Swarnandhra College of Engineering and Technology

AUTONOMOUS

Department of Mechanical Engineering

Design of Machine Elements

Unit –III

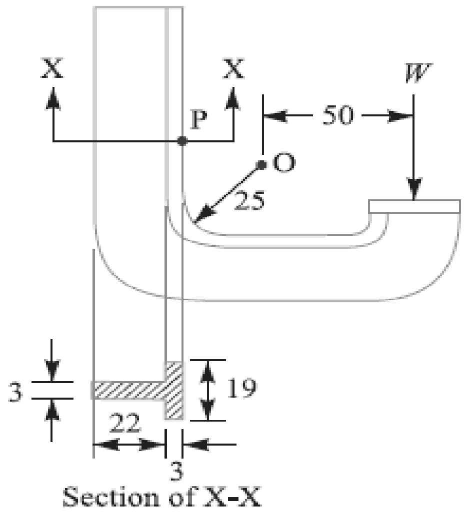
Shafts and Curved Beams

Short:

1. What type of stresses are induced in shafts?
2. A line shaft rotating at 200 r.p.m. is to transmit 20 kW. The shaft may be assumed to be made of mild steel with an allowable shear stress of 42 MPa. Determine the diameter of the shaft, neglecting the bending moment on the shaft.
3. Define equivalent bending moment in the design of shafts and write down its expression.

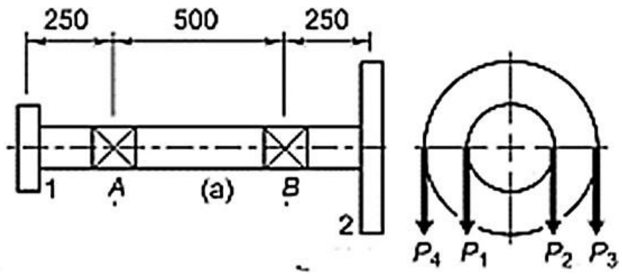
Essay:

1. Determine: (i) Location of neutral axis, (ii) Maximum and minimum stresses. When a curved beam of trapezoidal section of bottom width 30 mm, top width 20 mm and height 40 mm is subjected to pure bending moment of + 600 Nm. The bottom width is towards the centre of curvature. The radius of curvature is 50 mm and beam is curved in a plane parallel to depth. Also plot the variation of stresses across the section.
2. A C-clamp is subjected to a load of W, as shown in Fig. If the maximum allowable tensile stress in the clamp is limited to 140 MPa, find the load carrying capacity of the clamp.



3. Compare the weight, strength and stiffness of a hollow shaft of the same external diameter as that of solid shaft. The inside diameter of the hollow shaft being half the external diameter. Both the shafts have the same material and length

4. The layout of a shaft carrying two pulleys 1 and 2, and supported on two bearings A and B is shown inFig.2. The shaft transmits 7.5 kW power at 360 rpm from the pulley 1 to the pulley 2. The diameters of pulleys 1 and 2 are 250 mm and 500 mm respectively. The masses of pulleys 1 and 2 are 10 kg and 30 kg respectively. The belt tensions act vertically downward and the ratio of belt tensions on the tight side to slack side for each pulley is 2.5:1. The shaft is made of plain carbon steel 40C8 (Syt= 380 N/mm2) and the factor of safety is 3. Estimate suitable diameter of shaft. If the permissible angle of twist is 0.5° per metre length, calculate the shaft diameter on the basis of torsional rigidity. Assume G = 79300 N/mm^2.



5. A solid circular shaft is subjected to a bending moment of 3000 N-m and a torque of 10 000 N-m. The shaft is made of 45 C 8 steel having ultimate tensile stress of 700 MPa and an ultimate shear stress of 500 MPa. Assuming a factor of safety as 6, determine the diameter of the shaft.
6. (a) A hollow shaft has greater strength and stiffness than solid shaft of equal weight. Explain

   (b) A shaft is supported on bearings A and B, 800 mm between centres. A 200 straight tooth spur gear having 600 mm pitch diameter, is located 200 mm to the right of the left-hand bearing A and a 700 mm diameter pulley is mounted 250 mm towards the left of bearing B. The gear is driven by a pinion with a downward tangential force while the pulley drives a horizontal belt having 1800 angle of wrap. The pulley also serves as a flywheel and weighs 2000 N. The maximum belt tension is 3000 N and the tension ratio is 3:1. Determine the maximum bending moment and the necessary shaft diameter if the allowable shear stress of the material is 40 MPa.

Unit -IV

Springs, Brakes and Clutches

Short:

1. What is the objective of nipping of leaf spring?
2. What is nipping in leaf springs
3. Define the terms free length, spring rate and stress factor.
4. What do you understand by full length and graduated leaves of a leaf spring?
5. Derive the deflection of Helical Spring of circular wire
6. What are the two theories applied to friction plates? Briefly explain them.

Essay:

1. **a**) A compression coil spring made of an alloy steel is having the following specifications: Mean diameter of coil = 50 mm; Wire diameter = 5 mm; Number of active coils = 20. If this spring is subjected to an axial load of 500 N; calculate the maximum shear stress (neglect the curvature effect) to which the spring material is subjected**.**

   b) Design a leaf spring for the following specifications: Total load = 140 kN; Number of springs supporting the load = 4; Maximum number of leaves = 10; Span of the spring = 1000 mm; Permissible deflection = 80 mm. Take Young's modulus, E = 200 kN/mm^2 and allowable stress in spring material as 600 MPa
2. Design a close coiled helical compression spring for a service load ranging from 2250 N to 2750 N. The axial deflection of the spring for the load range is 6 mm. Assume a spring index of 5. The permissible shear stress intensity is 420MPa and modulus of rigidity, G = 84kN/mm^2.

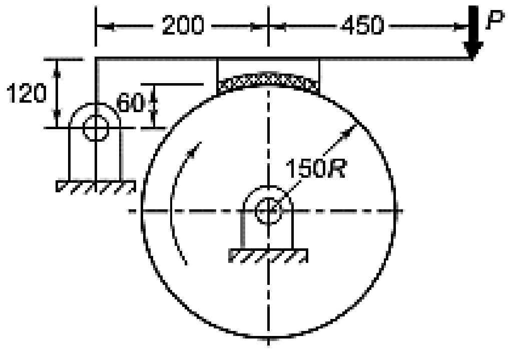
   Neglect the effect of stress concentration. Draw a fully dimensioned sketch of the spring, showing details of the finish of the end coils.
3. A concentric spring for an aircraft engine valve is to exert a maximum force of 5000 N under an axial deflection of 40 mm. Both the springs have same free length, same solid length and are subjected to equal maximum shear stress of 850 MPa. If the spring index for both the springs is 6, find (i) the load shared by each spring, (ii) the main dimensions of both the springs and (iii) the number of active coils in each spring. Assume G = 80 kN/mm2 and diametral clearance to be equal to the difference between the wire diameters.
4. A rail wagon of mass 20 tones is moving with a velocity of 2 m/s. It is brought to rest by two buffers with springs of 300 mm diameter. The maximum deflection of springs is 250 mm. The allowable shear stress in the spring material is600 MPa. Design the spring for the buffers.
5. A semi-elliptic leaf spring used for automobile suspension consists of three extra full-length leaves and 15 graduated-length leaves, including the master leaf. The centre-to-centre distance between two eyes of the spring is 1 m. The maximum force that can act on the spring is 70 kN. For each leaf,

the ratio of width to thickness is 9:1. The modulus of elasticity of the leaf material is 208000 N/mm2. The leaves are pre-stressed in such a way that when the force is maximum, the stresses induced in all leaves are same and equal to 450N/mm^2. Determine (i) the width and thickness of the leaves; (ii) the initial nip; and (iii) the initial pre-load required to close the gap between extra full-length leaves and graduated-length leaves.

6. It is required to design a helical compression spring for the valve mechanism. The axial force acting on the spring is 300 N when the valve is open and 150 N when the valve is closed. The length of the spring is 30 mm when the valve is open and 35 mm when the valve is closed. The spring is made of oil-hardened and tempered valve spring wire and the ultimate tensile strength is 1370 N/mm2. The permissible shear stress for the spring wire should be taken as 30% of the ultimate tensile strength. The modulus of rigidity is 81370 N/mm2.The spring is to be fitted over a valve rod and the minimum inside diameter of the spring should be20 mm. Design the spring and calculate:(i) wire diameter; (ii) mean coil diameter; (iii) number of active coils; (iv) total number of coils; (v) free length of the spring; and (vi) pitch of the coil. Assume that the clearance between adjacent coils or clash allowance is 15% of the deflection under the maximum load.
7. A carriage spring 800 mm long is required to carry a proof load of 5000 N at the center. The spring is made of plates 80 mm wide and 7.5 mm thick. If the maximum permissible stress for the material of the plates is not to exceed 190 MPa, determine :1. The number of plates required, 2. The deflection of the spring, and 3. The radius to which the plates must be initially bent. The modulus of elasticity may be taken as 205 kN/mm^2.
8. A cone clutch is used to connect an electric motor running at 1440 rpm with a machine which is stationary. The machine is equivalent to a rotor of 150 kg mass and radius of gyration as 250 mm. The machine has to be brought to the full speed of 1440 rpm from stationary condition in 40s. The semi-cone angle is 12.5°. The mean radius of the clutch is twice the face width. The coefficient of friction is 0.2 and the normal intensity of pressure between contacting surfaces should not exceed 0.1 N/mm^2. Assuming uniform wear criterion, calculate:

   i. the inner and outer diameters;
   ii. the face width of friction lining;
   iii. the force required to engage the clutch; and
   iv. the amount of heat generated during each engagement of clutch.

9. A single block brake with a torque capacity of 15 N-m is shown in Figure. The coefficient of friction is 0.3 and the maximum pressure on the brake lining is $1 N/mm^2$. The width of the block is equal to its length. Calculate:



(i) the actuating force;

(ii) the dimensions of the block;

(iii) the resultant hinge-pin reaction; and

(iv) the rate of heat generated, if the brake drum rotates at 50 rpm.

Unit -V

Bearings & Gears

Short:

1. What condition must be satisfied in order that a pair of spur gears may have a constant velocity ratio?
2. Differentiate static load carrying capacity and dynamic load carrying capacity of rolling contact bearings.
3. List the important physical characteristics of a good bearing material.

Essay:

1. A rolling contact bearing is subjected to the following work cycle: (a) Radial load of 6000 N at 150 r.p.m. for 25% of the time; (b) Radial load of 7500 N at 600r.p.m. for 20% of the time; and (c) Radial load of 2000 N at 300 r.p.m. for 55% of the time. The inner ring rotates and loads are steady. Select a bearing for an expected average life of 2500 hours.
2. a) Select a ball bearing for an industrial machine press fit onto a shaft and intended for continuous 8-hour per day operation at 1800 rpm. Radial and thrust loads are 1.2 kN and 1.5 kN, respectively, with light-to-moderate impact.

   b) A 100-mm-diameter shaft is supported by a bearing of 80-mm length with a diametral clearance of 0.10 mm. It is lubricated by oil having a viscosity of 50 m Pa-s. The shaft rotates 600 rpm and carries a radial load of 5000 N. Estimate the bearing coefficient of friction and power loss.
3. Design a suitable journal bearing for a centrifugal pump from the following available data: Load on the bearing = 13.5 kN; Diameter of the journal = 80 mm; Speed = 1440 rpm; Bearing characteristic number at the working temperature (75°C) = 30; Permissible bearing pressure intensity= 0.7 N/mm2 to 1.4 N/mm2; Average atmospheric temperature=30°C. Calculate the cooling requirements, if any.
4. It is required to design a pair of spur gears with 20° full-depth involute teeth. The input shaft rotates at 720 rpm and receives 5 kW power through a flexible coupling. The speed of the output shaft should be 144 rpm. The pinion as well as the gear are made of steel Fe 410 (Sut = 410 N/mm2). The service factor for the application is 1.25. The gears are machined to meet the specifications of Grade 6. Assume suitable number of teeth for the pinion and the gear. For preliminary calculations, assume the pitch line velocity as 5 m/s and the factor of safety as 2. Estimate the module and select the first preference value of the module. Using this value of the module, calculate the pitch circle diameters of the pinion and gear and the face width. Determine static load and the dynamic load by Buckingham's equation. Also, calculate the beam strength and the correct value of factor of safety based on beam strength. Using a factor of safety of 2 for wear strength, specify the surface hardness for gears.

5. A pair of spur gears with a 20º pressure angle consists of a teeth pinion meshing with a 60 teeth gear. The module is 5 mm, while the face width is 45 mm. The pinion rotates at 500 rpm. The gears are made of steel and heat treated to a surface hardness of 220 BHN. Assume the dynamic load is accounted by means of the velocity factor. The service factor and the factor of safety are 1.75 and 2 respectively. Calculate i) wear strength of the gears ii) The static load that the gears can transmit without pitting and iii) Rated power that can be transmitted by gears.