CONSTRUCTION OF SINGLE PHASE INDUCTION MOTOR

For general lighting purpose in shops, offices, houses, schools etc. Single phase a.c. supply is commonly used. Hence instead of d.c. motors, the motors which work on single phase a.c. supply are very popularly in use. These a.c. motors are called single phase induction motors. The numerous domestic applications use single phase motors. The power rating of such motors is very small. Some of them are even fractional horse power motors, which are used in applications like small toys, small fans, hair dryers etc. This chapter explains the construction, working principle and applications of various types of single phase induction motors.

Similar to a d.c. motor, single phase induction motor has basically two main parts.one rotating and other stationary. The stationary part in single phase induction motors is called stator while the rotating part is called rotor.

The stator has laminated construction, made up of stampings. The stampings are slotted on its periphery to carry the winding called stator winding or main winding. This is excited by a single phase a.c. supply. The laminated construction keeps iron losses to minimum. The stampings are made up of material like silicon steel which minimizes the hysteresis loss. The stator winding is wound for certain definite number of poles means when excited by single phase a.c. supply, stator produces the magnetic field which creates the effect of certain definite number of poles. The number of poles for which stator winding is wound, decides the synchronous speed of the motor. The synchronous speed is denoted as N_s and it has a fixed relation with supply frequency f and number of poles P. The relation is given by,

$$N_s = \frac{120 f}{P} \quad \text{r.p.m}$$

The induction motor never rotates with the synchronous speed but rotates at a speed which is slightly less than the synchronous speed.

The rotor construction is of squirrel cage type. In this type, rotor consists of uninsulated copper or aluminium bars, placed in the slots. The bars are permanently shorted at both the ends with the help of conducting rings called end rings. The entire structure looks like cage hence called squirrel cage rotor. The construction and symbol is shown in the Fig.5.1

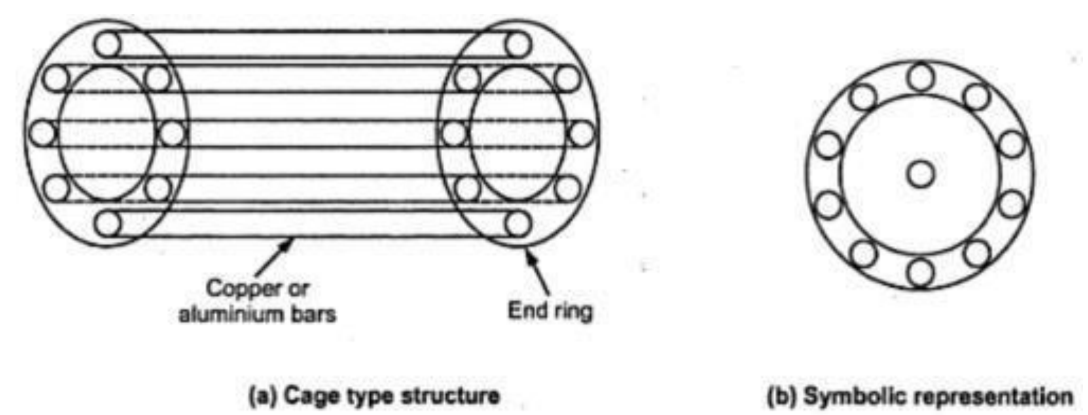

Fig. 5.1.1 Types of rotor

As the bars are permanently shorted to each other, the resistance of the entire rotor is very very small. The air gap between stator and rotor is kept uniform and as small as possible. The main feature of this rotor is that it automatically adjusts itself for same number of poles as that of the stator winding.

The schematic representation of two pole single phase induction motor is shown in the Fig.5.2.

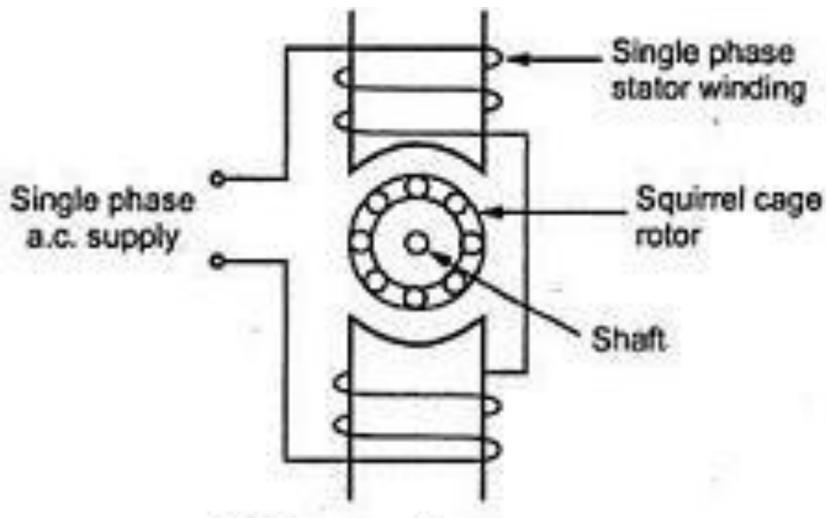

Fig 5.2 construction

Working Principle of 1-phase Induction Motor

For the motoring action, there must exist two fluxes which interact with each other to produce the torque. In d.c. motors, field winding produces the main flux while d.c. supply given to armature is responsible to produce armature flux. The main flux and armature flux interact to produce the torque.

In the single phase induction motor, single phase a.c. supply is given to the stator winding. The stator winding carries an alternating current which produces the flux which is also alternating in nature. This flux is called main flux. This flux links with the rotor conductors and due to transformer action e.m.f. gets induced in the rotor. The induced e.m.f. drives current through the rotor as rotor circuit is closed circuit. This rotor current produces another flux called rotor flux required for the motoring action. Thus second flux is produced according to induction principle due to induced e.m.f. hence the motor is called induction motor. As against this in d.c. motor a separate supply is required to armature to produce armature flux. This is an important difference between d.c. motor and an induction motor.

Another important difference between the two is that the d.c. motors are self starting while single phase induction motors are not self starting.

Let us see why single phase induction motors are not self starting with the help of a theory called double revolving field theory.

Double Revolving Field Theroy

According to this theory, any alternating quantity can be resolved into two rotating components which rotate in opposite directions and each having magnitude as half of the maximum magnitude of the alternating quantity.

In case of single phase induction motors, the stator winding produces an alternating magnetic field having maximum magnitude of Φ_{1m}.

According to double revolving field theory, consider the two components of the stator flux, each having magnitude half of maximum magnitude of stator flux i.e. $(\Phi_{1m}/2)$.

Both these components are rotating in opposite directions at the synchronous speed N_s which is dependent on frequency and stator poles.

Let Φ_f is forward component rotating in anticlockwise direction while Φ_b is the backward component rotating in clockwise direction. The resultant of these two components at any instant gives the instantaneous value of the stator flux at the instant. So resultant of these two is the original stator flux.

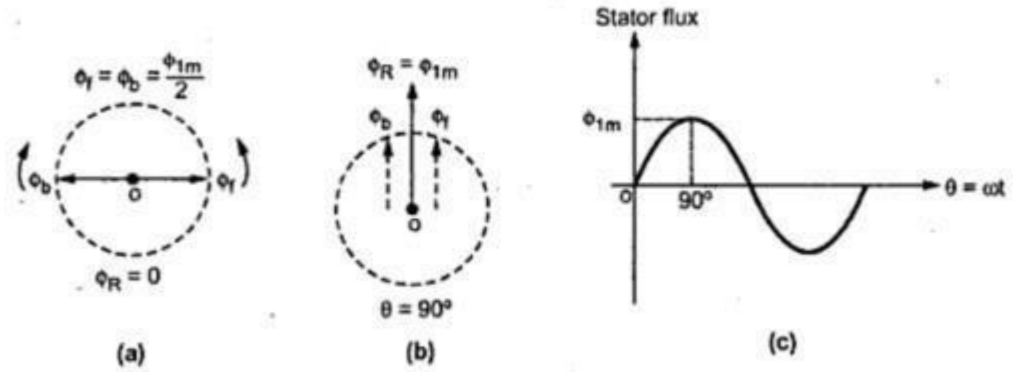

Fig 5.1.2 Stator flux and its two components

The Fig. 1 shows the stator flux and its two components Φ_f and Φ_b. At start both the components are shown opposite to each other in the Fig.1(a). Thus the resultant Φ_R = 0. This is nothing but the instantaneous value of the stator flux at start. After 90^o, as shown in the Fig. 5.3, the two components are rotated in such a way that both are pointing in the same direction. Hence the resultant Φ_R is the algebraic sum of the magnitudes of the two components. So $\Phi_R = (\Phi_{1m}/2) + (\Phi_{1m}/2) = \Phi_{1m}$. This is nothing but the instantaneous value of the stator flux at θ = 90^o as shown in the Fig 5.3 Thus continuous rotation of the two components gives the original alternating stator flux.

Both the components are rotating and hence get cut by the motor conductors. Due to cutting of flux, e.m.f. gets induced in rotor which circulates rotor current. The rotor current produces rotor flux. This flux interacts with forward component Φ_f to produce a torque in one particular direction say anticlockwise direction.

While rotor flux interacts with backward component Φ_b to produce a torque in the clockwise direction. So if anticlockwise torque is positive then clockwise torque is negative.

At start these two torque are equal in magnitude but opposite in direction. Each torque tries to rotate the rotor in its own direction. Thus net torque experienced by the rotor is zero at start. And hence the single phase induction motors are not self starting.