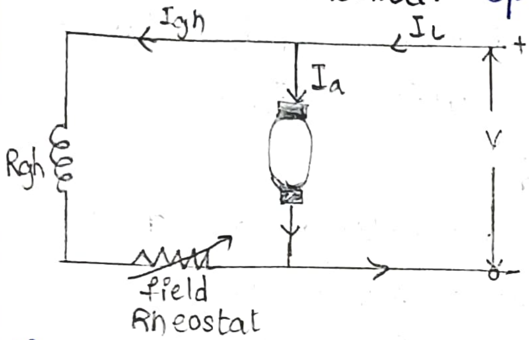
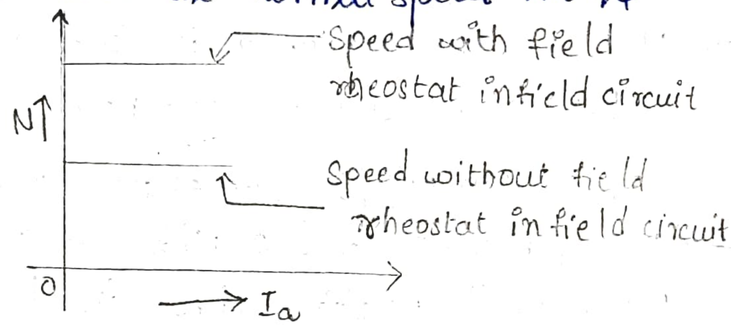
1 (a) Explain the various methods of speed control of DC shunt motor and discuss their relative merits and demerits?

Speed control methods of Dc Shunt Motors:-

(i) Flux control method:- Speed above the normal speed $N \alpha 1/\phi$





It is based on the fact that by varying the flux ϕ the motor speed can be changed and hence the name flux field control method.

In this method a variable resistance is placed in series with field winding as shown if figure. the field rheostat reduces the field current If Hence the flux is reduced therefore we can only raise the speed of the motor above the normal speed.

Advantages:-

(i) This is an easy and convenient method.

(ii) It is an in expensive method since very little power is wasted in the shunt field rheostat due to relatively small value of Ish.

(iii) The speed control expercised by this method is independent of load on the machine.

Disadvantages:-

(i) Only speeds higher then the normal speed can be obtained since the total field circuit resistance cannot be reduced below Rsh.

(ii) There is a limit to the maximum speed obtainable by this method. It is because if the flux is too much weakened, commutation becomes poorer.

(b) Derive the torque expression of a DC motor.

→ When armature conductors of DC motor carry current in the presence of statur field flux, a mechanical torque is developed between the armature and the statur. Torque is given by the product of the force and the radius at which this force acts.

→ Torque $T = F \times r$ [N-m] --- where F = force and r = radius of the armature.

→ work done by this force in once revolution = Force × distance
= $F \times 2\pi r$ [where, $2\pi r$ = circumference of the armature]

→ Net power developed in the armature = word done / time
= [Force × circumferance × no. of revolutions)/time

= $[F \times 2\pi r \times N]/60$ Joules per Second.

→ But, $F \times r = T$ and $2\pi N/60$ = angular velocity ω in radians per second. putting these in the above equation
Net power developed in the armature = $P = T \times \omega$. J.

(C) Describes how swimborne's test is conducted on DC shunt machine. State its advantages and disadvantages.

Swinburne's test:-

It is an indirect method of testing of DC machines. In this method the losses are measured separately and the efficiency at any desired load is predetermined. Machines are tested for finding out losses, efficiency and temparature rise. For small machines direct loading test is performed, for large shunt machines, indirect methods are used like Swinburne's test.

Procedure:-

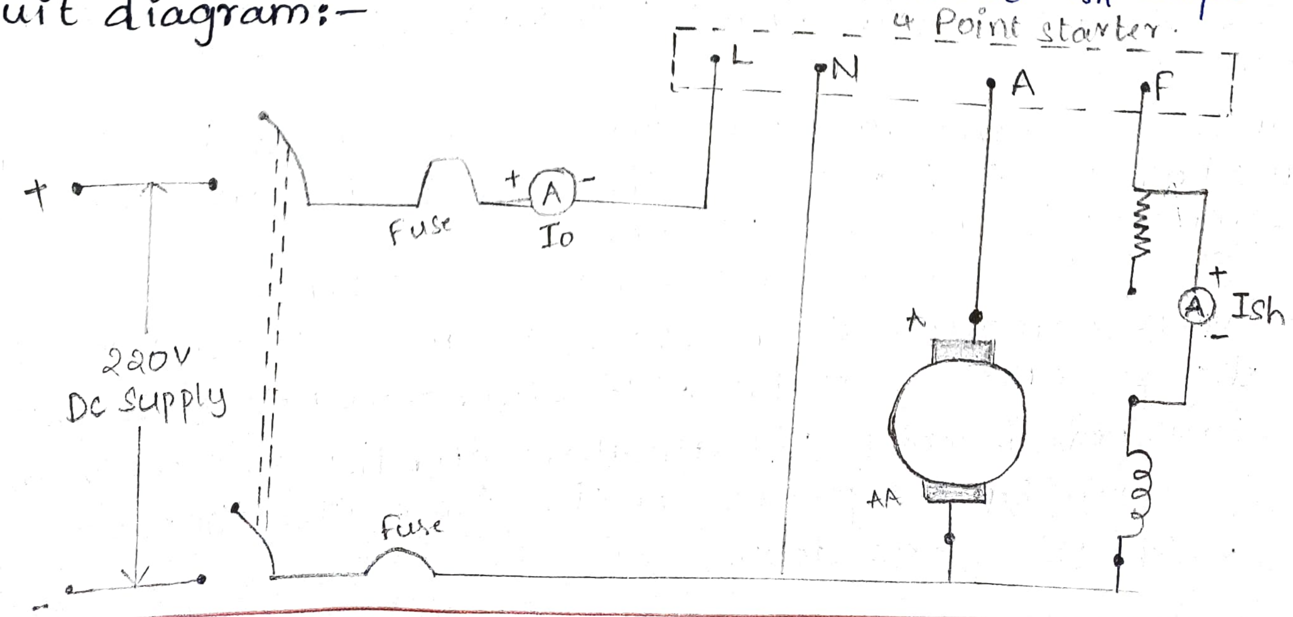
→ It is a simple indirect test which is applicable when flux's is constant like shunt machine.

→ The machine is run as motor at no load at its rated speed with the help of shunt field resistance.

→ The supply voltage, no load input current and field current are measured by ammeters.

→ Then the no load armature current $I_{ao} = I_o - I_{sh}$ amps.

Circuit diagram:-



→ Where I_0 = No load input current
I_{sh} = shunt field current
→ No load input power = $V^* I_0$ watts
→ Constant losses (Wc) = input − Ar. Co. losses = $VI_0 - (I_{a0})^2 R_a$
where R_a = armature resistance.

Advantages:-
→ Efficiency and losses at any desired load can be determined due to knowing of losses.
→ Though the test is carried on dc machine as a motor the efficiency and losses can be evaluated for motor as well as generator.
→ This test is very simple and is suitable for only shunt and compound motors.

Disadvantages:-
→ It is no-load test so it cannot be applicable for series motor.
→ Temparature rise in machine on load condition cannot be predicted.

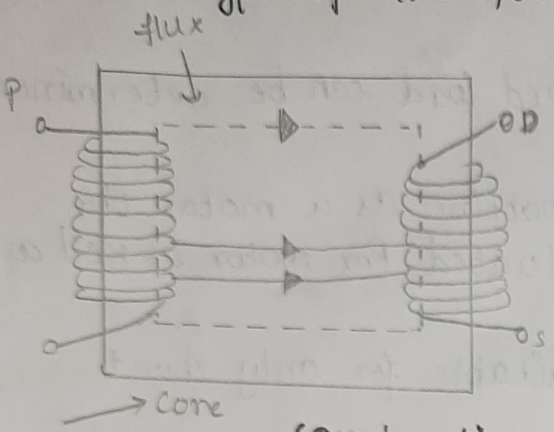
2. (a) Explain the principle of operation of single phase transformer and Derive the expression for induced EMF of a transformer.

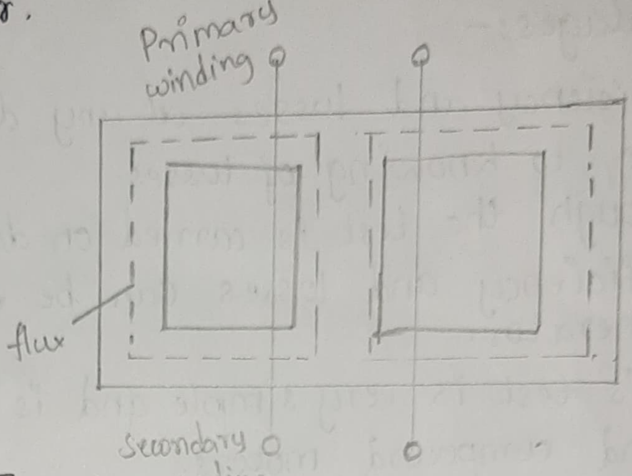
Operator of Transformer:-
→ The transformer has primary and secondary winding.
→ The core leminations are joined in the form of strips.
→ A mutual electro-motive force is induceed in the transformed form the alternating flux. that is set up in the laminated core due to the coil that is connected to a source of alternating voltage.
→ Most of the alternating flux developed by this coil is linked with other coil and thus produces the mutual induced electro motive force.
→ The so produced electro-motive force can be explained with the help of faraday's law of electromagnetic induction as
$$ie = M^* dI/dt$$
→ If the second coil circuit is closed a current flow in it and thus electrical energy is transformed magnetically from the first to the second coil.
→ The alternating current supply is given to the coil and

(thus electrical energy is transformed magnetically) hence. it can be called as the primary winding.

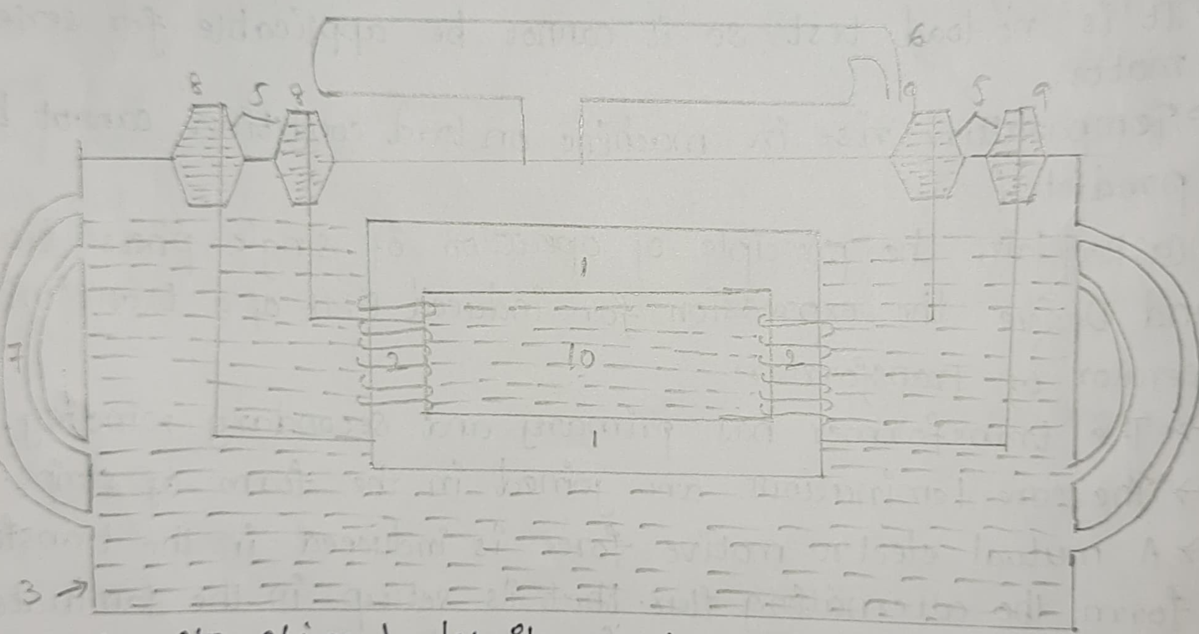
→ The alternating current supply is given to the circuit and hence can be called as the secondary winding.

Type of Transformer.





Construction of Transformer.



Constructional details of transformer.

The important parts of a transformer are:

① core ② windings ③ Tank ④ conservation ⑤ Bushings ⑥ Breather ⑦ Radiations ⑧ winding leads (input) ⑨ winding leads (output) ⑩ Transformer oil.

Core:-

→ Transformer core is made up of silicon steel or sheet with 4% silicon.

→ Sheet are laminated with an oxide layer to reduce the iron losses.

→ The thickness of lamination are 0.35mm for 60Hz and 5mm for 25Hz operations.

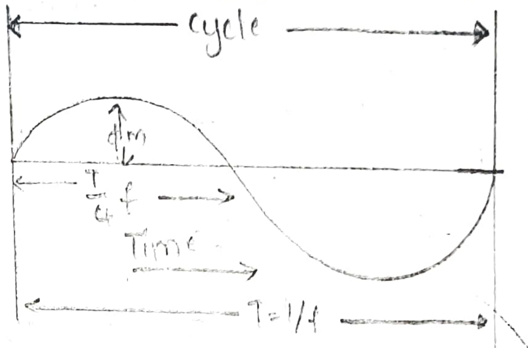
→ The purpose of the core is to provide a magnetic path of low reluctance between the two windings so that

Whenever one winding is execited, the flux established by the winding will link folly with the other binding without any appreciable leakage.

Windings:—

→ Transformer has two windings.
→ Primary winding which receives energy.
→ Secondary winding which delivers energy.
→ The windings are provided with insultion such that any one turn will not come into contact with other turn.
→ For carrying higher currents standard conductors are used.

EMF equation of a Transformer.



Let N_1 = No. of turns in primary
N_2 = No. of turns in secondary
ϕ_m = Maximum flux in core in webers.
$= B_m \times A$
F = frequency of a.c input in Hz

As shown in fig ① flux increase from its zero value to maximum value ϕ_m in one quater of the cycle, i,e 1/4 f second maximum

$\therefore$ Average rate of change of flux $= \frac{\phi_m}{1/4f}$

$= 4f \phi_m$ Wbls or Volt

Now, rate of change of flux per turn mean induced emf in volts

$\therefore$ Average emf/turn $= 4f\phi_m$ volt

* If flux ϕ varies sinusoidally then n, r.m.s value of induced emf is obtained by multiplying the average value with from factor.

Form Factor $= \frac{\text{r.m.s value}}{\text{average value}} = 1.11$

Now r.m.s value of the induced emf in the whole of primary winding
= induced emf (turn) × No. of primary turn.

$E_1 = 4.44 f N_1 \phi_m = 4.44 f N_1 B_m A$

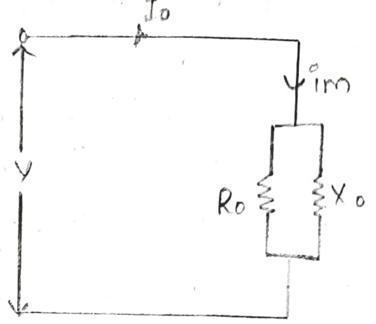
Similarly r.m.s value of the emf of induced in Secondary
It is seen form (i) and (ii) that $E_1/N_1 = E_2/N_2 = 4.44 f \phi_m$

It means that emf turn is the same in both the primary and secondary windings.

In on-ideal transformer on no-load $V_1 = E_1$ and E_2 where V_2 is the terminal voltages.

(b) Write short notes on O.C & S.C test on sing phase transformer.

Open-circuit or No-load Test:-

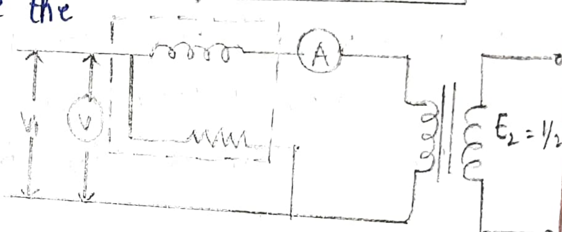


→ To determine the iron losses core. losses) and parameter Ro and x_o of the transformer.

→ Reted voltage is applied to the primary usally low-voltage winding) while the secondary is left open circuited.

No-load Pf $\cos\phi_o = \frac{w_o}{V_1} I_o$

$I_w = I_o \cos\phi_o$; $I_m = I_o \sin\phi_r$.



$R_o = \frac{V_1}{I_w}$ and $X_o = \frac{V_1}{I_m}$

Oc test producer:-

→ Connected should be given according to the clat diagram

→ Switch on the supply.

→ very the auto transformer till rated voltage is applied to LV winds.

→ Note down the reading [voltmeter, Ameter, watt meter]

→ Bring back to zero position of auto trens formation.

→ Then switch off the supply.

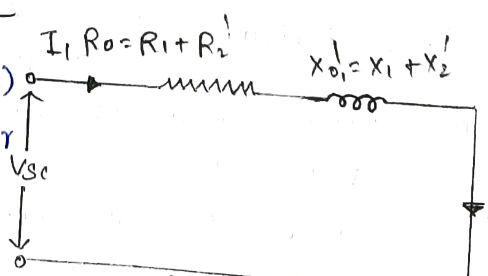
Ro & x_o

No. of load p.f → $\cos\phi_o = \frac{w_o}{V_o I_o}$

I_w = working component current.

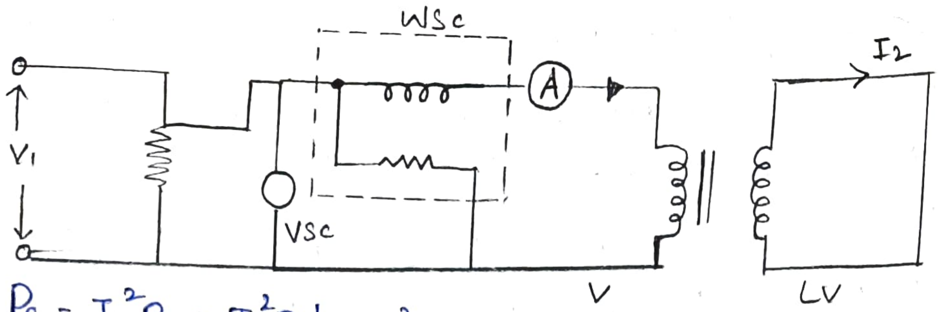
I_m = Magnetising component current.

Short-circuit or Impedence test:-



→ To determine Ro1 (or Ro2) Xo1 (or Xo2) and full-load copper of the transformer

→ The secondary usually low-voltage winding is short-circuited by a thick conductor and variable low voltage (Vsc) is applied such that full-load current flow in the primary.



$P_c = I_1^2 R_1 + I_1^2 R_2' = I_1^2 R_{01}$

$R_{01} = \frac{P_c}{I_1^2} \Rightarrow P_c = I^2 R$

where R_{01} is the total resistance of transformer reflered to primary

Total independence reflererced to primary

$$Z_{01} = \frac{V_{sc}}{I_1}$$

Total leekage reactance reffered to primary

$$X_{01} = \sqrt{Z_{01}^2 - R_{01}^2}$$

Short-circuit p.f $\cos\phi_2 = \frac{P_c}{V_{sc} I_1}$

(C) Define the terms (i) slip (ii) Synchronous speed (iii) rotor current frequency.

A 3-ϕ induction motor is wound for 4 poles and is supplied from 50Hz system. calculate (i) Synchronous speed (ii) Speed of motor when slip is 4% (iii) rotor current frequency when the motor runs at 600rpm.

Slip:—

Slip is defined as the ration of difference between synchronous speed and rotor speed to the Synchronour speed.

N_s = speed of rotating magnetic field in rpm

N = speed of rotor i,e motor in rpm.

$R_0 = \frac{V_1}{I_w}$ and $X_0 = \frac{V_1}{I_m}$

[Oc test producer:—

→ Connected should be given according to the clat diagram

→ Switch on the supply.

→ very the auto transformer till rated voltage is applied to LV winds

→ Note down the reading (voltmeter]

$N_s - N$ = Relative speed between the two speeds is called speed.

→ In practical rotor continuous to rotate with a speed slightly less than the synchronous speed of the rotating magnetic field $(N<N_s)$

→ Induction motor never rotates at synchronous speed.

→ $S = (N_s - N)/N_s$ —— absolute slip.

→ $\% S = (N_s - N)/N_s \times 100$ —— percentage slip

→ At starting actual speed N is zero, so, $S = 1$

Rotor current frequency:-

→ Rotor carries a field winding which is supplied with direct current through two slip rings by a seperate DC source.

→ This DC source is called as EXCITER and is generally a DC shunt generator or a DC compound generator. mounted on the shaft of the alternator.

→ Rotor construction is of two types.

(i) Salient pole type.

(ii) Non-Salient pole type

3.(a) Explain the working principle of three phase induction motor.

Principle of operation 3-ϕ induction motor:—

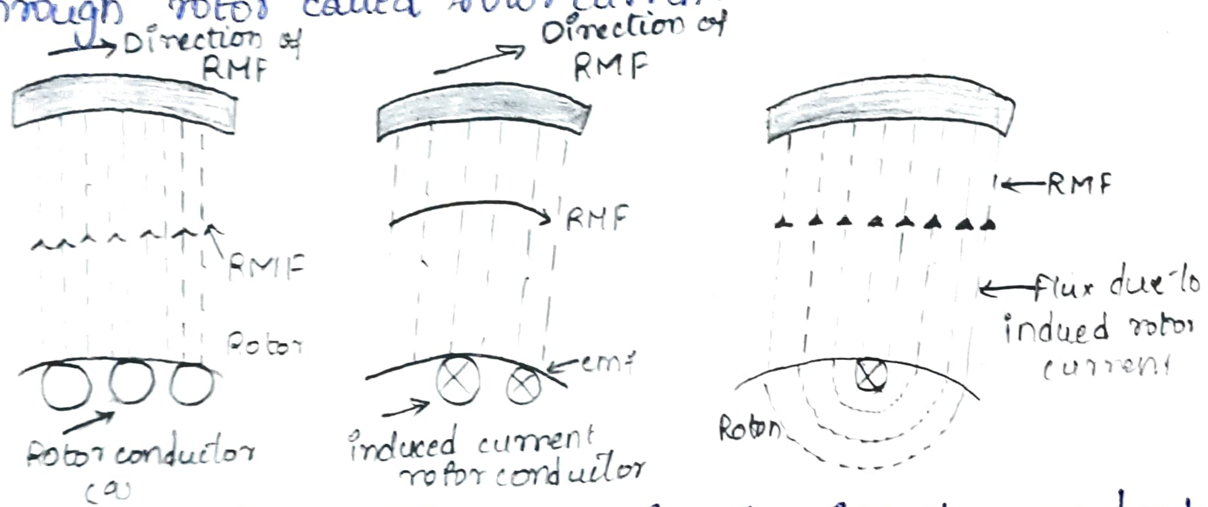
→ Induction motor work on the principle of electromagnetic induction.

→ When a 3-ϕ supply is given to the 3-ϕ stator winding a rotating magnetic field of constant magnetic is synchronous speed $N_s = 120f/p$ rpm.

→ Now at this instant rotor stationary and stator flux RMF is rotating so its obvious that there exists a relative motion between the RMF and rotor conductors.

→ Now RMF gets cut by the rotor conductor as RMF sweeps over rotor conductors. whenever conductor cut the flux. EMF get induced in it called rotor induced EMF [Faradays laws]

→ A rotor forms closed circuit, induced emf circulates current through rotor called rotor current.



→ Let direction of this current is going into the paper denoted (x) in fig 1.b.

→ Any current carrying conductor products its own flux, so rotor produces its flux called (pro) flux. for assumed direction of rotor current, the direction of rotor flux is clock wise.

→ Now there exists interact, one RMF and other is rotor flux. Both the fluxes interact with each fig(1)c.

→ One left the rotor conductors two fluxes are in same direction hence add up to get high flux area on the right as flux lines act like a streched rubber. conductor towards low flux density area. So rotor conductor emp experience a force.

→ As all the operator rotor experience a force the overall

rotor experience a torque and start rotating so interaction of the two flux is very essential for a motoring action
→ Hence rotor start rotating in the same direction as that of rotating.

(b) Explain the constructional details of 3-phase alternator (or) Synchronous generator (salient pole and cylinder pole type)

Construction of alternator synchronous generator:-

→ Basic parts of a synchronous generator are
→ Stator - stationary part of the machine.
→ It carries armature winding in which voltage is generated.
→ It has a three phase winding excited by AC supply
→ The output of the machine is taken from the stator.
→ Rotor - It is the rotating part of the machine.
→ It carries the winding which is excited by a DC source.
→ Thus rotor produces main field flux.

Salient pole type:-

→ Poles are projecting outside.
→ Large diameter and small axial length.
→ Non-uniform Airgap.
→ vertically axis type.
→ Suitable for low speed hydro generator.
→ Needs damper winding
→ Windage loss is higher.

Cylindrical pole type:-

→ No projection of poles.
→ Small diameter and large axial length.
→ uniform Airgap.
→ Horizontal axial type.
→ Suitable for high speed turbo.
→ No need of Damper winding
→ windage loss is lower.