Electrical Machines Theory

1) What do you mean by motor and generator?
= Answer
Motor : The device which converts electrical energy into mechanical energy is called a motor.
Generator : The device which converts mechanical energy into electrical energy is called a generator.

2) What is electromechanical energy conversion?
= Answer
The process by which we converts electrical energy into mechanical energy as well as mechanical energy into electrical energy is called electromechanical energy conversion.

3) State the basic principle of a generator and a motor.
= Answer
Basic principle of a generator :

Whenever a good number of conductors or coils connected in series are placed on a cylindrical rotor which is called an armature is rotated with the help of rotating device called the primemover,due to magnetic field produced by the field magnets an emf is induced in rotor conductors or coils by Faraday's law of electromagnetic induction.When load is connected across the armature or rotor conductors current flows through it.

Basic principle of a motor :

Whenever a good number of conductors or coils connected in series are placed on a cylindrical rotor which is called an armature and current is allowed to flow through the conductors or coils,due to magnetic field produced by the field magnet a torque will be developed on the rotor which will cause the rotor to rotate.

4) What is permanent magnet?
= Answer
The magnet whose strength and polarities are permanently fixed is called permanent magnet.

5) What is electromagnet?
= Answer
The magnet whose strength and polarities are not permanently fixed is called electromagnet.

6) How an electromagnet is formed?
= Answer
A coil is wound on a piece of magnetic material and connecting a source of supply across the coil .When current flows through the coil,lines of forces are established.

7) How will you defined north pole and south pole of a magnet?
= Answer
The north pole is one from where the lines of force come out of the magnet body,whereas the south pole is one where the lines of force enter the magnet body.

8) In which parameter strength of an electromagnet is depend?
= Answer
The strength of an electromagnet is proportional to the total ampere turn provided on the magnet.

Ampere-turn = NI

Where,

N = Number of turns

I = Current flowing through the coil

As N remaining constant,the strength f an electromagnet will be proportional to the magnitude of current flowing through its coil.

9) What do ou mean by reluctance?

= Answer

Reluctance is the property of a material by virtue of which it opposes the establishment of magnetic flux through it.

10) Calculate torque due to nonalignment of two magnetic fields.

= Answer

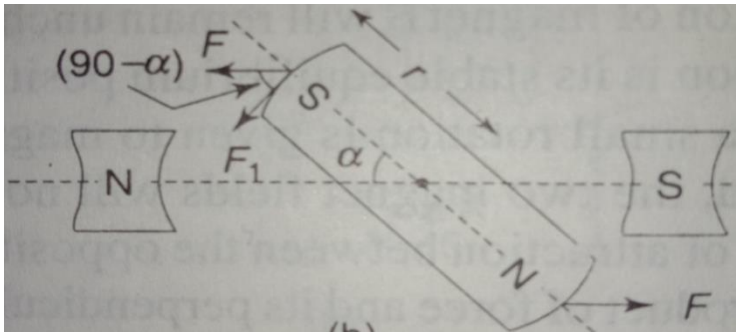


Fig.Torque due to nonalignment of two magnetic fields.

Cos(90 – α) = $\frac{F_1}{F}$

=>F_1 = Fcos(90 – α)

$\therefore F_1$ = Fsinα

Torque,

T = Force × Perpendicular distance from the centre of rotation

= F_1 × r

= Fsinα × r

= Frsinα

Total torque due to two pairs of poles,

T = 2Frsinα

= Flsinα

Where,

F = Force between two opposite poles.

α = angle between the axis of the two magnetic fields.

F_1 = Perpendicular component of F.

l = Length of the magnet.

As l constant so,

T ∝ Fsinα

Therefore torque depends upon the force between two opposite poles which in turn depends upon the strength of the magnetic poles and sinα.

11) Calculate the force when a current carrying conductor placed in a magnetic field.

= Answer

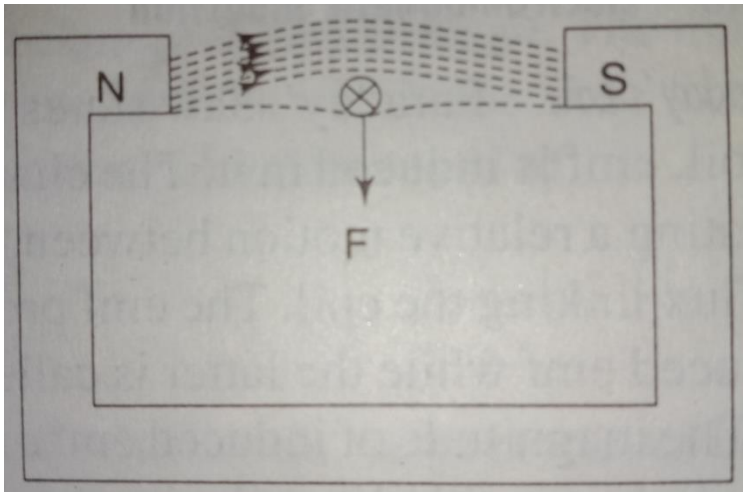


Fig . Force on a current-carrying conductor placed in a magnetic field.

There is an interaction of the two magnetic fields the main field and the field produced by the current carrying conductor.

This interaction results in a force on the conductor which is given by,

$$F = Bil$$

Where,

B = Flux density.

i = current in the conductor

l = Effective length of the conductor placed in the magnetic field.

12) Calculate torque when a current carrying conductor placed in a magnetic field.

= Answer

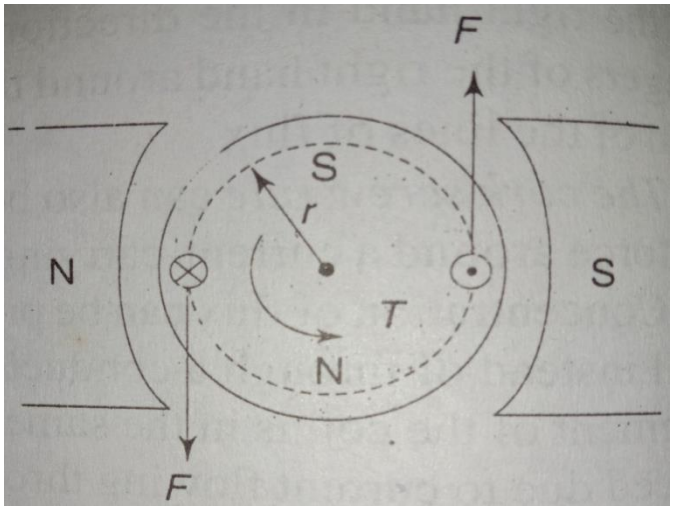


Fig. Force on a current carrying coil placed in a magnetic field.

The net result is a torque which causes rotation.

Torque is given by,

$$T = \text{Force} \times \text{Perpendicular distance}$$

$$= F \times r$$

$= Bil \times r$

$= Bilr$

Where,

B = Flux density.

i = Current in the conductor.

l = Effective length of the conductor.

r = Effective radious of the core.

Total torque,

$T = 2Bilr$

If the coil contains N turns then,

$T = 2BilrN$

$= 2(\frac{\emptyset}{A})ilrN$

Where,

$\emptyset$ = Flux

A = Area of the coil.

$T = \frac{2\emptyset lirN}{A}$

$= (\frac{2lrN}{A})\emptyset i$

$= K\emptyset i$

Where,

$K = \frac{2lrN}{A}$

= Constant

13) State Faraday's law of electromagnetic induction.

= Answer

Whenever a conductors or coils placed in a magnetic field and if there is change in flux linkage with a coil,emf is induced in it.

Mathematically,

$e = \frac{-d(N\emptyset)}{dt}$

$= -N\frac{d\emptyset}{dt}$

'-ve' sign due to Lenz's law.

14) What is dynamically and statically induced emf?

= Answer

When change in flux linkages can be produced by creating a relative motion between the coil and flux is called dynamically induced emf.

When change in flux linkages can be produced by changing the magnitude of flux linking the coil is called statically induced emf.

15) State Lenz's law.

= Answer

Whenever a conductors or coils placed in a magnetic field and if there is change in flux linkage with a coil,emf is induced in coil.When the circuit is closed a current flows through the coil and it sets up flux lines in a opposite to those of the main magnet,thus opposing the increase in flux linkage.

16) Calculate induced emf in a conductor when rotated in a magnetic field.

= Answer

The magnitude of induced mf in a conductor when rotated in a magnetic field is given by –

$$e = Blv$$

Where,

B = Fulux density of the magnetic field,wb/m^2.

l = length of the conductor,m.

v = velocity f the conductor perpendicular to the field,m/s.

Since there are two coil-sides in a coil,

$$e = 2Blv$$

If the coil has N turns,

$$e = 2NBlv$$

As the coil-sides does not always cut the lines of force in a perpendicular direction,

$$e = 2NBlv\sin\theta$$

Where,

θ = Angle between the direction of coil velocity and the direction of the lines of force.

17) State elementary concept of an electrical generator.

= Answer

Consider a coil being rotated in a magnetic field.An emf will be induced in the coil due to the change of flux linked by the coil.If the coil ends are connected to an external resistor R_L,a current i will flow.

The torque developed by the current carrying coil is the electromagnetic torque T_e,which will act in a direction opposite to the applied mechanical torque T_m.Applied mechanical torque T_m will then be utilized in overcoming the frictional orque T_f and T_e.

$$T_m = T_e + T_f$$

$$\Rightarrow T_m = T_e \ [T_f = 0]$$

$$\therefore T_m = T_e$$

Current through the coil,

$$i = \frac{e}{R_L + r} \text{ ------ (i)}$$

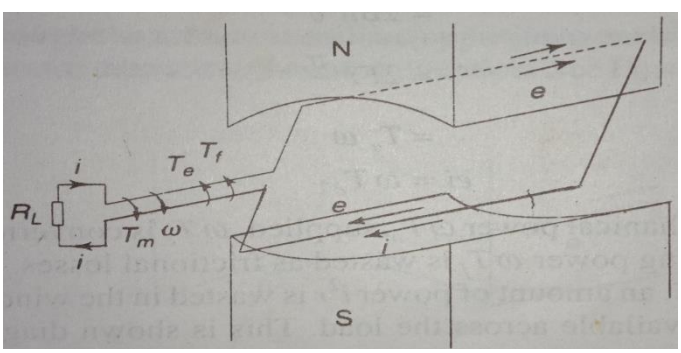


Fig. An elementary generator

Where,

r = Resistance of the coil.

R_L = Load resistance

From (i),

$$e = iR_L + ir$$

$$\Rightarrow ei = i^2R_L + i^2r$$

$$\therefore ei = vi + i^2r \ [\ v = iR_L\ ]$$

Electrical power developed = Electrical power used in the electrical load + Power lost in the resistance of the coil.

18) State elementary concept of an electrical motor.
= Answer
Consider a coil is placed in a magnetic field.If the coil ends are connected to a power supply a current flowing through the armature coil will produce a torque on the coil which will cause coil to turn.

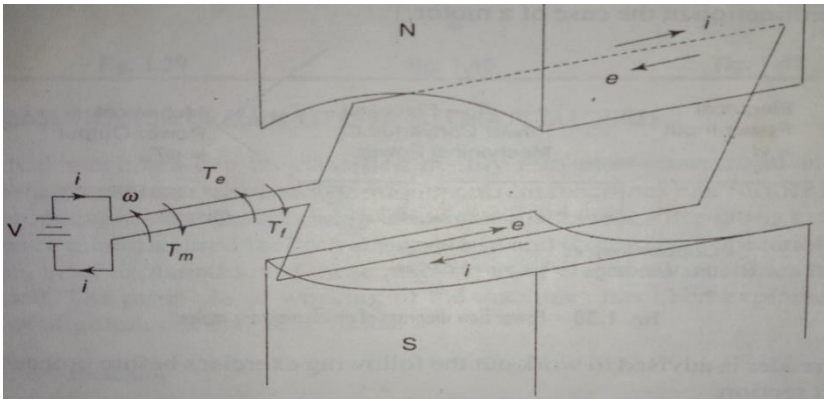


Fig. An elementary motor

Applying KVL,

V – e = ir

=>V = e + ir

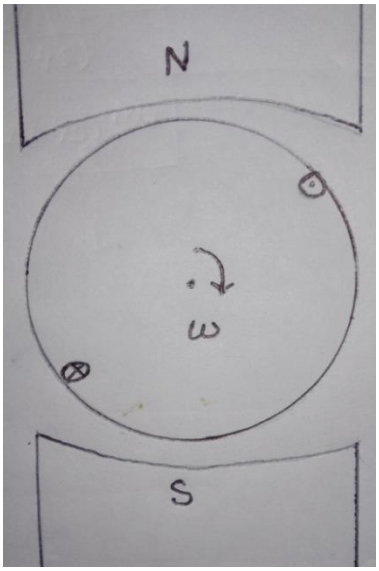
∴Vi = ei + i^2r

Power supplied = Electrical power being available for conversion to mechanical power + Copper oss.

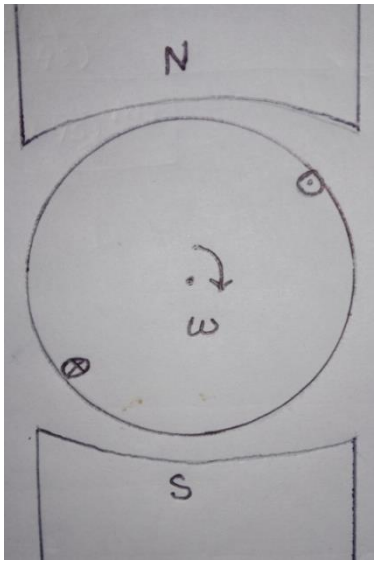
∴ $T_e = T_m + T_f$

19) What are the basic differences between a generator and a motor?
= Answer
(i) In generator the directions of e and i are the same,where as in motor they are opposite.
(ii) In generator rotational and electromagnetic torque are in the opposite directions,where as they are in the same direction in motor.

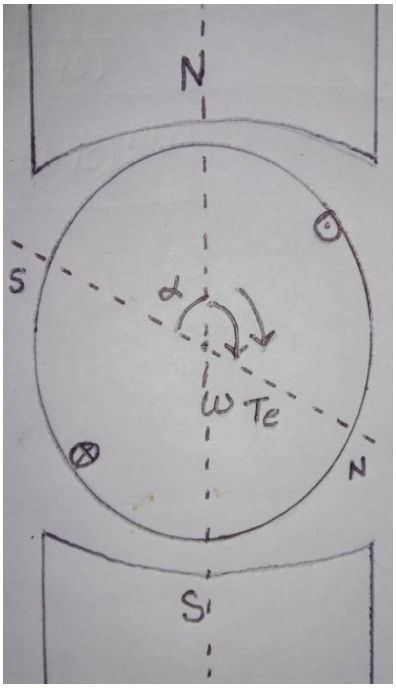
20) Figure given below shows the cross sectional view of a rectangular coil rotating in a magnetic field.The direction of rotation of the coil and the direction of current in the coil sides are shown
(a) Determine the direction of induced emf in the coil sides.
(b) Show the direction of electromagnetic torque developed and also the torque angle.
(c) Show the direction of frictional torque.
(d) Write the relationship for mechanical,frictional and electromagnetic torques.



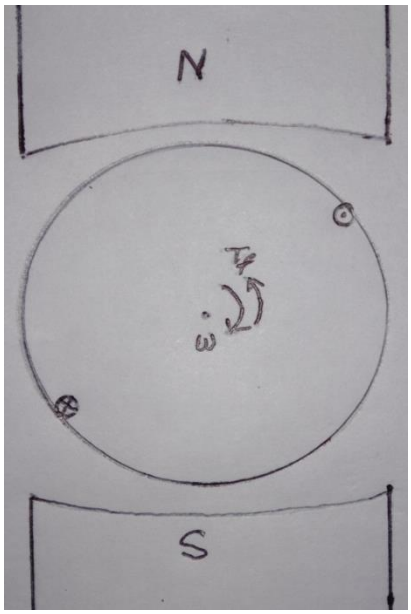
= Answer
(a)



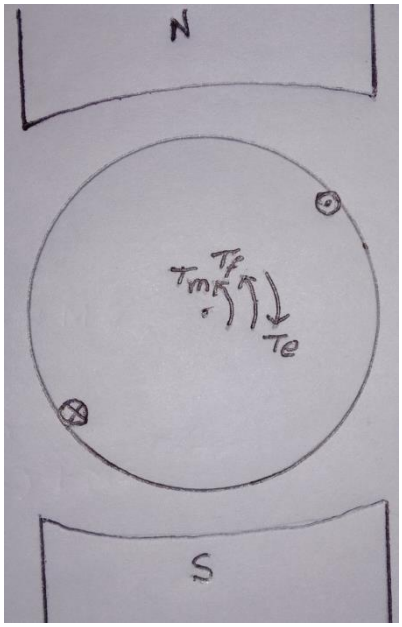
There is no prime mover so it is a motor.
(b)



(c)

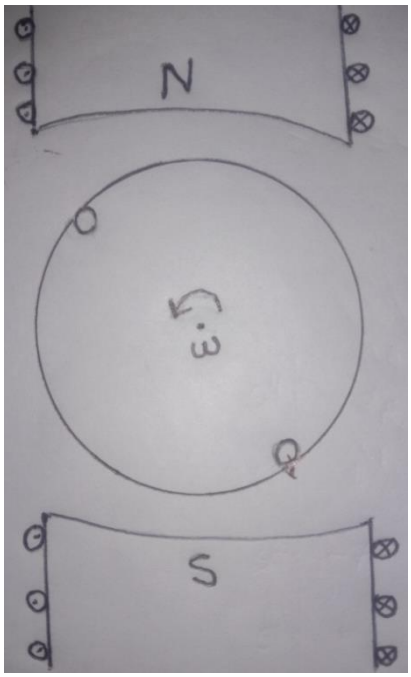


(d)



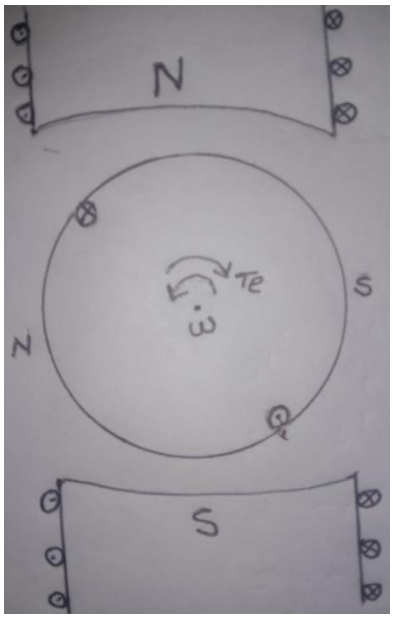
$T_e = T_m + T_f$

21) Figure given below shows the cross sectional view of a rectangular coil placed in a magnetic field created by electromagnets.The coil is rotated in anticlock wise direction.Show the direction of emf induced in the coil and also the direction of electromagnetic torque developed on the rotor when the coil is connected across a load resistance.



= Answer

Since coil is connected across a load resistance so it is a gene



22) State classification of main types of electrical machines.
= Answer
(1) Direct current machines
(i) Separately excited dc macines
(ii) Self excited dc machines
(a) Shunt-field conection
(b) Series-field connection
(c) Compound-field connection
(2) Alternating current machines
(i) Induction machines
(ii) Synchronous machines
Alternating current machines are manufactured for both single phase and three phase operations.

23) Filled up the following statement
a) In a dc machines field winding are excited from a ---------
b) The polarity of the magnetic poles in dc machines will depend upon the ----------
c) The armature carries conductors in side ----------
d) Two brushes are placed at ----------
e) The direction of the induced emf in dc machines is found by ----------
f) The direction of induced emf will depend upon the ---------- if the field polarity remains unchanged.
g) The magnitude of T_e will depend on ---------
h) The strength of the field poles and armature fields will depend upon the ----------
= Answer
(a) DC source
(b) Direction of field current
(c) Slots
(d) Right angles to the main field axis
(e) Fleming's right-hand rule

(f) Direction of rotation
(g) The strength of the field oles and also on the strength of the armature field
(h) Current flowing through he field windings and armature windings respectively

24) What happened if the external load on the generator is increased?
= Answer
As,i = $\frac{e}{R_L+r}$
The magnitude of the armature current and hence the strength of the armature field ill increase.This will in turn cause an increase in T_e.As T_e acts in a direction opposite to the applied torque T_a.So,with increase in load more and more torque should be applied to keep the armature rotating at a particular speed.

25) How can you reverse the direction of rotation of the dc machines?
= Answer
Either the direction of current in the field winding or in the armature winding will have to be reverse.

26) How can you supply ac in the rotor circuit?
= Answer
Through slip-rings.

27) What is the relation between electrical and mechanical degrees?
= Answer
1^0 mechanical = $(\frac{P}{2})^0$ electrical
The distance between two adjacent pole is always taken as 180^0 electrical.This is done by 2-pole,4-pole and 6-pole machine
When,

1^0 mech. = $(\frac{2}{2})^0$ elect.= 1^0 elect.
1^0 mech. = $(\frac{4}{2})^0$ elect. = 2^0 elect.
1^0 mech. = $(\frac{6}{})^0$ elect. = 3^0 elect.

So,
180^0 mech. = 180^0 elect.
90^0 mech. = 180^0 elect.
60^0 mech. = 180^0 elect.

28) What is polyphase winding?
= Answer
If the number of phases are more than one,it is called a polyphase winding.

29) Define Screw rule.
= Answer
The cork Screw rule can be applied to determine the direction of the lines of force around a current carrying conductor.

30) What do you mean by breath factor and pitch factor?
= Answer

The magnitude of induced emf in a distributed stator or rotor winding is effected by a factor called distribution factor or breath factor (K_d).
The effect of use of short pitch coil on the magnitude of induced emf is expressed by another factor called pitch factor (K_p).

Direct Current Machines

31) What is the material used for pole cores?
= Answer
The pole cores are usually made of a number of steel sheets stacked and riveted together.

32) Filled up the following statements
i) The yoke may be made of ---------
i) The strength of the magnetic field depends upon the ---------
iii) The armature core is separated from the field poles by a ---------- which allows the armature of rotate freely.
iv) The air gap is kept very small to keep the ---------
v) The armature laminations are about --------- thick.
vi) The armature is laminated to reduce ---------
vii) ---------- may not be laminated as they encounter dc flux.
viii) The stator pole shoes should be laminated ---------
ix) To neutralize the effect of armature reaction ---------- poles used.
x) The slots are lined with ---------- insulating material.
xi) The conductor in the slots are secured in their places by ----------
xii) --------- are used for the armature winding.
xiii) The function of the commutator is to ---------
xiv) In case of a dc motor the function of the commutator is to produce a ----------
xv) --------- is provided between the commutator segments.
xvi) Brushes are made of ---------
= Answer
(i) Cast steel or fabricated rolled steel
(ii) Field current
(iii) Small air-gap
(iv) Reluctance to the magnetic circuit low
(v) 0.4-0.6mm
(vi) The eddy current loss in the core
(vii) The stator core,the yoke and the poles
(viii) To reduce the eddy current loss
(ix) Interpoles
(x) Tough
(xi) By hard wooden wedges or fibre glass wedges
(xii) Enamel insulated copper wires
(xiii) Produce a unidirectional torque
(xiv) Unidirectional torque
(xv) Mica insulation
(xvi) Carbon

33) What is the function of compensating winding?
= Answer

The compensating winding is connected in series with the armature winding and neutraluizes the effect of armature reaction.

34) What do you mean by commutation?
= Answer
The conversion of alternating current induced in the armature winding into direct current at the brushes is called commutation.

35) Why aluminium wires are not used in the dc machine?
= Answer
Aluminium wires are not used because the restriction on winding space in slots and a number of other limitations.Such as formation of oxide coating and jointing problems.

36) State characteristics of insulating materials.
= Answer
(i) High dielectric strength at increased temperature.
(ii) Good thermal conductivity to transfer conductor I^2R loss to the surrounding structure and coolant.
(iii) Good mechanical strength.
(iv) Resistance to failure by moisture,vibration abrasion and bending.

37) Give a statement about conductor insulation.
= Answer
For small size machines double-cotton-covered-copper wires are used.for medium size machines the conductors are rectangular in shape.Each conductor is machine-taped with superfine cotton tape,whereas for large size machines each conductor is machine-taped with one layer of 0.2mm thick impregnated cotton tape with half overlap.

38) Write aboput slot insulation.
= Answer
For slot insulation,leatheroid,manila paper or mica folium of appropriate thicknesses are used.

39) What do you mean by back pitch,front pitch,resultant pitch and commutator pitch?
= Answer
Back pitch : Away from the commutator end of the armature is callad the back pitch (Y_b).
Front pitch : The distance between two coil-sides connected to the same commutator segment is called the front pitch (Y_f).
Resultant pitch : The distance between the start of one coil and the start of the next coil is called resultant pitch (Y_R).
Commutator pitch : The distance between the two commutator segments is called commutator pitch (Y_C).

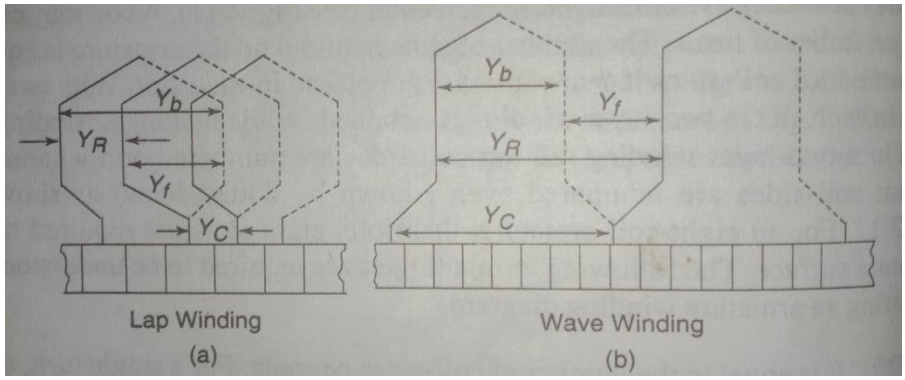


Fig.Shows back pitch (Y_b),front pitch (Y_f),resultant pitch (Y_R) and commutator pitch (Y_C) in (a) lap winding (b) wave winding

40) What is dummy coils?
= Answer
In wave winding the number of coil-sides needed to be placed in all the slots may be more than the required number.In such a case,the extra coils are left unconnected.These coils are called dummy coils.Dummy coils are used to make the armature dynamically balanced.They do not contribute to the induced emf or developed torque.

41) Prepare a layout winding diagram for a simplex lap type dc armature winding.The winding is for four poles.The armature has 16 slots and 16 commutator segments.
= Answer
Number of armature coils = Number of commutator segments = 16
Number of coil sides or conductors,

$$Z = 16 \times 2$$
$$= 32$$

Back pitch,

$$Y_b = \frac{Z}{P} \pm 1$$
$$= \frac{32}{4} \pm 1$$
$$= 8 \pm 1$$
$$= 7 \text{ or } 9$$

Again,

$Y_b - Y_f = 2m$
=>$Y_b - Y_f = 2$ [For simplex winding m = 1]
=>$9 - Y_f = 2$ [Taken,$Y_b = 9$]
$\therefore Y_f = 7$ and $Y_b = 9$

Since,$Y_b > Y_f$ the winding is a progressive one i.e. it progresses from left to right.
Coil side 1 is connected to coil side 10 ($1 + Y_b = 1 + 9 = 10$) on the other side of commutator and coil side 10 is connected to coil side 3 ($10 - Y_f = 10 - 7 = 3$) on the commutator end.
Again,coil side 3 is connected to coil side 12 ($3 + Y_b = 3 + 9 = 12$) on the other side of the commutator and coil side 12 is connected to coil side 5 ($12 - Y_f = 12 - 7 = 5$) on the commutator end and so on.

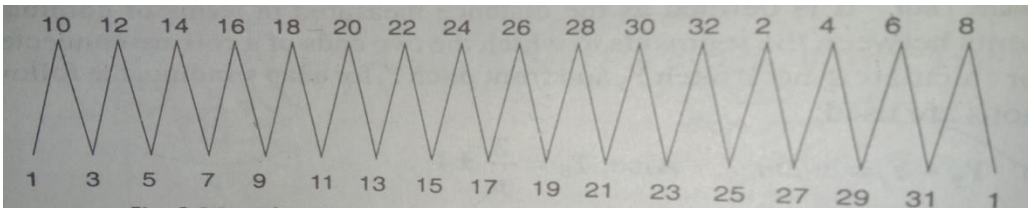


Fig.Scheme for connections of the coil-sides of a dc armature windings

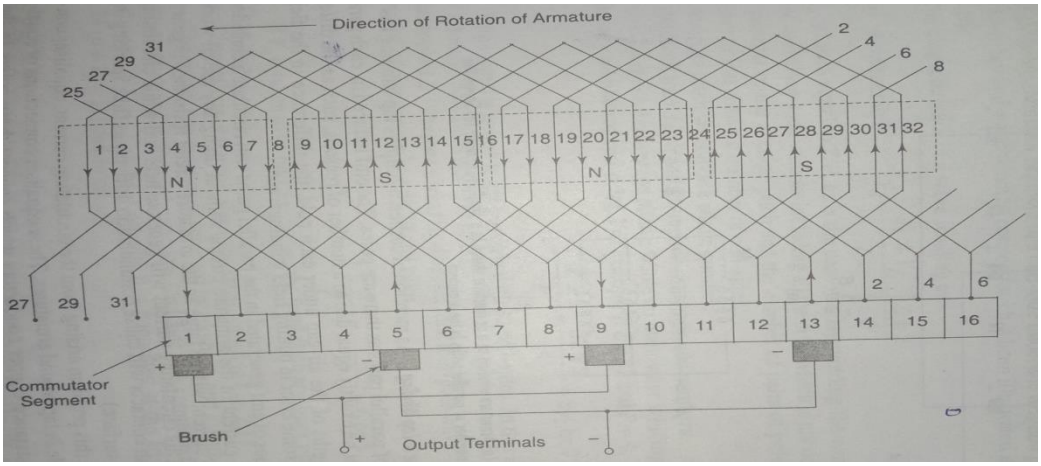


Fig.Layout diagram for a lap winding

42) What is the function of equiliser connections?
= Answer
The emf induced in each parallel path may not be exactly equal due to the difference in the lengths of the air gap under each pole,the difference in the field strength.Unequal values of emf generated in the parallel paths will circulate a considerable amount of current in the armature circuit without doing any useful work.This circulating current is large as armature circuit resistance is very low.This circulating current will generate heat and while circulating through the brush contacts will cause commutator sparking.

To overcome this problem arising from the circulating current,equiliser connections are made in lap wound armatures.These equiliser connections or equilisers are low resistance copper conductors which connect those points in the winding which under ideal conditions should be at equal potential.

43) State factors determining induced emf.
= Answer
If B is the average flux density over the pole pitch,then the average emf induced in one conductoris given by,

e/conductor = Blωr V

where,

ω = Angular velocity of the armature
r = Radious of the armature
l = length of the pole

A number of parallel path contains Z number of conductor

∴1 number of parallel path contains $\frac{Z}{A}$ number of conductor

Total induced emf,

$$E = \frac{Z}{A} Bl\omega r$$

Again,

$$B = \frac{\emptyset}{A}$$

Where,

$$A = \frac{2\pi rl}{P}$$

$\emptyset$ = Flux in wb/pole

$$\therefore E = \frac{\emptyset}{A} l\omega r . \frac{Z}{A}$$

$$=> E = \frac{\emptyset}{2\pi rl/p} \times \frac{l\omega rZ}{A}$$

$$=> E = \frac{P\emptyset}{2\pi rl} \times \frac{lrZ \times 2\pi N}{60A}$$

$$=> E = \frac{(\emptyset ZNP) \times 2\pi rl}{60A \times 2\pi rl}$$

$$\therefore E = \frac{\emptyset ZNP}{60A}$$

E will be increase when speed as well as field strength are increased.

44) State factors determining electromagnetic torque.

= Answer

Generating action : A single turn coil placed on the rotor is rotated by an external applied torque or by a primemover T (Nm) at constant velocity ω (rad/s) in a magnetic field of constant flux density b (tesla).

Applied torque,

$$P_m = T\omega \text{ Nm/S -------- (i)}$$

Emf induced in both the coil sides,

$$E = 2Bl\omega r \text{ V}$$

Where,

l = Length of the conductor

r = Radious of the core

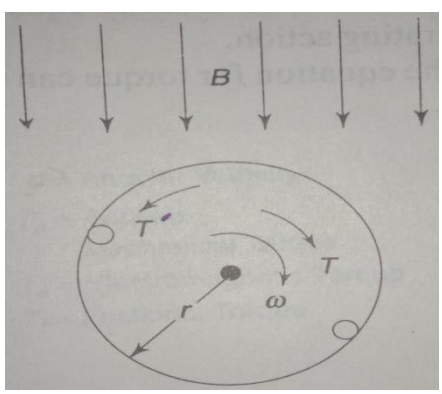


Fig. Electromagnetic torque developed in a dc machine

When the coil ends are connected across a resistive load R,a current i will flow through to the coil.

$$i = \frac{e}{R}$$

From Newton's third law we know that every force has an equal and opposite force.Therefore T must be counter balanced by an equal torque $T^{/}$. $T^{/}$ is due to a force exerted on the two sides of the coil by the current flowing in the coil while it rotates through the magnetic field.

$T^{/}$ = 2Fr

= 2Bilr

Since,

T = $T^{/}$ = 2Bilr

From (i),

P_m = Tω

= 2Bilrω

= ei

Therefore in a generator mechanical power is converted into electrical power through the magnetic field.

Motoring action : A single turn coil placed on the rotor is connected across a voltage source 'V' capable of supplying a current 'i' A.

Electrical power supplied to the machine is –

P_e = Vi = ei watts.

If the resulting speed of the rotor is constant ω (rad/s) and the torque is T (Nm) then,

P_e = ei

= 2Blωri

= 2(Bil)ωr

= 2Fωr

= Tω

= P_m

Therefore in a motor electrical energy is converted into mechanical energy.

It is observed that the equation Tω = ei holds good for both motoring and generating action.

Tω = ei

=>T = $\frac{ei}{\omega}$

=>T = $\frac{\emptyset ZNP}{60A} \times \frac{i}{\frac{2\pi N}{60}}$

=>T = $\frac{\emptyset ZNP}{60A} \times \frac{60 \times i}{2\pi \times N}$

=>T = $\frac{\emptyset ZPi}{2\pi A}$

=>T = $(\frac{ZP}{2\pi A})\emptyset$i

=>T = $K_t\emptyset$i [K_t = $\frac{ZP}{2\pi A}$]

∴T = $K_t\emptyset$i

45) State principles of generating and motoring actions and relationship between terminal voltage and induced emf.

= Answer

Generating action : In a dc generator mechanical energy is converted into electrical energy.This electrical energy is utilised to the electrical load.

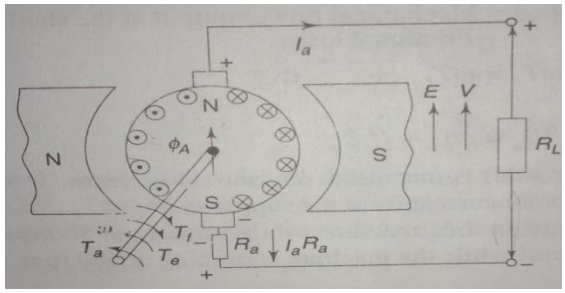


Fig. Generating

Where,

T_e = Electromagnetic torque

T_a = Applied mechanical torque

T_f = Frictional torque

ω = Angular velocity

Again,

E – I_aR_a = V

∴E = V + I_aR_a

In generating E>V.

EI_a = VI_a + ${I_a}^2R_a$

i.e. mechanicalpower input = electrical power developed + electrical power loss in the armature circuit.

We know,

T_a = T_e + T_f

=>ωT_a = ωT_e + ωT_f

=> ωT_a = ωT_e [ωT_f<<]

∴ ωT_a = ωT_e

If the load R_a increases, I_a increases.Since, ωT_e = EI_a so ωT_e also increases.Again ωT_a = ωT_e i.e. ωT_a should also increase.

Motoring action : In a dc motor electrical energy is converted into mechanical energy.This mechanical energy is utilised to drive some mechanical load connected to the shaft of the motor.

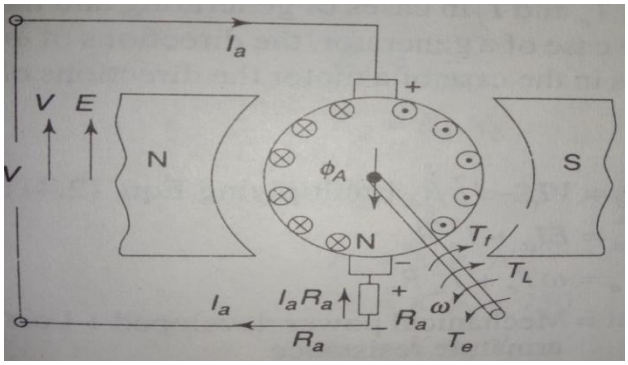


Fig. Motoring

V - I_aR_a = E

=>V = E +I_aR_a

=>VI_a = EI_a + ${I_a}^2R_a$

=> VI_a = ωT_e + ${I_a}^2R_a$ ---------- (i)

i.e.Electrical power input = Mechanical power developed + electrical power lost n the armature circuit.

We know,

$T_e = T_L + T_f$

=>$\omega T_e = \omega T_L + \omega T_f$

=>$\omega T_e = \omega T_L$ [ωT_f<<]

From (i),

$VI_a = \omega T_L + I_a{}^2 R_a$

If the load torque T_L increases, VI_a should increase.V being constant,therefore motor will draw more current from the supply mains.

46) On which parameters speed ofa dc motor depends.

= Answer

Emf equation for a dc motor is given by –

E = KØN

Again,

E = V - $I_a R_a$

=>KØN = V - $I_a R_a$

∴N = $\frac{V - I_a R_a}{K\emptyset}$

Therefore speed of a dc motor depends on

(i) Applied voltage

(ii) Field flux

(iii) Drop in the armature circuit resistance

Different methods of speed control of a dc motor are

(i) control of speed by varying the applied voltage

(ii) control of speed by varying the field flux

(iii) control of speed by adding extra resistance in the armature circuit

47) Write uses of permanent magnets.Write its advantages and disadvantages.

= Answer

Permanent magnet used in small size machines like oys,battery operated cassette recorders,techogenerators,dynamos in motorcycles etc.

Advantage : (i) Compact.

(ii) No field winding.

(iii) No field copper-losses.

Disadvantage : (i) Low flux.

(ii) Flux density deterioration of the magnet with time.

48) State separately excited dc machines.

= Answer

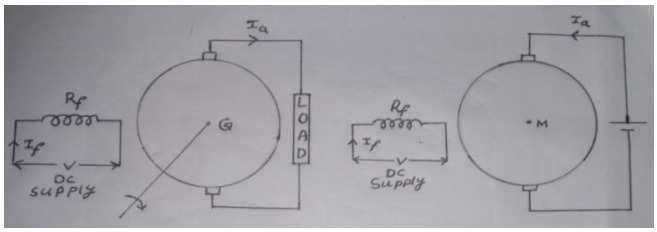


Fig.Separately excited dc generator

Fig. Separately excited dc motor

In separately excited dc motor and generator current flowing through the field winding is independent of the load.Both the cases $\emptyset \propto I_f$.

49) State dc machines with shunt field connection.
= Answer
In dc shunt machines field winding is connected in parallel with the armature.
In dc shunt generator the field winding is connected across the armature terminals.In dc shunt motor the field winding and armature are connected across a dc supply and $\emptyset \propto I_f I_a$.

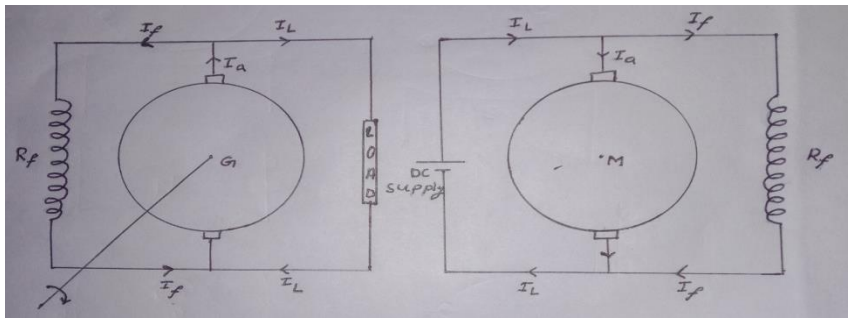


Fig. dc shunt generator Fig. dc shunt motor

50) State dc series machines.
= Answer
In dc series machines field winding is connected in series with the armature.The field winding is made up of thick winding wires such that the armature current can flow through the wires without overheating and $\emptyset \propto I_a$.

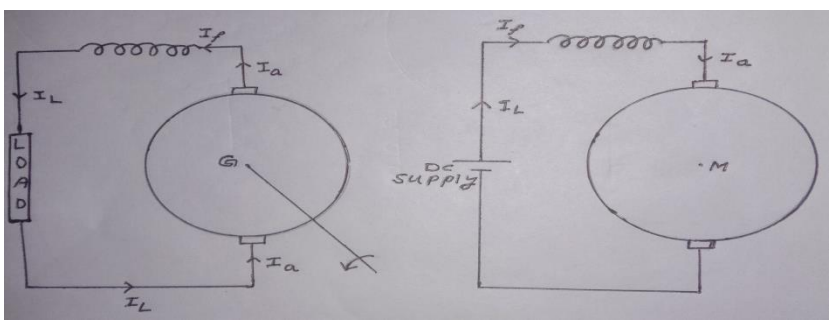


Fig. Connection diagram for dc series generator and motor

51) State dc compound machines.
= Answer
In dc compound machines there are two field winding namely a shunt field winding and a series field winding.The shunt field winding is connected in parallel with the armature and the series field winding is connected in series with the combinations.The resistance of a series winding is small and the resistance of a shunt winding is large.

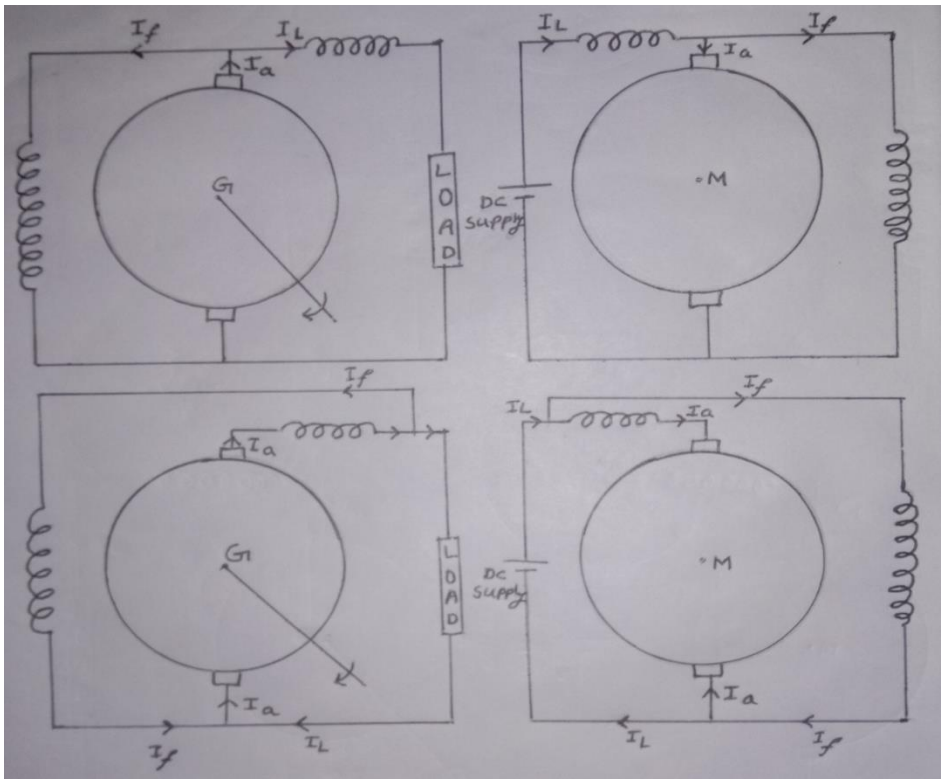


Fig. Connection diagrams of dc compound generator and motor

Shunt winding can be connected in two ways

(a) Across the armature winding is called a short shunt connection.

(b) Across both the armature and series winding is called a long shunt connection.

The series field winding flux can act either in the same direction or in opposition to shunt field flux,depending on the direction in which the series field is wound with respect to the shunt field.

When the series field flux helps the shunt field flux,the connection is called cumulative compound.

When the series field flux opposes the shunt field flux,the connection is called differential compound.

In practice cumulative compound connection is more commonly used.$\emptyset = K_1 I_f \pm K_2 I_a$.

52) Explain dc shunt motor characteristics.

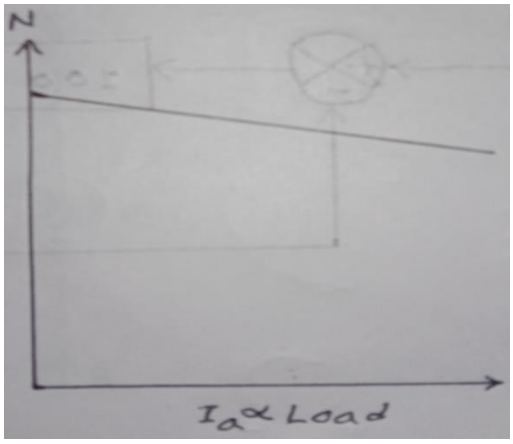
= Answer

(i) Speed-armature current :

We know,

$$N = \frac{V - I_a R_a}{K\emptyset}$$

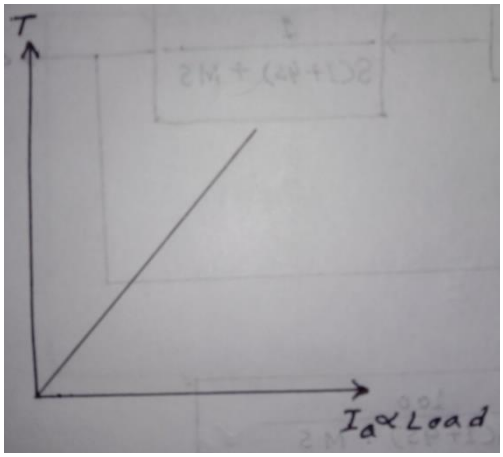
Taking V constant so flux (Ø) produced by the field current (I_f) will be constant.In practice the air gap flux is slightly ereduced due to the effect of the armature reaction.When I_a increases N decreases.The variation of speed of the shunt motor from no load to full load can be made by inserting an extra resistance in the field circuit.



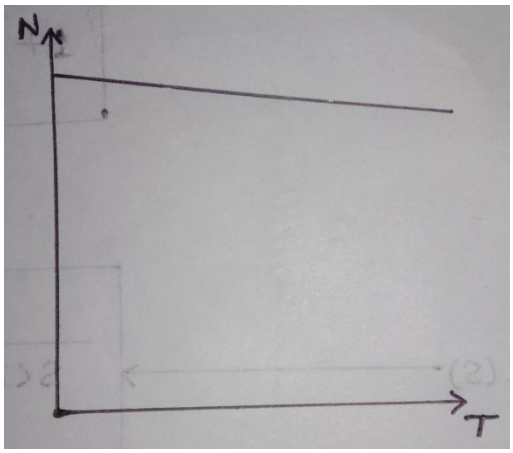
(ii) Torque-armature current :
We know,

$$T = K\emptyset I_a$$

Taking Ø constant so T constant so T ∝ I_a



(iii) Speed-torque :



Uses : Driving of line shafts,lathes,conveyors etc.

53) Explain dc series motor characteristics.
= Answer
(i) Speed-armature current :
We know,

$$N = \frac{V - I_a R_a}{K\emptyset}$$

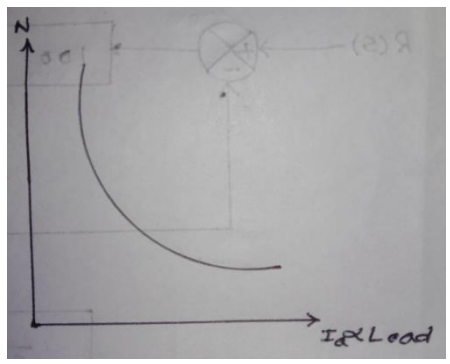
In series motor,

$$\emptyset \propto I_a$$

So,

$$N = \frac{V - I_a R_a}{K I_a}$$

Taking V constant so $N \propto \frac{1}{I_a}$



At low load speed is very high which may damage the motor.For this reason series motors are never started on no load.The load on the series motor is connected through gears and not through a belt pulley arrangement.
(ii) Torque-armature current :
We know,

$$T = K\emptyset I_a$$

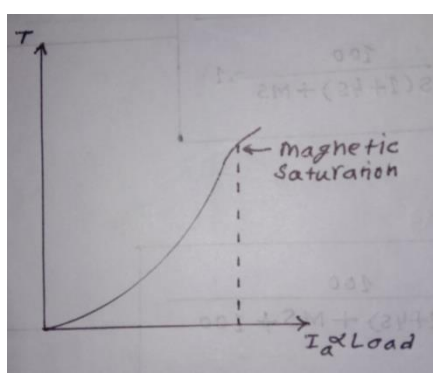
In series motor,

$$\emptyset \propto I_a$$

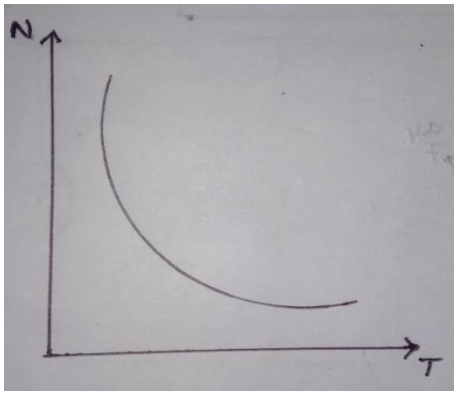
So,

$$T = K I^2{}_a$$

Therefore when series motor started on no load develops a very high starting torque and due to saturation of the magnetic core,beyond a certain magnitude of I_a,the increase in flux is very negligible.



(iii) Speed-torque :



Uses : Electric trains,hoists,trolleys.

54) Explain dc compound motor characteristics.
= Answer
(i) Speed-armature current :
We know,

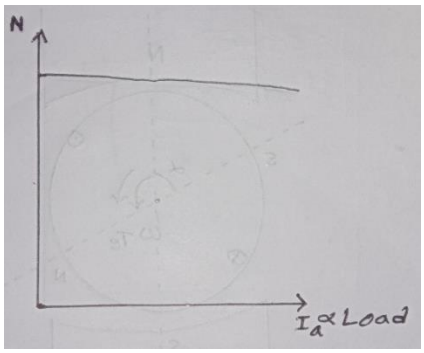
$$N = \frac{V - I_a R_a}{K\emptyset}$$

Again,

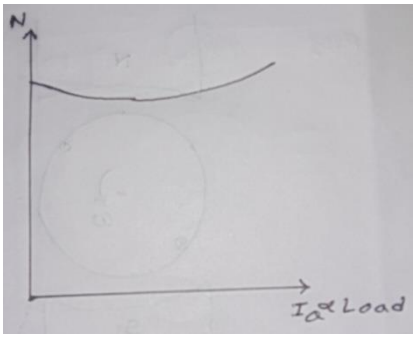
$$\emptyset = K_1 I_f \pm K_2 I_a$$

$$\therefore N = \frac{V - I_a R_a}{K_1 I_f \pm K_2 I_a}$$

In cumulative compound motor speed $\propto \frac{1}{(K_1 I_f + K_2 I_a)}$



In differential compound motor N$\propto \frac{1}{(K_1 I_f - K_2 I_a)}$



(ii) Torque-armature current :
We know,

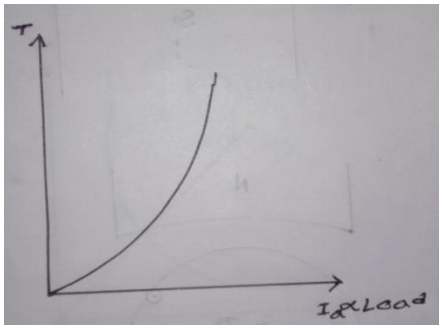
T = K$\emptyset I_a$

Again,

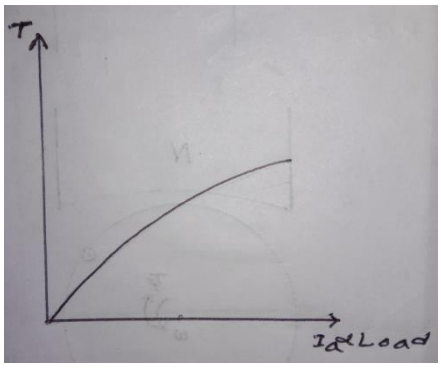
Q = $K_1 I_f \pm K_2 I_a$

$\therefore$ N = K$I_a(K_1 I_f \pm K_2 I_a)$

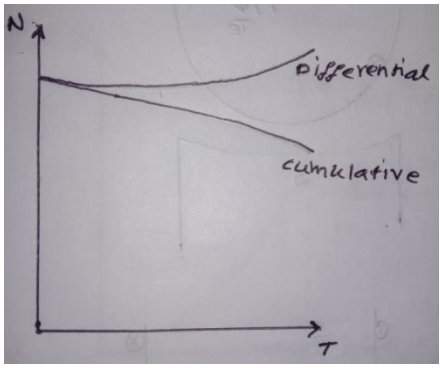
In cumulative compound motor T$\propto I_a(K_1 I_f + K_2 I_a)$



In differential compound motor T$\propto I_a(K_1 I_f - K_2 I_a)$



(iii) Speed-torque :



55) Why starter is necessary when dc motor starts up?
= Answer

At the starting there is no induced emf i.e. E = 0.As $I_a = \frac{V-E}{R_a}$ so,$I_a = \frac{V}{R_a}$.As the R_a is very small I_a becomes large.Due to this armature will draw much more current than its rated current.This may cause damage the armature winding.

56) Describe different types of dc motor starters.
= Answer
(i) Two point starter :

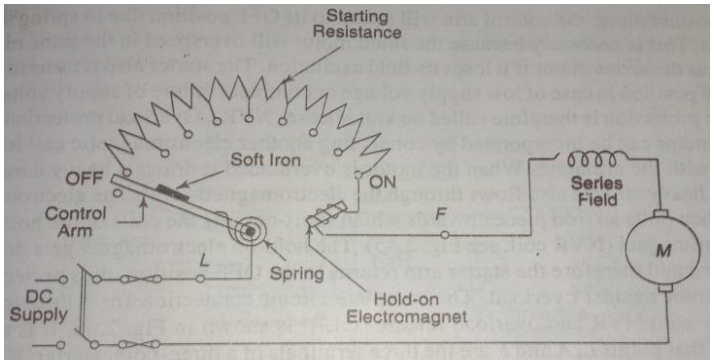


Fig. Two point starter for a dc series motor.

A two point stater is used for starting a dc series motor,which has the problem of overspeeding due to the loss of load from its shaft.
When load losses from its shaft motor speed increases and due to this emf also increases as E = KØN.So current $I_a = \frac{V-E}{R_a}$ decreases and hence strength of the electromagnet also decreases and control arm returns to the OFF position,thus motor speed decreases.
(ii) Three point starter :

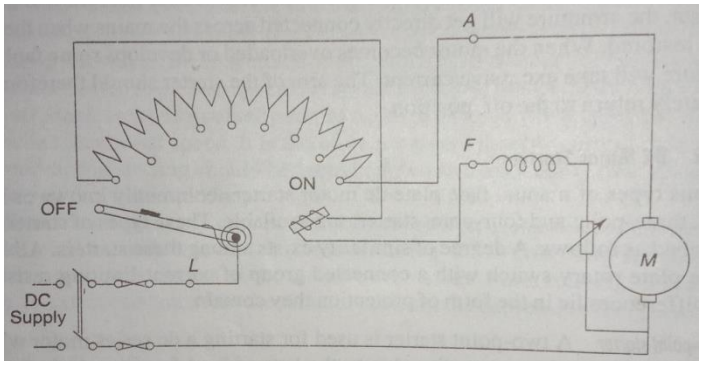


Fig. Three point starter for a dc shunt or compound motor.

A three point starter is used for starting a dc shunt or compound motor.
In shunt motor E = Ki_fN i.e. N = $\frac{E}{Ki_f}$.If i_f decreases N increases,so strength of the electromagnet also decreases as the electromagnet is connected in series with the shunt field coil and control arm return to the OFF position.
In low supply voltage or complete failure of supply voltage the strength of the electromagnet decreases and control arm return to the OFF position.This protection is called no volt release (NVR).

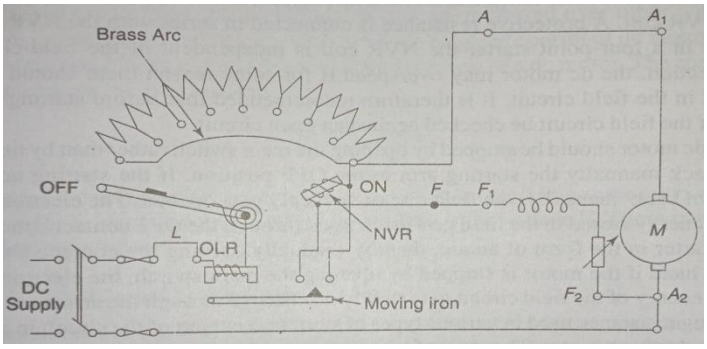


Fig. Three point starter with NVR and OLR arrangement.

When the motor is over loaded,speed decreases and hence emf will be decreases as E = KØN.Again I_a = $\frac{V-E}{R}$ so I_a increases and strength of the electromagnet of OLR also increases and it upwards an iron piece which short circuit the electromagnet of NVR and it get de-energised.Therefore the starter arm return to the OFF position,thus protecting the motor against overload.

A three point starter is not suitable where a large field current adjustment by using field regulator is needed.

(iii) Four point starter :

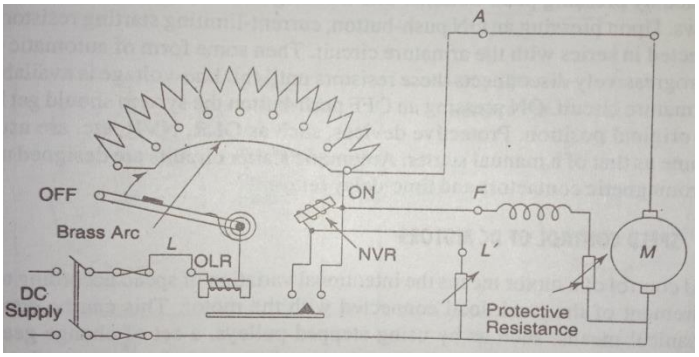


Fig. A four point starter with NVR and OLR arrangement.

The disadvantage of three-point starter is overcome by using four point starter by connecting a resistance in series with the shunt field circuit.

A dc motor should be stopped by opening the main switch not by throwing back manually the starting arm to the OFF position.If the starting arm is thrown back manually,the field circuit suddenly gets opened.The electromagnetic energy stored in the field gets discharged through the OFF contact button of the starter in the form of an arc and gradually burning the contact.On the other hand if the motor is stoped by opening the main switch,the electromagnetic energy of the field circuit slowly discharged through the armature.

Also drum-rotary-switch starter is able to handle a large current and it is suitable for motors with high ratings.

57) What do you mean by armature reaction?

= Answer

In general GNA (geometrical neutral axis)and MNA (Magnetic neutral axis) are in same line when generator or motor is unloaded.But when generator or motor is loaded MNA is shifted.This may cause armature reaction.

The effect of armature flux on the main field flux is called armature reaction.

The angle of shift of MNA will depend upon the magnitude of armature current or load on the machine.

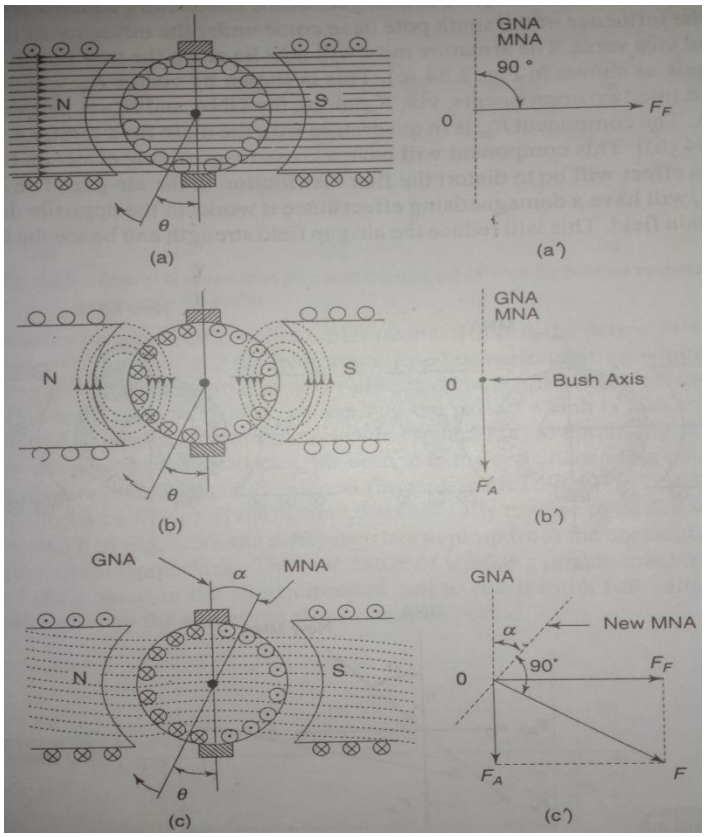


Fig. (a) Flux distribution due to field (b) Flux distribution due to armature (c) Armature reaction (a') (b') and (c') are the vectorial representations of flux density distribution due to field current,armature current and combined effect of field and armature current respectively.
Shifting of the brush axis may solve this problem,but in practice it is not possible.

58) What is commutation?
= Answer
The process by which current in a armature coil is reversed during the period in which it passes under the brushes is called commutation.

59) Explain-method of neutralising effect of armature reaction for better commutation.
= Answer
(i) Use of high brush contact resistance :
By using high brush contact resistance.
(ii) Shifting of brushes :
By shifting the brushes to the new MNA.This may achieve by shifting brushes in the forward direction in generator and backward in a motor.But it is difficult to arrange.
(iii) Use of commutating poles :
Flux produced by commutating or compole or interpole is reverse to the flux produced by armature.Compole is connected in series with the armature winding.
(iv) Use of compensating winding :
Flux produced by the compensating winding is opposite to the flux produced by the armature.Compensating windings are connected in series with the armature winding and they are placed in slots made on the main pole.

60) Describe different types of losses in a dc machines.
= Answer
(i) I^2R loss in the armature winding :

This loss varies with the variation of load on the machine and hence it is called variable loss.It varies as the square of the load current.The resistance of the armature winding can be measured by the ammeter-voltmeter method.

(ii) Iron loss in the armature winding :

Iron loss consists of hysteresis loss and eddy current loss.

The hysteresis loss is due to alternate magnetisation of atoms,forming domain in the magnetic material of the core.Each domain behaves as a tiny magnet.As the flux changes its direction when the rotor rotates,these tiny magnets rotate to and fro.Power is wasted due to this movement and develops heat in the armature core.This is called hysteresis loss.

Hysteresis loss = K${B^{1.6}}_m$fV_c Watts

Where,

K = Constant depends upon the core material.
B_m = Maximum flux density.
f = Frequency of flux.
V_c = Volume of the core.

When the armature core rotates in the magnetic field,emf is induced in the core and produces a circulating current in the core material.These are called eddy currents and they produce power loss in the resistance of all the magnetic parts.

Eddy current loss = K${B^2}_m f^2 t^2 V_c$ Watts.

Where,

T = Thickness of the core laminations.

Eddy current loss also takes place in the pole cores due to flux pulsation.

(iii) Losses in the field windings :

Losses in the shunt field is expressed as the product of the field current and terminal voltage.Losses in the series field,interpoles and compensating windings are proportional to the square of the armature current.

(iv) Frictional losses :

These losses are bearing friction loss,brush friction loss and windage friction loss.

Windage friction loss$\propto speed^3$
Brush friction loss$\propto$speed
Bearing friction loss$\propto$speed.

61) Determine efficiency of a dc machines.
= Answer
In case of a generator,

$$\eta = \frac{Output}{Input}$$
$$= \frac{Output}{Output+Losses}$$
$$= \frac{VI_a}{VI_a+{I^2}_a+VI_f+c}$$

η will be maximum when denomination is minimum.To determine the condition for which the denominator is minimum differentiate it with respect to the variable quantity $I_{a.}$

$$\frac{d}{dI_a}(V+I_aR_a+\frac{VI_f+c}{I_a}) = 0$$

$=> R_a - \frac{(VI_f + c)}{I^2{}_a} = 0$

$=> I_a{}^2 R_a - (VI_f + c) = 0$

$\therefore I_a{}^2 R_a = VI_f + c$

Variable loss = Constant loss.

In case of a motor,

$$\eta = \frac{Output}{Input}$$

$$= \frac{Input - Losses}{Input}$$

$$= \frac{VI_a - I^2{}_a R_a - VI_f - c}{VI_a}$$

$$= 1 - \left(\frac{I_a{}^2 R_a + VI_f + c}{VI_f}\right)$$

η will be maximum when $\left(\frac{I_a{}^2 R_a + VI_f + c}{VI_f}\right) = 0$

$$\frac{I_a{}^2 R_a + VI_f + c}{VI_f} = 0$$

$=> I^2{}_a R_a + VI_f + c = 0$

$=> I^2{}_a R_a = -(VI_f + c)$

$\therefore I^2{}_a R_a = (VI_f + c)$

62) Write applications of dc machines.

= Answer

DC generators :

Direct current is widely used for electrolytic processes,for variable speed motor drives and welding processes.Earlier generators are used but now a days static rectifiers are used.

DC motors :

For variable dspeed control and where severe torque variations occur,dc motors are widely used.In recent years variable frequency ac drives are slowly replacing by dc drives.

(i) DC shunt motors :

It is used where the speed has to be maintained constant between no-load to full-load.Such as line shafting and driving a lathe.

(ii) DC series motors :

It is used where large starting torque is required such as hoists,cranes,trains etc.

(iii) DC compound motors :

It is used where large starting torque is required but it is not overspeeding even when load falls.

63) What do you mean by armature?

= Answer

Whenever a good number of conductors or coils are connected in series are placed on a cylindrical rotor is called the armature.

64) Explain maintenance of a dc machines.

= Answer

Proper maintenance improves the performance and life of a machine.In a dc machine the commutator and brushes should be regularly checked.Powdered carbon particles appearing on the commutator surface should be regularly cleaned.Periodic greasing will increase the life of a bearing and give trouble

free service.The bearing life is affected due to non-alignment during installation or too light belt tension.These maintenance are required when machines shows abnormal sounds,vibrations,excess surface temperature etc.

Transformers

65) What do you mean by transformer?
= Answer
A transformer is an electrical device,having no moving parts,by which electric energy transfer from one circuit to another circuit at the same frequency,usually with changed values of voltage and current.It consists of two windings insulated from each other and wound on a common core made up of magnetic material.

66) What is step-up and step-down transformer?
= Answer
When number of turns in the secondary winding is more than the primary winding is called step-up transformer.
When number of turns in the secondary winding is less than the primary winding is called step-down transformer.

67) Why transformer is necessary?
= Answer
Electricity is generated at places which are away from the residances,offices and industries.For this reason generated power is stepped up to a much higher voltage through a step up transformer.Electricity is then transmitted through a transmission line and at the receiving end stepped down to a lower voltage through step down transformer.The secondary side of stepped down transformer is connected to the various loads through distribution lines.Due to high voltage lower cross sectional area wire is needed and it minimised cost as well as lower current.

68) Write various parts of transformer.
= Answer
(i) Magnetic core.
(ii) Primary and secondary winding.
(iii) Insulation of windings.
(iv) Lead and tappings for coils with their supports,terminals and terminal insulators.
(v) Tank,oil,cooling arrangement,conservators,dryers.

69) Draw diagram from generation to distribution or consumers.
= Answer

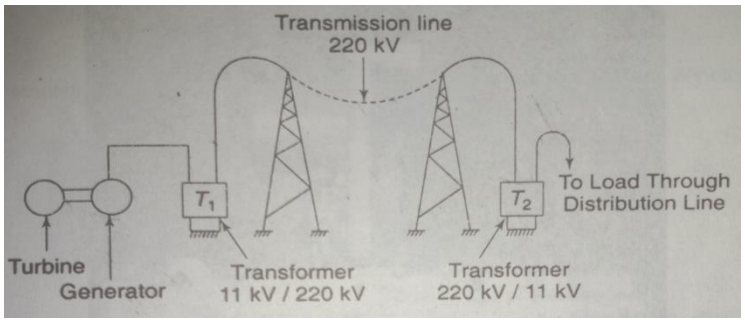


Fig. Eectricity generated at the power station is brought to the places of consumption through transmission lines.

70) What is core type transformer?
= Answer
A core type is one in which the iron core is surrounded by windings.

71) What is shell type transformer?
= Answer
A shell type is one in which the windings are surrounded by iron cores.

72) Fill up the following statements-
(i) In transformer the magnetic circuit is made up of a _____
(ii) _____ are stacked together to form the core.
(iii) The core is laminated to reduce _____
(iv) Eddy currents are induced in the core due to _____
(v) The thickness of laminations used is _____
(vi) Hysteresis loss depends upon the _____
(vii) Thickness cannot be reduced too much because the _____
(viii Special silicon steel (silicon content 4 to 5%) due to _____
(ix) The sum of hysteresis and eddy current loss is called _____
(x) Now days _____ are used for the construction of transformer core.
(xi) In a transformer core the orientation of the grains _____
(xii) Small core type transformers are made of _____
(xiii) Large core type transformers are made of _____
(xiv) A circular cross section is used due to _____
= Answer
(i) laminated iron core.
(ii) Thin silicon sheet-steel.
(iii) eddy current loss.
(iv) core is cut by alternating flux produced in the core by alternating current flowing through the windings.
(v) 0.4mm or less.
(vi) core material.
(vii) the area of the hysteresis loop of the core material.
(viii) small hysteresis loop area but a high value of saturation flux density and high resistivity.
(ix) iron loss or core loss.
(x) cold-rolled grain-orientation (CRGO) silicon-steel.
(xi) is parallel to the flux path.
(xii) rectangular-section core limbs.
(xiii) circular-section core.
(xiv) low turns of winding and reduces the cost of copper wire.

73) Draw core type and sheel type transformer.
= Answer

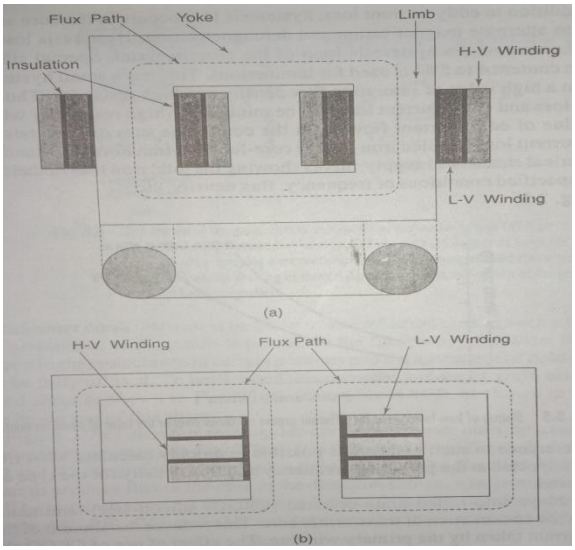


Fig. (a) Core-type (b) Shell-type

74) What are the advantages of three phase transformers over the banks of three single phase transformer?
= Answer
(i) Less space
(ii) Less weight
(iii) Less cost

75) How many types of transformer windings?
= Answer
(i) Cylindrical concentric coils :
In core type transformer it is used.
(ii) Sandwich coils :
In shell type transformer it is used.

76) What are the various cooling arrangements in transformer?
= Answer
(i) air natural
(ii) air blast
(iii) oil natural
(iv) oil blast
(v) Forced circulation of oil
(vi) oil and water-cooled
(vi) Forced oil and water cooled

77) What is the name oil used in transformer?
= Answer
Refining crude petroleum.

78) Stae function of conservator and breather.
= Answer
Conservator :

Transformer oil will expand due to heat generated because of losses taking place in the transformer.If the tank is completely sealed stresses will develop on the tank.Therefore some ventilating arrangement is to be made for free expansion of oil by conservator.

Breathers :

When the oil cools fresh air will be drawn in and as the atmospheric air contains moisture by using silicagel or calcium chloride which is kept in breathers moisture is absorbed.

79) Explain phasor diagram of a transformer on No-load.

= Answer

Under the no-load condition the secondary winding is open and no current flows through it.When an alternating voltage V_1 is applied across the primary winding emf will be induced in primary (E_1) and secondary (E_2) as current I_0 will set up a flux in the core.Emf induced in both the windings are opposite to the applied voltage.The no load current can be broken into two components I_m and I_c. I_m will lag voltage V_1 by 90^0 taking loss-less induction coil and I_c will be in phase with V_1.Taking N_1=N_2 and no voltage drop in the windings.

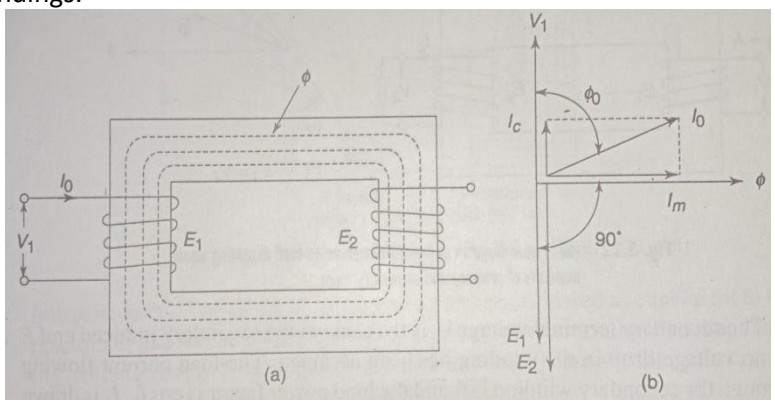


Fig. (a) Transformer on no-load (b) Phasor diagram of a transformer on no-load

80) What is voltage transformation ratio or phase transformation ratio?

= Answer

It is the ratio of secondary phase voltage to the primary phase voltage.

$$K = \frac{V_2}{V_1} = \frac{E_2}{E_1} = \frac{N_2}{N_1} = \frac{I_1}{I_2}$$

81) Explain phasor diagram of a transformer on-load.

= Answer

Under the on-load condition the secondary winding is connected across a load.When an alternating voltage V_1 is applied across the primary winding emf will be induced in primary (E_1) and secondary (E_2) as current I_0 will set up flux on the core.Emf induced in both the windings are opposite to the applied voltage.The load current can be broken into two components I_m and I_c.Current $I_2{}^{/}$ represents the primary current to neutralise the demagnetising effect of secondary current I_2.I_1=I_0+$I_2{}^{/}$.

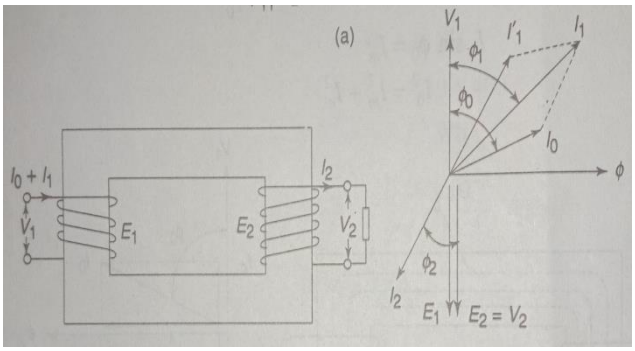


Fig. Phasor diagram of a transformer on no-load assuming equal numbers of primary and secondary turns

82) Draw equivalent circuit of a transformer at on-load.
= Answer

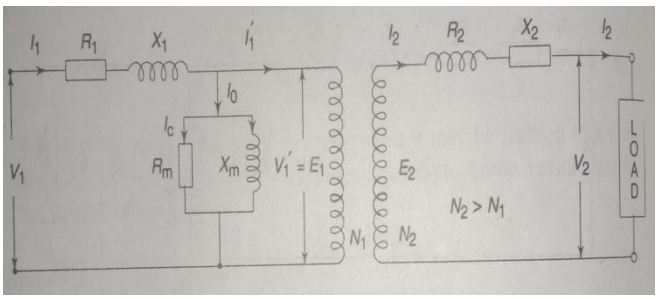


Fig. Equivalent circuit of a transformer on load

83) Draw phasor diagram from the equivalent circuit ofa transformer at on load.
= Answer

$V_1 = V'_1 + I_1R_1 + JI_1X_1$

$V_2 = E_2 - I_2R_2 - JI_2X_2$

$E_1 = V'_1$

Assume no voltage drop in the windings.

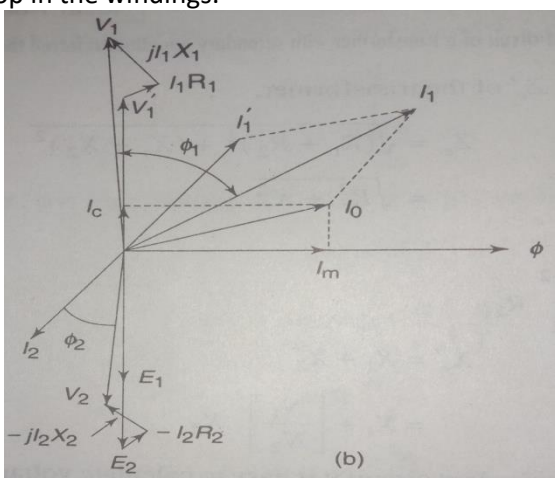


Fig. Phasor diagram of a transformer on load

84) What do you mean by impedance ratio?
= Answer

$Z_2 = \frac{V_2}{I_2}$

$Z_1 = \frac{V_1}{I_1}$

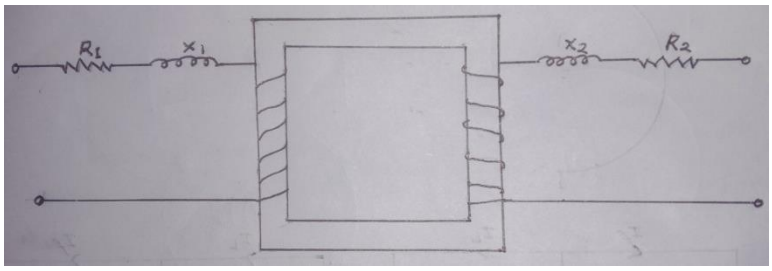
$\therefore \frac{Z_2}{Z_1} = \frac{V_2}{V_1} \times \frac{I_1}{I_2}$

= K×K

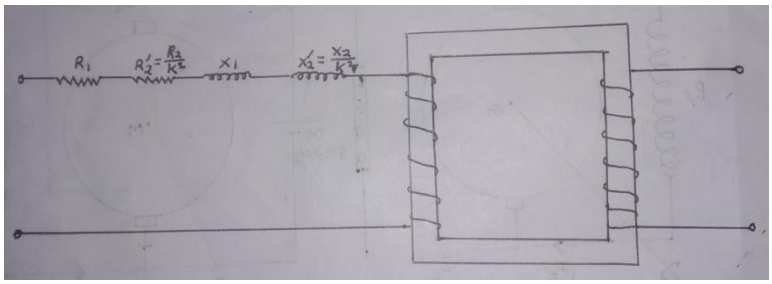
= K^2

85) Explain shifting impedances in a transformer.

= Answer



Referred to primary :

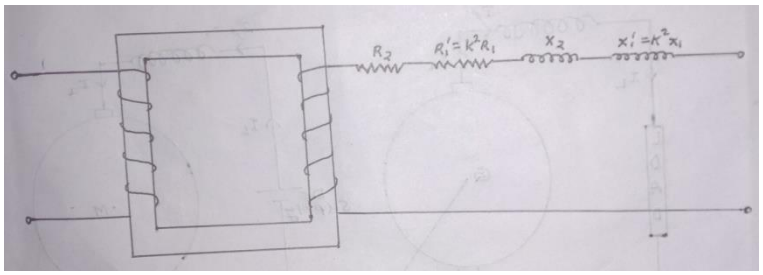


$R_{01} = R_1 + R^{/}{}_2$

$X_{01} = X_1 + X^{/}{}_2$

$Z_{01} = \sqrt{{R_{01}}^2 + {X^2}_{01}}$

Referred to secondary :



$R_{02} = R_2 + R^{/}{}_1$

$X_{02} = X_2 + X^{/}{}_1$

$Z_{02} = \sqrt{{R_{02}}^2 + {X^2}_{02}}$

86) What is voltage regulation of a transformer?

= Answer

Voltage regulation of a transformer is defined as the change in secondary terminal voltage from no load to full load.

$$\text{Voltage regulation} = \frac{No\ load\ voltage - Full\ load\ voltage}{Full\ load\ voltage}$$

Referred to primary,

$$\text{Regulation} = \frac{I_2(R_e{}^{/} cos\emptyset_2 \pm X_e{}^{/} sin\emptyset_2)}{V_2} \times 100$$

Referred to secondary,

$$\text{Regulation} = \frac{I_{2(R_e{}^{//} cos\emptyset_2 \pm X_e{}^{//} sin\emptyset_2)}}{V_2}$$

87) Describe transformer tests.

= Answer

(i) Open circuit test or no-load test :

The rated voltage is applied to the primary while the secondary is left open circuited.As the rated voltage is applied to the primary iron losses occur in the transformer core.Since no load current is very small (2-10% of rated current) $I_0{}^2$R or Cu losses in the primary are negligible.Iron losses are same at any load.

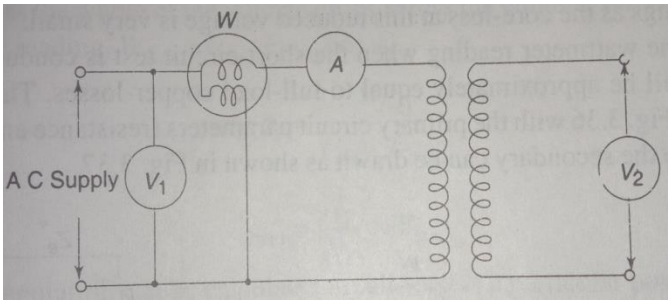


Fig. Circuit diagram for open circuit test on a transformer

Iron losses,

P_i = Wattmeter reading = W

No load current,

Ammeter reading = I_0

Applied voltage,

Voltmeter reading = V_1

Input power,

$P_i = V_1 I_0 \text{Cos}\emptyset_0$

No load p.f. = $\text{Cos}\emptyset_0 = \frac{W_0}{V_1 I_0}$

$I_W = I_0 \cos\emptyset_0$

$I_m = I_0 \sin\emptyset_0$

Open circuit test gives P_i, I_0, $\cos\emptyset_0$, I_W and I_m.

(ii) Short circuit test or full load test :

The rated voltage is applied to the primary while the secondary is short circuited by a thick conductor.There is no output from the transformer under short circuit conditions.Input power is all loss and it is copper loss.While making a short circuit test low voltage winding is always short circuited and measurements are made on the high voltage winding as on the low voltage winding the voltage will be inconveniently low.By using wattmeter full load copper loss will be determine.

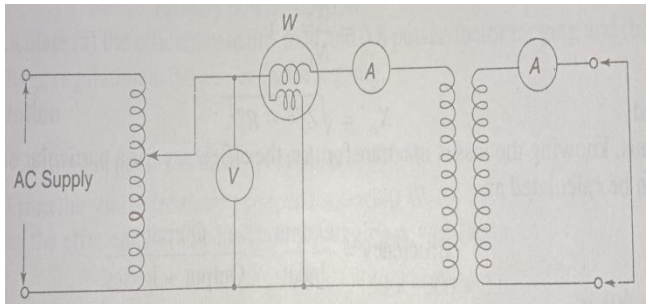


Fig. Circuit diagram for short-circuit test on a transformer

Full load copper loss,

P_c = wattmeter reading = W

Applied voltage,

Voltmeter reading = V_{sc}

F.L. primary current,

Ammeter reading = I_1

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

R_{01} = Resistance referred to primary

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

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

$\text{Cos}\emptyset_S = \frac{P_c}{V_{sc} I_1}$

88) How can you calculate temperature rise of transformer?

= Answer

The temperature rise of a transformer can be determined by running the transformer on load for a long time and measuring the temperature of the oil at periodic interval of time using an alcohol thermometer.

89) Give a statement about Back-to-Back test.

= Answer

For big transformer it is difficult to determine temperature rise of a transformer as heavy loads may not be available in the test laboratory and also large amount of energy will be wasted in load during the duration of the test.

Large transformer can be tested for determining the temperature rise by the Sumpner test also called the back-to-back test.

In the back–to-back test two identical transformers are needed.Two primary windings are connected across the rated supply voltage of the transformers.A wattmeter,an ammeter and a voltmeter are connected to the input side.The two secondary windings are connected in phase opposition such that the voltage measured across terminals B_2 and D_2 is zero.This can be done by first connecting any two terminals,say A_2 and C_2 together and connecting a double range voltmeter across the terminal B_2 and D_2.For corret bact back-to-back connections,the voltmeter should give zero reading.If the voltmeter gives a reading twice the voltage rating of the secondary,the terminal connections should be reversed.If the B_2 and D_2 are shorted no current will flow in secondary windings.Full load current can allowed to flow in the secondary windings by a regulating transformer.The secondary full load current will then induce full load current in primary windings.This

current will circulate through the primary windings only and will not affect the wattmeter reading,connected in the primary circuit.

The wattmeter reading W_1 when the secondary windings are open will give the core losses of the two transformer.The wattmeter reading W_2 will give copper losses of the two transformers.The core and copper losses in one transformer will $(W_1 + W_2)/2$.

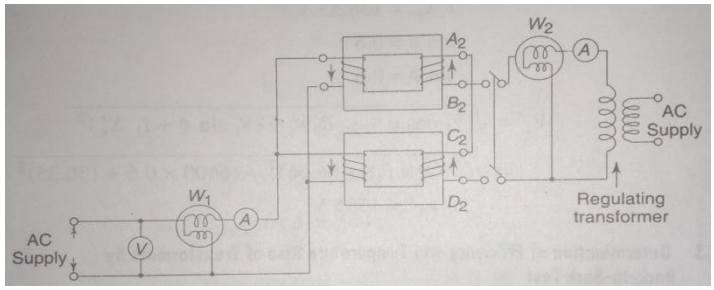


Fig. Back-to-Back test on two similar transformers

90) What is the advantage of back-to-back test?
= Answer
The transformers are tested under full load conditions without much expenditure of energy i.e. simply supplying energy equal to the losses of the two transformer only.

91) How can you do back-to-back test by a single transformer?
= Answer
A single transformer can be tested for temperature rise by short circuiting one winding and applying a voltage to the other.The temperature rise of oil will be the same as would happen under actual loading conditions and hence can be used for checking the temperature rise of a transformer when two identical transformer are not available for back-to-back connections.

92) Write about transformer efficiency.
= Answer

$$\text{Efficiency} = \frac{Output\ power}{Input\ power}$$
$$= \frac{Output\ power}{Output\ power + Losses}$$
$$= \frac{V_2 I_2 cos\emptyset_2}{V_2 I_2 cos\emptyset_2 + core\ loss + copper\ loss}$$
$$= \frac{V_2 I_2 cos\emptyset_2}{V_2 I_2 cos\emptyset_2 + P_c + {I_1}^2 R_1 + {I^2}_2 R_2}$$

Core loss is constant if the input voltage is constant but copper-losses vary as the square of the load current.

$$\eta = \frac{V_2 I_2 cos\emptyset_2}{V_2 I_2 cos\emptyset_2 + P_c + {I_2}^2 {R_e}^{//}}$$
$$R_e^{//} = R_2 + R_1 [\frac{N_2}{N_1}]$$
$$\therefore \eta = \frac{V_2 cos\emptyset_2}{V_2 cos\emptyset_2 + \frac{P_c}{I_2} + I_2 R_e^{//}}$$

Condition for maximum efficiency,

$$\frac{d}{dI_2}(V_2 cos\emptyset_2 + \frac{P_c}{I_2} + I_2 R_e^{//}) = 0$$
$$=> -\frac{P_c}{{I_2}^2} + R_e^{//} = 0$$

$\therefore I^2{}_2 R_e{}^{//} = P_c$

A transformer is designed such that its efficiency is maximum at a load slightly lower than the full load.This is because transformer works at a load lower than the full load rating.When a transformer is installed,its rating is chosen higher than the estimated load.

93) What do you mean by all day efficiency?

= Answer

The ratio of output in KWh to the input of KWh of a transformer over a 24-hour is known as all-day efficiency.

94) Compare copper used in an auto transformer and a two winding transformer of the same rating.

= Answer

$$\frac{Weight\ of\ cu\ required\ in\ an\ auto\ transformer}{Weight\ of\ cu\ required\ in\ a\ two\ winding\ transformer} = \frac{n-1}{n}$$

Where,

$$n = \frac{N_p}{N_s}$$

Auto transformer used as a Variac.

95) What do you mean by instrument transformers?

= Answer

The device by which we can measure voltage or current of a high voltage system is called instrument transformer.Like potential transformer (PT) and current transformer (CT).

96) How can you measure current of a high voltage system by using CT?

= Answer

The primary winding of a CT consists of a few turns and is connected in series with the line whose current is to be measured.The secondary has more number of turns.A low-range ammeter (0-5A) is connected in the secondary of the CT.

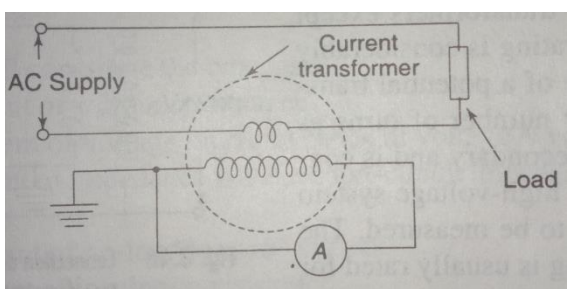


Fig. Connection diagram of a current transformer

97) How can you measure voltage of a high voltage system by using PT?

= Answer

The primary winding of a PT consists of a many number of turns as compared to secondary and is connected in parallel with the line whose voltage is to be measured.A low range voltmeter (110V) is connected in the secondary of the PT.

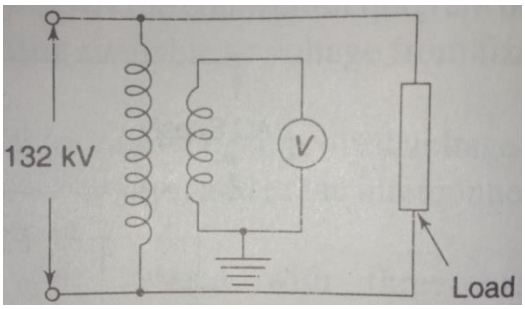


Fig. Connection diagram of a potential transformer to 132 kV circuits

98) How many types of transformers?
= Answer
(i) Instrument transformer.
(ii) Starting transformer.
(iii) Testing transformer.
(iv) Traction transformer.
(v) Welding transformer.
(vi) Mining transformer.
(vii) Earthing transformer.
(viii) X-ray transformer.
(ix) Reactors transformer.
(x) Furnace type transformer.

99) Explain testing of transformer.
= Answer
(i) Routine test :
(a) Measurement of winding resistance.
(b) Measurement of voltage ratio and voltage vector relationship.
(c) Measurement of impedance voltage/short circuit impedance and load loss.
(d) Measurement of no load loss and current.
(e) Measurement of insulation resistance.
(f) Dielectric test.
(g) On load tap-changers test.
(ii) Type test :
Same as routine test.
(iii) Special test :
(a) Dielectric tests.
(b) Measurement of zero sequence impedance of 3-Ø transformer.
(c) Short circuit tests.
(d) Measurement of acoustic noise level.
(e) Measurement of harmonics of no load current.
(f) Measurement of the power taken by fans and oil pumps.
Measurement of winding resistance :
It can be done by Wheatstone bridge or Kelvin bridge method.
Measurement of voltage ratio and voltage vector relationship :
It can be done by using a precisely calibrated voltmeter.
Measurement of impedance voltage/short circuit impedance and load loss :

It can be done by using a variable voltage source,voltmeter and ammeter.Load loss test can be determined by performing the back-to-back test.

Measurement of no load loss and current :

It can be done by using no-load test i.e. rated voltage is applied to the primary while secondary open.

Measurement of insulation resistance :

It can be done by using a megger.It is noted that insulation resistance depends on temperature.

Temperature ise test/Heat run test :

It can be done by using back-to-back test.

100) What should be fitted with rating plates of transformer?

= Answer

(i) Number of Indian Standard.
(ii) Manufacturer's name,country of manufacture.
(iii) Manufacturer's serial number.
(iv) Rated KVA.
(v) Number of phases.
(vi) Frequency.
(vii) Rated voltage at no load.
(viii) Rated current.
(ix) Percentage impedance voltage at $75^0 c$.
(x) Vector group.
(xi) Type of cooling.
(xii) Weight of core and windings in kg.
(xiii) Total quantity and weight of insulating liquids in litres and kilograms.
(xiv) Temperature rise in oil.
(xv) Year of manufacture.

101) Why parallel operation of transformers is necessary?

= Answer

To supply excess load we connect transformer in parallel.

102) Draw parallel connection of a single phase transformer.

= Answer

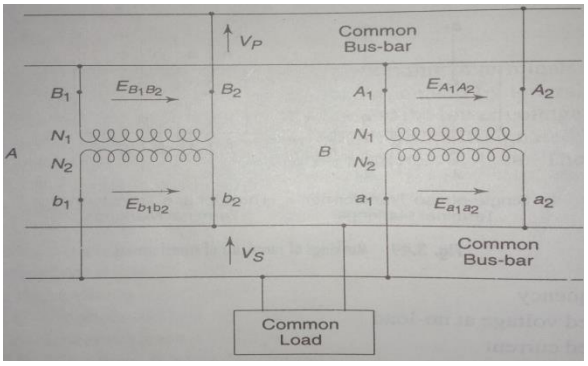


Fig. Two single phase transformers connected in parallel

103) What are the advantages of 3-Ø transformer over a three 1-Ø transformers?
= Answer
(i) Low cost to supply the same KVA output.
(ii) Low weight.
(iii) Less space required.
(iv) Bus-bar structure,switchgear and other wiring are simpler.

104) What are the advantages of 3-Ø system over 1-Ø system?
= Answer
(i) KVA and horsepower ratings are higher.
(ii) Operating characteristics is better.
(iii) The efficiency of transmission and distribution of power is better.

Three-Phase Induction Machines

105) State applications of 3-Ø induction motor.
= Answer
(i) Lifts.
(ii) Cranes.
(iii) Pumps.
(iv) Exhaust fans.
(v) Lathes.

106) State applications of 1-Ø induction motor.
= Answer
(i) Fans.
(ii) Refrigerators.
(iii) Washing machines.
(iv) Exhaust pumps.

107) How many types of induction motor?
= Answer
(i) Squirrel cage type.
(ii) Slip-ring type.

108) What do you mean by cogging?
= Answer
In an induction motor the rotor slots are not made parallel to the rotor shaft but are skewed at a certain angle with the shaft to reduce magnetic noise during motor operation,to produce more uniform torque and to prevent possible magnetic locking or cogging of the rotor with the stator.

109) What is slip?
= Answer
The speed of the rotor field relative to the speed of the stator field is called slip.

$$\text{P.U. slip} = \frac{Synchronous\ Speed\ (N_s) - Rotor\ Speed\ (N_r)}{Synchronous\ Speed\ (N_s)}$$

$$\%\ \text{Slip} = \frac{N_s - N_r}{N_s} \times 100$$

110) In an induction motor when rotor ritates synchronous speed what happened?
= Answer
When rotor rotates synchronous speed no flux will be cut by the stator field as stator field also rotates at synchronous speed.Therefore no emf will be in the rotor and hence no current flows through to the rotor conductor and no flux will be developed.No torque will be produced.Therefore rotor will always rotate at a speed slightly lower speed than synchronous speed.

111) Present a realtions of slip,rotor input and rotor I^2R-loss.
= Answer
(Power transferred from stator to rotor) – (Mechanical power developed by the rotor) = Rotor I^2R-loss
=>$\frac{2\pi TN_S}{60}$ - $\frac{2\pi TN_r}{60}$ = Rotor I^2R-loss
=> Rotor I^2R-loss = $\frac{2\pi T}{60}(N_s - N_r)$
=>$\frac{Rotor\ I^2\text{R}-\text{loss}}{Rotor\ input}$ = $\frac{\frac{2\pi T}{60}(N_S - N_r)}{\frac{2\pi T}{60}.N_S}$
=>$\frac{Rotor\ I^2\text{R}-\text{loss}}{Rotor\ input}$ = $\frac{N_S - N_r}{N_S}$
=>$\frac{Rotor\ I^2\text{R}-\text{loss}}{Rotor\ input}$ = S
$\therefore\ Rotor\ I^2\text{R} - \text{loss}$ = S× $Rotor\ input$

112) Give a statement about factors determining torque and torque-slip characteristic.
= Answer
Electrical power generated in the rotor = m$E_2I_2cos\emptyset_2$
Where,
m = number of phases
Electrical power lost in the rotor = $Rotor\ I^2\text{R} - \text{loss}$
As,
m$E_2I_2cos\emptyset_2$ = $Rotor\ I^2\text{R} - \text{loss}$
$\therefore\ Rotor\ I^2\text{R} - \text{loss}$ = m$E_2I_2cos\emptyset_2$ ---------- (i)
Again,
$Rotor\ I^2\text{R} - \text{loss}$ = S× $\frac{2\pi TN_S}{60}$ ---------- (ii)
Comparing (i) and (ii) –
m$E_2I_2cos\emptyset_2$ = S× $\frac{2\pi TN_S}{60}$
=>m×SE_{20} × $\frac{SE_{20}}{\sqrt{{R_2}^2+(SX_{20})^2}}$ × $\frac{R_2}{\sqrt{{R_2}^2+(SX_{20})^2}}$ = S$\frac{2\pi TN_S}{60}$
=>S× $\frac{2\pi TN_S}{60}$ = $\frac{mS^2{E_{20}}^2R_2}{{R_2}^2+(SX_{20})^2}$
=>T = $\frac{60}{2\pi N_S}$ × $\frac{mS^2{E_{20}}^2R_2}{S[{R_2}^2+(SX_{20})^2]}$
=>T = $\frac{60}{2\pi N_S}$ × $\frac{S{E_{20}}^2R_2}{{R_2}^2+(SX_{20})^2]}$
∴T∝ $\frac{S{E_{20}}^2R_2}{{R_2}^2+(SX_{20})^2}$
Where,
E_2 = emf induced per phase when the rotor is rotating at a slip S
I_2 = Rotor current
E_{20} = emf induced per phase when the rotor is at standstill.
Since rotor induced emf at standstill is proportional to air gap flux ∅.

T$\propto \frac{S\emptyset^2 R_2}{{R_2}^2+S^2{X_{20}}^2}$

Again flux produced in the air-gap is proportional to the supply voltage to the stator.

T$\propto {V_1}^2$

In special cases T$\propto$S and T$\propto \frac{1}{S}$

For lower values of slip the torque-slip characteristic is represented as a straight line where as for higher values of slip the torque-slip characteristic is represented as a rectangular hyperbola.When slip increases from say 0 to 1 the rotor speed decreases.When S = 1 rotor speed zero.The magnitude of starting torque and the maximum torque depend upon the rotor resistance.

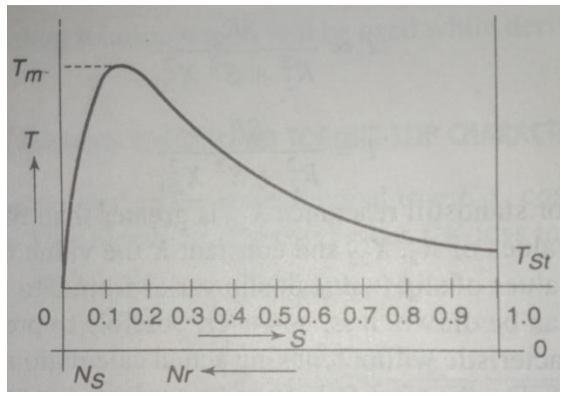


Fig. Torque-slip or torque-speed characteristic of a three-phase induction motor

113) State effect of variation of rotor resistance on the torque-slip characteristic.

= Answer

(i) Starting torque increases with in increase value of rotor resistance.

(ii) Maximum torque remain constant and is independent of the value of rotor resistance.

(iii) Maximum torque is developed at starting.

114) Find the condition for maximum torque.

= Answer

$$T = \frac{SR_2}{{R_2}^2+S^2{X_{20}}^2}$$

$$\frac{dT}{dS} = \frac{({R_2}^2+S^2{X_{20}}^2)R_2 - SR_2(2S{X_{20}}^2)}{({R_2}^2+S^2{X_{20}}^2)^2}$$

$$= \frac{R_2({R_2}^2-S^2{X_{20}}^2)}{({R_2}^2+S^2{X_{20}}^2)^2}$$

When $\frac{dT}{dS}$ = 0,T will be maximum.

$${R_2}^2 + S^2{X_{20}}^2 = 0$$

$$\Rightarrow {R_2}^2 = S^2{X_{20}}^2$$

$$\therefore R_2 = SX_{20}$$

As,X_2 = SX_{20}

So,R_2 = X_2

$$T_{max} = \frac{KS^2X_{20}}{S^2{X_{20}}^2+S^2{X_{20}}^2}$$

$$= \frac{KS^2X_{20}}{2S^2{X_{20}}^2}$$

$$= \frac{K}{2X_{20}}$$

If X_{20} is constant the value of maximum torque is same for any value of rotor resistance.

115) Give a statement of starting torque of an induction motor.
= Answer
For achieving high starting torque and high efficiency the motor should have high rotor circuit resistance at starting and low rotor circuit resistance under running condition.In slip ring motor this is achieved by inserting extra resistance in the rotor circuit at starting and gradually reducing this resistance as the motor accelerates.In squirrel cage motors high starting torque is achieved by using double cage rotors.

116) Explain achieving high starting torque in squirrel-cage type motors.
= Answer
High starting torque in squirrel-cage motors can be achieved by using double cage rotors.In a double cage rotor there are two separate squirrel cage on the rotor.The outer cage can be of high resistance alloy,such as brass and the inner one can be of copper.As the lower cage conductors are placed deep inside the rotor,there will be more leakage flux around them as compared to the upper cage conductors.Therefore inductance and hence the inductive reactance of the lower cage will be higher than that of the upper cage.Thus the impedance offered by the lower cage will be high and hence current flow through to the lower cage will be low as compared to the upper cage.Most of the current will,therefore,flow through to the upper cage conductors.Under running condition,most of the rotor current will flow through the lower cage conductors.

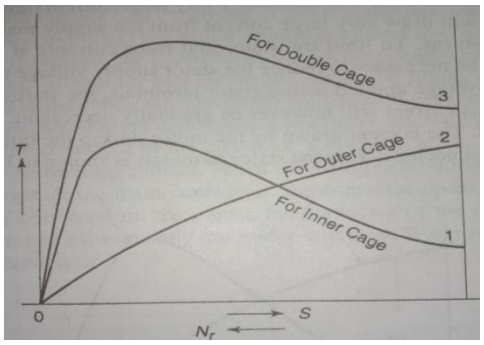


Fig. Torque-speed characteristics of double-cage induction motors

117) What are the advantages of double cage induction motor?
= Answer
(i) High starting torque and high efficiency.
(ii) Start up the motor by direct-on-line (DOL) as low starting current.small motors upto 5 hp ratings may be started by direct-on-line (DOL).

118) What is the function of fuse?
= Answer
Fuses are provided for short-circuit protection.

119) Describe starting of induction motor.
= Answer
(i) Full voltage or Direct-On-Line (DOL) starting.
(ii) Reduced voltage starting.
  (a) Auto transformer starting.
  (b) Star-delta method of starting.

120) Explain achieving high starting torque in slip ring type motors.
= Answer
The easiest method of starting wound rotor or slip ring induction motors is to connect extra resistance in the slip ring terminal of the rotor.When the motor attains rated speed the resistance is fully cut out and the slip ring terminals are short circuited.

121) What is the difference between transformer and induction motor?
= Answer
(i) In a transformer no load current is about 2 to 3 percent of the full load current.
In an induction motor no load current is about 50 percent of the full load current.
(ii) In a transformer hysteresis and eddy current losses take place.
In an induction motor hysteresis,eddy current,friction and windage losses take place.

122) Give a statement of current and power factor of an induction motor.
= Answer
The no-load power factor of an induction motor is less than 0.4 lagging.As the motor is loaded its slip increases.As E_2 = SE_{20},the rotor induced emf increases again I = E_2/R,hence rotor current also increases.The rotating field produced by the rotor mmf rotates at slip frequency aith respect to the rotor and synchronous speed produced by the stator mmf rotates at synchronous speed with respect to the stator.Thus both stator and rotor field rotate at synchronous speed with respect to the stator.Therefore both the fields are stationary with respect to each other.At low value of slip the rotor power factor is quite high as cosØ = $\frac{R_2}{\sqrt{{R_2}^2+(SX_{20})^2}}$ .The power factor of a fully loaded induction motor may be as high as 0.85 to 0.9.To maintain a high p.f. the air gap of the motor should be kept minimum.

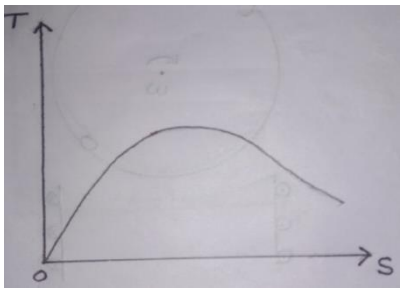
123) Describe speed control of an induction motor.
= Answer
(i) We know that,

$$T = \frac{KSR_2{E_{20}}^2}{{R_2}^2+S^2{X_{20}}^2}$$

In slip ring type motor speed is control by controlling rotor circuit resistance which is connected in slip ring.
(ii) We know that,

$$T \propto V^2$$

Speed is control by controlling applied stator voltage.If the voltage is reduced,torque is reduced as the square of the supply voltage.The torque-slip characteristic at reduced stator voltage (270V) is shown below.



(iii) Injected voltage method of speed control :

If the injected emf has a component in phase with the rotor induced emf,the speed will be above the synchronous speed.
(iv) We know that,

$$N_r = \frac{120f}{P}(1 - S)$$

By gradually changing supply frequency speed can be increased or decreased smoothly.
(v) We know that,

$$N_r = \frac{120f}{P}(1 - S)$$

Speed is control by controlling or changing pole of an induction motor.If instead of one stator winding,two independent windings are wound for different number of poles say for four poles and for eight poles are made on the stator.When any of the windings is used,the other should be kept open circuited.

124) List out the losses of an induction motor.
= Answer

(i) I^2 R-loss in the stator winding.
(ii) Core loss in stator core.
(iii) I^2 R-loss in the rotor winding.
(iv) Core loss in the rotor core.
(v) Frictional losses in the bearings,brush and slip rings.
(vi) Windage loss due to rotation of the rotor in air.

125) How can you determine efficiency of an induction motor?
= Answer
By no load and blocked rotor test.

126) Explain no load and blocked rotor test of an induction motor.
= Answer
No load test :

In this test the shaft of the rotor is not loaded.Full voltage is applied to the stator winding terminals.At no load the speed of the rotor is very nearly equal to synchronous speed.The emf induced in the rotor is high and the rotor current is small.The rotor can be considered as an open circuit.
The losses at no-load are –

(i) I^2 R-loss in the stator winding.
(ii) Core losses in the stator.
(iii) Core losses in the rotor.
(iv) Friction and windage loss.

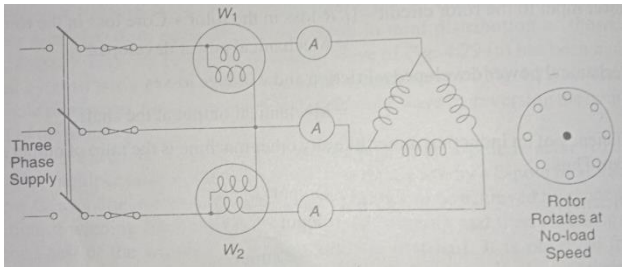


Fig. No-load test of an induction motor

Blocked rotor test :

In this test the rotor of the motor is blocked,i.e. the rotor is not allowed to rotate.Low voltage is applied across the stator terminals through a three phase auto-transformer.The voltage needed to circulate full load current under blocked rotor condition is low.Since full load current is allowed to flow through the stator and rotor windings,the input power be approximately equal to full load I^2 R losses.From the input power it is possible to calculate equivalent resistance of the motor referred to the stator terminals.

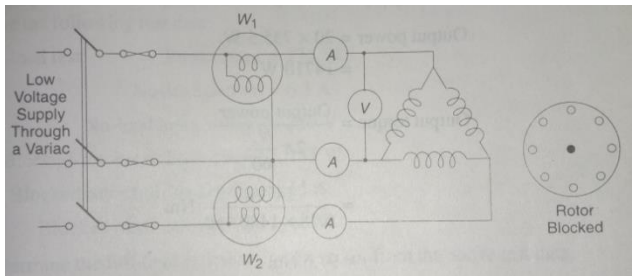


Fig. Blocked rotor test or short circuit test on an induction motor

127) Explain-equivalent circuit of an induction motor and its use.
= Answer
The equivalent circuit of an induction motor is similar to transformer equivalent circuit which is given below –

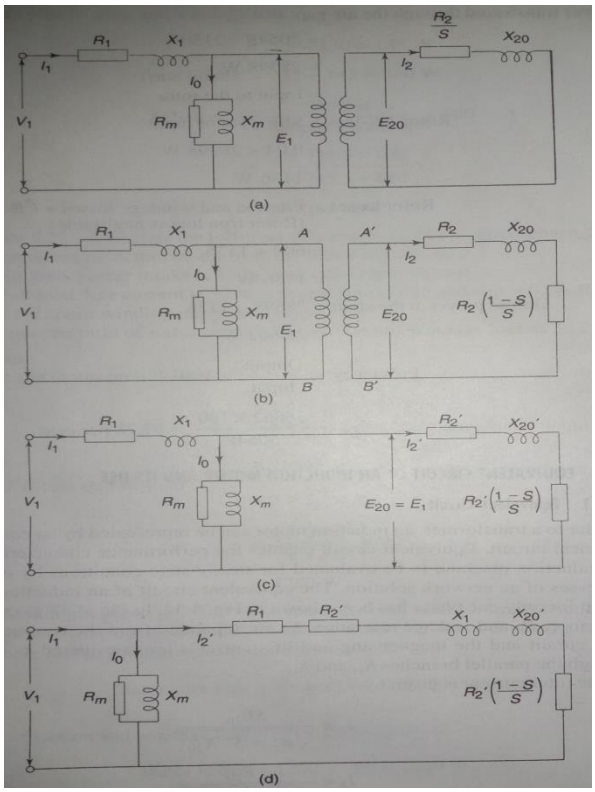


Fig. Equivalent circuit of an induction motor

Rotor output power,

$$P_r = I_2{}^2 R_2 [\frac{1-s}{s}]$$

Rotor input power,

$$P_i = I_2{}^2 R_2 [\frac{1-s}{s}] + I_2{}^2 R_2$$

$=> P_i = \frac{{I_2}^2 R_2}{s}$

$=> P_i s = {I_2}^2 R_2$

$\therefore s P_i = {I_2}^2 R_2$ ---------- (i)

Again,

$P_i = sP_i + P_i - sP_i$

$=> P_i = sP_i + (1-s)\, P_i$

$\therefore P_i = sP_i + (1-s)\, P_i$

Therefore rotor power input P_i is utilised in the rotor resistance as sP_i and the equivalent resistance representing mechanical load (1-s) P_i.

$P_r = {I_2}^2 R_2 [\frac{1-s}{s}]$

$=> P_r = sP_i [\frac{1-s}{s}]$

$=> P_r = (1-s)\, P_i$

$\therefore P_r = (1-s)\, \frac{{I_2}^2 R_2}{s}$ ---------- (ii)

Rotor current,

$$I_2 = \frac{sE_{20}}{\sqrt{{R_2}^2 + (sX_{20})^2}}$$

From (ii),

$P_r = (1-s)\, \frac{{I_2}^2 R_2}{s}$

$=> P_r = (\frac{1-s}{s}).R_2 \times (\frac{sE_{20}}{\sqrt{{R_2}^2 + (sX_{20})^2}})^2$

$=> P_r = (\frac{1-s}{s}) R_2 \times \frac{s^2 {E_{20}}^2}{{R_2}^2 + s^2 {X_{20}}^2}$

$\therefore P_r = \frac{s(1-s) R_2 {E_{20}}^2}{{R_2}^2 + s^2 {X_{20}}^2}$ ---------- (iii)

Again,

$P_r = \frac{2\pi T N_r}{60}$ ---------- (iv)

Comparing (iii) and (iv) –

$$\frac{2\pi T N_r}{60} = \frac{s(1-s) R_2 {E_{20}}^2}{{R_2}^2 + (sX_{20})^2}$$

$$=> T = \frac{60}{2\pi N_r} \times \frac{s(1-s) {E_{20}}^2 R_2}{{R_2}^2 + s^2 {E_{20}}^2}$$

$$=> T = \frac{60}{2\pi N_s (1-s)} \times \frac{s(1-s) {E_{20}}^2 R_2}{{R_2}^2 + s^2 {E_{20}}^2}$$

$$\therefore T = \frac{60}{2\pi N_s} \times \frac{s {E_{20}}^2 R_2}{{R_2}^2 + s^2 {E_{20}}^2}$$

128) From the circle diagram of an induction motor,what we have got?

= Answer

(i) Full load current.

(ii) Power factor.

(iii) Maximum power output.

(iv) Pull out torque.

(v) full load efficiency.

129) What do you mean by asynchronous generator?

= Answer

When the stator windings of an induction motor are connected across a three phase supply of constant voltage and frequency and it is mechanically coupled to a primemover capable of driving the induction machine at a speed higher than the synchronous speed,the machine will then work as an induction generator.Since the speed of the rotor is different from the synchronous spedd,such generators will be called asynchronous generators.In this case the value of slip will be '-ve'.

130) How can we eliminate crawling effect?
= Answer
By arranging coil pitch and distribution of coils.

131) What is cogging?
= Answer
The alignment force at the instant of start become stronger than the starting torque if the number of stator and rotor slots of an induction motor are either equal or have an integral ratio resulting in failure of the motor to start.This phenomenon of motor to start is known as cogging.

132) Write the function of an induction regulator.
= Answer
An induction regulator is used to maintain the voltage at the feeder end.

Three-Phase Synchronous Machines

133) What do you maen by synchronous generator and motor?
= Answer
A synchronous machine has two main parts,viz. the stator and the rotor.The armature windings are placed on the stator slots.The field poles are placed on the rotor.When the rotor is rotated by a primemover such a machine is called generator or alternator since it generates alternating voltage.
A synchronous machine has two main parts,viz. the stator and the rotor. The armature windings are placed on the stator slots.The field poles are placed on the rotor.When a three phase supply is fed to armature winding such a machine is called synchronous motor.

134) Filled up the following statements –
(i) In a thermal or nuclear power station a _____ is used to drive the alternator.
(ii) Steam turbines are designed to rotate at a high speed _____
(iii) The efficiency of the steam turbine is high as its _____
(iv) An alternator driven by a steam turbine which is required to generate voltage at 50 Hz will have only _____
(v) In hydel power stations turbine to be used depends upon the _____ available in the power station.
(vi) For water head upto 50m,_____ are used
(vii) Francis turbine are used upto a water head of about _____
(viii) Above 380m _____ are used
(ix) Diesel engine are of _____ as compared to steam turbines
(x) In synchronous machines poles used are _____
(xi) An overexcited synchronous motor is often used for _____ of a system
= Answer
(i) steam turbine
(ii) 3000 rpm

(iii) high speeds
(iv) two rotor poles
(v) water head
(vi) Kaplan turbines
(vii) 380m
(viii) Pelton wheels
(ix) low speeds
(x) projected type
(xi) power factor correction

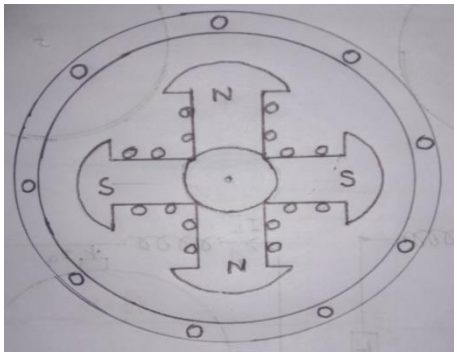
135) What are the advantages of rotating field and stationary armature?
= Answer
(i) It is easier to insulate armature winding for high voltages,for which the alternator are usually designed.
(ii) The stationary 3-phase winding can be directly connected to load without going through large unidirectional slip rings and brushes.
(iii) Two slip rings are required for d.c. supply to the field winding on the rotor.Since the exciting current is small,the slip rings and brush gear required are of light construction.
(iv) Due to simple and robust construction of the rotor,higher speed of rotating d.c. field is possible.

136) How many types of rotor poles of an synchronous machine?
= Answer
(i) Salient type or projected type.
(ii) Non-salient type or cylindrical type.

137) Explain use of salient type rotor poles.
= Answer
We know that,

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

In hydel power station the speed of water is low so to generate electricity at 50 Hz it is necessary to keep the number of rotor poles large.The diameter of such rotors become bigger than their lengths.



138) Explain use of non-salient type rotor poles.
= Answer
We know that,

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

In thermal or nuclear power station the speed of steam is very high about 3000 rpm so to generate electricity at 50 Hz it is necessary to keep the number of rotor poles small.Also to reduce centrifugal force developed on the rotor winding at this high speed,the rotor diameter is to be kept small.It is made for synchronous generators.

139) Explain-principle of alternator or synchronous generator.
= Answer
The rotor winding is excited from a dc source and alternate N and S pole developed on the rotor.The 3-phase armature winding is placed on the stator slot.When rotor is rotated by a primemover the armature conductor cut by the magnetic flux of the rotor.Therefore emf is induced in the armature winding.The induced emf is alternating in nature as alternate N and S pole pass through the conductor.

Induced emf,

$$E = \frac{\emptyset ZNP}{60A}$$

Where,

$\emptyset$ = Flux
Z = Total number of conductor
N = Speed of the rotor
P = Number of poles
A = Number of parallel path in the armature

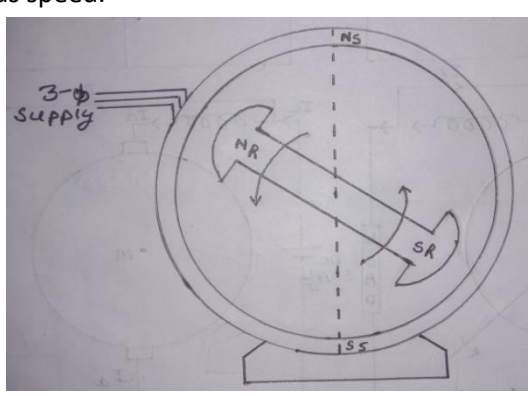
From the above equation we can write $E \propto N$ and $E \propto \emptyset \propto i_f$.
Where,

i_f = D.C. exciting current of the rotating field.This is arranged by two slip-rings.

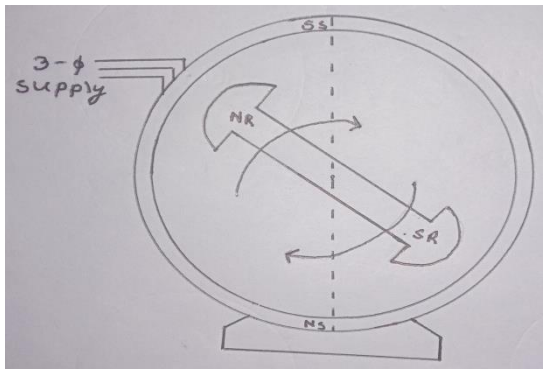
140) Explain-principle of synchronous motor.
= Answer

Consider a 3-$\emptyset$ synchronous motor having two rotor poles N_R and S_R.Therefore the stator will also be wound for two poles N_S and S_S.

The direct voltage is applied to the rotating field winding through slip rings and 3-$\emptyset$ supply applied to the stator winding.The stator winding produces a rotating magnetic flux which is revolve round the stator at synchronous speed.



It is clear from the figure that N_S and N_R repel each other and so S_S and S_R.Therefore the rotor is tends to move in the anticlock wise direction.



Again it is clear that from the figure that after a period of half cycle the polarities of the stator poles are reversed but the polarities of the rotor poles remains same.Now S_S and N_R attract each other and so N_S and S_R.Therefore the rotor is tends to move in the clock wise direction.

Since stator change their polarities within $\frac{1}{2f}$ = $\frac{1}{100}s$ = 0.01s,they tend to pull the rotor first in one direction and then after period of 0.01s in other direction.Due to high inertia of rotor,the motor fails to start.

141) Give a statement about exciters.
= Answer
For moderately rated alternators,exciters are dc shunt generators.Exciters for large alternators may be separately excited type.Three phase synchronous generator also used as a exciter.This is achieved through a bank of rectifiers.

142) What is pilot exciter?
= Answer
The generator whose field windings are fed from another shunt generator is called pilot exciter.

143) How to get unidirectional torque of a synchronous motor?
= Answer
If the rotor is rotated by some external motor at such a speed that they change their polarities along with the stator poles,then the rotor will experience a continuous unidirectional torque.

144) What do you mean by concentrated winding?
= Answer
In concentrated winding the total number of coil per phase has been only two.Each coil should have a large number of turns to have considerable amount of induced emf per phase.Such a winding is called concentrated winding.

145) What is distribution factor?
= Answer
It is the ratio of emf induced with a distributed winding to the emf induced with a concentrated winding.

146) What is pitch factor?
= Answer
It is the ratio of emf induced in short pitch coil to the emf induced in a full pitch coil.

147) What is damper winding?
= Answer
The damper winding consists of copper bars which is short circuited at the end.It is similar to squirrel cage winding those used in an induction machine.

148) What are the advantages of parallel operation of synchronous generator?
= Answer
(i) Repairs and maintenance of individual generating units can be done keeping the continuity of supply.
(ii) Operating on maximum efficiency it is run near to its full load capacity.
(iii) Additional set can be connected in parallel to meet the increasing demand.

149) What are the conditions for parallel connection?
= Answer
(i) The generated voltage of the incoming alternator to be connected in parallel with a bus-bar should be equal to the bus-bar voltage.
(ii) The generated frequency of the incoming alternator to be connected in parallel with a bus-bar should be equal to the bus-bar frequency.
(iii) The generated phase sequence of the incoming alternator to be connected in parallel with a bus-bar should be equal to the bus-bar phase sequence.

150) What is pull out torque?
= Answer
The load at which the motor pulls out of synchronism is called pull out torque.

151) What do you mean by hunting?
= Answer
When load increases or decreases on a motor the rotor slips backwards or forwards.This phenomena is called hunting.

152) Explain-effect of change of field excitation.
= Answer
(i) Under excitation :
The motor is said to be under excited if the field current is such that E_b<V.In this case field excitation is minimum as E_b<i_f.CosØ =Lagging.
(ii) Normal excitation :
The motor is said to be normal excited if the field excitation such that E_b=V.In this case field excitation is normal. CosØ = 1.
(iii) Over excitation :
The motor is said to be over excited if the field excitation is such that E_b>V.In this case field excitation is maximum. CosØ = Leading.

153) Which motor is known as constant motor?
= Answer
Synchronous motor as the speed of the synchronous motor is constant and it is independent of load.

154) What are the losses occur in an alternator during on load?
= Answer
(i) Voltage drop in armature resistance.

(ii) Voltage drop in leakage reactance.
(iii) Voltage drop due to armature reaction.

155) What are the disadvantages of synchronous machine?
= Answer
(i) Higher cost.
(ii) Necessity for a dc excitation.
(iii) Initial cost is high.
(iv) Maintanance cost is high.

<u>*My another topic of Electrical Engineering is Power System Theory will coming soon*</u>