ANNAI MATHAMMAL SHEELA ENGINEERING COLLEGE

DEPARTMENT OF MECHANICAL ENGINEERING

DESIGN OF MACHINE ELEMENTS

UNIT I – STEADY STRESSES AND VARIABLE STRESSES IN MACHINE MEMBERS

1. What are the various phases in design process? .[AUT CBE 2010]

a. Recognition of need
b. Definition of problem
c. Synthesis
d. Analysis and Optimization
e. Evaluation
f. presentation

2. How the machine design may be classified?

a. Adaptive design
b. Developed design
c. New design
d. Rational design
e. Empirical design
f. Industrial design

3. What are the types of loads that can act on machine components?

a. Steady load
b. Variable load
c. Shock load
d. Impact load

4. Differentiate between resilience and toughness.

Resilience is the property of the material to absorb energy and to resist shock and impact loads. This property is essential for spring materials. Toughness is the property of the material to resist fracture due to high impact load. This property is desirable in parts subjected to shock and impact loads.

5. Define Creep.

When a part is subjected to a constant stress at high temperature for a long period of time, it will undergo a slow and permanent deformation called creep.

6. Shock resistance of steel is increased by adding _____.

Ans: Nickel and Chromium

7. What are the factors affecting selection of material for machine element?

1. Load applied
2. Purpose and operating conditions of the part.
3. Suitability for manufacture.
4. Minimum weight and optimal size
5. Availability and cost.

8. What is optimum design?

In iterative nature of design, we can arrive at a design which provides the best possible technical conditions like maximum on the best performance of the product with the least cost per unit, consistent with weight, size, strength and similar considerations. Such a design is called Optimum design.

9. Define factor of safety.

Factor of safety (FOS) is defined as the ratio between the maximum stress and working stress.

10. Define working stress.

When designing machine parts it is desirable to keep the stress lower than the maximum or ultimate stress at which the failure of the material takes place. This is known as working stress or design process.

11. What is contact stress? It is defined as the localized compressive stress developed at the area of contact between two curved members that are in relative motion.

12. Define bearing (or) crushing stress.

A localized compressive stress at the surface of contact between two members of machine part that are relatively at rest is known as bearing stress or crushing stress.

13. List out the factors involved in arriving at factor of safety.

1. Material properties
2. Nature of load
3. Presence of localized stress

4. Presence of initial stress 5. Mode of failur

14. Identify the design of the following components whether it is adaptive design or developed or new design.

Lathe, crane, gear box and Ratchet mechanism.
Lathe – developed design
Crane – new design
Gear box – adaptive design
Ratchet mechanism – adaptive design

15. How the allowable stress is estimated in ductile and brittle materials?

For ductile materials
Allowable stresses = yield stress / factor of safety
For brittle materials
Allowable stresses = ultimate stress/factor of safety.

16. What are the types of variable stresses?

a. completely reversed or cyclic stresses b. fluctuating stresses
c. repeated stresses d. alternating stresses

17. What are preferred numbers?

When a machine is to be made in several sizes with different powers or capacities, it is necessary to decide what capabilities will cover a certain range efficiently with a minimum number of sizes. The preferred numbers are the conventionally rounded off values derived from geometric series including the integral powers of 10 and having a common ratio of the following factors.

18. Differentiate between direct stress and bending stress.

Direct stress: Load is applied axially; the stress distribution is uniform throughout the cross section. Bending stress: load is applied laterally, ie) perpendicular to the axis.

19. The neutral axis of a beam is subjected to _____ stress.

Ans: zero

20. The neutral axis of a section is always passes through its _____.

Ans: Centroid

21. Define principal stress.

The direct stresses acting along the principal planes (which have no shear stress) in a strained material is known as principal stresses.

22. Differentiate between repeated stress and reversed stress.

Repeated stress refers to a stress varying from zero to a maximum value of same nature. Reversed stress or cyclic stress varies from one value of tension to the same value of compression.

23. State Griffith theory.

A crack can propagate if the energy release rate of crack is greater than the crack resistance.

24. Define factor of safety for fatigue loading.

Factor of safety for fatigue loading = endurance limit stress/Design stress

25. Define Endurance limit.

Endurance limit is the maximum value of completing reversed stress that can sustain an infinite number (10^6) of cycles without failure.

26. What are the factors affecting endurance strength of a material? [AU MAY 2008]

1. load 2. surface finish 3. size
4. Temperature 5. impact 6. reliability

27. What is S-N curve?

S-N curve is a diagram having fatigue stress on y axis and number of loading cycles in x axis. It is used to find the fatigue stress value corresponding to a given number of cycles.

28. For torsional shear stress, it is _____ at the centroid axis and _____ at the outer surface.

Ans: zero, maximum.

29. Write down the bending equation.

The bending equation is given by, $\frac{M}{I}=\frac{\sigma_b}{y}=\frac{E}{R}$

Where,

M - Bending moment acting at the given section

σ_b - Bending Stress

E – Young's modulus of the material of the beam

I – Moment of inertia of cross section about the neutral axis.

Y – Distance from neutral axis to the extreme fibre

R – Radius of curvature of the beam.

30. Write the applications of curved beam.

1. crane hookes 2. chain links 3. frames of punches
4. presses 5. planers

31. What is torsional shear stress?

When a machine member is subjected to the action of two equal and opposite couples acting in parallel planes (or torque or twisting moment, then the machine member is said to be subjected to torsion. The stress set up by torsion is known as torsional shear stress.

32. What are the assumptions made in torsion equation?

1. The material of the shaft is uniform throughout.
2. The twist along the shaft is uniform.
3. The normal cross section of the shaft, which were plane and circular before twist, remain plane and circular after twist.

33. Write down the torsion equation.

The torsion equation is given by,

$$\frac{T}{J}=\frac{\tau}{R}=\frac{G\theta}{1}$$

T – Torque acting at the given section.

J – Polar moment of inertia of cross section about neutral axis.

τ – Shear stress

R – Radius of curvature

G – Modulus of rigidity of material of beam.

q – Angle of twist

l – Length of twist

34. Write down the general expression for the bending stress in a curved beam?

The general expression for the bending stress in a curved beam is given by,

$$\sigma_b=\frac{M}{Ae}\left(\frac{y}{R_a-Y}\right)$$

Where,

σ_b = Bending stress.

M = Bending moment acting at the given section about the centroidal axis.

A = Area of cross section

e = Distance from the centroidal axis to the neutral axis.

Y = Distance from the neutral axis to the fibre under consideration.

35. What is eccentric load and eccentricity?

An external load, whose line of action is parallel but does not coincide with the centroidal axis of the machine component, is known as an eccentric load. The distance between the centroidal axis of the machine component and the eccentric load is called eccentricity. (e.g) c-clamps, punching machines, brackets, offset connecting links etc.

36. State different theories of failures.

1. Maximum principal stress theory (or) Rankines theory
2. Maximum shear stress theory (or) Guest's theory
3. Maximum principal strain theory (or) Saint Vanant theory

4. Maximum distribution energy theory
5. Maximum strain energy theory

37. State St.Vanent theory of failure.

According to this theory, failure occurs when the maximum strain developed in the machine member is equal to maximum strain at yield point in a tension test.

38. What are the appropriate theories of failure for ductile and brittle materials? For ductile materials – maximum distortion energy theory.For brittle materials – maximum principle stress theory

39. Maximum shear stress developed in a beam of rectrangular section is _____ the average shear stress.

Ans: 1.5 times

40. State maximum shear stress theory.

According to maximum shear stress theory failure occurs when the maximum shear stress developed in a machine members is equal to the maximum shear stress at yield point in a tension test.

41. Explain reasons for using different theories of failures.

The problem of predicting the failure stresses for members subjected to bi axial or tri axial stresses is much complicated. Hence we are using different theories of failure.

42. Define the term fatigue.

When the material is subjected to repeated stresses, it fails at stresses below the yield point stresses, such type of failure is known as fatigue.

43. Design of a part subjected to bending moment is done on the basis of safe tensile stress. Why?

Due to bending loads, the stress is tensile at outer fibre and compressive at inner fibre. All materials are weak under tension than compression, hence the design of a part subjected to bending moment is done on the basis of safe tensile stress.

44. Differentiate between direct shear stresses and torsional shear stress.

The induced stress due to tangential load to the specific cross section is direct shear stress and distribution is uniform throughout.

A pure twisting moment acting on the machine member of a circular cross section induces torsional shear stress. This stress is zero at the centre and increases with increase in radius.

45. State any two methods of solving problems involving combined steady or variable stresses.

a) Gerber method b) Goodman method c) Soderberg method

46. Define Goodman line.

It is a straight line connecting the endurance limit and ultimate strength in variable stress diagram and Goodman line is applicable for designing of brittle materials.

47. What are Gerber curve and Soderberg line.

Gerber curve is a parabola drawn between endurance limit and ultimate tensile strength. Soderberg line is a straight line connecting endurance limit and the yield strength in variable stress diagram Soderberg line applicable for designing of ductile materials.

48. What is stress concentration and stress concentration factor? [AUT CBE DEC 2010 & MAY 2008]

The irregularity in stress distribution caused by abrupt changes of form is called stress concentration.Stress concentration factor = maximum stress at the change of cross section / nominal stress.

49. What are the three important points while designing member for impact loads?

1. Parts for impact load should be designed to have maximum volume of material stresses to highest existing stress.

2. Stress concentration must be eliminated. 3. If plastic flow is tolerable and advantage is to be taken of its energy absorbing potential, then ductile materials should be used.

50. What are different methods to reduce stress concentration?

1. providing fillets
2. Drilling additional holes
3. providing additional grooves
4. reducing shank diameters in threaded fasteners.
5. drilling additional counter sunk.

51. State the different failure theories and the type of materials for which these are applicable?

1. Maximum principal theory –brittle material.
2.Shear Stress Theory –Ductile Material.

52. Define The Morphology Of Design?

Morphology of design consisting of problem formulation analysis search for alternative an evaluation decision taking and specification of the solution.

53. Stress Intensity Factor?

$$\text{STRESS INTENSITY FACTOR} = \frac{MAXIMUM\ STRESS}{NORMINAL\ STRESS}$$

54. Define fit and tolerance.

Fit:

Fit is the relation between the two matting parts in which one is inserted in to the other with degree of tightness or looseness

Tolerance:

A tolerance is the limit of acceptable *unintended* deviation from a nominal or theoretical dimension. Therefore, a pair of tolerances, upper and lower, defines a range within which an actual dimension may fall while still being acceptable

55. write down the factors influencing machine design ?

i) cost
ii) efficiency
iii) strength
iv) stiffness
v)wear resistance
vi) dimension

PART-B

1. A simply supported beam has concentrated load at the centre which fluctuates a value from P to 4P. The span of the beam is 500 mm and its cross section is circular with a diameter of 60 mm. Beam material is cold drawn 0.2% carbon steel. Calculate the maximum permissible value of P for a factor of safety of 1.3. Beam surface is ground.

2. A medium force fit on a 50 mm shaft requires a hole tolerance of 0.025 mm and a shaft tolerance of 0.016 mm. The maximum interference is to be 0.042 mm. How will you dimension the hole and the shaft, if hole deviation is H?

3. A transmission shaft is supported on two bearings which are 1m apart. Power is supplied to the shaft by means of a flexible coupling, which is located to the left of left hand bearing. Power is transmitted from the shaft by means of a belt pulley,250 mm diameter, which is located at a distance of 300 mm from the left hand bearing. The mass of the pulley is 20 kg and the ratio of belt tension on tight and slack sides is 2:1. The belt tensions act vertically downward. The shaft is made of steel with yield stress 300N/mm2 and the factor of safety is 3. Determine the shaft diameter, if it transmits 10 kW power at 360 rpm from the coupling to the pulley

4. Explain with mathematical expressions. Maximum principal stress theory and Von-Mises-Henky theory

5. A circular bar is simply supported with a span of 0.5mand is subjected to a concentrated cyclic load at its midspan. The load varies from a minimum value of20KN to maximum value of 45 KN. The load 3 direction is transverse to the shaft axis. Decide upon the diameter of the bar taking a factor of safety

of 1.5 and factor of 0.85 and 0.89 respectively for size effect and surface finish. Take often following values for material properties. Ultimate strength = 650N/mm2, Yield strength =450N/mm2 Endurance strength 350N/mm2

6. A steel member is subjected to a 3-D stress system and resulting principal stress are 120N/mm2 tension, 80N/mm2and 40N/mm2 co.mpression. If the proportional limit of the material in simple tension is 280N/mm2 and its poison's ratio is O.3.Determine the factor of safety according to (a) Maximum principal stress theory (b) Maximum principal strain theory (c) Maximum shear stress theory.

7. (a) A piston of a reciprocating compressor has a diameter of 60mm. The maximum pressure on the piston fall is 1.25MN/m2.Assuming the gudgeon pin passing through the small end of the connecting rod can be safely loaded in shear up to 10MN/m2, Calculate the minimum diameter of the gudgeon pin.

8. (a) Determine the diameter of the steel bar, which is a ductile in a nature subjected to an axial load of 60KN and torsional moment of 1600N-m.Use the factor of safety 2.5.E=200GPa.

9. Explain with mathematical expressions.Maximum shear theory and Venant's theory

10. A steel member is subjected to a 3-D stress system and resulting principal stress are 120N/mm2 tension, 80N/mm2and 40N/mm2 compression. If the proportional limit of the material in simple tension is 280N/mm2 and its poison's ratio is O.3.Determine the factor of safety according to (a) Maximum principal stress theory (b) Maximum principal strain theory (c) Maximum shear stress theory.

11. A bolt is subjected to a tensile load of 25KN and a shear load of 10KN. Determine the diameter of the bolt according to (a) Maximum principal stress theory (b) Maximum principal strain theory (c) Maximum shear stress theory. Assume factor of safety 2.5, Yield point stress in simple tension 300N/mm2, Poisson's ratio is 0.25.

12. Taking stress concentration in to account find the maximum stress induced when a tensile load of 20KN is applied to (i) A rectangular plate 80mm wide and 12mm thick with a transverse hole of 16mm diameter.(ii)A stepped shaft of diameters 60mm and 30mm width a fillet radius of 6mm.

13. A circular bar is simply supported with a span of 0.5mand is subjected to a concentrated cyclic load at its midspan. The load varies from a minimum value of20KN to maximum value of 45 KN. The load 3 direction is transverse to the shaft axis. Decide upon the diameter of the bar taking a factor of safety of 1.5 and factor of 0.85 and 0.89 respectively for size effect and surface finish. Take often following values for material properties.Ultimate strength = 650N/mm2 ,Yield strength = 450N/mm2 Endurance strength =350N/mm2 .

14. The bending stress in a machine part fluctuates between a tensile stress of 280N/mm2 and a compressive stress of 140N/mm2• What should be the minimum ultimate tensile strength of this part to carry this fluctuation indefinitely according to (i) Goodman's formula (ii) Soderberg formula Factor of safety is 1. 75. Assume that the yield point is never likely to be less than 55% of the Ultimate tensile strength or greater than 93 % of it.

15. Determine the thickness of a 120mm wide uniform plate for safe continuous operation if the plate is to be subjected to a tensile load that has a maximum value of 1000N.The properties of the plate materials are as follows. Endurance limit stress is 225MPa and yield point stress is 300MPa. The factor of safety based on yield point may be taken as 1.5.

16. A hot rolled bar of steel is subjected to a torsional load varying from-150N-m to 450N-m. Determine the required diameter of the bar using a factor of safety of 1.7. Properties of the material may beassumed as follow. Ultimate tensile stress = 450MPa Yield stress = 300MPa .

17. A transmission of shaft made C45 steel subjected to a fluctuating torque varying from -100N-m to +500N-m.Also a fluctuating bending moment acts on the shaft which varies from +500N-m to -500Nm. Let the stress concentration factor be 2. The shaft is machined for a factor of safety 1.5.Determine the required diameter of the shaft.

UNIT II –SHAFTS AND COUPLINGS

1. Define shaft.

A shaft is a rotating machine element which is used to transmit power from one place to another. Shaft is used for the transmission of torque and bending moment.

2. Differentiate between shaft and axle.

An axle, through similar in shape to the shaft, is a stationary machine element and is used for transmission of bending moment only. It simply acts as a support for some rotating body.

3. What is spindle?

A spindle is a short shaft that imparts motion either to a cutting tool or to a workpiece.

4. What are the materials used for shafts.

For ordinary shafts – mild steel

For high strength shafts – alloy steel such as Nickel, Ni-Cr steels (or) Cr – V steels.

5. What are the types of shafts and their importance?

1. Transmission shafts – These shafts transmit power between the source and the machines absorbing power. These shafts carry machine parts such as pulleys, gears etc. they are subjected to bending in addition to twisting.

2. Machine shafts – these shafts form an integrated part of the machine itself. The crankshaft is an example of machine shaft.

6. What are various types of stresses induced in the shafts. .[AUT CBE 2010]

1. Shear stresses due to transmission of torque.
2. Bending stresses.
3. Stresses due to combined torsional and bending loads.

7. What are standard sizes of transmission shafts?

1. 25mm to 60mm with 5mm steps.
2. 60mm to 110mm with 10mm steps.
3. 110mm to 140mm with 15mm steps.
4. 140mm to 500mm with 20mm steps.

Standard length – 5m, 6m and 7m.

8. On what basis the shafts are designed.

1. Based on rigidity and stiffness 2. Based on strength 3. Based on critical speed.

9. Differentiate the hollow shaft and solid shaft.

The hollow shafts are used in marine work. These shafts are stronger per kg of material and they may be forged on a mandrel, thus making the material more homogenous than a solid shaft.

10. Give examples for shafts subjected to axial load in addition to torsion and bending loads.

a. propeller shafts of ships b. shafts for driving worm gears

c. main shaft of Kaplan turbines.

11. What are the desirable properties for the materials for shafts and axles?

a. sufficient high strength
b. a low sensitivity to stress concentration
c. ability to withstand heat and case hardening treatment.
d. good machinability

12. How the shafts are designed when it is subjected to twisting moment only?

When the shaft is subjected to torque only, then it is designed based on torsion equation.

13. Why rotating shaft are generally made with circular cross section?

Stress distribution pattern will be uniform throughout the circular cross section.

14. Define Torsional stiffness of shaft.

It is defined as the resisting strength of a shaft to torsional load.

Mathematically it can be calculated by the formula.

15. If the shaft is subjected to torsion and bending moment, the shaft diameter can be determined based on the two theories namely _____

Ans: Guest's theory and Rankine's theory.

16. What are the ways of improving lateral rigidity of shafts?

1. maintaining proper bearing clearances
2. correct gear teeth alignment.

17. Define critical speed of a shaft.

Rotating shaft tends to vibrate violently in transverse direction at certain speeds known as critical (or) whirling speed. When the natural frequency of vibration is equal to the speed of the shaft, resonance will occur. Such a value of natural frequency is called critical or whirling speed.

18. State any two reasons for preferring hollow shaft over solid shaft.

1. for some weight of shaft, hollow shaft can transmit 1.5 times the torque transmitted by solid shaft.
2. for a particular power transmission hollow shaft requires minimum weight.

19. What is column factor?

If a long shaft subjected to axial load (compressive load) in addition to torsion and bending, a factor must be introduced to take the column effect into account.

20. What is key?

Key is an element which is used to connect two machine parts for preventing relative motion of rotation with respect to each other.

21. Name the stresses induced in a taper key.

1. shear stress
2. crushing stress

22. Name the types of keys.

1. saddle key
2. tangent key
3. sunk key
4. round key and taper pin

23. How sunk keys are provided?

Sunk keys are provided half in the key way of the shaft and half in the key way of the hub or boss of the pulley.

24. List various types of sunk keys.

1. Rectangular sunk key
2. Square sunk key
3. Parallel head key
4. Gib head key
5. Feather key
6. woodruff key

25. What is a keyway?

Keyway is a slot or recess in a shaft and hob of the pulley to accommodate a key.

26. What is gib head hey? What is the advantages?

In a rectangular sunk key with a head at one end is known as gib head key.

It is usually provided to facilitate the removal of key.

27. What is feather key?

A key attached to one member of a pair and which permits relative axial movement is known as feather key. It is a special type of parallel key which transmits a turning moment and also permits axial movement.

28. What is woodruff key? State its application.

It is piece from a cylindrical disc having segmental cross section. A woodruff key is capable of tilting in a recess milled out in the shaft by a cutter having the same curvature as the disc from which the key is made. They are largely used in machine tool and automobile construction.

29. What are advantages and disadvantages of a woodruff key?

1. It accommodates itself to any taper in the hub or boss of the mating piece.
2. It is useful on tapering shaft end. Its extra depth in the shaft prevents any tendency to turn over in its keyway.

30. What are the two types of saddle keys?

1. flat saddle key
2. hollow saddle key

31. What are round keys?

The round keys are circular in section and fit into holes drilled partly in the shaft and partly in the hub.

32. What are splines?

The keys are made integral with the shaft which fits in the keyways broached in the hub. Such shafts are known as splined shafts. These shafts usually have four, six, ten or sixteen splines. The splined shafts are relatively stronger than shafts having a single keyway.

33. List the advantages of splines over keys.

1. Splines can be used when both axial movements as well as positive drive is to be obtained.
2. It is used when the force to be transmitted is large in proportion to the size of the shaft as in automobile transmission and sliding gear transmission.

34. What are various forces acting on a sunk key?

1. Forces due to fit of the key in its keyway.
2. Forces due torque transmitted by the shafts.

35. List the various purposes of shaft couplings?

1. To provide for the connection of shafts of units that is manufactured separately and to provide for disconnection for repairs or alternations.
2. To provide misalignment of the shafts or to introduce mechanical flexibility.
3. To introduce protection against overloads.
4. To reduce the transmission of shock loads from one shaft to another.

36. List out the requirements of a shaft coupling?

1. It should be easy to connect or disconnect.
2. It should transmit the full power of the shaft
3. It should hold the shafts in perfect alignment.
4. It should have no projecting parts.

37. What is rigid coupling? What are its types?

It is used to connect two shafts which are perfectly aligned. The types are

1. sleeve or muff coupling
2. clamp or split muff or compression couling
3. flange coupling.

38. What is flexible coupling? What are its types?

Flexible coupling is a type of coupling used to connect two shafts having both lateral and angular misalignment.

Types: a) Bushed pin type coupling
b) Universal coupling
c) Oldham's coupling

39. What is a flange coupling?

It is a coupling having two seperate cast iron flanges. Each flange is mounted on the shaft end and keyed to it. The faces are turned up at right angle to the axis of the shaft. One of the flange has a projected portion and the other flange has a corresponding recess. This helps to bring the shafts into line and maintain alignment.

40. What are various types of flange coupling?

1. unprotected type flange coupling
2. protected type flange coupling
3. marine type flange coupling

41. The taper on a rectangular sunk key is _____

Ans: 1 in 100.

42. The sleeve or muff coupling is designed as a _____

Ans: hollow shaft.

43. What is the difference between rigid and flexible coupling?

Rigid coupling is used to connect two shafts which are perfectly aligned.

Flexible coupling is used to connect two shafts having both lateral and angular misalignment.

44. List any two methods used for manufacturing of shafts.

1. cold rolling
2. hot rolling
3. turning or grinding from rough bars.

45. What is the effect of keyway cut into the shaft?

The keyway cut into the shaft reduces the load carrying capacity of the shaft. This is due to the stress concentration near the corners of the keyway and reduction in the cross sectional area of the shaft. In other words the torsional strength of the shaft is reduced.

46. What is the difference between coupling and a clutch?

A coupling is a device used to make permanent or semi permanent connection where as a clutch permits rapid connection or disconnection at will of the operator.

47. What is the mode of failure of the bolts in a flange coupling?

Direct shear stress failure due to torque transmission.

48. When a solid flange coupling is preferred?

Solid flange couplings are preferred for very large shafts or when large torsional moments and forces are to be transmitted such as those used for propeller shafts,.

49. Indicate what type of coupling is used under following conditions.

a) shafts having collinear axis
b) shafts having intersecting axes
c) shafts having parallel axes with a small distance apart.

Ans:

a) Rigid or flexible coupling
b) Universal coupling
c) Double slider crank principle mechanism

50. How couplings are specified?

a) Diameter of shaft
b) Diameter of sleeve or muff
c) Length of sleeve or muff
d) Outer diameter of hub
e) Nominal diameter or bolt
f) PCD of bold circle

51. Differentiate between a cotter joint and a knuckle joint.

Cotter joint is used to connect two rigid rods for transmitting motion without rotation. This joint is subjected to axial forces. Knuckle joint is used for connecting two rods and transmitting axial force. This joint permits a small amount of flexibility.

52. Which type of key is used for mounting shifting gears in gear boxes?

Splines.

53. What is knuckle joint?

Knuckle joint is used to connect two rods which are under the action of tensile loads.

55. Identify the weakest component while designing shaft and hub assembly.

Key.

54. What are the various methods of failure of knuckle joint?

1. Failure of solid rod in tension
2. Failure of knuckle pin in shear
3. Failure of single eye or rod end in shear
4. Failure of single eye or rod in tension
5. Failure of single eye or rod end in crushing
6. Failure of forked end in tension
7. Failure of forked end in shear
8. Failure of forked end in crushing

56. In a steam engine, the valve rod is connected to an eccentric by means of a _____

Ans: Knuckle Joint

57. How hollow shaft are superior to solid shaft?

The weight of hollow shaft is 75% less then solid shaft for same torque transmission

58. Is what situation flexible coupling are used?

The flexible coupling is employed to tolerate lateral and angular misalignment of the shafts.

59. What kind of loading is permissible Knuckle Joint?

Ans: Tensile Load

60. Define Preferred Numbers?

Preferred Numbers from a general basis for standardizing and grding a series of simulator dimension characteristics or articles

61. Why a hallow shaft has great strength and stiffness then solid shaft of equal weight?

The weight of hollow shaft is 75% less then solid shaft for same torque transmission

62. What types of stresses are developed in the key ?

i) shear stress
ii) crushing stress

63. What are the various factors involved in good shaft coupling?

i) It should be easy to connect or disconnect
ii) It transmit full power of the shaft

PART-B

1.A line shaft rotating at 200rpm is to transmit 20KW power. the allowable shear stress for the shaft material is 42N/mm2.If the shaft carries a central load of 900N and is simply supported between bearing 3meters apart determine the diameter of the shaft. The maximum tensile or compressive stress is not to exceed 56N/mm2• (16)

2. An electric generator rotates at 200rpm and receives 300KW from the driving engine. The armature of the generator is 60cm long and located between bearing 120cm center to center. Owing to the combined weight of armature and magnetic pull, the shaft is subjected to 9000kg acting at right angles to the shaft. The ultimate stress for the shaft is 4480kg/cm2 and shear stress is 3920kg/cm2.Find the Diameter of the shaft for a factor of safety of 6. (16)

3. A mild steel shaft transmit 23KW to 200rpm.It carries a central load of 900N and is simply supported between the bearing 2.5meters apart. Determine the size of the shaft, if the allowable shear stress is 42MPa and the maximum tensile or compressive stress is not exceed 56MPa. What size of the shaft will be required, if it is subjected to gradually applied load? (16)

4. A shaft to transmit 50KW at 1200rpm.It is also subjected to a bending moment of 275NNm.Allowable shear stress is 60N/mm2.The shaft is not to twist more than 20 in a length of 2m.G=80XI03N/mm2.Design a shaft. (16)

5. A factory line shaft is 4.5m long and is to transmit 75KW at 200rpm.The allowable stress in shear is 45MPa and maximum allowable twist is 10 in a length of 20mm diameter. Determine the required shaft diameter. (16)

6. Design and draw a cast iron flange coupling for a mild steel shaft transmitting 90KW at 250rpm. The allowable shear stress in the shaft is 40MPa and the angle of twist is not to exceed 10mm in a length of 20mm diameters. The allowable shear stress in the coupling bolt is 30MPa. (16)

7. Design a cast iron protective type flange coupling to transmit 15KW at 900rpm from an electric motor to a compressor. The service factor may be assumed as 1.35. The following permissible stress may be used: Shear stress for the shaft, bolt and key material=40MPa Crushing stress for bolt and key=80Mpa Shear stress for cast iron=8Mpa (16)

8. A rigid type coupling is used to connect two shaft transmit 15KW at 200rpm.The shaft, key and bolts are made ofC45 steel and the coupling is of C.I. Design the coupling. (16)

9. Design and sketch protective type C.I flange coupling to transmit 10KW at 250rpm. The permissible shear stress for key, shaft, and bolt as 50N/mm2.Take crushing stress of key as 90N/mm2 and shear stress for C.I as 14N/mm2.Assume maximum torque is 30% higher than mean torque.

UNIT-III – TEMPORARY AND PERMANENT JOINTS

1. Define pitch and lead of a thread.

Axial distance from a point on one thread to corresponding point of next thread is called pitch. Lead is the distance the screw moves in one turn.

2. What are the stresses acts on screw fastening?

1. Initial stresses due to screwing up
2. Stresses due to external forces
3. Combined stresses

3. Give some examples for temporary joints and permanent joints.

Permanent joints – Riveted joints, welded joints, bonded joints

Temporary joints – Threaded joints, cotter joints, knuckle joints

4. List the advantages of screwed joints.

1. highly reliable
2. convenient to assemble and disassemble
3. relatively cheap to produce due to standardization and highly efficient manufacturing processes.

5. What are the various forms of screw threads?

1. British standard whitowrth (BSW) thread 2. British Association thread
3. Unified standard thread 4. American national standard thread
5. Square thread 6. ACME thread 7. Metric thread

6. A bolt of M24 x 2 mean that _____.

Nominal diameter of bolt is 24mm with pitch of 2mm.

7. Define pitch diameter of a screw thread.

It is the diameter of an imaginary cylinder on which screw thread surface would pass through the thread at such points make equal width of thread and equal width of spaces between threads.

8. V thread angle in BSW thread is _____.

Ans: 55°

9. How screw threads are formed?

A screw thread is formed by cutting a continuous helical groove on a cylindrical surface.

10. What is the difference between a stud and a bolt? Stud is a round bar threaded at both ends. Bolt is a cylindrical bar with threads for nut at one end and heat at the other end.

11. Explain why soft material is used for nut in power screws.

Soft bearing material used for nut wears fast and only a nut of small size needs replacement. It reduces the cost of replacement.

12. What do you mean by single start threads?

When a nut is turned on a bolt by one full turn which is having a single continuous thread cut on it, it advances axially through a distance equal to pitch. Hence in a single continuous thread (single start thread) the lead is equal to pitch.

13. List some locking devices

1. Lock nut 2. Castle nut 3. Sawn nut 4. Grooved nut

14. What are the initial stresses induced due to screwing up forces?

1. Tensile stress due to stretching of bolt.
2. Torsional shear stress caused by frictional resistance of threads during its tightening
3. Shear stress across threads
4. Compression or crushing stress on threads
5. Bending stress if the surfaces under the head or nut are not perfectly parallel to the bolt axis.

15. What is the designation of screw thread?

a) Size designation

M __ × __

↓ ↓

Nominal Pitch diameter

If pitch is not specified it means course pitch.

b) Tolerance designation

A letter followed by a number.

Letters used are,

H – Unit thread

d - Bolt thread with allowance

h - Bolt thread without allowance.

Number used are,

7 - For fine grade

8 - For normal or medium grade

9 - Coarse grade.

16. What is bolt of uniform strength?

A bolt of uniform strength has equal strength at the thread and shank position.

17. What are the ways to produce bolts of uniform strength?

1. Reducing shank diameter equal to root diameter 2. Drilling axial holes

18. What are the advantages of preloading?

1. Stops leakages 2. Improves fatigue strength

19. By what materials threaded fasteners are made of?

Steel is the material of which most of the fasteners are made. For improving their properties alloy steels like nickel steel, Ni-Cr steel, Cr-V steel are preferred.

20. Define the following terms.

a) Major diameter b) Minor diameter

a) Major diameter – It is the diameter of a coaxial cylinder that would just touch the crest of the external thread as in the case of bolt or root of an internal thread as in the case of nut. It is the maximum diameter or outside diameter or nominal diameter of thread.

b) Minor diameter – It is the diameter of a coaxial cylinder that would touch the root of an external thread and crest of an internal thread. This is the minimum diameter of screw also called as core diameter or root diameter of thread.

21. In what way coarse thread is differed from fine thread?

Fine and coarse threads are having same major and minor diameters except their pitch values. Fine threads are having smaller pitches than coarse threads.

22. What is a turn buckle and where it is used?

A turn buckle is a type of connecting element for connecting two tie rods. In this type of joint, one of tie rods is having right hand thread and the other is having left hand thread. These rods are screwed into the threaded hold of the turn buckle. It is also called as coupler nut.

23. State the relation between pitch and lead for a single start and double start threads.

$L = n \times p$

Where L – Lead

n – Number of starts

p – Pitch

For single start thread, lead = Pitch

For double start thread, lead = $2 \times$ Pitch

24. What are the various methods of preventing thread loosening?

1. Providing locking devices

2. Selecting screw having large number of threads per unit length.

25. Enumerate the demerits of screw joints.

1. Stress concentration is available in threaded portions and hence lowering of their life.

2. Self loosening properties and hence air tight joints cannot be maintained unless providing some locking devices.

26. Define self locking in power screws.

If the friction angle is greater that the helix angle of the power screw, the torque required lowering the load will be positive, indicating that an effort is applied to lower the load. This type

of screw is known as self locking screw. This efficiency of the self locking screw is less than 50%.

WELDED JOINTS:

27. What are the main indications of complete weld symbol?

1. Reference line
2. Arrow
3. Basic weld symbol
4. Dimensions
5. Tail
6. Supplementary symbol
7. Finish symbol
8. Specification
9. Process

28. What are the main types of welding?

1. Forge welding 2. Fusion welding 3. Electric resistance welding

29. What are various types of welded joints?

1. Lap (or) fillet joint
   a. Transverse fillet b. Parallel fillet c. Circular fillet
2. Butt joint
   a. Square butt b. V butt c. U butt
3. Corner joint
4. Edge jont
5. T joint

30. What are the advantages of welding?

1. Welded joints are higher in weight and have higher efficiency
2. Welded joints are leak proof
3. Economical from the point of coat of material and labours.
4. The design can be easily and economically modified to meet the changing product requirements.
5. Less time for production.

31. State the limitation of welding.

1. It has poor vibration damping characteristics.
2. Welding results distortion of parts which induces residual stresses.

32. Give expression used for calculating strength of single and double fillet and parallel fillet weld.

For single fillet, $p = 0.707\ sl\ \sigma_t$

For double fillet, $p = 1.414\ sl\ \sigma_t$

For parallel fillet, $p = 0.707\ sl\ \tau$

Where s = Weld size

l = Length of weld

σ_t = Tensile stress

τ = Shear stress

33. What are eccentrically loaded welded joints/

If the external load applied on the welded joint is not passing through its geometric centre then it is called as eccentrically loaded welded joint.

34. What are stresses induced in eccentrically loaded welded joint?

1. Direct shear stress
2. Bending (or) torsional shear stress

35. What are the types of eccentrically loaded welded joints?

1. Welded joint subjected to moment in the plane of the weld.
2. Welded joint subjected to moment in a plane normal to the plane of weld.

36. How to find the strength of a weld having combination of single transverse and double parallel fillet weld.

$$P = P_{transverse} + P_{parallel}$$
$$= 0.707\ sl_1\sigma_t + 1.414\ sl_2\ \tau$$

37. Why are welded joints preferred over riveted joints? [AUT CBE DEC 2009]

Rivetted Joints	Welded Joints
1. Metal plates are to be drilled and	1. Drilling work is eliminated, plates can

joined by rivets. 2. It may require covering plates	be directly welded. 2. No covering plate is required.

38. What are uncertainties to be considered in design of welds?

1. Stress concentration
2. Metallurgical change
3. Residual stresses

39. What are the assumptions made in design of welded joint? [AUT CBE DEC 2009]

1. It is assumed that the tensile stress is distributed uniformly across the section of the butt weld.
2. It is assumed that the shear stress in a parallel fillet weld is uniformly distributed along the entire length of the weld.
3. Stress situation in a fillet weld is complicated because of bending action of the force.

40. What are methods of minimizing welding distortion?

1. Use of rugged jigs and fixtures
2. Intermittent welding
3. Back-step welding
4. Welding on alternate sides.

41. Define the theory of bonded joints?

A rivet is a short cylindrical bar with a head integral to it. The cylindrical portion of the rivet is called shank or body and lower portion of the shank is known astail.The riveted joints are widely used for jointing light metals

42. What is meant by the efficiency of the riveted joint?

Efficiency of the riveted joint= leave of pt, ps and pc/ pt ft

P=pitch of the rivets

t=thickness of the plate

ft=permissible tensile stress of the plate material

43. What is caulking and fullering?In order to make the joints leak proof or fluid tight in pressure vessels like steam boilers, air receivers and tank, the process known as caulking.A more satisfactory way of making the joints arrest is known as fullering.

44. What is the meaning of bolt M24*2?

A bolt of M24*2 mean that the nominal diameter of bolt is 24 mm and pitch is 2 mm

45. Write down advantages and disadvantages of threaded fasteners?

Advantage:

i) Screwed joints are highly reliable in operation

ii) Screwed joints are convenient to assemble and dis assemble

Disadvantage

i) The stress concentration in the threaded portions which are vulnerable points under variable load conditions

PART-B

1.The cylinder head of a steam engine with 250mm bore is fastened by eight stud bolts made of 30C8 steel. Maximum pressure inside the cylinder is 1MPa.Determine the bolt size and approximate tightening torque. Take 20% over load. Assume stress =300MPa. (16)

2. A steam of effective diameter 300mm is subjected to a steam pressure of 1.5N/mm2.The cylinder head is connected by 8 bolts having yield point 330MPa and endurance limit at 240MPa.The bolts are tightened with an initial per load 1.5 times the steam load. A soft copper gasket is used to make the joint leak proof. Assuming a factor of safety 2, find engine size of bolt required. The stiffness factor for copper gasket may be taken as 0.5. (16)

3. A steam engine cylinder has an effective diameter of350mm and the maximum steam pressure acting on the cylinder cover is 1.25N/mm2.calculate the number and the size of studs are required to fix the cylinder cover. Assume the permissible stress in the stud 70N/mm2• (16)

4. A plate 100m wide and 12.5mm thick is to be welded to another plate by means of two parallel fillet welds. The plates are subjected to a load of 50KN.Find the length of the weld so that the maximum stress does not exceed 56N/mm2. (Do the calculations under static loading). (16)

5. A plate 75mm wide and 10mm thick is jointed with another plate by a single transverse weld and

double parallel fillet as shown in fig. The joint is subjected to a maximum tensile force of 55KN.The permissible tensile and shear stress are 70MPa and 50MPa respectively. Find the length of each parallel fillet weld. (16)

6. Determine the length of the weld run for a plate of size 120mm wide and 15mm thick to be welded to another plate by means of (1) A single transverse weld (2) Double parallel fillet welds when the joint is subjected to variable loads. Assume (Tensile stress =70MPa, shear stress =56MPa.)

UNIT-IV – ENERGY STORING ELEMENTS AND COMPONENTS

1. **What is spring and where it is employed?**
   A spring is an elastic body, which distorts when loaded and recover its original shape when the load is removed. It finds applications in many places such as automobiles, railway wagons, brakes, clutches, watches and so on.
2. **By what materials springs can made?**
   Springs are made of oil tempered carbon steel containing 0.6% to 0.7% carbon and 0.6% to 1% manganese. Phosper bronze, monel metal, beryllium, copper are used for special purpose.
3. **What type of spring is used in Rams bottom safety valve?**
   Helical tension spring.
4. **What are functions of the spring?**
   a. To measure forces in spring balance, meters and engine indicators.
   b. To store energy.
5. **Name various types of springs.**
   Helical springs, Spiral springs, leaf springs and disc (or) Belleville spring.
6. **What is Spring Index?**
   It is the ratio of mean pitch diameter to the diameter of the wire.
7. **What are Active and Inactive coils?**
   The coils which are free to defect under load is called active coils and the coils which do not take part in deflection of a spring is called inactive coils.
8. **When the helical spring is cut into two halves, the stiffness of the resulting spring will be _____.**
   (Doubled)
9. **Define the term "Spring Rate"?**
   It is defined as the load required per unit deflection. It is also called as stiffness of the spring.
   Define surging of springs
   The spring material is subjected to higher stresses, which may cause early fatigue failure of springs. This effect is called as surging of springs.
10. **How will you find whether the given helical spring is a compression spring or tension spring?**
    The ends of compression springs are flat whereas for tension springs, hooks will be provided at the ends. Coils will be slightly open for compression springs to facilitates compression whereas in tension springs the coils are very close.
11. **What material is used for leaf spring?**
    Plain carbon steel having 0.9% to 1% carbon is annealed condition is normally used for leaf springs chrome vanadium and silica manganese steels are used for the better grade springs.
12. **What are the functions a rebound clip and a U clip in a leaf spring?**
    A rebound and U clips are used for holding the leaves of the springs together.
13. **What is nipping of laminated leaf spring? Discuss its roll in spring design.**
    Pre stressing of leaf springs is obtained by a difference of radii of curvature known as nipping.
    The initial gap can be adjusted so that under max. load conditions the stress in all the leaves will be same or, if desired the stress is the full length leaves may be less.
14. **For springs in series, the spring rates (stiffness) add reciprocally - prove.**
    When the springs are connected in series then total deflection produced by the spring is equal to the sum of the deflections of the individual springs.
    $Y_{equ} = Y_1 + Y_2$

$p/q_{equ} = (p/q_1) + (q/q_2)$
$1/q_{equ} = (1/q_1) + (1/q_2)$

15. What are the end conditions of springs?

a. Plain en.
b. Plain and ground end.
c. Squared end.
d. Squared and ground end.

16. What is buckling of springs? The helical compression springs behaves like a column and buckler at a comparative small load when the length of the spring is move than four times the mean coil diameter.

17. Why Wahl's factor is to be considered in the design of helical compression spring?

When wire wound in the form of helix, compressive stress is induced in the inner side of spring and tensile stress is induced in outerside of spring. Due to this stress concentration is produced in outerside of spring. So Wahl's factor is to be considered in the design of kelical compression spring.

18. When two concentric springs of stiffness 100 N/mm and 50 N/mm respectively are subjected to an axial load of 750 N. What will be the deflection of each spring?

K_1 = 100 N/mm K_2 = 50 N/mm
load P = 750 N.
Concentric springs, so springs are in parallel.
Equivalent stiffness K = $K_1 + K_2$.
100 + 50 = 150 N/mm
Deflection = load / equivalent stiffness
= 750/150 = 5 mm.

19. Why leaf springs are made in layers in stead of a single plate?

Leaf springs are made in layer only for distributing the shear forces and bending moment evenly.

20. Define solid length of helical spring.

When compressions spring is compressed until the coils come in contact with each other, then the spring is said to be solid and resulting length is called solid length.

21. Define free length of a helical spring?

It is the length of the spring in free or unloaded condition.

22. Why the clearance is provided between adjacent of a helical spring?

To prevent closing of the coils during service with maximum working load.

23. Define the term spring stiffness (or) spring rate.

It is defined as the load required per unit defection of the spring.

24. Define pitch of the spring coil.

Pitch of the coil is defined as the axial distance between adjacent coils uncompressed state.

25. What are points to be considered in choosing the pitch of spring coils?

a. It should be such that if the spring is accidentally carelessly compressed, the stress does not increase the yield stress in torsion.
b. Spring should not close up before maximum service load is reached.

26. How to avoid buckling of spring?

In order to avoid buckling of spring, it is either mounted on a central rod or located on a tube.

27. What are the methods used for ellination of surges in springs?

1. By using friction dempers on the centre coils so that the wave propagation dies out.
2. By using springs of high natural frequency.
3. By using springs having pitch of coils near the ends different at the centre to have different natural frequencies.

28. What are disadvantages in Helical springs of non-circular wire?

a. The quality of material used for springs is not so good.
b. The shape of the wire does not remain square or rect angular while forming helix resulting in trapezoidal cross sections. It reduces the energy adsorbing capacity of the spring.
c. The stress distribution is not favourable as for circular wires.

29. When the concentric springs are preferred for usage?

a. To obtain greater sprig force within a given space.

b. To insure the operation of a mechanism in the event of failure of one of the springs.

30. How equalized stress in leaf spring leaves is achieved?

1. By making the full length of leaves of smaller thickness than the graduated leaves.
2. By giving greater radius of curvature to the full length leaves than graduated leaves.

31. What is meant by Initial tension in helical springs?

In tension helical springs, it is necessary to apply from 20 to 30% of the maximum load before the coils begin to separate duding close coil winding.

32. Name few applications of helical torsion springs.

1. Door winge springs.
2. Springs for starters in Automobiles.
3. Springs for brush holders in electric motors.

33. What are the purposes of composite springs?

A concentric or composite spring is used for one of the following purposes.

1. To obtain greater spring force within a given space.
2. To insure the operation of a mechanism in the event of failure of one of the springs.

34. What is torsion springs?

Torsion springs may be of helical or spiral type. The helical type may be used only in applications where the load tends to wind up the spring and are used in various electrical mechanisms. The spring type is also used where the load tends to increase the number of coils and when made of flat strip are used in watches and clocks.

35. Two concentric springs with stiffness equal to 100 N/mm and 80 N/mm respectively when subjected to a load of 900 N. Find deflection.

Total stiffness $k = k_1+k_2$

$= 100+80 = 180$ N/mm

Deflection = force/k

$= 900/180 = 5$ mm.

36. The helical spring rate 10 N/mm is mounted on top of another springs of rate 8 N/mm. Find the force required to give deflection of 45 mm.

Since the springs are arranged in series total stiffness.

$$\frac{1}{k}=\frac{1}{k_1}+\frac{1}{k_2}$$

$$\frac{1}{k}=\frac{k_1+k_2}{k_1k_2}$$

$$k=\frac{k_1k_2}{k_1+k_2}$$

$$k=\frac{8\times10}{8+10}$$

$$k=4.44\,N/mm$$

k = force/deflection

force = k × deflection

$= 4.45 \times 45 = 200$ N.

37. How the stiffness of a spring can be increased?

The stiffness of a spring can be increased by decreasing the number of turns.

38. What types of stresses are included in the wires of helical compression spring and torsional spring?

Compressive or tensile stresses in helical compression spring and

Bothe tensile and compressive stresses in case of torsional spring due to bending.

39. What are the stresses induced in helical springs of circular wire.

In addition to torsional shear stress, Direct shear stress due to load w and stress due to curvature wire are induced.

40. How concentric springs are obtained?

Two or more springs are joined to form a nest.

41. Write the advantage of leaf spring over helical springs?

Leaf springs are made out of flat plates. The advantage of leaf spring over helical spring is that the end of the spring may be guided along a definite path as it deflects to act as a structural member in addition to energy absorbing device.

42. Write down the formula for maximum stress and deflection of a cantilever spring.

Maximum stress $\sigma = 6PL/bt^2$

deflection $\gamma = 6PL^3/Ebt^3$

43. Define camber.

It is the vertical distance between centre of the eye to the maximum deflection in main or master leaf in leaf spring.

44. Name the spring used in gramophones.

Flat spiral springs.

45. _____ springs are used in applications where high spring rates and compact spring units are required.

Disc (or) Belleville.

46. Why full length leave are used in automobile?

This is desirable in automobile springs in which full length leave are designed or lower stress be cause full length leaves carry addition loads caused by the swaying and twisting.

47. What factor should be considered for the design of springs?

1. Deflection criterion 2. Material strength properties
3. Service environment 4. Desired life 5. Manufacturing cost etc.

48. How the load is made to act concentric with spring axis in helical springs.

By making the two ends of spring as squared and ground ends, the load can be made to act, concentric with spring axis.

49. Define Resilience Of a Spring ?

It is the amount of energy absorbed by the spring per unit deflection.

50. Where are Belleville spring used ?

It is the amount of energy absorbed by the spring per unit deflection.

51. Why are springs used in the machines?

a. Spring are used to absorb shock and vibrations of the machine
b. It is used where high spring rate and compact spring units are required

52. Define Resilience Of a Spring ?

It is the amount of energy absorbed by the spring per unit deflection.

53. Define free length of a spring ?

It is lenth of spring is the free or unloading condition

54. What is the function of a sping ?

The spring absorbs shock and vibration

55. State any two important applications of leaf spring ?

The leaf spring are commonly used used in automobile

PART-B

1. A helical valve spring is to be designed for an operating load range of 90N to 135N.The deflection of the spring for this load range is 7.5mm.Assuming a spring index of 10, a permissible shear stress of 480N/mm2 and a modulus of rigidity of 0.8Xl 05 N/mm2for the material, determine the dimensions of the spring. (16)

2. A gas engine valve spring is to have a mean diameter 37.5mm.The maximum load will have to sustain is 450N with a corresponding deflection of 12.5mm.The spring is to be subjected to repeated loading and fatigue must be considered a low working stress of 300N/mm2 will be used. Find the size for the wire and number of coil used. Take rigidity of modulus as 0.8XI05 N/mm2• (16)

3. A compressive helical spring is required to exert a minimum force 250N and maximum force of 600N and the deflection for this change in load to be 15mm. The spring must fit in a hole of 30mm diameter. The load is static. Ultimate tensile stress is 1393N/mm2 and shear stress is 606Mpa. (16)

4. A closely coil helical spring is made of 10mm diameter steel wire, the coil consisting of 10 complete turns with a mean diameter of 120mm.The springs carries an axial pull of 200N.Determine also deflection in the spring, its stiffness and strain energy stored by it if the modulus of rigidity of the material is 80KN/mm2• (16)

5. A helical compression of spring made of oil tempered carbon steel is subjected to a load which varies from 400N to 1000N. The spring index is 6 and the design factor of safety is 1.25.If the yield stress in shear is 770Mpa ,and endurance stress in shear is 350Mpa,find,(1) Size of the spring wire (2) Diameter of the spring wire (3) Number of turns of the spring (4) Free length of the spring. The compression of the spring at the maximum load is 30mm.The modulus of rigidity for the spring material may be taken as 80KN/mm2. (16)

6. A semi-elliptical leaf spring of 1m long and is required to resist a load of 50KN.The spring has 15 leaves of which three are full length leaves. The width of central band is 100mm. All the leaves are to be stressed to 420MPa.The ratio of total depth to width is 3.Take, =2.1Xl05MPa.Determine,
(i) The thickness and width of the leaves. (ii)The initial gap that should be provided between the full lengths and graduated leaves before assembly. (iii)The load exerted on the band for the assembly. (16)

7. A leaf spring for a small trailer is to support a load of 8KN. The spring has 8 graduated leaves and 2 free full length leaves of spring steel of safe stress 380MPa.The over all length 1m and the central band is 80mm wide. Taking ratio of total depth of leaves as 3.Design the spring and also determine the deflection of the spring. Take, E=2.1XI05MPa. (16)

8. Design of leaf spring for a truck to the following specifications:
Maximum load on the spring = 140KN, No of spring = 49
Material for spring chromium vanadium steel Permissible tensile stress = 600N/mm2
Maximum number of leaves =10
Span of spring = 1000mm
Permissible deflection = 80mm
Young's modulus of the spring = 200N/mm2 (16)

9. Design a cantilever leaf spring to absorb 600N-m energy without exceeding a deflection of 150mm and a stress of 800N/mm2• The length

UNIT V – BEARINGS

1. What is a bearing?

Bearing is a machine member, used to support the axles and power transmitting shafts, directs the motion of shafts and also reduce friction between contact surfaces, while carrying the load.

2. Classify the bearings.

a. Based on nature of contact between bearing surfaces.
   1. Sliding contact bearing.
   2. Rolling contact (or) Antifriction bearing.

b. Based on load applied.
   1. Radial bearing (Circumferentially loaded)
   2. Thrust bearing (Axially loaded)

3. What are the types of sliding contact bearings.

1. Zero film bearing.
2. Thin film bearing.
3. Thick film (or) Hydrodynamic bearing.
4. Externally pressurized (or) Hydrostatic bearing.
5. Pivot bearing.
6. Collar bearing.

4. What are the bearing materials .

Aluminium alloy, Copper alloy, Babbit, Cast Iron Steel, Silver etc.

5. What is babbit?

Babbit is the alloy of tin, lead, copper and antimony.

Types

Tin based babbit - Tin 90%, copper – 4.5%
Antimony 5%, lead - 0.5%

Lead based babbit – Lead 84%, tin – 6%
copper – 0.5%, Antimony 9.5%.

6. **Give the compassion of gun metal & phosphor bronze.**
   Gun metal – copper 88%, Tin – 10% Zinc 2%
   Phosphor bronze – copper 80%, Tin 10% Lead 9% phosphorus 1%.
7. **List the desirable properties of learning materials.**
   1. High compressive strength
   2. Sufficient fatigue strength
   3. Conformability
   4. Embed ability
   5. Bond ability
   6. Corrosion resistance
   7. Thermal Conductivity
   8. Thermal Expansion
8. **Define the terms Conformability and Embed ability.**
   Conformability is the ability of the bearing material to accommodate shaft deflections and bearing in accuracies by plastic deformation without excessive wear and heating. Embeddability is the ability of the bearing material to accommodate small particles of dust, grit etc, without scoring the material of the journal.
9. **What is meant by journal bearing?** A sliding contact bearing that supports load in a radial direction and there is sliding action along the circumference of circle is called as circle journal bearing. It consists of two parts. 1. Shaft. 2. Sleeve (or) Bearing.
10. **Differentiate between full journal bearing and partial journal bearing.**
    In full journal bearing, the Shaft (journal) is fully covered by bearing where as in partial journal bearing, the shaft is partly covered by the bearing.
11. **Define filled bearing.**
    When a partial journal bearing has no clearance ie., the diameter of journal and bearing are equal, then the bearings is called fitted bearing.

12. **Differentiate between thin film and thick film bearings.**

	Thick film bearing	Thin film bearing
1.	Working surfaces are completely separated from each other by lubricant.	Working surfaces are having partially contact each other atleast part of time.
2.	Also called as hydrodynamic lubricated bearings.	Also called as boundary lubricated bearing.

13. **What is Hydro static bearing?**
    Bearings which can support steady loads without any relative motion between the journal and the bearing is called as hydro static (or) externally pressurized lubricated bearing. This is achieved by forcing externally pressurized lubricant between the members.
14. **What are the assumptions made in the theory of hydrodynamic lubricated bearings.**
    1. The lubricant obeys Newton's law of viscous flow.
    2. The pressure is assumed to be constant through out the film thickness.
    3. The lubricant is assumed to be incompressible.
    4. The viscosity is assumed to be constant throughout the film.
    5. The flow in one dimensional ie., side leakage is neglected.
15. **What are the important factors to be considered for the formation of thick oil film in hydrodynamic bearing?**
    1. A continuous supply of oil.
    2. A relative motion between the two surfaces in a direction approximately tangential is the surfaces.
    3. The ability of one of the surfaces to take up a small inclination to the other surface in the direction of the relative motion.
    4. the line of action of resultant oil pressure must coincide with the line of action of the external load between the surfaces.
16. **What is the preferred angle of contact for partial journal bearing?**
    120°.
17. **What is lubricant and why is it employed?**

Lubricants are used in bearings to reduce friction between the rubbing surfaces and to carry away the heat generated by friction. It also protects the bearing against corrosion.

18. Specify the types of lubricant with example.

1. Liquid lubricants - Mineral and synthetic oils.
2. Semisolid lubricants - Grease , 3. Solid lubricants - Graphite

19. What are the desirable properties of lubricant?

Viscosity, Oiliness, Density, Viscosity index, Flash point, Fire point, Power point (or) Freezing point.

20. Define viscosity and Viscosity Index.

viscosity is the property of fluid which resists the flow of one layer of fluid from its adjacent layer.It is defined as force required to resists the layer of unit area running with unit velocity relative with its adjacent layer, when these two layers are separated by unit distance.

Viscosity Index is the term used to denote the degree of variation of viscosity with temperature.

21. What will happen if the velocity of lubricant is very low?

If the viscosity is very low, then it will not separate the relative rotating members, and hence metal to metal contact will occur which results wear of contacting members.

22. What are the materials for non metallic hearing?

Carbon-graphite, rubber, wood and plastics.

23. What is say bolt universal second?

The viscosity of the lubricant is measured key say bolt viscometer. If determines the time required for a standard volume of oil at a certain temperature to flow under a certain head through tube of standard diameter and length. The time so determined in seconds is the say bolt universal viscosity.

24. List the terms used in journal bearing.

Diametral clearance, clearance ratio, Eccentricity, Minimum oil film thickness, Attitude (or) eccentricity ratio.

25. Define Diametral clearance and Diametral clearance ratio.

Diametral clearance is the difference between diameters of bearing and journal.

Diametral clearance ratio is the ratio of diametral clearance to the diameter of the journal.

26. Define eccentricity and attitude.

Eccentricity is the radial distance between centre of the bearing and the displaced centre of bearing under load.

Attitude (or) eccentricity ratio is the ratio of the eccentricity to the radial clearance.

27. What is minimum oil film thickness?

It is the minimum distance between the bearing and the journal under complete lubrication condition.

28. What is long and short bearing.

It the ratio of length to diameter of journal is less than 1, then it is short bearing, on the other hand, if l/d is greater than 1 then the bearing is known as long bearing.

29. What is meant by square bearing? When the length of the journal (l) is equal to the diameter of the journal (d), then the bearing is called square bearing.

30. Expand the following: SAE, AFBMA and SKF.

SAE - Society of Automotive Engineers

AFBMA - Anti Friction Bearing Manufacturing Association

SKF - SKEFKO

31. Define bearing characteristic number.

The term ZN/P is called as bearing characteristic number. Where,

Z = Absolute viscosity

N = Speed of journal

P = Bearing pressure.

32. Define Bearing modulus.

The value of co-efficient of friction varies with the variation of bearing characteristic number (ZN/P). The value (ZN/P) for which the value of μ is minimum is identified as bearing modulus.

33. How lubricant oil is designated?

SAE followed by grade number.

34. Define Summerfield number.

It is the dimensionless parameter used is design of journal bearing.

$S = (ZN/P)\ (D/C)^2$

35. Write the formula used to calculate the amount of heat generated and heat dissipated in journal bearing.

Heat generated

$Hg = \mu\ WV$

Heat dissipated

$Hd = ((\Delta t+18)^2\ LD) / K$

36. Define kinematic viscosity

Kinematic viscosity = (Absolute viscosity / Density)

37. What is critical pressure of the journal bearing?

The pressure at which the oil film breaks down so that metal to metal contact begins, is known as critical pressure or minimum operating pressure of the bearing.

38. What is the nature of contact involved in bearing element?

Rolling.

39. Define Anti friction bearing.

The contact between the bearing surfaces is rolling and it has a very low friction, then the bearing is called as rolling contact bearing (or) Anti friction bearing.

40. Name a few applications of rolling Contact bearing.

Automobiles, Agricultural machineries, Fans, Motors, Machine tools etc.

41. Specify the materials by which the rolling contact bearings are made.

High carbon chromium steel.

42. What are the types of rolling contact bearings.

i. Based on type of rolling element.
   a. Ball bearing b. Roller bearing.
ii. Based on load to be carried.
   a. Radial bearing. b. Angular contact bearing c. Thrust bearing.

43. What are the components of rolling contact bearings?

1. Outer race 2. Inner race 3. Rolling element 4. Cage or Seperator

44. Name various ball bearings.

1. Deep groove ball bearing 2. Self aligning bearing 3. Angular contact bearing
4. Filling notch bearing 5. Double row bearing.

45. What are the types of roller bearings?

1. Cylindrical roller bearing 2. Spherical roller bearing
3. Needle roller bearing 4. Tapered roller bearing

46. List the factors should be considered when selecting roller bearing.

1. Space availability 2. Type and amount of load
3. Speed 4. Alignment 5. Environmental conditions.

47. Enumerate the advantages of rolling contact bearing over sliding contact bearing.

1. Low starting and running friction except at very high speeds.
2. Ability to withstand momentary shock loads.
3. Accuracy of shaft alignment.
4. Low cost of maintenance as no lubrication is required while in service.
5. Small overall dimensions.
6. Reliability of service.
7. Cleanliness
8. Easy to mount and erect.

48. List the disadvantages of rolling contact bearing.

1. More noisy at very high speeds. 2. Low resistance to shock loading.
3. More initial cost. 4. Design of bearing housing complicated.

49. What is nominal life and average life of rolling contact bearing?

The nominal life of rolling contact bearing is defined as the number of revolutions which the bearing is capable of enduring before the first evidence of fatigue, that is developed in the bearing material of either rings or rolling element. The average life of bearing is defined as the summation of all bearing lives in a series of life tests and is divided by the number of life tests. Usually this average life is approximately equal to five times the nominal life.

50. Indicate the influence of operating temperature on rolling bearing materials.

At elevated temperatures, the hardness of the bearing materials is reduced and thus their dynamic load carrying capacity is also reduced.

51. Define basic static load rating.

The basic static load rating is defined as the static radial load or axial load which corresponds to a total permanent deformation of the ball and race, at the most heavily stressed contact equal to 0.0001 times the ball diameter.

52. Define Equivalent load.

Equivalent load is defined as that constant stationary radial or axial load which, if applied to a bearing with rotating inner ring and stationary outer ring, would give the same life as that which the bearing will attain under the actual condition of load and rotation.

$P = (X F_r + Y F_a) S$ P = Equivalent load

X = Radial load factor Y = Axial load factor F_r = Radial load

F_a = Axial load

S = Service factor

53. Define dynamic load rating.

It is defined as the constant stationary radial load or constant axial load which a group of apparently identical bearing with stationary outer ring can endure for a rating life of one million revolutions with only 10% of failure.

54. How are rolling bearings designated?

According to AFBMA & ISO

Bore dia — Type of bearing — Type of duty

According to SKF

SKF _ _ _ _

Last two digits X 5 = bore diameter.

55. What are modes of failure of rolling contact bearings?

1. Fatigue pitting or spalling of contact surfaces
2. Abrasive wear of rubbing surfaces
3. Indenting of working surfaces
4. Scoring of working surfaces
5. Breakdown of retainers.

56. Name the assembly methods of rolling elements in the bearings.

1. Eccentric displacement method
2. Filling notch method

57. List the factors contributing to friction in rolling contact bearing.

1. Rolling resistance
2. Sliding between rolling elements & race
3. Sliding between rolling elements & cage
4. Sliding between rolling elements & guide flanges in roller bearings
5. Losses due to churning of lubricant.

58. Write down the formula for calculating the reliability of bearing.

$$\frac{L}{L_{10}'} = \left[\frac{\ln\left(1/p\right)}{\ln\left(1/p_{10}\right)} \right]^{\frac{1}{b}}$$

59. What are the two types of Taper roller bearings?

1. Single row taper roller bearing. 2. Double row taper roller bearing.

60. What is cubic mean load?

If bearings are subjected to variable load with time, in stead of equivalent load cubic mean load is to be considered for the design.

cubic mean load $F_m = \left[\frac{F_1^3 n_1 + F_2^3 n_2 + F_3^3 n_3 + \ldots}{\sum n} \right]$

Where,

F_1, F_2, … are loads.

n1, n2, … are corresponding revolutions.

61. State the merits of hydrostatic bearing?

The hydrostatic bearing steady loads without any relative motion between the journal and the bearing

62. Name the type of lubricant used in journal bearing?

a. Graphite
b. Grease
c. Mineral oil and synthetic oil

63. What is the advantage of Teflon which is used for bearing ?

i) It has lower co efficient of friction
ii) It can be used at high temperature
iii) It is practically chemically inert
iv) It is dimensionally stable

64. How do you eliminate the surge in spring ?

i) Use spring of high natural frequency
ii) By using friction dampers on the centre coil so that the wave preparation die out

65. What is the application of thrust bearing?

It is mainly used in turbines and propeller shafts

1. Design a journal bearing for a centrifugal pump with the following data:

PART-B

1.Diameter of the journal = 150mm
Load on bearing = 40KN
Speed of journal = 900rpm

2. Design a journal bearing for a centrifugal pump from the following data:
Load on the journal=20000N, Speed of the journal=900rpm, Type of oil is SAElO, for which the absolute viscosity at 55°C=0.017kg/m-s, Ambient temperature of oil = 15.50C, Maximum bearing pressure for the pump=1.5N/mm2.Calculate also mass of the lubricating oil required for artificial cooling, If the rise of temperature, if the rise of temperature of oil be limited to lOoC heat dissipation coefficient=1232W/m2/oC 3. A full journal bearing of 50mm diameter and 100mm long has a bearing pressure of l.4N/mm2• The speed of the journal is 900rpm and the ratio of journal diameter to the diametric clearance is 1000. The bearing is lubricated with oil, whose absolute viscosity at the operating temperature of 75°C may be taken as 0.011 kg/m-s. The room temperature is 350C.Find,
(1) The amount of artificial cooling required.
(2)The mass of lubricating oil required, if the difference between the outlet and inlet temperature of the oil is 10°C. Take specific heat of oil as 1850J/Kg/0C.

4. A 150mm diameter shaft supporting a load of 10KN has a speed of 1500rpm.The shaft run in whose bearing length is 1.5 times the shaft diameter. If the diametric clearance of bearing is 0.15mm and the absolute viscosity of the oil at the operating temperature is 0.011 Kg/m-s. Find the power wasted in friction.