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命題範圍:

Ch2 Working Stresses and Failure Theories

Ch3 Design of Shafts

Ch4 Springs

Ch5 Screws

Ch6 Belts, Clutches, Brakes, and Chains

Ch9 Ball and Roller Bearings

Ch10 Spur Gears

1. Find the value of the stress at each hole in Fig. 1.

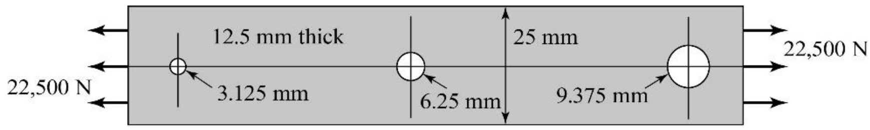

Fig.1

2. A shaft is loaded by a torque of 4,520,000 Nmm. The material has a yield point of 350 MPa. N_{fs} is equal to 2.

(a)Find the required diameter by the maximum shear theory.

(b) Find the required diameter by the von Mises–Hencky theory.

3. The link shown in Fig. 2 is subjected to a completely reversing load of 90,000 N. Find the maximum value of stress at each hole.

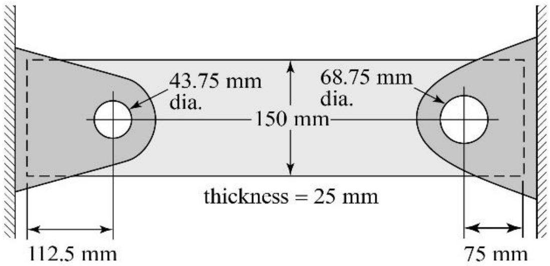

Fig. 2

4. The plate shown in Fig. 3 is 13 mm thick. Load P varies from 90,000 N to 45,000 N. If the material has σ_{yp} = 290 MPa; σ_e = 165 MPa, and q = 0.5 determine if the part will fail by the Soderberg equation if the factor of safety based on yield point is 2.

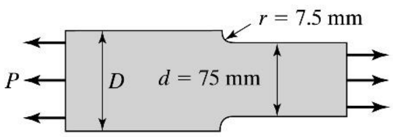

Fig. 3

5. Figure 4 shows a nonrotating shaft with load P varying from 4500 N to 13,500 N. The material tests q = 1.0, σ_{ult} = 500 MPa, σ_{yp} = 290 MPa, and σ_e = 130 MPa. Factor of safety is equal to 2. Find the permissible value for D if stress conditions at the fillets are to be satisfactory for continuous operation.

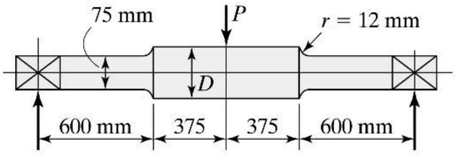

Fig.4

6. The hollow cylinder in Fig. 6 is fixed at the wall and has an outer diameter (OD) of 150 mm. and an inner diameter (ID) of 113 mm. Stress concentration factor at wall is equal to 3.

(a)Find value of N_{fs} if material is cast iron, σ_{ult} = 172 MPa, σ_{uc} = 690 MPa.

(b) Find value of N_{fs} if material is ductile with a steady load and σ_{yp} = 345 MPa.

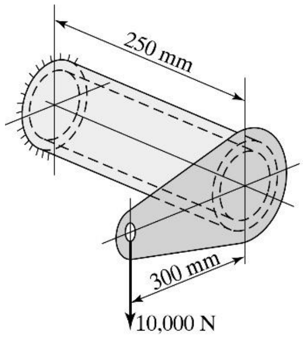

Fig. 6

7. A machine part is to be designed to have a finite life of 200,000 cycles. For 30% of the time (i.e., 60,000 cycles) the reversed bending stress had a value of 700 MPa, and for 60% of the time (120,000 cycles) the stress had a value of 575 MPa. If σ_e = 550 MPa and σ_u = 1240 MPa, use Basquin's equation to find the stress level that could be used for the remaining 20,000 cycles of the life of the part.

8. A beam machined of 4340 steel has been oil quenched and tempered at 705°C.

(a)If the beam is subjected to a steady bending stress of 207 MPa and the factor of safety is 2.0, is the part safe by the max shear stress theory of failure?

(b) If the beam is subjected to a cyclic load with σ_{max} = 207 MPa and σ_{min} = 177 MPa, K_f = 1.2 and the factor of safety is 2.0, is the part safe from failure by the Soderberg equation?

9. The shaft of Fig. 7 does not rotate, and is simply supported at *A* and *B*. The element at *C* is on the top surface; the element at *D* is at the elevation of the shaft axis.

(a)Draw a view of the element at *C* with sides parallel and perpendicular to the shaft axis; show arrows representing stresses, together with numerical values.

(b) Draw a view for the element at *C*, properly oriented with respect to the shaft axis, which has the maximum shearing stress. Show arrows and numerical values for all stresses acting.

(c)Work part (b) for the element at *D*.

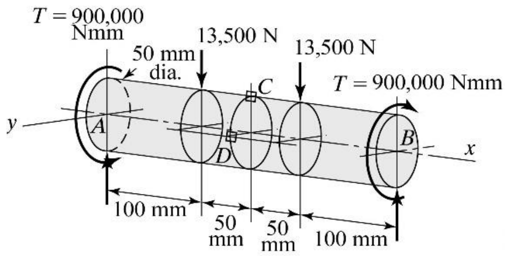

Fig.9

10. Determine the required outer diameter for the hollow shaft of Fig. 10 having an inner diameter 0.6 as great as the outer diameter. The shaft rotates and the loads are steady. You may use S_{yp} = 415 MPa, S_e = 305 MPa, N_{fs} = 2.0, and K_{ft} = K_{fb} = 1.0.

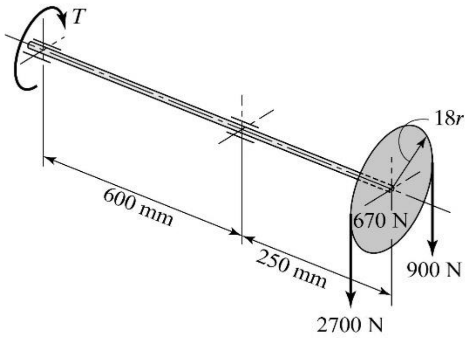

Fig.10

11. A 30 mm-diameter shaft of material with a yield point value of 500 MPa has a 7.5 × 7.5 × 50 mm key. What must the minimum yield point value be for the material in the key in order to transmit the torque of the shaft? The factor of safety equals 2. $\tau_{yp} = 0.5\ \sigma_{yp}$.

12. (a)Find the reactions, and draw and dimension the bending moment diagram for the shaft of Fig. 11. All bearings are on immovable supports at the same elevation. Include the effect of the dead load of the shaft. For the shaft, E = 206,900 MPa; $\gamma = 7.682 \times 10^{-5}$ N/mm^3.

(b) Find the values of the reactions if the bearing at C is 1.25 mm lower than the others. Include the effect of the dead load of the shaft.

(c)Let the center support consist of a 60 mm. I-beam, 0.1824 N per mm (I = 218,000 mm^4), 1 m long, simply supported, with bearing C at its center. Find the reactions for the shaft, and draw and dimension the bending moment diagram. Neglect effects of the dead loads.

(d) What must the moment of inertia be for a beam supporting the bearing at C if the value of the bending moments, as caused by the 2000 N loads at points B, C, and D, are to be numerically equal? What will be the deflection of point C?

Neglect effects of the dead loads.

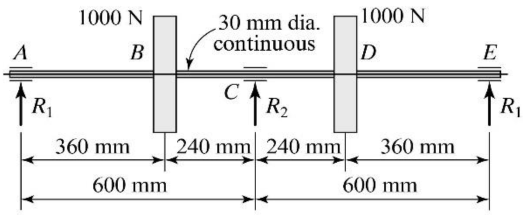

Fig. 11

13. Bearings A and B in Fig. 12 rest on immovable supports. Bearing at C is located at the center of a simply supported 60 mm I-beam 1.0 m long. Let a fill be placed under this bearing so that all bearings are at the same elevation before load is applied. Neglect dead load of the shaft.

(a)Find reactions at A, B, and C.

(b) If the bearing at C is resting on an unyielding support, find the three reactions.

(c)What change in elevation of bearing at C must be made if the bending moments in the shaft are to be numerically equal at the load and at bearing C?

(d) With the bearing at C supported by the beam, find the fill under the bearing required to make the bearing load equal to 750 N.

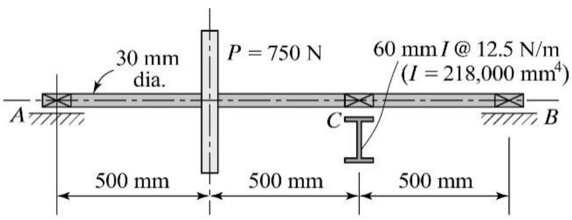

Fig.12

14. Find the lowest critical speed for the steel shaft shown in Fig.13.

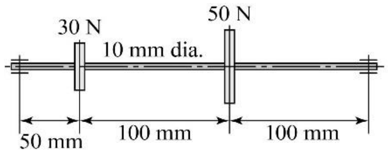

Fig. 13

15. A steel helical spring carries a compressive static load of 222.4 N at a deflection of 6.35 mm. Maximum stress is 482.65 MPa. End turns Q equal 1.5 turns. Find the value of c for the spring of minimum volume of material. Calculate the value of d and choose the nearest standard wire diameter for the actual spring. Calculate the corresponding R and the number of active coils N_c. Also find the volume of material in the spring.

16. A helical spring carries a static load of 1110 N. There are 10 active coils, and the radius of the helix to the center of the wire is 25 mm.
(a) What size square wire must be used and what will be the stress if the deflection is to be 50 mm?
(b) If this spring is made of round wire, find the required diameter and the stress. What percentage of weight of material is saved by the use of round wire?

17. How many coils must there be in a window-shade spring that is to exert a pull on the shade of 13.5 N after being wound up 15 revolutions? The spring is made of a 1.2-mm square wire. The helix diameter is 18.95 mm center to center of coils, and the roller diameter is 32 mm. What is the value of the maximum flexural stress?

18. An engine valve spring must exert a force of 60 N when the valve is closed and 100 N when the valve is open. The lift is 3.125 mm. Material tests τ_{yp} = 900 MPa and τ'_e = 480 MPa. N_{fs} = 1.5. If the spring index is 6, find the theoretical wire diameter. Also find the number of active coils and the initial compression of the spring.

19. In an assembly with loading arrangement equivalent to Fig. 14, the bolt is M20 × 2.5, and the total load varies from 9000 to 45,000 N. The material in the bolt tests σ_{ult} = 910 MPa and σ_{yp} = 450 MPa, with stress concentration factor for the threads equal to 3.85. Let the factor of safety based on the yield point be 2, and let E for both part and bolt be equal to 206,900 MPa. The threads are machined. The cross-sectional area of the part is equal to 800 mm^2.
(a) Draw the working-stress triangle for the bolt material, and plot the stresses when there is no initial stress in the bolt.
(b) If the initial force in the bolt is 36,000 N, plot the stress values for the bolt on the working-stress triangle.
It will be necessary to determine whether or not the part will have a compressive force when the maximum load is acting. Should all the initial compression be removed, the force in the bolt will have the same value as the load.
(c) Repeat part (b) with an initial bolt force of 58,500 N. Note the effect of excessive initial stress.
(d) Suppose the bolt is made of steel, but the part is made of aluminum, E = 69,000 MPa. Plot the stress values for the bolt if other data are the same as in part (b).
(e) Suppose the bolt were turned to the stress area of the thread over its entire length except for the nut. Plot the stress values for the bolt; other data are the same as in part (b).

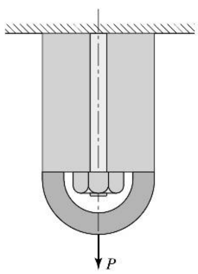

Fig.14

20. A load of 45,000 N is carried by a 60 mm single-thread Acme screw of standard proportions. The pitch is 8 mm and the pitch diameter is 56 mm. The OD of the collar is equal to 96 mm, and the ID is equal to 30 mm.

(a) For $\mu_1 = \mu_2 = 0.15$, find the horsepower required to rotate the screw if the weight is to be raised at the rate of 2880 mm/min.
(b) What is the efficiency when the friction of both the screw and collar is considered? What is the efficiency if the collar friction is made negligible by use of an antifriction bearing?
(c) Find the horsepower required to lower the load at the same rate.
(d) What horsepower will raise the load at the given rate when the collar is supported on a ball thrust bearing for which $\mu_2 = 0.003$? Let the collar radius be the same as for the plain bearing. What will the efficiency now be?
(e) Find the pitch of the thread at which overhauling will take place, using a ball thrust bearing. The pitch diameter is the same.
(f) Suppose the screw is made with pitch just sufficient to overhaul. What will be the efficiency for the screw alone?
(g) If the minimum major diameter of the screw is 59.592 mm and the maximum minor diameter of the nut is 52.392 mm, find the minimum length of the nut that must be engaged if the compressive stress on the projected area of the threads is equal to 4.6875 MPa.
(h) If the minimum minor diameter of the screw is 51.12 mm, find the average value of the compressive stress at the root of the thread. What is the bearing pressure for the collar?

21. The bolts in Fig. 15 are 20 mm in diameter, pitch 1.5 mm, made from cold-drawn 8740 steel. Machined threads; $K = 3.85$. The steel cylinder is 100 mm ID. Fluid pressure varies continuously from 0 to 14 MPa. Assume the end plates are rigid. Find the value of initial force F_o if the bolts are to have an N_{fs} equal to 4.

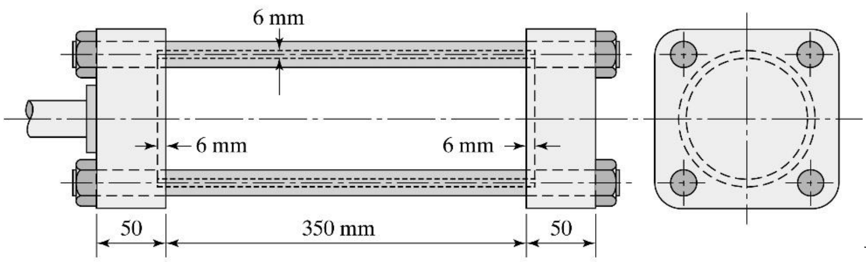

Fig.15

22. A 600-mm-OD plate clutch has a maximum lining pressure of 0.35 MPa. One hundred and thirty-five kW are to be carried at 400 rpm. If the coefficient of friction is 0.30, find the inside diameter and the spring force required to keep the clutch engaged.

23. Find the value of force P for the brake in Fig. 16. $p_{max} = 0.7$ MPa. $\mu = 0.25$.

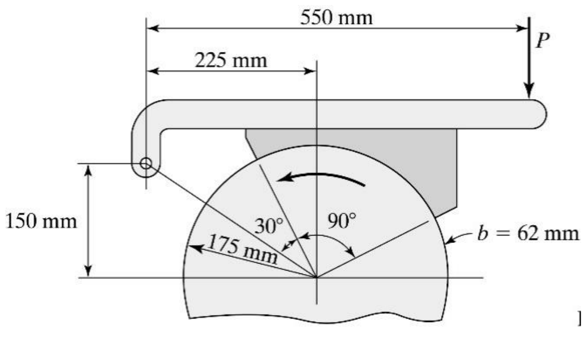

Fig.16

24. A 210 bearing has a work cycle with 1000 rpm for one-third of the time, 2000 rpm for one-third of the time, and 4000 rpm for one-third of the time. The inner ring rotates. Assume light-shock conditions. The radial load is 2000 N and the axial load is 750 N. Find the rating life at 5 hours per day for this bearing.
Ans. $L_{10} = 2.78$ yr.

25. A 206 bearing is subjected to the following work cycle:

Radial load of 2250 N at 150 rpm for 30% of the time
Radial load of 3375 N at 600 rpm for 10% of the time
Radial load of 1125 N at 300 rpm for 60% of the time

The inner ring rotates; loads are steady. What is the rating life at 8 hours per day of this bearing?

26. A 104 bearing operates under the following schedule of loads and speeds:

Radial load of 1500 N at 2000 rpm for 5% of the time
Radial load of 1000 N at 3300 rpm for 15% of the time
Radial load of 500 N at 1750 rpm for 35% of the time
Radial load of 400 N at 2200 rpm for 45% of the time

The inner ring rotates; loads are steady. Find the rating life at 2 hours per day for this bearing.

27. Two 20° full-depth gears have a modulus of 12 and operate with a center-to-center spacing of 75 mm as shown in Fig. 17. The speed ratio of the pair is 2:1. Would you expect to have undercutting on the pinion? What will be the contact ratio for the gear pair?

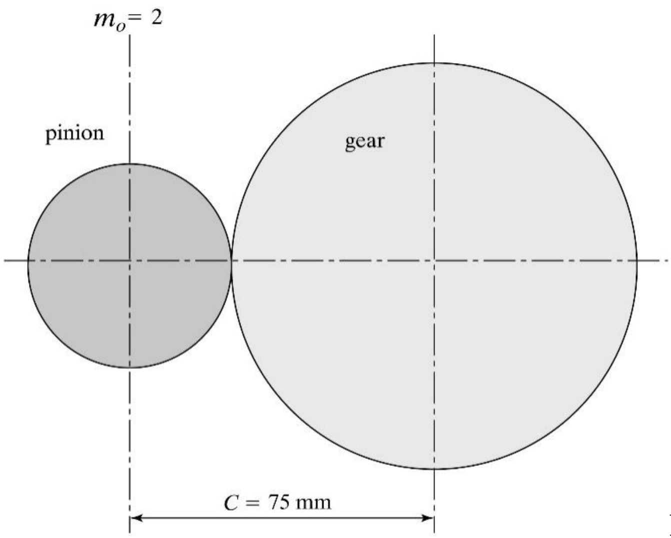

Fig.17

28. In Fig. 18, consider shaft B together with gears 2 and 3 as the free body. Determine the tooth forces for these gears based on the horsepower. Draw a top view of shaft B and show all horizontal loads and reactions. Draw an elevation of shaft B and show all vertical loads and reactions. m_O = 4; φ = 20°.

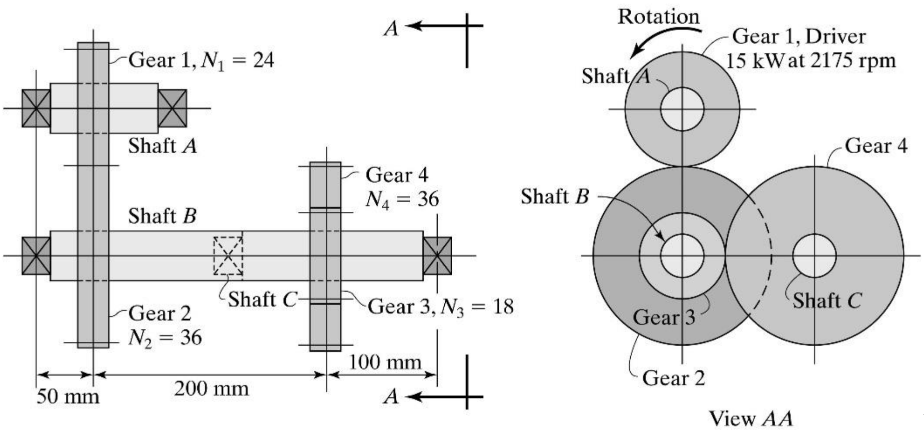

Fig.18

29. For the planetary gear train shown in Fig. 19, $N_1 = 70$, $N_2 = 30$, $N_3 = 60$, and $N_4 = 40$ teeth. If the arm is rotating at 100 rpm in a counterclockwise direction as viewed from the left, what will be the speed and direction of the rotation of the output shaft connected to gear 4?

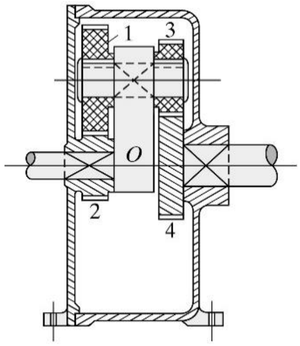

Fig.19