Electric motors

Single phase Induction motors:

Double revolving field theory and principle of operation.

Construction and operation of split-phase,

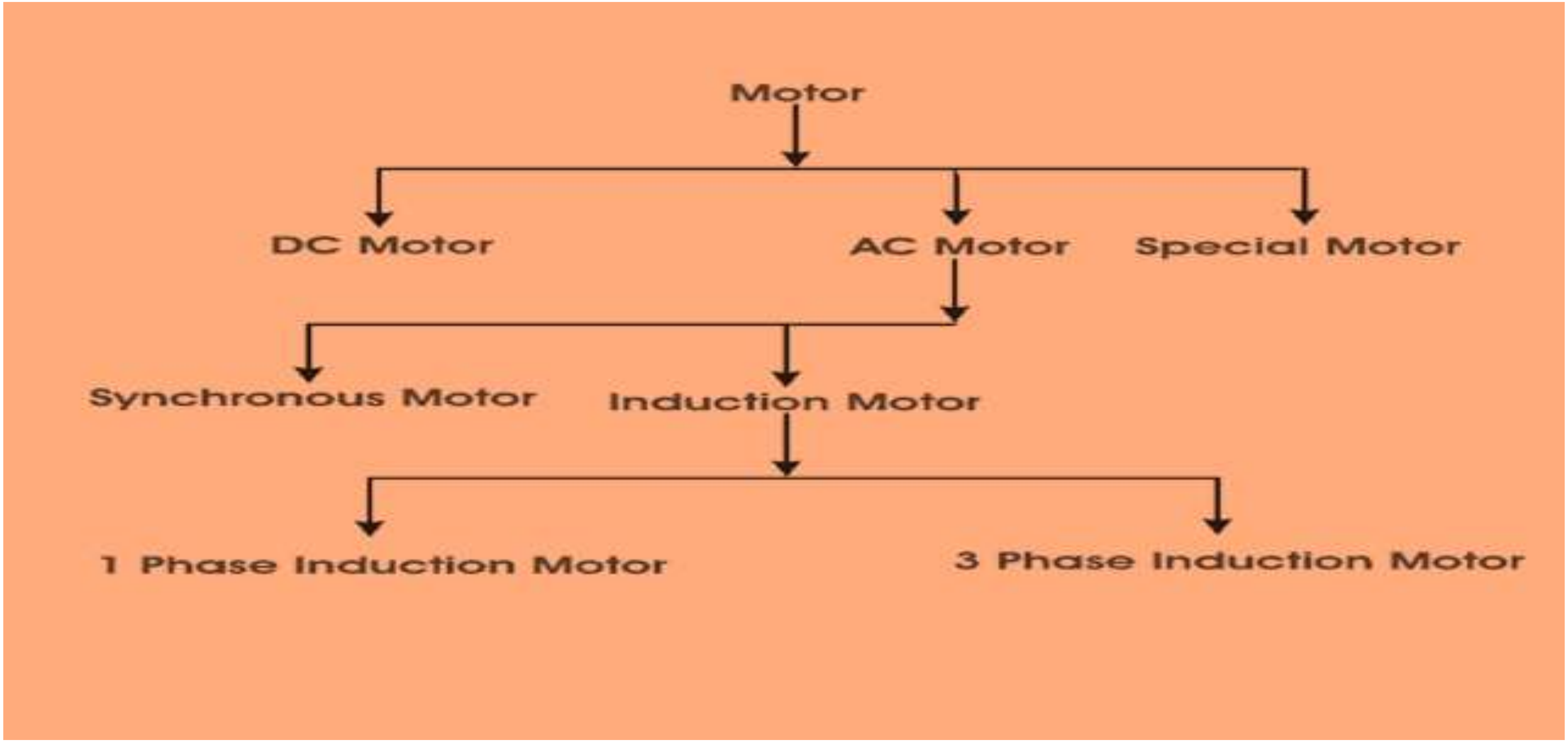
capacitor start,

capacitor run,

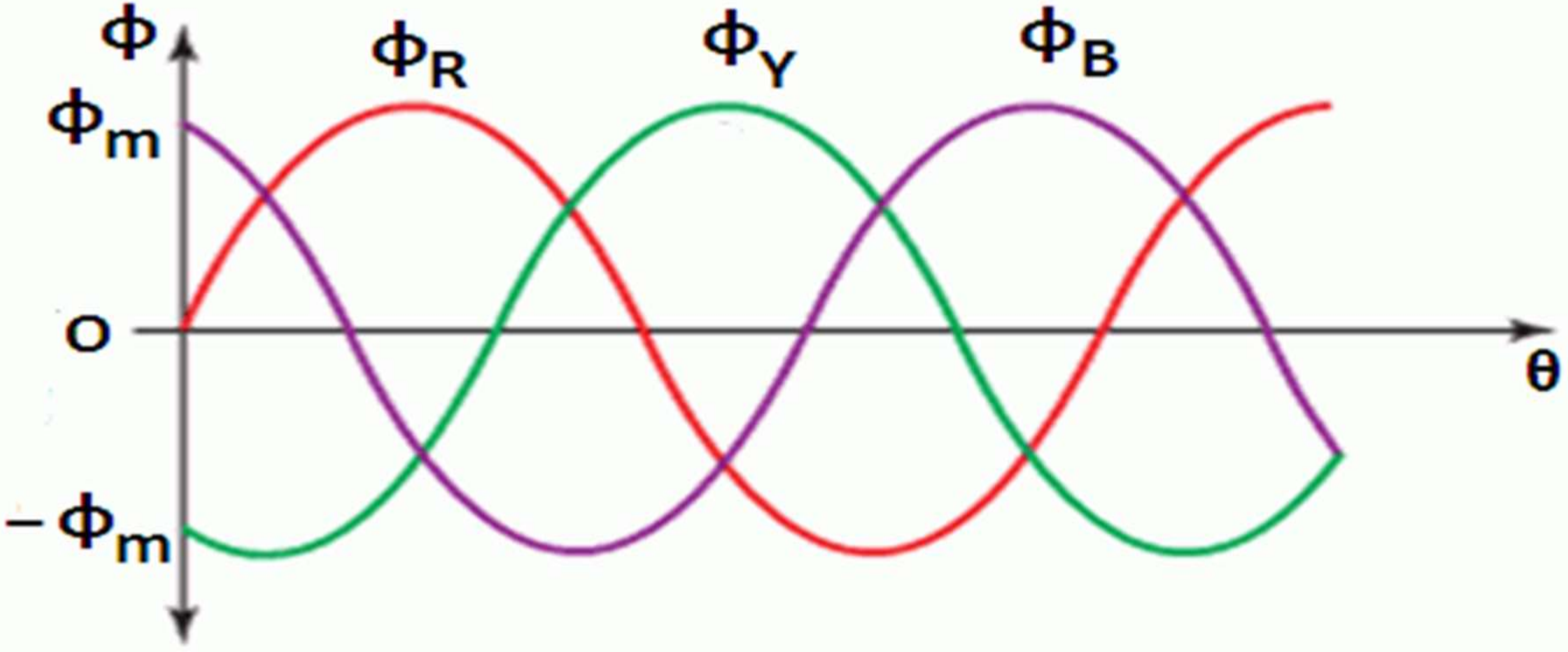
and shaded pole motors.

Comparison of single phase motors and applications.

Classification of electric motors



How rotating magnetic field is produced?



Fluxes produced by line currents

1. *Explain double field revolving theory as applied to a single phase induction motor and prove that it cannot produce any starting torque.*

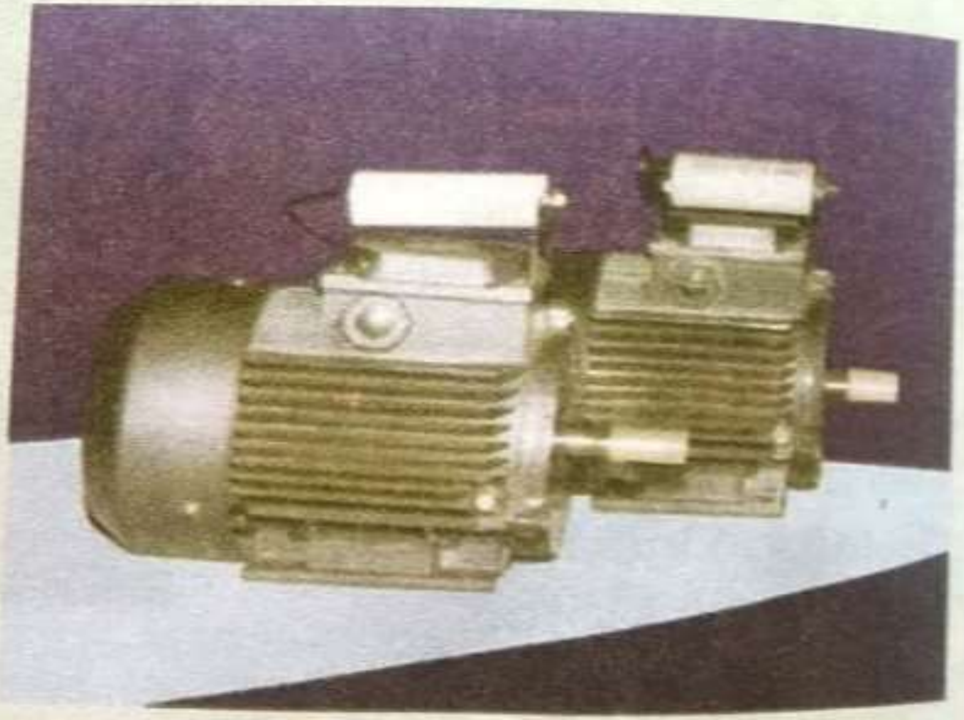
VTU : July-05, 06, 13, Jan.-06, 07, 10, 11, 12, 13, Marks 10

2. *Explain why single phase induction motor is not self starting.*

VTU : July-07, 11, 14, Jan.-09, 14, 15, Marks 5

36.2. Single-phase Induction Motor

Constructionally, this motor is, more or less, similar to a polyphase induction motor, except that (*i*) its stator is provided with a single-phase winding and (*ii*) a centrifugal switch is used in some types of motors, in order to cut out a winding, used only for starting purposes. It has distributed stator winding and a squirrel-cage rotor. When fed from a single-phase supply, its stator winding produces a flux (or field) which is only ***alternating i.e.*** one which alternates along one space axis only. It is not a synchronously revolving (or rotating) flux, as in the case of a two- or a three-phase stator winding fed from a 2-or 3-phase supply. Now, an alternating or pulsating flux acting on a ***stationary*** squirrel-cage rotor cannot produce rotation (only a revolving flux can). That is why a single-phase motor is *not self-starting*.

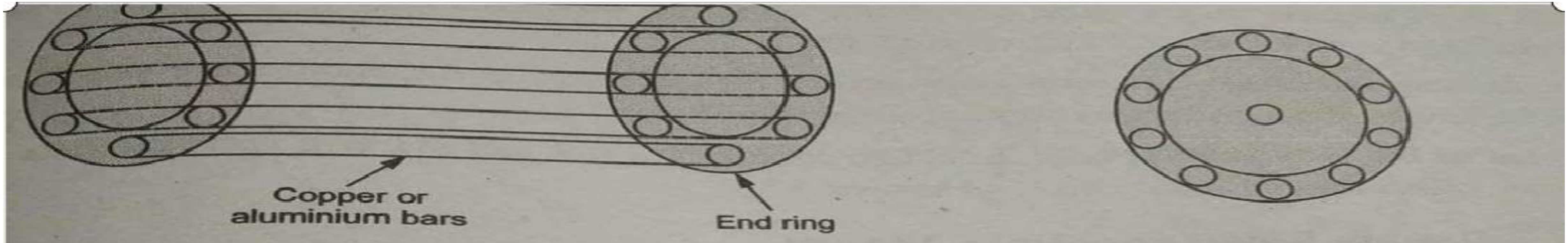


Single-phase induction motor

However, if the rotor of such a machine is given an initial start by hand (or small motor) or otherwise, ***in either*** direction, then immediately a torque arises and the motor accelerates to its final speed (unless the applied torque is too high).

This peculiar behaviour of the motor has been explained in two ways : (*i*) by two -field or double-field revolving theory and (*ii*) by cross-field theory. Only the first theory will be discussed briefly.

Introduction to single phase Induction motors

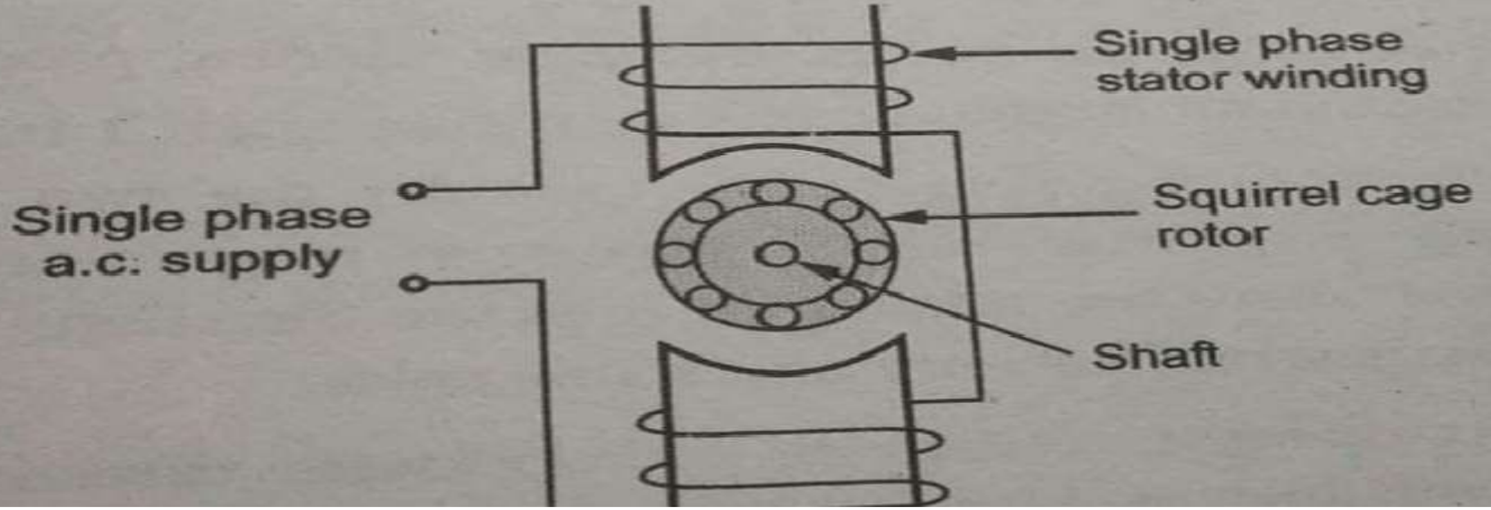


(a) Cage type structure

(b) Symbolic representation

Fig. 6.2.1

schematic representation of two pole single phase induction motor is shown
. 6.2.2.



Double field revolving theory

- This theory makes use of the idea that an alternating uni - axial quantity can be represented by 2 appositively rotating vectors of half magnitude, accordingly sinusoidal flux can be represented by 2 revolving fluxes each equal to half of the value of alternating flux and each rotating synchronously Ns(120f/p) in opposite direction as shown in fig below.

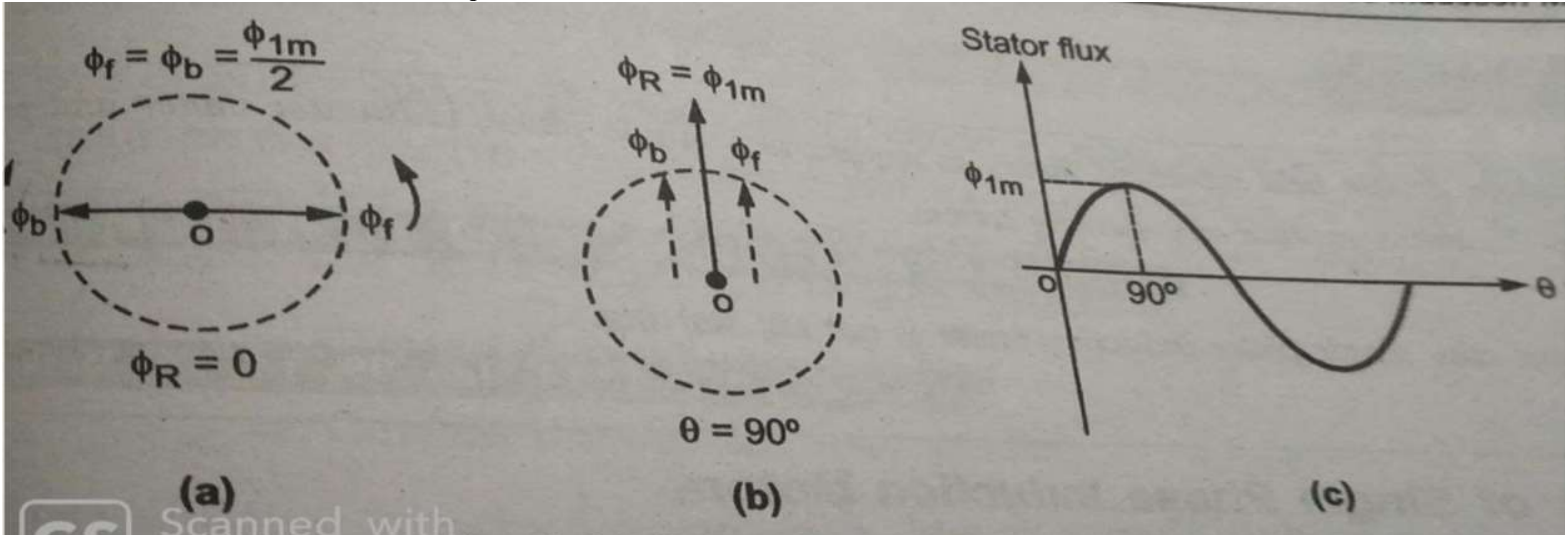


Fig. 6.4.1 Stator flux and its two components

Double field revolving theory-continued...........

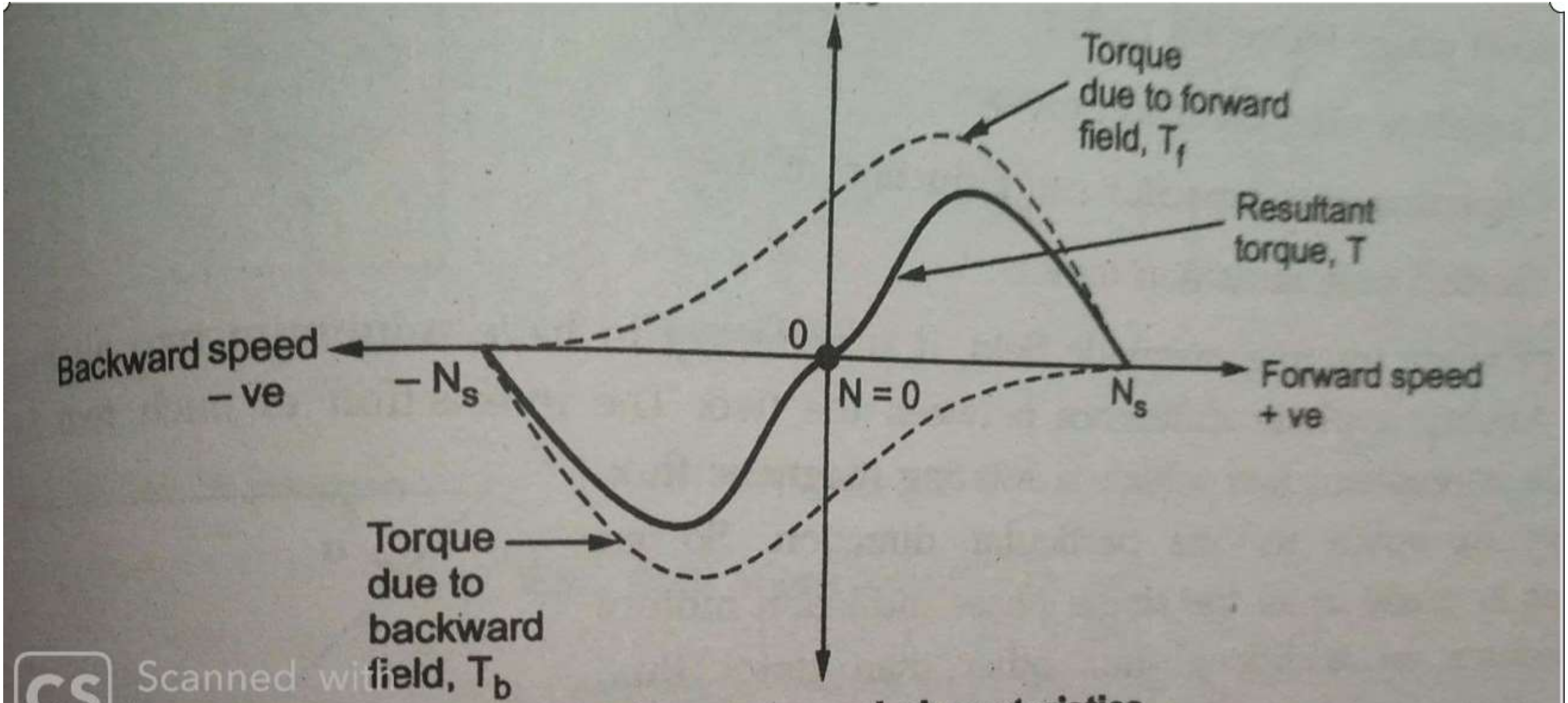


Fig. 6.4.2 Torque-speed characteristics

Types of single phase induction motors

6.5 Types of Single Phase Induction Motors

In practice some arrangement is provided in the single phase induction motors so that the stator flux produced becomes **rotating type** rather than the alternating type, which rotates in one particular direction only. So torque produced due to such rotating magnetic field is unidirectional as there is no oppositely directed torque present. Hence under the influence of rotating magnetic field in one direction, the induction motor becomes self starting. It rotates in same direction as that of rotating magnetic field. Thus depending upon the methods of producing **rotating** stator magnetic flux, the single phase induction motors are classified as,

Types of single phase induction motor

1. Split phase induction motor
2. Capacitor start induction motor
3. Capacitor start capacitor run induction motor
4. Shaded pole induction motor.

To produce rotating magnetic field, it is necessary to have minimum two alternating fluxes having a phase difference between the two. The interaction of such two fluxes produce a resultant flux which is rotating magnetic flux, rotating in space in one particular direction. So an attempt is made in all the single phase induction motors to produce an additional flux other than stator flux, which has a certain phase difference with respect to stator flux. Such two fluxes are shown in the Fig. 6.5.1

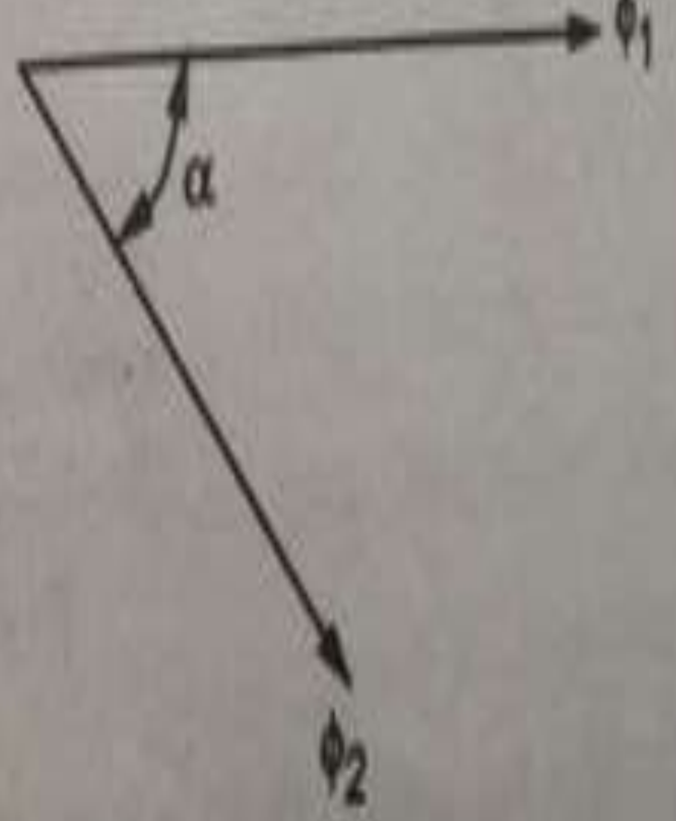


Fig. 6.5.1

Split phase IM

1. Using windings having different impedances(Zs&Zr).
2. Starting winding have high resistance low reactance.
3. Where as main winding has low resistance high reactance.

Split phase induction motor

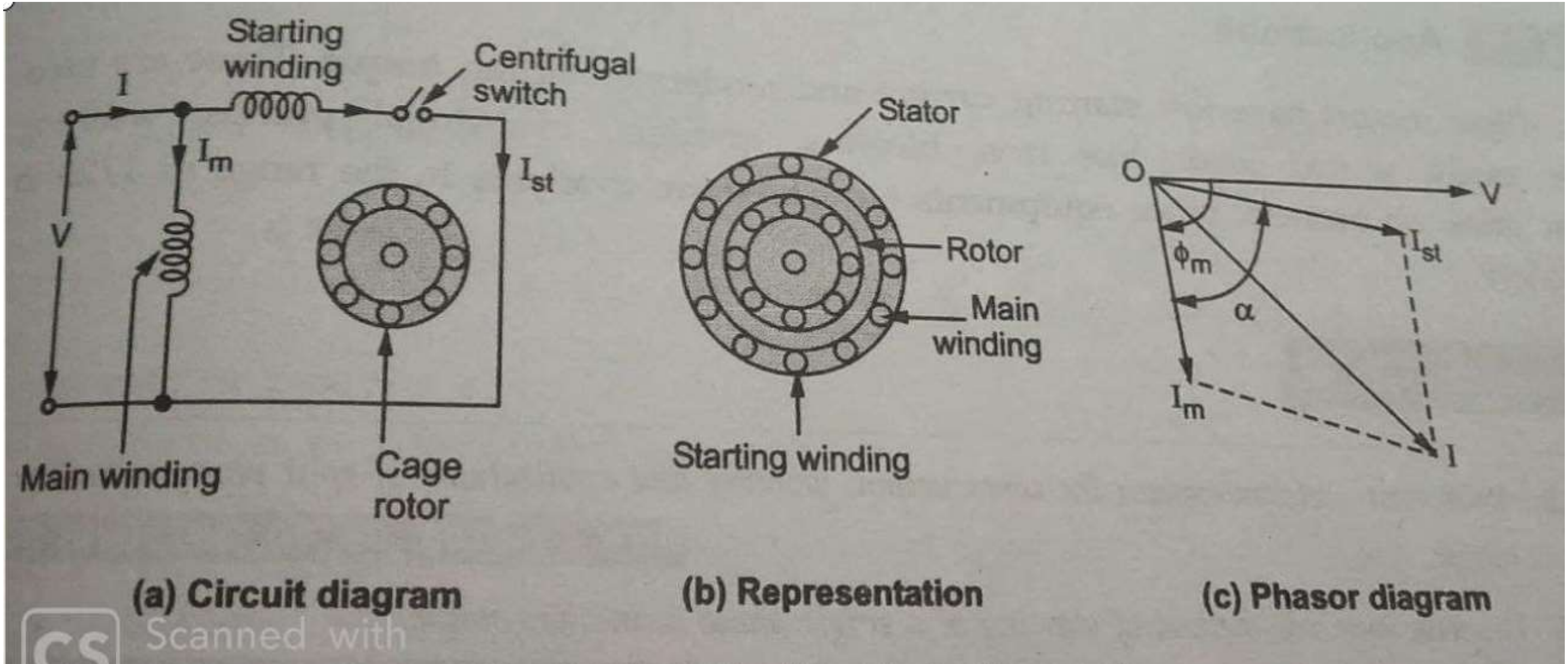


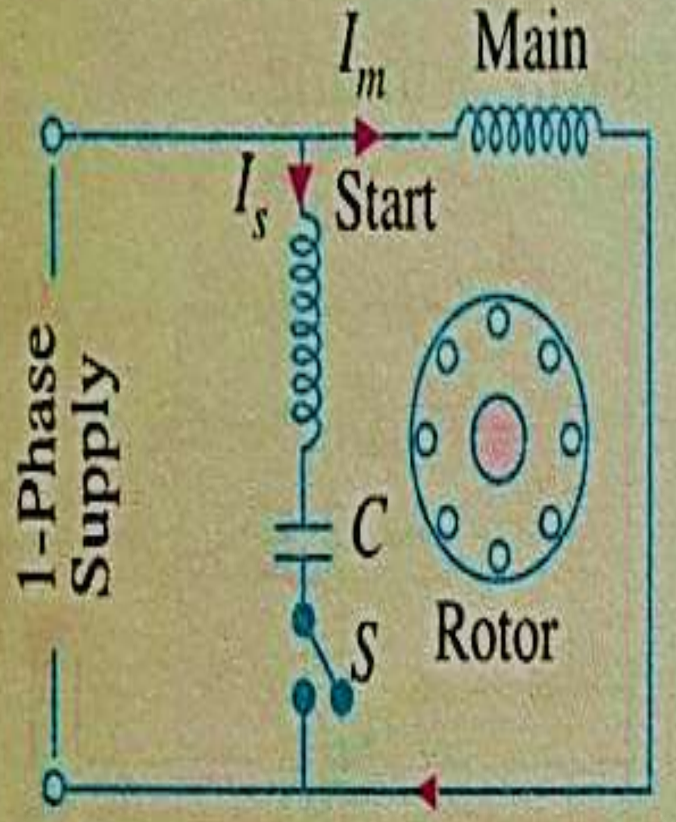
Fig. 6.6.1 Split phase induction motor

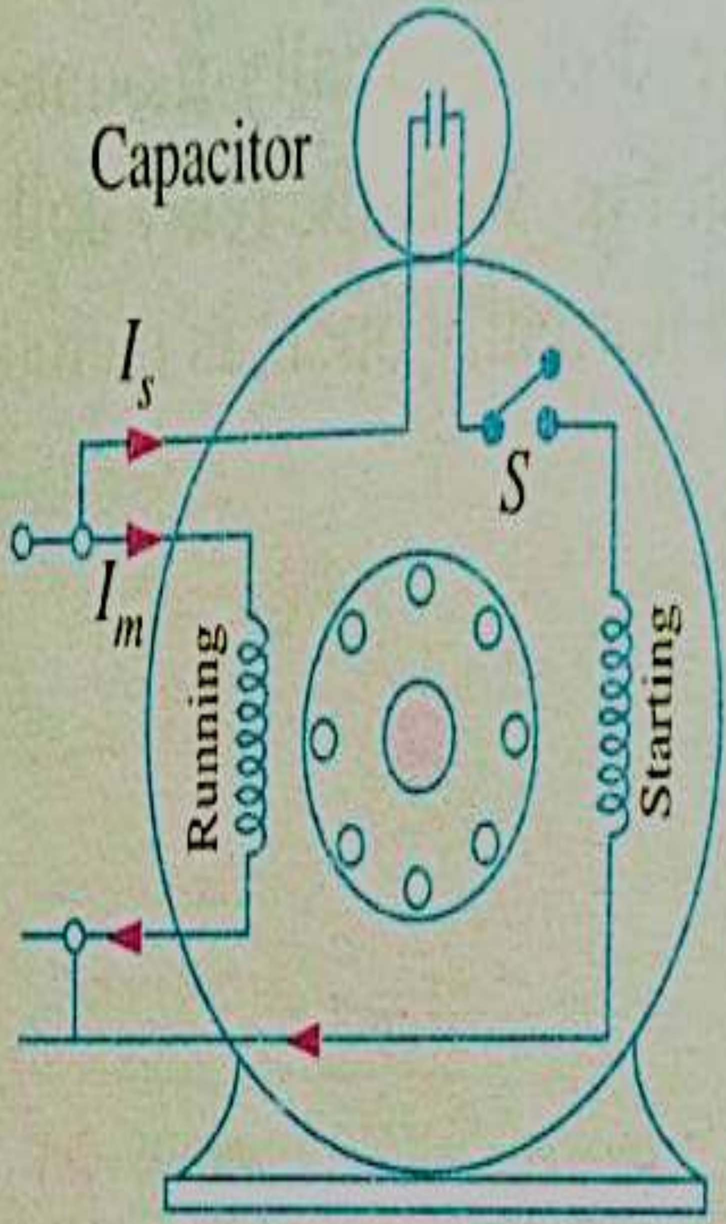
applications of split phase induction motor

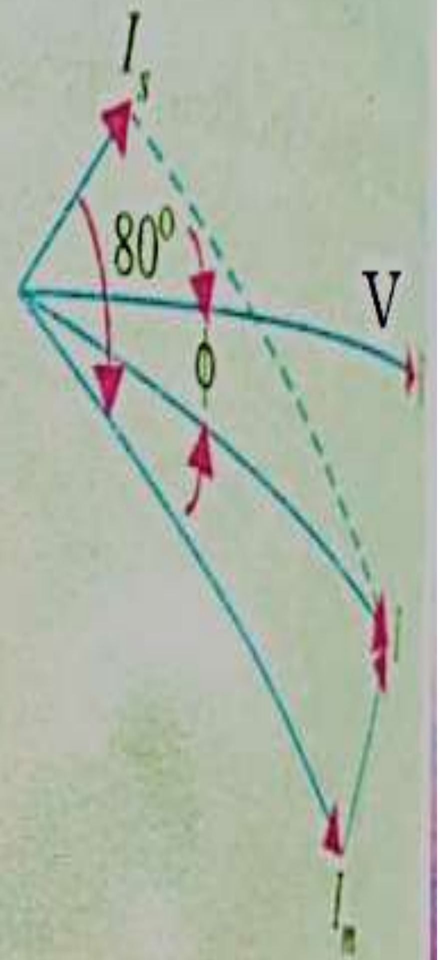
6.6.1 Applications

These motors have low starting current and moderate starting torque. These are used for easily started loads like fans, blowers, grinders, centrifugal pumps, washing machines, oil burners, office equipments etc. These are available in the range of 1/20 to 1 KW.

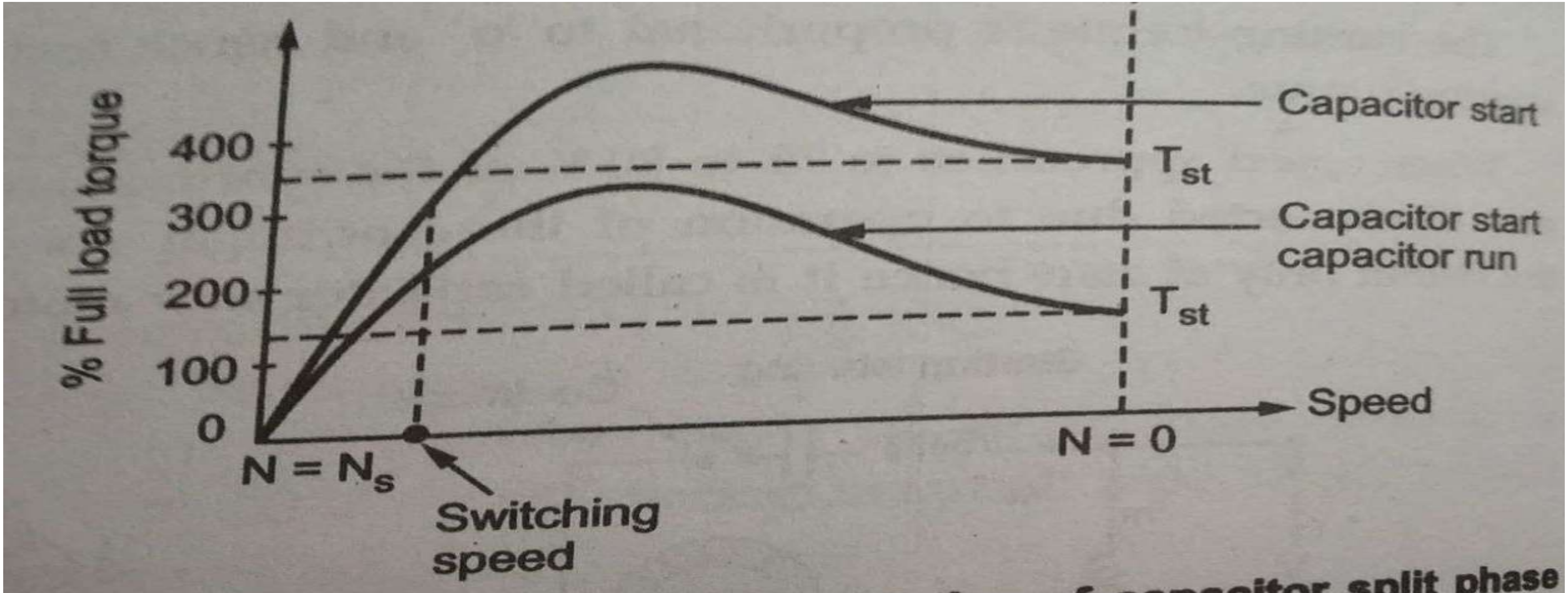
Capacitor start induction motors





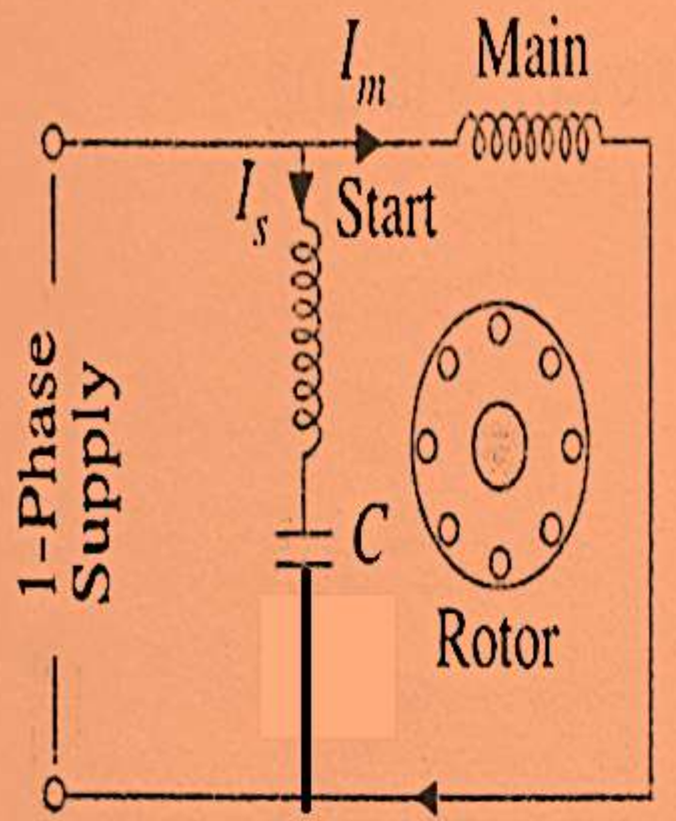


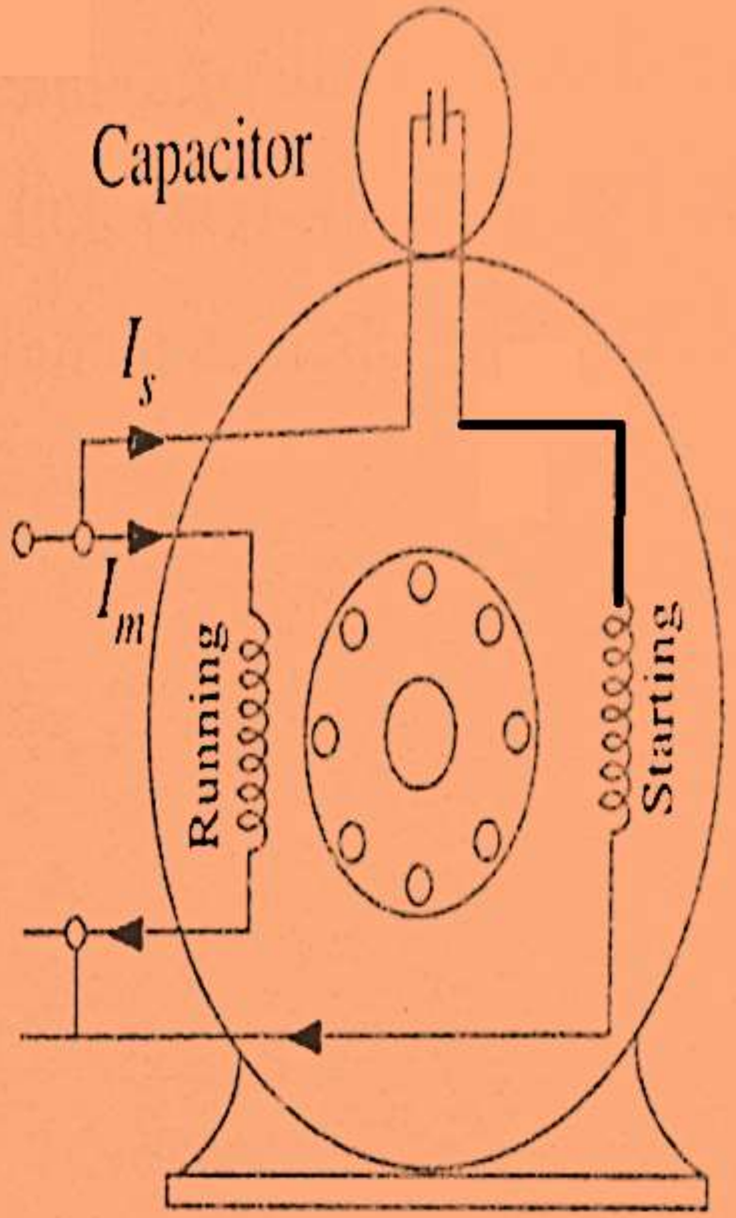
Torque speed characteristics of Capacitor start induction motor

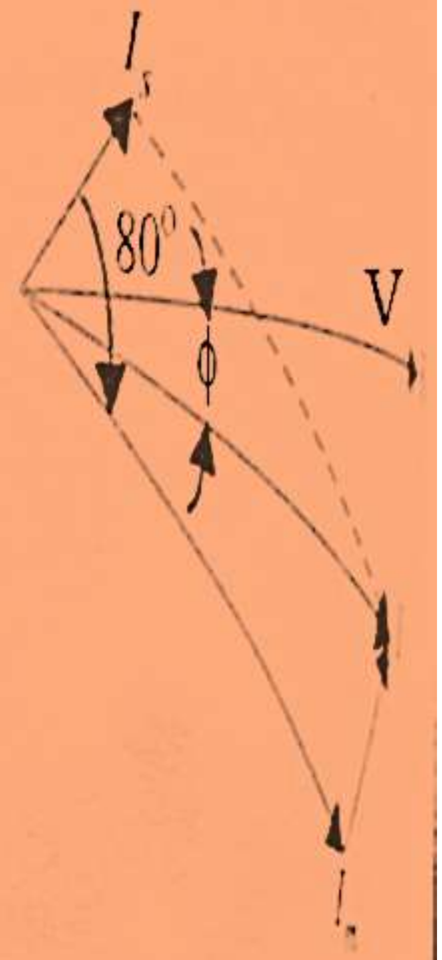


6.7.3 Torque-speed characteristics of capacitor split phase motor

Capacitor start -and Run Motor







Capacitor start and Run motors

- ➢Similar to capacitor start motors, except starting winding is connected all the time parallel to Running winding
- ➢Centrifugal switch is not required.

Advantages:

1. Improvement in over load capacity of the motor(25%)
2. Higher power factor
3. Higher efficiency &pf, ability to start heavy loads
4. Quieter running of the motor which is so much desirable for small drives in offices and labs.

Types of capacitor run single phase induction motors

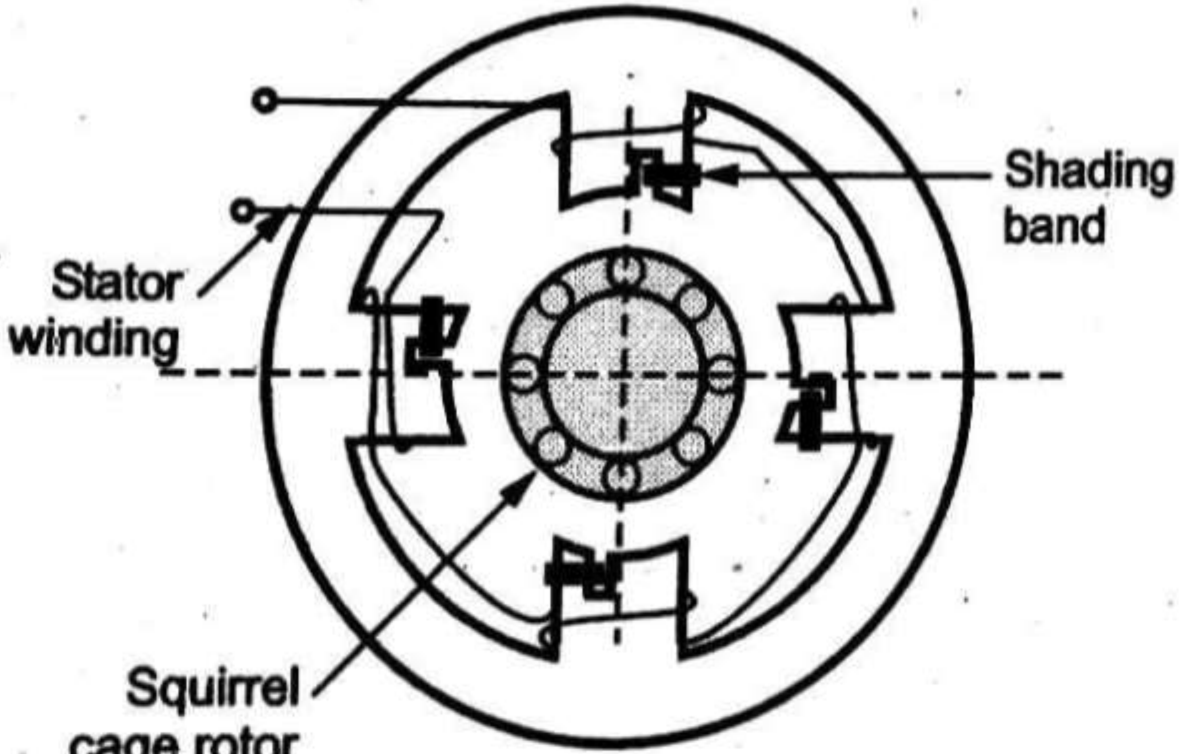
1. Single value capacitor run motor
2. Two value capacitor run motors

Applications: **compressors and fire strokers**

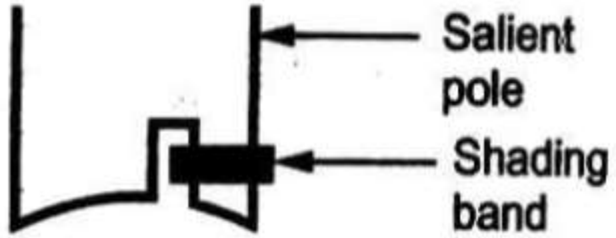
6.8 Shaded Pole Induction Motors

VTU : Jan.-07, 15, July-12, 15

This type of motor consists of a squirrel cage rotor and stator consisting of salient poles i.e. projected poles. The poles are shaded i.e. each pole carries a copper band on one of its unequally divided part called **shading band**. Fig. 6.8.1 (a) shows 4 pole shaded pole construction while Fig. 6.8.1 (b) shows a single pole consisting of copper shading band.



(a) 4 - pole shaded pole construction



(b) Salient pole with shading band

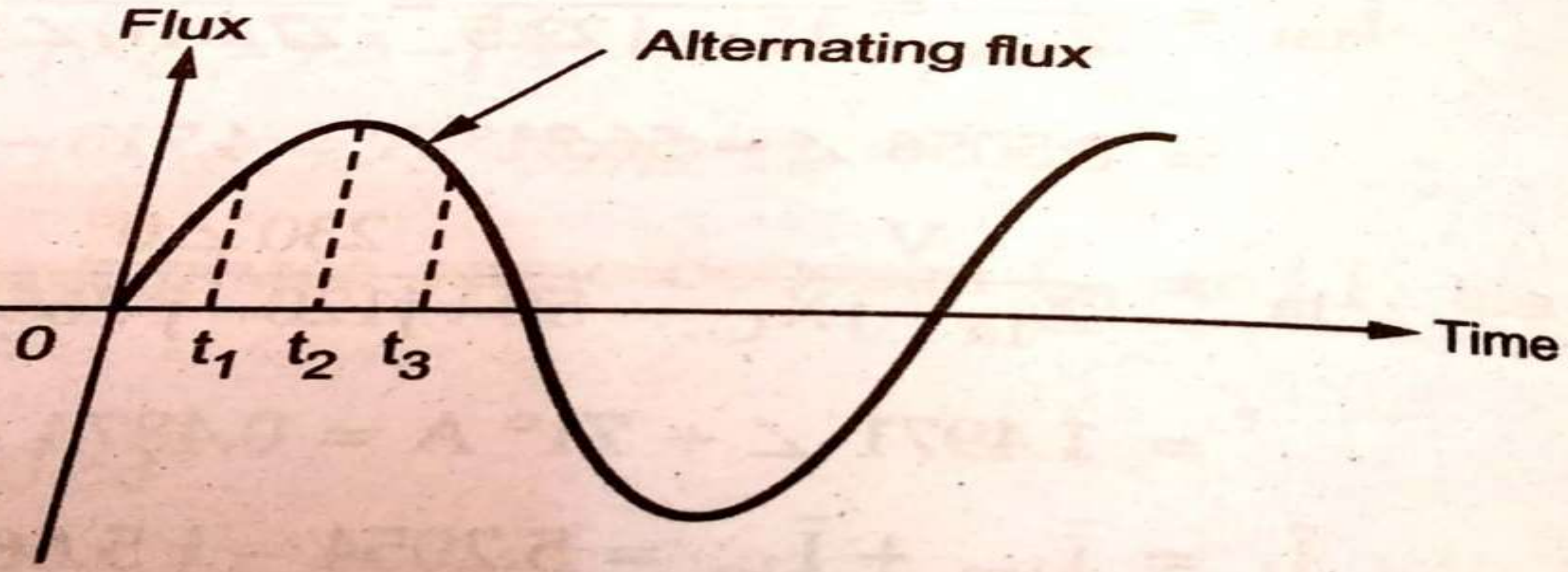


Fig. 6.8.2 (a) Waveform of stator flux

Shaded pole type single phase induction motor

- In this type of single phase induction motor, the necessary phase splitting is done by induction.
- These motors have salient pole on stator and a squirrel cage rotor
- The laminated pole is used in this type of motor
- The laminated pole has a slot cut across the laminations across 1/3 distance from one edge.
- Around the small part of the pole is placed a short circuited copper coil called shading coil. This part is known as shaded part and other part is known as un shaded part.
- When an ac current is passed through field winding surrounding the whole pole, the axis of the pole shifts from unshaded part to the shaded part, this resembles the actual movement of pole

Shaded pole type single phase induction motor

- Exciting current is rapidly increasing from 0 to A.
- This will produce an emf in the shading coil due to **transformer action** as shading coil is of **low resistance.**
- A large current will setup in such a direction to oppose the rise of exciting current. Hence flux shift from unshaded part to shaded part.
- Now exciting current is near to its peak value A to B here change in exciting current is very slow, practically no volt no current in the shading coil.so the magnetic axis shifts **to the center of the pole**.
- Now the exciting current is rapidly decreasing from **B to C.**
- this again set the induced current in the shading coil by transformation action. This current will flow to oppose the decrease in current. <u>Due to this flux strengthens in shaded part of the pole.</u>
- Consequently the magnetic axis shift to the middle part of the shaded pole.

- As per the discussion,
- During positive half cycle of the exciting current,

N pole shifts along the pole from the **unshaded to the shaded part.**

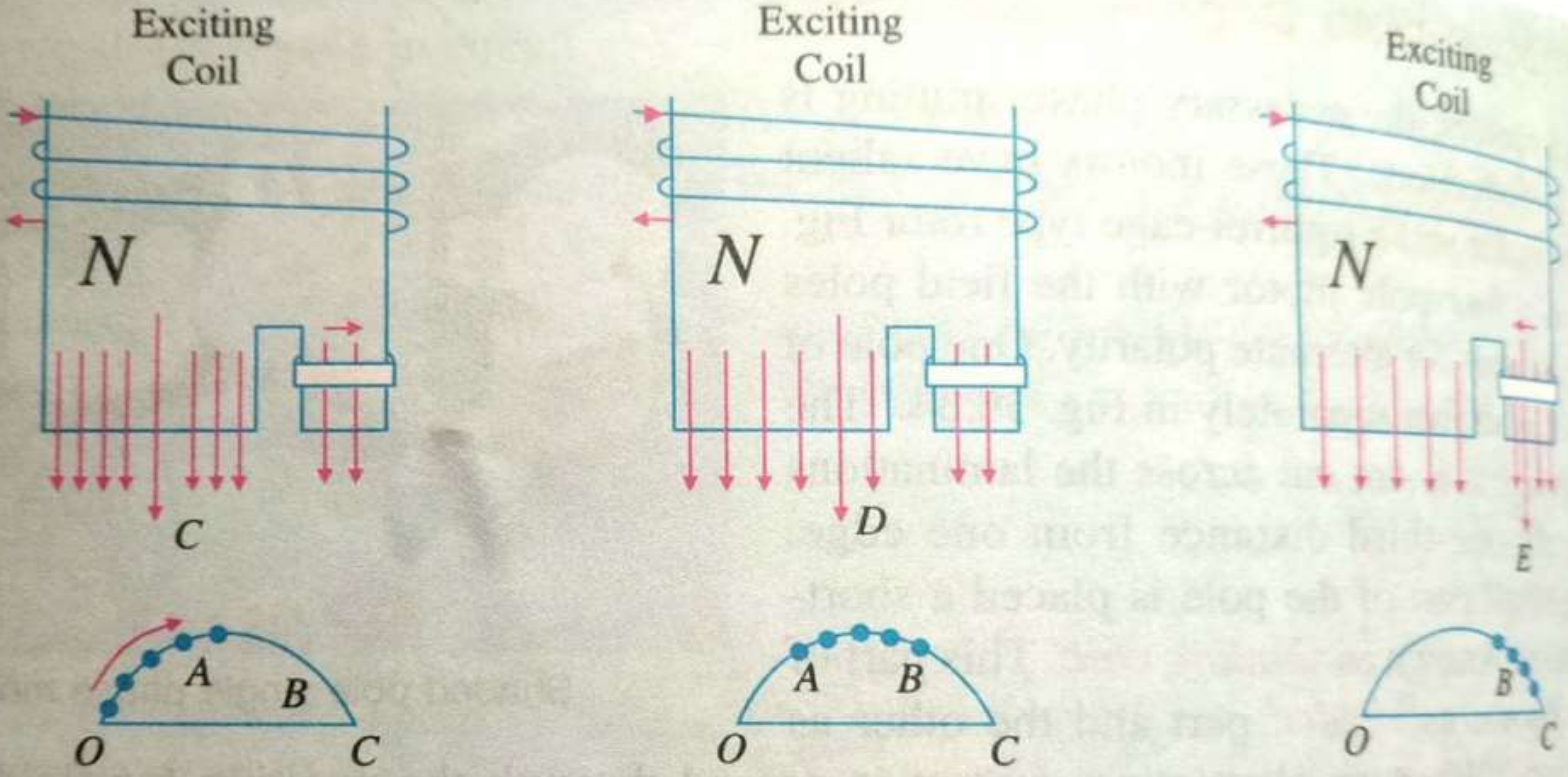
- During negative half cycle of the exciting current south pole trials along.
- This resembles the actual movement of poles.
- Rating of shaded pole motors available 1/250 HP to 1/6 HP

Advantages:

- very cheap, simple construction,extreamly rugged, reliable &cheap

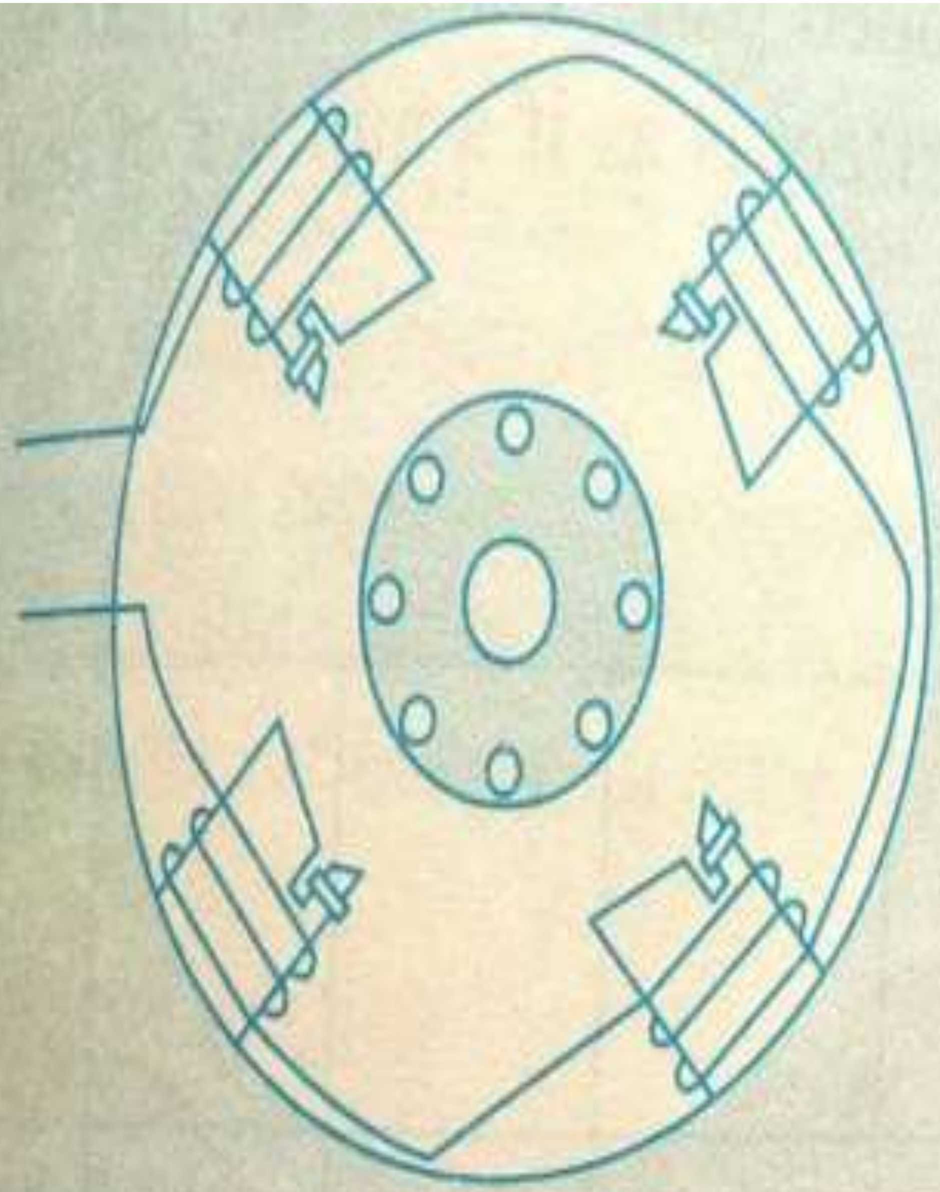
Disadvantages:

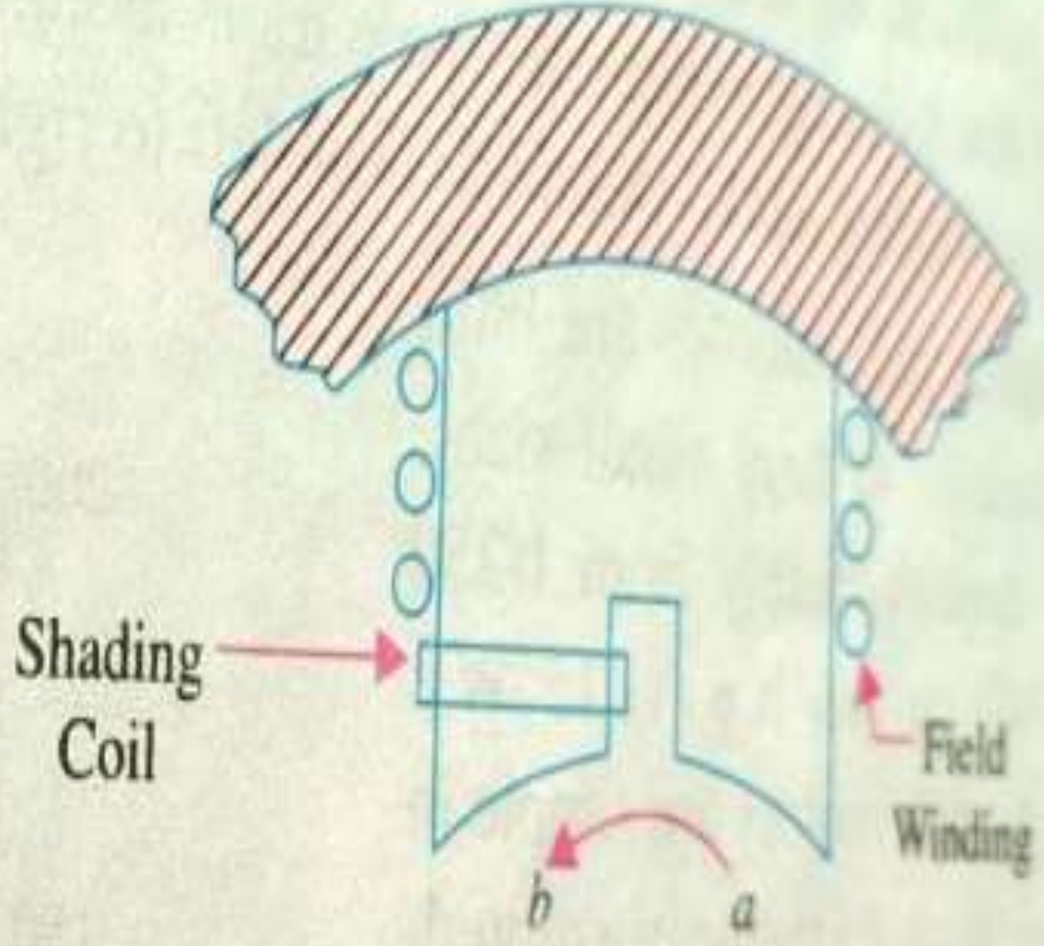
- Low starting torque,
- Very little over load capacity
- Low efficiency (5 to 35%)


Exciting Coil
N
C
A
B
O
C
Exciting Coil
N
D
A
B
O
C
Exciting Coil
N
E
B
O
C

(a) (b) (c)

...part to the shaded part.





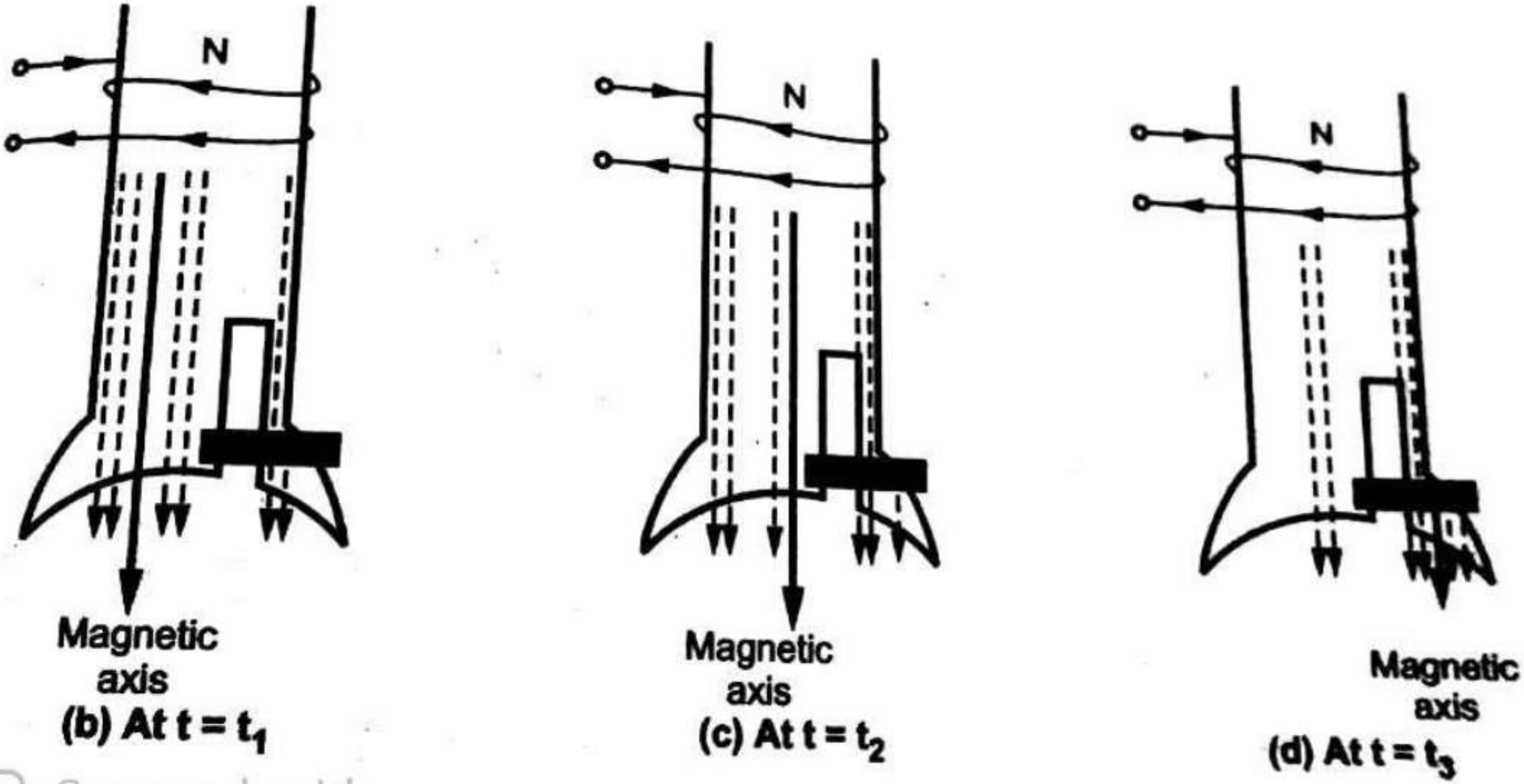
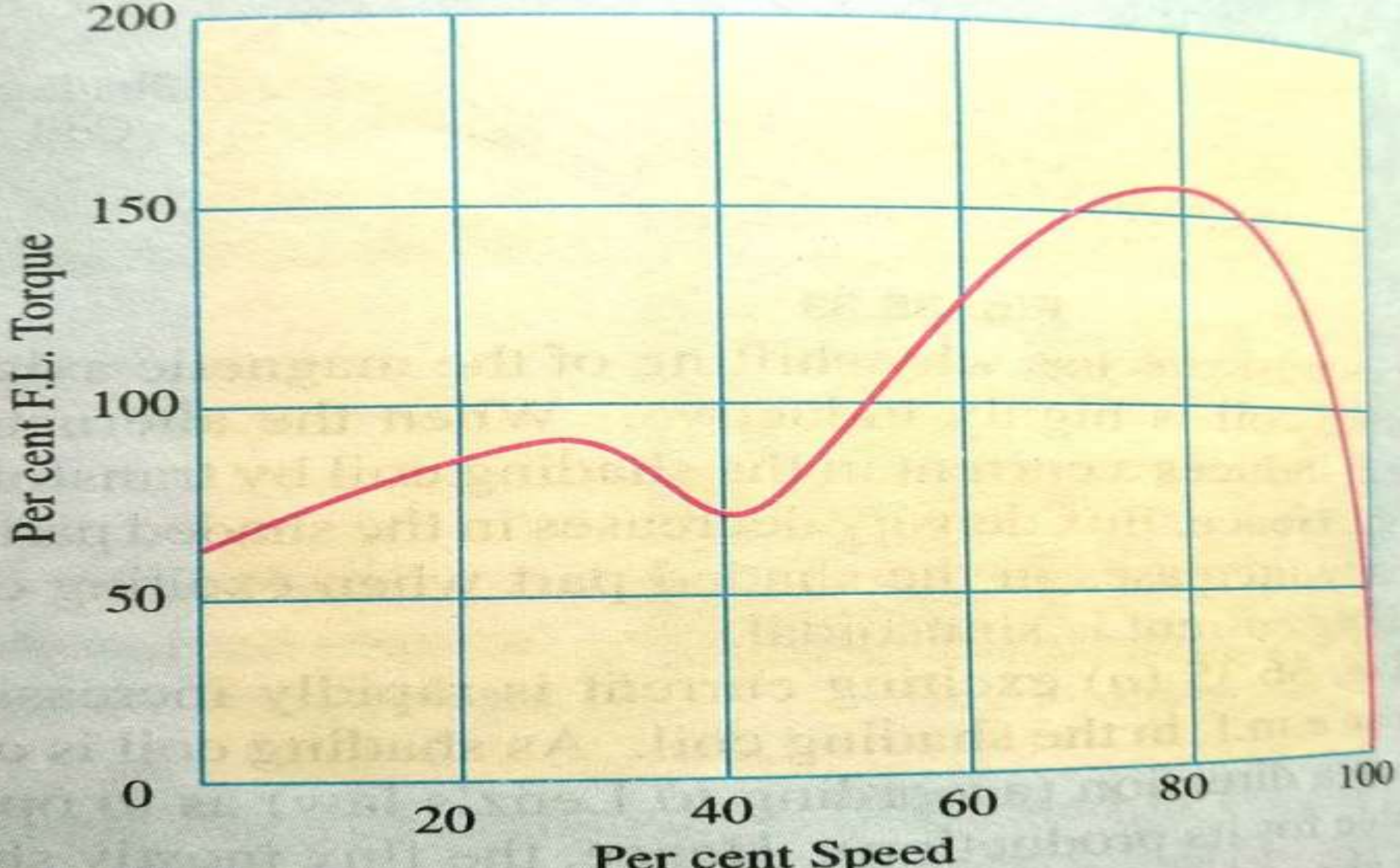


Fig. 6.8.2 (b), (c) and (d) Production of rotating magnetic field in shaded pole motor



200
150
100
50
0
Per cent F.L. Torque
20
40
60
80
100
Per cent Speed

Applications of shaded pole induction motor

6.8.1 Applications

These motors are cheap but have very low starting torque, low power factor and low efficiency. These motors are commonly used for the small fans, toy motors, advertising displays, film projectors, record players, gramophones, hair dryers, photo copying machines etc.