G. PULLAIAH COLLEGE OF ENGINEERING AND TECHNOLOGY
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Department of Mechanical Engineering

Bridge Course
On
Design of Machine Members – I

1. **Define stress.**

   When an external force acts on a body, it undergoes deformation. At the same time the body resists deformation. The magnitude of the resisting force is numerically equal to the applied force. This internal resisting force per unit area is called stress.

   Stress = Force/Area

   When a body is subjected to an external force, there is some change of dimension in the body. Numerically the strain is equal to the ratio of change in length to the original length of the body.= P/A unit is N/mm^2

2. **Define strain**

   Strain (e)= Change in length/Original length = $\delta L/L$

3. **State Hooke's law.**

   It states that when a material is loaded, within its elastic limit, the stress is directly proportional to the strain.

   Stress α Strain

   $\sigma \alpha e$

   $\sigma = Ee$

   $E = \sigma/e$ unit is N/mm^2

   Where,

   E - Young's modulus

   σ - Stress e – Strain

4. **Define shear stress and shear strain.**

   The two equal and opposite force act tangentially on any cross sectional plane ofthe body tending to slide one part of the body over the other part. The stress induced is called shear stress and the corresponding strain is known as shear strain.

5. **Define Poisson's ratio.**

   When a body is stressed, within its elastic limit, the ratio of lateral strain to the longitudinal strain is constant for a given material.

   Poisson' ratio (μ or 1/m) = Lateral strain /Longitudinal strain

6. **Define strain energy**

   Whenever a body is strained, some amount of energy is absorbed in the body. The energy which is absorbed in the body due to straining effect is known as strain energy.

7. **Define- elastic limit**

   Some external force is acting on the body, the body tends to deformation. If the force is released from the body its regain to the original position. This is called elastic limit

8. **Define Bulk-modulus**

   The ratio of direct stress to volumetric strain.

   K = Direct stress /Volumetric strain

9. Define – Young's modulus

The ratio of stress and strain is constant with in the elastic limit.

E = Stress/Strain

10. Give the relationship between Bulk Modulus and Young's Modulus.

E = 3K (1-2/m)

Where,

E - Young's Modulus

K - Bulk Modulus

1/m - Poisson's ratio

11. What is compound bar?

A composite bar composed of two or more different materials joined together such that system is elongated or compressed in a single unit.

12. Define- lateral strain

When a body is subjected to axial load P. The length of the body is increased. The axial deformation of the length of the body is called lateral strain.

13. Define- longitudinal strain

The strain right angle to the direction of the applied load is called lateral strain.

14. State principle plane.

The planes, which have no shear stress, are known as principal planes. These planes carry only normal stresses.

15. Define principle stresses and principle plane.

Principle stress: The magnitude of normal stress, acting on a principal plane is known as principal stresses.

Principle plane: The planes which have no shear stress are known as principal planes.

16. Define Torsion

When a pair of forces of equal magnitude but opposite directions acting on body, it tends to twist the body. It is known as twisting moment or torsion moment or simply as torque. Torque is equal to the product of the force applied and the distance between the point of application of the force and the axis of the shaft.

17. Define thin cylinder?

If the thickness of the wall of the cylinder vessel is less than 1/15 to 1/20 of its internal diameter, the cylinder vessel is known as thin cylinder.

18. What is mean by Circumferential stress (or hoop stress) and Longitudinal stress?

The stress acting along the circumference of the cylinder is called circumferential stress (or hoop stress) whereas the stress acting along the length of the cylinder is known as longitudinal stress.

19. What is mean by compressive and tensile force?

The forces in the member will be compressive if the member pushes the joint to which it is connected whereas the force in the member will be tensile if the member pulls the joint to which it is connected

20. How do you classify materials for engineering use?

Engineering materials are classified as
Metals and their alloys such as iron, steel, copper, aluminium etc.
Non-metals, such as glass, rubber, plastic etc.
The metals may be further classified as Ferrous Metals andNon ferrous metals

21. Define beam?

BEAM is a structural member which is supported along the length and subjected to external loads acting transversely (i.e) perpendicular to the center line of the beam.

22. What is shear force?

The algebric sum of the vertical forces at any section of the beam to the left or right of the section is called shear force.

23. What is shear force and bending moment diagram?

It shows the variation of the shear force and bending moment along the length of the beam.

24. What are the different properties of materials and discuss?

Strength: It is the ability of a material to resist the externally applied forces without breaking or yielding. The internal resistance offered by a part to an externally applied force is called stress.

Stiffness: It is the ability of a material to resist deformation under stress. The modulus of elasticity is the measure of stiffness

Elasticity: It is the property of a material to regain its original shape after deformation when the external forces are removed. This property is desirable for materials used in tools and machines. It may be noted that steel is more elastic than rubber.

Plasticity: It is property of a material which retains the deformation produced under load permanently. This property of the material is necessary for forgings, in stamping images on coins and in ornamental work.

Ductility: It is the property of a material enabling it to be drawn into wire with the application of a tensile force. A ductile material must be both strong and plastic. Mild steel, copper, aluminium, nickel, zinc, tin and lead are the ductile materials

Brittleness: It is the property of a material opposite to ductility. It is the property of breaking of a material with little permanent distortion. Cast Iron is a brittle material.

Malleability: It is a special case of ductility which permits materials to be rolled or hammered into thin sheets. A malleable material should be plastic but it is not essential to be so strong. Lead, soft steel, wrought iron, copper and aluminium.

Toughness: It is the property of a material to resist fracture due to high impact loads like hammer blows. The toughness of the material decreases when it is heated. This property is desirable in parts subjected to shock and impact loads.

Machinability: It is the property of a material which refers to a relative case with which a material can be cut.

Resilience: It is the property of a material to absorb energy and to resist shock and impact loads. It is measured by the amount of energy absorbed per unit volume within elastic limit. This property is essential for spring materials.

Creep: When a part is subject to a constant stress at high temperature for a long period of time, it will undergo a slow and permanent deformation called creep. This property is considered in designing internal combustion engines, boilers and turbines.

Fatigue: When a material is subjected to repeated stresses, it fails at stresses below the yield point stresses. Such type of failure of a material is known as fatigue. The failure is caused by means of progressive crack formations which are usually fine and microscopic size. This property is considered in designing shafts, connecting rods, springs, gears etc.

Hardness: It is a very important property of the metals and has a wide variety of meanings. It embraces many different properties such as resistance to wear, scratching, deformation and machinability etc. It also means the ability of a metal to cut another metal. The hardness is usually expressed in numbers which are dependent on the method of making the test.

25. What is impact strength?

Impact strength is a measure of the resistance of metals to impact loads. Also defined as the energy required bringing a specimen to rupture and calculated per unit area of its section.

26. What alloying element improves the Hardenability of steels?

Hardenability can be improved by using alloying elements like boron, vanadium, manganese, chromium and molybdenum.

27. What is strain hardening?

Strain Hardening: When drawing ductile materials like mild steel, copper, brass and aluminium through dies or when rolling them between rollers, plastic deformation takes place and this increases the yield point stress and ultimate strength. This is known as strain hardening.

28. How does the carbon content affect the hardness and toughness properties of CI and steel? / How carbon content influences the properties of steel?

If the carbon content is going to be less than 0.83%, increase in carbon content increases the ultimate strength. If the carbon content is going to be more than 0.83%, the increase in carbon content reduces the strength. Hardness increases with carbon content but ductility and weldability decreases as carbon content increases.

29. Why do we use alloy steels in some machine components?

In general, adding alloying elements to steel will improve the hardenability and steel may be heat treated to the desired hardness with less drastic quenching and therefore with less problem of distortion and cracking.

30. What are the effects of silicon and manganese on steel?

Silicon is added to steel as a deoxidizer to minimize the last traces of oxygen. As manganese content increases, ultimate strength and hardness increases and weldability decreases.

31. What are the effects of chromium, nickel and molybdenum on steel?

Chromium improves hardenability, corrosion resistance and increases wear resistance and hardness.

Nickel increases strength without decreasing ductility.

Molybdenum improves hardenability and creep strength, molybdenum is used in all creep resisting steel.

32. What is duralumin?

Duralumin is an Al-Cu-Mg-Mn alloy and it has good corrosion resistance and strength. This alloy is available in the form of sheets, plates, tubes, rods, extruded section, bolts and rivets and is widely used in aircraft industry.

33. What are proof resilience and proof stress?

Greatest strain energy that can be stored in a member without permanent deformation is called the proof resilience and the corresponding stress is called the proof stress. The proof resilience per unit volume of a material is known as modulus of resilience.

34. What do you mean by factor of safety? / What is factor of safety?

Factor of safety is defined, as the ratio of the maximum stress to the working stress or ultimate stress to the working/design stress or yield stress to the working/design stress.

35. What is design stress?

Permissible stress or design stress of a material is defined as the ratio between maximum stress (yield stress in case of brittle material / ultimate stress in case of ductile material) to the factor of safety.

36. What is the importance of principle stresses?

Machine elements are subjected to several external loads of different nature, like bending and twisting. Therefore it becomes necessary to determine the equivalent single stress using the concept of principle stresses.

37. Distinguish between endurance limit and endurance strength.

Endurance limit is the limiting value of alternating stress for which failure does not occur on the material for an infinite number of cycles.

Endurance (Fatigue) Strength is the alternating stress at which failure occurs for a particular finite value of life. Fatigue strength is always accompanied by a finite number of cycles.

38. What is contact stress?

When two bodies having curved surfaces are pressed against each other, point or line contact becomes an area contact. The area is very small and hence high contact stress (surface stress or Hertz stress) develops. Contact stresses occur in the contact between a wheel and rail, between a cam and its follower, between a ball and its race or between a pair of mating gear teeth.

39. What is bearing stress?

Local compression occurs between two members held in contact, i.e., between the pin and the eye. The pressure distribution will not be uniform and it is difficult to determine accurately. Hence the average bearing pressure or bearing stress is obtained by dividing the load by the projected bearing area. Bearing stress or Bearing pressure $P_b = \frac{F}{l.d}$, where l = Length of the pin in contact and d = diameter of the pin.

40. Differentiate between sudden and impact loads.

Suddenly applied loads – as produced by combustion in an engine or by an explosion

Direct – impact loads, as produced by the dropping of a weight by a ram in a forging press, by a pile driver or by vehicle crash.

41. In some situations, third principle stress being zero must be taken into calculation of maximum shear stress. Why?

In real bodies, three dimensional state of stress exists and hence it is best always to consider stresses as three dimensional. In uniaxial stress state (pure tension or compression), out of three principal stresses two of them are zero. In biaxial stress state one principal stress is zero. Forgetting about a zero principal stress will result in a serious error. Consider an element on the outer surface of a pressure vessel. On the outer surface load is zero and hence $\sigma_3 = 0$. $\sigma_1$and σ_2 are both tensile and hence positive.

42. What is meant by eccentric loading 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.

43. What is ratio for factor of safety for fatigue loading?

The ratio between the endurance limit of a material to the working/design stress of the material is called as Factor of safety for fatigue loading.

44. Define- Allowance.

It is the difference between the basic dimensions of the mating parts.

45. Define- Tolerance

It is the difference between the upper limit and lower limit of a dimension.In other words, it is the maximum permissible variation in a dimension.

46. Define shaft?

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

47. Differentiate between shaft and axle?

An axle though similar in shape to the shaft is a stationary machine element and is used for transmission of bending momentonly.it simply act as a support for some rotating body.

48. What is a spindle?

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

49. What are the materials used for shafts?

For ordinary shaft - mild steel

For high strength shafts - alloy steel such as nickel,
Ni-Cr steel and Cr-v steels

50. What are the various types of stresses induced in the shafts?

The various types of stresses induced in the shafts are b Shear stress due to transmission of torque bending stresses due to combined torsional and bending loads

51. Differentiate the hollow shaft over a 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 homogeneous than a solid shaft.

52. Write the theory of simple bending equation?

M/ I = F/Y = E/R

M - Maximum bending moment

I - Moment of inertia

F - Maximum stress induced

Y - Distance from the neutral axis

E - Young's modulus

R - Constant.

53. What do you mean by shear stress in beams?

The stress produced in a beam, which is subjected to shear forces is known as stresses.

54. State the main assumptions while deriving the general formula for shear stresses

The material is homogeneous, isotropic and elastic

The modulus of elasticity in tension and compression are same.

The shear stress is constant along the beam width

The presence of shear stress does not affect the distribution of bending stress

55. Explain normalizing process

To refine the grain structure of the steel to improve machinability, tensile strength and structure of weld

2. To remove strains caused by cold working processes like hammering, rolling, bending, etc., which makes the metal brittle and unreliable.

3. To remove dislocations caused in the internal structure of the steel due to hot working.
4. To improve certain mechanical and electrical properties.

The process of normalising consists of heating the steel from 30 to 50°C above its upper critical temperature (for hypoeutectoid steels) or Acm line (for hypereutectoid steels). It is held at this temperature for about fifteen minutes and then allowed to cool down in still air.

56. Explain annealing process

1. To soften the steel so that it may be easily machined or cold worked.
2. To refine the grain size and structure to improve mechanical properties like strength and ductility.
3. To relieve internal stresses which may have been caused by hot or cold working or by unequal contraction in casting.
4. To alter electrical, magnetic or other physical properties.
5. To remove gases trapped in the metal during initial casting.

57. Explain hardening process

1. To increase the hardness of the metal so that it can resist wear.
2. To enable it to cut other metals i.e. to make it suitable for cutting tools.