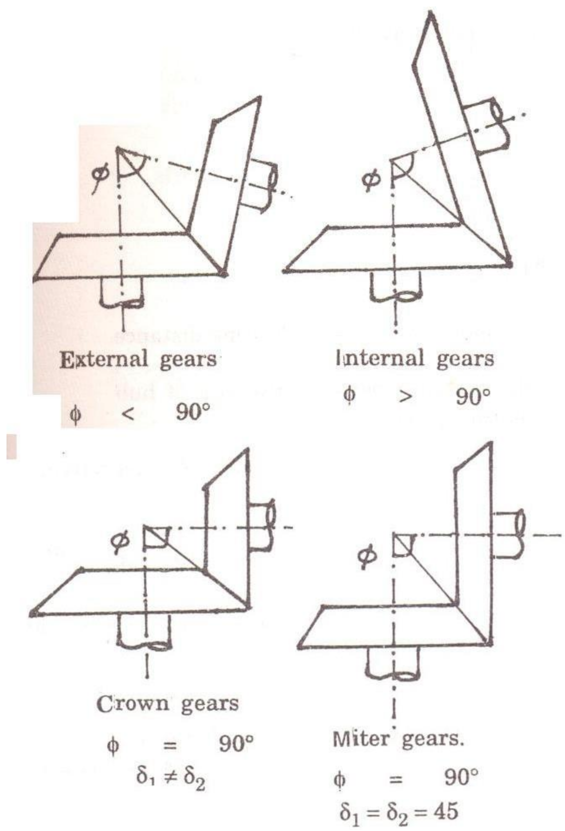
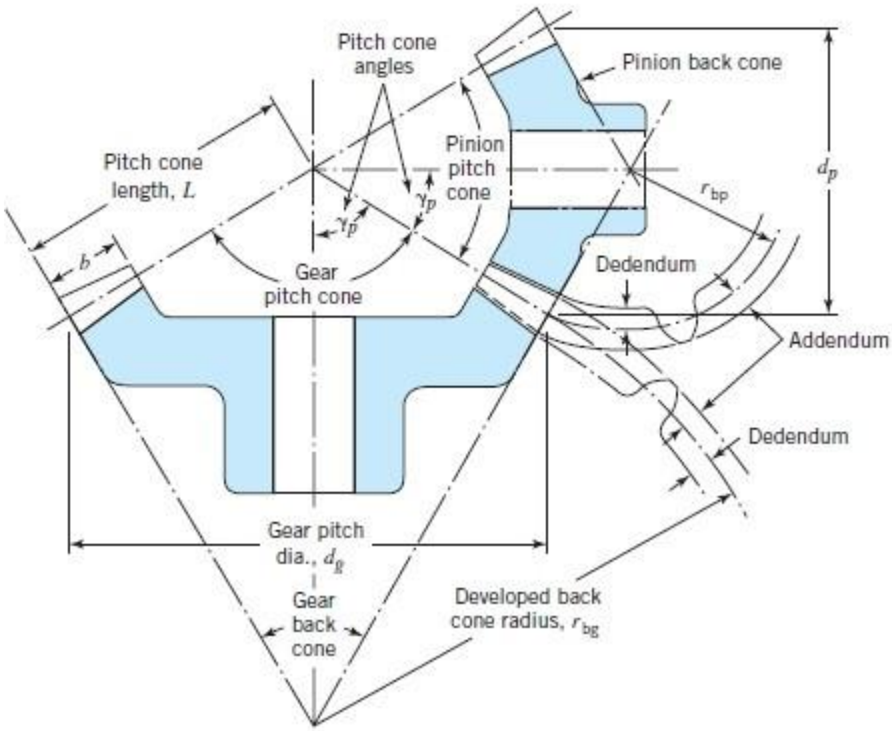
3 BEVEL, WORM AND CROSS HELICAL GEARS

3.1 BEVEL GEAR

Bevel gears are used to transmit power between the shafts whose axes are intersecting at an angle. In bevel gears, teeth are cut on conical surface in contrast with spur and helical gears, for which the teeth are cut on a cylindrical surfaces.The structure of the helical gear is similarly to an uniformly serrated frustum of a cone.



3.1.1 BEVEL GEAR TERMINOLOGY



CLASSIFICATION

1. Based on the shape of teeth such as
   a. Straight teeth bevel gears
   b. Curved teeth bevel gears
2. Based on the angle between the shafts
   a. External gear drive ,if shaft angle <90°
   b. Internal gear drive ,if shaft angle >90°
   c. Mitre gear, if shaft angle = 90°

Example.Design a bevel gear drive to transmit 7 kW at 1600 rpm for the following data

Gear ratio = 3

Material for pinion and gear = C45 Steel

Life = 10,000 hours

Since the pinion and gear are made of same material, pinion is weaker than gear and its teeth are subjected to more number of cycles.

STEP-1-MINIMUM CONE DISTANCE

Minimum cone distance based on surface compressive strength

$$\geq \sqrt{^2+1}\ \sqrt[3]{\left\{\frac{0.72}{(-0.5\quad)[\quad]}\right\}^2 \frac{[\quad]}{}}$$ **(PSG 8.13)**

Design torque $[M_t]=M_t.k.k_d$ **(PSG 8.15)**

$[M_t] = 97420x\frac{7}{1600}x1.5 = 640$ kgf-cm ; $k.k_d = 1.5$ (assumed)

Equivalent young's modulus = $2.15x10^6$kgf/cm^2 **(PSG 8.14)**

$[\sigma_c] = 5000$ kgf/cm^2 **(PSG 8.5)**

$\psi_y = R/b = 3$ (for i=3) **(PSG 8.15)**

$$\geq 3\ \sqrt{3^2+1}\ \sqrt[3]{\left\{\frac{0.72}{(3-0.5)5000}\right\}^2 \frac{2.1510^6 640}{3}} \geq 10.95 \text{ cm}$$

STEP-2-AVERAGE MODULE

$$\geq 1.26\ \sqrt[3]{\frac{[\quad]}{\ _1[\quad]}}$$ **(PSG 8.15)**

σ_b= 1400 kgf/cm^2 **(PSG 8.5)**

ψ_m= —— = 10 (initially assumed)

y_v= form factor

$z_v= z_{1/}\cos\delta_1$ for pinion **(PSG 8.39)**

$\tan\delta_2$=i = 3 ; $\delta_2 = \tan^{-1}i = \tan^{-1}3$=71.66

δ_1 = 90-71.56 = 18.43°

z_v=$z_{1/}$cos δ_1 = 20/cos 18.43 = 21

y_v = 0.396 **(PSG 8.18)**

$$\geq 1.26\ \sqrt[3]{\frac{640}{0.39614001020}} = 0.226 \text{ cm} \quad =2.3 \text{ mm}$$

STEP-3-TRANSVERSE MODULE

$m_t = m_{av} x \frac{}{(-0.5\quad)} = 2.3x\frac{3}{(3-0.5)} = 2.76$ mm

next standard module = 3 mm =0.3cm

STEP-4-CORRECTED CONE DISTANCE

$= 0.5_1 \quad \sqrt{(^2 + 1\ )}$ **(PSG 8.38)**

$10.95=0.5x0.3xz_1x\sqrt{(3^2+1)}$; $z_1= 23.08 \approx 24$

$z_1 =24$ and $z_2=ixz_1=3x24=72$

Final cone distance R= $0.50.324 \quad \sqrt{(3^2+1)} \quad = 11.4$ cm

Since the final cone distance is greater than initial distance our design is safe.

STEP-5-FACE WIDTH

b = — = $\frac{11.4}{3}$ = 3.8 cm ≈ 4 cm

STEP-6-CHECKING THE INDUCED STRESSES

$$= \frac{0.72}{(\ -0.5\ )}\sqrt{\frac{\sqrt{(^2+1\ )^3}\quad [\quad]}{}}$$ **(PSG 8.13)**

$$= \frac{0.72}{(\ 11.4-0.54\ )}\sqrt{\frac{\sqrt{(\quad 3^2+)1}\ ^3 2.1510^6 640}{34}}$$

= 4638 kgf/cm^2< [σ$_c$]= 5000 kgf/cm^2

Our design if safe.

$$= \frac{\sqrt{(^2+1\ )[\quad]}}{(-0.5\ ^2..)}\ \frac{1}{o} \leq [\sigma_b]$$ **(PSG 8.13a)**

A =20° usually **(PSG 8.38)**

$$= \frac{11.4\sqrt{(3^2+1)}640}{(\quad 11.4-0.54)\ ^2 40.30.396}\ \frac{1}{o20} = 591 \text{ kgf/cm}^2 \leq [\sigma_b] = 1400 \text{ kgf/cm}^2$$

STEP-7-PITCH CIRCLE DIAMETER

For pinion $d_1 = m_t z_1 = 3x24 = 72$ mm

For gear $d_2 = m_t z_2 = 3x72 = 216$ mm

STEP-8-TIP CIRCLE DIAMETER

$d_{a1} = m_t(z_1 + 2\cos\delta_1) = 3(24 + 2\cos 18.43) = 77.7 \approx 78$ mm **(PSG 8.38)**

$d_{a2} = m_t(z_2 + 2\cos\delta_2) = 3(72 + 2\cos 71.56) = 218$ mm

STEP-9-ADDENDUM ANGLE θ_a

$\theta_{a1} = \theta_{a2} = \tan^{-1}\left(\frac{o}{}\right) = \tan^{-1}\left(\frac{0.31}{11.4}\right) = 1.5°$

STEP-10-DEDENDUM ANGLE θ_f

$\theta_{f1} = \theta_{f2} = \tan^{-1}\left(\frac{(o+)}{}\right) = \tan^{-1}\left(\frac{0.3(1+0.2)}{11.4}\right) = 1.8°$

STEP-11-TIP ANGLE

For pinion $\delta_{a1} = \delta_1 + \theta_{a1} = 18.43 + 1.5 = 19.93°$

For gear $\delta_{a2} = \delta_2 + \theta_{a2} = 71.56 + 1.5 = 73.06°$

STEP-12-ROOT ANGLE

For pinion $\delta_{f1} = \delta_1 - \theta f_1 = 18.43 - 1.5 = 16.63°$

For gear $\delta_{f2} = \delta_2 - \theta_{f2} = 71.56 - 1.5 = 69.76°$

STEP-13-OTHER PARAMETERS

Addendum $h_a = m_t = 3$ mm

Dedendum$h_f = 1.1236 \times m_t = 1.1236x3 = 3.4$ mm

Tooth height $h = h_a + h_f = 3 + 3.4 = 6.4$ mm

SPECIFICATION

SL NO	SPECIFICATION	PINION	GEAR
1.	Material	C45 steel	C45 steel
2.	Cone distance	114 mm	114 mm