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# Induction Machines Study Material

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Induction machine operates in two modes i.e., generator and motor modes.

The speed of induction of induction motor is always less than synchronous speed

The speed of induction generator is always greater than synchronous speed

There is no constructional difference between induction motor and generator

Induction machine is also called asynchronous machine

| **Transformer** | **Induction machine** |
|---|---|
| Transformer is not an energy conversion device | Induction machine is an energy conversion device |
| Due to absence of airgap the no load current is less i.e., 5% of full load current | Due to presence of airgap the no load current is less i.e., 5% of full load current |
| Transformer is a constant frequency device | Induction machine is a variable frequency machine |
| In transformer both windings are stationary | Stator winding is stationary and rotor winding is rotating |

Induction motor has shunt type characteristics i.e., similar to DC shunt motor. Hence, induction motor replaces DC shunt motor due to availability of supply.

Induction motor is most versatile and most popular motor.

Induction generator requires variable speed prime mover. Hence, they are most widely used in wind energy generation.

**Rotating magnetic field (RMF).**

Conditions required to produce RMF with three phase system

1) Three phase windings must be physically displaced by 120 degrees with respective to space
2) The currents flowing through three phase windings must have time angle displacement of 120 electrical degrees

MMF distribution of single excited coil is rectangular.

The resultant MMF produced in induction machine is $F_r = \frac{3}{2}F_m Cos\ (wt - \theta)$ and it rotates with synchronous sped.

The resultant MMF produced with "m" phase system is $F_r = \frac{m}{2}F_m Cos\ (wt - \theta)$ and it rotates with synchronous sped.

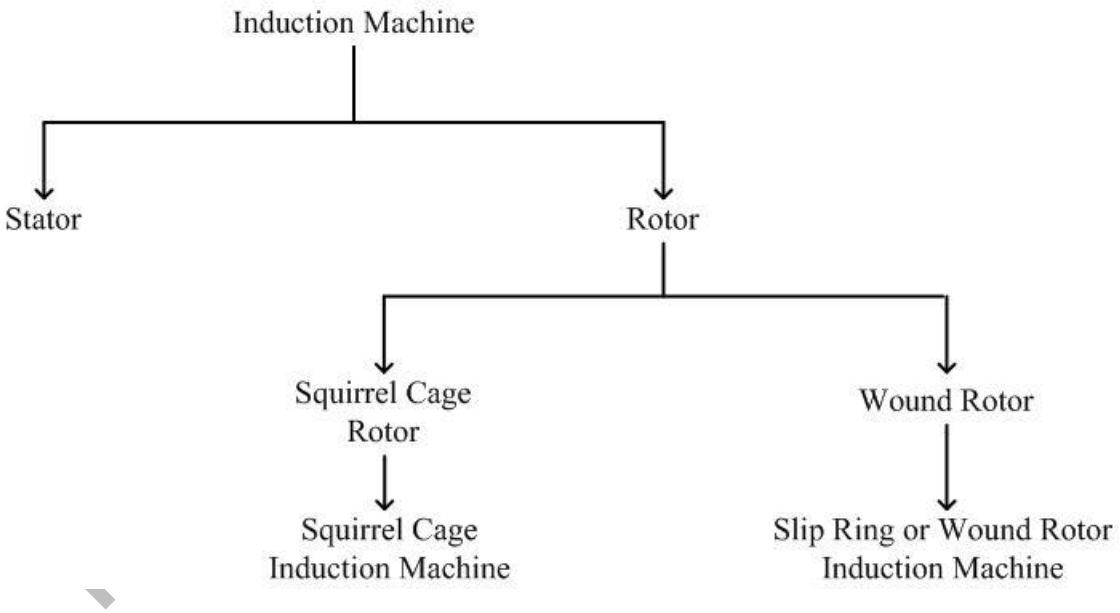
For production of RMF with 2 phase system, the physical displacement between two windings must be $90^o$ and currents flowing through them should have time angle displacement of $90^o$ electrical

**Construction**

The winding which produces the working flus is called field winding

The winding in which emf is induced due to working flus is called armature winding

The stator is made of thin silicon steel laminations and has cylindrical structure along with slots in the inner periphery.




There are three types of slots: 1) open , 2) closed, and 3) semi closed or semi open

| Open | Semi Open or Closed | Closed |
|---|---|---|
| Easy to place windings | Somewhat difficult to place windings | Difficult to place windings |
| Less leakage flux | Intermediate | More leakage flux |
| More power transfer capacity | Intermediate | Less power transfer capacity |
| No load power factor is less | intermediate | No lad power factor is more |
| Average air gap is more | Average airgap is intermediate | Average airgap is less |
| High torque | Intermediate torque | Less torque |

In induction machine semi open type slots are used.

For production of torque no of stator poles should be equal to no of rotor poles but no of stator phases need not be equal to no of rotor phases.

**Cage rotor features:**

1) Rotor is not wound for definite no of poles or phases but the no of poles or phases induced in rotor are same as stator
2) Rotor winding does not have overhang portion. Hence, leakage flus offered by rotor winding is less.
3) Rotor surface is smooth and the exciting current required is less
4) No load as well as full load operating power factor is good

**Drawbacks:**

1) Rotor impedance is less. Hence, motor draws high starting current to avoid this starters are used
2) The rotor winding resistance is less as well as starting torque is less.

Squirrel cage induction motor starting performance is poor but running performance is good.

**Wound rotor features:**

1) Three phase short pitched windings are used and rotor is wound for definite no of poles.
2) The rotor windings of slip ring induction motor are connected in star. However, stator winding can be connected in star or delta

3) Has starting torque greater than squirrel cage induction motor (IM) and the amount of starting torque can be increased by adding external resistance
4) Magnetizing current requirement of slip ring IM is greater than squirrel cage IM.
5) Due to the presence of overhang portion of rotor windings, the leakage reactance of wound rotor is greater than that of squirrel cage IM.

Slip ring induction motor starting performance is good but running performance is inferior to squirrel cage induction motor.

The maintenance and initial cost of slip ring induction motor is greater than squirrel cage induction motor.

The efficiency of slip ring induction motor is less than squirrel induction motor

**Working Principle of IM:**

When stator is connected to three phase supply, the stator winding produces a RMF.

Now there is a relative speed between RMF and rotor due to which an emf is induced in rotor according to faradays law.

To satisfy lenzs law rotor current flows through rotor winding in such a direction that will produce torque and rotor rotates in the direction of stator.

Slip of a induction motor is $S = \frac{N_s - N_r}{N_s}$, where $N_s$ is the synchronous speed and $N_r$ is the rotor speed

Rotor current frequency of induction motor is slip times supply frequency.

Speed of rotor RMF with rotor is slip speed = $N_s - N_r$.

The relative speed between stator RMF and rotor is $N_s + N_r$

**Torque Production**

Rotating machines has to produce at least two magnetic fields in the air gap and the relative speed between those two magnetic fields (stator and rotor) should be zero for production of torque.