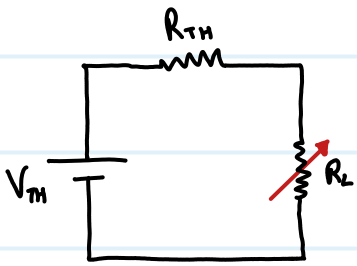
* Supermesh: Meshes that share a current source with other meshes forms a Supermesh.

* Nodal Analysis is based on Kirchhoff's current law which states that algebraic sum of currents meeting at a point is zero.

* Maximum Power Transfer Theorem

It states that 'the maximum power is delivered from a source to a load when load resistance is equal to the source resistance'.

i.e. $R_{TH} = R_L$



$$I_L = \frac{V_{TH}}{R_{TH} + R_L} = \frac{V_{TH}}{R_{TH} + R_{TH}} = \frac{V_{TH}}{2R_{TH}}$$

$$P_{max} = I^2 R = I_L^2 R_{TH}$$

$$= \left(\frac{V_{TH}}{2R_{TH}}\right)^2 R_{TH} = \frac{V_{TH}^2}{4R_{TH}^2} \times R_{TH} = \frac{V_{TH}^2}{4R_{TH}}$$

Steps:

1] Replace R_L by V_{TH} and find value of V_{TH}

2] Find the value of R_{TH}.

3] Find the maximum power.

$$I_L = \frac{V_{TH}}{2R_{TH}}$$

$$P_{max} = \frac{V_{TH}^2}{4R_{TH}}$$

Single Phase Transformer

- Transformer core depends on voltage, current & frequency.
- Core material used are soft iron & steel.
- Air core transformers are used when the voltage sovrce has high frequency (↑ 20 kHz)
- Iron core transformers are used when the source frequency is a low (↓ 20 kHz)
- Core is constructed of laminated steel to provide a continuous magnetic path.
- The steel used for constructing the core is high grade silicon steel called soft steel where hysteresis loss is very low.
- Due to alternating flux certain currents are induced in the core, called eddy current
- These current cause considerable loss in the core, called eddy current loss.
- Silicon content in the steel increases it's resitivity to eddy current loss.
- To reduce eddy current losses further, the core is laminated by a light coat of varnish or by an oxide layer on surface.

- Transformer consists of two coils, called windings which are wrapped around a core.
- The electrical energy is fed is called the primary winding.
- The winding which is connected to the load is secondary winding.
- Both made up of an insulated copper conductor in the form of a round wire & strip.

EMF eqn

$$\phi = \phi_m \sin \omega t$$

$$e_1 = -N_1 \frac{d\phi}{dt}$$

$$e_1 = -N_1 \phi_m \omega \cos \omega t$$

$$= N_1 \phi_m \omega \sin(\omega t - 90^\circ)$$

$$= N_1 \phi_m 2\pi f \sin(\omega t - 90^\circ)$$

$$e_{max} = 2\pi f \phi_m N_1$$

$$E_1 = \frac{e_{max}}{\sqrt{2}} = 4.44 f \phi N_1$$

$$E_2 = 4.44 f \phi_m N_2$$

$$\therefore \frac{E_2}{E_1} = \frac{N_2}{N_1} = K \rightarrow$$ Transformation ratio.

* Losses in Transformers

1) Iron or core loss

This loss is due to reversal of flux in core.

↳ Hysteresis loss

↳ Eddy Current loss

- Hysteresis loss
- This loss occurs due to setting of an alternating flux in the core.

Depends on:-

i] Area of hysteresis loop of magnetic material which depends on flux density.

ii] Volume of core.

iii] Frequency of magnetic flux reversal

- Eddy current loss
- This loss is due to the flow of eddy currents in the core caused by induced emf in the core

Depends on:-

1) Thickness of laminated core

ii) frequency of magnetic flux reversal

iii) volume of core

iv) Max value of flux density

v) Quality of magnetic material used.

- Copper loss :-

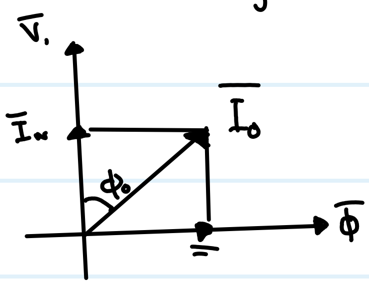
- This loss due to resistances of primary & secondary windings.

$$W_{cu} = I_1^2 R_1 + I_2^2 R_2$$

R_1 = Primary winding resistance

R_2 = Secondary winding resistance

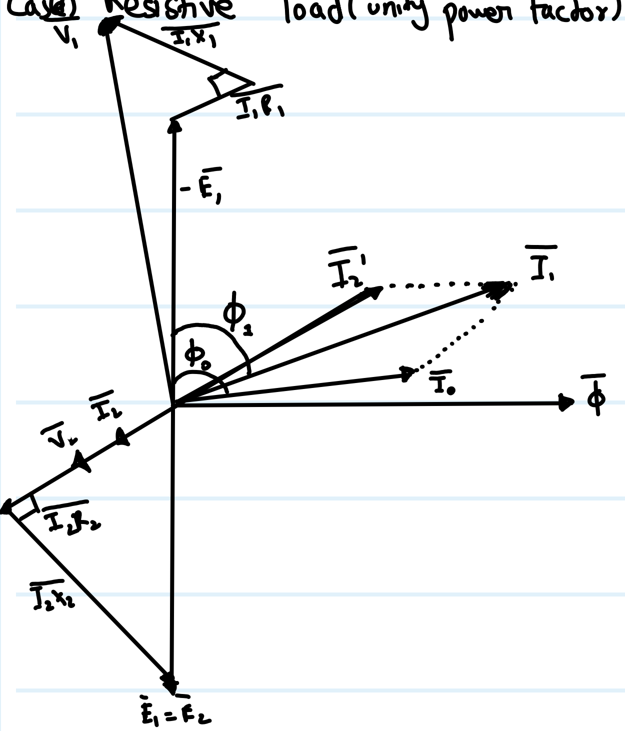
Phasor diagram on transformer on no load



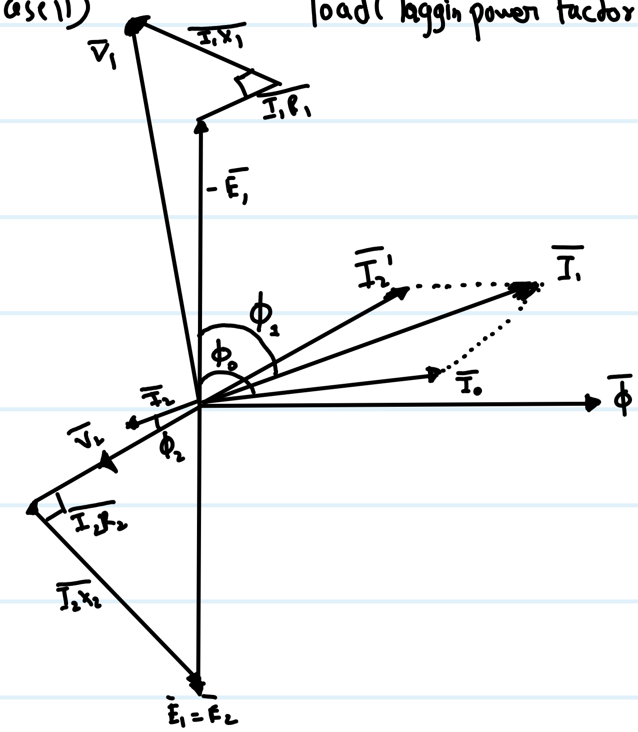
$$I_\mu = I_0 \sin\phi_0 \quad , \quad I_w = I_0 \cos\phi_0$$

$$I_0 = \bar{I}_\mu + \bar{I}_w = \sqrt{I_\mu^2 + I_w^2}$$

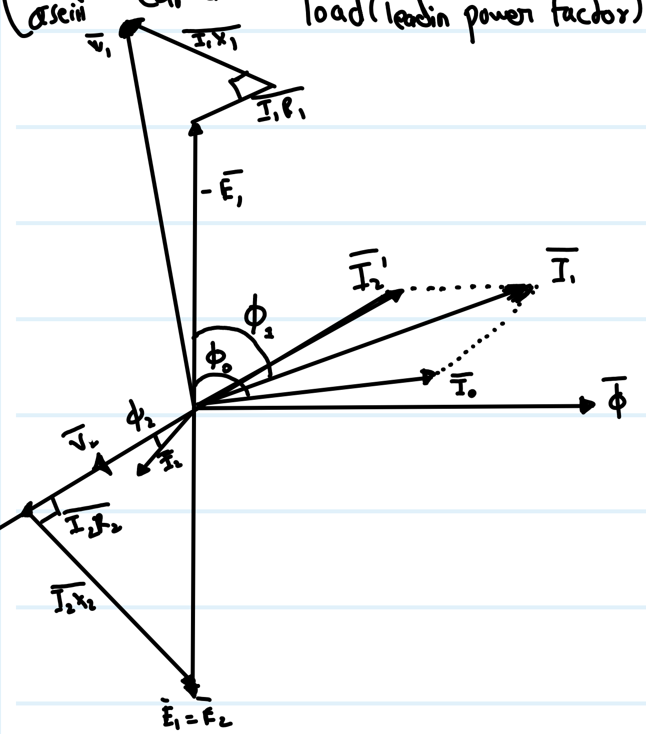
Case i) Resistive load (unity power factor)



Case ii) Inductive load (laggin power factor)



Case iii Capacitive load (leading power factor)



- Voltage Regulation

When transformer is loaded, the secondary terminal voltage ↓ due to drop across secondary winding resistance and leakage reactance. This change in secondary terminal voltage from no load to full load condition, expressed as a fraction of the no load secondary voltage is called regulation.

$$\text{Regulation} = \frac{\left(\begin{array}{c}\text{Secondary terminal}\\ \text{voltage on no load}\end{array}\right) - \left(\begin{array}{c}\text{Secondary terminal voltage}\\ \text{on full-load condition}\end{array}\right)}{\text{Secondary terminal voltage on no load}}$$

$$= \frac{E_2 - V_2}{E_2}$$

$$\%\ \text{Regulation} = \frac{E_2 - V_2}{E_2} \times 100$$

Efficiency of transformers

$$\eta = \frac{\text{Output}}{\text{Input}} = \frac{\text{Output}}{\text{Output + Losses}} = \frac{\text{Output}}{\text{Output + Copper loss + Iron loss}}$$

$$\eta = \frac{V_2 I_2 \cos\phi_2}{V_2 I_2 \cos\phi_2 + W_i + I_2^2 R_{02}}$$

$$\frac{\partial \eta}{\partial I_2} = \frac{(V_2 I_2 \cos\phi_2 + W_i + I^2 R_{02}) V_2 \cos\phi_2 - V_2 I_2 \cos\phi_2 (V_2 \cos\phi_2 + 2 I_2 R_{02})}{(V_2 I_2 \cos\phi_2 + W_i + I_2^2 R_{02})^2}$$

for efficiency$_{max}$ $\frac{\partial \eta}{\partial I} = 0$

$$\therefore \quad W_i = I_2^2 R_{o_2}$$

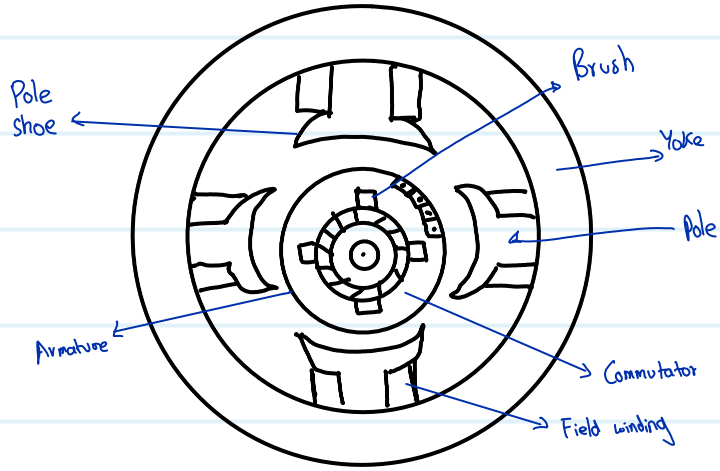
Similarly,

$W_i = I_1^2 R_{o_1}$ (Primay side)

Thus copper loss = iron loss efficiency of transformer is max.

* DC Motors

Construction :



① Yoke

The yoke acts as the outer cover of DC motor.

It provides mechanical protection to the outer parts

It provides low reluctance path for magnetic flux

② Poles & Pole shoe

Poles produce the magnetic flux when the field winding is excited.

Pole shoe is extended part of a pole.

③ Field winding

When DC current is passed through the field windings, it magnetizes poles which produce magnetic flux.

④ Armature windings

The conversion of power takes place in armature winding.

⑤ Commutator :

Converts alternating torque into unidirectional torque.

⑥ Carbon Brushes

The current is conducted from voltage source to armature by carbon brushes

* Back EMF in DC Motor

When armature winding of DC motor rotates in the magnetic field produced by field winding, it cuts magnetic flux. Hence EMF is induced in the armature winding according to the Faraday's law of EMI & as per Lenz's law, this induced EMF acts in opp direcⁿ to armature supply voltage.

∴ EMF is known as back emf (E_b)

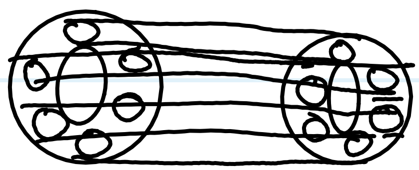
$$\boxed{E_b = \frac{\phi Z N P}{60A}}$$

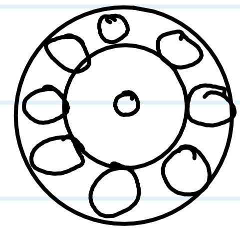
P = no. of poles
ϕ = flux per pole in Wb
N = Speed of motor in RPM
Z = no. of armature conducⁿ
A = no. of parallel path

* Single Phase Induction Motors

• Construction

Two main parts, one rotating other stationary





Stationary part is called strator

Rotating part is called rotor

Strator laminated constuction, made up of stampings ⇒ carry the winding

strator winding ← exicited by single phase ac supply. iron losses is ↓ &

due to silicon steel, hysteresis loss ↓. Strator produce mag field which

creates the effect of definite no. of poles. The no. of poles for

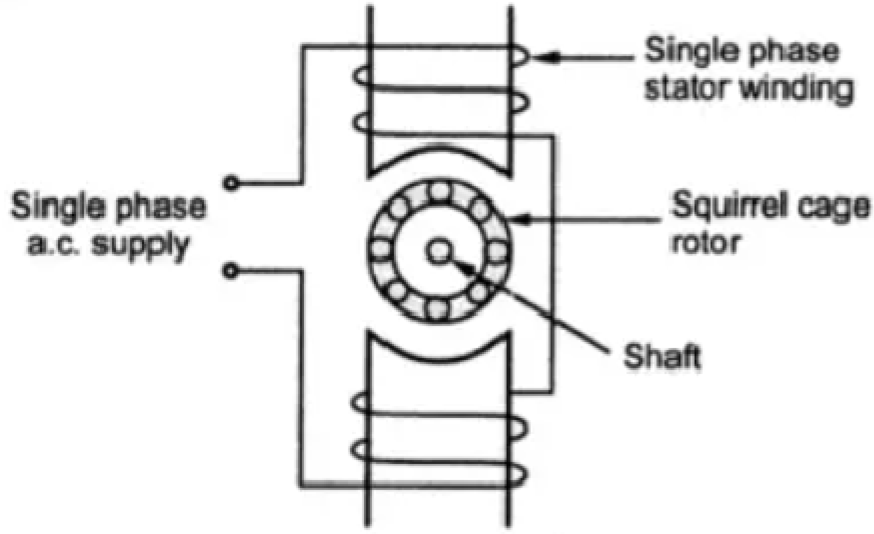
which strator winding is wound, decides synchronous speed of motor.

$$N_s = \frac{120f}{P} \text{ rpm.}$$

Induction motor rotates at speed slightly less than synchronous speed

The rotor construction is of squirrel cage type. In this type, rotor consists of uninsulatedcopper or aluminium bars, placed in the slots. The bars are permanently shorted at both theends with the help of conducting rings called end rings. The entire structure looks like cagehence called squirrel cage rotor.

As the bars are permanently shorted to each other, the resistance of the entire rotor is very-very small. The air gap between stator and rotor is kept uniform and as small as possible. Themain feature of this rotor is that it automatically adjusts itself for same number of poles asthat of the stator winding.



Working:-

In single phase induction motor, single phase AC supply is given to the stator winding. The stator winding carries an AC which produces flux which is also alternating in nature, this is the main flux. This flux links with the rotor conductors & due to transformer action emf gets induced in the rotor. This rotor current produces rotor flux required for monitoring action. Thus second flux is produced according to induction principle due to induced emf, hence motor is called induction motor.