Electrical Machine Design
Unit – I – 2 marks question and answers

1. What are the considerations to be made while designing a electrical machines?

    1. Cost
    2. Durability
    3. Compliance with the performance specification and consumer requirement

2. List some limitation of the design

    1. Magnetic Saturation
    2. Temperature rise
    3. Efficiency
    4. Standard specifications

3. Define total magnetic loading.

    The total magnetic load is defined as the total flux around the armature periphery and is given by $p\phi$ Weber's

4. Define total electric loading

    The total armature ampere conductors around the armature periphery is known as the total electric loading and is given by I_zZ

5. Define specific magnetic loading

    The specific magnetic loading is defined as the total flux per unit area over the surface of the armature periphery and is denoted by B_{av} also known as average flux density.

6. Define specific electric loading

    It is defined as the number of armature conductors per meter of armature periphery at the air gap.
    Specific electric loading=total number ampere conductors/armature periphery at air gap.

7. What are the factors that decide the choice of specific magnetic loading?

    1. Maximum flux density in iron parts of machine
    2. Magnetizing current
    3. Core losses

8. What is the factors that decide the choice of specific electric loading.

    1. Permissible temperature rise
    2. Voltage rating of machine
    3. Size of machine
    4. Current density.

9. How the design problems of electrical machines can be classified?

    1. Electromagnetic design
    2. Mechanical design
    3. Thermal Design
    4. Dielectric design

10. What are the major considerations to evolve a good design of electrical machine?

    The major considerations to evolve a good electrical machine are the specific magnetic loading, specific electric loading, temperature rise, efficiency, length of air gap and power factor.

11. Write short notes on standard specifications.

    The standard specifications are the specifications issued by the standards organization of a country. The standard specification serves as guidelines for the manufacturers to produce quality products at economical prices. The standard specifications for the electrical machines include Ratings, Types of Enclosure, Dimensions of the conductors, Name plate details, performance indices, permissible temperature rise, permissible loss, efficiency etc.,

12. What is a magnetic circuit?

    The magnetic circuit is the path of magnetic flux. The mmf of the circuit creates flux in the path against the reluctance of the path. The equation which relates flux, mmf and the reluctance is given by,

    Flux = mmf/reluctance

13. What are the constituents of magnetic circuit in rotating machine?

    The various elements in the flux path of the rotating machine are poles, pole shoe, air gap, rotor teeth and rotor core.

14. Write ant two similarities between magnetic and electric circuits.

    1. In electric circuit the emf circulates current in a closed path. Similarly in a magnetic circuit the mmf creates the flux in a closed path.
    2. In electric circuit the flow of current is opposed by resistance of the circuit. Similarly in magnetic circuit the creation of flux is opposed by reluctance of the circuit.

15. Write any two essential differences between magnetic and electric circuit.

    1. When the current flows in electric circuit the energy is spent continuously, whereas in magnetic circuit the energy in needed only to create the flux but not to maintain it.
    2. Current actually flows in the circuit, whereas the flux does not flow in a magnetic circuit but is only assumed to flow.

16. What is magnetization curve?

    The curve shows the relation between the magnetic field intensity (H) and the flux density (B) of a magnetic material. It is used to estimate the mmf required for the flux path in the magnetic material and it is supplied by the manufacturer of stampings or laminations

17. What is meant by magnetic circuit calculations?

    The calculations of reluctance, flux density and mmf for various sections of magnetic circuit are commonly referred as magnetic circuit calculations.

18. How the mmf of a magnetic circuit is determined?

    The magnetic circuit split into convenient parts (Sections) which may be connected in series or parallel. Then the reluctance, flux density and mmf for every section of the magnetic circuit is estimated. The summation of mmf of all sections in series gives the total mmf for the magnetic circuit.

19. Define gap contraction factor for the slots.

    The gap contraction factor for slots K_{gs} is defined as the ratio of reluctance of air gap in machine with slotted armature to the reluctance of air gap in machines with smooth armature.

20. Define gap contraction factor for the ducts.

    The gap contraction factor for the ducts K_{gd} is defined as the ratio of reluctance of air gap in machines with ducts to reluctance of air gap in machine without ducts.

21. Define total gap contraction factor, K_g.

The total gap contraction factor K_g, is defined as the ratio of reluctance of air gap of machines with slotted armature & ducts to the reluctance of air gap in machines with smooth armature and without ducts. The total gap contraction factor is equal to the product of gap contraction factors for slots and ducts.

22. What is carter's coefficient?

The carter's coefficient is a parameter that can be used to estimate the contracted or effective slot pitch in case of armature with open or semi enclosed slots. It is the function of the ratio w_0/l_g where w_0 is slot opening and l_g is air gap length.

23. Write the expression for the gap contraction factor for slots and ducts

Gap contraction factor for slots, $K_{gs} = y_s / (y_s - K_{cs}W_s)$

Gap contraction factor for ducts , $K_{gd} = L / (L - K_{cd}n_dw_d)$

24. Write down the formula for computing the mmf for the air gap length.

Mmf for the air gap = $800000BK_gl_g$ in AT

25. Write the expressions for reluctance of air gap in machines with smooth armature and slotted armature.

Reluctance of air gap in machines with smooth armature and without ducts

$= l_g / \mu_0 L y_s$

Reluctance of air gap in machines with open armature slots and ducts

$= l_g / \mu_0 L' y_s'$

26. Define field form factor.

The filed form factor K_f is defined as the ratio of average gap density over the pole pitch to maximum flux density in the air gap.

$K_f = B_{av} / B_g$ $\qquad$ $K_f \approx \psi$ = pole arc/pole pitch

27. List the methods used for estimating the mmf for the teeth(tapered teeth)

1. Graphical method
2. Three ordinate method (Simpson's rule)
3. $B_{t1/3}$ method

28. What is real flux density and apparent flux density?

The real flux density is due to actual flux through a tooth. The apparent flux density is due to total flux that has to be passed through the tooth. Since some of the flux passes through slot, the real flux density is always less than the apparent flux density

29. Define real flux density.

The real flux density is defined as the ratio of actual flux in the teeth to the area of the teeth

30. Define apparent flux density

The apparent flux density is defined as the ratio of the total flux in the slot pitch to the area of the teeth.

31. State the relation between real and apparent flux density.

$$B_{real} = B_{app} - \mu_0 \mathbf{at}_{real}(K_s - 1)$$

32. Define leakage coefficient

The leakage coefficient is defined as the ratio of total flux to the useful flux.

33. What is fringing flux?

The bulging of magnetic path at the air gap is called fringing. The fluxes in the bulged portion are called fringing flux.

34. List some leakage fluxes available in the rotating machine.

1. Slot leakage flux
2. Zig-zag leakage flux
3. Harmonic or differential leakage flux
4. Peripheral leakage flux
5. Tooth to leakage flux
6. Skew leakage flux

35. Define permeance.

Permeance is the inverse of reluctance. The reluctance of magnetic path is given by the reluctance $S = l/A\mu$.

36. Define specific permeance of a slot.

Specific permeance of a slot is defined as the paermeance per unit length of slot or depth of field.

37. What is unbalanced magnetic pull?

The unbalanced magnetic pull is the radial force acting on the rotor due to non uniform air gap around the armature periphery.

38. What do you understand by slot pitch?

The slot pitch is defined as the distance between centres of two adjacent slots measured in linear scale.

39. Define slot space factor or slot insulation factor.

The slot space factor is defined as the ratio of conductor area to slot area.

40. List the different types of slots that are used in rotating machines.

1. Parallel sided slots with flat bottom
2. Tapered slots with flat bottom
3. Parallel sided slots with circular bottom
4. Tapered sided slots with circular bottom
5. Circular slot

Unit – II – 2 marks question and answers

41. What is the relation between the power developed in armature and the power output in the dc machine?

    Output for generators = $P_a = P/\eta$
    Output for motors = $P_a = P$

42. Write the expression for the power developed an the armature of dc machine in terms of the maximum gap density.

    Power developed the armature $P_a = C_0 D^2 L n$

    $$C_0 = \pi 2 B_{av} ac \times 10^{-3}$$

43. What is the range of specific magnetic loading in a dc machine?

    The usual range of specific magnetic loading in dc machine is 0.4 to 0.8 wb/m^2

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

    1. Flux density in the teeth
    2. Frequency of flux reversals
    3. Size of the machine

45. What is the range of specific electric loading in dc machine?

    The usual range of specific electric loading in dc machine is 15000 to 50000 amp.cond/m

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

    1. Temperature rise
    2. Speed of the machine
    3. Size of the machine
    4. voltage
    5. Armature reaction
    6. Commutation

47. What is the purpose of constructing the pole body by laminated sheets?

    The laminated pole offers the homogeneous construction, (Because while casting internal blow holes may develop and while forging internal cracks may develop) Also the laminated poles offers the flexibility of increasing the length by keeping the diameter fixed, in order to increase the power output (or capacity) of the machine.

48. What are the factors to be considered for the selection of number of poles in dc machine?

    1. Frequency
    2. Weight of iron parts
    3. Weight of copper parts
    4. Length of commutator
    5. Labour charges
    6. Flash over and distorsion of filed form.

49. List the advantages of large number of poles
    . The large number of poles results in reduction of the following
    1. Weight of armature core and yoke
    2. Cost of armature and field conductors
    3. Overall length and diameter
    4. Length of Commutator
    5. Distortion of field form under load condition

50. List the disadvantages of large number of poles

    The large number of poles results in increase of the following
    1. Frequency of flux reversals
    2. Labour charges
    3. Possibility of lash over between brush arms.

51. Why square pole is preferred?

    If the cross section of the pole body is square then the length of the mean turn of field winding is minimum. Hence to reduce the copper requirement a square cross section is preferred for the poles of the dc machines.

52. What is square pole and square pole face?

    In square pole, the width of the pole body is made equal to the length of the armature. In square pole face, the pole arc is made equal to the length of the armature.

53. Mention guiding factors for the selection of number of poles

1. The frequency of flux reversals should lie between 25 to 50 Hz.
2. The value of current per parallel path is limited to 200 A. thus the current per brush arm should not be more than 400A
3. The armature mmf should not be too large. The mmf per pole should be in the range 5000 to 12500 AT.
4. Choose the largest value of poles which satisfies the above three conditions.

54. What are the advantages of large length of air gap in dc machine?

In dc machines a larger value of air gap length results in lesser noise, better cooling, reduced pole face losses, reduced circulating currents, less distortion of field form and lesser armature reaction.

55. What are the factors to be considered for estimating the length of air gap in dc machine?

The factors to be considered for estimating the length of air gap are armature reaction, cooling, iron losses, distortion of filed form and noise.

56. Mention the factors governing the choice of number of armature slots in a dc machine.

The factors governing the choice of number of armature slots are,
Slot pitch
Slot loading
Flux pulsations
Commutation
Suitability for winding

57. What is the purpose of slot insulation?

The conductors are placed on the slots in the armature. When the armature rotates the insulation the insulation of the conductors may damage due to vibrations. This may lead to a short circuit with armature core if the slots are not insulated.

58. What are the factors to be considered for deciding the slot dimensions?

1. Flux density in the tooth
2. Flux pulsations
3. Eddy current loss in conductors
4. Reactance voltage
5. Fabrication difficulties

59. What factor decides the minimum number of armature coils?

The maximum voltage between adjacent commutator segments decides the minimum number of coils.

60. Mention the two types of winding used in the dc machines.
    1. Lap winding
    2. Wave winding

61. What is meant by equalizer connections?

In lap winding, due to the difference in the induced emf in various parallel paths, there may be circulating currents in brushes and winding. The connections that are made to equalize the difference in induced emf and to avoid circulating currents through brushes are called equalizer connections.

62. What is the length of mean turn of filed coil?

Length of mean turn $L_{mt} = 2(L_p + b_p + 2d_r)$

63. Mention the factors to be considered for the design of shunt field coil?

    1. MMF per pole and flux density
    2. Loss dissipated from the surface of field coil
    3. Resistance of the field coil
    4. Current density in the field conductors

64. Define copper space factor of the coil.

The copper space factor of a coil is defined as the ratio of conductor area and the area of the cross section of the coil.

Copper space factor = Conductor area/Area of cross section of the coil
Conductor area = Number of turns x area of cross section of conductor

65. How the ampere turns of the series field coil is estimated?

In compound machines the ampere turns to be developed by the series field coil is estimated as 15 to 25% of full load armature mmf.
In series machines the ampere turns to be developed by the series field is estimated as 1.15 to 1.25 times the full load armature mmf.

66. What is meant by commutation?

The process of current reversal in a coil is called commutation.

67. Discuss the parameters governing the length of commutator.

The length of the commutator depends upon the number of brushes and cleanliness between the brushes. The surface area required to dissipate the heat generated by the commutator losses is provided by keeping sufficient length of the commutator,

68. What are the factors that influence the choice of commutator diameter?

1. The peripheral speed
2. The peripheral voltage gradient should be limited to 3 V/mm
3. Number of coils in the armature.

69. What is the purpose of mica strip between two adjacent commutator segments?

Mica is placed in between two commutator segments in order to insulate the segments from each other.

70. What are the factors to be considered for the design of commutator?

1. Peripheral speed
2. Voltage between adjacent segments
3. Number of coils in the armature
4. The number of brushes
5. Commutator losses.

71. What type of copper is used for commutator segments?

The commutator segments are made of hard drawn copper or silver copper (0.05% silver)

72. What is the need for brushes in dc machine?

The brushes are used in dc machines to collect or draw current from the rotating armature.

73. What are the materials used for brushes in dc machines?

1. Natural graphite
2. Electro graphite
3. Hard carbon
4. Metal graphite

74. How to design the number of brushes for a dc machine?

The numbers of brush locations are decided by the type of winding. In lap winding the number of brush locations is equal to number of poles and in wave winding it is always two.

In each location there may be more than one brush mounted on a spindle, whenever the current per brush location is more than 70A. Hence the number of brushes in a spindle is selected such that each brush dos not carry more than 70A.

75. What are the effects of armature reaction?

The various effect of armature reaction are reduction in induced emf, increase in iron loss, delayed commutation, sparking and ring firing.

Unit – III – 2 marks question and answers

76. What are the various types of Transformers?
    Based on construction
    1. Core Type
    2. Shell Type

    Based on the applications
    1. Distribution transformer
    2. Power transformer
    3. Special transformers
    4. Instrument transformer
    5. Electronics Transformers

77. What is the range of efficiency of transformers?

    The efficiency of the transformer will be in the range of 94% to 99%. Among the available electrical machines the transformer has the highest efficiency

78. What is transformer bank?

    A transformer bank consists of three independent single phase transformers with their primary and secondary windings connected either in star or delta.

79. What are the salient features of distribution transformer?

    1. The distribution transformer will have low iron loss and higher value of copper loss
    2. The capacity of transformers will be up to 500 KVA
    3. The transformers will have plain walled tanks or provided with cooling tubes or radiators.
    4. The leakage reactance and regulation will be low.

80. What is yoke section of distribution transformers?

    The sections of the core which connect the limbs are called yoke. The yoke is used to provide a closed path for the flux.

81. What are distribution transformers?

The transformers used at the load centres to step down the distribution voltage to a standard service voltage required for consumers are called distribution transformers.

82. What is the purpose of constructing the pole body by laminated sheets?

The laminated pole offers the homogeneous construction, (Because while casting internal blow holes may develop and while forging internal cracks may develop) Also the laminated poles offers the flexibility of increasing the length by keeping the diameter fixed, in order to increase the power output (or capacity) of the machine.

83. What are power transformers?

The transformers used in substations and generating stations for step up the voltage are called power transformers.

84. State the use of power transformers

.

1. In generating stations the power transformers are used to step up the voltage to a higher level required for the primary transmission.
2. In substations the power transformers are used to step down the voltage level required for the secondary transmission.

85. Distinguish between core and shell type transformer.

In core type transformer the coil surrounds the core, while in shell type transformer the core surrounds the coil

86. What are the advantages of shell type transformer over core type transformers?

In shell type transformers the coils are well supported on the all sides and so they can withstand higher mechanical stresses developed during short circuit conditions. Also the leakage reactance will be less in shell type transformers.

87. In transformers, why the low voltage winding placed near the core?

The winding & Core are both made of metals and so an insulation have to be placed in between them, the thickness of insulation depends on the voltage rating of the winding. In order to reduce the insulation requirement the low voltage winding place near the core.

88. What is window space factor?

The window space factor is defined as the ratio of copper area in window to total area of window.

89. Write down the output equation for the1phase and 3 phase transformer.

Output KVA of single phase transformer $Q = 2.22fB_mA_iK_wA_w\delta \times 10^{-3}$
Output KVA of three phase transformer, $Q = 3.33fB_mA_iK_wA_w\delta \times 10^{-3}$

90. How will you select the emf per turn of a transformer?

The equation of emf per turn in terms of KVA rating, flux frequency and ampere turn is given by,

Emf per turn, $E_t = K\sqrt{Q}$
Where $K = \sqrt{4.44f\,(\phi_m/AT)} \times 10^3$

91. Why circular coils are preferred in transformers?

The excessive leakage fluxes produced during short circuit and over loads, develop severe mechanical stresses on the coil. On circular coils these forces are radial and there is no tendency to change its shape. But on rectangular coils the force are perpendicular to the conductors and tends to deform the coil in circular form.

92. What are the advantages of stepped cores?

For same area of cross section the stepped cores will have lesser diameter of the circumscribing circle than square cores. This results in length of mean turn of the winding with consequent reduction in both cost of copper and copper loss.

93. What are the disadvantages of stepped cores?

With large number of steps a large number of different sizes of laminations have to be used. This results in higher labour charges for sheering and assembling different types of laminations.

94. Define copper space factor.

The copper space factor is the ratio of conductor area and window area in case of transformers.

95. What do you meant by stacking factor (iron space factor)?

In transformers, the core is made of laminations and the laminations are insulated from each other by a thin coating of varnish. Hence when the laminations are stacked to the form the core, the actual iron area will be less than the core area. The ratio of iron area and total core area is called stacking factor. The value is usually 0.9.

96. Why stepped cores are used?

When stepped cores are used the diameter of the circumscribing circle is minimum for a given area of the core. This helps in reducing the length of mean turn of the winding with consequent reduction in both cost of copper and copper loss.

97. What are the factors to be considered for choosing the type winding for a core type transformer?

1. Current density
2. Short circuit current
3. Temperature rise
4. Surge voltage
5. Impedance
6. Transport facilities

98. What is tertiary winding?

Some three phase transformers may have a third winding called tertiary winding apart from primary and secondary. It is also called auxiliary winding or stabilizing winding.

99. What is the purpose of tertiary winding?

1. To supply small additional loads at a different voltage
2. To give supply to phase compensating devices such as capacitors which work at different voltage.
3. To limit the short circuit current
4. To indicate voltage in high voltage testing transformer.

100. How the tertiary winding is connected?

The tertiary winding is normally connected in delta. When the tertiary is connected in delta, the unbalance in phase voltage during unsymmetrical faults in primary and secondary is compensated by the circulating currents flowing in the closed delta.

101. List some methods of cooling of transformers.

Air natural, Air blast, Oil Natural, Oil natural air forced, Oil natural water forced, Oil forced, Oil forced air natural, Oil forced air natural, Oil forced water forced.

102. What are the factors to be considered for choosing the method of cooling?

The choice of cooling method depends on KVA rating of transformer, size, application and the site conditions where it will be installed.

103. How the heat dissipates in a transformer?

The heat dissipation of a transformer occurs by convection, conduction and radiation.

104. Why transformer oil is used as a cooling medium?

When transformer oil is used as a coolant the heat dissipation by convection is 10 times more than the convection due to air. Hence transformer oil is used as a cooling medium.

105. Why cooling tubes are provided?

Cooling tubes are provided to increase the heat dissipating area of the tank.

106. How the heat dissipation is improved by providing the cooling tubes?

The cooling tubes will improve the circulation of oil. The circulation of oil is due to effective pressure heads produced by columns of oil in tubes. The improvement in cooling is accounted by taking the specific heat dissipation due to convection as 35% more than that without tubes.

107. What is a breather?

The breather is a device fitted in the transformer for breathing. In small oil cooled transformers some air gap is provided between the oil level and tank top surface. When the oil is cooled, it shrinks and air is drawn from the atmosphere through breather. This action of transformer is called breathing.

108. Why silica gel is used in breather?

The silica gel is used to absorb the moisture when the air is drawn from the atmosphere in to the transformer.

109. What is conservator?

A conservator is a small cylindrical drum fitted just above the transformer main tank. It is used to allow the expansion and contraction of oil without contact with surrounding atmosphere. When conservator is fitted in a transformer, the tank is fully filled with oil and the conservator is half filled with oil.

110. How the leakage reactance of the transformer is reduced?

In transformers the leakage reactance is reduced by interleaving the high voltage and low voltage winding.

Unit – IV – 2 marks question and answers

111. What are the different types of induction motor and how differ from each other?

The two different types of induction motor are squirrel cage and slip ring induction motor. The stator is identical for both but they differ in construction of rotor.

112. Why wound rotor construction is adopted?

The wound rotor has the facility of increasing the rotor resistance through slip rings. High value of rotor resistance is need during starting to get a high value of starting torque.

113. What is rotating transformer?

The principle of operation of induction motor is similar to that a transformer. The stator winding is equivalent to primary of the transformer and the rotor winding is equivalent to short circuited secondary of a transformer. In transformer the secondary is fixed but in induction motor it is allowed to rotate. Hence the induction motor also called rotating transformer.

114. How the slip ring motor is started?

The slip ring motor is started by using rotor resistance starter. The starter consists of star connected to slip rings. While starting the full resistance is included in the rotor circuit to get high starting torque. Once the rotor starts rotating the resistance is gradually reduced in steps. At running condition the slip rings are shorted and so it is equivalent to squirrel cage rotor.

115. What are the materials used to manufacture the brushes for slip rings of an induction motor?

The slip rings are made of brass and phosphor bronze. The brushes are made of metal graphite which is an alloy of copper and carbon.

What are the advantages of cage rotor over slip ring induction motor?

116.

1. It is cheaper than slip ring motor
2. In does not have any wear and tear parts like slip rings, brush gear and short circuiting devices. Hence the construction will be rugged.
3. No over hang therefore copper loss is less.
4. Better power factor, and over load capacity

Name the materials used to insulate the laminations of the core of

117.

induction motor.

The materials used to insulate the laminations are kaolin and varnish.

118. What are the advantages of slip ring motor over squirrel cage motor?

1. The starting torque can be varied by adding resistance to rotor.
2. The speed of the machine can be varied by injecting an emf through slip rings to the rotor.

119. Write the expression for the output equation and out coefficient of induction motor.

.

$Q = C_0 D^2 L n_s$ in KVA

$C_0 = 11 K_{ws} B_{av} \mathbf{ac} \times 10^{-3}$ in KVA/m^3-rps.

120. What are the factors to be considered for choosing the specific magnetic loading?

The choice of specific magnetic loading depends on power factor, iron loss and over load capacity.

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

The choice of specific loading depends on copper loss, temperature rise, voltage rating and over load capacity.

122. What are the main dimensions of an induction motor?

The main dimensions of induction motor are stator core internal diameter and stator core length.

123. How the induction motor can be designed for best power factor?

For best power factor the pole pitch, τ is chosen such that, $\tau = \sqrt{0.18L}$

124. What are the different types of stator winding in induction motor?

The different types of stator windings are mush winding, lap winding and wave winding.

125. Where mush windings are used?

The mush windings are used in small induction motors of ratings below 5 HP.

126. What types of slots are preferred for the induction motor?

Semi enclosed slots are preferred for induction motor. It results in less air gap contraction factor giving a small value of magnetizing currents, low tooth pulsation loss and much quieter operation(less noise)

127. What is slot space factor?

The slot space factor is the ratio of conductor (or copper) is per slot and slot area. It gives an indication of the space occupied by the conductors and the space available for insulation. The slot space factor for induction motor varies from 0.25 to 0.4.

128. What is the minimum value of slot pitch in induction motor?

The minimum value of slot pitch in three phase induction motor is 15mm.

129. What are the factors to be considered for selecting number of slots in induction machine stator?

The factors to be considered for selecting the number of slots are tooth pulsation loss, leakage reactance, magnetizing current, iron loss and cost. Also the number of slots should be multiple of slots per pole per phase for integral slot winding.

130. Which part of induction motor has the maximum flux density? What is the maximum flux density in that part?

The teeth of the stator and rotor core will have maximum flux density. The maximum value of flux density in the teeth is 1.7 wb/m^2

131. What are the factors to be considered for estimating the length of air gap.

1. Power factor, 2. Unbalanced magnetic pull, 3. Overload capacity
4. Pulsation loss, 5. Cooling, 6. Noise.

132. What are the advantages and disadvantages of large air gap length in induction motor?

Advantage: A large air gap length results in higher overload capacity, better cooling, reduction in noise and reduction in unbalanced magnetic pull.

Disadvantages: The disadvantage of large air gap length is that it results in high value of magnetizing current.

133. What happens if the air gap length is doubled?

If the air gap of an induction motor is doubled then the mmf and magnetizing current approximately doubles. Also increase in air gap length increases the overload capacity, offers better cooling, reduces noise and reduces unbalanced magnetic pull.

134. List out the methods to improve the power factor of the induction motor.

The power factor of the induction motor can be improved by reducing the magnetizing current and leakage reactance. The magnetizing current can be reduced by reducing the length of air gap. The leakage reactance can be reduced by the depth of stator & rotor slots, by providing short chorded winding and reducing the overhang in stator winding.

135. Why the air gap of an induction motor is made as small as possible?

The mmf and the magnetizing current are primarily decided by length of air gap. If air gap is small then mmf and magnetizing current will be low, which in turn increase the value of power factor. Hence by keeping small air gap, high power factor is achieved.

136. Write the formula for air gap in case of three phase induction motor in terms of length and diameter.

The length of air gap, $l_g = 0.2 + 2\sqrt{DL}$ in mm

Where D, L are expressed in metre.

137. Discuss the relative merits and demerits of open and closed slots for induction motor.

The closed slots will not increase reluctance of air gap and has lesser noise but it has difficulty in casting the rotor bars.

The open slots increase the reluctance of air gap and has high noise but it offers flexibility in casting rotor bars.

138. List the undesirable effects produced by certain combination of rotor and stator slots.

1. The motor may refuse to start (cogging)
2. The motor may run at sub synchronous speed (Crawling)
3. Severe vibrations may develop and the noise will be excessive.

139. What are the different types of windings used for the rotor of induction motor?

The different types of windings employed in induction motor rotor are mush winding and double layer winding.

140. What is crawling and cogging?

Crawling is a phenomena in which the induction motor runs at a speed lesser than the sub synchronous speed.
Cogging is a phenomena in which the induction motor refuse to start.

141. What are the methods adopted to reduce harmonic torques?

The methods used for reduction or elimination of harmonic torques are chording, integral slot winding, skewing and increasing the length of air gap.

142. What is skewing?

Skewing is twisting either the stator or rotor core. The motor noise, vibrations, cogging and synchronous cusps can be reduced or even entirely eliminated by skewing.

143. Define dispersion coefficient.

The dispersion coefficient is defined as the ratio of magnetizing current to ideal short circuit current.

144. What is the condition for obtaining the maximum torque in case of 3 phase induction motor?

The maximum torque occurs in induction motor when rotor reactance is equal to rotor resistance.

Unit –V – 2 marks question and answers

145. Name the two types of synchronous machines.

1. Salient pole machines
2. Cylindrical rotor machines.

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

The two types of poles used in salient pole machines are round pole and rectangular poles.

147. 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.

148. 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.

149. 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.

Distinguish between cylindrical pole and salient pole construction.

150. 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

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

151.

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

152. 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.

153. 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.

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

.

1. Peripheral speed
2. Number of poles
3. Short circuit ratio

155. 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

156. 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.

157. 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.

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

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

159. Give typical values of flux density an ampere conductors per metre for large turbo alternators.

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

ac = 50000 to 75000 amp.cond/m (For conventionally cooled machine)
ac = 180000 to 200000 amp.cond/m (for water cooled machine)

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

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

161. 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.

162. 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.

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

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

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

$l_g = AT_{f0}/(B_g K_g \times 10^6)$ or $l_g = AT_a \times SCR \times K_f / B_{av} \times K_g \times 10^6$

165. List the influence of the air gap length on the performance of the synchronous machine.

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

166. List the factors to be considered for the choice of slot in synchronous machines,

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

167. 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 x 4 x 3 = 72 slots

168. 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

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

Length of air gap, $l_g = (0.5SCR\ ac\ \tau\ K_f \times 10^{-6})/(K_g\ B_{av})$

170. 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.

171. 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.

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

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.

Mention the advantages of fractional slot winding.

173.

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.

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

174.

For turbo alternators SCR is normally between 0.5 to 0.7 and that for salient pole alternator SCR varies from 1 to 1.5.

175. 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.

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

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

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

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.

178. Write the output equation of a synchronous machine.

$Q = C_0 D^2 L n_s$ in KVA
$C_0 = 11 K_{ws} B_{av} \mathbf{ac} \times 10^{-3}$ in KVA/m^3-rps.