_{out}$$

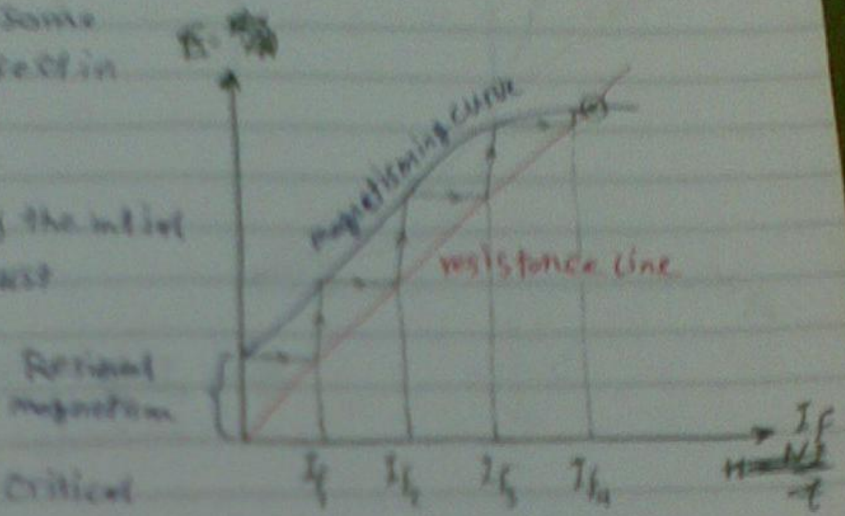
$$P_{in} = V_t I_L$$



* Build up process in Self excited Generator

- Build up requires (Requirments)

1- There must be ~~equal~~ some residual magnetic effect in the field poles.

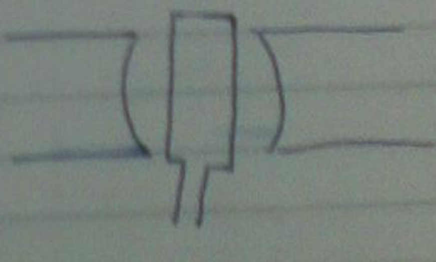


2- The flux produced by the initial exciting currents must assist the residual flux.

3- The field resistance must be below the critical resistance

4- The speed must be above the critical speed

* Drive the torque equation for DC shunt motor:-



$$F = B I l$$

$$F = \frac{Z\phi}{A} \frac{I_a}{a} l$$

$$F = \frac{Z\phi P}{2\pi r l} \frac{I_a}{a} l = \frac{Z\phi P I_a}{2\pi r a}$$

$$T = F \cdot r = \frac{Z\phi P}{2\pi r} \frac{I_a}{a} \cdot r$$

$$\therefore \boxed{T = \frac{Z\phi P}{2\pi} \frac{I_a}{a}}$$

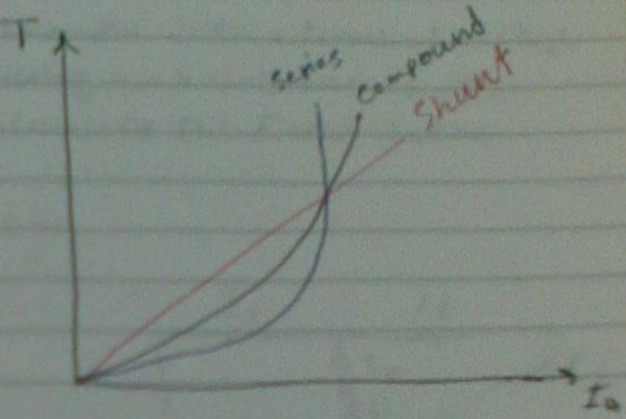
* Torque current ratio For DC-Motor :-

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

∵ Z & P & 2π & a are const

∴ get $\frac{ZP}{2\pi a} = K$

$\therefore T = K \phi I_a$



For series motor :-

$T \propto \phi I_a$ & $I_a \propto \phi$

$\therefore T \propto I_a^2$ (parabolic) علاقة

For shunt motor :-

$\phi = \text{Const}$

$\therefore T \propto \text{const} \cdot I_a \Rightarrow$

$T \propto I_a$ علاقة خطية

Example. 1

A 20 KW Shunt Generator with a terminal Voltage (V_t) of 250V, the armature winding has a resistance 0.05 Ω and field resistance 100 Ω. Calculate the E.m.f in the armature.

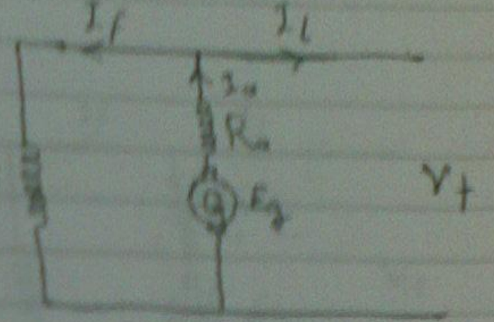
Solution

$P_o = 20\ KW = 20 \times 10^3\ W$

$V_t = 250\ V$

$R_a = 0.05\ \Omega$

$R_f = 100\ \Omega$



$$I_f = \frac{V_t}{R_f} = \frac{250}{100} = 2.5A$$

$$P_o = I_L * V_t$$

$$I_L = P_o/V_t = \frac{20*10^3}{250} = 80\ A$$

$$I_a = I_L + I_f = 80 + 2.5 = 82.5\ A$$

$$E_g = V_t + I_a R_a$$

$$E_g = 250 + (82.5 * 0.05)$$

$$\boxed{E_g = 254.125\ V}$$

$E_g = V_t + I_a R_a$

$V_t = I_f R_f$

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

$P_o = I_L * V_t$

$I_a = I_L + I_f$

Example 2

A Generator is run as a motor on No Load with an input current of 7.8 A. A terminal Voltage of 500 V. If the Shunt field resistance is 200 Ω and the armature resistance is 0.43 Ω. Calculate the stray Losses.

Solution

Motor on No Load

~~$P_f + W = P_o$~~ $W = E_g I_a$

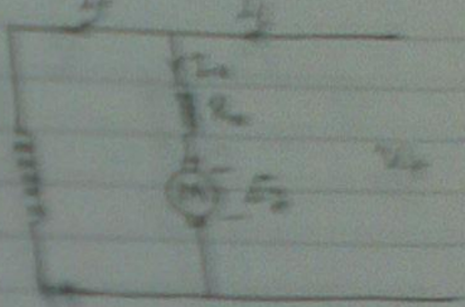
$I_L = 7.8\ A$

$V_t = 500V$

$R_f = 200\Omega$

$R_a = 0.43\ \Omega$

$W = ??$



$W = E_g I_a$

$I_f = \frac{V_t}{R_f} = \frac{500}{200} = 2.5\ A$

$I_a = I_L - I_f = 7.8 - 2.5 = 5.3\ A$

$E_g = V_t - I_a R_a = 500 - (5.3 * 0.43)$

$E_g =$ ~~48.925~~ $497.721\ V$

$W = E_g I_a =$ ~~489~~ $497.721 * 5.3$

$W = 2637.9\ W$	$\simeq 2.6\ kW$

$W =$ ~~P_f~~ $E_g I_a$

~~$P_r = I_a^2 R_a$~~

$I_f = V_t / R_f = —$

$I_a = I_L - I_f = —$

~~$P_r = I_a^2 R_a$~~

$E_g = V_t - I_a R_a$

Example 3

A 10 kW, 250V, DC-shunt Motor has a armature resistance 0.39 Ω, a shunt field resistance 200 Ω and stray losses of 200 W. Calculate

1) Efficiency for at input of 11 kW.
2) Load for max efficiency.
3) max efficiency.

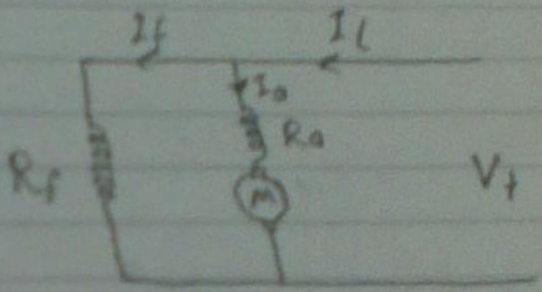
Solution

$P_o = 10\ kW$ $V_t = 250\ V$

$R_a = 0.39\ \Omega$ $R_f = 200\ \Omega$

$W = 200\ W$

1) η $P_{in} = 11\ kW$
2) $I_a)_{\eta_{max}}$ 3) η_{max}



~~Loss = $P_a + P_f + W$~~

$$\eta = \frac{P_o}{P_{in}} * 100 = \frac{P_{in} - loss}{P_{in}}$$

$$P_{in} = V_t I_L \Rightarrow I_L = \frac{11*10^3}{250} = 44\ A$$

$$I_f = \frac{V_t}{R_f} = \frac{250}{200} = 1.25\ A$$

$$loss = I_a^2 R_a + I_f^2 R_f + W$$

$$loss = (44)^2 * 0.39 + (1.25)^2 * 200 + 200$$

$$loss = 1067.54\ W$$

$$\therefore \eta = \frac{11*10^3 - 1067.54}{11*10^3} * 100 \Rightarrow \boxed{\eta = 90\ \%} \Rightarrow (1)$$

$$I_a)_{\eta_{max}} = \sqrt{\frac{P_f + W}{R_a}} = \sqrt{\frac{I_f^2 R_f + W}{R_a}} = \sqrt{\frac{1.25^2 * 200 + 200}{0.39}}$$

$$\boxed{I_a)_{\eta_{max}} = 36.3\ A} \Rightarrow (2)$$