SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

19ECT201 – ELECTRICAL ENGINEERING & INSTRUMENTATION

II YEAR IV SEM

UNIT 3 – INDUCTION MACHINES

TOPIC 6-Synchronous motor-construction , working principle , application

Synchronous motor

➢Electrical motors can be classified into AC and DC motors. While the AC motors are further classified into induction motors and synchronous motors

➢A synchronous motor is a type of motor that is used in industries for its constant speed.

➢A synchronous motor is a type of AC motor whose rotor rotates at the same speed as the rotating magnetic field.

➢The stator's magnetic field revolves at a speed that depends on the supply frequency known as synchronous speed. Hence the name synchronous motor.

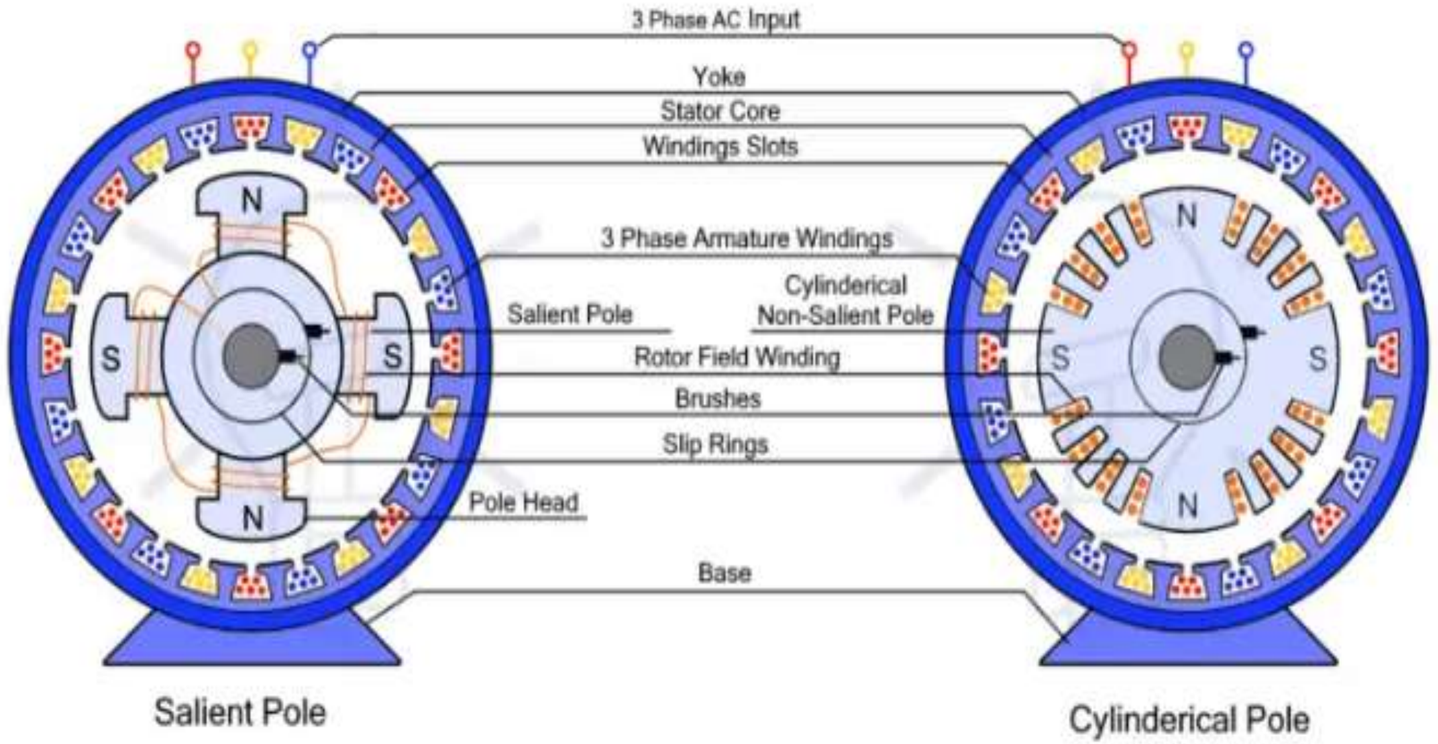
➢A synchronous motor is the same machine as Alternator or synchronous generator. a synchronous motor can be operated as a synchronous generator (alternator) without changing the rating and design.

Contd

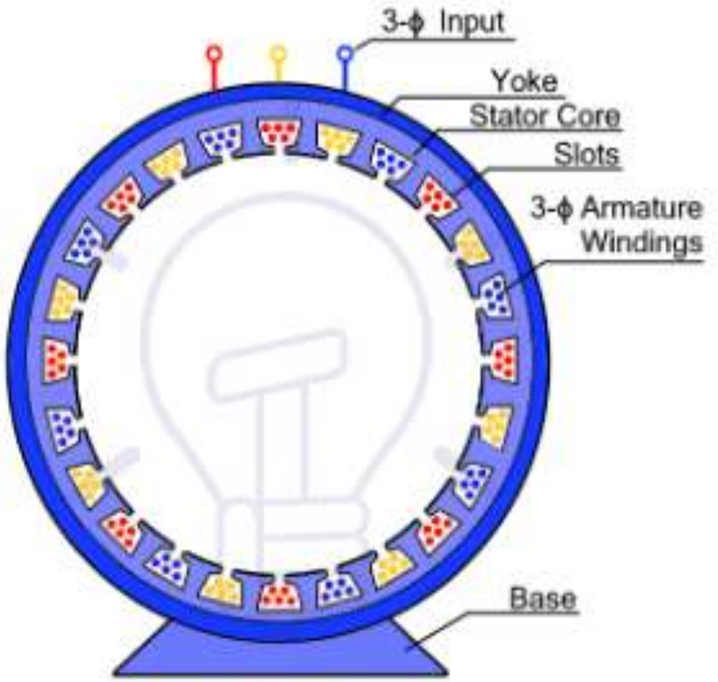
- When the machine converts the input electrical power into output mechanical power, it is known as a synchronous motor.
- When the same machine converts the input mechanical power into output electrical power, it is known to be a synchronous generator (alternator).

Construction

➢The construction of a synchronous motor is similar to an Alternator or Synchronous generator. it differs from induction motor based on its rotor design.



Stator



Stator

- The stator is the stationary part of the motor. Just like an induction motor, the stator core is made of thin laminated sheets of steel or cast iron of good magnetic quality to reduce hysteresis and Eddy current loss.
- The core has axial slots for holding the three-phase alternating stator field winding called armature winding.

The stator's armature winding is supplied with 3-phase power through its input terminal.

- It is responsible for generating the rotating magnetic field (RMF)

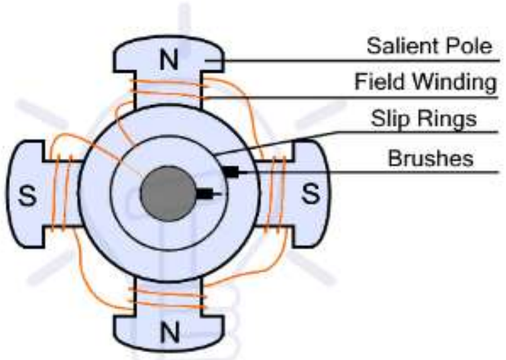
Rotor

- The rotor is the rotating part of the synchronous motor.
- It has a cylindrical shape and holds the field winding. It is responsible for generating the magnetic field or poles. It is energized using slip rings and brush assembly using a DC source.
- Usually, a small DC generator connected to its shaft is used for excitation.

The rotor of a synchronous motor can be designed in one of the following ways.

Salient Pole Rotor

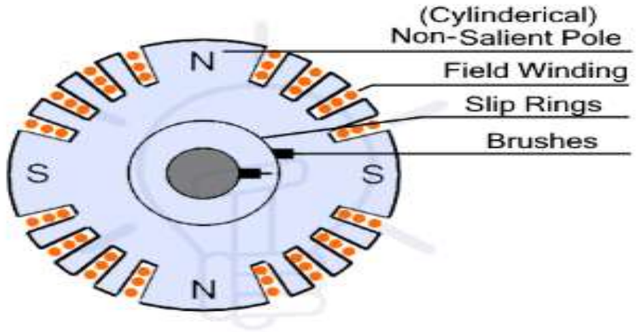
- The term ‘salient’ means ‘pointing outward’. The salient Pole rotor has protruding or projecting poles toward the armature winding. The rotor core is made of a laminated steel sheet for reduction in hysteresis and Eddy current. The field windings are wounded around each pole.
- The salient Pole rotor has a large number of poles. It is not suitable for high-speed operation due to its high windage losses (at high speed).
- It is used in low and medium-speed synchronous motors.
- Physically, it has a large diameter and small axial length.



Rotor contd…

Non-Salient Pole or Cylindrical Rotor:

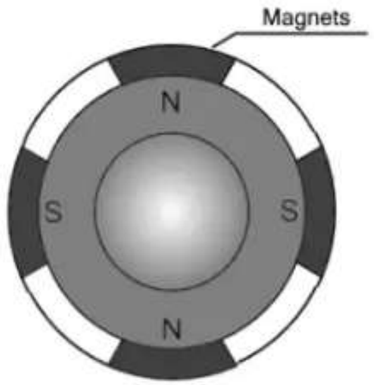
- Such type of rotor has a cylindrical shape rotor made of laminated steel.
- The core has slots for field windings that are secured with the help of wedges to prevent by pulled out.
- While the unslotted portion of the core becomes magnetic poles.
- It has less number of poles, having smaller diameter and longer axial length. It is costlier than the salient pole rotor.
- However, the rotor design helps in uniform distribution of flux, mechanical strength, robustness, etc. Therefore such synchronous motors are used for high speed



Permanent Magnet Rotor

- Modern synchronous motors use a permanent magnet rotor where the rotor has permanent magnets mounted on its surface.
- There are no field windings.
- These magnets generate the necessary field without the requirement of an excitation source.
- The permanent magnet is made of neodymium-boron-iron since they are easily available and cost-effective. Such rotor does not have a slip ring or brush assembly.

The disadvantage of a permanent magnet rotor is that the motor is not self-starting due to the rotor's inertia, it can't follow the fast revolving RMF right at the startup. Therefore VFD (variable frequency drive) is necessary for its operation.



Working principle

- Synchronous motor works on the principle of magnetic locking between the stator RMF (rotating magnetic field) and the rotor magnetic field.
- opposite poles attract each other, therefore the RMF poles attract the opposite rotor poles generating a rotating motion.
- A synchronous motor is a doubly excited machine i.e. it requires AC and DC supply for both parts stator as well as rotor to achieve synchronism.
- A three-phase AC is supplied to the stator's windings to generate RMF. The stator is designed to have the same number of poles as the rotor. These poles rotate at the speed that is in sync with the input frequency f is called synchronous speed. It is given by $N_S = 120f / p$
- DC supply is provided to the rotor's windings to generate a fixed magnetic field.

Contd…

- the DC source supplies constant current, the rotor's magnetic field does not vary. Magnetic poles are generated at the opposite ends of the rotor. The rotor's poles interact with the RMF of the stator and rotate at the same speed as it attains the synchronous speed.
- If the rotor rotates at the same speed as the stator RMF, there is no load torque. The rotor and stator poles align with each other.
- If a mechanical load is applied, the rotor starts oscillating about its new equilibrium position, this phenomenon is known as '**hunting**'.
- The rotor lags a few degrees behind the stator RMF and starts developing torque. As the load is increased the angle between them is increased until the rotor field lags by 90° behind RMF. At this point, the motor provides the maximum available torque called **breakdown torque**.
- If the load exceeds this limit, the motor stalls.

Advantages & Disadvantages of Synchronous Motor

Advantages

- It has a constant operating speed called synchronous speed that only depends on supply frequency and does not vary with any change in load.
- It has a relatively higher efficiency above 90% as compared to the induction motor.
- They are more cost-effective at a lower speed than an induction motor.

Disadvantages

- Synchronous Motors are inherently not self-starting
- It stalls if the load exceeds beyond breakdown limit.
- It requires an external DC source for its rotor field excitation
- Its speed cannot be varied unless the VFD variable frequency drive is used to very its supply frequency.
- Synchronous motors are generally more complicated and costlier than induction motors.

Applications

Constant Speed Application: They are usually used in constant speed applications where the speed does not vary with increasing load. However, VFD can be used to adjust its speed according to requirements.

Frequency Changer: A synchronous motor is used to run an alternator or synchronous generator to supply having a different frequency. Such a synchronous motor is known as a frequency Changer.

Very low-speed Applications: Using very low frequency, synchronous motor can be used for very low-speed applications with high efficiency.

Positioning: Due to their constant speed, they are used for precise positioning in robotics just like servo motors.

General Applications: grinders, pulp beaters, rock crushers, ball mills, steel mills, metal rolling mills, cement mills, rubber and textile mills, centrifugal pumps, air compressors, fans, blowers, line shafts, turn tables, timers, clocks, juicers, tap recorders and players, mixtures, signaling devices, phonographer, indicating, regulating ad controlling devices.


Thank You