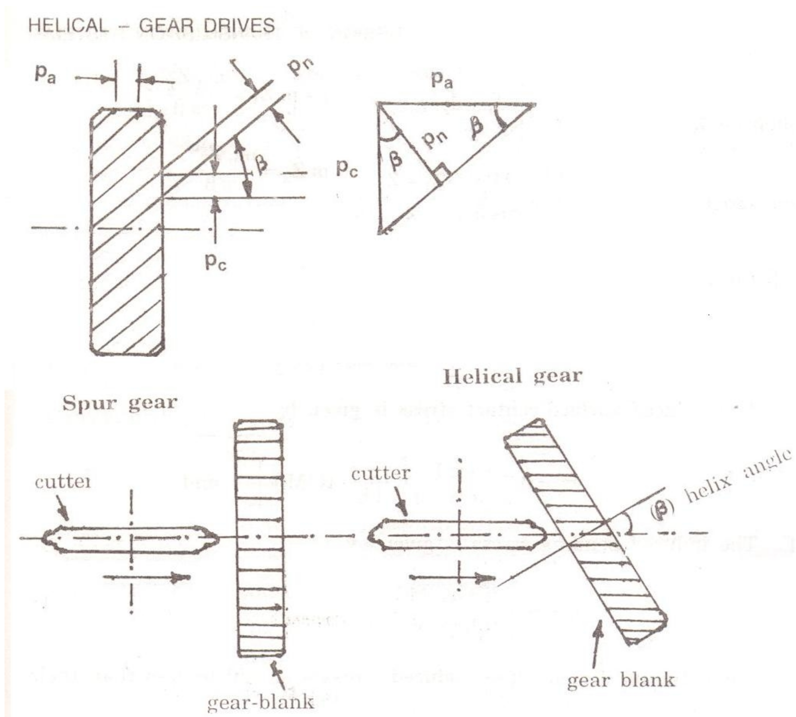
2.7 HELICAL GEAR DRIVES

Helical gears are the developed form of spur gears. In which all the teeth are cut at a constant angle known as helix angle to the axis of the gear, whereas in spur gear, teeth cut are parallel to the axis. Because of the inclined structure of the teeth more than one pair of the teeth will be in engagement and hence operation may be smooth due to their gradual contact and more power can be transmitted at higher speeds than spur gear drive.



Helical gear Herring bone gear

Crossed - axis Helical gears

DESIGN PROCEDURE

STEP-1

From the given problem find the amount of power to be transmitted, pinion speed, gear ratio, life of gear drive and determine their design stresses and young's modulus.

STEP-2

Calculate minimum centre distance **(PSG 8.13)**

STEP-3

Calculate the minimum normal module **(PSG 8.13a)**

$m_n \geq 1.15 cos\beta \sqrt[3]{\frac{[M_t]}{[\sigma_b]\psi_m z_1 y_v}}\psi_m$ from **(PSG 8.14)**

Select next nearest standard module **(PSG 8.2)**

STEP-4

Correct the number of teeth of pinion **(PSG 8.22)**

STEP-5

Determine the pitch circle diameters **(PSG 8.22)**

STEP-6

Decide the corrected centre distance

STEP-7

Determine the face width of gear teeth

$b = \psi.a$ or $b = \psi_m.m$

STEP-8

Correct the load correction factor and dynamic factor.

STEP-9

Check the induced stresses.

STEP-10

Find out the essential parameters of gear drive.

Example.Design a pair of helical gears to transmit 10 kW at 1000 rpm .The pinion reduction ratio of 5 is required.

Given

Power P =10 kW

Pinion speed n_1 = 1000 rpm

Speed ratio i = 5

Gear speed n_2 = 1000 / 5 = 200 rpm

Helix angle = 15 ° (assumed)

STEP-1

Select the material for pinion and gear as 40Ni2Cr1Mo28 steel **(PSG 8.5)**

$[\sigma_c] = 11000$ kgf/cm^2

$[\sigma_b] = 400$ kgf/cm^2

E = 2.15x 10^6 kgf/cm^2

I = 5

Ψ = b/a = 0.5 **(PSG 8.14)**

STEP-2

Minimum centre distance $a \geq (i+1)\sqrt[3]{\left(\frac{0.7}{[\sigma_c]}\right)^2 \frac{E[M_t]}{i\psi}}$ **(PSG 8.15)**

$[M_t] = M_t.k.k_d = 97420 \text{ x } \frac{10}{1000} \text{ x } 1.3 = 1266.46$ kgf-cm

$$a \geq (5+1)\sqrt[3]{\left(\frac{0.7}{[11000]}\right)^2 \frac{2.15x10^6x1266}{5x0.5}} \geq 9.84 \text{ cm}$$

STEP-3

Minimum module $m_n \geq 1.15\cos\beta \text{ x } \sqrt{\frac{[M_t]}{y_v[\sigma_b]\psi_m z_1}}$ **(PSG 8.13)**

Let z_1 =20 ψ_m = b/m = 10

$Z_v = z_1/\cos^2\beta$ = 20 / $\cos^2 15$ = 22.2 **(PSG 8.22)**

y_v = 0.402 for z_v=22 **(PSG 8.18)**

$m_n \geq 1.15\cos 15 \times \sqrt{\frac{1266}{0.402x4000x10x20}} \geq 0.175$cm = 1.75 mm

m_n=2mm = 0.2 cm

Next standard module m_n=2 mm =0.2 cm

STEP-4

Number of teeth corrected **(PSG 8.22)**

Number of teeth of pinion $z_1 = \frac{2a\cos\beta}{m_n(i+1)} = \frac{2x9.84x\cos 15}{0.2(5+1)}$ = 15.84 = 16

z_2 =i x z_1 = 5 x 16 = 80

STEP-5

Pitch circle diameters

Pitch circle diameter of pinion $d_1 = \frac{m_n}{\cos\beta} z_1$ = 02x16/cos15 = 3.3 cm **(PSG 8.22)**

d_2 = ix d_1 =5x3.3 = 16.5 cm

STEP-6

Corrected centre distance

$a = \frac{3.3+16.5}{2}$ = 19.8 / 2 = 9.9cm

STEP-7

Face width b = 0.5x9.84 = 4.95 mm.

STEP-8

Checking the induced stresses

Surface compressive stress

$$\sigma_c = 0.7\sqrt{\frac{(i+1)}{ib}E[M_t]}$$

= $0.7\sqrt{\frac{(5+1)}{5x5}x2.15x10^6x1266}$ =10843 < [σ_c] =11000kgf/cm^2 **(PSG 8.13)**

So our design is safe

Bending stress $\sigma_b = \frac{0.7(i+1)}{a.b.m_n.y_v}[M_t]$

$= \frac{0.7(5+1)x1266}{9.9x5x0.2x0.402}$ = 1336 kgf/cm^2 < [σ_b] = 4000 kgf/cm^2

So our design is safe

STEP-9

Other parameters

Addendum = m_n = 2 mm

Dedendum = 1.25 x m_n =1.25 x 2 =2.5 mm

Tip circle diameter of pinion = d_1+2xaddemdum = 33 + (2x2) = 37 mm

Tip circle diameter of gear = d_2+2xaddemdum = 165 + (2x2) =169 mm

Root circle diameter of pinion = d_1-(2xdedemdum) = 33 – 2x2.5 = 28 mm

Root circle diameter of gear = d_2-(2xdedemdum) = 165 – 2x2.5 =160 mm

Ex.Design a helical gear drive to transmit the power of 20 h.p. speed ratio 6, pinion speed 1200 rpm, helix angle is 25°.Select suitable materials and design the gear.

PROBLEMS FROM ANNA UNIVERSITY EXAMS

A pair of helical gears subjected to moderate shock loading is to transmit 37.8kW at 1750r.p.m of the pinion.The speed reduction ratio is 4.25 and the helix angle is 15^0.The service is continuous and the teeth are 20^0FD in the normal plane.Design the gears,assuming a life of 10,000 hours.[April/may2010]

Design a pair of helical gear to transmit 30 kW power at a speed reduction ratio of 4:1.The input shaft rotates at 2000 rpm. Take helix and pressure angles equal to 25^0 and 20^0 respectively. The number of teeth on the pinion may be taken as 30. [April/may2010]

A pair of helical gears is to transmit 14 kW. The teeth are 20^0 stub and helix angle is 45^0.Pinion runs at 10,000 rpm and has 80 mm PCD. Wheel has 320 mm PCD. Both gears are made of cast steel. Design the gear pair and obtain the basic dimensions assuming life of 1000 hours. [April/may2010]

A helical gear with 30^0 helix angle has to transmit 35 kW at 1500 rpm. With a speed reduction ratio 2.5.If pinion has 24 teeth, determine the necessary module, pitch diameter and face width of 20^0 full depth teeth. Assume 15 Ni2Cr1Mo15 for both pinion and wheel. [April/may2010]

A pair of helical gears subjected to heavy shock loading is to transmit 37.5 kW at 1750 rpm of the pinion.The speed reduction ratio is 4 and the helix angle is 15^0.The service is continuous and the teeth are 20^0 full depth in normal plane. Select suitable material and design the gears.Check for working stresses and sketch the drive. [April/may2009]

A pair of helical gear for a turbine has a transmission ratio of 10:1.The pinion rotates at 5000 rpm and made of carbon steel and the gear wheel is made of high grade cast iron. Power transmitted=90 kW.The gear pair is required to last for at least 12000 hrs. Select suitable gear materials. [April/may2012]

A helical gear speed reducer is to be designed .The rated power of the speed reducer is 75 kW at a pinion speed of 1200 rpm. The speed ratio of 3 to 1.For medium shock conditions and 24 hours operation;determine, the module, face width, number of teeth in each gear. The teeth are 20^0 full depth in normal plane.Assume suitable material. [April/may2009]

A pair of helical gears subjected to moderate shock loading is to transmit 20 kW at 1500 rpm of the pinion. The speed reduction ratio is 4 and the helix angle is 20^0.The service is continuous and the teeth are 20^0 full depth in the normal plane. For the gear life of 10000 hours, design the gear drive. [April/may2010]

Design a pair of helical gears to transmit 10 kW at 1000 rpm of the pinion. Reduction ratio of 5 is required. Give details of the drive in a tabular form. [AU, M/J 2013]

Design a pair of full depth involute teeth helical gears to transmit 5 kW at 1440 rpm. Use C45 steel for the gears. Number of teeth on pinion may be 24 and that in on gear 56. Check the compressive and bending stresses. Make a simple sketch and label the important dimensions of the drive. [AU, N/D 2012]

Design a pair of helical gears to transmit 37.5 kW at 1750 rpm of the pinion. The drive is subjected to heavy shock loading. The speed reduction is 4 and the helix angle is 15°. Select suitable material and design the gear. Check for working stresses and sketch the drive [AU, M/J 2012]

Design a pair of helical gears to transmit 10 kW at 1000 rpm of the pinion. Reduction ratio of 5 is required. [AU, M/J 2011]

A general purpose enclosed gear train is based on parallel helical gears, specified life is 36,000hours. Torque at driven shaft is 411 N-m. Driving shaft speed is 475 rpm. Velocity ratio is 4. It is desired to have standard centre distance. Design the gear drive. [AU, N/D 2011]