Problem of Practices
on
Mechanical Engineering Design
Chapter-4 Shafts & Associated Parts

Prepared By


Brij Bhooshan
Asst. Professor
B. S. A. College of Engg. And Technology
Mathura, Uttar Pradesh, (India)

Supported By:

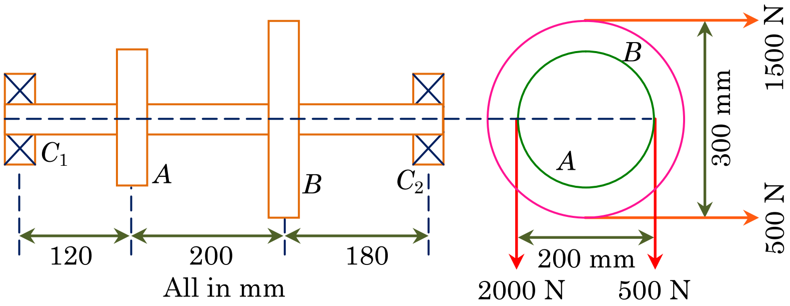
Purvi Bhooshan

Please welcome for any correction or misprint in the entire manuscript and your valuable suggestions kindly mail us *brijrbedu@gmail.com* or *brijbhooshanin@gmail.com*.

1. Design a suitable ordinary rigid flange coupling to connect an electric motor to a reduction gear of a machine. The motor has a rated output of 80 hp at 600 rpm. Working stresses in materials to be used for different parts are
Flange (C.I.) : shear 1700 N/cm^2, compression 8400 N/cm^2;
Shaft (M.S.) : Shear 4750 N/cm^2.
Bolt, Key (M.S): Shear 5800 N/cm^2, compressions 9000 N/cm^2.
These values take into account the service factor and weakening effect of the key way. Square keys are recommended for fixing the flanges on the shaft. For your calculations you may assume
Number of bolts = 4,
Outside diameter of hub = $2d$,
P.c.d. of bolts = $3d$,
Width and depth of key = $d/5$,
where d is the diameter of the shaft.
Make a fully dimensioned sketch of the coupling (one view only).

2. A transmission shaft supporting two pulleys A and B are mounted between two bearings C_1 and C_2 as shown in Fig. 2. Power is transmitted from pulley A to B

The shaft is made of plain carbon steel having ultimate tensile strength = 600 N/mm^2 and yield strength = 380 N/mm^2. Determine the shaft diameter on the basis of torsional rigidity, if the permissible angle of twist between two pulleys is 0.5° and the shear modulus of the material is 80 kN/mm^2. The permissible shear stress may taken as 30% of the yield strength or 18% of the ultimate tensile strength, whichever is minimum. Check for its safety.



3. A mild steel shaft has to transmit 100 hp at 200 rpm. Design a cast iron flange coupling for the shaft. The allowable stresses are as follows:
Shear stress for shaft and key = 40 N/mm^2
Shear stress for bolts = 28 N/mm^2
Shear stress for C.I. coupling = 20 N/mm^2
Take bearing stress as twice the shear stress value and number of bolts for the coupling as 6.
Sketch the Coupling showing various dimensions.

4. Design and draw a cast iron flange coupling for a mild steel shaft transmitting 80 kW at 220 r.p.m. with the following specifications:
Allowable shear stress in the shaft = 40 MPa.
Permissible angle of twist < 1° in a length of 20 diameters.
Allowable shear stress in the coupling bolts = 30 MPa.
Rigidity modulus of shaft material = 85 GPa.
Allowable shear stress for hub material = 15 MPa.
You may adopt, Width of key = 25 mm; Thickness of key = 14 mm.
You may also consider that the shaft and key are made of the same material.
Four number of bolts are to be used in the coupling. Find out the diameter of the shaft required and the main dimensions of the Flanges and the Key. Adopt suitable dimensions.

5. Draw a neat sketch for the Flange coupling with designed dimensions.

6. A shaft *ABCD* is supported at one end *A* and at point *C*. The other end *D* consists of a pulley which has belt tensions in the vertical direction. The distance *AD* is 1200 mm. *AC* distance is 800 mm. A spur gear having pressure angle 20° is mounted at point *B* which is at a distance 400 mm from *A*. The diameter of pulley is 450 mm and that of the gear is 300 mm. The gear is supplied power equal to 20 kW at 500 rpm by another gear at the top of it. The tension on the tight side is 3 times the tension on slack side in the belt. The combined shock and fatigue factors for bending moment and torsional moment may be taken as 1.5. The tensile strength of the material of the shaft and key is 700 MPa. Design the shaft and key for the pulley assuming factor of safety equal to 5. Assume allowance for the key way for stress as 0.75.

7. Most of the times the rotating disc-shafts have keys; under such conditions it cannot be assumed that the shaft has a uniform cross-section. For such a disc-shaft system how will you determine the limits of speed for instability?

8. A 100 mm steel drive shaft transmitting 150 kW at 300 r.p.m. has to be connected to a machine having same diameter shaft with a cast iron (CI) unprotected flange coupling. The permissible shear stress for the shaft, bolt and key are 50 MPa. The bearing stress for bolt and key are 50 MPa and shear stress for CI is 8 MPa. The basic dimensions of the coupling may be assumed as per the standard. Design the coupling and verify all the major dimensions for strength.

9. A shaft is to transmit 2 kW at 750 rpm. The shaft is supported in bearings A and C, 300 mm apart. Two pulleys of 300 mm diameter and 150 mm diameter are located at B and D as shown in Diagram a. Assume that the belt tensions are vertical for both pulleys. Ratio of belt tensions for both pulleys is 3. Neglect weight of pulleys and shaft. Take combined fatigue and shock factor in bending and twisting equal to $K_b = 1.5$, $K_t = 1.0$, respectively.

Determine uniform diameter of the shaft if allowable tensile stress is 110 MPa and allowable shear stress is 65 MPa. (Take shaft diameter in steps of 5 mm.)

10. A drive shaft of 40 mm diameter transmitting 25 kW at 300 rpm is connected to a gear by a flat key of width 22 mm and thickness 14 mm. It is made of steel having 300 MPa yield stress. Determine the length of the key to withstand shear. Use a factor of safety 2.

11. Square key of side $d/4$ and length l is used to transmit torque T from the shaft of diameter d to the hub of a pulley. Assuming the length of the key to be equal to the thickness of the pulley, find the average shear stress and crushing stress developed in the key.

12. Design a muff coupling to connect two steel shafts of same diameter in order to transmit 25 kW of power at 360 rpm. The shafts and keys are made of plain carbon steel 30C8 ($\sigma_{yt} = \sigma_{yc} = 400$ N/mm^2). The sleeve is made of grey cast iron FG 200 ($\sigma_{ut} = 200$ N/mm^2). The factor of safety for the shafts and key is 4 and for the sleeve the same is 6 based on yield strengths and ultimate strengths respectively. The standard proportion for the sleeve of muff coupling is usually taken as external diameter = (2 × shaft diameter + 13) mm. Axial length of sleeve = (3.5 × shaft diameter). Sketch the coupling showing all the dimensions of the shafts, sleeve and keys. Ensure safety of all components.

13. Differentiate between 'shaft' and 'axle'.

14. The shaft shown in the figure is to be designed from the standpoint of strength. Power is supplied to the pulley P by means of a flat belt and power is taken from the shaft through spur gear G. The shaft is supported by two deep groove ball bearings.

The following information has been established:

Power = 7.5 kW (steady load conditions), speed of shaft = 1000 rev/min, diameter of pulley = 250 mm, pitch diameter of the gear = 250 mm, weight of the pulley = 100 N, weight of the gear = 100 N. Ratio of belt tensions $T_1/T_2 = 2.5$, Gear pressure angle = 20°. Dimensions $A = B = C = 150$ mm in the figure. The belt forces are perpendicular to the plane of the paper, with $T_1 > T_2$ and the tangential force F_t on the gear is also perpendicular to the plane of the gear.

Shaft is to be machined from a hot rolled steel with σ_{ut} = 590 MN/m^2 and σ_{yt} = 380 MN/m^2. According to the ASME code, use allowable shear stress as minimum of either 0.18 σ_{ut} or 0.30 σ_{yt}. For steady load use k_b = 1.5 and k_t = 1.0.