

1. Define lubrication.

Lubrication is the science of reducing friction by application of a suitable substance called lubricant, between the rubbing surfaces of bodies having relative motion.

2. What are four objectives of lubrication?

The four objectives of lubrication are as follows:-

To reduce friction;

To reduce or prevent wear;

To carry away heat generated due to friction; and

To protect the journal and the bearing from corrosion

3. What is thick film lubrication?

Thick film lubrication describes a condition of lubrication, where two surface of the bearing in relative motion are completely separated by a film of fluid.

4. What is a zero film bearing?

Zero film bearing is a bearing, that operates without any lubricant

5. What is hydrodynamic lubrication?

Hydrodynamic lubrication is define as a system of lubrication in which the load supporting fluid film is created by the shape and the relative motion of the sliding surfaces.

6. What is hydrostatic lubrication?

Hydrostatic lubrication is define as a system of lubrication in which the load supporting fluid film, separating the two surfaces is created by an external source, like a pump, supplying sufficient fluid under pressure

7. What does journal bearing mean?

The portion of the shaft inside the bearing is called journal and hence the name journal bearing.

8. Why hydrostatic bearing is called externally pressurized bearing?

Since the lubricant is supplied under pressure, this type of bearing is called as externally pressurized bearing.

9. What is footstep bearing?

The footstep bearing is a thrust bearing in which the end of the shaft is in contact with the bearing surface.

10. What is collar bearing?

The collar bearing is a thrust bearing in which a collar integral with the shaft is in contact with the bearing surface

11. What is elastohydrodynamic lubrication?

When the fluid film pressure is high and the surface to be separated are not sufficiently rigid, there is a elastic deformation of the contacting surfaces. Since hydrodynamic film is developed due to elastic deflection of the part, this type of lubrication is called elastohydrodynamic lubrication.

12. What is bearing characteristic number as applied to the journal bearing?

A bearing characteristic number is a dimensionless group of parameters given by,

$(\eta N/p)$. where,

η =absolute viscosity of the lubricant

N =speed of the journal

p =unit bearing pressure(load per unit of projected area of bearing)

13. What is bearing modulus as applied to the journal bearing?

The value of the bearing characteristic number corresponding to this minimum coefficient is called the bearing modulus.

14. What is meant by 'square' bearing?

When (l/d) ratio is equal to 1,the bearing is called square bearing

15. What are the advantages and disadvantages of long bearings over short bearings?

The long bearing has more load carrying capacity compared to short bearing. A short bearing, on other hand has greater side flow, which improves heat dissipation. Long bearing are more susceptible to metal to metal contact at the two edges, when the shaft is deflected under load.

16. What are the advantages and disadvantages of circumferential oil-groove bearing over cylindrical oil-groove bearing

The disadvantage of circumferential oil-groove bearing is that it has a lower load carrying capacity as compared to cylindrical oil-groove bearing.

17. Give two applications of circumferential oil-groove bearings

Circumferential oil groove bearings are used for the connecting rods and crank shaft for automotive engines.

18. Give two applications of cylindrical oil-groove bearings

Cylindrical oil groove bearing are used for gear boxes and high speed applications.

19. State any four desirable properties of a good bearing materials

1)It should not stick or weld to the journal surface

2)It should have high compressive strength

3)It should have sufficient endurance strength

4)It should have property of conformability

20. Define conformability

The bearing material should have ability to yield and adopt its shape to that of the journal. This property is called conformability

21. Define embeddability

The bearing material should be soft to allow the dust particles in lubricating oil to get embedded in the lining and avoid further trouble. This property is called embeddability.

22. What are the advantages and disadvantages of babbitt as bearing material?

The advantages of babbitt as bearing material is that they have excellent conformability and embeddability. High cost and shortage of tin are there main limitations. They have poor fatigue strength

23. Where do you use sintered metal bearings?

Ans) Sintered metal bearings are used in automobiles, textile machinery and machine tools.

24. State any four desirable properties of a good lubricant

- 1) It should be available in wide range of viscosities
- 2) There should be little change in viscosity of the oil with change in temperature
- 3) The oil should be chemically stable with the bearing material and atmosphere
- 4) It should be commercially available at reasonable cost.

25. What is SAE?

The Society of Automotive Engineers (SAE) of USA as classified as lubricating oils by a number, which is related to the viscosity of the oil in Saybolt Universal Seconds.

26. Define 'additive' for mineral oil

An additive is a substance added to mineral oil in order to improve a particular property of that oil. Mineral oil in which additive are mixed is called doped oil or base oil.

27. What is the purpose of additive?

An additive is a substance added to mineral oil in order to improve a particular property of that oil.

28. What are EP additives? Where do you use them?

Extreme pressure (EP) additives are used in applications such as gears, where the lubricant is subjected to extremely high local pressures, at which oiliness additives are ineffective.

29. What is 2T oil? What are its advantages? Where do you use 2T oil?

2T oil is a popular variety of lubricating oil used on two-stroke engines in scooters, mopeds and motorcycles. Its advantages are: 1) It is self mixing with petrol. 2) It

prevents corrosion of engine components. 3) It controls deposits in the combustion chamber and reduces preignition.

30. What is grease? State its applications

Grease is a semisolid substance composed of mineral oil and soap. It is used in applications where clearance is large due to rough machining. Grease is normally recommended for inaccessible parts, where leakage of oil is objectionable.

31. State four important assumptions of Reynolds equation?

The lubricant obeys Newton's law of viscosity

The lubricant is incompressible

The viscosity of lubricant is constant

The shaft and bearing are rigid

32. What is mean by square bearing?

When length to diameter ratio is 1, the bearing is known as square bearing

33. Define unit bearing pressure?

The unit bearing pressure is the load per unit of projected area of the bearing in running condition

34. When length to diameter ratio is 1, what is optimum value of (h/c) for maximum load carrying capacity?

The maximum load carrying capacity is 0.66, when the length to diameter ratio is 1

35. When length to diameter ratio is 1, what is optimum value of (h/c) for minimum friction loss?

The optimum value of minimum friction loss is 0.60, when the length to diameter ratio is

1

36. Give two applications of circumferential oil groove bearing?

Circumferential oil groove bearing are used for the connecting rods and crankshafts of automotive engines

37. Give two applications of cylindrical oil groove bearing?

Cylindrical oil groove bearing are used for gear boxes and high speed applications

38. Define eccentricity ratio in hydrodynamic journal bearing?

The eccentricity ratio is defined as the ratio of eccentricity to radial clearance

39. Define radial clearance?

The radial clearance should be small to provide the necessary velocity gradient

40. Define minimum film thickness?

The surface finish of the journal and the bearing is governed by the value of film thickness.

41. What is bearing characteristic number as applied to the journal bearing?

A bearing characteristic number is a dimensionless group of parameters by bearing characteristic

42. What is bearing modulus as applied to the journal bearing?

The value of bearing characteristic number corresponding to this minimum coefficient is called the bearing modulus

43. What are the advantages and disadvantages of long over short bearing?

Long bearing has more load carrying capacity as compared to the short bearing.

Long bearing are more susceptible to metal to metal contact at the two ends when the shaft is deflected. The longer the bearing more difficult it is to get sufficient oil flow.

44. What are the advantages and disadvantages of short bearing over long bearing?

Has greater side flow which improves heat dissipation.

Short bearing has lower load carrying capacity

45. Explain the principle of oil bearing?

Oil ring in contact with shaft & dipping in bath below. Ring rotates along with shaft with lower speed & carries oil to shaft.

46. State any 4 desirable properties of good bearing material ?

It should not stick or weld to journal contact surface

it should have high compressive strength

it should have strength to avoid failure due to pitting

it should have reasonable cost & easily available in market

47. Define conformability?

Ability of bearing material to yield & adopt its shape to journal

48. Why babbitt is called white metal?

Due to silvery appearance, it is called white metal

49. What are advantages & disadvantages of babbitt as bearing material?

Advantages-

Excellent conformability, embeddability

Corrosion resistance

Easily bonded to steel shell

Disadvantages-

High cost and shortage of tin

Poor fatigue strength

Strength decrease with increase in temperature

50. What are 2 varieties of babbitt?

lead based babbitt

tin based babbitt

51. Compare bronze with babbit as bearing material ?

Bronze is cheaper, stronger at high pressure, got excellent casting & machining characteristics

Drawback is tendency to stick surface at high temperature

52. What are sintered metal bearing? What are 2 varieties of it?

It is made of compressed metal powder by sintering. types are

copper based sintered metal

iron based sintered metal

53. Give typical composition of copper lead bearings? Where do you use it?

-70% of copper & 30% of Pb

It is used in theme lining like white metal

It is used in heavy duty appln. At high temp.

54. State any 4 desirable properties of good lubricant?

Availability in wide range of viscosity

Small change in viscosity with change in temp.

Sufficient specific heat to carry away frictional heat

Available at reasonable cost

55. What is the approximate relationship between SAE number and viscosity of lubricating oil ?

SAE number corresponds to approximately one half of the viscosity of oil at 210 °F measured in terms of SUS (Saybolt Universal Minimum). When the SAE number is more, it indicates more viscous oil.

56. State any four advantages of gear drive over other type of drives.

It is a positive drive.

Velocity ratio remains constant.

It can transmit very large power.

Efficiency is very high.

57. State any two disadvantages of gear drive over other type of drives.

Maintenance cost is high.

Require careful attention for lubrication and cleanliness.

58. In a gear speed reducer, why is the diameter of an output shaft greater than input shaft.

Diameter is inversely proportional to velocity so as to reduce speed of output shaft, diameter of output shaft is greater than input shaft

59. In which gear drive is self locking possible?

Self locking is possible in Worm gears.

60. What is herringbone gear?

It is a special type of helical gear consisting of two helical gears with the opposite hand of helix.

61. What are the advantages of cycloidal teeth gears?

- # Large contact area and good wear strength
- # Phenomenon of Interference does not occur.

62. What are the advantages of involute teeth gears?

- # Pressure angle remain constant.
- # Manufacturing cost is low.

63. State two important reasons for adopting involute curve for gear tooth profile.

- # It satisfies the law of gearing.
- # Module and pressure angle are completely interchangeable.
- # Module and pressure angle can be machined from one single tool.

64. What are the advantages of 14.5° full-depth involute teeth gears?

- # Basic rack system is composed of straight sides.
- # System is satisfactory when the number of teeth on gears is large

65. What are the advantages of 20° full-depth involute teeth gears?

- # It reduces the risk of undercutting.
- # It reduces interference.
- # It has greater length of contact.

66. What are the advantages of 20° stub involute teeth gears?

- # Since the pinion is small, drive is more compact.
- # Stub system transmit very high load.
- # Lower production cost.

67. What is full-depth involute gear tooth system?

It is a system in which basic rack is composed of straight sides except for the fillet arcs.

68. Why is the tangential component of gear tooth force called 'useful' component?

The tangential component is a useful load because it determines the magnitude of the torque and consequently the power which is transmitted

69. Why is the radial component of gear tooth force called 'separating' component?

The radial component is a separating force towards the centre of the gear.

70. What is pitting?

Initial pitting or corrective pitting is a localised phenomenon i.e. pits at high spot and destructive pitting is fatigue failure at the surface of the gear due to load.

71. What is scoring?

It is stick slip phenomenon in which alternative welding and shearing take place

rapidly at higher spot.

72. What is the minimum number of teeth on spur gear? Why?

Minimum number of teeth on spur gear is 14. This is to avoid interference and undercutting.

73. What is a 'hunting' tooth?

The extra tooth which causes pinion to rotate before the same pair of teeth will engage again.

74. Which type of gear is used for high velocity ratio?

Helical gears are used for high velocity ratio.

75. What is meant by spur gear?

In spur gear the teeth are cut parallel to the axis of shaft.

76. What conditions must be satisfied for a pair of gears to have a constant velocity ratio?

The distance between center of the two gear is constant and they have a common point.

77. State the fundamental law of gearing?

The fundamental law of gearing states that the common normal to the tooth profile at the point of contact should always pass through a fixed point called the pitch point in order to obtain constant velocity ratio.

78. What are the conditions required for interchangeability in toothed gearing?

The condition which is required for interchangeability is pressure angle.

79. Which curves satisfy fundamental law of gearing?

Involute and cycloidal curves satisfy the fundamental law of gearing.

80. Define involute curve?

An involute is a curve traced by point on a line as the line rolls without slipping on a circle.

81. Define cycloidal curve?

A cycloid is a curve traced by a point on the circumference of a generating circle as it rolls without slipping along the inside and outside of another circle.

82. What are the advantages of cycloidal teeth gears?

1. In case of cycloidal gears a convex flank on one tooth comes in contact with concave flank of mating tooth. This increases contact area and wear strength. 2. There is no interference in cycloidal gear.

83. What are the advantages of involute teeth gear?

1) Involute gear results in reduction in manufacturing cost. 2) involute gear increases the maximum value in reverse direction.

84. What is pitch circle?

Pitch circle is a curve of intersection of the pitch surface of revolution and the plane of rotation.

85. What is base circle?

The base circle is an imaginary circle from which the involute curve of the tooth profile is generated.

86. What is dedendum circle?

The dedendum circle is an imaginary circle that borders the bottom of space between teeth in the cross section .

87. What is circular pitch?

The circular pitch is the distance measured along the pitch circle between two similar points on adjacent teeth.

88. What is a module ?

Module is defined as the ratio of pitch diameter to the number of teeth .

89. How do you specify the size of gear tooth ?

The module specifies the size of gear tooth . As the module increases size also increases

90. What is the pressure angle of gear tooth ?

The angle between common normal at the point of contact & with the common tangent to the two pitch circle is called as pressure angle

91. What is the effect of increasing or decreasing the pressure angle in gear design ?

Increasing the pressure angle makes tooth stronger , reduces interference & undercutting , while reducing it causes in reduction in noise during operation

92. What is crowning of gear teeth ?

In crowning process the ends of the tooth are made slightly thinner by small amount. This is done to shift load toward the middle

93. What are the advantage & disadvantage of stub tooth ?

Advantage) They have low interference & reduces undercutting , drive is more compact & strong

Disadvantage) due to insufficient overlap vibration are likely to occur

94. What is a gear ratio ?

The gear ratio or the velocity ratio is equal to the no. of teeth on on the last driven gear to the no of teeth on first driving gear

95. What is backlash in gear teeth ?

It is defined as the amount by which the width of tooth space exceeds the thickness of engaging tooth measured along the pitch circle

96. What factors influence backlash in gear tooth ?

Factors include error in profile , pitch , tooth thickness , helix angle & centre distance

97. Why tangential component of gear tooth force is called useful component ?

It is called useful because it determines the magnitude of torque to be transmitted

98. How will you decide the direction of tangential & radial components of gear tooth force ?

The direction is decided by drawing FBD in which radial component acts towards the centre of base circle , while tangential component acts in the direction perpendicular to it.

99. What are the basic modes of gear tooth failures?

There are two basic modes of gear tooth failures:

- 1) Breakage of the tooth due to static and dynamic loads.
- 2) Surface destruction.

100. What are types of gear tooth wear?

The principal types of gear tooth wear are as follows:

- 1) Abrasive wear
- 2) Corrosive wear
- 3) Initial Pitting
- 4) Destructive Pitting
- 5) Scoring

101. What is pitting?

Pitting is of two types viz Initial and destructive

- 1) Initial Pitting: The initial pitting is a localized phenomenon, characterized by small pits at high spots.
- 2) Destructive Pitting: It is a surface fatigue failure, which occurs when the load on Gear tooth exceeds the surface endurance strength of the Material

102. What is scoring?

Scoring is a stick slip phenomenon, in which alternate welding and shearing takes place rapidly at the high spots.

103. What are types of gear tooth wear?

The principal types of gear tooth wear are as follows:

- 1) Abrasive wear
- 2) Corrosive wear
- 3) Initial Pitting
- 4) Destructive Pitting
- 5) Scoring

104. What is pitting?

Pitting is of two types viz Initial and destructive

- 1)Initial Pitting: The initial pitting is a localized phenomenon, characterized by small pits at high spots.
- 2)Destructive Pitting: It is a surface fatigue failure, which occurs when the load on gear tooth exceeds the surface endurance strength of the material.

105. State the desirable properties of gear materials?

- 1)The gear material should have sufficient strength to resist failure due to breakage of the tooth.
- 2)The gear material should have sufficient surface endurance strength to avoid failure due to destructive pitting.
- 3)The material should have low coefficient of friction to avoid failure due to scoring.
- 4)The material should be made of alloy steels rather than plain carbon steels to avoid thermal distortion or warping during heat treatment process

106. What are non-metallic gears? Where do you use them?

Non-metallic gears are those in which only pinion is made of non-metals such as molded nylon, laminated phenolics like Bakelite or Celcon. Non-metallic gears are used under following conditions:

- 1)The load is low and the pitch line velocity is low.
- 2)A long life is expected.
- 3)It is required to have quiet operation free from noise and vibrations.
- 4)The gears are likely to be affected by water and oil.

107. Where do you make gear integral with shaft?

If the diameter of dedendum circle exceeds the diameter of the shaft (D_s), at the point where the pinion is fitted, by less than ($D_s/2$), the pinion is made integral with the shaft.

108. What are the advantages of forged gears?

Forged gears offer following advantages:

- 1)In case of forgings, material utilization factor is $(2/3)$, which is twice. This reduces the cost of the material.
- 2)Forged gear has lightweight construction which reduces inertia and centrifugal forces.
- 3)The fibre lines of the forged gears are arranged in a predetermined way to suit the direction of external force.

109. What is rimmed gear? What is its advantage?

A rimmed gear consists of a steel rim fitted on a central casting with hub, arms or webs. The rim is forged from alloy steel. Rim gears save costly high strength material.

110. What is interference in gears?

The tip of the tooth on mating gear, which is involute, interferes with non involute portion of the addendum. This phenomenon of tooth profiles overlapping and cutting into each other is called 'interference'.

111. How will you eliminate interference in gear teeth?

The following methods can eliminate the interference;

- 1) Increase the number of teeth on pinion.
- 2) Increase pressure angle.
- 3) Use long and short addendum gearing.

112. What is a hunting tooth?

It is an extra tooth on the larger of two gear wheels so that the total number of teeth will not be an integral multiple of the number on the smaller wheel.

113. What is the optimum value of face width in terms of module?

The optimum value of face width is $(8m < b < 12m)$. In the preliminary stages of gear design, the face width is assumed as ten times of module.

114. State the assumptions of Lewis equation?

The Lewis equation is based on the following assumptions:

- 1) The effect of the radial component which induces compressive stresses is neglected.
- 2) It is assumed that the tangential component is uniformly distributed over the Face width of the gear. This is possible when the gears are rigid and accurately machined.
- 3) The effect of stress concentration is neglected.
- 4) It is assumed that at any time, only one pair of teeth is in contact and takes the total load.

115. What is beam strength?

The beam strength is the maximum value of the tangential force that the tooth can transmit without bending failure.

116. What is Lewis form factor?

It gives relation between tangential forces & corresponding stress

117. When pinion and gear are made of same material, which component is to be designed? Why?

Pinion. It is easy to manufacture & less cost with low FOS.

118. Why pinion is weaker than the gear made of same material?

If pinion is stronger than gear it will damage the gear. As cost of the gear is more than pinion.

119. Why permissible bending stress for gear tooth is taken as one third ultimate tensile strength?

Repeated or reversed stress cause bending stress in gear which is difficult to determine hence we considered it is $1/3$ of ultimate tensile strength.

120. What is service factor for gear tooth load?

External load dynamics, reliability, and life and is used to calculate equivalent horsepower.

121. What is velocity factor for gear tooth load?

It is a factor used for determining the approximate dynamic load in the primary stages of gear design.

122. What is dynamic load? What are its causes?

This load occurs when a pair of teeth is just coming into mesh. It causes noise and vibration.

123. What is wear strength of gear tooth?

Failure of gear tooth due to pitting occurs when contact stresses between two meshing teeth exceed the surface endurance strength of material.

124. What is internal and external gearing?

Internal- Two gears are meshing internally by means of proper engagement.

External- Two gears are meshing externally by means of proper engagement

125. State two advantages of internal gear.

Compact construction and smooth, quiet working.

126. What are the advantages of planetary reduction gears as compared to ordinary gearboxes?

Planetary gears over parallel axis gears include high power density, large reduction in a small volume, multiple kinematic combinations, pure torsion reactions and coaxial shafting.

127. What is helical gear?

The gear whose teeth are cut in the form of a helix on the pitch cylinder called as helical gear.

128. Compare the contact between mating teeth of spur and helical gears ?

In spur gear contact occur along the entire face width of the tooth while in helical gear contact begins with point and gradually extends along the diagonal line across the tooth.

129. What are the advantages of helical gears over the spur gears ?

Load pick up is gradual, smooth engagement , quiet operation even at high speed.

130. What is crossed helical gear ?

These mounted on shaft with crossed axes. Their teeth may have same or opposite hand of the helix.

131. What is helix angle ?

It is defined as the angle between the axis of shaft and the centre line of the tooth taken on the pitch plane.

132. What is transverse circular pitch ?

The transverse pitch of a helical gear corresponds to the pitch of a spur gear with the same number of teeth and the same pitch diameter. It is measured in the plane rotation of the gear

133. What is normal circular pitch ?

The normal pitch of a helical gear is the pitch of the tool used to cut the teeth. It is measured in a plane perpendicular to the direction of the teeth.

134. What is transverse module ?

The module of tooth datum orthogonal to the center axis of gear is called transverse module.

135. What is axial pitch ?

It is the distance ,parallel to the axis ,between similar faces of adjacent teeth .

136. What is normal pressure angle ?

Normal pressure angle is the pressure angle in the normal plane of a helical gear tooth

137. What is virtual or formative helical gear ?

In the design of helical gears, an imaginary spur gear is considered in plane A-A(normal to the tooth) with centre o having a pitch circle radius of r and module m_n It is called as formative helical gear.

138. What is the main disadvantage of a single helical gear? What is the remedy?

The main disadvantage of single helical gear is a axial thrust, it is problem overcome by herringbone and double helical gears having two sets of teeth that are set in a v shape.

139. How is the axial thrust in helical gears overcome?

Axial thrust in helical gears is overcome by herringbone and double helical gears having two sets of teeth that are set in a v shape.

140. What is the double helical gear?

These are the gears constructed by joining two identical helical gears and having a groove between them

141. What is herringbone helical gear?

These are the gears constructed by joining two identical helical gears, they don't have any gears between two helical gears.

142. What is the difference between double and herringbone helical gears?

Double helical gears have a groove between two helical gears while the gears without groove are called as herringbone gears.

143. State two advantage of herringbone and double helical gears?

1.The net axial force that acts on the bearings is zero.

2. Power transmitting capacity is high.

144. What is a crossed helical gear?

Helical gears which are mounted on non-parallel shafts are called crossed helical gears.

145. Why crossed helical gears are not used for high power transmission?

They have very low load capacity, therefore they are not used in high power transmission.

146. What is a worm gear?

Worm gear consists of worm which is threaded screw while worm wheel is a toothed gear.

147. Why do you use worm gear drive ?

Worm gear drives are used to transmit power between two non-intersecting shafts at right angles to each other.

148. What are the advantages of worm gear drives ?

The advantages of worm gear drives are as follows:

- (i) The most important characteristic of worm gear drives is their high speed reduction. A speed reduction as high as 100 : 1 can be obtained with a single pair of worm gears.
- (ii) The worm gear drives are compact with small overall dimensions, compared with equivalent spur or helical gear drives having same speed reduction.
- (iii) The operation is smooth and silent.
- (iv) Provision can be made for self locking operation, where the motion is transmitted from worm to worm wheels.

149. What are the draw backs of worm gear drives ?

The drawbacks of the worm gear drives are as follows:

- (i) The efficiency is low compared with other types of gear drives.
- (ii) The worm wheel, in general, is made of phosphor bronze, which increases the cost.
- (iii) Considerable amount of heat is generated in worm gear drives, which is required to be dissipated by a lubricating oil to the housing walls and finally to the surroundings.
- (iv) The power transmitting capacity is low. Worm gear drives are used for upto 100 kW of power transmission.

150. What kind of contact occurs between worm and worm wheel ?

The worm is a threaded screw, while the worm wheel is a toothed gear. The teeth on the worm wheel envelope the threads on the worm and give line contact between mating parts.

151. Why are worm gear reduction units not preferred over other types of gearboxes for transmitting large powers?

The efficiency is low as compared to other gear boxes. Also the power transmitting capacity is low. Heat is generated during power transmission which is not desirable.

152. What are single-enveloping and double enveloping worm gear drives ?

Single-enveloping worm gear drive :

A single-enveloping worm gear set is one in which the gear wraps around or partially encloses the worm. This results in line contact between the threads of the worm and the teeth of the worm wheel. It is also called as 'cylindrical' worm.

Double-enveloping worm :

A double-enveloping gear set is one in which the gear wraps around the worm and the worm also wraps around the gear. This results in area contact between the threads of the worm and the teeth of the worm wheel. It is also called as 'hourglass' worm.

153. What are advantages of double-envelope worm gear drives over single worm gear drives ?

Double-enveloping worm gear drive has the following advantages :

- (i) The contact pressure between the threads of the worm and the teeth of the worm wheel is low. This reduces wear.
- (ii) The drive occupies less space for a given capacity. Double-enveloping worm gear drive needs only about two-thirds of the space and has about one-third of the weight compared to single-enveloping worm gear drive.

154. What is diametrical quotient ?

The diametrical quotient is the ratio of the pitch circle diameter of the worm to the module.

155. What is axial pitch of the worm ?

The axial pitch of the worm is defined as the distance measured from a point on one thread to the corresponding point on the adjacent thread, measured along the axis of the worm.

156. What is the lead angle of the worm ?

The lead angle is defined as the angle between a tangent to the thread at the pitch diameter and a plane normal to the worm axis.

157. What is the relationship between number of starts on worm, diametrical quotient and lead angle of worm ?

Lead angle of worm is the ratio of number of starts on worm to the diametrical quotient of the worm.

158. What is the material for worm ? Why ?

The threads of the worm are subjected to fluctuating stresses and the number of stress cycles fairly large. The surface endurance strength is an important criterion in worm material. The core of worm should be kept ductile and tough to ensure maximum energy absorption. Therefore, worms are made of case hardened steel with a surface hardness of 60HRC and a case depth of 0.75 - 4.5 mm.

- 159. What is the material for worm wheel ? Why ?**
The number of stress cycles is reduced by a factor equal to speed reduction. The final profile and finish of the worm wheel teeth is the result of plastic deformation. Therefore, the material should be soft and comfortable. Phosphor-bronze, with a surface hardness of 90-120BHN. Phosphor-bronze worm wheels are sand-cast, sand-cast and chilled, or centrifugally cast.
- 160. Why is the efficiency of worm gear drive low ?**
Worm gear drives gives large speed reduction by obtaining large velocity ratio. So, the efficiency becomes low.
- 161. What is thin cylinder?**
When the ratio of the inner diameter of the cylinder to the wall thickness is than 15, it is called as thin cylinder.
- 162. What are the types of stresses in thin cylinder?**
Circumferential stress or tangential stress (σ_t) and longitudinal stress (σ_l) are the types of stresses induced in thin cylinder
- 163. 'In case of thin cylinder subjected to internal pressure, the tendency to burst lengthwise is twice as great as at tranverse section.' Why?**
In thin cylinder, the circumferential stress (σ_t) is twice the longitudinal stress (σ_l), therefore, when the circumferential stress exceeds the yield strength, failure will occur lengthwise. Thus the tendency to burst lengthwise is twice as great as at tranverse section.
- 164. What is thick cylinder?**
When the ratio of the inner diameter of the cylinder to the wall thickness is less than 15, it is called as thick cylinder.
- 165. What is the criterion to distinguish between thin and thick cylinder?**
The ratio of inner diameter to wall thickness can be used to distinguish between thin and thick cylinder. If the ratio is more than 15, it's a thin cylinder, if it's less than 15, it's a thick cylinder
- 166. When do you use Lame's equation for cylinder wall thickness?**
Lame's equation is used to determine the wall thickness when the material of the cylinder is brittle, such as cast iron or cast steel.
- 167. When do you use Clavarino's equation for cylinder wall thickness?**
Clavarino's equation for cylinder wall thickness is used for cylinders with closed ends and made of ductile materials such as mild steel or alloy steel
- 168. What is compound cylinder?**
When two concentric cylinders are used with outer cylinder shrunk onto the inner one, it is known as compound cylinder