

B.E. CHEMICAL ENGINEERING SECOND YEAR SECOND SEMESTER 2025

MACHINE DESIGN

Time: 3hrs

Full Marks: 100

(Answer any five questions).

(Parts of each question must be answered together in same place)

(Do not attempt extra question, which will not be evaluated)

(Assume data if missing)

1. a) State in details about the factors on which the magnitude of factor of safety depends.
- b) Describe the typical application of cotter joint with examples.
- c) Two rods, made of plain carbon steel 40C8 ($S_{yt} = 380 \text{ N/mm}^2$), are subjected to a tensile force of 50 kN, are to be connected by means of a cotter joint. Calculate the dimensions of the socket end with the following assumptions: (i) the yield strength in compression is twice of the tensile yield strength; and (ii) the yield strength in shear is 50% of the tensile yield strength. The factor of safety is 5.

[3+3+14=20]

2. a) State different applications and advantages of using knuckle joints?
- b) A knuckle joint is connecting two circular rods subjected to an axial tensile force of 50 kN. The rods are co-axial and a small amount of angular movement between their axes is permissible. Find the dimensions of the Pin based on shear, crushing and bending strength. The material for two rods and pin is plain carbon steel of Grade 30C8 ($S_{yt} = 400 \text{ N/mm}^2$).

[6+14=20]

3. a) Discuss the advantages and disadvantages of rigid coupling. What are the different types of misalignments?
- b) A rigid coupling is used to transmit 20 kW power at 700 rpm. There are four bolts and the pitch circle diameter of the bolts is 125 mm. The bolts are made of steel 45C8 ($S_{yt} = 380 \text{ N/mm}^2$) and the factor of safety is 3. Determine the diameter of the bolts. Assume that the bolts are finger tight in reamed and ground holes.

[8+12=20]

4. a) State the different types of riveted joint failure?
- b) What are the assumptions in the analysis of bolted joints?

[Turn over

- c) The structural connection shown in Fig. 1 is subjected to an eccentric force P of 10 kN with an eccentricity of 500 mm from the CG of the rivets. The centre distance between rivets 1 and 2 is 200 mm, and the centre distance between rivets 1 and 3 is 150 mm. All the rivets are identical and made from plain carbon steel 30C8 ($S_{yt} = 400 \text{ N/mm}^2$) and the factor of safety is 2.5. Determine the size of the rivets.

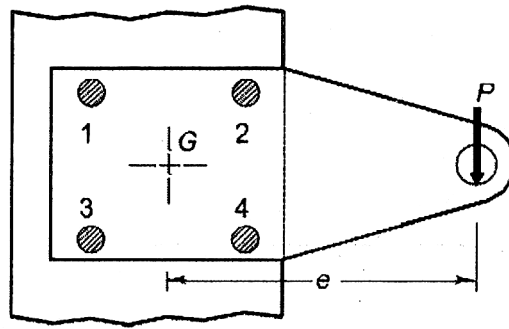


Fig. 1

[5+3+12=20]

5. a) Differentiate between thin and thick pressure vessel. What is hoop stress?
b) Derive the expression of tangential, radial and longitudinal stresses for thick cylinder vessel subjected to internal pressure only. Also determine the wall thickness when the cylinder material is brittle.

[6+14=20]

6. a) Derive the belt tension ratio considering centrifugal effect.
b) The layout of a leather belt drive transmitting 15 kW of power is shown in Fig.2. The centre distance between the pulleys is twice the diameter of the bigger pulley. The belt should operate at a velocity of 20 m/s approximately and the stresses in the belt should not exceed 2.25 N/mm^2 . The density of leather is 0.95 g/cc and the coefficient of friction is 0.35. The thickness of the belt is 5 mm. Calculate: (i) the diameter of pulleys; (ii) the length and width of the belt; and (iii) the belt tensions.

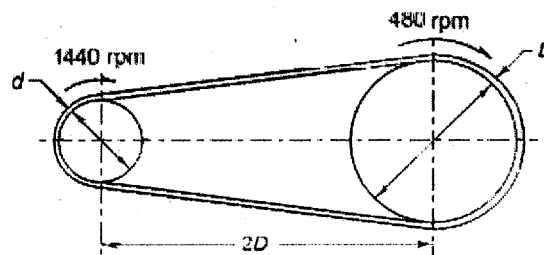


Fig.2

[10+10=20]

7. a) A riveted joint, consisting of two identical rivets, is subjected to an eccentric force of 15 kN as shown in Fig.3. Determine the diameter of rivets, if the permissible shear stress is 60 N/mm².

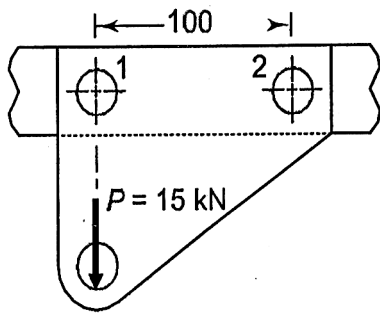


Fig.3

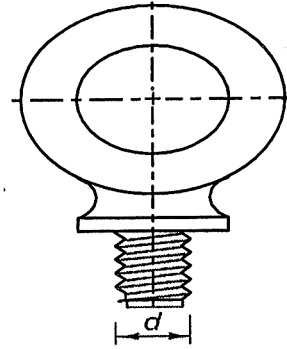


Fig.4

- b) The standard cross-section for a flat key, which is fitted on a 50 mm diameter shaft, is 16 x 10 mm. The key is transmitting 475 N-m torque from the shaft to the hub. The key is made of commercial steel ($S_{yt} = S_{yc} = 230 \text{ N/mm}^2$). Determine the length of the key, if the factor of safety is 3.
- c) An electric motor weighing 10 kN is lifted by means of an eye bolt as shown in Fig. 4. The eye bolt is screwed into the frame of the motor. The eye bolt has coarse threads. It is made of plain carbon steel 30C8 ($S_{yt} = 400 \text{ N/mm}^2$) and the factor of safety is 6. Determine the size of the bolt. [6+8+6=20]

8. The hinged connection shown in fig.5 carries a load of 54.6 kN. All components are made from steel. The allowable stresses in tension and shear 75.0 N/mm² and 60 N/mm². (four bolts are used to make this connection, two bolts in row A and two bolts in row B). Determine the size of the bolts. [20]

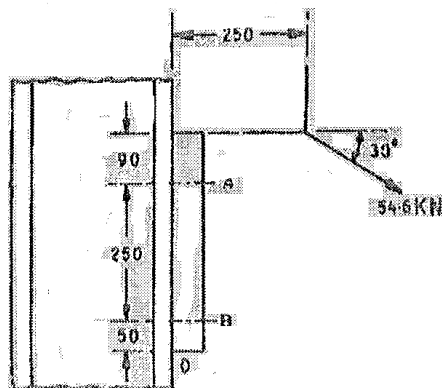


Fig.5