15.1 INTRODUCTION

There are two basic reasons for the use of single-phase rather than 3-phase motors.

First, for reasons of economy, most houses, offices and also rural areas are supplied with single-phase ac, as power requirements of individual load items are rather small.

The second factor is the economics of the motor and its branch circuit. Fixed loads requiring not more than 0.5 kW can generally be served most economically with single-phase power. Single-phase motors are simple in construction, reliable, easy to repair and comparatively cheaper in cost and, therefore, find wide use in fans, refrigerators, vacuum cleaners, washing machines, other kitchen equipment, tools, blowers, centrifugal pumps, small farming appliances etc. To avoid the need for special branch circuits, portable tools are also usually single phase.

Because of above reasons motors of comparatively small ratings (mostly in fractional kW ratings) are manufactured in large number to operate on single-phase ac at standard frequencies.

Single-phase ac motors may be divided in three general classes namely (*i*) induction motors (*ii*) commutator motors and (*iii*) synchronous motors.

Induction motors are further classified as split-phase motors, shaded-pole motors and repulsion– start induction motors according to the method of producing starting torque.

Single-phase induction motors in very small sizes $\left(\frac{1}{400}\text{ kW to }\frac{1}{25}\text{ kW}\right)$ are used in toys, hairdryers, vending machines etc.

The main drawbacks of single-phase motors are low overload capacity, low efficiency, low power factor and low output as compared to that of a 3-phase motor of the given frame size.

15.2 PRINCIPLE OF OPERATION OF SINGLE-PHASE INDUCTION MOTORS

If one line of a three-phase induction motor is opened while the motor is running with moderate or light load, it is found that the motor continues to run though at slightly lower speed. This condition is known as *single-phase operation*. Opening of one line (phase) leaves the equivalent of a single phase connected to the stator. In other words a 3-phase induction motor has become a single-phase motor.

Scanned by CamScanner

A single-phase induction motor is similar to a 3-phase squirrel cage induction motor in physical appearance. The rotor of a single-phase squirrel cage motor is essentially the same as that employed in 3-phase induction motors and needs no further description. There is uniform air gap between stator and rotor but no electrical connection between them (stator and rotor). Except for shaded-pole types, the stator core is also very similar. A single-phase motor can be wound for any even number of poles, two, four, and six being most common. Like three-phase machines, adjacent poles have opposite magnetic polarity and synchronous speed equation ($N_s = \frac{120f}{P}$) also applies.

An elementary single-phase induction motor is shown in Fig. 15.1. Instead of being a concentrated coil, the actual stator winding is distributed in slots to develop an approximately sinusoidal space distribution of mmf.

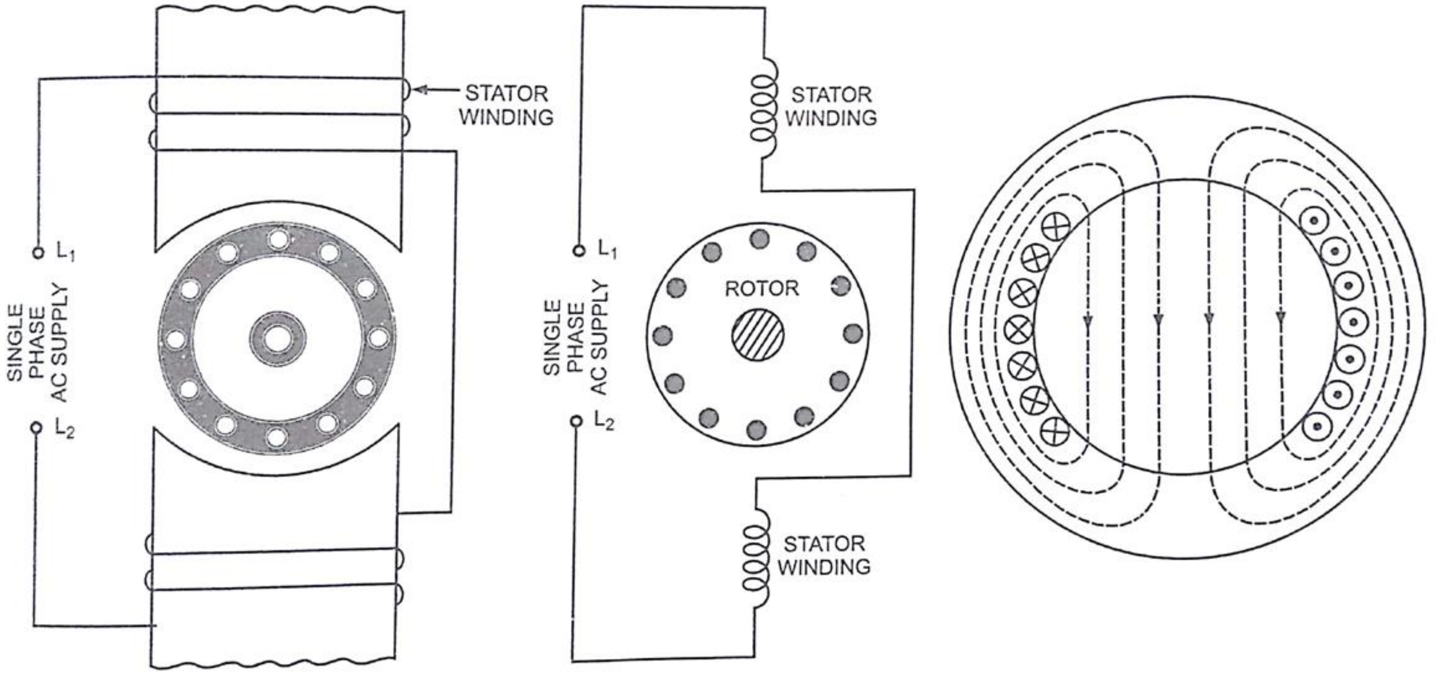


Fig. 15.1 *Elementary Single-Phase Induction Motor*

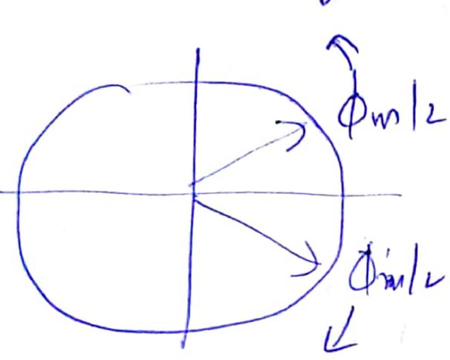
When the stator winding of a single-phase induction motor is connected to single-phase ac supply, a magnetic field is developed, whose axis is always along the axis of stator coils. With alternating current in the fixed stator coil the mmf wave is stationary in space but pulsates in magnitude and varies sinusoidally with time. Currents are induced in the rotor conductors by transformer action, these currents being in such a direction as to oppose the stator mmf. Thus the axis of the rotor mmf wave coincides with that of the stator field, the torque angle is, therefore, zero, and no torque is developed at starting. However, if the rotor of such a motor is given a push by hand or by another means in either direction, it will pick up the speed and continue to rotate in the same direction developing operating torque. Thus a single-phase induction motor is not self starting and needs special starting means.

The peculiar behaviour, mentioned above, of a single-phase induction motor may be explained by

Scanned by CamScanner

Double Field Revolving Theory

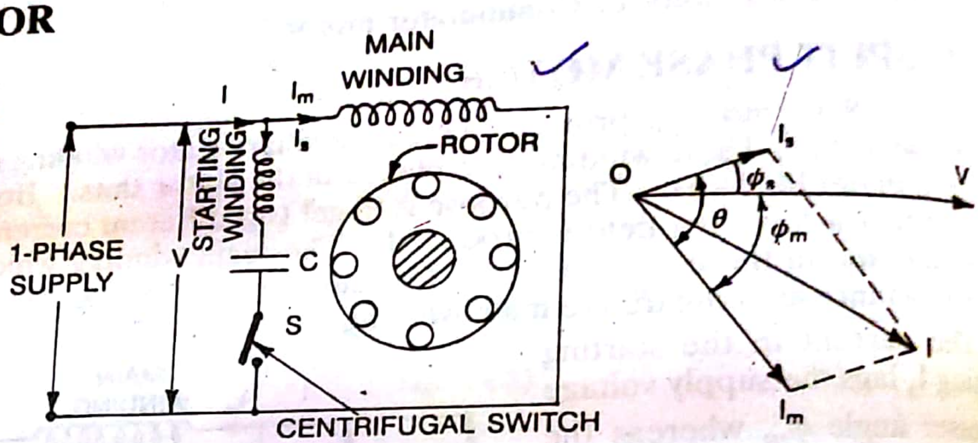
→ Pulsating Field produced in single phase motor can be resolved into 2 components of half the magnitude and rotating in opposite direction at synchronous speed.



The two revolving field will produce torque in opposite directions
Resultant torque is zero

14.28. CAPACITOR MOTOR

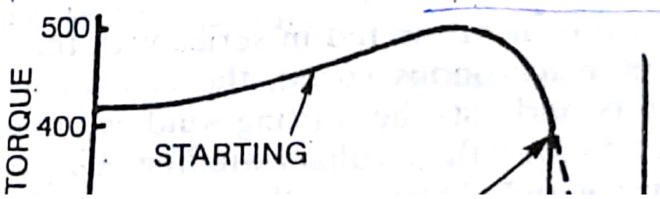
It is also a split phase motor. The starting winding has capacitor in series with it. This is imporved form of above said split phase motor. In these motors, the angular displacement between I_s and I_m can be made nearly 90° and high starting torques can be obtained since starting torque is directly proportionalto sine of angle θ. The capacitor in the starting winding may be connected permanently or temporily. Accordingly, capacitor motors may be



(a) Fig. 14.27 (b)

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

1. Capacitor start motor : In the capacitor start induction motor capacitor C is of large valu such that the motor will give high starting torque. Capacitor employed is of short time duty rating Capacitor is of electrolytic type. Electrolytic capacitor C is connected in series with the startin winding along with centrifugal switch S as shown in fig. 14.27 (*a*). When the motor attains the speed o about 75% of synchronous speed starting winding is cut-off. The construction of the motor and winding is similar to usual split phase motor. It is used where high starting torque is required like refrigerators.



Scanned by CamScanner

3. **Capacitor start and capacitor run motor :** In this case, two capacitors are used one for starting purpose and other for running purpose as shown in fig. 14.30 (*a*). The capacitor used for starting purpose C_S is of electrolytic type and is disconnected from the supply when the motor attains 75% of synchronous speed with the help of centrifugal switch S. Whereas, the other capacitor C_R which remains in the circuit of starting winding during operation is a paper capacitor. This type of motor gives best running and starting operation. Starting capacitor C_S which is of higher value than the value of running capacitor C_R.

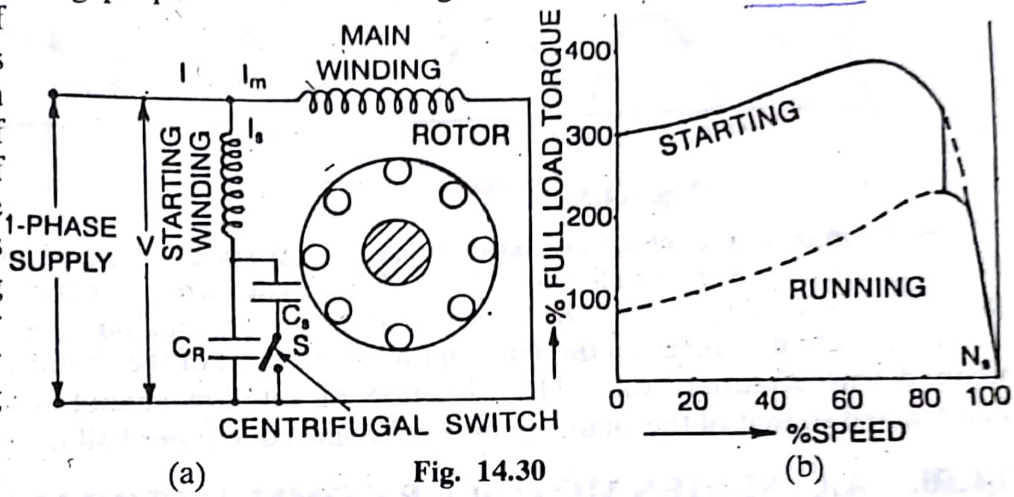


Fig. 14.30

Performance and characteristics : Such motors operate as two phase motors giving best performance and noiseless operation. Starting torque is high, starting current is low and gives better efficiency and higher p.f. The only disadvantage is, high cost. A typical torque speed curve is shown in fig. 14.30 (*b*).