Department of Electrical Engineering
Assignment
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Course Details

Course Title:	AC Machines	**Module:**	B-Tech
Instructor:	Engr. Rashid Aleem	**Total Marks:**	50

Student Details

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Q1	In which motors the rotor does not receive power by conduction?Explain the advantages and disadvantages in detail of that motor?	Marks (5)
Q2	A slip-ring induction motor runs at 290 r.p.m at full load,when connected to 50Hz supply?Determine the no of poles and slip?	(5)
Q3	The power input to the rotor of 440V,50Hz ,6 pole ,3 phase induction motor is 80KW.The rotor electromotive force is observed to make 100 complete alteration per minute.Calculate the slip,the rotor speed and rotor copper losses per phase?	(5)
Q4	Explain in detail the basic principle of alternators and also discusss its construction?	(5)
Q5	A 3-phase,16-pole alternator has a star connected winding with 144 slots and 10 conductor per slots.The flux per pole is 0.03 weber,sinusoidally distributed and the speed is 375 r.p.m.Find the frequency rpm and the phase and line e.m.f.Assume full pitched coil?	(5)
Q6	Write a note on three phase transformer connections?	(5)
Q7	A 500KVA,3 phase,50 Hz transformer has a voltage ratio of 33/11-KV and is delta/star connected.The resistances per phase are :high voltage of 35 ohm low voltage 0.876 ohm and the iron loss is 3050 W.Calculate the value of	(10)

	efficiency at full load and one –half of full load respectively at unity power factor and at 0.8 pf.	
Q8	Answer the following short questions? Q1)What Is The General System Requirements Of Alternator? Q2)Will The Alternators Have Rotating Armature System Or Stationary Armature System? Q3)What Are The Advantages Of Stationary Armature And Rotating Field System? Q4)What Are The Advantages Of Three Phase Motor Over Single Phase Motor? Q5)What Is Meant By Turbo Alternators?	(10)

Answer Sheet

Q1:

In which motors the rotor does not receive power by conduction? Explain the advantages and disadvantages in detail of that motor?

Ans:

In AC motors (Induction motor) the rotor does not
receive electrical power but conduction by induction in the same way as the secondary of 2-winding transformer receives its power from the primary winding. Drives. → the stator of induction motor is made up of a number of stampings, which are slotted to receive the windings.

Or

In Induction motor the rotor does not receive electric power by conduction but by induction in exactly as the secondary of 2 – winding transformer receives its power from the secondary. That is why such motors are known as rotating transformer. When you give three phase supply to the three phase stator winding then it is called as three phase induction motor.

Advantages:

1. The most important advantage of an induction motor is that its construction is quite simple in nature. The construction of the Stator is similar in both Synchronous motors as well as induction motors. However, a slip ring is required to feed DC Supply to the Rotor in the case of a Synchronous Generator. These Slip rings are not required in a Squirrel cage induction motor because the windings are permanently short circuited. When compared with a DC Motor, the induction motor does not have Brushes and hence, maintenance required is quite low. This leads to a simple construction.
2. The working of the motor is independent of the environmental condition. This is because the induction motor is Robust and mechanically strong.
3. A Squirrel cage induction motor does not contain Brushes, Slip rings and Commutators. Due to this reason, the cost of the motor is quite low. However, Slip Rings are used in Wound type induction motor to add external resistance to the rotor winding.
4. Due to the absence of Brushes, there are no sparks in the motor. It can also be operated in hazardous conditions.
5. Unlike synchronous motors, a 3 phase induction motor has a high starting torque, good speed regulation and reasonable overload capacity.
6. An induction motor is a highly efficient machine with full load efficiency varying from 85 to 97 percent.

Disadvantages:

1. A single phase induction motor, unlike a 3 phase induction motor, does not have a self-starting torque. Auxiliaries are required to start a single phase motor.

2. During light load conditions, the power factor of the motor drops to a very low value. This is because during the start, the motor draws a large magnetizing current to overcome the reluctance offered by the air gap between the Stator and the Rotor. Also, the induction motor will take very less current from the supply main. The vector sum of Load current and Magnetizing current lags the voltage by around 75-80 degrees and hence, the power factor is low. Due to high magnetizing current, the copper losses of the motor increase. This in turn leads to decrease in the efficiency of the motor.
3. Speed control of an induction motor is very difficult to attain. This is because a 3 phase induction motor is a constant speed motor and for the entire loading range, the change in speed of the motor is very low.
4. Induction motors have high input surge currents, which are referred to as Magnetising Inrush currents. This causes a reduction in voltage at the time of starting the motor.
5. Due to poor starting torque, the motor cannot be used for applications which require high starting torque.

Q2:

A slip-ring induction motor runs at 290 r.p.m at full load,when connected to 50Hz supply?Determine the no of poles and slip?

Ans:

Solution

Since N is 290 rpm. N_s

Has to be somewhere near it say 300 rpm

If N_s is assumed as 300 rpm then\

$$300 = \frac{120 \times 50}{P}$$

$\therefore$ P=20

$$\therefore \quad \text{Slip} = \frac{300-20}{300} = 3.33\%$$ **Ans.**

Q3:

The power input to the rotor of 440V, 50Hz ,6 pole ,3 phase induction motor is 80KW.The rotor electromotive force is observed to make 100 complete alteration per minute. Calculate the slip, the rotor speed and rotor copper losses per phase?

Ans:

Solution

100 alternations minutes = $\frac{100}{60}$ cycles/sec

1.6667Hz = sf

Hence, the slip $s = \frac{1.6667}{50}$ = 0.3333p.u or 3.333%

(ii) rotor speed N = (1-0.3333)1000

Since $N_2 = \frac{120\ .50}{6}$ =1000rpm, N=966.67rpm

(iii) Rotor copper losses phase = $\frac{1}{3}$. (S. rotor input)

Total rotor power input = 80KW

Rotor power input per phase = 80/3KW

Rotor copper losses per phase

$\frac{0.333\ \ .80}{3}$ KW = 0.8888KW **Ans.**

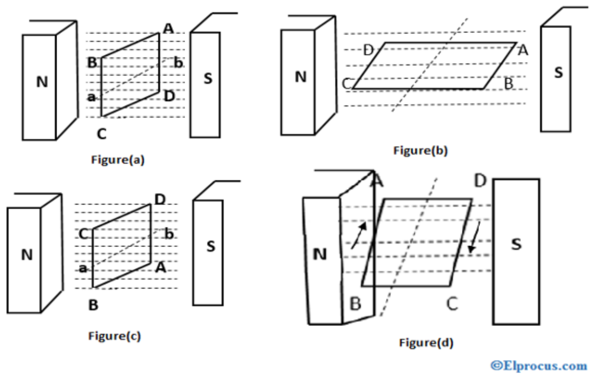
Q4:

Explain in detail the basic principle of alternators and also discuss its construction?

Ans:

Working Principle of Alternator

All the alternators work on the principle of electromagnetic induction. According to this law, for producing the electricity we need a conductor, magnetic field and mechanical energy. Every machine that rotates and reproduces Alternating Current. To understand the working principle of the alternator, consider two opposite magnetic poles north and south, and the flux is traveling between these two magnetic poles. In the figure (a) rectangular coil is placed between the north and south magnetic poles. The position of the coil is such that the coil is parallel to the flux, so no flux is cutting and therefore no current is induced. So that the waveform generated in that position is Zero degrees.

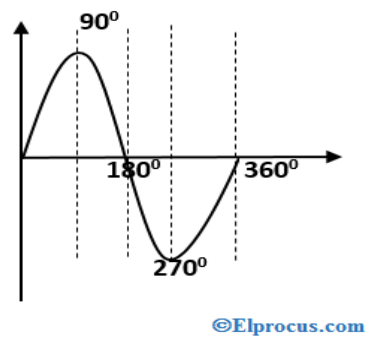


If the rectangular coil rotates in a clockwise direction at an axis a and b, the conductor side A and B comes in front of the south pole and C and D come in front of a north pole as shown in figure (b). So, now we can say that the motion of the conductor is perpendicular to the flux lines from N to S pole and the conductor cuts the magnetic flux. At this position, the rate of flux cutting by the conductor is maximum because the conductor and flux are perpendicular to each other and therefore the current is induced in the conductor and this current will be in maximum position.

The conductor rotates one more time at 90^0 in a clockwise direction then the rectangular coil comes in the vertical position. Now the position of the conductor and magnetic flux line is parallel to each other as shown in figure (c). In this figure, no flux is cutting by the conductor and therefore no current is induced. In this position, the waveform is reduced to zero degrees because the flux is not cutting.

In the second half cycle, the conductor is continued to rotate in a clockwise direction for another 90^0. So here the rectangular coil comes to a horizontal position in such a way that the conductor A and B comes in front of the north pole, C and D come in front of the south pole as shown in the figure (d). Again the current will flow through the conductor that is currently induced in the conductor A and B is from point B to A and in conductor C and D is from point D to C, so the waveform produced in opposite direction, and reaches to the maximum value. Then the direction

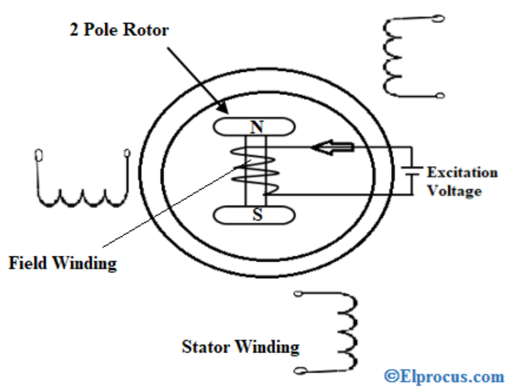
of the current indicated as A, D, C and B as shown in figure (d). If the rectangular coil again rotates in another 90^0 then the coil reaches the same position from where the rotation is started. Therefore, the current will again drop to zero.
In the complete cycle, the current in the conductor reaches the maximum and reduces to zero and in the opposite direction, the conductor reaches the maximum and again reaches zero. This cycle repeats again and again, due to this repetition of the cycle the current will be induced in the conductor continuously.



This is the process of producing the current and EMF of a single-phase. Now for producing 3 phases, the coils are placed at the displacement of 120^0 each. So the process of producing the current is the same as the single-phase but only the difference is the displacement between three phases is 120^0. This is the working principle of an alternator.

Construction of an Alternator

The main components of an alternator or synchronous generator are rotor and stator. The main difference between rotor and stator is, the rotor is a rotating part and stator is not a rotating component means it is a stationary part. The motors are generally run by rotor and stator.



The stator word based on the stationary and the rotor word based on the rotating. The construction of the stator of an alternator is equal to the construction of the stator of an induction motor. So induction motor construction and synchronous motor construction are both are same. Thus the stator is the stationary part of the rotor and the rotor is the component that rotates inside of the stator. The rotor is located on the stator shaft and the series of the electromagnets arranged in a cylinder causing the rotor to rotate and create a magnetic field. There are two types of rotors.

Salient Pole Rotor

The meaning of the salient is projecting outward, which means the poles of the rotor are projecting outward from the center of the rotor. There is a field winding on the rotor and for this field winding will use DC supply. When we pass the current through this field winding N and S poles are created. The salient rotors are unbalanced so the speeds are restricted. This type of rotor used in hydro stations and diesel power stations. The salient pole rotor used for low-speed machines approximately 120-400rpm.

Cylindrical Rotor

The cylindrical rotor is also known as a non-salient rotor or round rotor and this rotor is used for high-speed machines approximately 1500-3000 rpm and the example for this is a thermal power plant. This rotor is made up of a steel radial cylinder having the number of slots and in these slots, the field winding is placed and these field windings are always connected in series. The advantages of this are mechanically robust, flux distribution is uniform, operates at high speed and produces low noise.

Q5:

A 3-phase,16-pole alternator has a star connected winding with 144 slots and 10 conductor per slots. The flux per pole is 0.03 weber,sinusoidally distributed and the speed is 375 r.p.m.Find the frequency rpm and the phase and line e.m.f.Assume full pitched coil?

Ans:

Solution

$$F = PN/120 = \frac{16\times375}{120} = 50\text{Hz}$$

Since K_e is not given would be taken as unity

$$n = \frac{144}{16} = 9;\ \beta = 180°/9 = 20°;\ m = \frac{144}{16\times3} = 3$$

$K_d = \sin 3 \times \frac{(20°/2)}{3\sin(20°/2)} = 0.96$

$Z = 144 \times 10/3 = 480. T = \frac{480}{2} = 240/\text{phase}$

$E_{ph} = 4.44 \times 1 \times 0.96 \times 50 \times 0.03 \times 240 = 15.34V$

Line voltage $E_L = \sqrt{3}\, E_{ph} = \sqrt{3} \times 1534 = 2658V$ **Ans.**

Q6:

Write a note on three phase transformer connections?

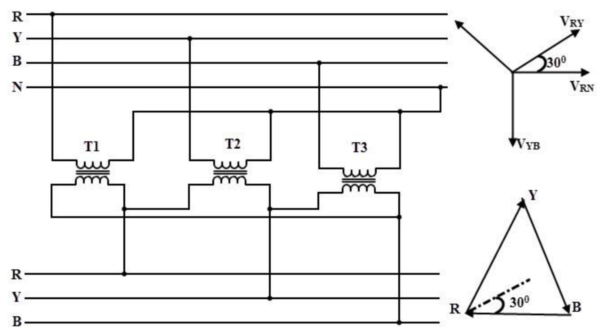
Ans:

Three Phase Transformer Connections

As discussed above, either by a single three phase transformer or by three single phase transformers combination, three phase transformations can be carried out. The way of connecting the windings for three phase transformation is same whether the three windings of a three phase transformer or three windings of three single phase transformers are used. The primary and secondary windings are connected in different ways, such as in delta or star or combination of these two. The voltage and current ratings of the three phase transformer is depends on suitable connection. The most commonly used connections are

- Star-delta
- Delta-star
- Delta-delta
- Star-star

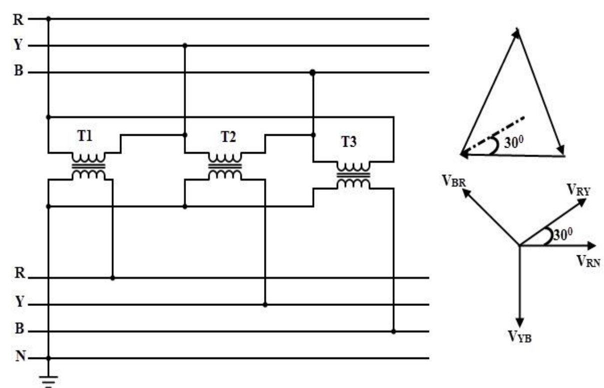
Star – Delta Connection



This type of connection is commonly used to step-down the voltages to a lower value in transmission end substations. Utility companies use this connection to reduce the voltage levels for distribution systems.

- In this, the primary winding of the transformer is connected in star and secondary in delta connection.
- The neutral point on the primary or high voltage side can be grounded which is desirable in most of the cases.
- The line voltage ratio between secondary and primary is 1/√3 times the transformation ratio of each transformer.
- There exists 30 degrees phase difference between primary and secondary line voltages.
- Since the actual primary coil voltage is 58% of the primary line voltage, the insulation requirements for HV windings is reduced by using this winding.
- In this connection balanced three phase voltage are obtained at the secondary or LV side, even when the unbalanced currents are flowing the in the primary or HV side due to neutral wire. The neutral wire grounding also provides lightning surge protection.

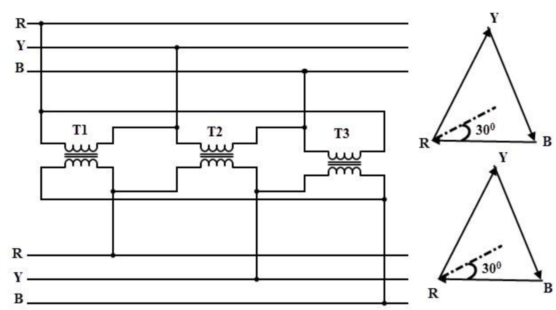
Delta – Star Connection



- This connection is used to step-up the voltage level and is commonly employed in sending end or starting of high tension transmission system.
- In this, the primary is connected in delta fashion and secondary in star fashion so that three phase 4 wire system at secondary is possible.
- The secondary voltage to the load is √3 times the delta connected primary voltage. Also the load and secondary currents will be the same due to the same series circuit.

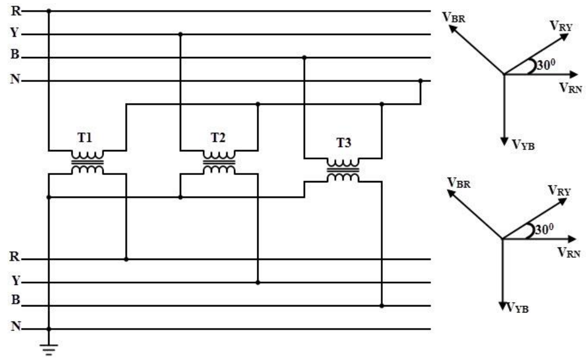
- This connection provides three single phase circuits at both lower and higher voltages and one three phase circuit at higher voltage so that single and three phase loads can be supplied.
- Dual voltages are obtained delta-star connection. Low single phase voltages are obtained by wiring between any phase and ground. Higher single phase voltages are obtained by wiring between any two phases. And by connecting all three phases to the load, three phase voltage is obtained.
- The insulation requirement on high voltage side is lowered due to the star (less number of turns per phase) connected secondary.
- Similar to star-delta, this connection causes to create a 30 degrees phase difference between primary and secondary line voltages.
- By using this connection, it is not possible to connect it parallel with delta-delta and star-star transformers due to the primary and secondary voltage phase difference.

Delta-delta



- This type of connection is used when the supply source is delta connected and the secondary load needs single voltage with high current. This is generally employed for three phase power loads (like three phase motor).
- In this, both primary and secondary windings are connected in delta fashion.
- The voltage across the load is equal to the secondary voltage and voltage across the primary winding is equal to source voltage. In this, the current flow through the load will be 1.732 times the secondary current and the feeder current will equal to the 1.732 times current through the primary winding. Due to these high supply and load currents, it is recommended to place transformer much closer to both source and load circuits.
- In this, there exists no phase difference between the primary and secondary voltages.
- The three phase voltages remains constant even with unbalanced load, thus allows unbalanced loading.
- The main advantage of this connection is if the one transformer is defective or removed for service (open delta connection), then remaining two transformers continue to deliver thee phase power at reduced load capacity.

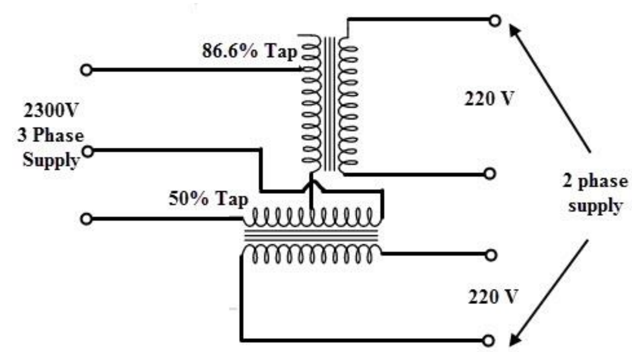
Star – Star Connection



- In this, both primary and secondary windings are connected in star fashion and also there exist no phase difference between the primary and secondary voltages.
- In this, current flowing through both primary and secondary windings are equal to the currents of the lines to which they are connected (supply source and load). And voltages between line phases on either end equal to 1.732 times respective winding voltages.
- Due to neutral availability, it is well suited for three phase four wire system.
- This type connection satisfactorily works if the load is balanced. But if the load is unbalanced, the neutral point shift causes unequal phase voltages.
- Large third harmonic voltages would appear in both primary and secondary windings without the neutral tie. This may lead to the insulation failures.
- This connection considerably generates interference with communication lines and hence with this connection configuration, telephone lines cannot be run in parallel.
- Due to these disadvantages, the star-star connection is rarely used and not employed in practice.

Scott Connection

- This connection is used to convert the three phase power into two phase power using two single phase transformers.
- One transformer called as main transformer having center or 50 percent tap and is connected between the two lines of the three phase wires. The other transformer called as teaser transformer having 86.6 tap and is connected between the third phase wire and 50 percent tap of the main transformer.
- The secondary winding of each transformer provides the phases of two phase systems.
- The secondary voltages in the two transformers will be equal in magnitude if both transformers are wound for equal number of turns on secondary. And produced voltages are 90 degrees out of phase with each other.
- This connection is mainly used to supply the power to the two phase motor.



Q7:

A 500KVA,3 phase,50 Hz transformer has a voltage ratio of 33/11-KV and is delta/star connected. The resistances per phase are :high voltage of 35 ohm low voltage 0.876 ohm and the iron loss is 3050 W.Calculate the value of efficiency at full load and one –half of full load respectively at unity power factor and at 0.8 pf.

Ans:

Solution

Transformation ratio K = $\frac{11,000}{\sqrt{3}\times 33,000} = \frac{1}{3\sqrt{3}}$

Per phase $R_{02} = 0.876+(\frac{1}{3\sqrt{3}})^2 \times 35 = 2.172\Omega$

Secondary phase current = $\frac{500,000}{\sqrt{3}\times 33,000} = \frac{500}{11\sqrt{3}}$ A

Full load condition

Full load total Cu loss = $3\times(\frac{11}{\sqrt{3}})^2 \times 2.172$ =4,490 W; Iron loss= 3,050 W

Total full load losses

= 4,490+3,050 = 7,540 W; Output at unity p.f. =500 kW

- F.L Efficiency = 500,000/507.540
  = 0.9854 or 98.54% ; Output at 0.8 p.f. =400kW
- Efficiency = 400,000/407.540

=0.982 or 98.2%

Half load condition

Output at unity p.f =250 kW
Cu losses = $(1/2)^2 \times 4{,}490$
=1,222 W
Total loss
=3,050+1,122=4,172 W

N= 250.000/254,172 = 0.9835 = 98.35%
Output at 0.8p.f = 200KW ∴ n=200,000/204,172 =98% **Ans.**

Q8:

(Q1) What Is The General System Requirements Of Alternator?

Ans:

For the generation of emf, there should be two basic systems.

(i) magnetic field system to produce the magnetic field
(ii) Armature system which houses the conductors on which the EMF is to be induced.

(Q2) Will The Alternators Have Rotating Armature System Or Stationary Armature System?

Ans:

Generally in alternators, the armature is stationary and the field rotates. Small low-voltage alternators often have a rotating armature and a stationary field winding. But in large alternators rotating armature field type is used.

(Q3) What Are The Advantages Of Stationary Armature And Rotating Field System?

Ans:

Advantages of Stationary Armature and Rotating Field System:

1. In this case of high voltage generation, the instruction problem is server. If the armature is rotating, this is due to centrifugal states develop in the body due to the rotation. But if the armature is the stationery armature can be included easily even from vary high voltage up to 33000 volt.
2. If the rotating armature stationary field system is provides. If require three slip ring to collect the emf and send it in the external circuit from rotating field system no slip ring are required. The emf which is produced in the armature and can be load out directly from the armature as the armature is stationary. **OR**

The stationary armature coils can be insulated easily.
Higher peripheral speed can be achieved in the rotor.
Cooling of the winding is more efficient.
Only two slip rings are required to give DC supply to the field system
Output current can be easily supplied to the load circuit. Slip-rings and brushes are not necessary.

(Q4) What Are The Advantages Of Three Phase Motor Over Single Phase Motor?

Ans:

The Advantages of Three Phase Motor over Single Phase Motor are:

1. A polyphase/3 phase transmission line requires less conductor material than a single phase line for transmitting the same amount power at the same voltage.

2. For a given frame size a polyphase/3 phase machine gives a higher output than a single-phase machine. For example output of a 3-phase motor is 1.5 times the output of single-phase motor of same size.

3. Polyphase/3 phase motors have a uniform torque where most of the single-phase motors have

a pulsating torque.

4. Polyphase/3 phase induction motors are self-starting and are more efficient. On the other hand single-phase induction motors are not self-starting and are less efficient.

6. Per unit of output. The polyphase/3 phase machine is very much cheaper.

7. Power factor of a single-phase motor is lower than that of polyphase motor of the same rating.

8. Rotating field can be set up by passing polyphase current through stationary coils.

9. Parallel operation of polypahse alternators is simple as compared to that of single-phase alternators because of pulsating reaction in single-phase alternator.

It has been found that the above advantages are best realized in the case of three-phase systems. Consequently, the electric power is generated and transmitted in the form of three-phase system.

(Q5) What Is Meant By Turbo Alternators?

Ans:

Turbo Alternators: Turbo-alternators are basically hydrogen cooled cylindrical rotor alternators used to generate electric power in generating stations. They have only 2 poles and are run by a 3000 rpm turbine for 50 Hz machine and 3600 rpm for 60 Hz machine.

OR

The alternator which coupled directly to the steam turbines are called turbo-alternator.
The turbine converts heat energy in the steam into mechanical work and the alternator converts mechanical energy into electrical energy.