Unit-4 Electrical Machines

Generator

In electrical machines which converts Mechnical energy into Electrical energy is known as Generator.

The classification of Generator are

- Generator
  - DC Generator
    - Separately excited
    - Self excited
      - Series
      - Shunt (parallel)
      - Compound
        - Longshunt
        - Short shunt
  - AC Generator
    - Synchronous Generator
    - Induction Generator

Motar:

In electrical machines which Converts Electrical energy into Mechnical energy is known as Motar.

The classification of motar are

- Motar
  - D.C Motar
    - Separately Excited
    - Self excited
      - Series
      - Shunt (Parallel)
      - compound
        - Longshunt
        - short shunt
  - AC Motar
    - Sychronous motar
    - Induction motar

Slip: It is defined as ratio of difference b/w Synochronous speed and rotar speed to synchronous speed.

The mathematical eexpression slip is

$$S = \frac{Ns - Nr}{Ns}$$

Where

Ns = sychronous speed

Nr = Rotar speed.

The percentage of slip is given as

$$\boxed{\% S = \frac{Ns - Nr}{Ns} \times 100}$$

To determine the Rotar speed based on the above equation is given as

$$\% S = \frac{Ns - Nr}{Ns} \times 100$$

$$Ns\,S = Ns - Nr$$

$$Nr = Ns - Ns\,S$$

$$\boxed{Nr = Ns\,(1-S)\ \text{RPM}}$$

Synchronous Speed:

It is defined as the speed which magnetic field rotates is known as synchronous speed. It is denoted by Ns

$$\boxed{Ns = \frac{120f}{P}\ \text{RPM}}$$

RPM - Revolution per Minute

Where p = No. of poles

f = frequency

Rotar frequency

It is defined as the product of slip and actual frequency is known as Rotar frequency. It is denoted by fr

$$\boxed{f_r = S \times f \text{ Hz}}$$

Q) Three phase induction motar has four poles is connected 400 V, 50 Hz supply and percentage of slip is 6% and calculate the Nr.

Given data

3-ø Induction motar

No. of poles = 4

Voltage V = 400 V

frequency = 50 Hz

% slip = 6%

= 0.06

Nr = ?

$$\boxed{N_r = N_s(1-S)}$$

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

$$= \frac{120 \times 50}{4}$$

$$\boxed{N_s = 1500 \text{ RPM}}$$

$N_r = N_s(1-S)$

$N_r = 1500(1-0.06)$

$$\boxed{N_r = 1410 \text{ rpm}}$$

Q) Three phase induction motar 50 Hz and full load rotar speed 960 RPM calculate the

i) No. of poles

ii) slip frequency and consider synchronous speed 1000 rpm.

Given data

frequency = 50 HZ

Rotar Speed = 960

Sychronous Speed = 1000

$$N_s = \frac{120f}{P}$$

$$P = \frac{120f}{N_s}$$

$$= \frac{120 \times 50}{1000}$$

$$\boxed{P = 6}$$

$$S = \frac{N_s - N_r}{N_s}$$

$$= \frac{1000 - 960}{1000}$$

$$\boxed{S = 0.04}$$

$$f_r = S \times f$$

$$= 0.04 \times 50$$

$$\boxed{f_r = 2\ HZ}$$

Q) 3-ø induction motar 400V., 50 HZ which 6 poles as rotar frequency 2 HZ calcuate the Slip and Rotar Speed.

Given data

Voltage V = 400

frequency = 50 HZ

Rotar frequency = 2 HZ

$$f_r = S \times f$$

$$S = \frac{f_r}{f} = \frac{2}{50} = 0.04$$

$$S = \frac{N_s - N_r}{N_s}$$

$$= \frac{120f}{P}$$

$$= \frac{120 \times 50}{6}$$

$$N_s = 1000$$

$$N_r = N_s(1-S)$$

$$= 1000(1-0.04)$$

$$N_r = 960 \text{ RPM}$$

Construction of Synchronous Machines (or) Alternator

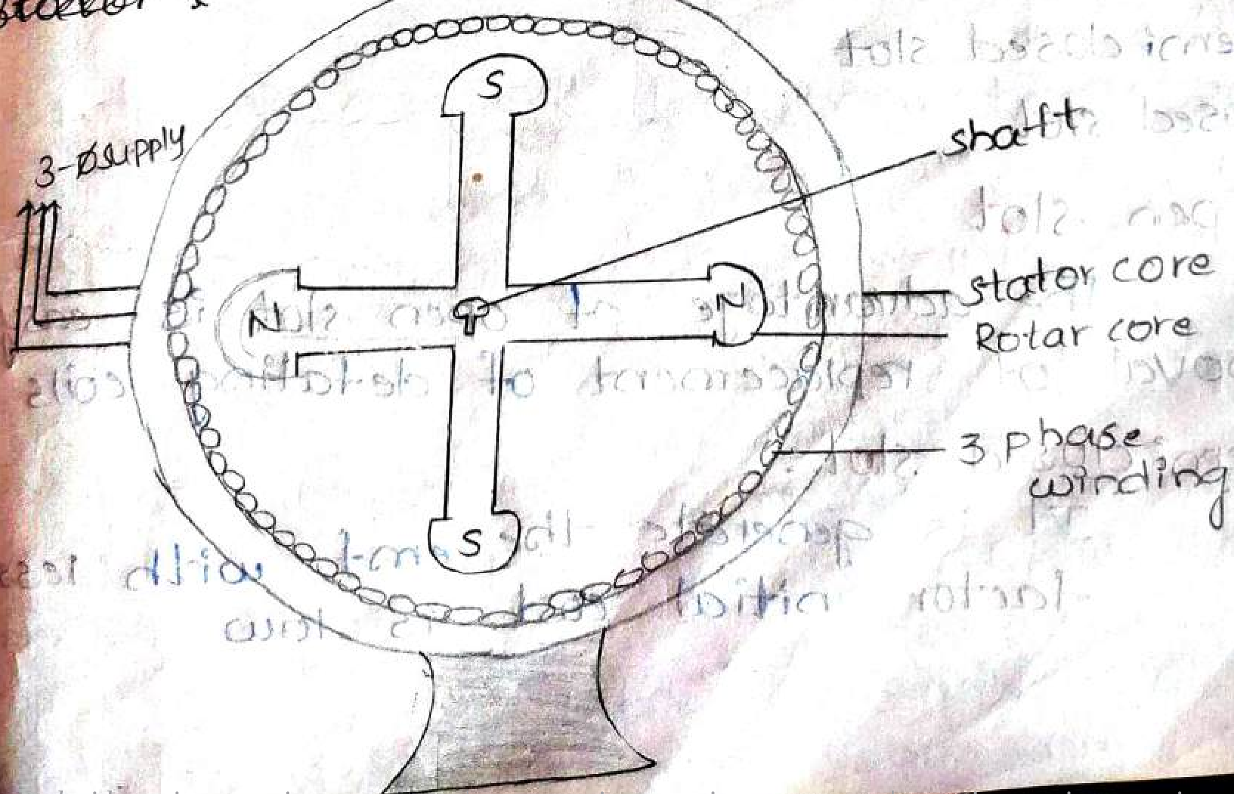
Synchronous machines is double excited energy conversion device. Since it is field winding is connected to dc supply and Armature winding deliever the Ac power

Synchronous machines reduce the Iron losses and alternaters consisting of two parts.

i) stator [Armature winding]

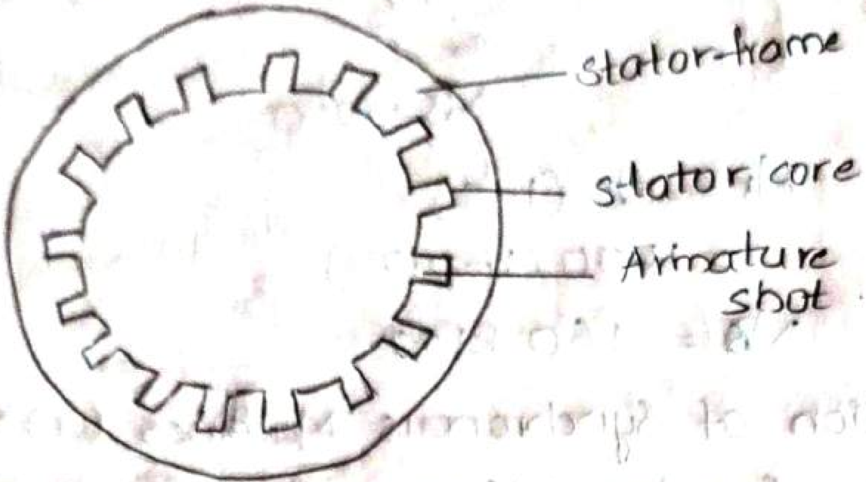
ii) Rotor [field winding]

stator :



Stator:

Stator is the stationary part and cylindrical structure an shown in fig.



The stator carries Armature winding and this type of stator by using ~~no~~ low rating material iron and cast iron used and high rating material 4% of silicon steel is used. which is Build up of ~~the~~ lamination 0.5mm which are insulated each other reduce the Eddy currents losses.

⇒ The stator core classified into 3 types
i) open slot
Semi closed slot
closed slot

i) Open slot

The advantage of open slot is easy removal of replacement of detating coils

ii) Semi closed slot:

It is generate the emf with less Re factor initial cost is low

iii) closed slot :

It is air gap is uniform.

Rotar:

Rotar is a Rotating part and it carries fielding winding and produce the magnetic flux.

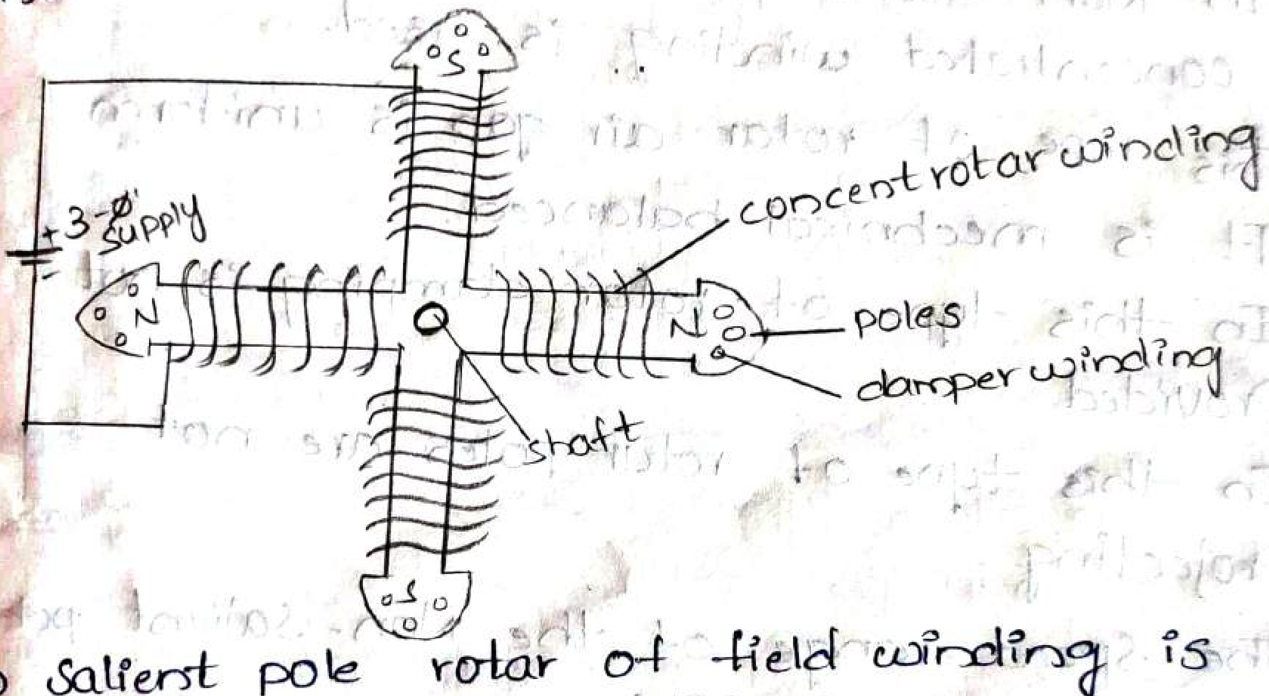
→The Rotar is classified into two types

i) Salient pole rotar (or) Non-cylindral rotar

ii) Non Salient pole rotar (or) cylindral rotar.

i) Salient pole rotar:

The Salient pole rotar as shown in fig.



In salient pole rotar of field winding is concentrated winding is used

→This type of rotar ~~Arear~~ gap is non uniform

→It is not mechincal balanced

→In this type of rotar damping is provided

→In this type of rotar poles are projecting.

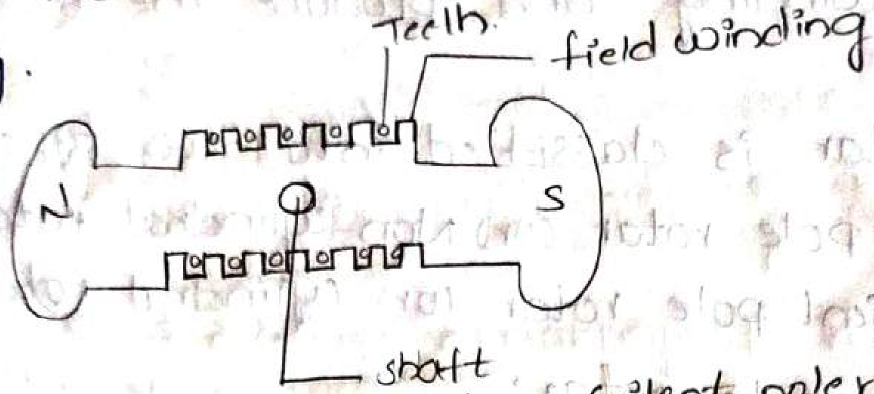
→The speed range of the salient pole rotar is 50 – 1000 RPM.

→In this type of rotar larger diameter and smaller axial length

→ It is used in water turben and IC engines.

Non salient pole rotar.

In Non salient pole rotar as shown in fig.



Non- Sailent pole rotar

In Non Salient pole rotar of field winding is concentrated winding is used.

⇒ This type of rotar air gap is uniform

⇒ It is mechnical balanced.

⇒ In this type of rotar damping is not Provided.

⇒ In this type of rotar poles are not Projecting

⇒ The Speed range of the Non- Salient pole rotar is 1500 – 3000 RPM.

→ In this type of rotar Smaller diameter and larger axial length.

Note:

Damper winding is used in preventing hunting in alternator to provide starting torque of electrical motars and shaft is used in transformation of power [They receiving dc power and deliever the Ac power]

Construction of 3 phase Induction motar

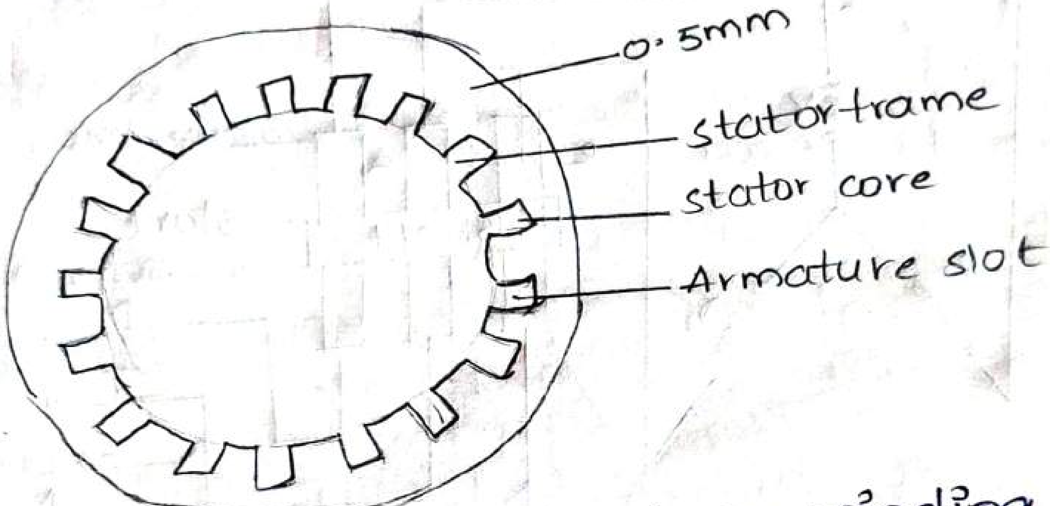
The 3-phase Induction motar is self starting device and ~~consis~~ consiting of two parts

i) stator

ii) Rotar

stator:

The stator is stationary part and cylindral structure as shown in fig



The stator carries 3-phase winding & 3 phase supply is connected and this type of stator 4% of silicon steel is used

The stator is definite no of poles depends upon speed of the motar. If the no. of poles increases and speed of motar the increases.

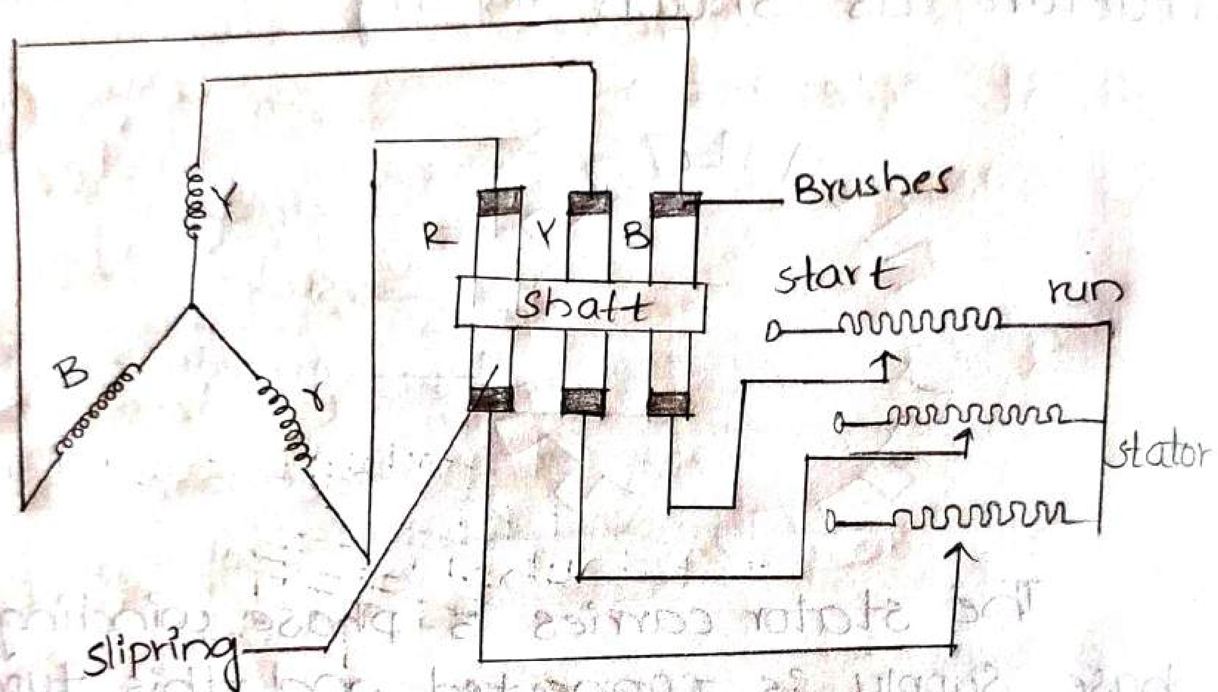
The thickness of the lamination 0.5mm is used which are insulated by reducing Eddy current losses

Rotar

Rotar is a Rotating part and classified into two types

i) slip ring rotar
ii) squirrel cage rotar

i) Slip ring rotar:
The slip ring rotar as shown in fig



In this type of Rotar consisting of 3 phase supply similar to the stator.

⇒ In this type of rotar external resistance will be added.

⇒ It is complex Construction and High Cost
In this type of rotar maintance cost is more

⇒ It is low effiency and low power factor

⇒ In this type of rotar slip ring and brushers are present

- It is high starting torque is appiled.
- In this type of rotar copper losses is high due to external resistance
- In this type of rotar is used in lift and cranes.

Speed control is possible.

Advantages

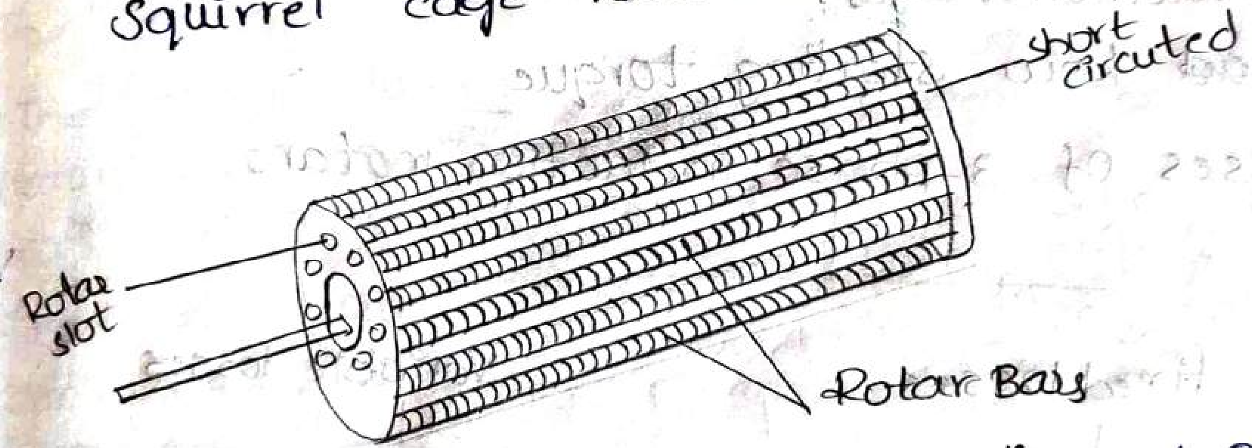
i) Speed is constant
ii) Low starting Current
iii) High starting torque

Disadvantages

i) Low efficiency
ii) Low power factor.

Squirrel cage rotar:

Squirrel cage rotar as shown in fig



In this type of rotar consisting of Bars which are short circuited with the help of Bendings

In this type of rotar external resistance can't be added

It is complex construction is low cost

In this type of rotar maintance cost is high.

⇒ It is high effiency and high power factor.
⇒ In this type of rotar sliping and brushers are absent
⇒ It is low starting torque ~~can be~~ can't be obtained.
⇒ In this type of rotar copper losses is low due to external resistance
⇒ In this type of rotar is used in fans and Grigders
⇒ Speed control is not possible.

Advantages:

Low cost

More efficiency

High overload capacity

Disadvantages:

~~Load~~ Low starting torque

Losses of 3-phase Induction motar:

- fixed losses
  - core losses
    - Stator core losses
    - Rotar core losses
  - friction losses
  - Windage losses
- Variable losses
  - Ohmic losses
    - Statorohmic losses
    - Rotar ohmic losses.
  - Brush Contact losses
  - stray losses

⇒ The losses Occurs whenever the motar remains Constant for any Speed and Voltage is known as fixed losses.

→ The fixed losses occurs speed of the motor changes very slightly and compare to the speed of the induction motor. The frequency value will be decrease

→ The core losses also divided into stator core losses and Rotar core losses and friction and windage losses are constant.

→ The no load test of three phase induction motar determine the fixed losses

fixed losses

Variable losses

→ The losses occurs whenever the motar load increases and the losses also increases is known as Variable losses.

→ The ohmic losses known as I^2R losses.

→ The ohmic losses occurs resistance of the stator and Rotar winding and generate the heat in increasing temperature.

→ Load test of 3-phase induction motar (or) back rotar test of 3-phase induction motar determine the Variable losses.

Efficiency of 3-phase Induction motar:

It is defined as the ratio of mechnical energy output to electrical energy input is known as efficiency of 3-phase induction motar.

The mathematical expression of the 3-phase induction motar is given as

$$\%\eta = \frac{\overset{(\text{Rotar})}{\text{Mechnical energy output}}}{\underset{(\text{stator})}{\text{Electrical energy input}}} \times 100$$

Let consider

P_{shaft} = rotar outpower of induction motar

$P_{stator core}$ = Stator core losses

$P_{rotor core}$ = rotor core losses

$P_{fricwin}$ = friction losses + windage losses

$P_{I^2R\,stator}$ = Stator ohmic losses

$P_{I^2R\,rotar}$ = Rotar ohmic losses

$P_{additional}$ = Brush contact losses + stray losses

$$P_c = P_{\substack{stator\\core}} + P_{\substack{rotar\\core}} + P_{fric\,w}$$

$$P_{I^2R} = P_{\substack{I^2R\\stator}} + P_{\substack{rotor\\I^2R}} + P_{add}$$

$$\eta = \frac{P_{out}}{P_{input}}$$

P_{out} = Input − Total losses

P_{in} = o/p + Total losses

Total losses = $P_c + P_{I^2R}$

The efficiency of 3-phase induction motar is given as

$$\boxed{\%\,\eta = \frac{P_{shaft}}{P_{shaft} + (P_c + P_{I^2R})} \times 100}$$

Q) 3-phase induction motar 6 poles 440 V and 50 Hz the rotar input power 60 kilowatts it is observed that the rotar emf 90 complete cycle for minute calculate the

i) slip
ii) Rotar Speed
iii) Rotar copper losses for phrase
iv) Mechnical power develop
v) Rotar resistance for phrase with current $I_R = 60$ Amp

Given data
3-ø induction motar
No. of poles = 6
Voltage V = 440V
frequency = 50 HZ
Rotar Input power = 60 KW
Rotar emf = 90 cycle/minute

i) $S = ?$
ii) $N_r = ?$
iii) Rotar cu per phase = ?
iv) $P_m = ?$
v) $R_r = ?$

$$f_r = \frac{90}{60}$$

$$\boxed{f_r = 1.5\ HZ}$$

i) $f_r = S \times f$

$$S = \frac{f_r}{f}$$

$$= \frac{1.5}{50}$$

$$\boxed{S = 0.03}$$

ii) $\boxed{N_r = N_s(1-S)\,rpm}$

$$N_s = \frac{120 f}{P}$$

$$= \frac{120\,(50)}{6}$$

$$\boxed{N_s = 1000\ rpm}$$

$N_r = 1000(1-0.03)$

$\boxed{N_r = 970 \text{ rpm}}$

iii) Rotar copper per phase = $\frac{\text{Rotar I/p power} \times \text{slip}}{3}$

$= \frac{60\times10^3 \times 0.03}{3}$

$\boxed{\text{Rotar copper losses per phase} = 600}$

iv) Mechnical power develop

$P_M = P_{in}(1-s)$

$P_M = 60(1-0.03)$

$\boxed{P_M = 58.2 \text{ KW}}$

v) Rotar copper losses per phase

$I_R^2 R_r$

$600 = (60)^2 \times R_r$

$600 = 3600 \times R_r$

$R_r = \frac{600}{3600}$

$\boxed{R_r = 0.16\,\Omega}$

Q) 3-ø induction motar 50 HZ, 600V 9 voltage and 4 poles rotar input Power 75 Kilowatt it is observed the rotar emf 120 complete cycle per min. calculate the

i) Slip

ii) Rotar Speed

iii) Rotar Cupper losses

iv) Mechnical power develop

v) Rotar resistance with $I_R = 80$ Amp

Given data

3-ø induction motar

No. of poles = 4

Voltage V = 9

frequency = 50Hz

Rotar input power = 75 kW

Rotar emf = 120 cycle / minute

i) S = ?

ii) Nr = ?

iii) Rotar cu per losses = ?

iv) Pm = ?

v) Rr = ?

$fr = \frac{\cancel{120}^{4}}{\cancel{60}_{3}}$

$\boxed{fr = 2 \text{ Hz}}$

i) $fr = S \times f$

$S = \frac{fr}{f}$

$= \frac{2}{50}$

$\boxed{S = 0.04}$

ii) $Nr = Ns(1-S)$

$Ns = \frac{120f}{P}$

$= \frac{120(50)}{4}$

$= \frac{6000}{4}$

$Ns = 1500$

$Nr = Ns(1-S)$

$= 1500(1-0.04)$

$\boxed{Nr = 1440 \text{ rpm}}$

iii) Rotar copper losses = Rotar I/p × slip

$= 75 \times 10^3 \times 0.04$

$\boxed{\text{Rotar copper losses} = 3000\,W}$

iv) Mechnical power

$P_M = P_{in}(1-S)$

$= 75(1-0.04)$

$\boxed{P_M = 72\,KW}$

v) Rotar copper losses $= I_R^2 \times R_r$

$= (80)^2 \times R_r$

$3000 = 6400 \times R_r$

$R_r = \frac{3000}{6400}$

$\boxed{R_r = 0.46\,\Omega}$

Q) 3-ø induction motar 50HZ the line voltage 500 V and 6 poles gives an ~~inp~~ rotar output power 37.3 kw at 955 rpm the power factor 0.86 the stator frictional and windage losses 1.492 kw the line losses approximately 1.5 kw. determine the line current, efficiency and rotar Copper losses this motar.

given data

3-ø induction motar

frequency f = 50HZ

Line voltage V_L = 500V

No. of poles = 6

Rotar out put = 37.3 kw

N_r = 955 rpm

$\cos\phi = 0.86$

stator

i) $S = \frac{N_s - N_r}{N_s}$

$N_s = \frac{120f}{P} =$

$\boxed{N_s =}$

$S = \frac{1000 - }{1000}$

$\boxed{S = 0.04}$

Rotar copper

Mech

Rotar

Rota

Rotar I

=

=

Rotar

Rotar

Rotar co

Rotar

ii) % η =

stator in

stator in

iii) %

iii) Rotar copper losses = Rotar I/p × slip

$= 75 \times 10^3 \times 0.04$

$\boxed{\text{Rotar copper losses} = 3000\,W}$

iv) Mechnical power

$P_M = P_{in}(1-S)$

$= 75(1-0.04)$

$\boxed{P_M = 72\,KW}$

v) Rotar copper losses $= I_R^2 \times R_r$

$= (80)^2 \times R_r$

$3000 = 6400 \times R_r$

$R_r = \frac{3000}{6400}$

$\boxed{R_r = 0.46\,\Omega}$

Q) 3-Ø induction motar 50 HZ the line voltage 500 V and 6 poles gives an ~~rap~~ rotar output power 37.3 KW at 955 rpm the power factor 0.86 frictional and windage losses 1.492 KW the stator losses approximately 1.5 KW. determine the line Current. efficiency and rotar copper losses this motar.

given data

3-Ø induction motar

frequency $f = 50\,HZ$

Line voltage $V_L = 500\,V$

No. of poles $= 6$

Rotar out put $= 37.3\,KW$

$N_r = 955$ rpm

$\cos\phi = 0.86$

frictional and windage losses = 1.492 KW

Stator losses = 1.5 KW

i) $S = \frac{N_s - N_r}{N_s}$

$N_s = \frac{120f}{P} = \frac{120 \times 50}{6}$

$\boxed{N_s = 1000 \text{ rpm}}$

$S = \frac{1000 - 955}{1000}$

$\boxed{S = 0.04}$

Rotor copper losses = Rotor I/P power × slip

Mechanical Power

$\frac{\text{Rotor output power}}{\text{Rotor input power}} = \frac{N_r}{N_s}$

$\text{Rotor I/p} = \frac{\text{Rotor o/p} \times N_s}{N_r}$

$= \frac{37.3 \times 10^3 \times 1000}{955}$

Rotor I/p = 39057.5 W

$\boxed{\text{Rotor I/p} = 39.05 \text{ KW}}$

Rotor copper losses $= 39.05 \times 10^3 \times 0.04$

$= 1562 \text{ W}$

$\boxed{\text{Rotor copper losses} = 1.562 \text{ KW}}$

ii) $\% \eta = \frac{\text{Mechnical energy output power}}{\text{electrical energy input power}} \times 100$

stator input power = Rotor input power + stator losses

$= 39.05 + 1.5$

$\boxed{\text{stator input power} = 40.55 \text{ KW}}$

iii) $\% \eta = \frac{37.3}{40.55} \times 100$

$\boxed{\% \eta = 91.98 \%}$

v) $I_L = ?$

Stator input power $= \sqrt{3}\, V_L I_L \cos\phi$

$$40.55\times10^3 = \sqrt{3}\times500\times I_L\times0.86$$

$$I_L = \frac{40.55\times10^3}{\sqrt{3}\times500\times0.86}$$

$$\boxed{I_L = 54.44\,A}$$

Q) 3-ϕ induction motor 50Hz, 600V line voltage and 6 poles the rotar output power 47.5 Kw the frictional at 800 RPM. The power factor 0.45 the frictional and windage losses 1.7 Kw and stationary losses 1.75 Kw approximately. Determine the line current efficiency rotar copper losses of the motor.

Given data

3-ϕ induction motor

frequency = 50 Hz

Line voltage = 600 V

No. of poles = 6

rotar output power = 47.5 Kw

$N_r = 800$ RPM

$\cos\phi = 0.45$

frictional and windage losses = 1.7 Kw

i) $S = \frac{N_s - N_r}{N_s}$

$$N_s = \frac{120f}{P} = \frac{120\times50}{6}$$

$N_s = 1000$ rpm

$$S = \frac{1000 - 800}{1000} = \frac{200}{1000}$$

$$S = 0.2$$

rotor copper losses = Rotor I/p power × slip

Mechnical power

$$\frac{\text{Rotor o/p Power}}{\text{Rotor I/p power}} = \frac{N_r}{N_s}$$

$$\text{Rotar I/p} = \frac{\text{rotor o/p} \times N_s}{N_r}$$

$$= \frac{47.5 \times 1000 \times 10^3}{800}$$

$$= 59375 \text{ W}$$

$$= 59.37 \text{ KW}$$

Rotar copper losses $= 59.37 \times 10^3 \times 0.2$

$= 11874 \text{ W}$

$= 11.874 \text{ KW}$

$$\% \eta = \frac{\text{mechnical energy O/P power}}{\text{electrical energy I/p power}} \times 100$$

stator I/p power = Rotar I/p power + stator losses

$= 59.37 + 1.7$

$= 61.12$

$$\% \eta = \frac{47.5}{61.07} \times 100$$

$= 77.7\%$

$I_L = ?$

Stator I/p power $= \sqrt{3}\, V_L I_L \cos\phi$

$61.07 \times 10^3 = \sqrt{3} \times 600 \times I_L \times 0.45$

$$I_L = \frac{61.07 \times 10^3}{\sqrt{3} \times 600 \times 0.45}$$

$I_L = 130.70 \text{ A}$

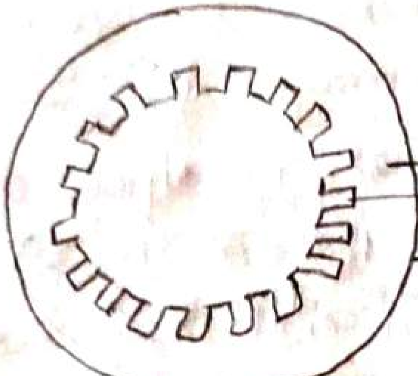
Construction of Single phase Induction Motor

⇒ The Single phase induction motor is not self-starting device and it consisting of two parts

i) Stator
ii) Rotor

i) Stator

Stator is a stationary device and cylindral structure as shown in fig.



The stator carries 1-Ø supply two connected and which are insulted by ~~nominal~~ lamination of 4% of silicon steel is used in this material and thickness of the lamination from 0.036 - 0.06 cm and reduce the Eddy current losses.

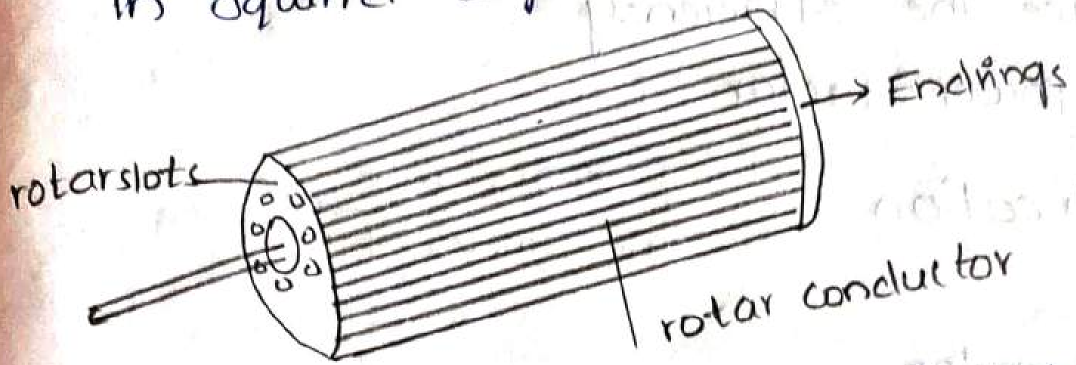
Rotor :

Rotor is a rotating part and in classification rotar are

i) Squirrel cage rotar
ii) Slip ring rotar

i) Squirrel cage rotar

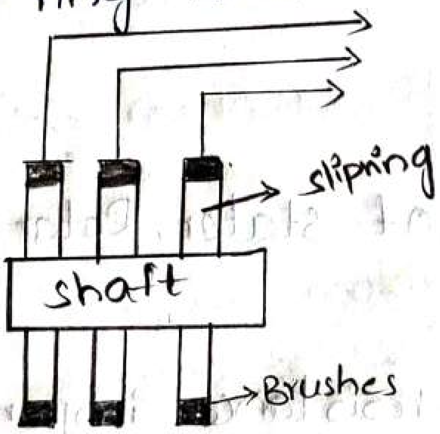
In squirrel cage rotar as shown in fig



In type of rotar consisiting of rotar slots to the lamination of the silicon steel is used and rotar slots connected in series which carries the rotar bars and rotar conductors connected to end rings it reduce the copper losses is low due to low power factor.

ii) Slip ring rotar:

In slip ring rotar as shown in fig



In this type of rotar consisiting of sliprings are connected rotar and shaft.

⇒ The slip rings connected to the shaft in Parallel connection and reduce the copper losses and high power factor

Advantages:

i) Most economical

ii) easy to repair

Disadvantages

i) Reduce the efficiency

ii) Low power factor

Application

i) fans.

ii) Refrigerator

iii) Vaccum cleaners

iv) Printing machines

v) Washing maches

vi) Mixes, Grindes

factors of single phase Induction Motar

The classification of factors of Single phase induction motar are

i) Rotar resistance

ii) Air gap length

iii) physical structure of stator, Rotar

i) Rotar resistance

The rotar resistance important parameters of Performance of 1-ϕ induction motar which are determine with help of area of cross section of the material.

If the rotar resistance increases and the torque will be maximum.

If the rotar resistance increases decrease the starting current and effiency and percentage of voltage regulation is increases.

Air gap length:

Reduction of the air gap length it causes more losses and reduce the over load capacity.

The air gap length completely depends upon power factor and no. of poles.

Physical structure of stator, Rotar.

These parameters very important role of working of single phase induction motar the maximum torque will be produced reduce the intergal slot winding and increase the air gap length.

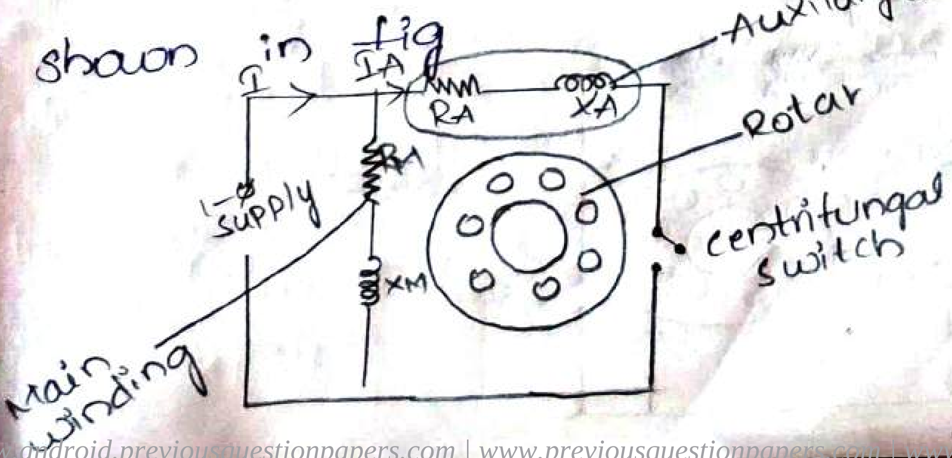
Starting methods / classification of 1-ø induction motar.

The starting methods of 1-ø induction motar.

i) Split phase Induction motar
ii) capacitor start induction motar
iii) capactor run Induction motar
iv) Two value capacitor Induction motar

i) Split phase induction motar:

In type of motar in the circuit as shown in fig



In type of induction motar connected in single phase supply and flow of current divided into auxeillary and main winding current.

→ In auxeilary winding resistance, reactance and centrifungal switch are connected in series and parallel with main winding.

⇒ In this type of motar has low efficiency, low powerfactor and slow starting torque

start characteristic of Split phase induction motar:-

i) The starting torque of the motar 100-250%

ii) Break down torque of the motar upto 300%

iii) The efficiency of motar 55-65%

iv) The power factor of the induction motar 0.5-0.65

v) The power rating induction motar range from ½ HP - 1 HP

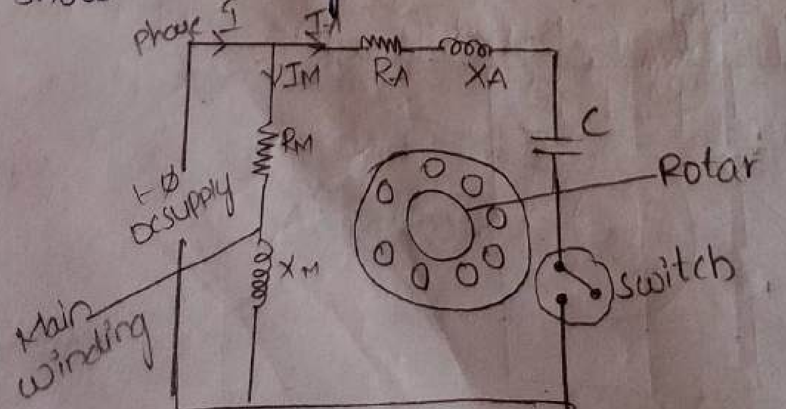
Applications:

i) Washing machines

ii) Mixes, Grinders

Capacitor start induction motar.

In this type of motar in the circuit as shown in fig.



In this type ... resistance, reacta... in series with c... with main windi...

In this type o... and low power... characteristic ... motar.

i) The starting ... 250-400%

ii) Breakdown t...

iii) The efficienc...

iv) The powerfa... 0.5-0.65%

v) The power ... from 1/8 HP ...

Applications

i) Motar pu...

ii) Air comp...

Capacitor ...

as shown ...

In type of induction motar connected in single phase supply and flow of current divided into auxeilary and Main winding current

→ In auxeilary winding resistance, reactance and centrifungal switch are connected in series and parallel with main winding.

→ In this type of motar has low efficiency, low power factor and slow starting torque

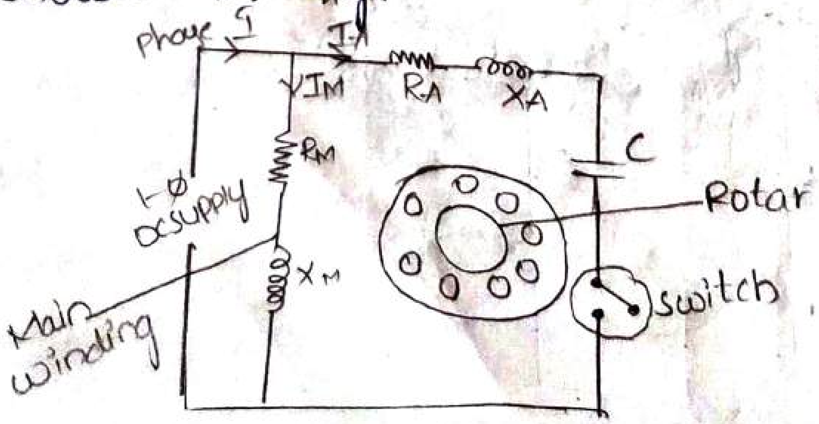
~~Start~~ characteristic of Split phase induction motar:-

i) The starting torque of the motar 100-250%
ii) Break down torque of the motar upto 300%
iii) The efficiency of motar 55-65%
iv) The power factor of the induction motar 0.5-0.65
v) The power rating induction motar range from 1/2 HP - 1 HP

Applications:
i) Washing machines
ii) Mixes, grinders

Capacitor start induction motar.

In this type of motar in the circuit as shown in fig.



In this type of motar auxilary winding resistance, reactance and capacitor connected in series with centrifugal switch and parallel with main winding.

in this type of motar also low efficiency and low power-factor.

characteristic of capacitor start induction motar.

i) The starting torque of the induction motar 250-400%

ii) Breakdown torque of the motar upto 350%

iii) The efficiency of motar 55-65%

iv) The powerfactor of the induction motar 0.5-0.65%.

v) The power rating of induction motar range from 1/8 HP - 1 HP

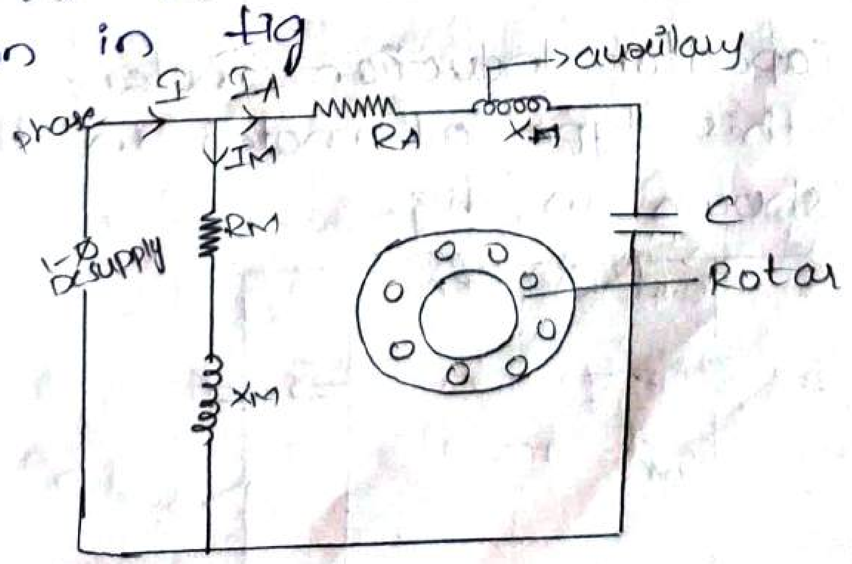
Applications:

i) Motar pump

ii) Air compression

capacitor Run induction motar:

In this type of motar in the circuit as shown in fig



In this type of motar in auxilary resistance, reactance and capacitance are connected in Series in the circuit no centrifugal switch is required and parallel with main winding.

In this type of motar high starting torque, high power factor and high efficiency.

characteristic Capacitor run Induction motar:

i) The starting torque of the induction motar 50 - 100%

ii) Break down torque of the motar upto [illegible] 250

iii) efficiency of the motar 60 - 70

iv) The power factor of the induction motar 0.75 - 0.9

v) The power rating induction motar range from 1/8 HP - 1 HP

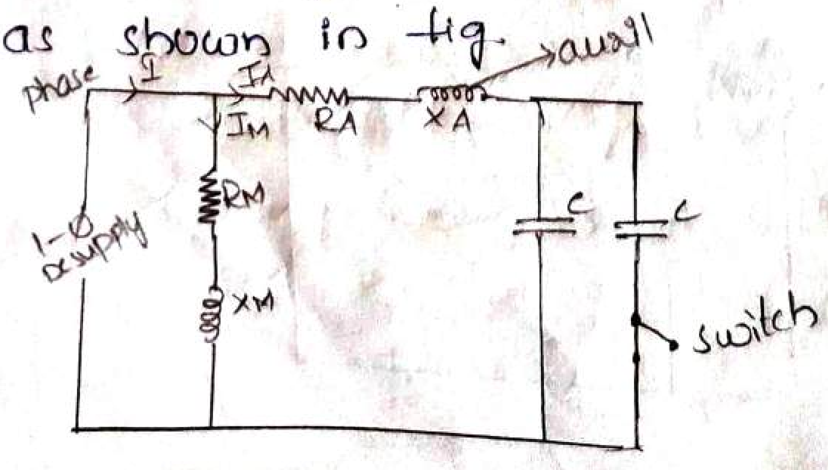
Applications;

i) fans

ii) voltage regulator.

Two value Capacitor Induction motar:

In this type of motar in the circuit as shown in fig.



In this type of motar in auxilary winding resistance, reactance and capacitance CR is series connection

CR = Permanent circuit are parallel with CS where CS = short-time capacitor in the circuit and parallel with main winding.

In this type of motar high starting torque, high power-factor and high efficiency.

characteristic of two value capacitor induction motar are.

i) The starting torque of the induction motar 200-300 %

ii) Breakdown torque of the motar upto 250%

iii) The ~~pow~~ efficiency of the induction motar 60--70%.

iv) The power-factor of the induction motar 0.75 - 0.9

v) The power rating induction motar range from 1/8 HP - 1HP

Applications:

i) ~~Re~~ Refrigenerator

ii) Air condition compression.

Speed controlled Methods of 3-phase induction Motar:

- Statorside
  - By changing frequency
  - By changing no.of poles
  - By changing supply voltage
- Rotar side
  - By adding external resistance
  - By cascaded connections
  - By injected emf in rotar.

The Various factors of Speed controlled motar are 3-ø induction motar

⇒ Speed controlled By changing frequency:

i) In the Speed controlled method the Speed is directly proportional to supply frequency. If the supply frequency changes the speed of the motar changes simulateously.

ii) In Speed Control method the supply voltage is constant the frequency value decreases and flux is increases.

iii) If the flux is increases reduce the iron losses and efficiency.

iv) If the frequency increases the flux value will be decreases and reduce the maximum torque

Speed controlled method by changing no. of poles:

i) It is suitable for only squirrel cage induction motar because squirrel cage rotar is automatically developed no. of poles equal to poles of the stator winding.

ii) Suppose motar has two winding for 6 poles and 4 poles and 50 Hz supply the synchronous speed will be 1000 - 1500 RPM. respectively and for slip value 5% the rotar speed will be 950 and 1425 RPM respectively.

iii) By changing no. of poles increases and the rotar and synchronous speed will be decreases.

iv) In the speed controlled method not possible it is more costly.

Speed controlled method by changing supply voltage:

i) In this method of speed controlled is constant frequency and varied the supply voltage

ii) The torque will be produced by induction motar which is directly proportional to square of rotar induced emf

$$\boxed{T \propto S E^2}$$

iii) This rotar induced emf is directly proportional to supply voltage

$$\boxed{E_2 \propto V}$$

iii) The torque is directly proportional to square of the supply voltage is given as

$$\boxed{T \propto SV^2}$$

from based on the above eq supply voltage decreases and the torque value also decreases.

Speed controlled method of by adding external resistance:

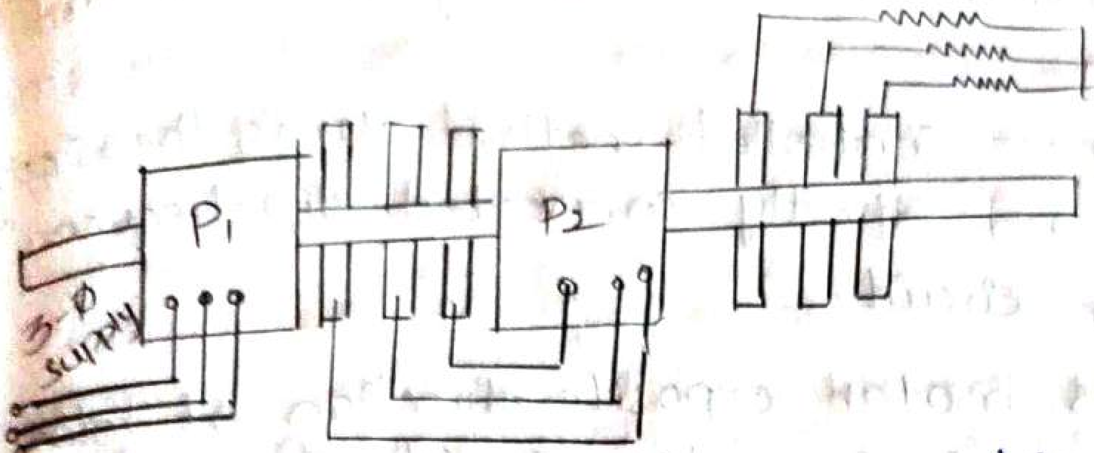
i) In the speed controlled method suitable for slip ring induction motar and the speed controlled method similar to speed control of DC shunt motar.

ii) In the speed control method speed is valued by adding external resistance in rotar circuit the starting torque will be increases it causes more losses.

iii) In the speed control method frequency and supply voltage is constant and the speed of the motar continuously decreases.

Speed controlled method by cascaded connection

i) It the speed controlled method basically arrangements of both motar connected signal shaft then they are motar run same side of the rotar



for P_1 motar can be run separately from the synchronous speed will be

$$N_s = \frac{120f}{P_1}$$

for P_2 motar can be run separately from the synchronous speed will be

$$N_s = \frac{120f}{P_2}$$

Basically constiting of both motars connected in cascaded connection and the synchronous speed is $N_s = \frac{120f}{P_1+P_2}$

It is consisting of both motars connected in different mode based on the no. of poles the synchronous speed is given as

$$N_s = \frac{120f}{P_1-P_2} \text{ (or) } N_s = \frac{120f}{P_2-P_1}$$

In the speed Control method torque and speed of the shaft will be increases and the frequency and the synchronous speed decreases.

Speed Controlled method by injected emf in rotar.

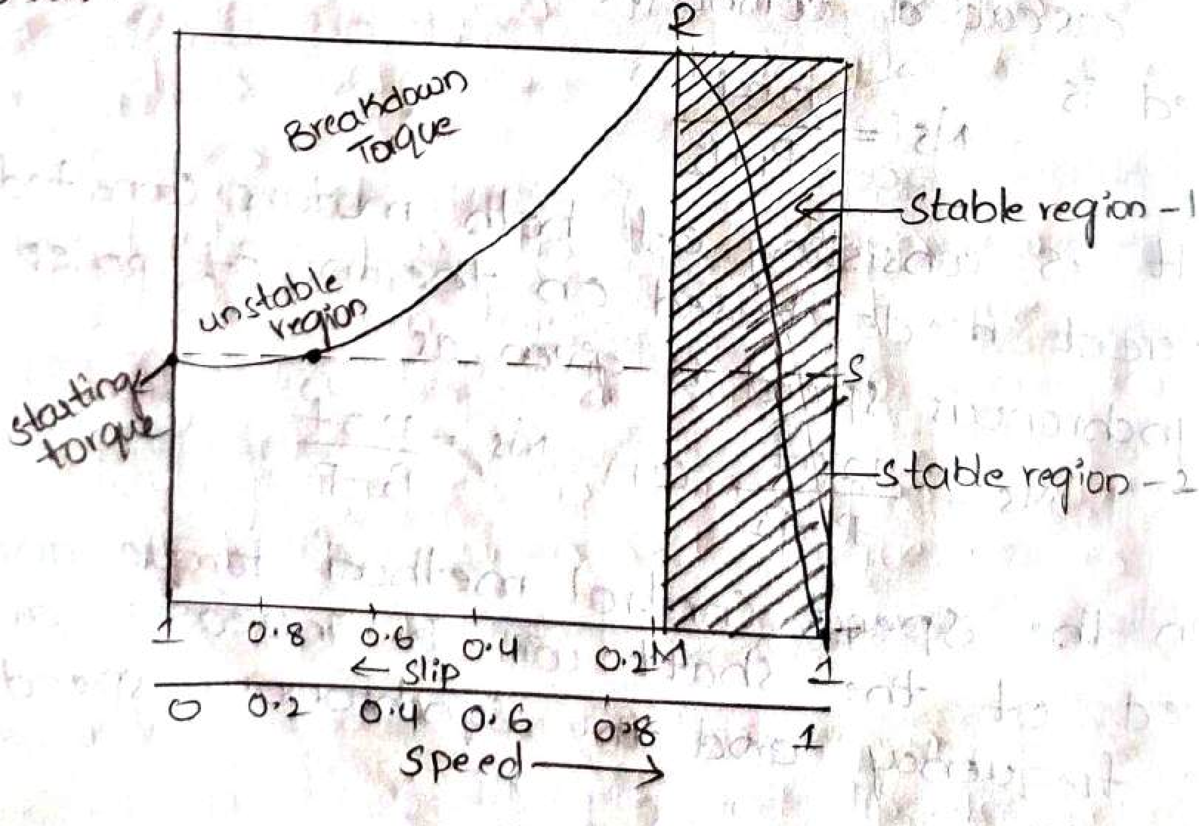
In Speed Controlled method varies the supply voltage and directly connected slip frequency in rotar circuit.

In this motar opposite direction of rotar induced emf in rotar circuit the voltage resistance will be increases and the Speed of the motar decreases.

In injected emf of rotar connected in motar the total resistance decreases and speed of the motar increases.

In this method speed control is possible

Imp
Torque - Slip characteristic of 3-phase induction motar.



Torque Slip characteristic of 3-ø induction motar is given as

$$T \propto \frac{S E_2^2 R_2}{(R_2)^2 + (S X_2)^2}$$

$$T = \frac{K S E_2^2 R_2}{(R_2)^2 + (S X_2)^2}$$

Where

K = Rotar constant

S = Slip

E_2 = Rotar induced emf

R_2 = Rotar resistance

X_2 = Rotar reactance

for case 1 : No load condition

In no load condition of 3-ø induction motar is rotar speed will be equal to zero $[N_r = 0]$ Based on the above condition the slip is given as

$$S = \frac{N_s - N_r}{N_s}$$

$$S = \frac{N_s - 0}{N_s}$$

$$\boxed{S = 1}$$

When $S=1$ torque reaches starting point is known as starting torque.

for case 2 : Increasing load condition.

In Increasing load condition of 3-ø induction motar is torque is inversly proportional to slip $\boxed{T \propto \frac{1}{S}}$

In this condition if the load is increases torque and speed will be decreases and slip is increases.

for case 3 : Maximum torque condition

The maximum torque condition of 3-ø induction motor is torque is directly proportional to slip $\boxed{T \propto S}$

Based on the above eqn if the increasing load and the rotor and slip also increases. the torque reaches max torque is known as breakdown torque

for case 4 : Different nodes of 3-ø induction motor

3-ø induction motor consisting of four different nodes are follows

i) PQ - Unstable region
ii) ST - Stable region
iii) OP - Starting Torque
iv) MR - Maximum torque

i) PQ - Unstable region : In this region if the load is increases and torque value will be decreases.

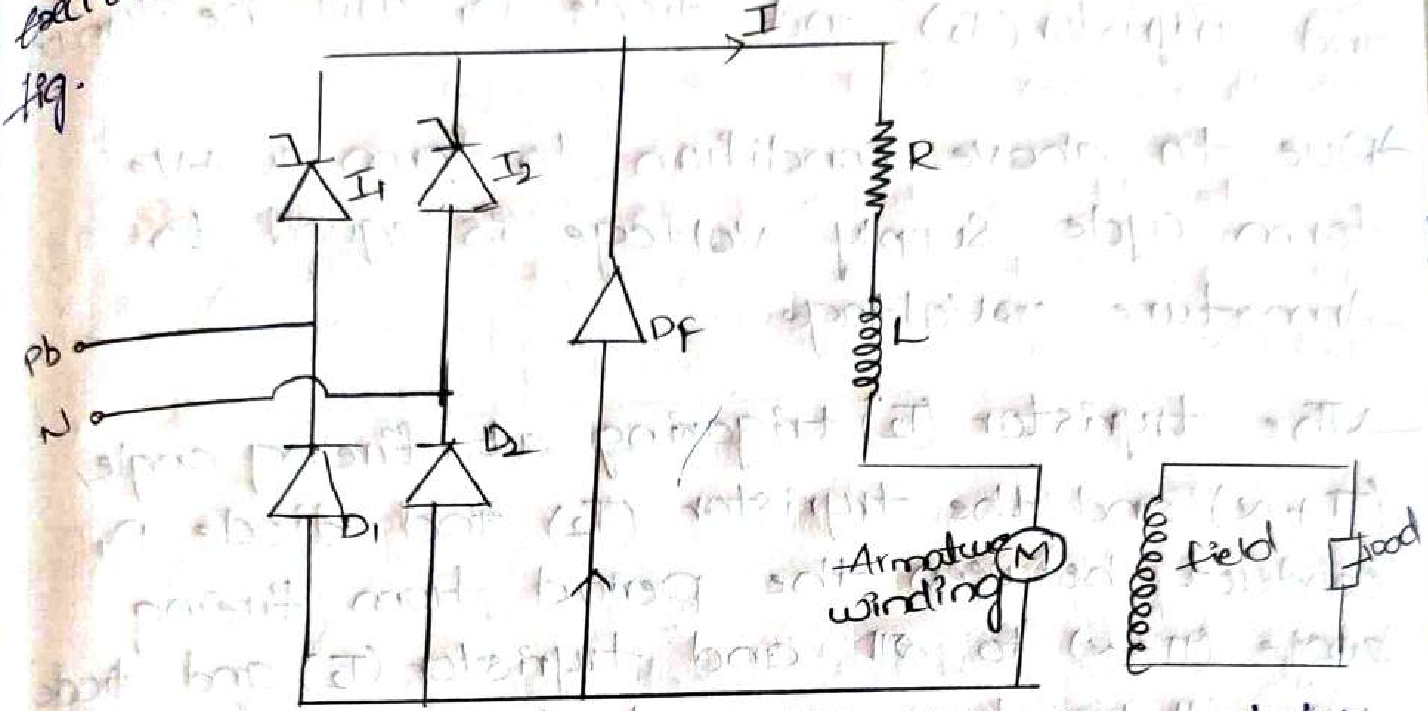
ii) ST - stable region : In this region torque reaches maximum torque then torque constinuosly decreases and slip also decreases

iii) OP - Starting Torque : In this region whenever the appiled load when S=1 torque reaches the starting point

iv) MR - Maximum Torque : In this region if the load is increases torque and slip also increases

Speed control method of Separately excited 1-phase D.c motor:

Speed control method of separately excited 1-ø D.c motar in the circuit show in fig.



In speed control method of separately excited single phase simi convertor are controlled by Armature Voltage an varying freeing angle (α) and depending upon circuit parameters and operation

→ In the speed control method the armature current can be continuous are discontinuous mode.

→ The effect of Armature current in discontinuous mode are given as

i) poor relgulation

ii) The p-form factor of the armature current will be increased

Hence by using 1-ø dc motar the continuous armature current can be operated

→ The Tryristor (T_1) trigaring at fireing angle (α) and the tryristor (T_1) and diode D_2 conduct between the period from fireing α to π and the tryristor (T_1) Diode D_2 will be turn on and tryristor (T_2) and diode D_1 will be turn on

→ Due to above condition to form a +Ve form cycle supply voltage is equal to Armature ~~a~~ Voltage

→ The tryristor (T_2) trigaring at fireing angle $(\pi+\alpha)$ and the tryristor (T_2) and diode D_1 conduct between the period from fireing angle $(\pi+\alpha)$ to 2π and tryristor (T_2) and diode (D_1) will be turn on and tryristor (T_1) and diode (D_2) will be turn on

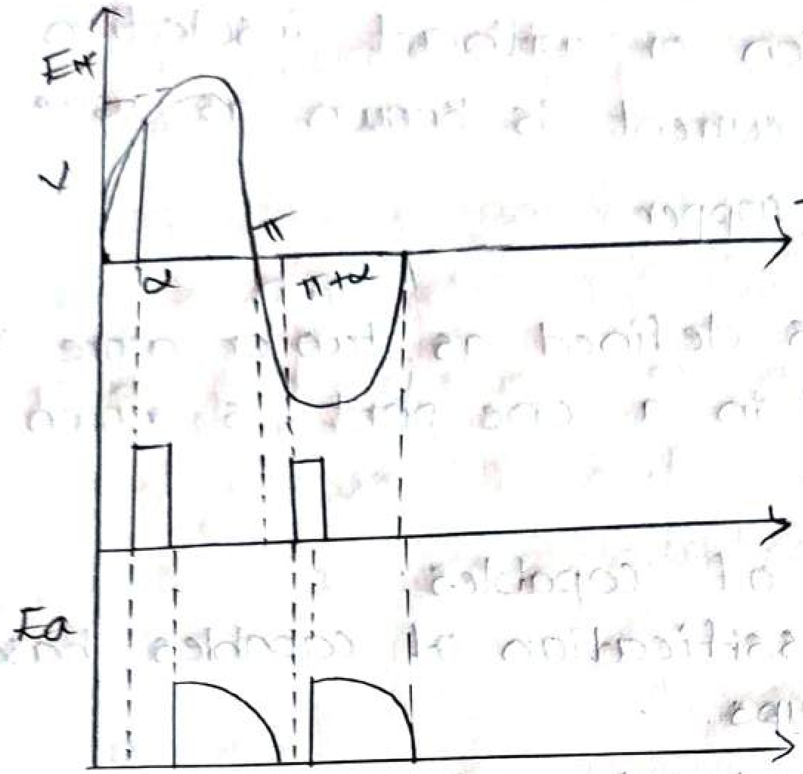
Due above condition to form a -Ve ~~of~~ cycle supply voltage reverse to +Ve of cycle.

→ The purpose of freeveling Diode ~~is~~ used in Circuit control the armature voltage in -Ve of cycle and freeveling diode and passing to the reverse direction of Armature Current and the armature Voltage will be zero.

→ The Average armature Voltage is given as

$$\boxed{E_a = \frac{E_M\,(1+\cos\alpha)}{\pi}}$$

The separately excited DC motor in supply voltage sinusiodal wave form as shown in fig



Torque speed characteristic separately excited d.c motor in this method the torque is directly proportional to torque increase speed also increases.