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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE NAME: 2EEB210 / Electrical Machines and Drives

II YEAR / IV SEMESTER

Unit II – ELECTRICAL MOTORS

Topic : Three Phase Induction Motor

Three Phase Induction Motor

- The motor serves the purpose of converting electrical energy into mechanical form. Motors are categorized into AC motors and DC motors based on the type of power supply. In this post, we will talk about the different types of three-phase induction motors with working and applications.
- The induction motors especially three-phase induction motors are by and large used AC motors to convey mechanical power in modern applications. 80% of the motor is a three-phase induction motor among all motors used in undertakings. Consequently, the induction motor is the fundamental motor among any excess types of motor.

Three Phase Induction Motor

A three-phase induction motor is a type of AC induction motor that deals with a phase supply when diverged from the single-phase induction motor where the single-phase supply is supposed to work. The three-phase supply current makes an electromagnetic field in the stator winding which prompts the production of the torque in the rotor bending of the three-phase induction motor having a magnetic field. Next, we will be Going Through Faraday's Law of Induction Motor.

Faraday's Law of Induction Motor

Faraday's law of electromagnetic induction is a significant decision that figures out the fundamental movement of a three-phase induction motor. It was sorted out by Michael Faraday and portrays the association between a changing magnetic field and the prompted electromotive force (EMF).

Three Phase Induction Motor

The basic idea of Faraday's regulation is summarized as follows

Exactly when the attractive field around a conductor changes, it induces an electromotive power (EMF) in the conductor. The size of the induced EMF corresponds comparatively with the speed of progress of magnetic flux through the conductor.

•**Rotating Magnetic Field :** In a 3-phase induction motor, three arrangements of windings are set 120 degrees separated in space. At the point when a three-phase AC voltage is applied to these windings, it delivers a rotating magnetic field.

•**Interaction with Rotor Conductors :** The rotating magnetic field induces an EMF in the rotor conductors because of Faraday's law. As the magnetic field rotates, it cuts across the rotor conductors, causing an adjustment of attractive motion.

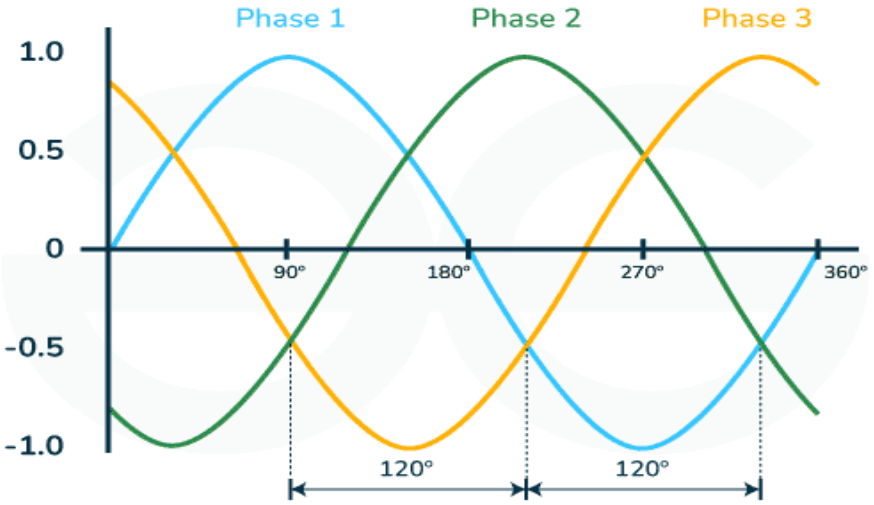
Three Phase Induction Motor

- **Generation of Current in Rotor :** The induced EMF in the rotor conductors causes the progression of current in the rotor. This current in the rotor conductors connects with the magnetic field, creating a torque that makes the rotor turn.

Rotor Movement and Synchronization : The rotor begins to follow the rotating magnetic field, endeavoring to find its rotational speed. The asynchronous development (slip) between the rotor and the turning magnetic field permits the motor to ceaselessly create torque and rotate.

Three Phase Induction Motor

Three-phase power is a type of electrical power transmission or distribution wherein three sinusoidal voltages of a similar recurrence are produced or utilized. It is a typical strategy utilized in electrical systems, industrial systems, and huge electrical motor. The three-phase system is more proficient and gives a more steady power supply contrasted with a single-phase system.

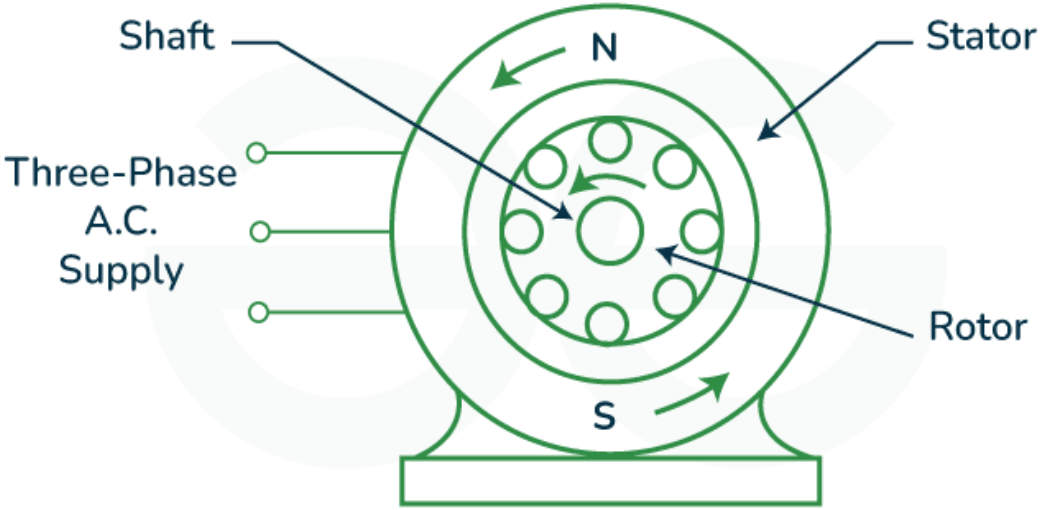


Three Phase Induction Motor

Three Phase Induction Motor

Construction of 3 Phase Induction Motor

The construction of an induction motor is exceptionally basic and robust. It has predominantly two sections :



Three Phase Induction Motor

Three Phase Induction Motor

Stator of 3 Phase Induction Motor

As the name recommends, the stator is a fixed piece of the motor. The stator of the induction motor comprises of three primary parts;

- Stator Casing
- Stator Core
- Stator Winding

Stator Casing

The stator outline is the external piece of the motor. The capability of the stator outline is to offer help to the stator core and stator winding. It gives mechanical strength to the inward pieces of the motor. The casing has balances on the external surface for heat dissemination and cooling of the motor.

The enclosure is cast for small machines and is produced for a large machine. Depending on the applications, the enclosure is constructed from die-cast or fabricated steel, aluminum/aluminum alloys, or stainless steel.

Three Phase Induction Motor

Stator Core

The stator core's function is to carry the alternating magnetic flux, leading to hysteresis and eddy current losses. To limit these losses, the core is coated with high-quality steel stampings with a thickness ranging from 0.3 to 0.6 mm.

These stampings are protected from one another by stain. All stampings stamp together looking like the stator center and fixed it with the stator outline.

An inward layer of the stator core has various number of slots.

Three Phase Induction Motor

Stator Winding

The stator winding is positioned within the available spaces inside the stator core. The stator winding consists of three phases, and a three-phase power supply is provided to it.

The motor's pole count is determined by the internal arrangement of the stator winding, and it Controls the motor's speed. When the number of poles is higher, the speed is lower, whereas if the number of poles is fewer, the speed is higher. The poles are generally two by two. Subsequently, the absolute number of poles generally a much number. The connection between simultaneous speed and number poles is as displayed in the below equation,

$$Ns = 120f / P$$

Three Phase Induction Motor

Where;

f = Supply Frequency

P = Total Number of Poles

Ns = Synchronous Speed

As the end of winding connected with the terminal box. Consequently, there are six terminals (two of each phase) in the terminal box.

As per the application and sort of turning over techniques for motors, the stator winding is associated in star or delta and it is finished by the association of terminals in the terminal box.

Three Phase Induction Motor

Rotor of 3 Phase Induction Motor

As the name proposes, the rotor is an rotating part of the motor. As indicated by the type of rotor, the induction motor is delegated;

- Squirrel Cage Induction Motor

- Phase Wound (Wound Rotor) induction motor / Slip-ring induction motor

The development of the stator is same in the two kinds of induction motor. We will examine the kinds of rotors utilized in 3-phase induction motor in the accompanying part of types of three phase induction motor.

Three Phase Induction Motor

Types of 3 Phase Induction Motor

Three phase motors are arranged mainly in two classes in light of the rotor winding (Armature coil winding) for example squirrel cage and slip ring (wound rotor motor).

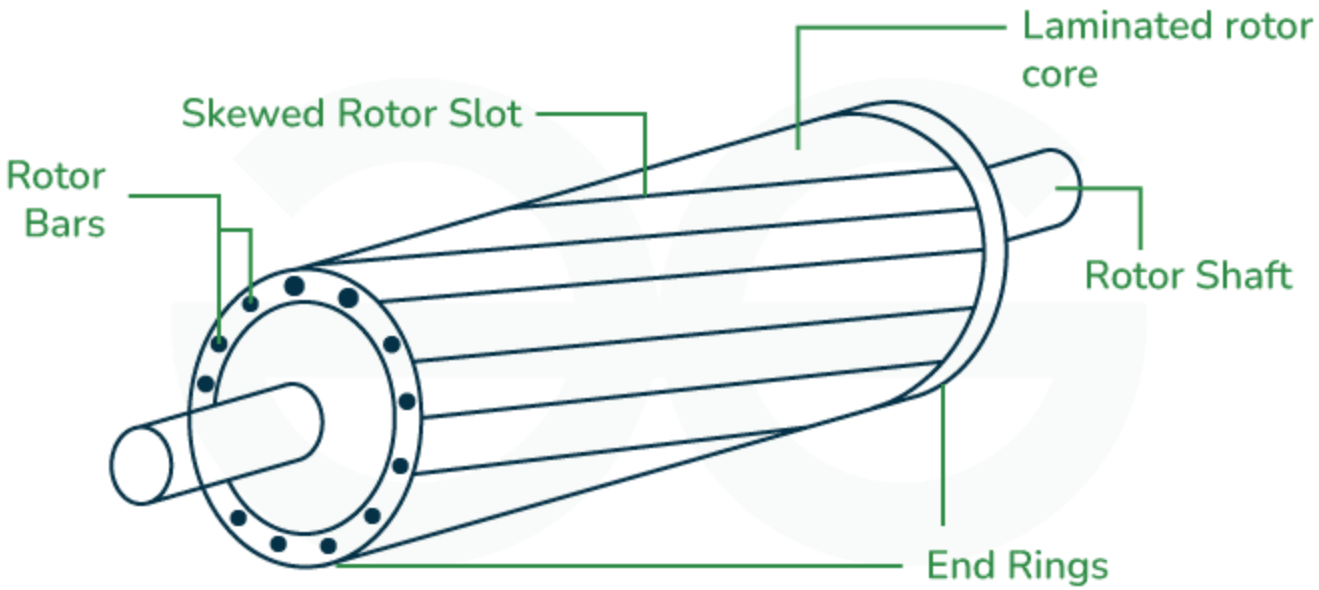
•Squirrel Cage Induction Motor

•Slip-ring or Wound Rotor Induction Motor

Squirrel Cage Induction Motor

The condition of this rotor is seeming to be the condition of the enclosure of a squirrel. As a result, this motor is referred to as an induction squirrel cage motor. This kind of rotor is easy to make and durable to make. In this way, basically 80% of the induction motor is a squirrel confine induction motor.

Three Phase Induction Motor



Three Phase Induction Motor

Three Phase Induction Motor

The covered center of the rotor is shaped like a tube, and the outside edges have spaces. The spaces are not equivalent anyway it is skewed eventually. It helps with magnetic locking between the stator and rotor teeth. It achieves smooth action and diminishes the mumbling commotion. Because it increases the length of the rotor guide, the rotor resistance gets bigger.

Three Phase Induction Motor

Instead of a rotor winding, the squirrel cage rotor is made up of rotor bars. Aluminum, metal, or copper make up the rotor bars. End rings permanently shorten rotor bars. It creates a complete closure in the rotor circuit in this manner.

Mechanical support is provided by welding or propping the rotor bars to the end rings. The rotor bars are short-circuited. Along these lines, it is ridiculous to hope to add external assurance from the rotor circuit.

In this sort of rotor, the slip rings and brushes are not used. As a result, the construction of this kind of motor is simpler and more durable.

Three Phase Induction Motor

Advantages of Squirrel Cage Induction Motor

- **Simplicity:** Squirrel cage motors have a basic and hearty turn of events, making them smooth and solid.

- **Low Maintenance:** There are fewer parts that are susceptible to wear and maintenance issues because the rotor is a closed cage with no external connections.

- **High Starting Torque:** In situations where high starting torque is required, squirrel cage motors frequently exhibit excellent characteristics.

- **Wide Range Of Application:** These motors are affordable for numerous modern machines, such as pumps, fans, compressors, and others.

Three Phase Induction Motor

Disadvantages of Squirrel Cage Induction Motor

•**Limited Speed Control:** Speed control options for squirrel cage motors are limited, and their speed is largely determined by the voltage and frequency applied.

•**Limited Starting Control**: While slip-ring motors have greater command over starting force, squirrel cage motors typically have greater starting torque.

Three Phase Induction Motor

- **Slip-Ring or Wound Rotor Induction Motor**
- Slip-ring Induction Motor are generally called wound rotor motor. The rotor is made up of a tube-shaped center with slots on the outside edges. The rotor winding is placed inside the slots.
- In this type of rotor, the winding is arranged in such a way that the number of rotor winding slots matches the number of stator winding poles. The rotor winding can be related as a star or delta.
- The slip-rings are connected to the end terminals of the rotor windings. As a result, it is referred to as a slip-ring induction motor engine. The external block can without a doubt interact with the rotor circuit through the slip-ring and brushes.
- Likewise, it is uncommonly useful for controlling the speed of the motor and dealing with the starting force of the three-phase Induction Motor.

Three Phase Induction Motor

The outside opposition is used solely for the starting reason. The rotor copper loss will be increased if it remains connected while the system is operating. For the initial condition, a high rotor resistance is extremely advantageous. During the initial state, the rotor circuit is linked to the outside resistance in this manner. The metal collar short-circuits the slip-rings when the motor is running close to the actual speed. By this arrangement, the brushes and outside obstruction is taken out from the rotor circuit.

Copper loss from the rotor and brush friction are both reduced as a result of this. The rotor advancement is fairly perplexed stood out from the squirrel keep engine in light of the presence of brushes and slip-rings. This motor requires more maintenance. As a result, this motor might be used in applications requiring high starting force and variable speed control. In any case, the slip-ring induction motor is superior to the squirrel confine induction motor.

Three Phase Induction Motor

Advantages

Variable Speed Control: One of the main advantages of slip-ring motors is the ability to control the speed and power by moving the external block related with the rotor windings. Because of this, they are suitable for applications that require variable speed.

High Starting Torque Control: Slip-ring motors can give high starting torque, and the external devices can be changed as per control the starting torque.

Smooth Acceleration: The ability to control the rotor resistance results in less mechanical pressure during starting and a smoother speed increase.

Three Phase Induction Motor

Disadvantages

Complex Construction: Slip-ring motors have a more marvelous improvement as a result of the external securities and slip rings, inciting higher gathering and backing costs.

Higher Maintenance: The slip rings and brushes in the rotor require high maintenance, and the external devices are require.

Lower Efficiency: Due to the complexity of the rotor development and the additional losses in the external protections, slip-ring motors typically have lower performance than squirrel confine motors.

Working of Three Phase Induction Motor

Working Principle of 3 Phase Induction Motor

The stator winding is covered at 120˚ (electrically) to one another. When the stator winding is supplied with a three-phase power source, it results in the induction of a rotating magnetic field (RMF) within the stator circuit.

The speed of the rotating magnetic field is known as synchronous speed (NS).

As per Faraday's law, EMF induced in the guide because of the pace of progress of transition (dφ/dt). The rotor circuit cut the stator magnetic field and an EMF actuated in the rotor bar or rotor winding.

The rotor circuit is a nearby way. Thus, because of this EMF current will move through the rotor circuit.

Working of Three Phase Induction Motor

Presently, we realize that the current-conveying guide actuates the attractive field. In this way, the rotor current prompts a second magnetic field. The general movement between the stator flux and rotor flux, the rotor begins to rotate to diminish the reason for relative movement. The rotor attempts to get the stator transition and starts rotating. The heading of revolution is given by the Lenz's law. Furthermore, is toward the rotating magnetic field induced by the stator.

Here, the rotor current is created because of inductance. Hence, this motor is known as the induction motor.

Working of Three Phase Induction Motor

The speed of the rotor is not exactly the speed of synchronous speed. The rotor attempts to get the alternating attractive field of the stator. Yet, it never gets it. Consequently, the rotor speed is slightly less than the synchronous speed.

The synchronous speed is determined by the number of poles and the supply frequency. The difference between the rotor's actual speed and the synchronous speed is referred to as slip.

Advantages of 3 Phase Induction Motor

- **Reliability:** These motors are known for their strong and solid activity. They have a with less moving parts, decreasing the probability of mechanical disappointment.

- **High Power Output:** 3-phase motors can convey high power yield, making them appropriate for modern applications that require significant mechanical power.

- **Cost-Effective:** 3-phase induction motor are for the most part financially savvy to produce and keep up with, adding to their far reaching use in different industries.

Disadvantages of 3 Phase Induction Motor

•**Starting Torque:** The starting torque induction motor is lower contrasted with a few other motor types. This can be a constraint in applications where high beginning torque is essential.

•**Complex Control:** Accomplishing exact speed control can be more intricate with 3-phase induction motor contrasted with a few other engine types. Extra gear might be expected for calibrated control.

•**Power Factor**: The power component of 3-phase induction motor may not be ideal under all working circumstances, prompting power misfortunes in the electrical system.

Applications of 3 Phase Induction Motor

•**Wastewater Treatment Plants:** Pumps and other hardware in wastewater treatment plants frequently depend on 3-phase Induction motors for their operation. These motors can deal with the constant and variable loads related with wastewater treatment.

•**Oil and Gas Industry:** Induction motors are utilized in different cycles inside the oil and gas industry, including driving siphons, blowers, and boring equipment.

•**Electric Traction**: Various electric trains, cable cars, and electric vehicles utilize 3-phase induction motor for drive. These motors give a decent overall influence and effectiveness for transportation applications.

Applications of 3 Phase Induction Motor

•**Air Conditioning and HVAC Systems:** Induction motors power the fans and blowers in cooling and warming, ventilation, and cooling (air conditioning) system. Their effectiveness and capacity to deal with differing loads make them ideal for these applications.

•**Water Pumping Stations:** Induction motors are generally utilized in water siphoning stations for providing water to urban communities and horticultural regions. Their dependability and capacity to work under changing burden conditions make them appropriate for water pumping applications.

•Mining Operations: In mining, 3-phase Induction motors power rollers, transports, and other equipment. Their hearty plan and capacity to work in testing conditions make them appropriate for mining applications.

KEEP
LEARNING.

Thank u

SEE YOU IN NEXT CLASS