Problem of Practices
on
Mechanical Engineering Design
Chapter-9 Spur Gears

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1. A spur pinion is driven by an electric motor of power 15 kW running at 740 rpm. Pitch diameter of pinion is 108 mm and speed reduction is 3 : 1. Module is 6 mm and pressure angle 20°. The pinion is mounted on a shaft located in symmetrical bearings over a span of 300 mm. The gear is overhanging by 50 mm on the left of two bearings 200 mm apart. Calculate the bearing reactions for the gear when the pinion rotates clockwise.

2. A spur steel pinion (S_0 = 200 MN/m²) is to drive a spur steel gear (S_0 = 140 MN/m²). The diameter of the pinion is to be 100 mm and the center distance is 200 mm. The pinion is to transmit 5 kW at 900 rpm. The teeth are to be 20° full depth. Determine the necessary module and width of face to give greatest number of teeth.

Design for strength only using Lewis equation.

S_0 is the endurance strength corrected for average stress concentration?

The allowable stress S is given $S = S_0\left(\frac{3}{3+V}\right)$.

where V is the pitch line velocity in m/sec.

The following table gives the form factor y for use in Lewis strength equation.

TABLE 1—Form Factors y - for use in Lewis strength equation

Number of Teeth	14½ ° Full-Depth Involute or Composite	Full-Depth Involute	20° Stub Involute
12	0.067	0.078	0.099
13	0.071	0.083	0.103
14	0.075	0.088	0.108
15	0.078	0.092	0.111
16	0.081	0.094	0.115
17	0.084	0.096	0.117
18	0.086	0.098	0.120
19	0.088	0.100	0.123
20	0.090	0.102	0.125
21	0.092	0.104	0.127
23	0.094	0.106	0.130
25	0.097	0.108	0.133
27	0.099	0.111	0.136
30	0.101	0.114	0.139
34	0.104	0.118	0.142
38	0.106	0.122	0.145
43	0.108	0.126	0.147
50	0.110	0.130	0.151
60	0.113	0.134	0.154
75	0.115	0.138	0.158
100	0.117	0.142	0.161
150	0.119	0.146	0.165
300	0.122	0.150	0.170
Rack	0.124	0.154	0.175

3. A pair of straight teeth spur gears having 20° full depth involute teeth is to transmit 20 kW. The pinion runs at 300 r.p.m. and the speed ratio is 3 : 1. The following data are given:
Number of teeth on pinion = 15.
Service factor $C_s = 1$.

Velocity factor $C_v = \dfrac{3}{3+v}$ where v is the pitch line velocity in m/sec.

Tooth form factor

$$y = 0.154 - \frac{0.912}{T}$$

where T = Number of teeth.
Face width = 14 m where m = module in mm
Allowable static stress for pinion and gear materials are 120 MPa and 100 MPa respectively.
Check the gear for wear if the surface endurance limit is 600 MPa and modulus of elasticity for pinion and gear materials are 200 GPa and 100 GPa respectively.

4. A simple gear train consists of three gears with 18, 16 and 72 teeth. The 18 teeth pinion is connected to a 4 kW electric motor running at 2400 rpm. Design the shaft for 72 teeth gear if the shearing stress is not to exceed 60 MPa in the shaft.

5. A pair of spur gears with 20° full-depth involute teeth consists of a 20 teeth pinion meshing with a 41 teeth gear. The module is 3 mm while the face width is 40 mm. The material for pinion as well as for gear is steel with an ultimate tensile strength of 600 N/mm^2. The gears are heat treated for a surface hardness of 400 BHN. The pinion rotates at 1450 rpm and the service factor for the application is 1.75. Assume that the velocity factor accounts for the dynamic load and the factor of safety is 1.5. Determine the rated power that the gears can transmit, taking Lewis form factor as 0.32.

6. A gear set consists of an 18-tooth pinion driving a 45-tooth gear. The module is 10 mm. The gears are cut using a pressure angle of 20°. In mounting the gears, the centre distance was incorrectly made 8 mm larger. Compute the new values of the pressure angle and pitch circle diameter. If the pinion transmits 20 kW and rotates at 950 r.p.m., determine the forces on the tooth for mounted gears.

7. A pair of spur gears with pressure angle 20° consists of a 24-tooth pinion which rotates at 950 r.p.m. and transmits power to a 60-tooth gear. The module is 6 mm and face width is 60 mm. Both the gears are made of 45 C8 steel (σ_y = 330 N/mm^2, σ_u = 680 N/mm^2 and σ_e = 0.55 σ_u). Take surface endurance limit 1500 N/mm^2. Assuming overload factor as 1.8, dynamic factor as 20.5 and taking factor of safety of 2.5, determine:

(i) Beam strength.

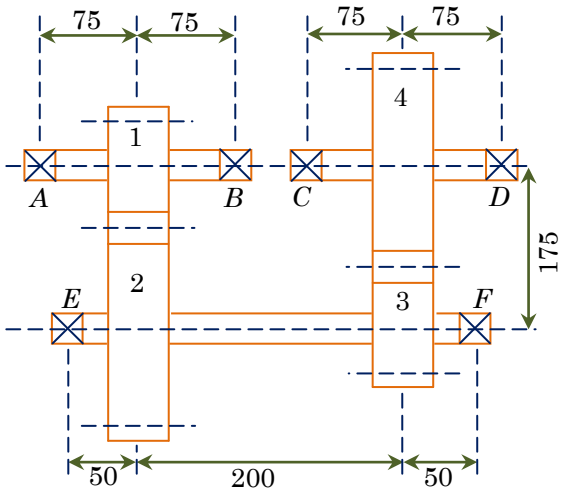
(ii) Wear strength.

(iii) The rated power, the gears can transmit.

$E = 2.1 \times 10^5$ N/mm^2.

8. Two parallel shafts, about 600 mm apart, are to be connected by spur gears. One shaft is to run at 360 rpm and the other at 120 rpm. Design the gears, if the circular pitch is to be 25 mm.

9. The layout of a two-stage gear box is shown in the figure.



The number of teeth on the gears are as follows:

$$z_1 = 20 \qquad z_2 = 50 \qquad z_3 = 20 \qquad z_4 = 50$$

Pinion 1 rotates at 1440 rpm in anti-clockwise direction when observed from the left side and transmits 10 kW power to the gear train. The pressure angle is 20°. Draw a free body diagram of the gear tooth forces and determine the reactions at bearings *E* and *F*.

10. A pair of gears is to be designed to transmit 4 kW at 600 rpm of the pinion to a gear rotating at 150 rpm. 20° FD involute teeth are to be used. The centre distance should be as small as possible. Only from strength considerations (Lewis equation), determine the module, face width and number of teeth on gears, assuming spur gear drive or helical gear drive.

11. Design a spur gear drive required to transmit 45 kW at a pinion speed of 800 r.p.m. The velocity ratio is 3.5:1. The teeth are 20° full-depth involute with 18 teeth on the pinion. Both the pinion and gear are made of steel.

12. The pinion in a spur gear set having a speed ratio 3 rotates at 900 RPM and has 20 full depth teeth of pressure angle 20°. The face width is 30 mm and the module is 3 mm. What is the power rating of the gear set based only on tooth bending strength if both the gear and pinion are made of the same material having an ultimate strength of 400 MPa and an yield strength of 210 MPa? Assume a factor of safety of 2.

13. A pair of 20° full depth straight teeth spur gears is to transmit 25 kW. The pinion rotates at 400 rpm and the velocity ratio is 1:4. The allowable static stresses for gear and pinion materials 100 MPa and 120 MPa respectively. The pinion has 16 teeth and the face width is 12 times the module. Design the gear for static strength.

14. A compressor running at 300 rpm is driven by a 15 kW 1200 rpm motor through a 14.5° full depth gear. The centre distance is 0.375m. The motor pinion is to be of C-30 forged steel hardened and tempered, and the driven gear is to be of cast steel. Assuming medium shock conditions : (i) Determine the module, face width and number of teeth on each gear. (ii) Check the gears for wear.

15. A pair of 20° stub teeth spur gears is to transmit 20 kW. The pinion rotates at 500 rpm and the velocity ratio is 1 : 4. The allowable static stresses for gear and pinion materials 100 MPa and 120 MPa respectively. The pinion has 20 teeth and the face width is 10 times the module. Design the gear for static strength.

16. A pair of straight teeth spur gears is to transmit 25 kW when the pinion rotates at 300 rpm. The velocity ratio is 1:3. The allowable static stresses for the pinion and gear materials are 120 MPa and 100 MPa respectively. The pinion has 15 teeth and its face width is 15 times the module. Determine module, face width and pitch circle diameters of both pinion and the gear from the standpoint of strength only, taking into consideration the effect of the dynamic loading. Assume 20° full depth involute pairs with ordinary cutting.

17. A bakelite pinion is used to transmit power at 400 rpm. The module is 10 mm and the pitch diameter is 0.25m and the face width is 0.127m. The teeth are 20° standard involute. Determine (i) number of teeth, circular pitch and outside diameter of pinion (ii) the power the pinion should transmit for smooth intermittent service and (iii) the power for continuous service.

18. Two parallel shafts with center distance 200 mm are to be connected by 20° full depth spur gear and pinion for a speed ratio of 3 : 1. The speed of the pinion is 600 rpm. Module and width of the gear and pinion are 5 mm and 50 mm respectively. The safe static stresses for pinion and gear are 110 and 55 MPa respectively. Find maximum power that can be transmitted safely.

19. A Bronze Spur pinion (σ_{safe} = 83 MN/m^2) rotating at 600 rev/min drives a cast steel spur gear (σ_{safe} =103 MN/m^2) at a transmission ratio of 4 to 1. The pinion

has 16 standard 20° full depth involute teeth of 8 module. The face width of both gears is 90 mm. How much power can be transmitted from the standpoint of strength?

20. A steel pinion with 20° full depth involute teeth is transmitting 7.5 kW power at 1000 rpm from an electric motor. The starting torque of the motor is twice the rated torque. The number of teeth on the pinion is 25, while the module is 4. The face width 45 mm. Assuming that velocity factor accounts for the dynamic load, calculate

(i) Effective load on the gear tooth.

(ii) Bending stress in the gear tooth.