BACHELOR OF ENGINEERING (MECHANICAL ENGINEERING) 2nd Yr 2nd Sem. 2019

Machine Design I

Time: 3hrs Full marks: 100

(Answer Group A and B from the following)

Missing data if any are to be reasonably assumed.

Group A 8×5=40

Answer any five

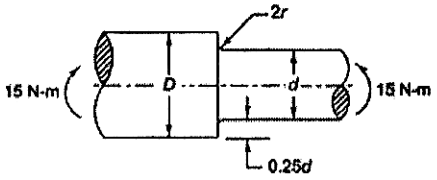
1. A plate subjected to tensile load that has maximum value of 600 kN and a minium value of 400 kN. The plate is 250 mm wide. The properties of the plate material are as follows:
   Ultimate tensile strength= 850 MPa
   Yield limit strength= 380 MPa
   Corrected endurance limit= 280 MPa
   Factor of safety= 2.5
   Determine the thickness of the plate according to Soderberg theory and Goodman theory.
2. The principal stresses induced at a point in a machine component made of steel 50C4 (σ_{yt}=460 N/mm^2) are as follows:
   σ_1=200 N/mm^2, σ_2=150 N/mm^2, σ_3=100.
   Calculate the factor of safety by (i) the maximum shear stress theory and (ii) the distortion energy theory.
3. A thin steel tyre is shrunken to a locomotive wheel of 1.5 m. Find the internal diameter of the tyre, if after shrinking on, the hoop stress in tyre is 120n/mm^2. Given, E=200 kn/mm^2.
4. Find out the numbers of R20/3 (200,…) derived series.
5. Explain the different mechanical properties of engineering materials.
6. Explain with neat sketch the different types of keys and key failure.
7. A hollow circular shaft of outer and inner diameters of d_0 and d_1 respectively is subjected to a tensional moment of M_t over a length l. The permissible angle of twist is θ degrees. Determine the outer diameter of the shaft.

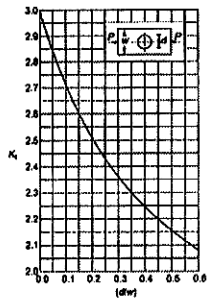
Group B 12×5=60

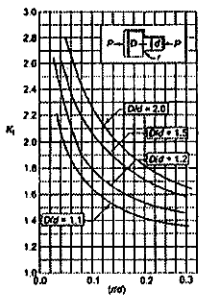
Answer any five

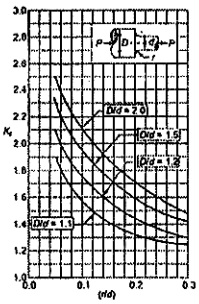
1. A Steel flat key (σ_{yt}=400 N/mm^2, factor of safety 2.5, cross section 22×14 mm^2) is fitted into the shaft having diameter 45 mm. The power transmitted by the shaft to the hub is 20 kW at 250 rpm. Determine the length of the key.
2. A solid circular shaft is subjected to a bending moment of 5000 N-m and a twisting torque of 5000×√3 N-m. The shaft is made from plain carbon steel having ultimate tensile stress of 700 MPa and ultimate shear stress is 400 MPa. If the factor of safety is 5, determine the diameter of the shaft.

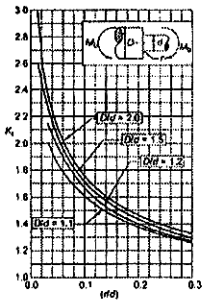
3. A Propeller shaft is required to transmit 50 kW power at 600 rpm. It is a hollow shaft, having an inside diameter 0.8 times of the outside diameter. It is made of steel (σ_{yt}=380 N/mm^2) and the factor of safety is 4. Calculate the inside and outside diameters of the shaft. Assume (σ_{sy}=0.5 σ_{yt})
4. The piston rod (σ_{yt}=380 N/mm^2 and E= 2.07×105 N/mm^2) of a steam engine having length 1 m is designed on the basis of buckling strength. The factor of safety is 5. The cylinder internal diameter is 200 mm, while the operating steam pressure is limited to 1 N/mm^2. It is assumed that one end of the piston rod is fixed and other end is hinged. Determine the diameter of the piston rod.
5. A 25 × 50 mm bar of rectangular cross-section is made of plain carbon steel 40C8 (S_{yt} = 380 N/mm^2 and E = 207 000 N/mm^2). The length of the bar is 500 mm. The two ends of the bar are hinged and the factor of safety is 2.5. The bar is subjected to axial compressive force.
   (i) Determine the slenderness ratio;
   (ii) Which of the two equations—Euler's or Johnson's—will you apply to the bar?
   (iii) What is the safe compressive force for the bar?
6. (a) A solid circular shaft of diameter 100 mm is subjected to an axial stress of 50Mpa. It is further subjected to a torque of 10 kNm. Determine the maximum principal stress experienced on the shaft.
   (b) A small element at the critical section of a component is in a bi-axial state of stress with the two principal stresses being 360 Mpa and 140 Mpa. Determine the maximum working stress according to the distorsion energy theory.
7. A round shaft made of brittle material and subjected to bending moment of 20 N-m is shown in Figure. The stress concentration factor at the fillet is 1.5 and the ultimate tensile strength of the shaft material is 220 N/mm^2. Determine the diameter d, the magnitude of stress at the fillet and the factor of safety.

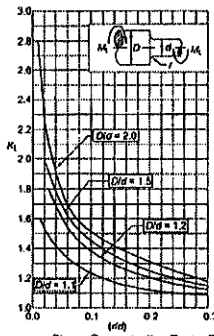



Stress Concentration Factor (Rectangular Plate with Transverse Hole in Tension or Compression)


Stress Concentration Factor (Flat Plate with Shoulder Fillet in Tension or Compression)


Stress Concentration Factor (Round Shaft with Shoulder Fillet in Tension)


Stress Concentration Factor (Round Shaft with Shoulder Fillet in Bending)


Stress Concentration Factor (Round Shaft with Fillet in Torsion)