

UNIT V

SYNCHRONOUS MACHINES

1. Name the two types of synchronous machines?

1. Salient pole machines
2. Cylindrical rotor machines.

2. What are the two type of poles used in salient pole machines?

The two types of poles used in salient pole machines are

1. round pole and
2. rectangular poles.

3. What is run away speed?

The runaway speed is defined as the speed which the prime mover would have, if it is suddenly unloaded, when it is working at its rated load.

4. State three important features of turbo alternator rotors?

1. The rotors of turbo alternators have large axial length and small diameters.
2. Damping torque is provided by the rotor itself and so there is no necessity for additional damper winding.
3. They are suitable for high speed operations and so number of poles is usually 2 or 4.

5. What are the prime movers used for a) Salient pole alternator, b) Non salient pole alternator?

The prime movers used for salient pole alternators are water wheels like Kaplan turbine, Francis turbine, Pelton wheel etc., and diesel or petrol engines. The prime movers used for non-salient pole alternators are steam turbines and gas turbines.

6. Distinguish between cylindrical pole and salient pole construction?

In cylindrical pole construction the rotor is made of solid cylinder and slots are cut on the outer periphery of the cylinder to accommodate field conductors

In salient pole construction, the circular or rectangular poles are mounted on the outer surface of the cylinder. The field coils are fixed on the pole.

The cylindrical pole construction is suitable for high speed operation, whereas the salient pole construction is suitable for slow speed operations

7. Salient pole machines are not suitable for high speed operations, why?

The salient pole rotors cannot withstand the mechanical stresses developed at high speed. The projecting poles may be damaged due to mechanical stresses.

8. What is critical speed of alternator?

When the rotor of the alternator has an eccentricity, it may have a deflection while rotating. This deflection will be maximum at a speed called critical speed. When a rotor with eccentricity passes through critical speed, severe vibrations are developed.

9. Mention the uses of damper windings in a synchronous machine?

1. Damper winding is used to reduce the oscillations developed in the rotor of alternator when it is suddenly loaded.
2. The damper winding is used to start the synchronous motor as an induction motor.

10. List the factors to be considered for separation of D and L for salient pole machines?

The factors to be considered are

1. Peripheral speed
2. Number of poles

3. Short circuit ratio

11. Define pitch factor?

The pitch factor is defined as the ratio of vector sum of emf induced in a coil to arithmetic sum of emf induced in the coil

12. Define distribution factor?

The distribution factor is defined as the ratio of vector sum to arithmetic sum of emf induced in the conductor of one phase spread.

13. Why alternators are rated in kVA?

The kVA rating of ac machine depends on the power factor of the load. The power factor in turn depends on the operating conditions. The operating conditions differ from place to place. Therefore the kVA rating is specified for all ac machines.

14. What are the factors to be considered for the choice of specific magnetic loading?

The factors to be considered for the choice of specific magnetic loading are

1. Iron loss
2. Voltage rating
3. Transient short circuit current
4. Stability
5. Parallel operation.

15. Give typical values of flux density and ampere conductors per metre for large turbo alternators?

The typical values of flux density are

$$B_{av} = 0.54 \text{ to } 0.65 \text{ wb/m}^2$$

$$ac = 50000 \text{ to } 75000 \text{ amp.cond/m (For conventionally cooled machine)}$$

$$ac = 180000 \text{ to } 200000 \text{ amp.cond/m (for water cooled machine)}$$

16. What are the factors to be considered for the choice of specific electric loading?

The factors to be considered for the choice of specific electric loading are

1. Copper loss
2. Temperature rise
3. Voltage rating
4. Synchronous reactance
5. Stray load losses

17. What is short circuit ratio?

The short circuit ratio is defined as the ratio of field current required to produce rated voltage on open circuit to field current required to circulate the rated current on short circuit. It is also given as the reciprocal of synchronous reactance.

18. How the value of SCR affects the design of alternator?

For high stability and low regulation, the value of SCR should be high, which requires large air gap, when the length of air gap is large, the mmf requirement will be high so the field system will be large. Hence the machine will be costlier.

19. What are the advantages of large air gap in synchronous machines?

The advantages of having large air gap in synchronous machines are

1. Reduction in armature reaction
2. Small value of regulation
3. Higher value of stability
4. A higher synchronous power which makes the machine less sensitive to load variation
5. Better cooling
6. Lower tooth pulsation loss
7. Less noise
8. Smaller unbalanced magnetic pull

20. Write the expression for length of air gap in salient pole synchronous machine?

The expression for length of air gap in salient pole synchronous machine is

$$l_g = AT_{f0}/(B_g K_g \times 10^6) \text{ or}$$

$$l_g = AT_a \times SCR \times K_f / B_{av} \times K_g \times 10^6$$

21. List the factors which influence of the air gap length on the performance of the synchronous machine?

The factors which influence of the air gap length are

1. Armature reaction
2. Noise
3. Unbalanced magnetic pull
4. Regulation
5. Tooth pulsation loss
6. Sensitivity to load variations

22. List the factors to be considered for the choice of slot in synchronous machines?

The factors to be considered for the choice of slot in synchronous machines are

1. Balanced winding
2. Cost
3. Hot spot temperature in
4. Leakage reactance
5. Tooth losses
6. Tooth flux density

23. Determine the total number of slots in the stator of an alternator having 4 poles, 3 phase, 6 slots per pole per phase?

Total no. of slots = slots per pole per phase x no. of poles x no. of phase

$$= 6 \times 4 \times 3 = 72 \text{ slots}$$

24. What is the limiting factor for the diameter of synchronous machine?

The limiting factor of synchronous machine is the peripheral speed. The limiting value of peripheral speed is 175 m/s for cylindrical and 80 m/s for salient pole machines

25. Write the expression for air gap length in cylindrical rotor machines?

Length of air gap,

$$l_g = (0.5SCR \text{ ac } \tau K_f \times 10^{-6}) / (Kg B_{av})$$

26. What are the factors to be considered for selecting the number of poles in an alternator?

The number of poles depends on the speed of the prime mover and frequency of generated emf.

27. Discuss how the ventilation and cooling of large high speed alternator is carried out?

For high speed alternator two cooling methods are available and they are conventional cooling and direct cooling.

In conventional cooling methods, radial and axial ventilating ducts are provided in the core. Cooling is performed by forced circulation of air or hydrogen at a pressure higher than atmosphere.

In direct cooling methods, cooling ducts are provided in the stator and rotor slots or conductor itself will be in the form of tubes. Coolants like water or oil or hydrogen are circulated in the ducts to remove the heat directly from the conductors.

28. Mention the factors that govern the design of field system of the alternator.

The factors that govern the design of field system of the alternators are

1. Number of poles and voltage across each field winding
2. Amp-turn per pole
3. Copper loss in the field coil
4. Dissipating surface of field coil
5. Specific loss dissipation and allowable temperature rise.

29. Mention the advantages of fractional slot winding?

The advantages are

1. In low speed machines with large number of poles, fractional slot winding will reduce tooth harmonics
2. A range of machines with different speeds can be designed with a single lamination
3. The fractional slot winding reduces the harmonics in mmf and the leakage reactance of the winding.

30. What are the typical values of SCR for salient pole and turbo alternators?

For turbo alternators,

SCR is normally between 0.5 to 0.7 and

For salient pole alternators,

SCR varies from 1 to 1.5.

31. What type of prime movers is used in hydro electric stations depending on the head?

The type of water turbine used in hydroelectric station depends on water head.

Pelton wheel is used for water heads of 400 m and above.

Francis turbine is used for water heads upto 380 m.

Kaplan turbine is used for water heads upto 50m.

32. List the types of synchronous machines operating on general power supply?

The types of synchronous machines are

1. Hydro generators
2. Turbo generators
3. Engine driven generators
4. Motors
5. Compensators

33. Give the approximate values of runaway speed of the turbines with full gate opening?

The approximate values of runaway speed of the turbines are

Pelton wheel – 1.8 times the rated speed.

Francis turbine – 2 to 2.2 times the rated speed.

Kaplan turbine – 2.5 to 2.8 times the rated speed.

34. Write the output equation of a synchronous machine?

For synchronous machines, the output equation is

$$Q = C_0 D^2 L n_s \text{ in KVA}$$

$$C_0 = 11 K_{ws} B_{av} a c \times 10^{-3} \text{ in KVA/m}^3\text{-rps}$$