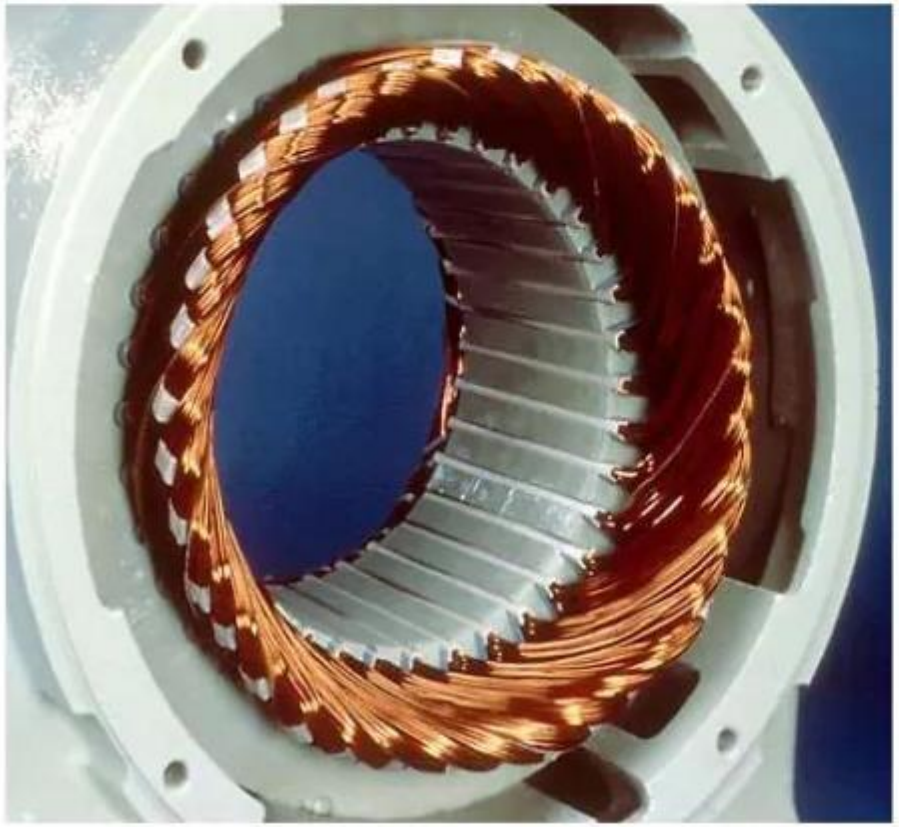
Single Phase Induction Motor

Stator Winding Design

STATOR

- The stator is an static part of the motor which acts as outer body to house the driven windings on a laminated steel core for creating a rotating magnetic field.
- The stator core is made up of a stack of pre punched laminations assembled into a motor housing that is made of aluminum or cast iron or no separate housing designs.

STATOR SIZES



STATOR DESIGN CONSTRAINTS

- Stator Lamination.
- Magnet Wire.
- Stator Insulation.

STATOR LAMINATION

- Lamination Material
- Lamination Pattern

a)One Piece Lamination

b)T-Shaped Segmented Lamination

c)Connected Segmented Lamination

d)Two-Section Stator Lamination

e) Stator Lamination Integrated by Individual Teeth.

f)Slot less Stator core

g)Slinky Lamination Stator Core.

MAGNET WIRE

- Regular Magnet Wire
- Self-Adhesive Magnet Wire
- Litz Wire

STATOR INSULATION

- Injection Moulded Plastic Insulation
- Slot Liner
- Glass Fibre Reinforced Mica Tape
- Powder Coating on Stator Core

MANUFACTURING PROCESS OF STATOR

- Stator Lamination Cutting
- Lamination Fabrication Process
- Lamination Annealing
- Lamination Stacking
- Stator Winding

LAMINATION STACKING TECHNIQUES

- Welding
- Bonding with Adhesive Materials
- Riveting
- Fastened by pins
- Lamination Interlocking
- Using Slot-Liners
- Using Thin Sleeves
- Bolting

STATOR WINDING

- One of the important parameters in stator winding is the slot fill ratio, which is defined as the percentage of the space occupied by magnet wires to the total available space of the slot.
- In order to lower the wire resistive loss and increase the power density, it is highly preferable to have the maximum copper fill, that is, maximum slot fill ratio.

STATOR WINDING Contd..

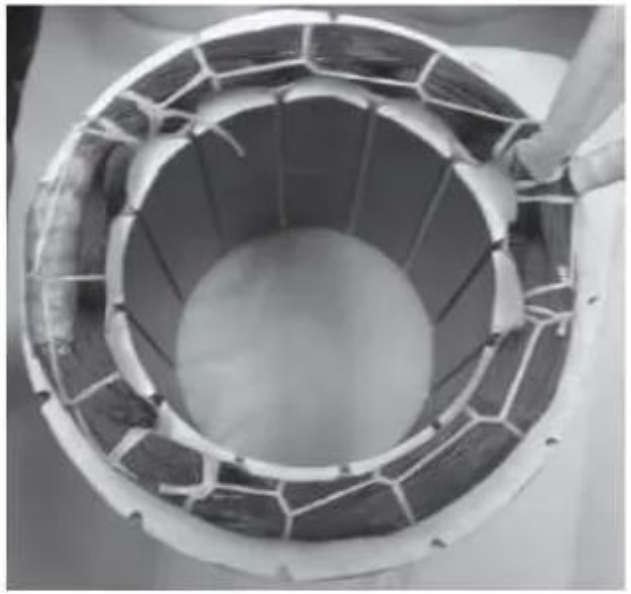
- A winding end turn refers to the amount of the winding extending beyond each end of the stator's magnetic core structure.
- Though the end turns are necessary to complete the electrical path within the winding, they contribute little to the motor torque output.
- Motor torque is only generated by the winding that lies within the stator's magnetic core structure.

STATOR WINDING Contd..

- So it is highly desired to minimize the length of the winding end turns.
- This can not only save the wiring material and lower the material cost but also reduce the copper loss and increase the motor efficiency.
- The shorter the winding stack length, the greater the impact of the end turn length on motor efficiency.

WINDING METHODS

- Random Winding.
- Distributed Winding by Hand.
- Concentrated Winding.
- Conductor Bar



Distributed Winding

Concentrated Winding

STATOR ENCAPSULATION & IMPREGNATION

- Encapsulating and impregnating stators can strengthen stator winding electrical insulation, provide reliable protection to chemicals and harsh environments, enhance thermal dissipation, promote stator structure integrity, and stabilize motor operation.
- Partial encapsulation is basically applied to the stator end windings for integrating them with other stator components against vibration and for enhancing heat transfer.

STATOR DESIGN CONSIDERATIONS

- Cogging Torque
- Air Gap
- Stator Cooling
- Robust Design of Stator

COGGING TORQUE

- Cogging torque is one of inherent characteristics of PM motors, resulted from the interaction of the PM MMF harmonics and the air gap permeance harmonics due to slotting.
- As cogging torque can cause speed ripples, induce motor vibration, and deteriorate motor performance, it is one of the major design goals for motor engineers to reduce cogging torque. Electromagnetic design primarily determines the level of cogging torque.

AIR GAP

- The radial distance between the rotor and stator in a motor is defined as the air gap. Normally, a smaller air gap provides a more efficient and powerful motor.
- Hence, it is highly desired to maintain the air gap dimension as small as possible and within a small variation in operation. The control of the air gap dimension involves the design of several components such as the stator, rotor, motor housing, and end bells.

AIR GAP Contd..

- An important factor that affects the air gap dimension is the accuracy of the coincidence of the stator and rotor axes.
- To provide a motor with a small air gap dimension within only a small tolerance, preciseness in manufacturing of these parts is required.

STATOR COOLING

- An important objective in motor design is to control the motor temperature below its allowable value. Increased motor temperature often reduces motor efficiency and affects bearing life. The Thermal Engineers focus on cooling for following reasons.
- The stator winding is usually the main heat source in a motor. Test data show that in most applications heat generated in a motor is primarily attributed to the stator.

STATOR COOLING Contd..

- Cooling in the stator end-winding region is particularly difficult and still remains a challenge due to various factors.
- As a stationary component, the stator is much easier to be cooled compared with the rotor. In fact, the stator often serves as a heat sink for the motor.
- For some electric motors, the pumping effect, which is resulted from the rotor rotation, is strong enough to generate turbulent circulating flows for making the motor self-cooling.

ROBUST DESIGN OF STATOR

- The root causes of motor failure are often related to mechanical deterioration such as vibration, static and cyclic loads, insulation fracture, and bearing lubricant contamination and leakage.
- Because the rotor is supported on bearings located at the end bells of the machine, the stator design is significantly impacted by the dynamic behaviour of the rotor.
- Motor vibration is greatly influenced by its base. A weak motor base usually results in high vibration.


THANK YOU