2- Synchronous Generator (Alternator):

The A.C generators or alternators are operating on the same fundamental principles of electromagnetic induction as DC generator they also consist of an armature winding and magnetic field, but there is on important difference between the two. In DC generator the armature rotates and the field system is stationary the arrangement in alternator is just the reverse of it. In their case standard construction consist of armature winding mounted on stationary element called(stator), and field winding on a rotating element called(rotor).

Then we have:

-Armature (stator), rotor (inductor)

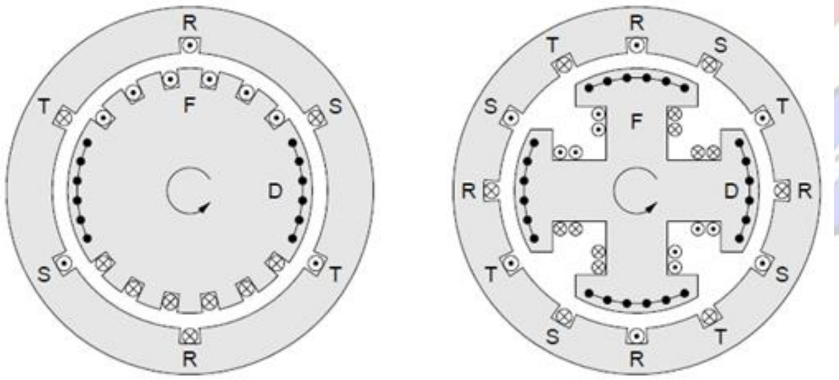
- Armature winding, excitation winding

- Damper winding.

$V_o \approx 14\ KV \quad , \quad P_{ex} = 3\% P_o \quad , \quad V_{ex} = 100 - 250\ V$

-Stationary Armature and rotating inductor

Rotating Armature and stationary inductor



Round rotor   Salient pole rotor

2-1 Ventilation or Cooling of an Alternator

• The slow speed salient pole alternators are ventilated by the fan action of the salient poles which provide circulating air.

• Cylindrical rotor alternators are usually long, and the problem of air flow requires very special attention.

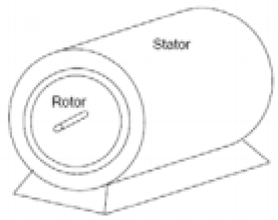
• The cooling medium, air or hydrogen is cooled by passing over pipes through which cooling water is circulated and ventilation of the alternator.

• Hydrogen is normally used as cooling medium in all the turbine-driven alternators because hydrogen provides better cooling than air and increases the efficiency and decreases the windage losses.

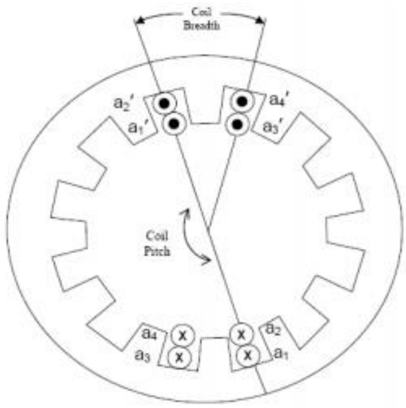
• Liquid cooling is used for the stators of cylindrical rotor generators.

2-2 Operating Principles:

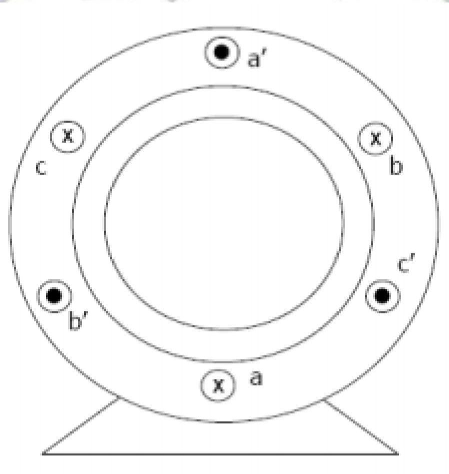
Principle of Operation A three-phase synchronous machine consists of an inner rotating cylinder called the rotor and an outer stationary housing called the stator as shown in Figure. A shaft runs through the rotor and it is balanced on bearings.



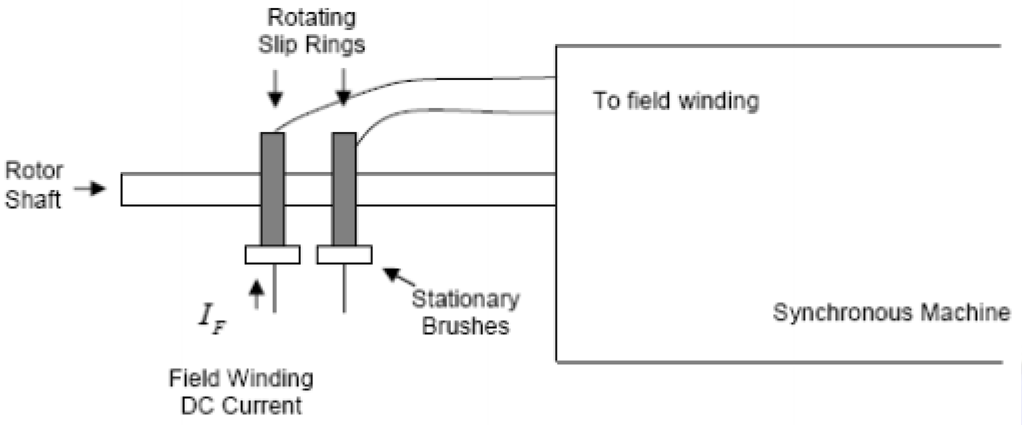
The internal periphery of a three-phase stator normally has a number of slots, the number typically being an integer multiple of six. A three-phase machine will require three identical coils of wire, each with many turns, and each coil is distributed in multiple stator slots. An example of one phase winding is shown in Figure. These windings are normally called the armature. The angular distribution of the turns is called the coil breadth. The angular distance between the sides of a given turn is termed the coil pitch. The other two-phase coils are positioned similarly about the stator periphery, with the centers of those coils spatially displaced by 120°.



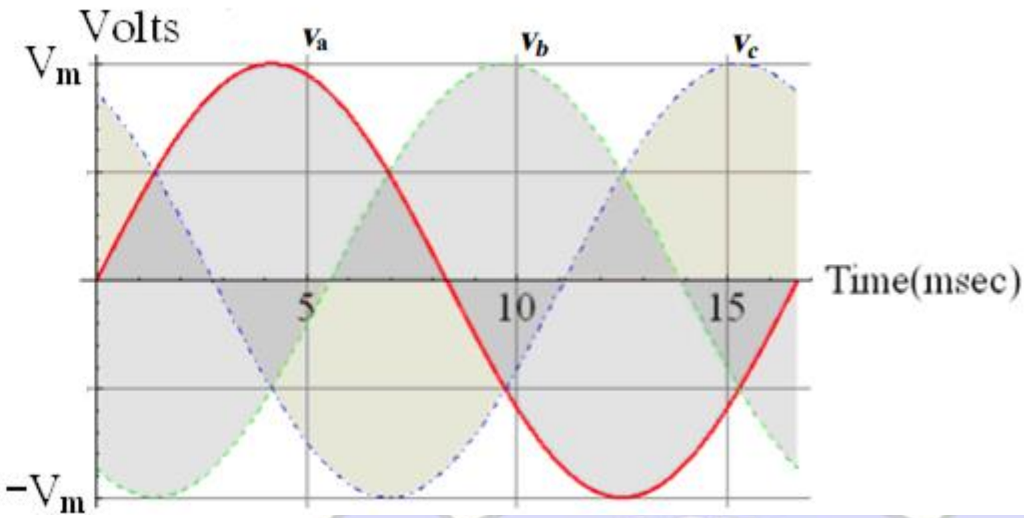
Instead of having to draw all of the slots and windings each time, we represent each distributed coil by a concentrated coil located in the center of the distribution. This is shown in Figure 5.4. The circle with a dot denotes that current is referenced out of the page while a circle with a cross indicates that current is referenced into the page. We use a, b, and c to reference the three stator phases represented in Figure.



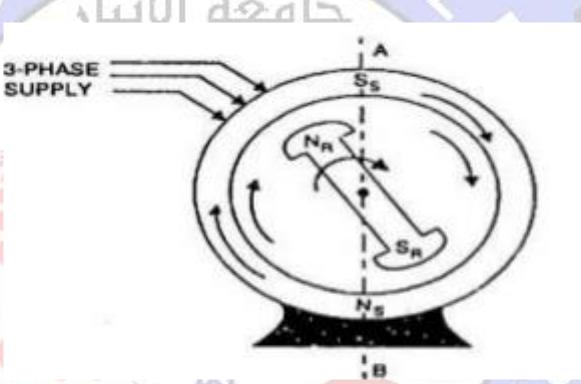
The rotor of a synchronous machine contains a winding called the field winding, which generates the magnetic field needed to generate a voltage (remember Faraday's Law). For simplicity, we will consider the case of a round rotor with a uniform air gap about the circumference of the rotor. The rotor may be slotted with the turns of the field winding distributed in those slots. The field winding will be supplied with a DC current. You say, "Wait a second, the field winding is on the rotor, and the rotor is spinning. How can we supply DC current to something that is moving?" The simplest solution to this dilemma is to use slip rings and brushes as illustrated in Figure. Note that the end connections of the field winding are tied to two copper rings mounted on the rotor shaft. Stationary carbon brushes are then made to ride upon the rings. A stationary DC voltage source is then applied to the brushes allowing DC current to flow through the field winding. Since the brushes are not commutating (i.e., reversing the current) coils as in a DC machine, the wear and maintenance requirements are not as intensive.



The DC current flowing in the field winding will set up a magnetic field on the rotor (think North and South poles). The prime mover (mechanical engine) will then spin the rotor at what we will soon refer to as synchronous speed. The magnetic field sweeping past the stationary stator coils will induce voltages. This phenomenon is described by Faraday's law, and was present as the back EMF in the DC motors you studied previously. Since the phase coils are spatially displaced, the induced voltages will be time displaced and will constitute a balanced set (i.e., same frequency, equal amplitude, and 120° displaced in phase). The voltage produced by each phase coil is shown in Figure. If we imagine that the rotor magnetic field moves past the "a" stator phase first, we would expect a strong induced voltage for the a-phase. As the rotor turns and moves its magnetic field past the b and c coils, those coils would also show a surge in voltage respectively. The sequence of voltages shown in the figure is termed the abc-phase sequence since the a-phase takes its peak first, then the b-phase and finally the c-phase. Note that the voltages all have the same frequency and equal amplitude but are displaced from each other by 120°. (As the rotor turns and moves past the a', b' and c', the negative voltage peaks occur.)



$V_e \rightarrow I_e \rightarrow F_e \rightarrow \emptyset_e$



At no load $V_1 = E_e = E_o$

n_r-prime mover speed

$F_i = \frac{P_{nr}}{60}$ emf frequency

At load $I_1 = I_a \rightarrow F_a \rightarrow \emptyset_a$ rotating with (n_s)

$$n_s = \frac{60\, F_1}{P} = \frac{60}{P}\left(\frac{P_{nr}}{60}\right) = n_r$$

$$n_s = n_r$$