Three Phase Induction Motor: A Review

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Abstract- A 3-phase induction motor is an electromechanical energy conversion device which converts 3-phase input electrical power into output mechanical power. A 3-phase induction motor consists of a stator and a rotor. The stator carries a 3-phase stator winding while the rotor carries a short-circuited winding called rotor winding. The stator winding is supplied from a 3-phase supply. The rotor winding drives its voltage and power from the stator winding through electromagnetic induction and hence the name.

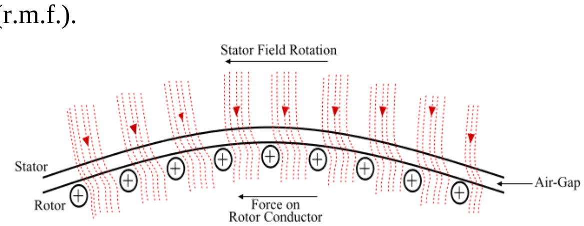
Keywords: 3-phase induction motor

I.INDUCTION MOTOR

An electric motor converts electrical energy into mechanical energy, which is then supplied to different types of loads. A.C. motors operate on an A.C. supply and they are classified into synchronous, single phase and 3 phase induction, and special purpose motors. Out of all types, 3 phase induction motors are most widely used for industrial applications mainly because they do not require a starting device. The first AC commutator-free polyphase induction motors were independently invented by Galileo Ferraris and Nikola Tesla, a working motor model having been demonstrated by the former in 1885 and by the latter in 1887. Tesla applied for US patents in October and November 1887 and was granted some of these patents in May 1888.

A 3 phase induction motor derives its name from the fact that the rotor current is induced by the magnetic field, instead of electrical connections.

The operating principle of a 3 phase induction motor is based on the production of a rotating magnetic field (r.m.f.).



Working Principle of a 3-Phase Induction Motor-The working principle of a 3-phase induction motor can be explained by considering a portion of it as follows−

- When the 3-phase stator winding is fed from a balanced 3-phase supply, a rotating magnetic field (RMF) is produced in the motor. This RMF rotates around the stator at *synchronous speed* which is given by,

  Synchronous speed of rotation = (120 x supply frequency) / Number of poles on the stator.

- The RMF passes through the air gap and cuts the rotor conductors, which as yet are stationary. Due to the relative motion between the RMF and the stationary rotor conductors, EMFs are induced in the rotor conductors. As the rotor circuit is closed with short-circuit so currents start flowing in the rotor conductors.
- Since the current carrying rotor conductors are placed in the magnetic field produced by the stator winding. As a result, the rotor conductors experience mechanical force. The sum of the mechanical forces on all the rotor conductors produces a torque which moves the rotor in the same direction as the rotating magnetic field. Hence, in such a way the three phase input electric power is converted into output mechanical power in a 3-phase induction motor.
- Also, *according to Lenz's law*, the rotor should move in the direction of the stator field, i.e., the direction of rotor currents would be such that they tend to oppose the cause producing them. Here, the cause producing the rotor currents is the relative speed between the RMF and the rotor conductors. Thus to reduce this relative speed, the rotor starts running in the same direction as that of the RMF.

Production of a rotating magnetic field-The stator of an induction motor consists of a number of overlapping windings offset by an electrical angle of 120°. When the primary winding or stator is connected

to a 3 phase A.C. supply, it establishes a rotating magnetic field which rotates at a synchronous speed.
The direction of rotation of the motor depends on the phase sequence of supply lines and the order in which these lines are connected to the stator. Thus, interchanging the connection of any two primary terminals to the supply will reverse the direction of rotation.
The number of poles and the frequency of the applied voltage determine the synchronous speed of rotation in the motor's stator. Motors are commonly configured to have 2, 4, 6 or 8 poles. The synchronous speed, a term given to the speed at which the field produced by primary currents will rotate, is determined by the following expression.

Synchronous speed of rotation = (120 x supply frequency) / Number of poles on the stator.

Production of magnetic flux- A rotating magnetic field in the stator is the first part of the operation. To produce a torque and thus rotate, the rotors must be carrying some current. In induction motors, this current comes from the rotor conductors. The revolving magnetic field produced in the stator cuts across the conductive bars of the rotor and induces an electromotive force (e.m.f).
The rotor windings in an induction motor are either closed through an external resistance or directly shorted. Therefore, the e.m.f induced in the rotor causes current to flow in a direction opposite to that of the revolving magnetic field in the stator and leads to a twisting motion or torque in the rotor.
As a consequence, the rotor speed will not reach the synchronous speed of the r.m.f in the stator. If the speeds match, there would be no e.m.f. induced in the rotor, no current would be flowing, and therefore no torque would be generated. The difference between the stator (synchronous speed) and rotor speeds is called the slip. The rotation of the magnetic field in an induction motor has the advantage that no electrical connections need to be made to the rotor.

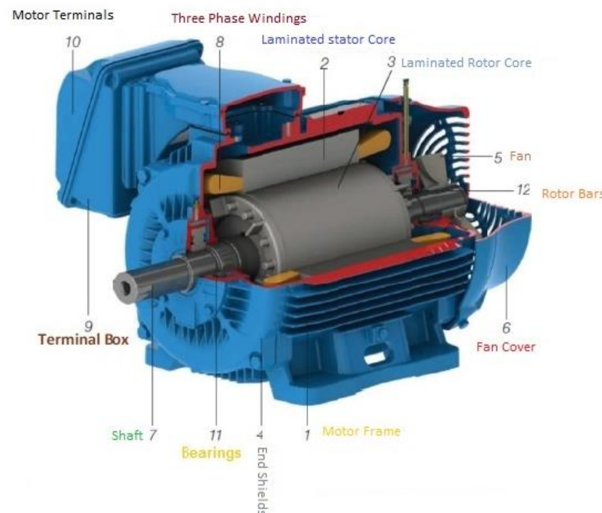
II CONCLUSIONS

Advantages of Three Phase Induction Motor Following are the chief advantages of a 3-phase induction motor

- It has simple and rugged construction.
- It requires less maintenance.
- It has high efficiency and good power factor.
- It is less expensive.
- It has self-starting torque.

Disadvantages of Three Phase Induction Motor The disadvantages of a 3-phase induction motor are given as follows −

- The 3-phase induction motors are constant speed motors; hence their speed control is very difficult.
- 3-phase induction motors have poor starting torque and high inrush currents (about 4 to 8 times of the rated current).
- They always operate under lagging power factor and during light loads, they operate at very worst power factor (about 0.3 to 0.5 lagging).



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