TYPES OF SINGLE PHASEINDUCTIONMOTOR

In practice some arrangement is provided in the single phase induction motors so as that the stator flux produced becomes rotating type rather than the alternating type, which rotates in 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,

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 produces 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.

More the phase difference angle α, more is starting torque produced. Thus production of rotating magnetic field at start is important to make the single phase induction motors self starting. Once the motor starts, then another flux Φ_2 may be removed and motor can continue to rotate under influence of stator flux or main flux alone. Let us see how the rotating magnetic field is produced in various types of single phase induction motors.

Split Phase Induction Motor

This type of motor has single phase stator winding called main winding. In addition to this, stator carries one more winding called auxiliary winding or starting winding. The auxiliary winding carries a series resistance such that its impedance is highly resistive in nature. The main winding is inductive in nature.

Let I_m = Current through main winding

and Ist = Current through auxiliary winding

As main winding is inductive, current I_m lags voltage by V by a large angle $\Phi_m$while Ist is almost in phase in V as auxiliary winding is highly resistive. Thus three exists a phase difference of α between the two currents and hence between the two fluxes produced by the two currents. This is shown in the Fig.1(c). The resultant of these two fluxes is a rotating magnetic field. Due to this, the starting torque, which acts only in one direction is produced.

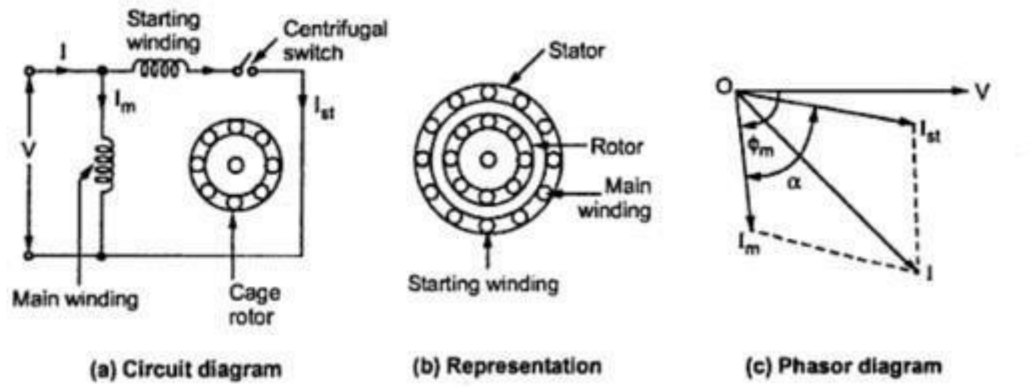
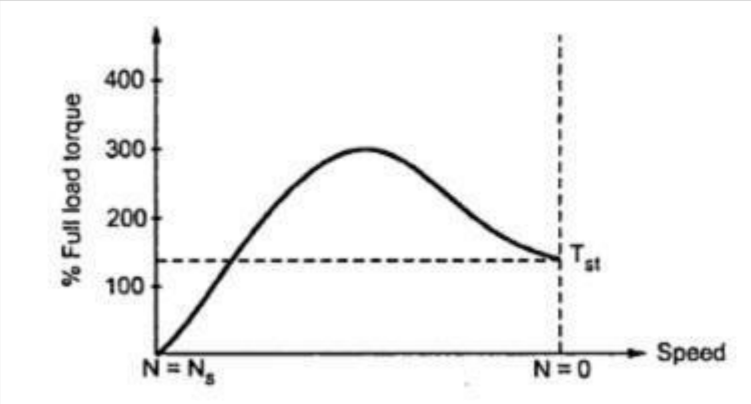


Fig. 5.3.1 **Split phase induction**

The auxiliary winding has a centrifugal switch in series with it. When motor gather a speed upto 75 to 80% of the synchronous speed, centrifugal switch gets opened mechanically and in running condition auxiliary winding remains out of the circuit. So motor runs only stator winding. So auxiliary winding is designed for short time use while the main winding is designed for continuous use. As the current $I_m$and are splitted from each other by angle 'α ' at start, the motor is commonly called split phase motor.



The torque-speed characteristics of split phase motors is shown in the Fig.5.3.2

The starting torque Tst is proportional to the split angle 'α ' but split phase motors give poor starting torque which is 125 to 150% of full load torque.

The direction of rotation of this motor can be reversed by reversing the terminals of either main winding or auxiliary winding. This changes the direction of rotating magnetic field which in turn changes the direction of rotation of the motor.

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 1/120 to 1/2 kW.

Capacitor Start Induction Motors

The construction of this type of motors is similar to the resistance split phase type. The difference is that in series with the auxiliary winding the capacitor is connected. The capacitive circuit draws a leading current, this feature used in this type to increase the split phase angle α between the two currents I_m and Ist.

Depending upon whether capacitor remains in the circuit permanently or is disconnected from the circuit using centrifugal switch, these motors are classified as,

1. Capacitor start motor and 2. Capacitor start capacitor run motors

The connection of capacitor start motor is shown in the Fig. 1(a). The current $I_m$lags the voltage by angle Φ_m while due to capacitor the current Ist leads the voltage by angleΦ_{st}. Hence there exists a large phase difference between the two currents which is almost 90^o , which is an ideal case. The phasor diagram is shown in the Fig.5.8.

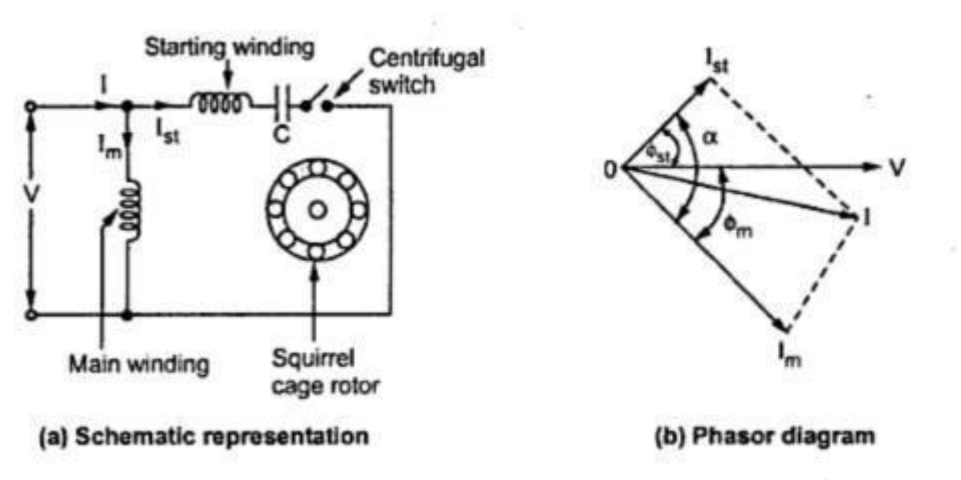


Fig 5.3.3 Capacitor start

The starting torque is proportional to 'α 'and hence such motors produce very high starting torque .

When speed approaches to 75 to 80% of the synchronous speed, the starting winding gets disconnected due to operation of the centrifugal switch. The capacitor remains in the circuit only at start hence it is called capacitor start motors.

Key point : In case of capacitor start capacitor run motor, there is no centrifugal switch and capacitor remain permanently in the circuit. This improves the power factor.

The schematic representation of such motor is shown in the Fig. 5.3.4

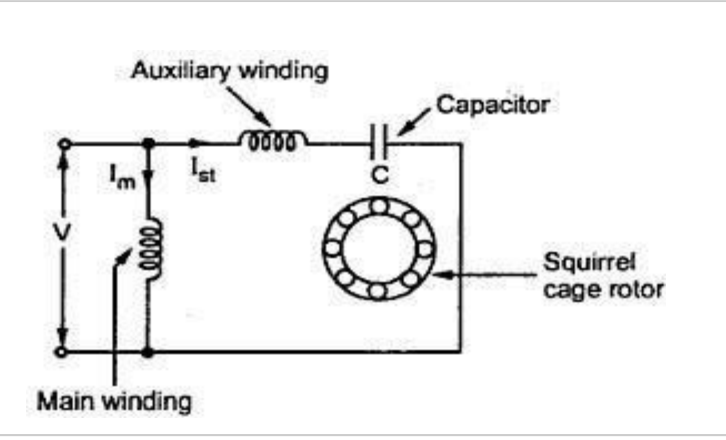
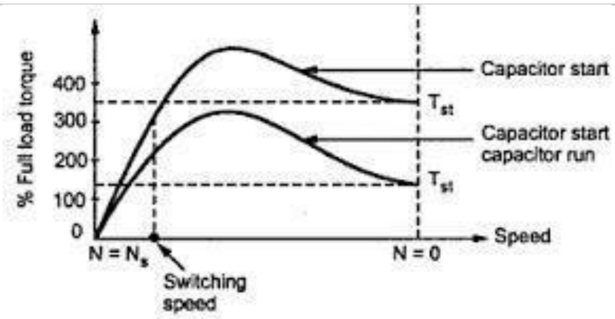


Fig.5.3.4 Capacitor start capacitor run motor

The phasor diagram remains same as shown in the Fig.1(b). The performance not only at start but in running condition also depends on the capacitor C hence its value is to be designed so as to compromise between best starting and best running condition. Hence the starting torque available in such type of motor is about 50 to 100% of full load torque.

The direction of rotation, in both the types can be changed by interchanging the connection of main winding or auxiliary winding. The capacitor permanently in the circuit improves the power factor. These motors are more costly than split phase type motors.

The capacitor value can be selected as per the requirement of starting torque, the starting torque can be as high as 350 to 400 % of full load torque. The torque-speed characteristics is as shown in the Fig.3.



Fi .5.3.5 Torque speed characteristic of capacitor split phase motor

Applications

These motors have high starting torque and hence are used for hard starting loads. These are used for compressors, conveyors, grinders, fans, blowers, refrigerators, air conditions etc. These are most commonly used motors. The capacitor start capacitor run motors are used in celling fans, blowers and air-circulations. These motors are available upto 6 kW.

ShadedPole InductionMotor

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 ban Fig.5.3.6 shows 4 pole shaded pole construction while Fig. 5.10 shows a single pole consisting of copper shading band.

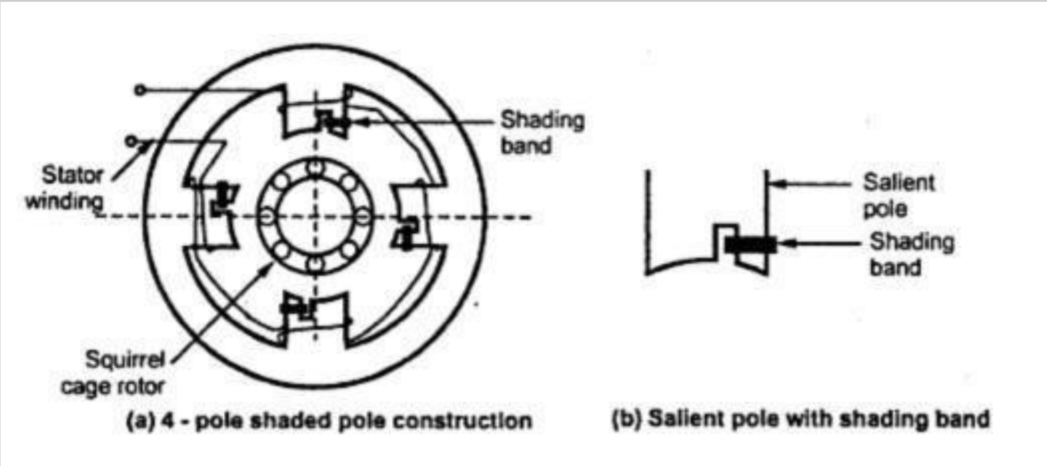


Fig.5.3.6 Shaded Pole Induction Motor

Key point : When single phase a.c. supply is given to the stator winding, due to shading provided to the poles, a rotating magnetic field is generated.

The production of rotating magnetic field can be explained as below :

The current carried by the stator winding is alternating and produces alternating flux. The waveform of the flux is shown in the Fig. 2(a). The distribution of this flux in the pole area is greatly influenced by the role of copper shading band. Consider the three instants say t_1, t_2 and t_3 during first half cycle of the flux as shown, in the Fig 5.3.7

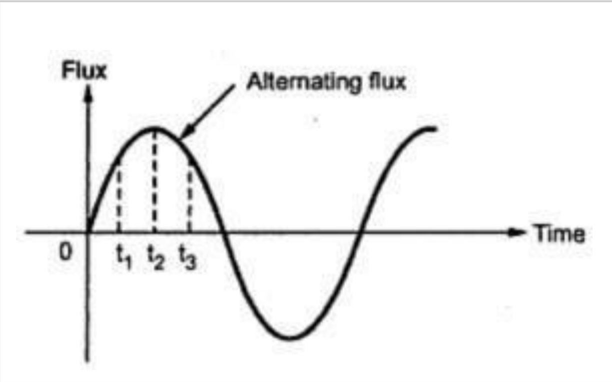


Fig.5.3.7 Waveform of stator flux

At instant $t = t_1$, rate of rise of current and hence the flux is very high. Due to the transformer action, large e.m.f. gets induced in the copper shading band. This circulates current through shading band as it is short circuited, producing its own flux. According to lenz's law, the direction of this current is so as to oppose the cause i.e. rise in current. Hence shading ring flux is opposing to the main flux. Hence there is crowding of flux in nonshaded part while weakening of flux in shaded part. Overall magnetic axis shifts in nonshaded part as shown in the Fig. 5.12.

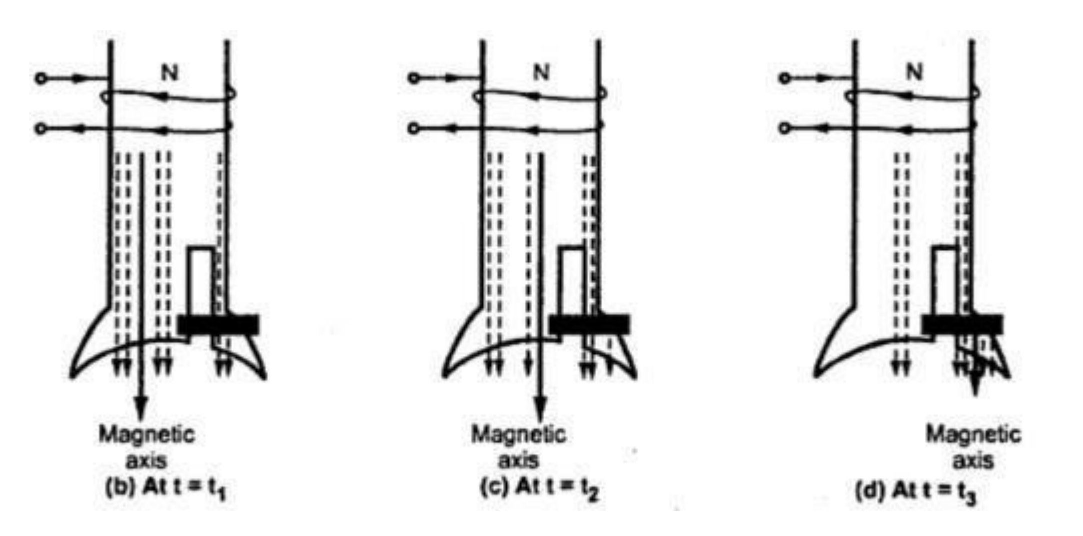


Fig. 5.3.8 Production of rotating magnetic

At instant t = t_2, rate of rise of current and hence the rate of change of flux is almost zero as flux almost reaches to its maximum value. So $d\Phi/dt = 0$. Hence there is very little induced e.m.f. in the shading ring.

Hence the shading ring flux is also negligible, hardly affecting the distribution of the main flux. Hence the main flux distribution is uniform and magnetic axis lies at the centre of the pole face as shown in the Fig. 2(c).

At the instant t = t_3, the current and the flux is decreasing. The rate of decrease is high which again induces a very large e.m.f. in the shading ring. This circulates current through the ring which produces its own flux. Now direction of the flux produced by the shaded ring current is so as to oppose the cause which is decrease in flux. So it oppose the decrease in flux means its direction is same as that of main flux, strengthening it. So there is crowding of flux in the shaded part as compared to nonshaded part. Due to this the magnetic axis shifts to the middle of the shaded part of the pole. This is shown in the Fig. 5.13.

This sequence keeps on repeating for negative half cycle too. Consequently this produces an effect of rotating magnetic field, the direction of which is from nonshaded part of the pole to the shaded part of the pole. Due to this, motor produces the starting torque is low which is about 40 to 50% of the full load torque for this type of motor. The torque speed characteristics is shown in the Fig. 5.13.

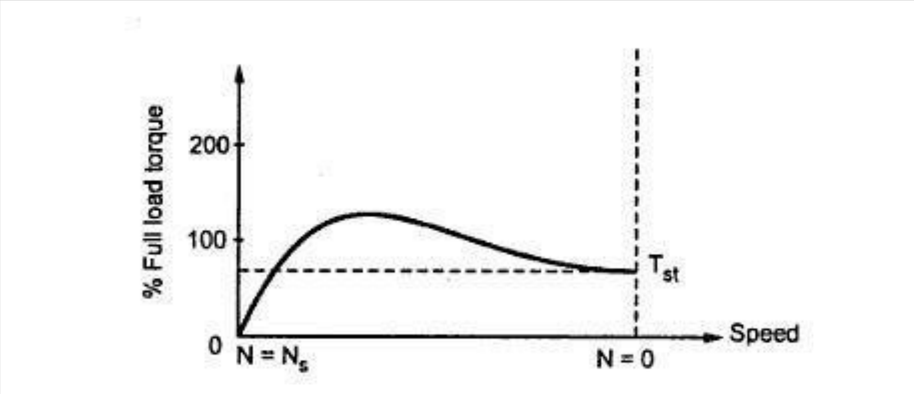


Fig. 5.3.9 Torque-speed characteristics of shaded pole motor

Due to absence of centrifugal switch the construction is simple and robust but this type of motor has a lot of lamination as :

1. The starting torque is poor.
2. The power factor is very low.
3. Due to I^2R, copper losses in the shading ring the efficiency is very low.
4. The speed reversal is very difficult. To achieve the speed reversal, the additional set of shading rings is required. By opening one set and closing other, direction can be reversed but the method is complicated and expensive.
5. The size and power rating of these motors is very small. These motors are usually available in a range of 1/300 to 1/20 kW.

Application

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, by motors, advertising displays, film projectors, record players, gramophones, hair dryers, photo copying machines etc.