AC Machines

SYNCHRONOUS MOTOR

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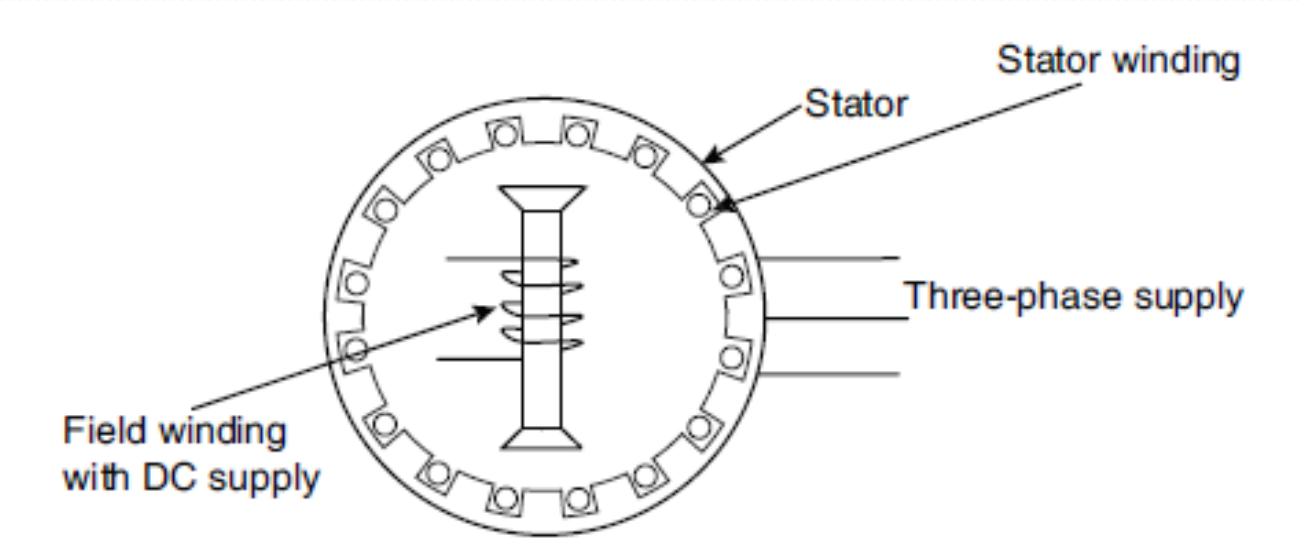
INTRODUCTION

Synchronous motors are widely used in the industry for high-precision applications. This motor runs at constant speed and it does not depend on the torque acting on it. So it has a constant-speed torque characteristic. The efficiency of synchronous motor is around 90%–93%.

INTRODUCTION

Synchronous motor is a doubly fed motor; three-phase power is given to the stator while the rotor is fed from a DC source for excitation of the field winding.

CONSTRUCTION

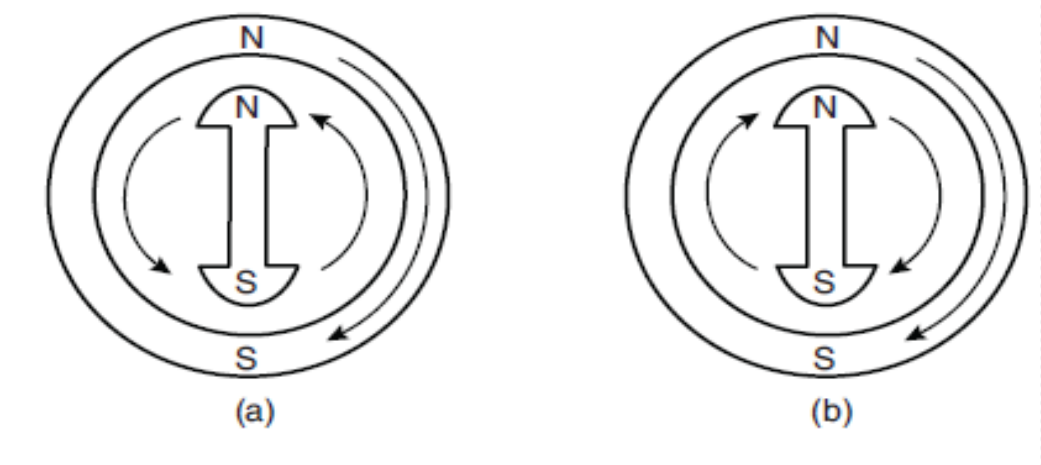


- There is no constructional difference between synchronous motor and synchronous generator

CONSTRUCTION

- The stator has a laminated core with slots to hold the three-phase windings.
- Rotor holds the field winding. The rotor can be of salient-pole type or cylindrical type.
- Synchronous motor is likely to hunt and so damper windings are also provided in the rotor poles.

PRINCIPLE OF OPERATION OF SYNCHRONOUS MOTOR



• When a three phase-supply is given to the stator of the synchronous motor, it produces a rotating magnetic flux of constant magnitude, rotating at synchronous speed.

PRINCIPLE OF OPERATION OF SYNCHRONOUS MOTOR

- DC supply on the rotor will also produce a flux of constant magnitude.
- A three phase synchronous motor is not self-starting.
- If the rotor of the synchronous motor is rotated by some external means at the start.

PRINCIPLE OF OPERATION OF SYNCHRONOUS MOTOR

•DC supply on the rotor will also produce a flux of constant magnitude.

• A three-phase synchronous motor is not self-starting.

If the rotor of the synchronous motor is rotated by some external means at the start, there will be a continuous force of attraction between the stator and the rotor.

PRINCIPLE OF OPERATION OF SYNCHRONOUS MOTOR

- This is called magnetic locking.
- Once this stage is reached, the rotor pole is dragged by the revolving stator field and thus the rotor will continue to rotate.

Explain with reason why synchronous motor is not self starting. Discuss the methods of starting the synchronous motor. (7)

STARTING METHODS FOR SYNCHRONOUS MOTOR

The different methods that are generally followed to start the synchronous motor are

i) By using a pony motor (Small induction motor)

ii) By using a damper winding

iii) By using DC motor

iv) Starting as an induction motor

STARTING METHODS FOR SYNCHRONOUS MOTOR

By using a pony motor (Small induction motor)

In this method, the rotor of the synchronous motor is brought to its synchronous speed with the help of an external induction motor. This external motor is called the pony motor.

STARTING METHODS FOR SYNCHRONOUS MOTOR

By using a damper winding

- The damper windings are provided on the pole face slots in the fields.
- These windings are short-circuited at both ends with the help of end rings, thus forming a squirrel-cage system.

STARTING METHODS FOR SYNCHRONOUS MOTOR

By using a damper winding

- Now, when a three-phase supply is given to the stator of a synchronous motor, it will start as a three-phase induction motor.

STARTING METHODS FOR SYNCHRONOUS MOTOR

- By using DC motor

In this method of starting, the synchronous motor is brought to its synchronous speed with the help of a DC motor coupled to it. Once the rotor of the synchronous motor attains synchronous speed, the DC excitation to the rotor is switched on.

STARTING METHODS FOR SYNCHRONOUS MOTOR

- Starting as an induction motor

The synchronous motor is started as a squirrel-cage induction motor.

- When the synchronous motor is started as a slip-ring induction motor, the three ends of the windings are connected to an external resistance in series through slip-rings.

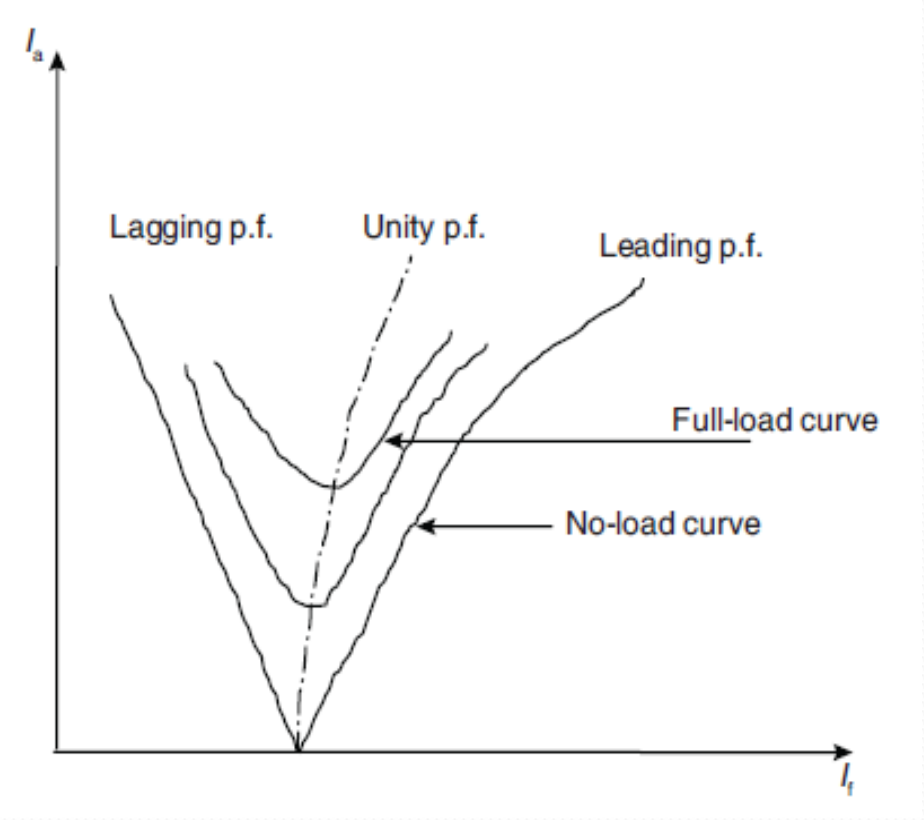
POWER ANGLE OF SYNCHRONOUS MOTOR

The synchronous motor rotates at synchronous speed. But increase in shaft load causes the rotor magnet to change its angular position with respect to the rotating flux of the stator by an electrical angle δ. This angle is called the power angle or load angle or torque angle.

Explain V-curves and its importance for synchronous motors. (7)

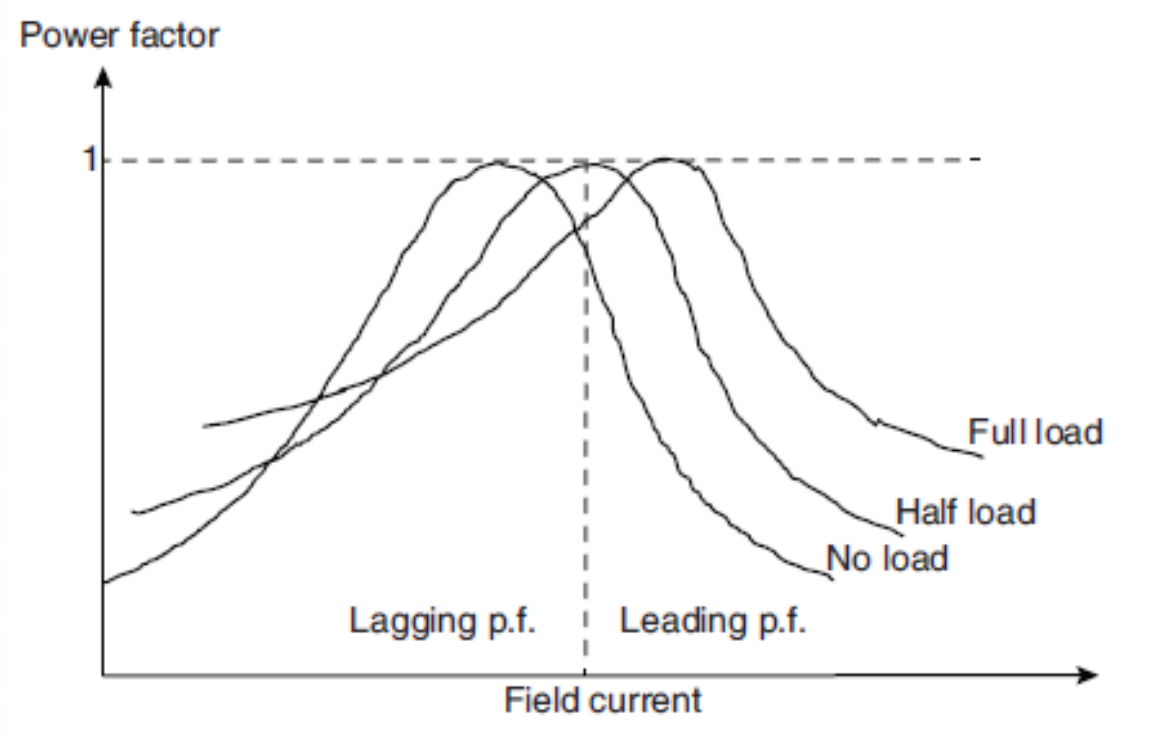
V-Curve

The plot between armature current and field current of synchronous motor is called the V-curve



Inverted V-Curve

The plot between power factor and field current of synchronous motor is called the inverted V-curve



Hunting in Synchronous Motor

At no-load, the magnetic axis of the stator and rotor coincides as the load angle $\delta = 0$. However, when the motor is loaded, the rotor axis lags the stator axis by an angle δ. If the load is suddenly changed, the rotor will not immediately attain its equilibrium position but pass beyond it producing more torque than required. The rotor will now swing in the opposite direction to reduce the load angle. This periodic swing of the rotor to either side before stopping at the equilibrium position is called *Hunting* of the rotor.

Causes of Hunting in Synchronous Motor

1. Sudden change in load
2. Sudden change in field current
3. A load containing harmonic torque
4. Fault in supply system.

Effects of Hunting in Synchronous Motor

1. It may lead to loss of synchronism.
2. It produces mechanical stresses.
3. Increases machine loss and causes temperature rise.
4. Causes greater surges in current and power flow.

Reduction of Hunting in Synchronous Motor

i) By using damper winding: Damper winding damps out hunting by producing torque opposite to slip of rotor. The magnitude of damping torque is proportional to the slip speed.

ii) By using Flywheels: By providing large and heavy flywheel to the prime mover, its inertia can be increased, which in turn, helps in maintaining the rotor speed constant.

Application of Synchronous Motor

1. Synchronous motor having no load connected to its shaft is used for power factor improvement.
2. Synchronous motor finds application where operating speed is less and high power is required.

Application of Synchronous Motor

3. As synchronous motor is capable of operating under either leading or lagging power factor, it can be used for power factor improvement. A synchronous motor under no-load with leading power factor is connected in a power system where static capacitors cannot be used.

Application of Synchronous Motor

4. It is used where high power at low speed is required such as rolling mills, chippers, mixers, pumps, pumps, compressors etc.

Write a short note on auto synchronous motor. (7)

-Self Study