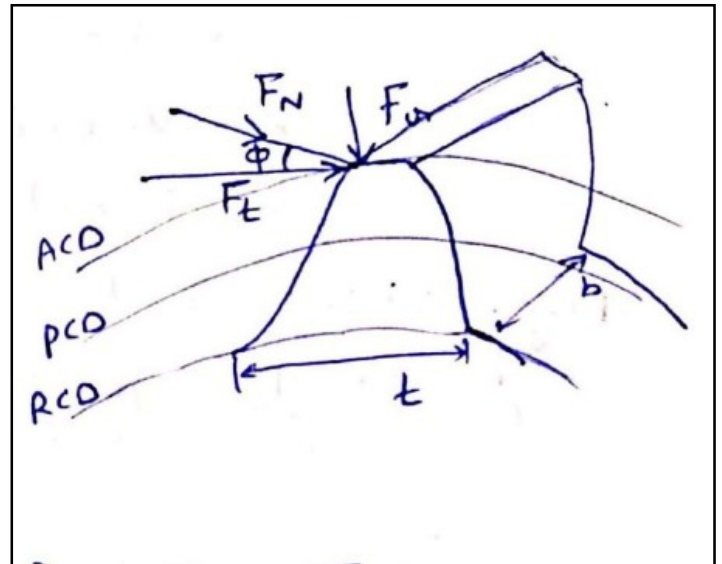
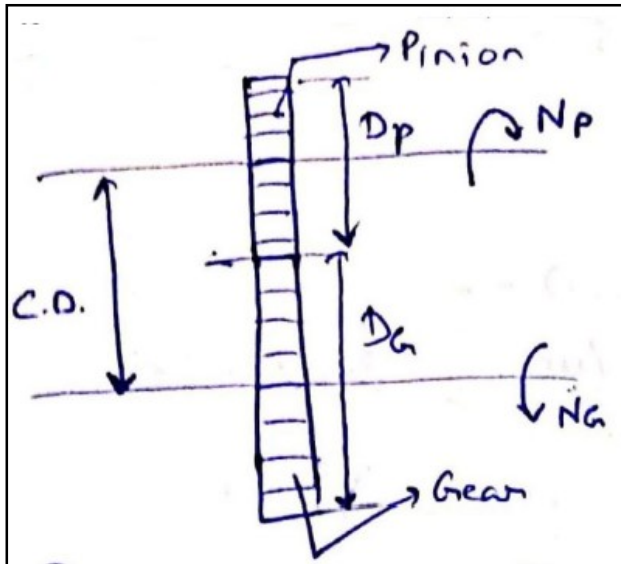


Standard size of Rod/Shaft/Tube/Bolts

Range of Size	Increment steps
0-10	1mm
10-24	2mm
24-45	3 mm
45-100	5 mm
>100	10 mm

Design of Spur Gear Reducer

Design 8: A pair of Spur Gear Reducer is to transmit 30/35/40/50 kW of power at 1800 rpm of pinion with a velocity ratio of 4:1 between two shafts. Assume a 20° pressure angle with a Full Depth Involute (FDI) system. The gear is made up of bronze SAE 62 for which the allowable static stress (S_0) is 76 N/mm². The pinion's material is cast steel with allowable static stress (S_0) of 138 N/mm². Design the gear for strength and check for dynamic and wear load. Take E_P and E_G as modulus of elasticity of pinion and gear materials respectively.



PCD = Pitch Circle Diameter

ACD = Addendum Circle Diameter

RCD = Root Circle Diameter

D_p = PCD of Pinion (mm)

D_G = PCD of Gear (mm)

N_p = RPM of Pinion

N_G = RPM of Gear

T_G = Torque transmitted by gear

m = Module

Z_G = Teeth of Gear, **Z_p** = Teeth of Pinion

C.D. = Centre Distance between two shafts

b = face width

t = tooth thickness

F_N = Resultant Load (N)

F_t = Tangential Load (N)

F_r = Radial Load (N)

T_p = Torque transmitted by pinion

Design Steps:

1. Velocity Ratio (VR):

$$VR = \frac{N_P}{N_G} = \frac{D_G}{D_P} = \frac{Z_G}{Z_P} = \frac{T_G}{T_P}$$

Find N_G ?

and, Center Distance between two shafts:

$$C.D. = \frac{D_P + D_G}{2}$$

2. For 20° FDI to avoid interference, minimum number of teeth on pinion is 17

So let us choose $Z_P \geq 18$, say 18, 19, 20, 21, 22....etc.

Then we find

$$Z_G = VR \cdot Z_P$$

3. Form Factor (y):

$$y = 0.154 - \frac{0.912}{Z} \text{ for } 20^\circ \text{ FDI system}$$

Find y_P and y_G i.e. form factor for both pinion and gear respectively.

4. Strength Factor (SF):

$$SF = S_o \cdot y$$

Find both SF_P and SF_G . The lower value of the two will decide the weaker gear if their materials are different. For the same materials, pinion is always weaker as it stressed more being smaller in size.

Now, further steps are applicable to the design of weaker gear only.

5. We know power is given by:

$$P = \frac{2\pi NT}{60} \text{ Watts}$$

Calculate Torque (T) from above in Nmm.

From modified Lewis equation:

$$S_o C_v m^3 = \frac{2T}{k\pi^2 y Z}$$

$$\text{Take } k = \frac{b}{\pi m} = 3 \text{ to } 4$$

$$C_v = \frac{4.5}{4.5 + v} \quad [0 < C_v < 1]$$

where C_v is velocity factor and v is pitch line velocity in m/s

$$v = \frac{\pi DN}{60}$$

Let

$$A = \frac{2T}{k\pi^2 y Z}$$

Iteration 1

Let $C_v = 0.5$

Allowable stress, $S_a = 0.5 S_o$

Therefore from equation (in bold),

$$m = \sqrt[3]{\frac{A}{S_a}} \text{ (std size)}$$

Calculate

$$D = m \cdot Z \quad v' = \frac{\pi DN}{60} \text{ m/s}$$

$$C'_v = \frac{4.5}{4.5 + v'}$$

$$S'_a = C'_v \cdot S_o$$

$$\text{and, } S'_i = \frac{A}{m_{std}^3}$$

Check that $S'_i < S'_a$ else reiterate.

6. Find D_G, D_P, Z_G, Z_P from step 1. Also calculate face width from following equation:

$$b = k \cdot \pi \cdot m$$

7. Dynamism Check:

Tangential Load in Newton,

$$F_t = \frac{T}{D/2}$$

Increment Load,

$$F_i = \frac{21v(bC + F_t)}{21v + \sqrt{bC + F_t}}$$

where v is pitch line velocity (m/s) given by:

$$v = \frac{\pi DN}{60}$$

b is Face width, C is Deformation Factor and given by:

$$C = \frac{a \cdot e}{\frac{1}{E_P} + \frac{1}{E_G}}$$

Here $a = \text{constant} = 0.111$ for 20° FDI, $E_P = 207000$ MPa and $E_G = 86000$ MPa

Therefore, total Dynamic Load, $F_d = F_t + F_i$

Endurance Load, $F_{end} = S_e \cdot b \cdot \pi \cdot y \cdot m$

Check that $F_{end} > F_d$

Margin of safety = $F_{end} - F_d$

8. Wear check/Wear Load

Wear Load in Newton,

$$F_w = K \cdot b \cdot D_P \cdot Q$$

$$Q = \text{Relative size factor} = \frac{2Z_G}{Z_G + Z_P}$$

$$K = \text{Load stress factor} = S_{end,c}^2 \cdot \frac{\sin \phi}{1.4} \left[\frac{1}{E_P} + \frac{1}{E_G} \right]$$

where, $S_{end,c}^2$ is compressive endurance limit for the material of the pinion

ϕ is pressure angle

Check that $F_w > F_d$ else find

$$K' = \frac{F_d}{bD_p Q}$$

Increase K to K' by heat treatment.

VIVA QUESTIONS

Q1. What is a hunting tooth in spur gears?

Q2. Why helical gears are preferred over spur gears?

Q3. Why are Involute teeth preferred over Cycloidal teeth? State the applications of Cycloidal teeth.

Q4. How do you find the weakness of a gear if the material of both pinion & gear are different?