1 Introduction

Although, 3-phase induction motors are invariably employed in the industry for bulk power conversion from electrical to mechanical. But for small power conversions 1-phase induction motors are mostly used.

These motors, usually have output less than one horse-power or one kilowatt, hence are called fractional horse-power or fractional kilowatt motors. AC single-phase, fractional kilowatt motors perform variety of services in the homes, offices, business concerns, factories etc. Almost in all the domestic appliances such as refrigerators, fans, washing machines, hair driers, mixer grinders etc., only 1-phase induction motors are employed. In this chapter, we shall focus our attention on the general principles, operation and performance of single-phase induction motors.

2 Classification of A.C. Motors

With the almost universal adoption of A.C. system of distribution of electric energy for light and power, the field of application of A.C. motors have widened considerably during recent years. As a result, motor manufactures have tried, over the last few decades, to perfect various types of A.C. motors suitable for all classes of industrial drives and for both single and three-phase A.C. supply. This has given rise to bewildering multiplicity of types whose proper classification often offers considerable difficulty. Different A.C. motors may, however, be classified and divided into various groups from the following different points of view:

2.1 AC Motors classification based on Principle of Operation:

2.1.1 Synchronous Motors

The rotational speed of the stator current is equal to the rotational speed of the rotor. They don't have a slip with respect to stator current. In this group we can specify two types of induction motors:

1. Plain
2. Super

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2.1.2 Asynchronous Motors

In this motor design, the movement of the rotor cannot be synchronized through the moving stator field. The rotating stator field of this motor can induce a current within the windings of the rotor. In turn, this current will generate a force to push the rotor in the direction of the stator. In this motor, as the rotor is not in phase with the stator, then the torque will be generated. These motors slip with respect to the stator current field. They are used in different varieties of pumps etc. this type of AC motors can be divided into:

a) **Induction Motors**
- Squirrel Cage
- Slip-Ring

b) **Commutator Motors**
- Series
- Compensated
- Shunt
- Repulsion
- Repulsion induction
- Repulsion-start induction

2.2 AC Motors classification based on Type of Current

- Single Phase
- Three Phase

2.3 AC Motors classification based on Speed of Operation

- Constant Speed
- Variable Speed
- Adjustable Speed

2.4 AC Motors classification based on Structural Features:

- Open
- Closed
- Semi-enclosed
- Ventilated
- Pipe-ventilated
- Riveted Frame-eye

2.5 Other classification AC Motors:

2.5.1 Constant, Variable & Adjustable Speed Motors

- Flexible for controlling speed.
- Constant speed is performed in air compressors.
- Cooling pumps can function at variable speeds by making a switch in the number of poles used. Changing the number of poles results in speed change.
- Motor's speed can also be changed accordingly with some electronic arrangements, which are ideal for the ship's cargo pump where the discharge rate needs to be lowered as per the requirement of the tunnels.

2.5.2 Varied Structure Motors

Depending upon the industrial requirements, motors have a variety of outer cage arrangements. For example, motors that are used in oil and gas terminals should have safely enclosed casing to prevent sparks produced in the motor from causing fire outside of it.

3 General Construction of Induction Motor

- **Stator:** It is the stationary part of the motor. It has three main parts, namely.

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(i) Outer frame.

(ii) Stator core.

(iii) Stator winding.

(i) Outer frame: It is the outer body of the motor. Its function is to support the stator core and to protect the inner parts of the machine. Usually, it is made of cost iron. To place the motor on the foundation, feet are provided in the outer frame as shown in Fig. 1(a).

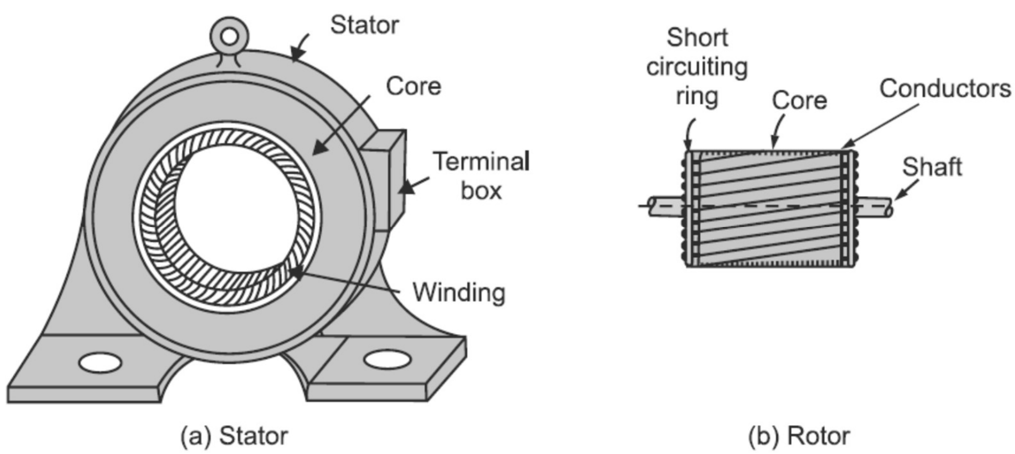


Fig. 1

(ii) Stator core: The stator core is to carry the alternating magnetic field which produces hysteresis and eddy current losses. To minimize these losses high grade silicon steel stampings are used to build core. The stampings are assembled under hydraulic pressure and are keyed to the outer frame. The stampings are insulated from each other by a thin varnish layer. The thickness of the stamping usually varies from 0.3 to 0.5 mm. Slots are punched on the inner periphery of the stampings to accommodate stator winding.

(iii) Stator winding: The stator core carries a single-phase winding which is usually supplied from a single-phase AC supply system. The terminals of the winding are connected in the terminal box of the machine. The stator of the motor is wound for definite number of poles, as per the need of speed.

- **Rotor:** It is the rotating part of the motor. A squirrel cage rotor is used in single phase induction motors.

It consists of a laminated cylindrical core of some high-quality magnetic material. Semi-closed circular slots are punched at the outer periphery. Aluminum bar conductors are placed in these slots and short circuited at each end by aluminum rings, called short circuiting rings, as shown in Fig. 1(b). Thus, the rotor winding is permanently short circuited.

The rotor slots are usually not parallel to the shaft but are skewed. Skewing of rotor has the

following advantages:

(a) It reduces humming thus ensuring quiet running of a motor,

(b) It results in a smoother torque curve for different positions of the rotor,

(c) It reduces the magnetic locking of the stator and rotor,

(d) It increases the rotor resistance due to the increased length of the rotor bar conductors.

The other miscellaneous parts of a 1-phase induction motor are shaft, bearings, end-rings, fan, nut-bolts, etc. as shown in disassembled view of the motor.

4 Working principle of single-phase induction motor

4.1 Basic definition

To better understand the working of a single-phase induction motor, let's consider it with only one turn in the main and auxiliary windings.

Analysis of the case with two windings having one turn

Consider the case when no current flows in the auxiliary winding. When the main stator winding is turned on, the alternating current, passing through the winding, creates a pulsating magnetic field, stationary in space, but varying from $+\Phi_{max}$ to $-\Phi_{max}$.

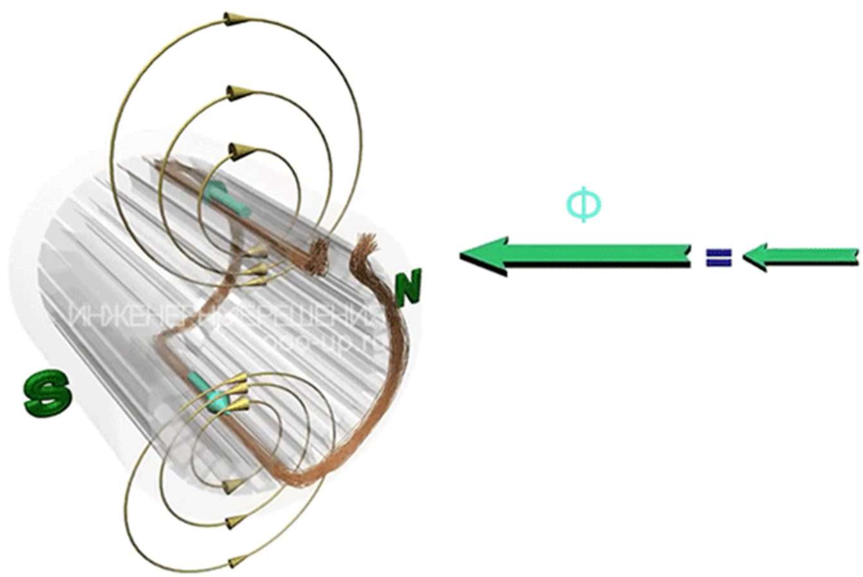
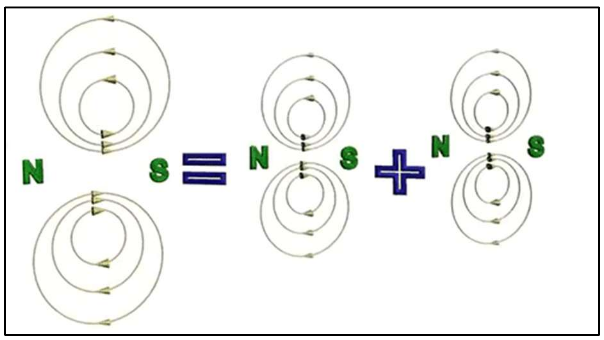


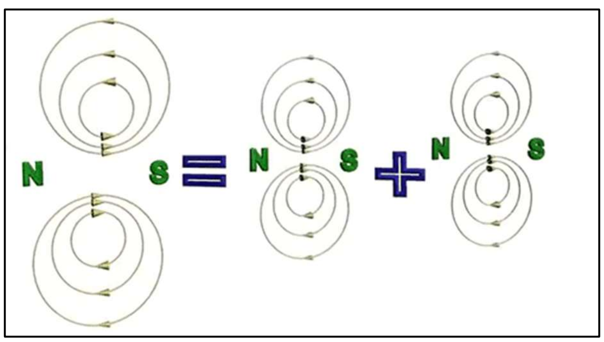
Fig. 1

To understand the working principle of a single-phase induction motor, we separate the fluctuating magnetic field into two identical rotating fields having an amplitude equal to $\Phi_{max}/2$ and rotating in opposite directions with the same frequency:

$$n_f = n_r = \frac{f_1 \cdot 60}{p} = n_1,$$

- where n_f is the rotational speed of the magnetic field in the forward direction, rpm,
- n_r is the rotational speed of the magnetic field in the opposite direction, rpm,
- f_1 is stator current frequency, Hz,
- p is a number of poles pairs,
- n_1 is the rotational speed of magnetic flux, rpm





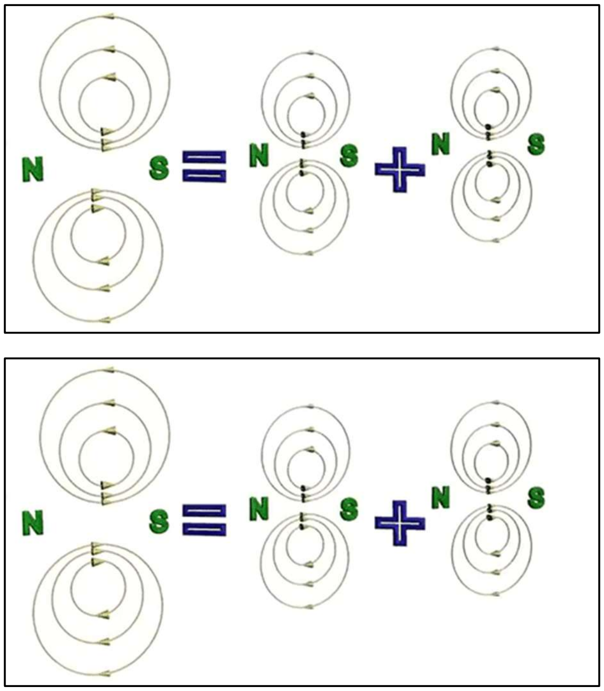


Fig. 2

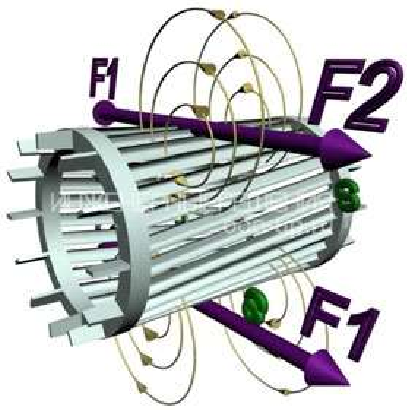
4.2 The braking effect of the reverse field

The effect of the rotating magnetic field on the rotor is interesting. Since the magnetic field is varying, electricity is induced in the rotor bars due to electromagnetic induction. In Fig.1 blue arrows on the bars represent current induced. So here is a situation of current carrying bars are which are immersed in a magnetic field. This will produce a force according to Lawrence law, so the rotor will start to rotate.

But here we have got 2 such oppositely rotating magnetic fields, so the torques produced by them will be equal and opposite. The net effect will be zero torque on the rotor. So the rotor won't start, it will simply buzz.

But if we can somehow give this rotor an initial rotation, one torque will be greater than other. There will be a net torque in the same direction of initial rotation. As a result the loop will keep on rotating in the same direction. This is the way a single phase induction motor works.

$F_1 = F_2$



With one phase, the rotor cannot be started.

The rotor having the initial rotation will continue to rotate in the field created by the single-phase stator

$F_1 > F_2$

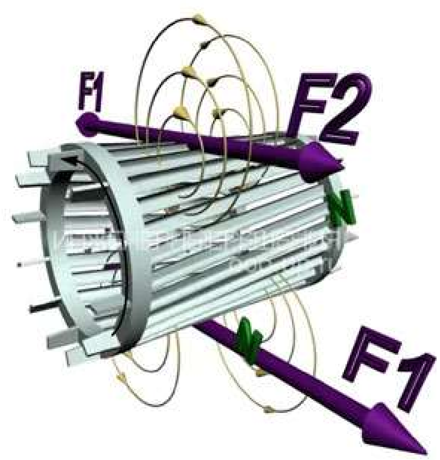


Fig. 3

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