Problem of Practices
on
Mechanical Engineering Design
Chapter-2 Design Against Static Load

Prepared By

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1. A circular bar of 500 mm length is supported freely at its two ends. It is acted upon by a central concentrated cyclic load having a minimum value of 2000 kgf and a maximum value of 5000 kgf. Determine the diameter of bar by taking a factor of safety of 1.5, size effect of 0.85, surface finish factor of 0.9. The material properties of bar are given by: ultimate strength of 65 kgf/mm^2, yield strength of 50 kgf/mm^2, and endurance strength of 35 kgf/mm^2.
2. A bar of circular cross-section is subjected to alternating tensile forces varying from a minimum of 200 kN to a maximum of 500 kN. It is to be manufactured of a material with an ultimate tensile strength of 900 MPa and an endurance limit of 700 MPa. Determine the diameter of bar using safety factors of 3.5 related to ultimate tensible strength and 4.0 related to endurance limit and a stress concentration factor of 1.65 for fatigue load Use Goodman straight line as basis for design.
3. A hot rolled steel shaft is subjected to a torsional load that varies from 300 kNmm clockwise to 100 kNmm anticlockwise as an applied bending moment at a

critical section varies from +400 kNmm to –200 kNmm. The shaft is of uniform cross-section and no key-way is present at the critical section. Determine the required shaft diameter by taking factor of safety 1.5. For the material, take ultimate tensile stress as 560 MPa, stress at yield point 420 MPa design stress is 280 MPa.

Also take the modification factor as 0.62, size correction factor as 0.85, the load factor for bending as 1 and the load factor for torsion as 0.58.

4. A hollow shaft is subjected to a steady bending moment of 40 N-m and twisting moment of 50 N-m. Outer diameter of the shaft is twice the inside diameter. Calculate the diameters of the shaft using ASME Code for transmission shafting on the basis of maximum shearing stress theory of failure. Take:
Yield point stress in tension of shaft material = 280 MPa.
Factor of safety = 2.0.
Combined bending and fatigue shock factor = 1.5.
Combined shock and fatigue factor for twisting = 1.0.

5. The piston rod of diameter 20 mm and length 700 mm in a hydraulic cylinder is subjected to a compressive force of 10 kN due to internal pressure. The piston end of the rod is guided along the cylinder and the other end of the rod is hinged at the cross-head. The modulus of elasticity for piston rod material is 200 GPa. Estimate the factor of safety taken for the piston rod design.

6. Stress concentration factor is not considered harmful for ductile materials in static loading but for brittle materials it has damaging effect in both static and dynamic loading.
Justify the above statement giving illustrations.

7. A hollow shaft whose ratio of internal diameter to external diameter (k) is 0.5, transmits 1.5 kW at 1400 rpm. At a certain section it is also subjected to a bending moment of 5 N.m. The shaft is to be made from chrome-vanadium steel having allowable shearing stress of 200 MPa.
Design the shaft using the ASME code formula for transmission shafting as given below:

$$D_o(\text{outer diameter}) = \left[\frac{16}{\pi\,\tau_{\text{all}}}(C_{\text{m}}M^2 + C_{\text{t}}T^2)\frac{1}{1-k^4}\right]^{1/3},$$

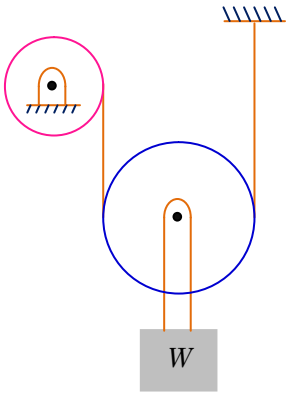
Combined shock and fatigue factor for bending moment (C_{m}) is 1.5.
Combined shock and fatigue factor for torque (C_{t}) = 1.0.
Determine the internal and outer diameter of the shaft.

8. What is Bauschinger's effect? Make a neat sketch of stress-strain diagram and explain how yield strength in compression is reduced than the yield strength in tension.

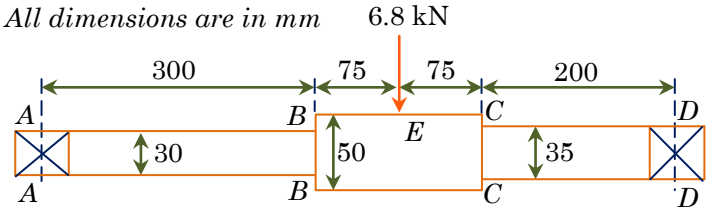
9. What are common modes of failure of rolling element bearings?

10. What are different types of threads used for power transmission? Make a simple sketch of each. Give special features of each thread and their applications.

11. Fatigue life of a 6 × 37 wire rope of nominal diameter of 12 mm is to be achieved to be 0.2 billion bends. Tensile stress designation of wire rope is 1960 MPa. How much load can be lifted through a sheave of diameter 400 mm, through the arrangement shown in figure? Take ratio of bearing pressure between rope and sheave to ultimate strength of rope = 0.0024.



12. A rotating shaft shown in the figure below is supported in ball bearings at *A* and *D* and loaded by a non-rotating force of 6.8 kN. The shaft is made of 40 C8 steel (σ_y = 360 N/mm^2, σ_u = 650 N/mm^2). Endurance limit σ_e may be taken as 55% of σ_u. The shaft is machined. The reliability is 90% (reliability factor c_r is 0.897). Static stress concentration at *BB* may be taken as 1.5 and at *CC* 1.4. The notch sensitivity factor *q* may be taken as 0.95. Find out the critical section and factor of safety.



13. Explain with suitable illustration the S-N curve of a ferrous material and briefly discuss its significance in the design of machine elements.

14. A shaft made of mild steel is required to transmit 100 kW at 300 rpm. The supported length of the shaft is 3 metres. It carries two pulleys, each weighing 1500 N supported at a distance of 1 metre from the ends respectively. Assuming the safe value of stress to be 60 N/mm^2, determine the diameter of the shaft.