Ref. No.: Ex/ME(M2)/PC/B/T/314/2024(S)

**B.E. MECHANICAL ENGINEERING 3rd YEAR 1st SEMESTER SUPPLEMENTARY EXAM– 2024**

**DESIGN OF MACHINE ELEMENTS-II**

**Time: 3 hours** **Full Marks: 100**

**Data if missing may be assumed reasonably**
**The symbols used in the questions, bear their usual meaning**
**Necessary data are provided in Tables**

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**Answer any five questions**

1. Design a rigid flange coupling (protective type) to connect two shafts to transmit power of 25 kW at 720 rpm. Select suitable materials for the pin, key, flange and the shaft as well as suitable factor of safety. (tabulate the dimensions at the end.). Also make a neat sketch of the coupling. [15+5]

2. a) What do you understand by the efficiency of riveted joint? Draw and explain with the help of a simple riveted lap joint. [8]

   b) What are the advantages of butt joint over a lap joint in case of riveting? [2]

   c) A bracket, attached to a vertical column by means of four identical rivets, is subjected to an eccentric force of 25 kN as shown in Fig. Q2c. Determine the diameter of rivets, if the permissible shear stress is 60 N/mm$^2$. [10]

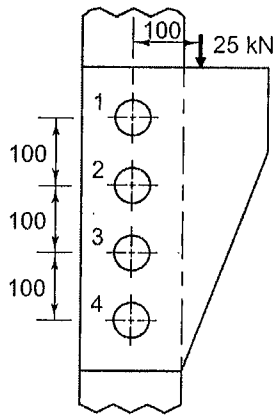


Fig. Q2c

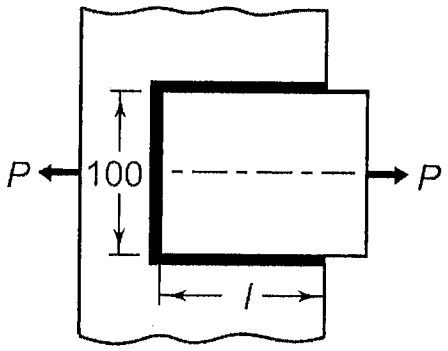


Fig. Q3b

3. a) Why are riveted joints nowadays largely replaced by welded joints? [2]

   b) A steel plate, 100 mm wide and 10 mm thick, is joined with another steel plate by means of single transverse and double parallel fillet welds, as shown in Fig. Q3b. The strength of the welded joint should be equal to the strength of the plates to be joined. The permissible tensile and shear stresses for both weld material and the plates are 70 and 50 N/mm$^2$ respectively. Assuming the tensile force acting on the plates as static,
   i) Find the length ($l$) of each parallel fillet weld.
   ii) If $l$ is doubled, what is the percentage increase in the strength of the joint? [10]

   c) Derive the expression for torque required in case of lowering a load for a square threaded power screw and explain the concept of self-locking screw? [8]

[ Turn over

4. a) A bracket is fastened to the steel structure by means of six identical bolts as shown in Fig. Q4d Assume the following data: $l_1$ = 300 mm $l_2$ = 200 mm $l_3$ = 100 mm $l$ = 250 mm P = 60 kN. Neglecting shear stress, determine the size of the bolts, if the maximum permissible tensile stress in any bolt is limited to 100 N/mm$^2$. [10]

b) Show that in case of hard gasket for bolted joint under preloading and subjected to external load, the resultant load on the bolt is mostly equal to initial tension (due to preload) only. [10]

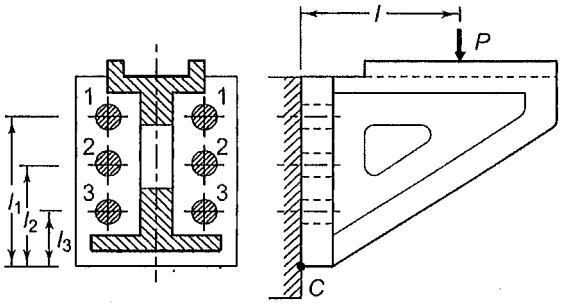


Fig. Q4a

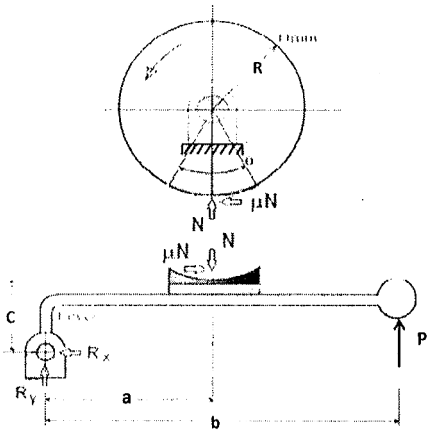


Fig. Q5b

5. (a) State the essential factors for design of brakes. [2]

(b) For a single block brake (Fig. Q5b) following are some input data: i) torque capacity = 35 Nm, ii) R = 400 mm, iii) a = 250 mm, iv) b = 550 mm, v) c = 80 mm, vi) friction coefficient of lining with steel drum = 0.4 and vii) θ = 14.36°.
If the width of lining is equal to its length, determine i) dimensions of the block, ii) actuating force P, iii) resultant reaction at hinge and iv) rate of heat generated for brake drum rotation of 100 rpm. [8]

c) A single plate clutch consists of only one pair of contacting surfaces. It is used for an engine, which develops a maximum torque of 120 N-m. Assume a factor of safety of 1.5 to account for slippage at full-engine torque. The permissible intensity of pressure is 350 kPa and the coefficient of friction is 0.35. Assuming uniform wear theory, calculate the inner and outer diameters of the friction lining. Assume the clutch is operating at maximum power transmitting capacity. [10]

6. a) A horizontal flat belt drive is to be designed such that it is capable of transmitting a rated load of 25kW from a motor at 720 rpm to a pump at 1450 rpm. The pulleys are to be made of CI while abrasion resistant polyamide belts ($S_{yt}$ = 2.0 N/mm$^2$, ρ = 1.0 g/cc), joined by machine lacing is available. Speed ratio is approximately 2.0 Both the pulleys rotate in the same direction and the belt slip over both the pulleys is 2.0%. Consider an overload factor of 1.15 and the load being transmitted with a jerk. Arc of contact factor can be taken as 1.0. Select pulley diameters and a standard belt size appropriate for the present drive. Also specify the following parameters: Length of the belt, Initial belt tension, Belt tensions on both sides of the pulleys, centrifugal tension. [15]

b) Explain why the major axis of the elliptical section (of arms) is preferably located in the plane of rotation of the pulley. [5]

7. Write short notes on the following (any 4) [4 × 5]
(a) Uniform strength bolt
(b) Leak proof methodologies in riveted joint
(c) Quality assessment in weldments
(d) Necessity of crowning in pulleys
(e) Thermal consideration in friction clutches

## Data for Reference

**Table 1 List of materials and their properties**

| Grade | Tensile strength ($N/mm^2$) | Yield strength ($N/mm^2$) |
|---|---|---|
| *Cast Iron* | | |
| FG 150 | 150 | -- |
| FG 200 | 200 | -- |
| FG 260 | 260 | -- |
| FG 300 | 300 | -- |
| FG 400 | 400 | -- |
| *Plain carbon steel* | | |
| 7C4 | 320 | -- |
| 10C4 | 340 | -- |
| 30C8 | 500 | 400 |
| 40C8 | 580 | 380 |
| 45C8 | 630 | 380 |
| 50C4 | 660 | 460 |
| 55C8 | 720 | 460 |

**Table 2: Proportions of standard parallel, tapered and gib head keys**

| *Shaft diameter (mm) upto and including* | *Key cross-section* | | *Shaft diameter (mm) upto and including* | *Key cross-section* | |
|---|---|---|---|---|---|
| | *Width (mm)* | *Thickness (mm)* | | *Width (mm)* | *Thickness (mm)* |
| 6 | 2 | 2 | 85 | 25 | 14 |
| 8 | 3 | 3 | 95 | 28 | 16 |
| 10 | 4 | 4 | 110 | 32 | 18 |
| 12 | 5 | 5 | 130 | 36 | 20 |
| 17 | 6 | 6 | 150 | 40 | 22 |
| 22 | 8 | 7 | 170 | 45 | 25 |
| 30 | 10 | 8 | 200 | 50 | 28 |
| 38 | 12 | 8 | 230 | 56 | 32 |
| 44 | 14 | 9 | 260 | 63 | 32 |
| 50 | 16 | 10 | 290 | 70 | 36 |
| 58 | 18 | 11 | 330 | 80 | 40 |
| 65 | 20 | 12 | 380 | 90 | 45 |
| 75 | 22 | 14 | 440 | 100 | 50 |

[ Turn over

**Table 3 Standard bolt size**

| Designation | Nominal or major dia d/D (mm) | Pitch (p) (mm) | Pitch diameter $d_p$/ $D_p$ (mm) | Minor diameter (mm) | | Tensile stress area ($mm^2$) |
|---|---|---|---|---|---|---|
| | | | | $d_c$ | $D_c$ | |
| M 4 | 4 | 0.70 | 3.545 | 3.141 | 3.242 | 8.78 |
| M 5 | 5 | 0.80 | 4.480 | 4.019 | 4.134 | 14.20 |
| M 6 | 6 | 1.00 | 5.350 | 4.773 | 4.917 | 20.10 |
| M 8 | 8 | 1.25 | 7.188 | 6.466 | 6.647 | 36.60 |
| M 10 | 10 | 1.50 | 9.026 | 8.160 | 8.376 | 58.00 |
| M 12 | 12 | 1.75 | 10.863 | 9.853 | 10.106 | 84.30 |
| M 16 | 16 | 2.00 | 14.701 | 13.546 | 13.835 | 157 |
| M 20 | 20 | 2.50 | 18.376 | 16.933 | 17.294 | 245 |
| M 24 | 24 | 3.00 | 22.051 | 20.319 | 20.752 | 353 |
| M 30 | 30 | 3.50 | 27.727 | 25.706 | 26.211 | 561 |
| M 36 | 36 | 4.00 | 33.402 | 31.093 | 31.670 | 817 |
| M 42 | 42 | 4.50 | 39.077 | 36.479 | 37.129 | 1120 |
| M 48 | 48 | 5.00 | 44.752 | 41.866 | 42.587 | 1470 |
| M 56 | 56 | 5.50 | 52.428 | 49.252 | 50.046 | 2030 |
| M 64 | 64 | 6.00 | 60.103 | 56.639 | 57.505 | 2680 |
| M 72 | 72 | 6.00 | 68.103 | 64.639 | 65.505 | 3460 |
| M 80 | 80 | 6.00 | 76.103 | 72.639 | 73.505 | 4340 |
| M 90 | 90 | 6.00 | 86.103 | 82.639 | 83.505 | 5590 |
| M 100 | 100 | 6.00 | 96.103 | 92.639 | 93.505 | 7000 |

**Table 4 Relation between belt and pulley widths**

| Belt width in mm | Width of pulley to be greater than belt width by (mm) |
|---|---|
| upto 125 | 13 |
| 125-250 | 25 |
| 250-375 | 38 |
| 475-500 | 50 |

**Table 5 Standard pulley diameters**

| Standard Pulley Diameters (mm) |
|---|
| 40, 45, 50, 56, 63, 71, 80, 90, 100, 112, 125, 140, 160, 180, 200, 224, 250, 280, 315, 355, 400, 450, 500, 560, 630, 710, 800, 900, 1000, 1120, 1250, 1400. |

**Table 6 Service Factors**

| Service Condition | Service factor |
|---|---|
| Normal Load | 1.00 |
| Jerky Load | 1.20 |
| Shock & Reverse Load | 1.40 |
| Oily & Wet/Dusty environment | 1.35 |

**Table 7 Joint Efficiency**

| Type of joining | Efficiency |
|---|---|
| Cemented by belt maker | 1.00 |
| Cemented | 0.98 |
| Wire laced by m/c | 0.90 |
| Wire laced by hand | 0.82 |
| Raw hide laced | 0.60 |
| Metal hooks | 0.35 |

**Table 8 Friction Coefficients**

| Belt Material | Coefficient of friction against CI or steel pulley |
|---|---|
| Leather (oak tanned) | 0.25 |
| Leather (chrome tanned) | 0.35 |
| Rubber | 0.30 |
| Balata | 0.32 |

1.

**Table 9 Standard Belt Dimensions**

| Standard belt thickness (mm) | Standard belt widths (mm) |
|---|---|
| 5 | 25, 32, 40, 50, 63 |
| 6 | 50, 63, 71, 80, 90, 100, 112, 125, 140 |
| 8 | 90, 100, 112, 125, 140, 160, 180, 200, 224 |
| 10 | 125, 140, 160, 180, 200, 224, 250, 280, 315, 355, 400 |
| 12 | 250, 280, 315, 355, 400, 450, 500, 560, 600 |