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**Question Paper Code : 41381**

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2024.

Fifth/Seventh Semester

Mechanical Engineering

ME 3591 – DESIGN OF MACHINE ELEMENTS

(Common to : Mechanical Engineering (Sandwich))

(Regulations 2021)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. What do you understand by preferred numbers?

2. List out the various phases of design process.

3. List out types of stresses that induced in shafts.

4. Differentiate between keys and splines.

5. List out the materials that used for rivets.

6. Distinguish between cotter joint and knuckle joint.

7. Why I-section is chosen for the connecting rod?

8. List out the main function of a flywheel in an engine.

9. List the important physical characteristics of a good bearing material.

10. In hydrodynamic bearing, what are the factors which influence the formation of wedge fluid film?

PART B — (5 × 13 = 65 marks)

11. (a) A crane hook having an approximate trapezoidal cross-section is shown in Fig. 11 (a). It is made of plain carbon steel 45C8 ($Syt$ = 380 N/mm$^2$) and the factor of safety is 3.5. Determine the load carrying capacity of the hook.

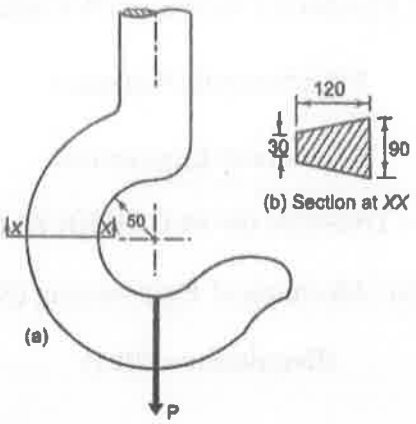


Figure 11 (a)

Or

(b) The load on a bolt consists of an axial pull of 10 kN together with a transverse shear force of 5 kN. Find the diameter of bolt required according to

(i) Maximum shear stress theory; (5)

(ii) Rankine's Theory; and (4)

(iii) Maximum distortion energy theory (4)

Take permissible tensile stress at elastic limit = 100 MPa and Poisson's ratio = 0.3.

12. (a) A rigid coupling is used to connect a 45 kW, 1440 rpm electric motor to a centrifugal pump. The starting torque of the motor is 225% of the rated torque. There are 4 bolts and their pitch circle diameter is 150 mm. The bolts are made of steel 45C8 ($Syt$ = 380 N/mm$^2$) and the factor of safety is 2.5. Design the coupling. Assume ($S_{sy} = 0.577 S_{yt}$).

Assume that the bolts are finger tight in reamed and ground holes.

Or

(b) A flexible coupling, illustrated in Fig. 12 (b), is used to transmit 15 kW power at 100 rpm. There are six pins and their pitch circle diameter is 200 mm. The effective length of the bush (lb), the gap between two flanges and the length of the pin in contact with the right hand flange are 35, 5 and 23 mm respectively. The permissible shear and bending stresses for the pin are 35 and 152 N/mm² respectively. Calculate: (i) pin diameter by shear consideration; and (ii) pin diameter by bending consideration.

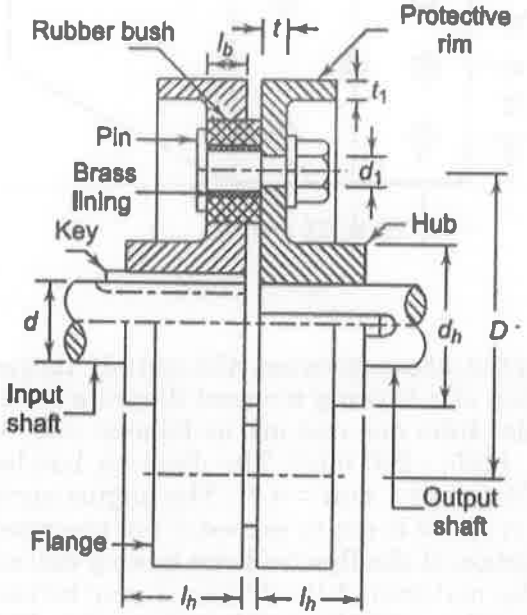


Figure 12 (b)

13. (a) A welded connection, as shown in Fig. 13 (a) is subjected to an eccentric force of 60 kN in the plane of the welds. Determine the size of the welds, if the permissible shear stress for the weld is 100 N/mm². Assume static conditions.

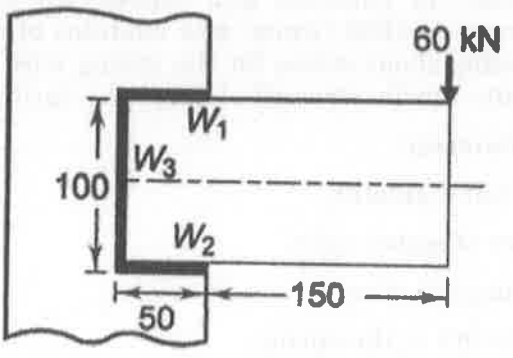


Figure 13 (a)

Or

(b) A bracket is riveted to a column by 6 rivets of equal size as shown in Fig. 13 (b). It carries a load of 100 kN at a distance of 250 mm from the column. If the maximum shear stress in the rivet is limited to 63 MPa, find the diameter of the rivet.

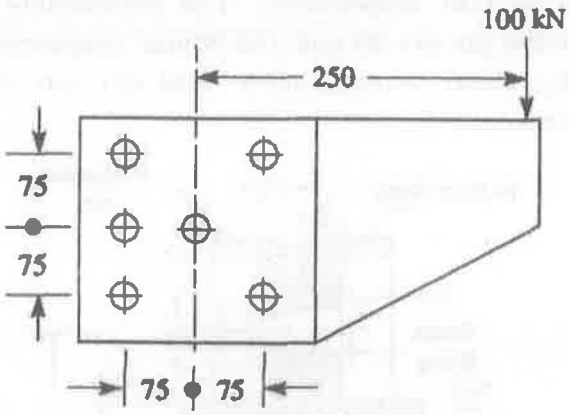


Figure 13 (b)

14. (a) The intercepted areas between the output torque curve and the mean resistance line of a turning moment diagram for a multi cylinder engine, taken in order from one end are as follows: –35, +410, –285, +325, –335, +260, –365, +285, –260 $mm^2$. The diagram has been drawn to a scale of 1 mm = 70 N-m and 1 mm = 4.5°. The engine speed is 900 r.p.m. and the fluctuation in speed is not to exceed 2% of the mean speed. Find the mass and cross-section of the flywheel rim having 650 mm mean diameter. The density of the material of the flywheel may be taken as 7200 $kg/m^3$. The rim is rectangular with the width 2 times the thickness. Neglect effect of arms, etc.

Or

(b) A helical compression spring, made of circular wire, is subjected to an axial force, which varies from 2.5 kN to 3.5 kN. Over this range of force, the deflection of the spring should be approximately 5 mm. The spring index can be taken as 5. The spring has square and ground ends. The spring is made of patented and cold-drawn steel wire with ultimate tensile strength of 1050 $N/mm^2$ and modulus of rigidity of 81370 $N/mm^2$. The permissible shear stress for the spring wire should be taken as 50% of the ultimate tensile strength. Design the spring and calculate

(i) wire diameter;

(ii) mean coil diameter;

(iii) number of active coils;

(iv) total number of coils;

(v) solid length of the spring;

(vi) free length of the spring;

(vii) required spring rate; and

(viii) actual spring rate.

15. (a) Design a full hydrodynamic journal bearing with the following specification for machine tool application:

Journal diameter = 75 mm

Radial load = 10 kN

Journal speed = 1440 rpm

Minimum oil film thickness = 22.5 microns

Inlet temperature = 40°C

Bearing material = Babbitt

Determine the length of the bearing and select a suitable oil for this application.

Or

(b) A single-row deep groove ball bearing is subjected to a radial force of 8 kN and a thrust force of 3 kN. The values of X and Y factors are 0.56 and 1.5 respectively. The shaft rotates at 1200 rpm. The diameter of the shaft is 75 mm and Bearing No. 6315 (C = 112 000 N) is selected for this application.

(i) Estimate the life of this bearing, with 90% reliability. (7)

(ii) Estimate the reliability for 20 000 h life. (6)

PART C — (1 × 15 = 15 marks)

16. (a) The layout of a transmission shaft carrying two pulleys B and C and supported on bearings A and D is shown in Fig. 16 (a) Power is supplied to the shaft by means of a vertical belt on the pulley B, which is then transmitted to the pulley C carrying a horizontal belt. The maximum tension in the belt on the pulley B is 2.5 kN. The angle of wrap for both the pulleys is 180° and the coefficient of friction is 0.24. The shaft is made of plain carbon steel 30C8 (Syt = 400 N/mm$^2$) and the factor of safety is 3. Determine the shaft diameter on strength basis.

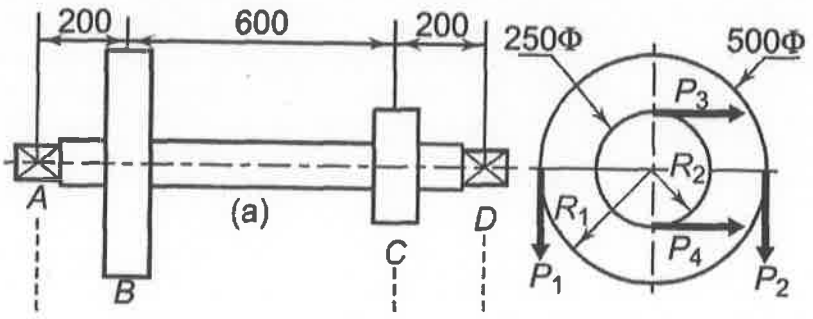


Figure 16 (a)

Or

(b) Design a connecting rod for a high-speed IC engine using the following data:

Cylinder bore = 125 mm

Length of connecting rod = 300 mm

Maximum gas pressure = 3.5 MPa

Length of stroke = 125 mm

Mass of reciprocating parts = 1.6 kg

Engine speed = 2200 rpm

Assume suitable data and state the assumptions.

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