PRESENTATION ON
"SYNCHRONOUS MACHINES"

Submitted By --

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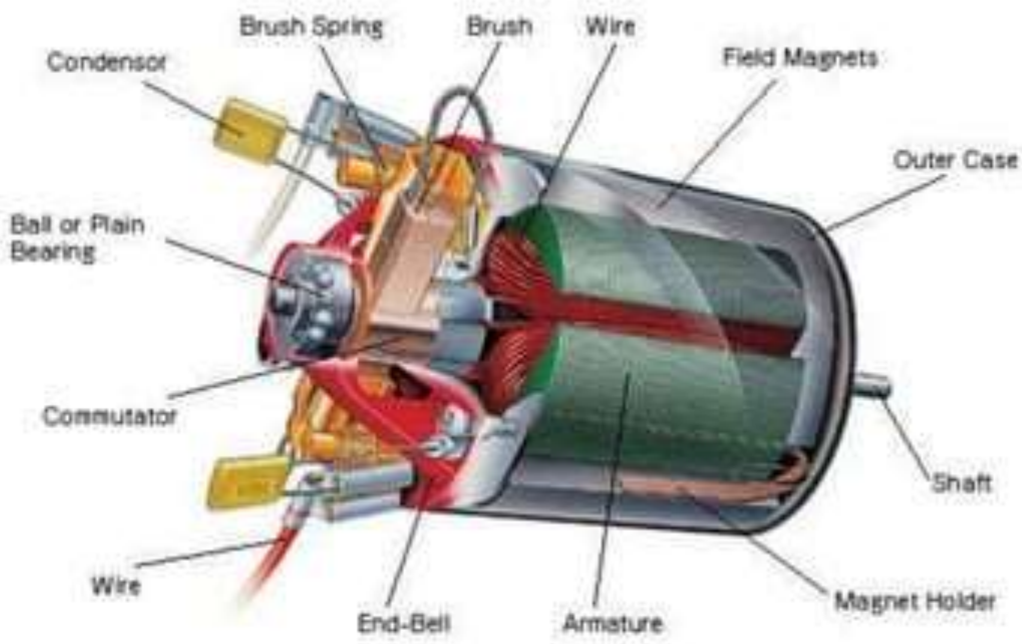
Synchronous Machines

Synchronous Machines

- *Synchronous generators* or *alternators* are used to convert mechanical power derived from steam, gas, or hydraulic-turbine to ac electric power
- Synchronous generators are the primary source of electrical energy we consume today
- Large ac power networks rely almost exclusively on synchronous generators
- *Synchronous motors* are built in large units compare to induction motors (Induction motors are cheaper for smaller ratings) and used for constant speed industrial drives

Construction

- **Basic parts of a synchronous generator:**
  - **Rotor - dc excited winding**
  - **Stator - 3-phase winding in which the ac emf is generated**
- **The manner in which the active parts of a synchronous machine are cooled determines its overall physical size and structure**

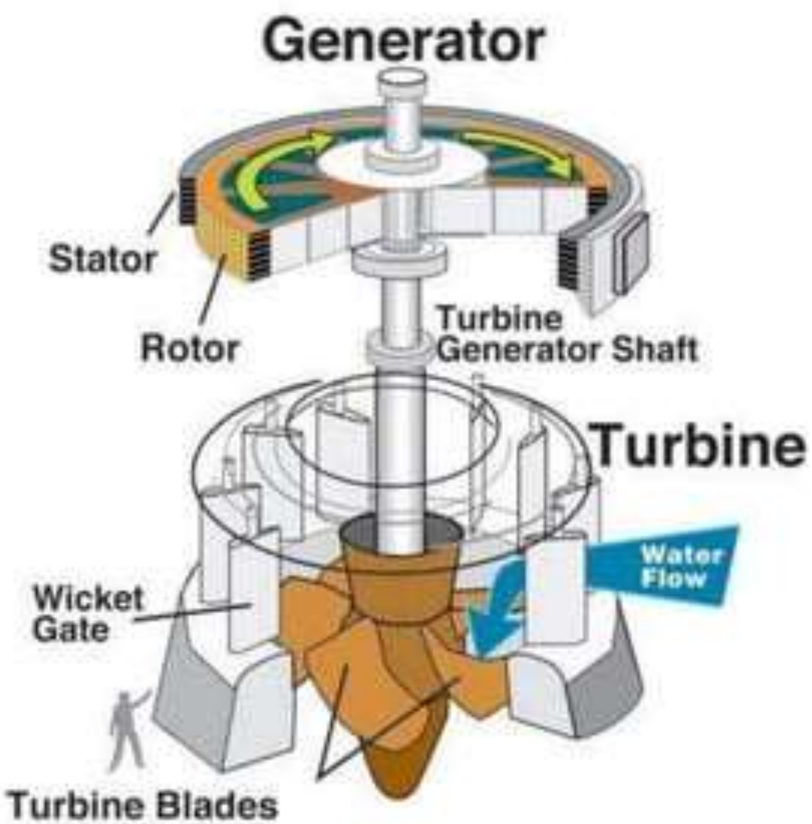


Types of Synchronous Machines

- Salient-pole synchronous machine
- Cylindrical or round-rotor synchronous machine

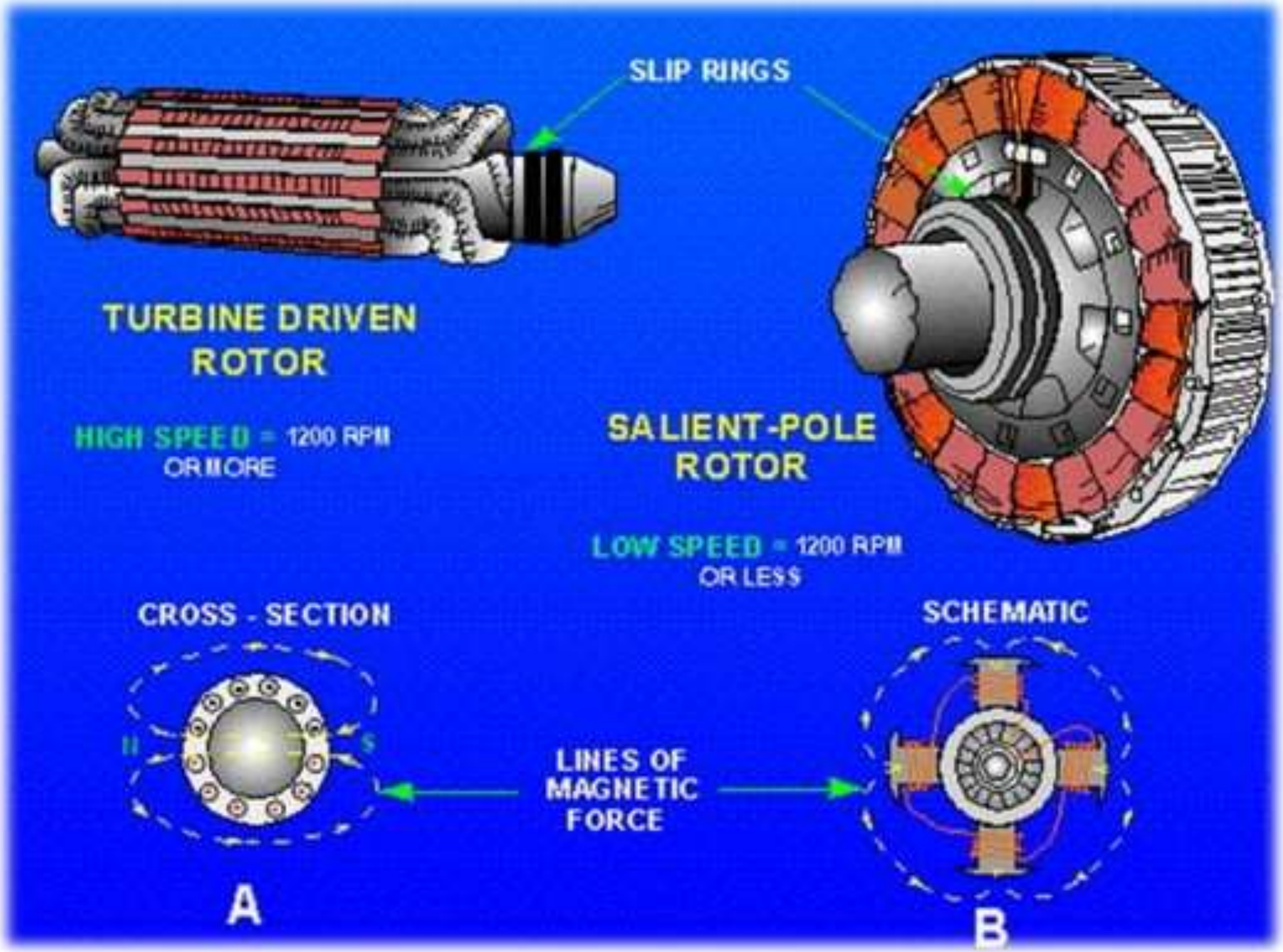
Salient-Pole Synchronous Generator

1. Most hydraulic turbines have to turn at low speeds (between 50 and 300 rpm)
2. A large number of poles are required on the rotor

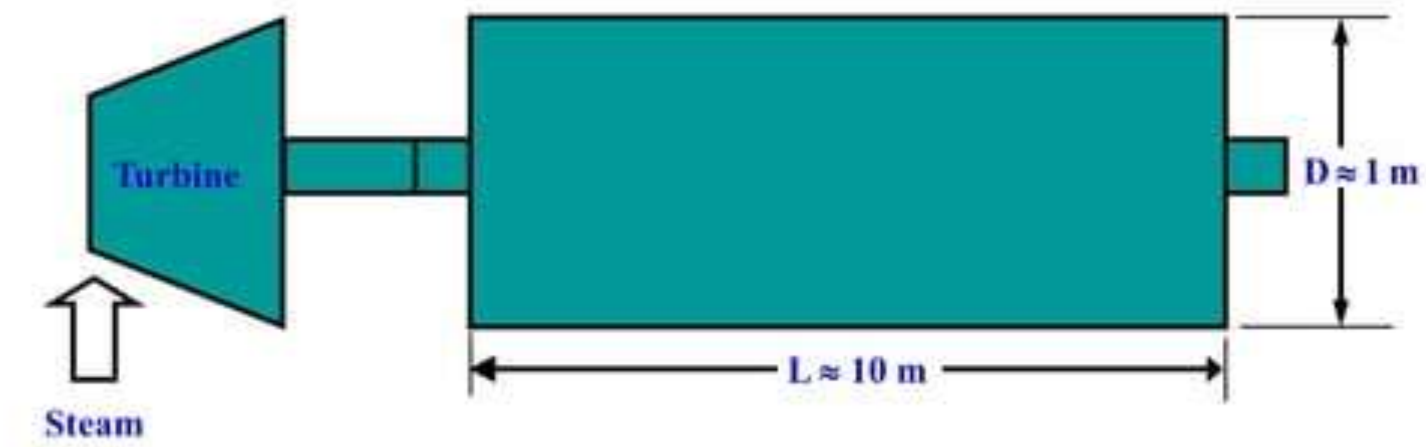


HABU POWER STATION (UNIT 2), MALAYSIA
UPRATING OF 11 KV, 2.5 MW HYDRO GENERATOR TO 2.75 MW
COMPLETE 'H' CLASS REINSULATION OF ROTOR POLES

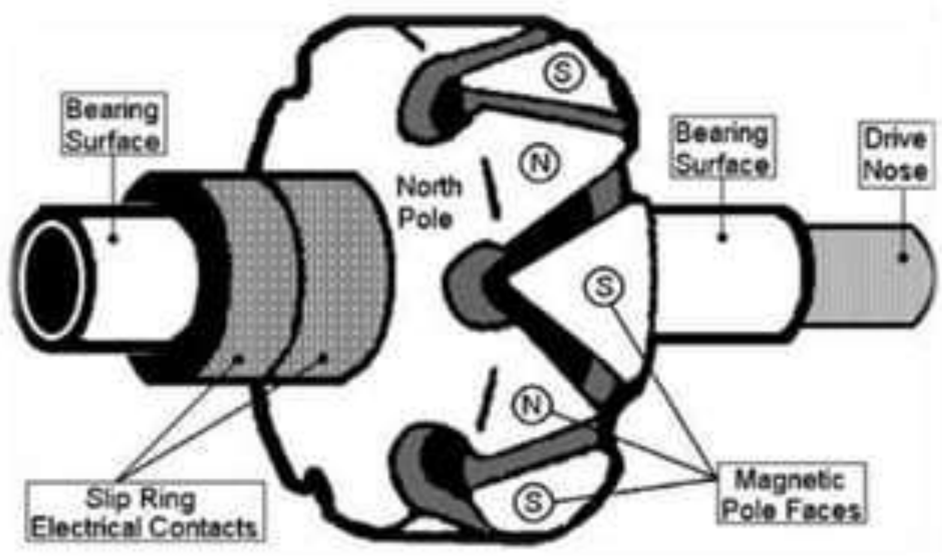
Salient-Pole Synchronous Generator



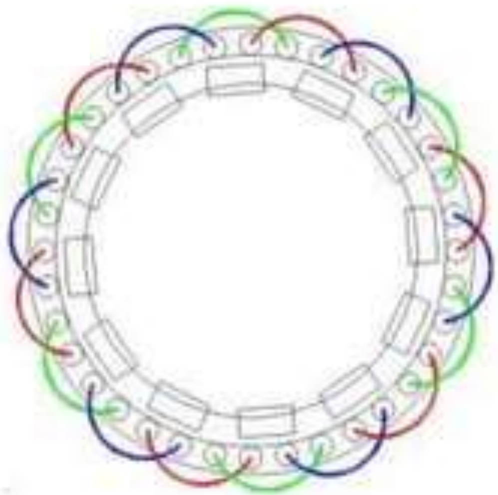
Cylindrical-Rotor Synchronous Generator



- High speed
- 3600 rpm ⇒ 2-pole
- 1800 rpm ⇒ 4-pole
- Direct-conductor cooling (using hydrogen or water as coolant)
- Rating up to 2000 MVA



Cylindrical-Rotor Synchronous Generator



Stator

Cylindrical rotor

Operation Principle

The rotor of the generator is driven by a prime-mover

⇩

A dc current is flowing in the rotor winding which produces a rotating magnetic field within the machine

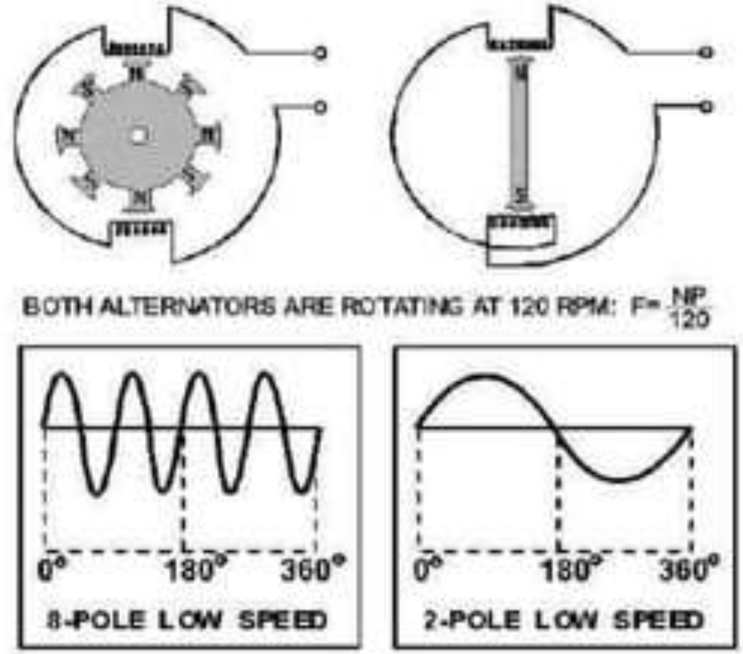
⇩

The rotating magnetic field induces a three-phase voltage in the stator winding of the generator

Electrical Frequency

Electrical frequency produced is locked or synchronized to the mechanical speed of rotation of a synchronous generator:

$$f_e = \frac{P n_m}{120}$$



where f_e **= electrical frequency in Hz**

P **= number of poles**

n_m **= speed of the rotor in rpm**

Generated Voltage

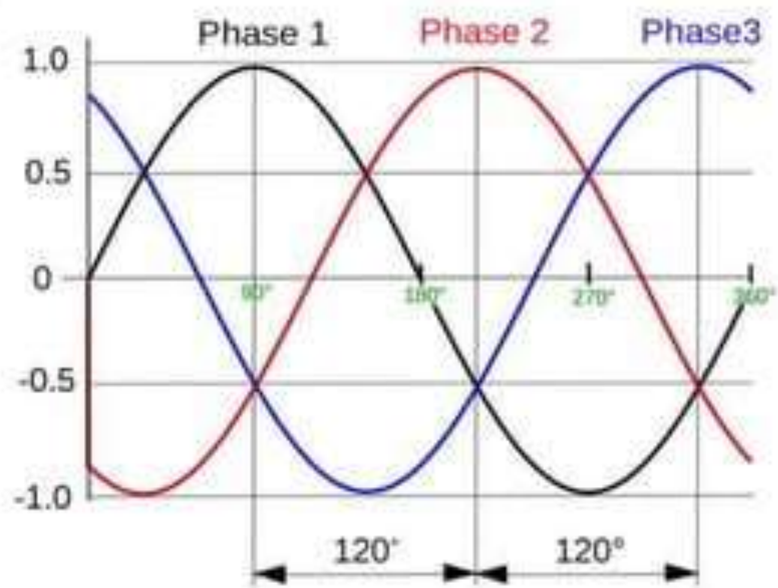
The generated voltage of a synchronous generator is given by

$$E = K_c \phi \, f_e$$

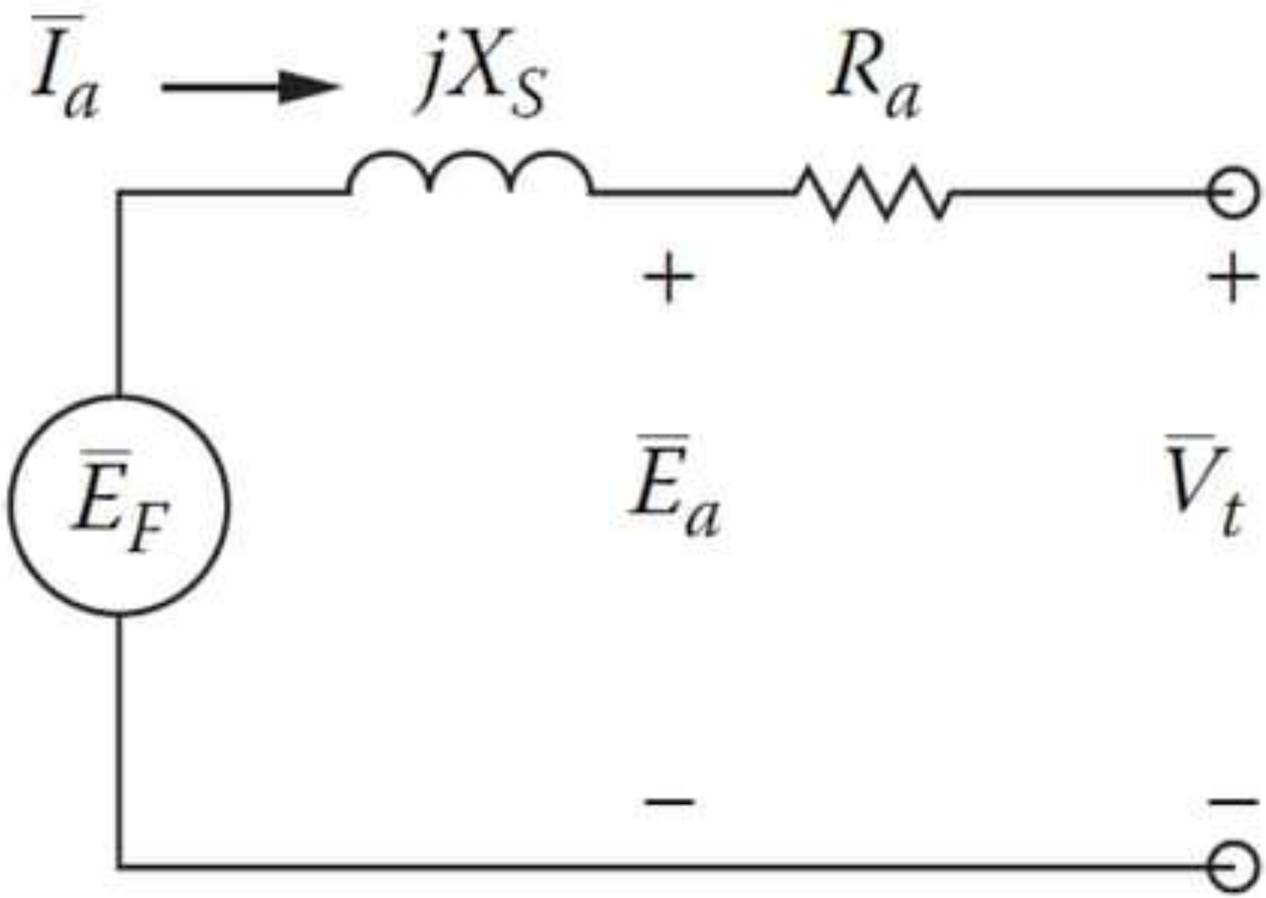
where ϕ **= flux in the machine (function of** I_f**)**

f_e **= electrical frequency**

K_c **= synchronous machine constant**



Per-phase equivalent circuit



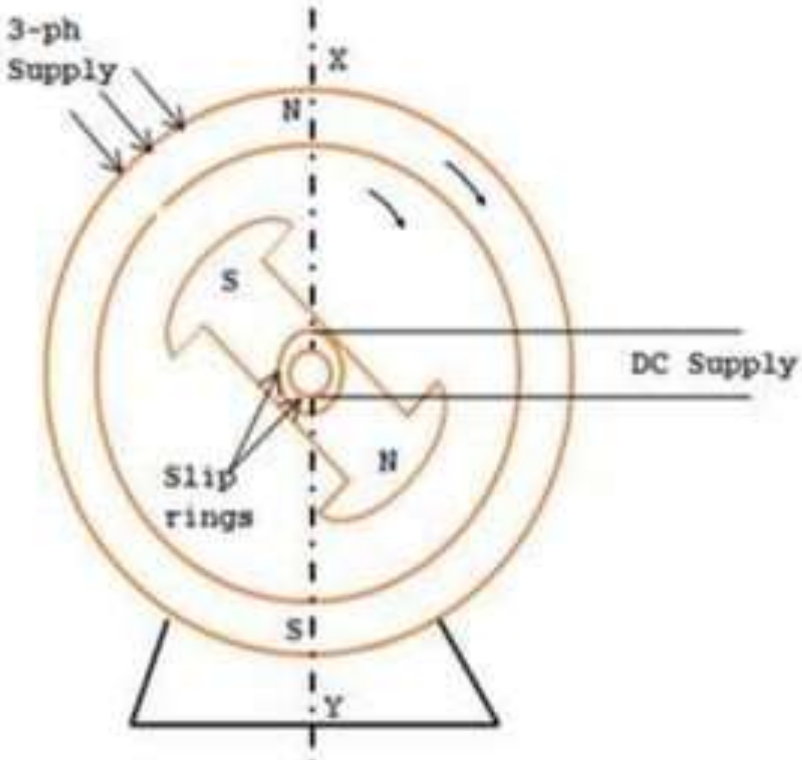
Synchronous Motors

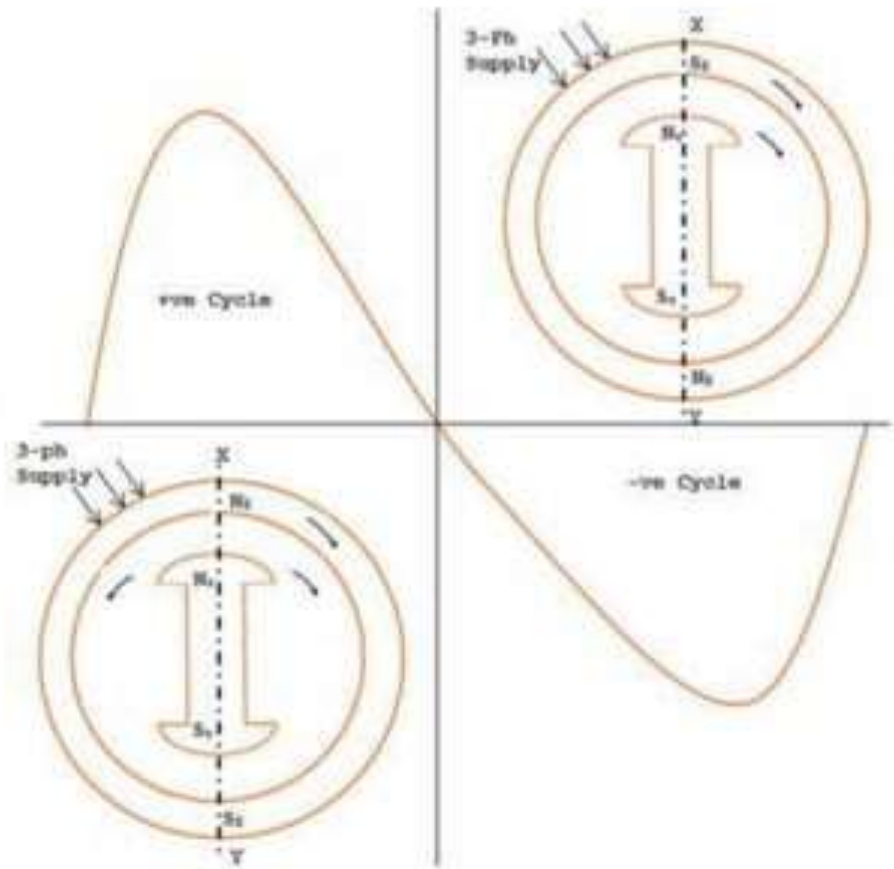
- A synchronous motor is the same physical machine as a generator, except that the direction of real power flow is reversed
- Synchronous motors are used to convert electric power to mechanical power

Operation Principle

- The field current of a synchronous motor produces a steady-state magnetic field B_R
- A three-phase set of voltages is applied to the stator windings of the motor, which produces a three-phase current flow in the windings. This three-phase set of currents in the armature winding produces a uniform rotating magnetic field of B_s
- Therefore, there are two magnetic fields present in the machine, and *the rotor field will tend to line up with the stator field*, just as two bar magnets will tend to line up if placed near each other.
- Since the stator magnetic field is rotating, the rotor magnetic field (and the rotor itself) will try to catch up
- The larger the angle between the two magnetic fields (up to certain maximum), the greater the torque on the rotor of the machine

Operation Principle





Application of Synchronous Motors

Synchronous motors are usually used in large sizes because in small sizes they are costlier as compared with induction machines. The principal advantages of using synchronous machine are as follows:

- Power factor of synchronous machine can be controlled very easily by controlling the field current.
- It has very high operating efficiency and constant speed.
- For operating speed less than about 500 rpm and for high-power requirements (above 600KW) synchronous motor is cheaper than induction motor.

In view of these advantages, synchronous motors are preferred for driving the loads requiring high power at low speed; e.g; reciprocating pumps and compressor, crushers, rolling mills, pulp grinders etc.