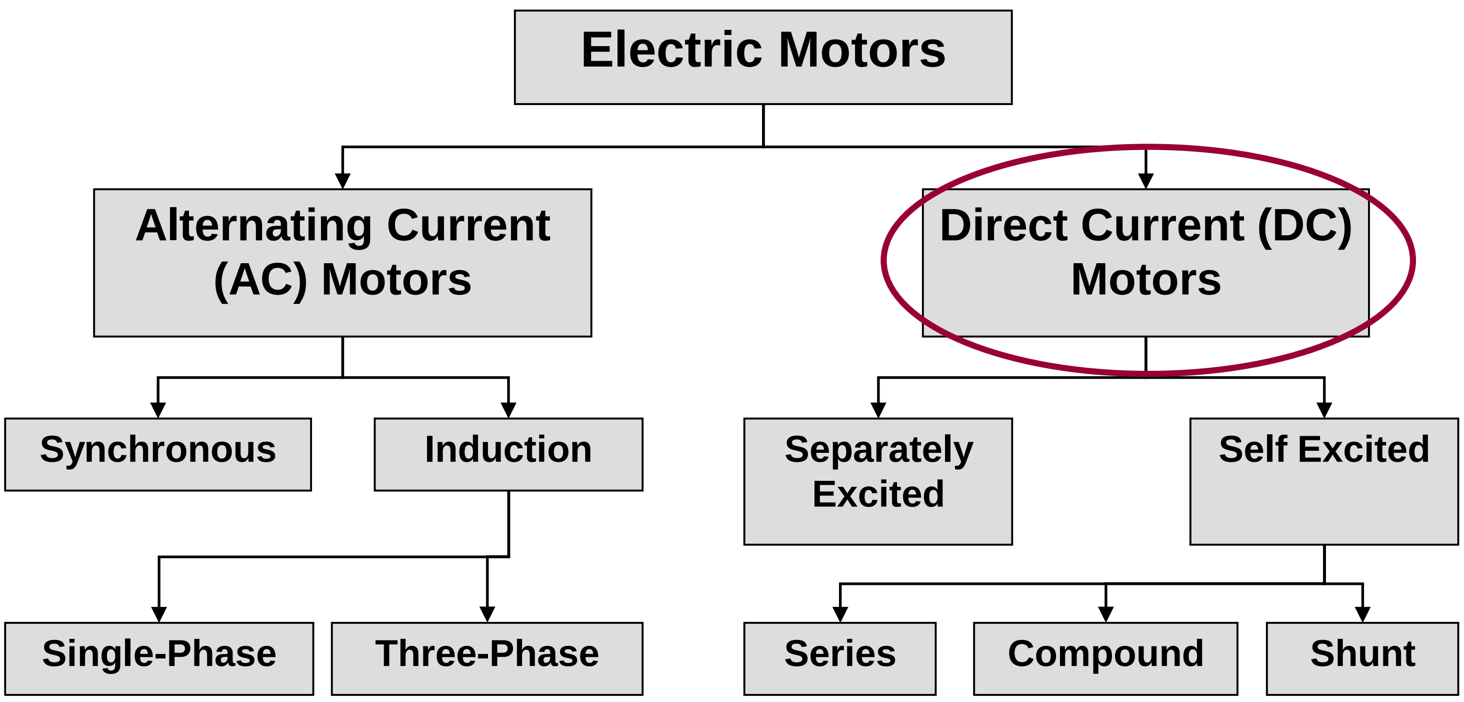
What is an Electric Motor?

- Electromechanical device that converts electrical energy to mechanical energy
- Mechanical energy used to e.g.
  - Rotate pump impeller, fan, blower
  - Drive compressors
  - Lift materials
- Motors in industry: 70% of electrical load

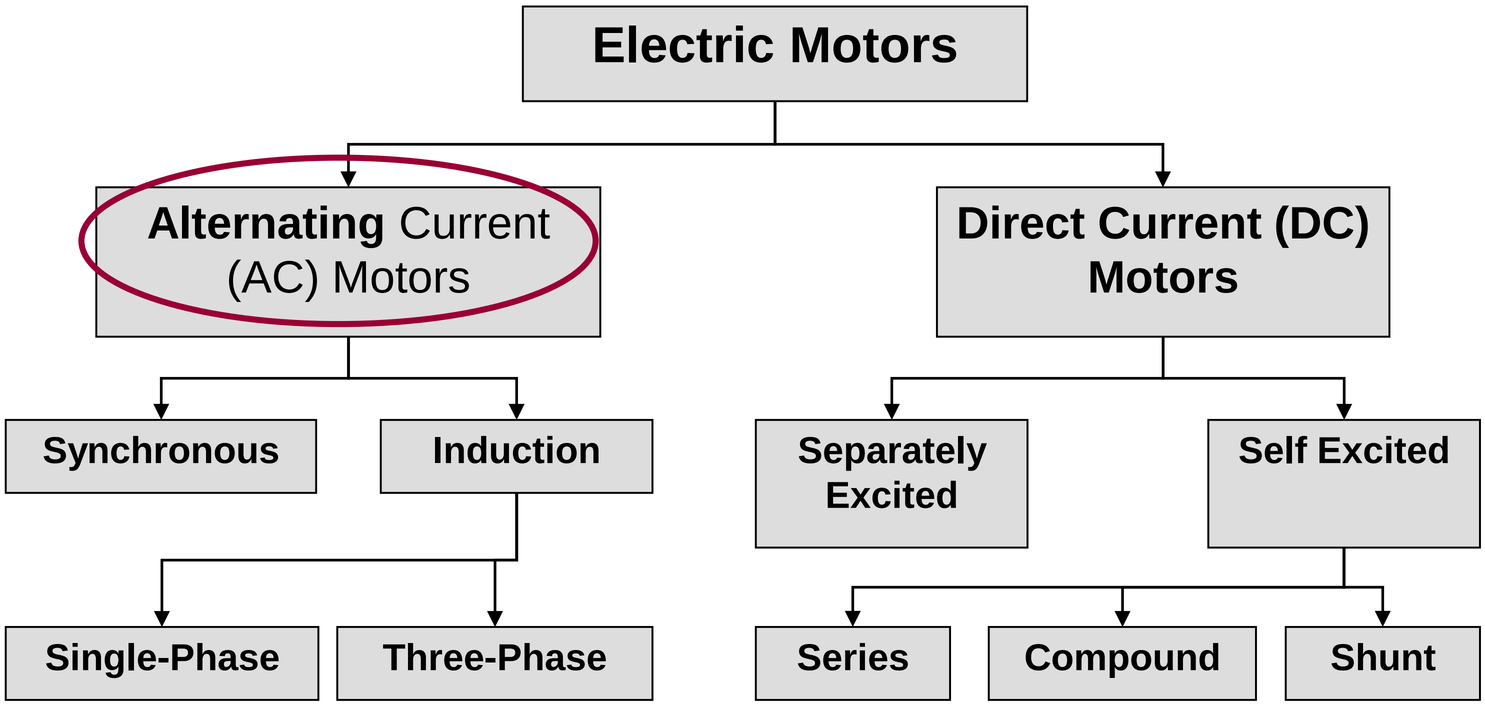
Type of Electric Motors

Classification of Motors



Type of Electric Motors

Classification of Motors



Chapter one
Three phase Induction Motor Construction

or

(*The asynchronous machine)*

- The larger part of electrical energy in the world is converted into mechanical energy in electric motors.

- Among electric motors, induction motors are most used both for home appliance and in various industries.

- The rating of induction motors vary from a few tens watts to 45000hp.

Chapter one

Three phase Induction Motor Construction or (*The asynchronous machine)*

The advantages of three phase IM are:

1-Simple and extremely rugged in construction, especially squirrel cage IM.

2-High reliability and low cost due to simplicity of construction.

3-It requires minimum of maintenance(especially squirrel cage type).

4-The simplicity of starting arrangement.

5-The efficiency vary from 85% to 94%, with a good power factor 0.85 to 0.92 lagging in nature.

6-Better magnetic, better insulation materials and cooling systems.

7-Developments of induction motors for super high speed and high power rating.

The disadvantages of three phase IM are:

1- starting torques, it is inferior to that of DC motors.

2-The speed decreases with increasing the load.

3-The speed can not be varied without scarifying some of its efficiency

Chapter one

Three phase Induction Motor Construction

Stator Construction

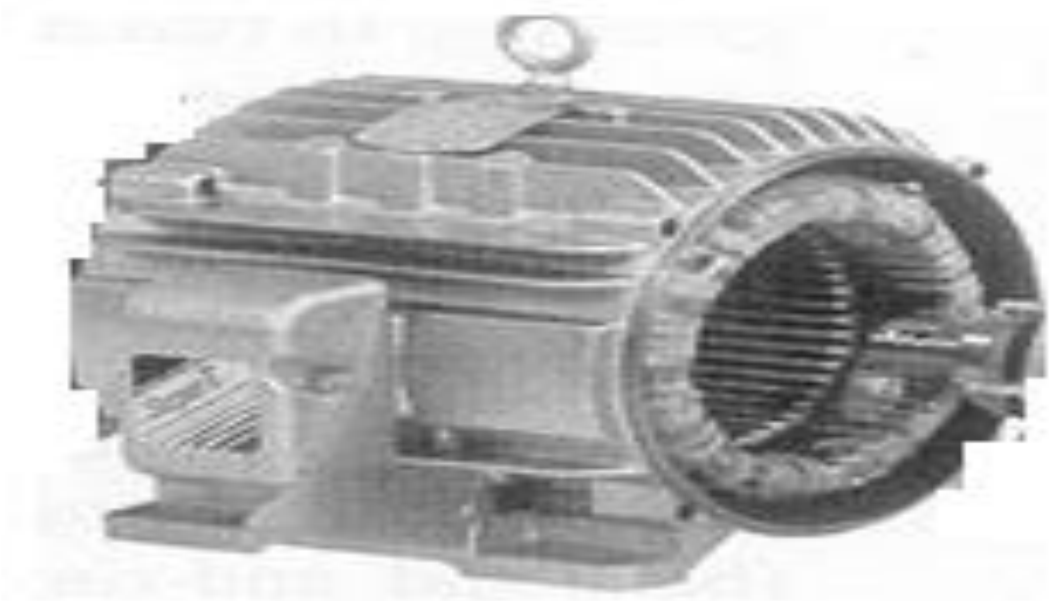
1-Frame
2-Stator Core
3-Three Phase Stator Windings

Rotor Construction

1-Squirrel Cage Rotor type
2-*Slip Ring Rotor*

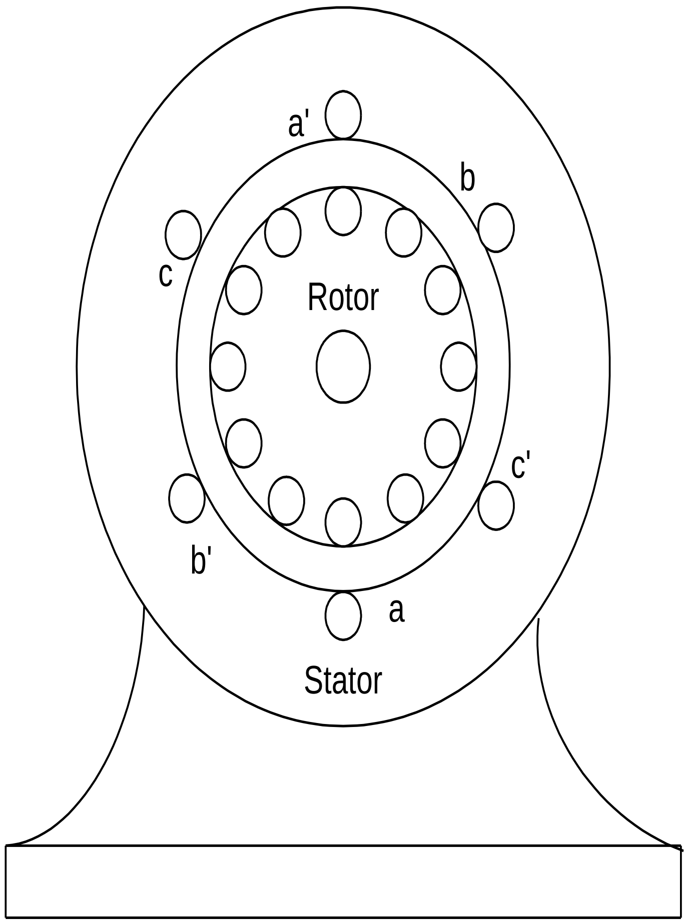
Construction

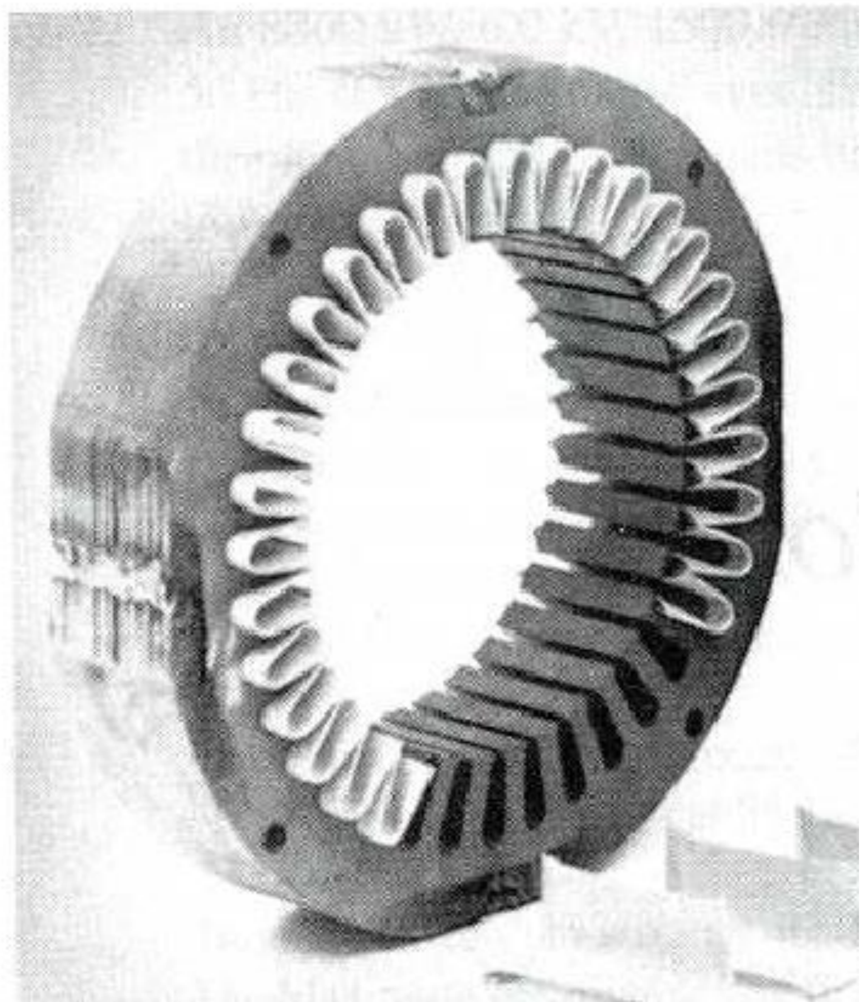
1. **Frame:** *It gives complete support and protection to all the inner parts. The outer surface may be provided with fins so as to increase the heat dissipating area without increasing the over diameter. It makes of closed –grained alloy cast iron.*

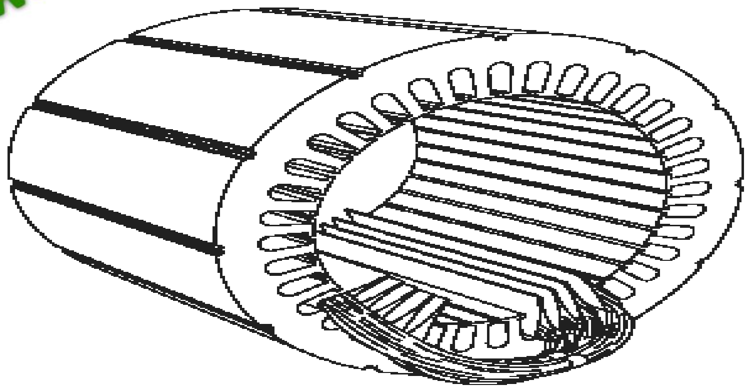


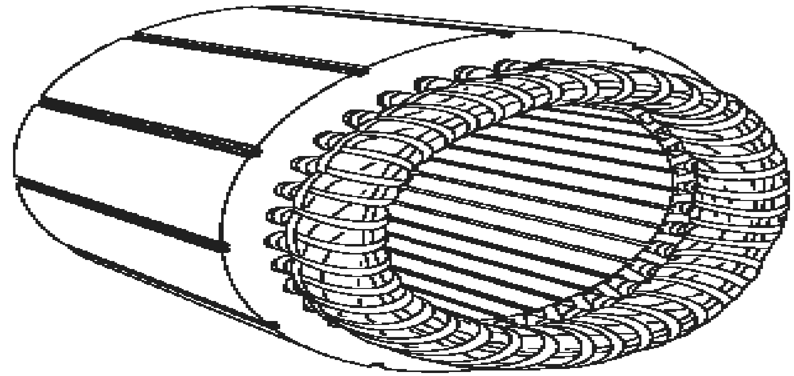
Construction

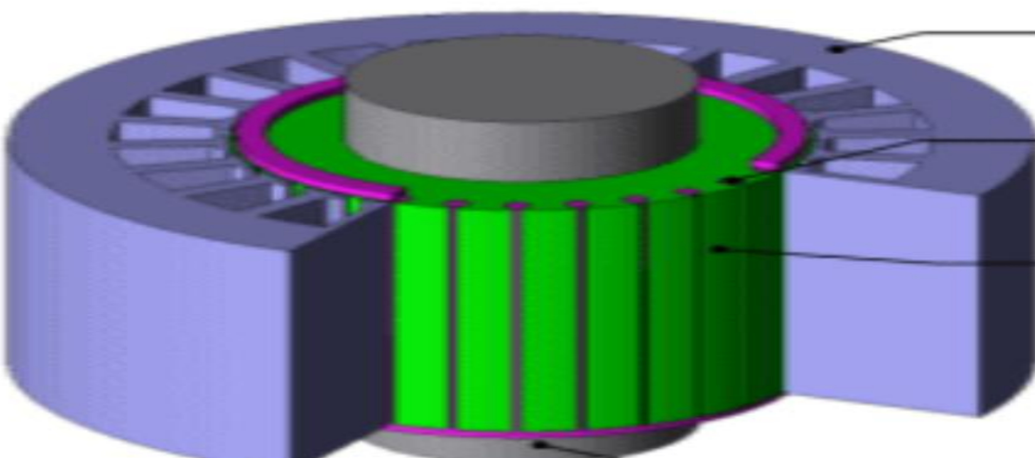
2-The stator Core: ***The stator core provides the space of housing the three phase stator windings and forms the path for the rotating magnetic field. The stator core subjected to alternate current changes in polarity of the magnetic field due its rotating nature, hysteresis and eddy current (together they are called iron losses) losses are produced in it. To reduce hysteresis losses , silicon (3-5%) are added to the high grade steel. But to reduce the eddy current losses the stator core is made up of several thin laminations (0.35-0.65)mm thickness of aluminum or cast iron. The stator stamping, after punched to the required dimension are provided with thin varnish coating to increase core body resistance.***


a'
b
c
Rotor
c'
b'
a
Stator



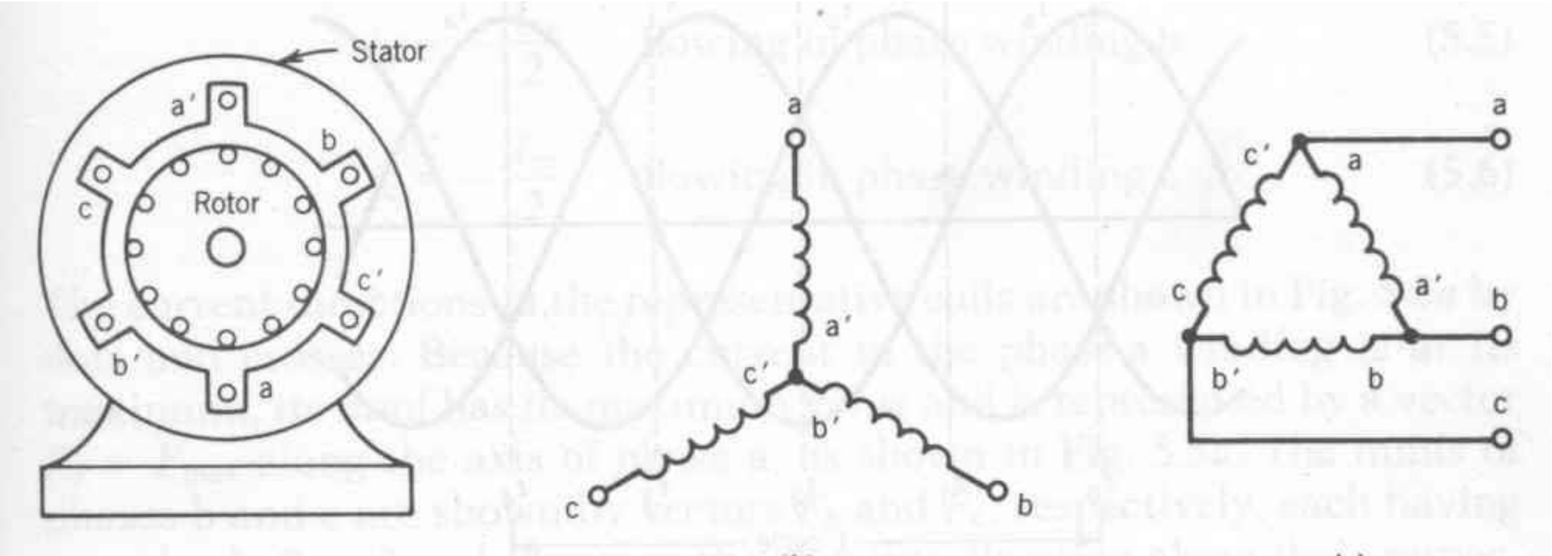





Stator core
Cage (bar)
Rotor core
Shaft

3-Three Phase Stator Windings:

The stator core carries a three phase windings and its fed from a three phase supply. It is wound for a definite number of poles. Coils belonging to each phase are normally connected in series and finally one starting end and one finishing end are available for interconnection with other phase winding in star Y or in delta Δ.



The number of stator slots (N) is given by integer multiplies of three times the number poles (P) for which the machine is designed;

, where n= 1,2,3,…

$$N = n \times 3 \times P$$

If we assume that; C= No. of coils,

m= No. of phases

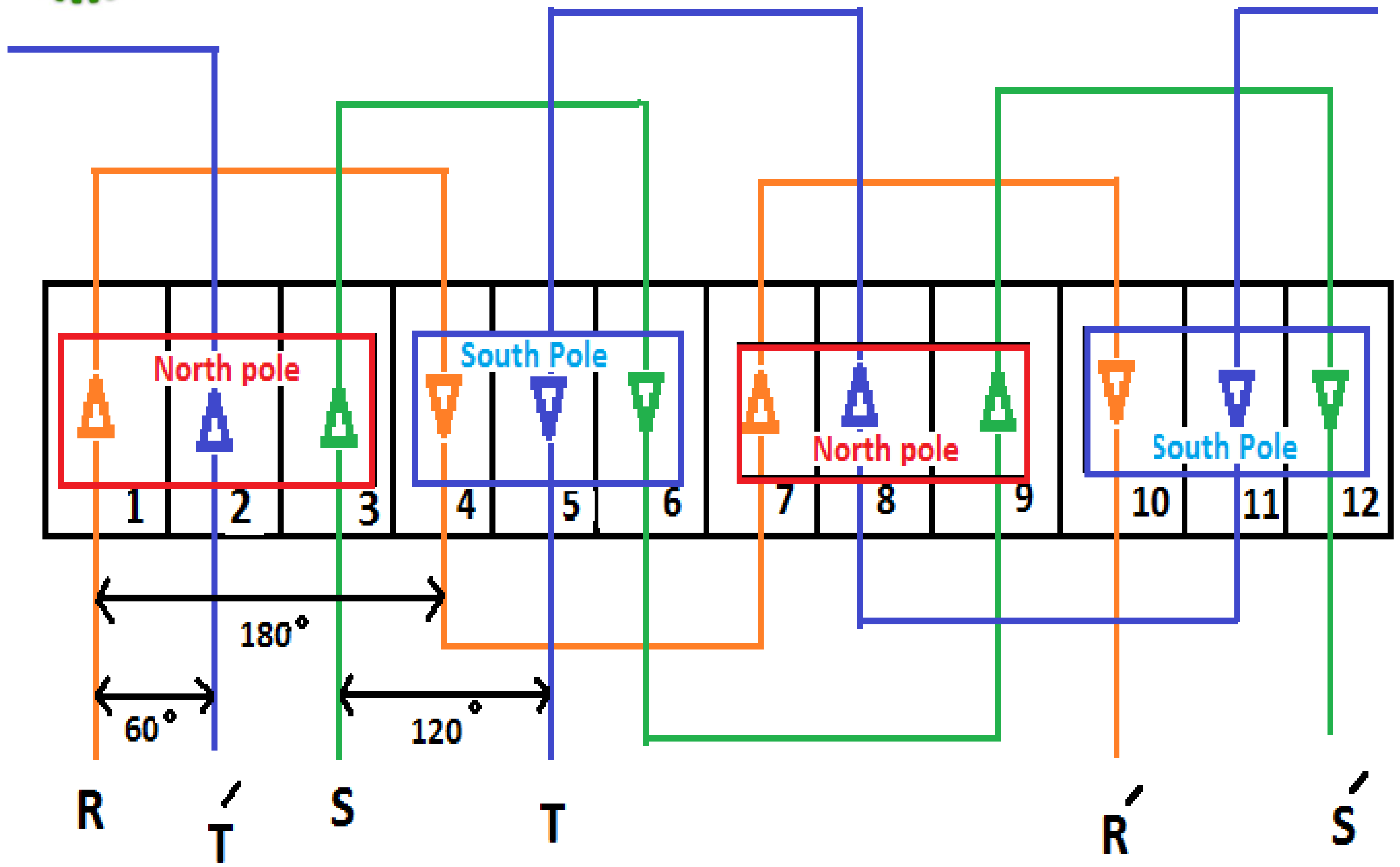
q = No. of slot/ pole/ phase,

γ_p=pole pitch = N/P

α_{ele}= slot pitch (angle of displacement)= $\dfrac{180 \times P}{N}$

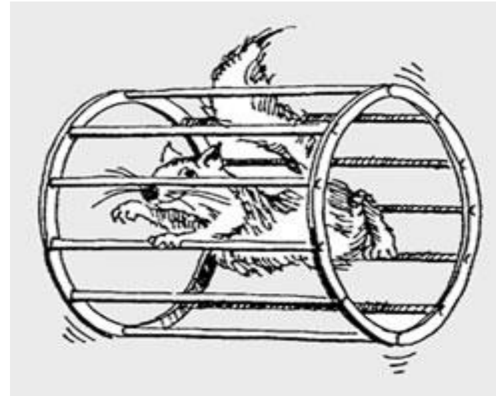
Example: ***Draw the schematic winding diagram for 4-pole, 12 slot stator winding of three phase induction motor.***

Solution: ***q= (12/3/4)= 1 slot/ pole/phase, N= 12, γp=pole pitch = N/P=3. To get maximum emf two side of a coil should be one pole pitch apart. Phase R starts at slot one passes through slots 4,7 and 10. Phase S starts 120 degree after word, which is two slots away from the start of R phases passes through slot 6, 9 and 12 and so for phase T.***



North pole
South Pole
North pole
South Pole
1
2
3
4
5
6
7
8
9
10
11
12
180°
60°
120°
R
T′
S
T
R′
S′

1.3 The Rotor Construction



1- ***The Squirrel Cage Rotor type:***

- ***Its about 90% of the IMs. They simple, rugged and unbreakable in construction.***
- ***The rotor is comprised of a number of thin bars, usually aluminum, slightly longer than the rotor mounted in a laminated cylinder.***
- ***The bars are arranged horizontally and almost parallel to the rotor shaft. At the ends of the rotor, the bars are connected together with a "shorting ring."***

The entire construction (bars and end rings) resembles a squirrel cage from witch the name is derived.

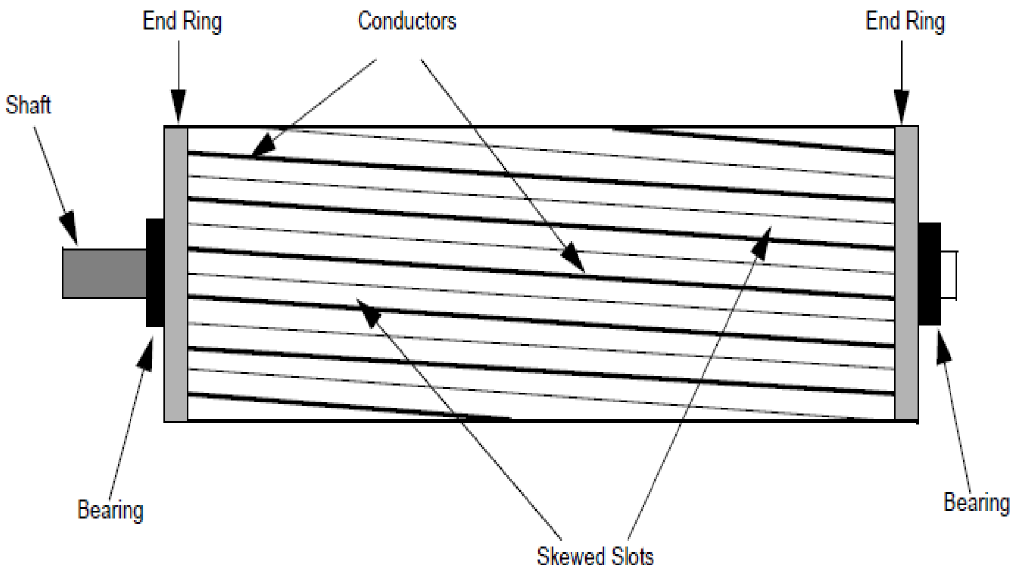
1.3 The Rotor Construction

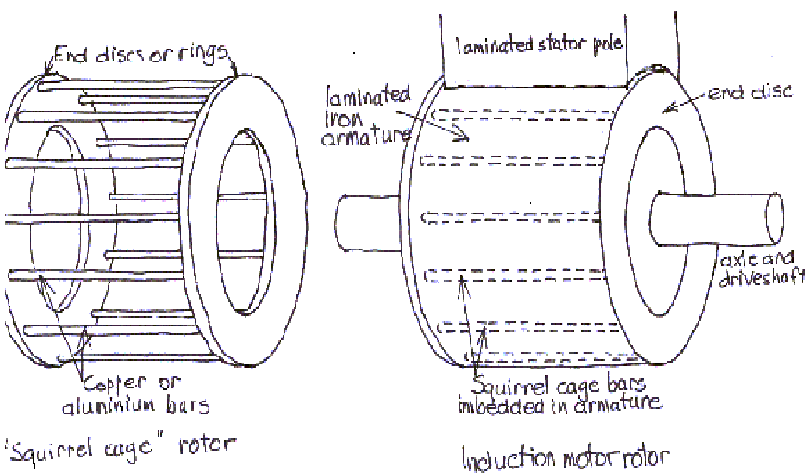
- ***The rotor slots are not exactly parallel to the shaft. Instead, they are given a skew for two main reasons.***

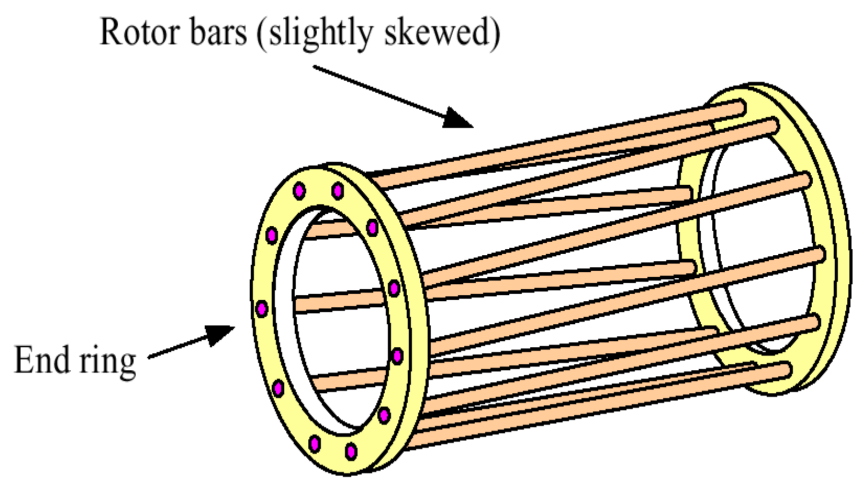
1. ***The first reason is to make the motor run quietly by reducing magnetic hum and to decrease slot harmonics.***
2. ***The second reason is to help reduce the locking tendency of the rotor. The rotor teeth tend to remain locked under the stator teeth due to direct magnetic attraction between the two. This happens when the number of stator teeth are equal to the number of rotor teeth.***

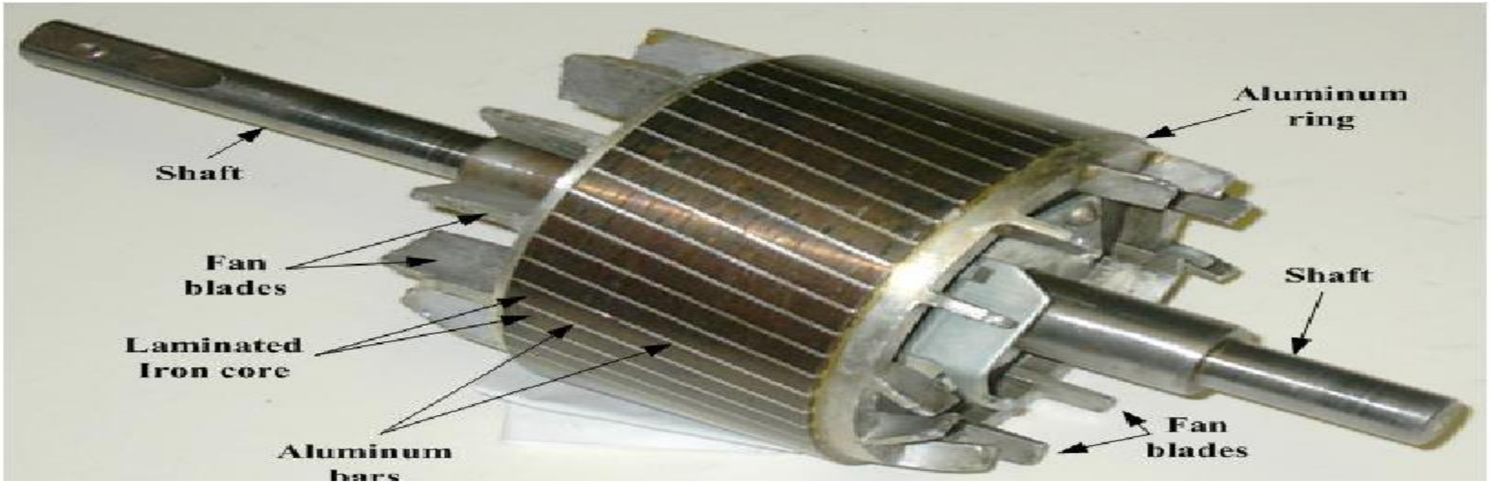
- ***In small motors, the bars and end-rings are die-casting in aluminum to form an integral block.***
-

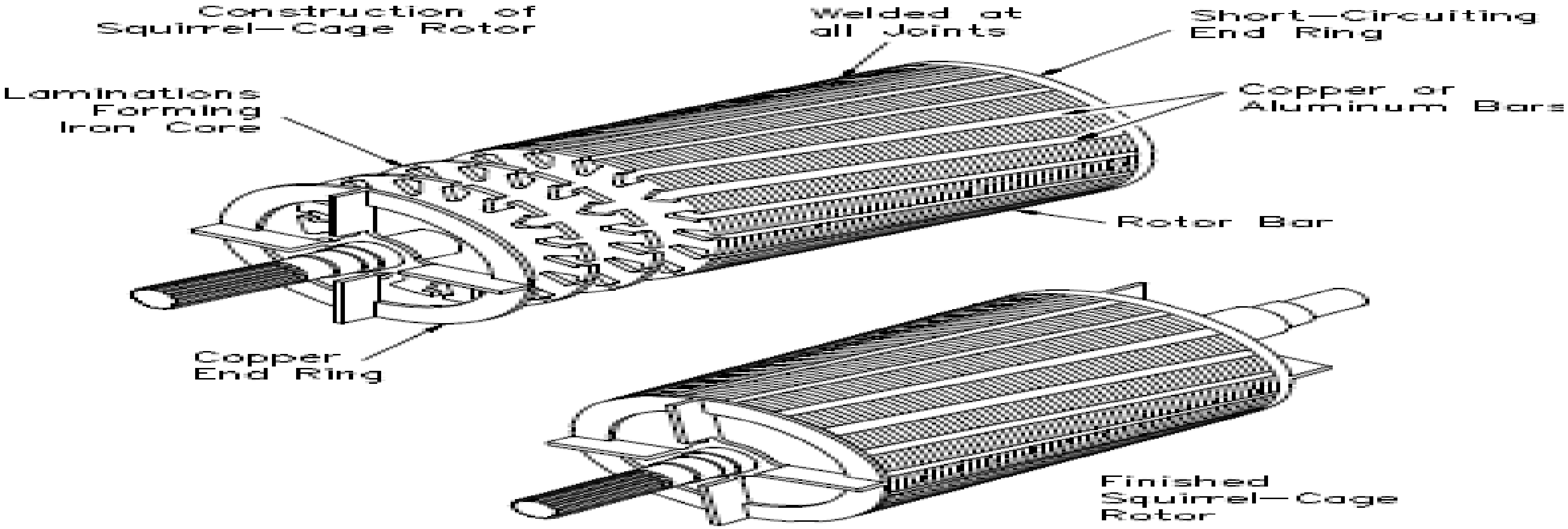
Rotor Construction
1- Squirrel cage type

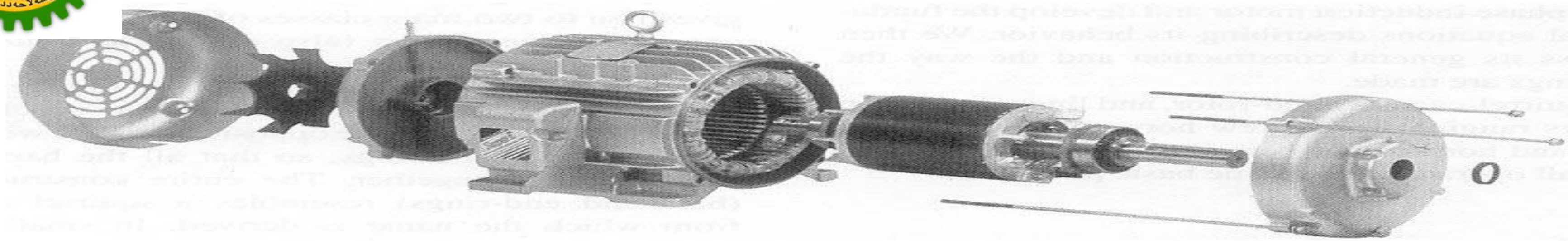


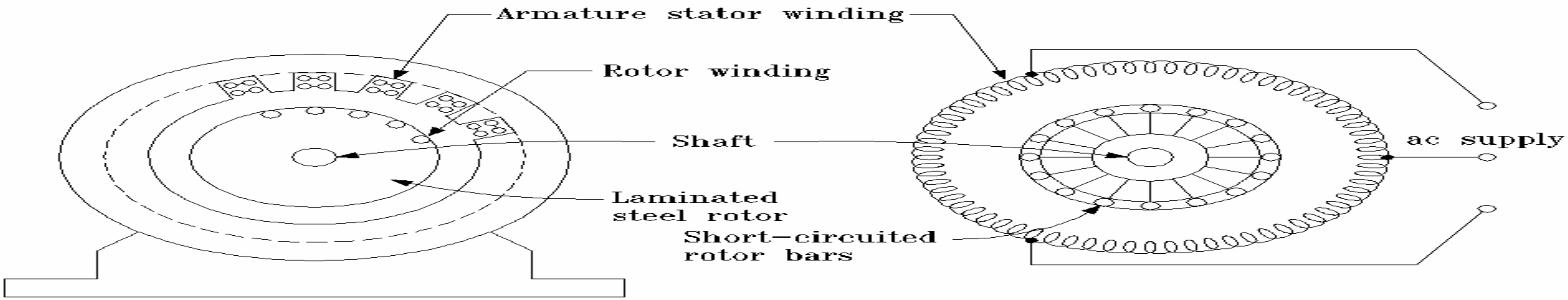




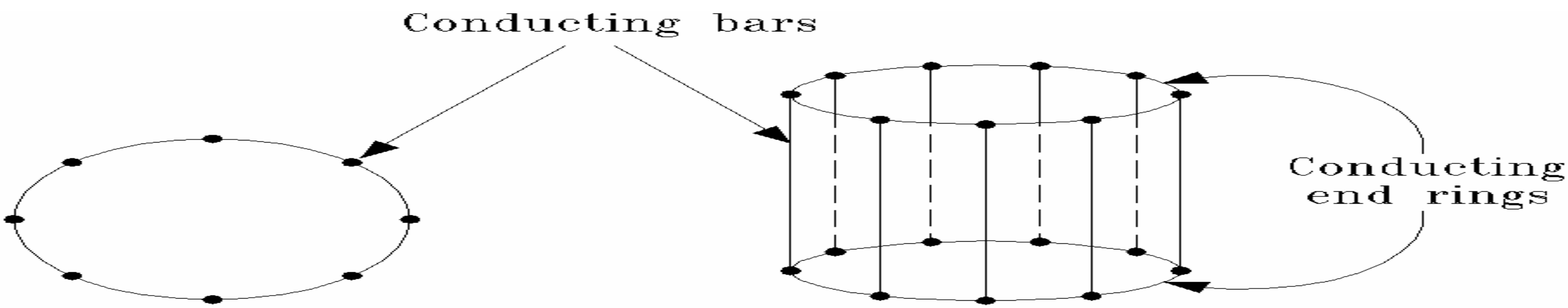

Aluminum ring
Shaft
Fan blades
Shaft
Laminated Iron core
Aluminum bars
Fan blades


Construction of Squirrel—Cage Rotor
Welded at all Joints
Short—Circuiting End Ring
Laminations Forming Iron Core
Copper or Aluminum Bars
Rotor Bar
Copper End Ring
Finished Squirrel—Cage Rotor





(a) Induction dynamo cross-section (b) Electrical connections



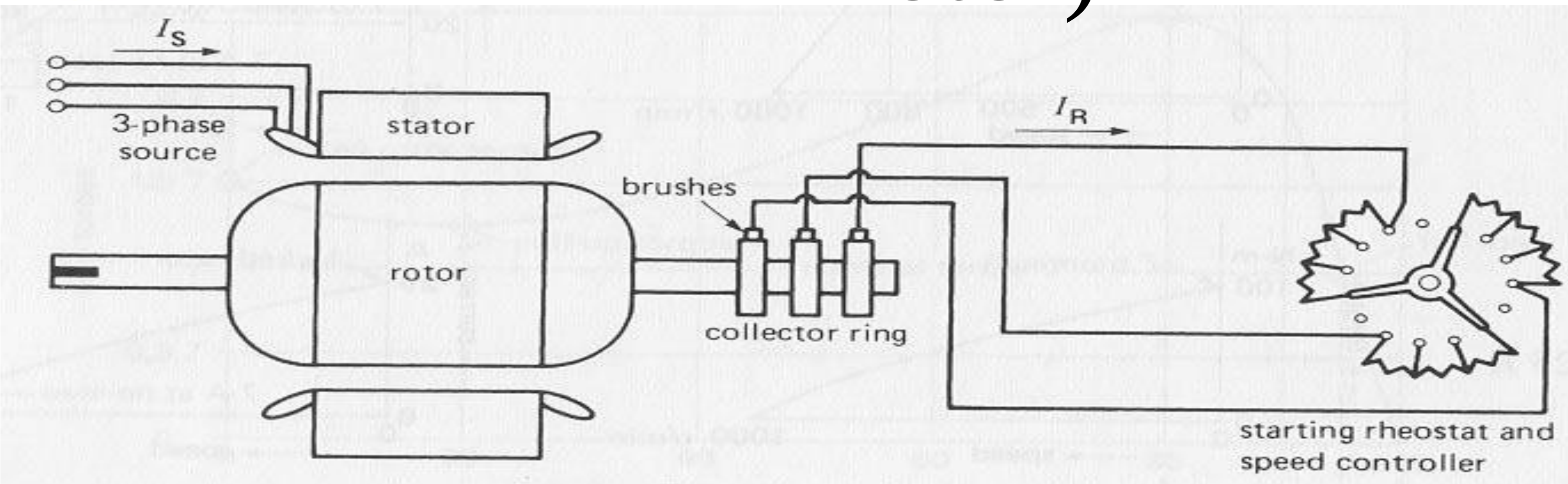
(a) End view (b) Top view (isometric)

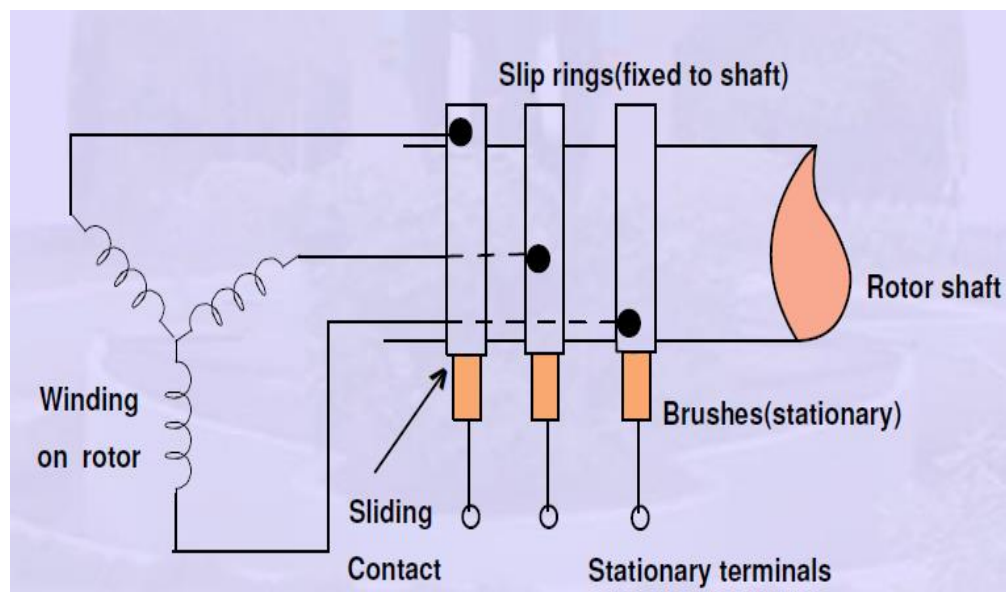
1.3 The Rotor Construction

2 - Slip Ring Rotor

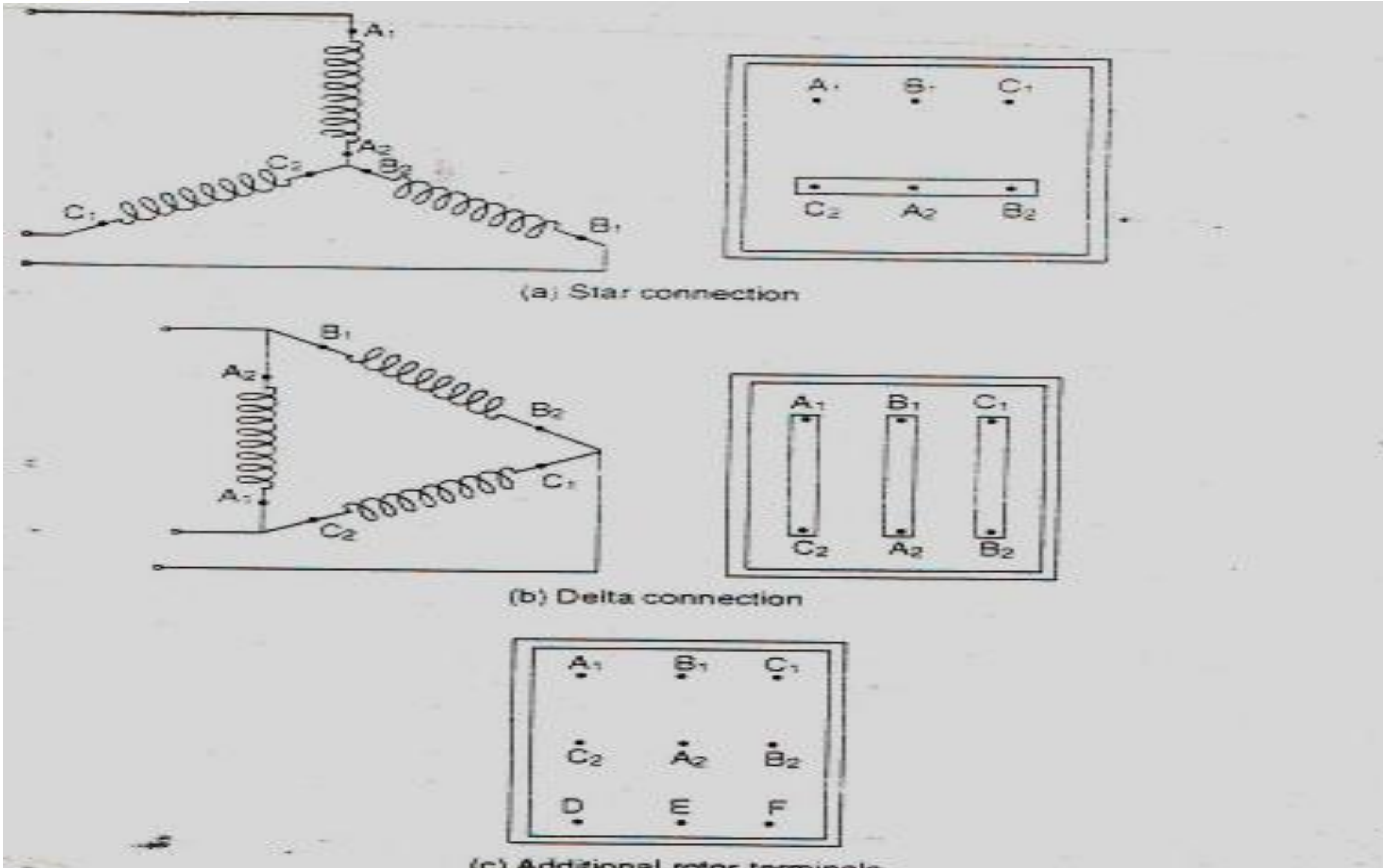
- The slip ring induction motor(wound rotor induction motor), has semi closed rotor slots with in three phase windings.
- It wounds for the same number of stator winding poles. The winding is normally connected in star and the resultant three terminals are connected to three slip-rings provided one end of the shaft.
- The slip rings are made of brass or phosphor-bronze. The rotor winding terminals are connected to three slip rings which turn with the rotor.
- The slip rings/brushes allow external resistors to be connected in series with the winding. The external resistors are mainly used during start-up under normal running conditions the windings short circuit externally

Wound rotor (slip ring Induction motor)





The terminal Box



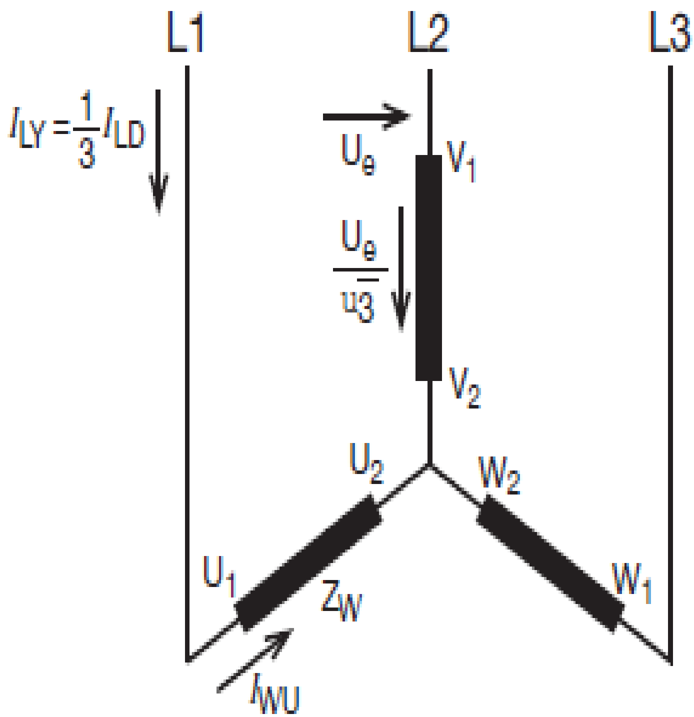
(a) Star connection

(b) Delta connection

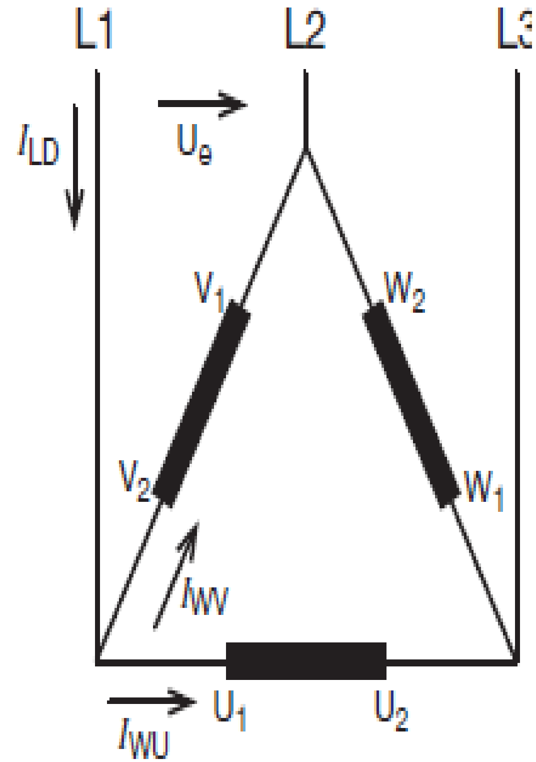
(c) Additional rotor terminals

Chapter one

Three phase Induction Motor Construction



Star Connection



Delta Connection

Note:

1- The clearance between the inner surface of the stator core and the outer surface of the rotor core called air-gap, it is kept as small.

2- It is necessary that the shaft to be made shorter and stiffer so that the rotor may not any significant deflection, because even a small deflection would create large irregularities in the air-gap length which lead to production of unbalance magnetic pull.

A TYPICAL NAME PLATE

<Name of Manufacturer>

ORD. No.	1N4560981324					
TYPE	HIGH EFFICIENCY			FRAME	286T	
H.P.	42			SERVICE FACTOR	1.10	3 PH
AMPS	42			VOLTS	415	Y
R.P.M.	1790			HERTZ	60	4 POLE
DUTY	CONT			DATE	01/15/2003	
CLASS INSUL	F	NEMA DESIGN	B	NEMA NOM. EFF.	95	

<Address of Manufacturer> CSA

NAME PLATE TERMS AND THEIR MEANINGS

Term	Description
Volts	Rated terminal supply voltage.
Amps	Rated full-load supply current.
H.P.	Rated motor output.
R.P.M	Rated full-load speed of the motor.
Hertz	Rated supply frequency.
Frame	External physical dimension of the motor based on the NEMA standards.
Duty	Motor load condition, whether it is continuos load, short time, periodic, etc.
Date	Date of manufacturing.
Class Insulation	Insulation class used for the motor construction. This specifies max. limit of the motor winding temperature.
NEMA Design	This specifies to which NEMA design class the motor belongs to.
Service Factor	Factor by which the motor can be overloaded beyond the full load.
NEMA Nom. Efficiency	Motor operating efficiency at full load.
PH	Specifies number of stator phases of the motor.
Pole	Specifies number of poles of the motor.
CSA	Specifies the motor safety standard.
Y	Specifies whether the motor windings are start (Y) connected or delta (Δ) connected.