UNIT – II

SPUR GEARS AND PARALLEL AXIS HELICAL GEARS

GEAR DRIVES:

Introduction:

A Gear drive is a mechanical drive which transmits power through toothed wheels called as gears

In the gear drive arrangement the smaller wheel is named as pinion and the higher wheel is known as wheel or gear regardless of the nature of working such as the smaller wheel may be operated as driving member or driven member as soon.

Classification of Gears:

1, Based on the position of the axes of gear shafts such as
- (a) Parallel :- Ex :- Spur, helical, herring - bone gears.
- (b) Intersecting - Bevel gear
- (c) Non Intersecting and non Parallel - Crossed helical. Worm gear - hypraid, Speraid, Planaid, bevelaid, helican, face gear, etc.

2, Based on the type of engagement
- (a) External gearing
- (b) Internal gearing
- (c) Rack and pinion gear
- (d) Sector gearing.

3, Based On the Position of teeth on the wheel rim.

4, Based on the Pheripheral Speed of gears

(a) Low Speed gears $V < 3 m/s$

(b) Medium Speed gears $3 < V < 15 m/s$

(c) High Speed gears $V > 15 m/s$

5, Based on Profile

(a) Involute Profile gear

(b) Cycloidal Profile gear

(6). Based on Pressure angle

(a) Gears with 20° Pressure angle.

(7) Based on tooth height (or) working deapth.

Design Parameters:

1, Tooth Profile
2, Base Circle
3, pitch Circle
4, Gear centre
5) Line of Centre
6, Addendum Circle
7, Dedendum circle
8, Paint of Contact
9, Patch of Contact
10, Line of action
11, Pressure angle
12, Module
13, Circular Pitch
14, Base Pitch.

15, Diametral Pitch
16, Addendum
17, Dedendum
18, Clearance
19, Tooth height (or) total depth
20, Working depth
21, Face width
22, Face
23, Flank
24, Top Land.
25, Bottom Land
26, Centre distances
27, Height factor
28, Tooth thickness
29, Width of Spaces
30, Back lash
31, Gear ratio.

Contact Ratio:

In a Spur gear drive, when are pinion drivers the wheel the Contact b/w teeth of Pinion and wheel well be gradual from up to food and end of teeth..

The ratio of its length of action to the Circular pitch is Cormed as Contact ratio.

Law of Gearing:

The law of gearing states the for Obtaining a Constant Velocity ratio at any instant of tooth, the Common normal at each Point of Contact should always Pass through the Pitch Point Situated on the Line Joining the Centres of rotation of the Pair of mating gear.

Design Analysis of Spur Gear Drive:

1, Force acting on gear tooth

$$M_t = \frac{60P}{2\pi N}$$

$$T_t = \frac{\text{Torque}}{\text{Pinion radius}} = \frac{M_t}{\frac{d_1}{2}}$$

normal force $F_n = \frac{F_t}{\cos\alpha} = \frac{2M_t}{d_1 \cos\alpha}$

Centre distance $a = \frac{d_2 \pm d_1}{2}$

2, Load Concentrations:

$$k = \frac{\sigma_{max}}{q}$$

3, Dynamic Load

$$k_d = \left(1 + \frac{F_i}{F_a}\right)$$

M_t = Design torque = $M_t k k_d$

4, Induced Stresses an gear tooth:

5, Dynamic effects:

1, For ordinary and Commercialls cut gears made with $V < 10$ m/s

$$C_v = \frac{3}{3+v}$$

2, For accurately hobbed and generated gears with m/s

1, $C_v = \frac{6}{6+v}$

3, For Precision gear with grinding and Lapping Operation

$$C_v = \frac{0.75}{1+v} + 0.25$$

$$F_d = \frac{F_i}{C_w}$$

6) Factor of Safety:

Factor of Safety the bending

$$F_{bending} = \frac{\text{Beam Strength of gear tooth}}{\text{Dynamic load at gear tooth}}$$

The recommented factor of Safety 1.5 to 2

Fos for Pitch

$$S_{pitch} = \frac{\text{Gear Strenth of gear tooth}}{\text{Dynamics load Gear tooth}}$$

7) Problem:

Design a Part of Spur Gears to transmit 20 kw at a Pinion Speed of 1400 rpm, The transmission ratio is 4, which Assume Suitable materials and Stresses.

Solution

Power to be transmitted $P = 20$ kw

Pinion Speed, $n = 1400$ rpm

Gear ratio $i = 4$

$$\text{Gear Speed} = \frac{P}{i} = \frac{1400}{4} = 350 \text{ rpm}.$$

let the arrangement may be external gearing.

Material Selection:

Now the materials for Pinion and Gear are Selected as follow

Name	Material	σ_c in N/mm²	σ_t N/mm²
Pinion	15Ni 2Cr 1 MO15	950	320
Gear	C45	500	340

Minimum Centre distance

$$a \geq i+1 \left[\frac{74}{\sigma_c}\right]^2 \left(\frac{1+m_t}{i4}\right)^{1/2}$$

$E = 2.15 \times 10^5$ N/mm² table 7.14

$\sigma_c = 500$ N/mm².

$i = 4$

$\psi = \frac{b}{a} = 0.3$

$[m_t] = M_t \; k k_c$

$M_t = \frac{60P}{2\pi N}$

$= \frac{60 \times 20000}{2\pi \times 1400}$

$= 136.4$ N

$= 136.4 \times 10^3$ N·mm

$k k_b = 1.3$ initially

$M_t = 136.4 \times 10^3 \times 1.3$

$= 177.3 \times 10^3$ N·mm

Subsuite the above value in the equation

$$a \geq (4+1)\left[\left(\frac{74}{500}\right)^2 \times \frac{2.15\times10^5 \times 117.3\times10^3}{4\times3}\right]^{\frac{1}{3}}$$

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3, Minimum Module

$$m \geq 1.26\left[\frac{M}{\sigma_b\, 4m\, Z}\right]^{1/3}$$

$M = 177.3\times10^3$ N-mm

$\sigma_b = 140$ N/mm^2

$V_{az} = \frac{b}{m} = 10$ (Assumed)

$Z_1 = 20$ Assumed.

$y = 0.389$, $Z_1 = 20$ table 7.18

$$m \geq 1.28\left[\frac{177.3\times10^3}{140\times10\times20\times0.389}\right] \times 3.2$$

$m = 4$ mm from table

$$Z_1 = \frac{2a}{m(i+1)}$$

$Z_1 = 22$ $Z_2 = i\, Z_1$

$= 4\times22 = 88$ teeth.

4, Pitch Circle diameter:

Pitch Circle dia for Pinion $d_1 = m Z_1$

$= 4\times22 = 88$ mm

Gear $d_2 = m Z_1 = 4\times88 = 352$

5, Corrected Centre distance:

$$a = \frac{d_1+d_2}{2} = \frac{88+352}{2} = 220\,\text{mm}$$

6, Face width

$b = \psi a = 0.3 \times 220 = 66 mm$

$b = 4m = 10 \times 4 = 4 mm$

$b = 66$ (Higher Value)

$b/d = \frac{66}{88} = 0.75$

$k = 1.5$

$V = \frac{\pi d_1 n_1}{60 \times 1000}$

$= \frac{\pi \times 88 \times 1400}{60 \times 1000} = 6.45 m/s$

$m_t = m_t \cdot k \cdot k_c$

$= 136.4 \times 10^3 \times 1.05 \times 1.4$

$= 200.5 \times 10^3 N.m$

7, Checking of induced Compressive Stress and bending Stress

$\sigma_c = 0.74 \left(\frac{i+1}{a}\right) \left(\frac{i+1}{ib} \times E m_t\right)^{1/2}$ table

$= 0.74 \left(\frac{4+1}{200}\right) \left(\frac{4+1}{4 \times 66} \times 2.15 \times 10^5 \times 200.5 \times 10^3\right)$

$= 486 N/mm^2$

Wly bending Stress

$\sigma_b = \frac{(i+1) m_t}{a \cdot m \, b \, y}$

$= \frac{4+1 \times 200.5 \times 10^3}{220 \times 4 \times 66 \times 0.402}$

$= 42 N/mm^2$, $\sigma_b = 140 N/mm^2$

8) Other Parameters:

Added $h_i = f_0 m = 1 \times 4 = 4 mm$

$h_f = (f_f + c) m = (1 + 0.25) 4$

$= 5 mm$

Tip Centre dia

$d_b = d_1 + 2h_0$

$= 88 + 2 \times 4$

$= 96 mm.$

Tip Circular dia of Gear

$d_2 = d_2 + 2h$

$= 352 + 2 \times 4 = 366 mm$

Root Circle dia of D = PCD of Dia + 2 ded

$d_1 = d_1 - (2 \times b_1)$

$= 88 - 21.5 = 78 mm$

Root Circle dia of pitch = PCD − 2 × d

$= d_1 - 2 \times b_1$

$= 88 - 2 \times 5 = 78 mm$

Root Circle dia d_2 = PCD of Gear − 2 × ded

$= d_2 - 2 \times b_5$

$= 352 - (2 \times 5) = 342 mm$

$h = h_a + h_f = 4 + 5 = 9 mm$

Result

Description	Pinion	Gear
1, Material	15 Ni 2 Cr Mo Steel	C45 Steel
2, No of teeth	22	88
3, Pitch Circle dia	86 mm	352 mm

Result:

4, Tip Circle dia	96mm	360mm
5, Root Circle dia	78	342 mm
6, face width	66	66
7, Module	4mm	4mm
8, Tooth height	9mm	9mm

9, Centre distance between = 220mm

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Helical Gears

Helical gears are the modified form of Spur gears in which all the teeth are cut a constant angle known as helix angle to the axis of the gear.

Types of helical Gears

1, Parallel helical Gear.

* They operate on two parallel shafts.

2, Crossed helical gears.

Advantages:

1, Noise
2, Load Carrying Capacity
3, Manufacture

Design Procedure:

The steps given below may be observed for the design of helical and herring bone gear.

1, Note down the amount of Pass to be transmitted. Pinion Speed, gear ratio Life of Gear drive and otherwise Condition.

2, Calculate the minimum Centre distance

3, Based on bending Stress evaluate The minimum normal module.

4, Select the nearest standard module

5, Correct the number of teeth of pinion.

6, Determine the Pitch Circle diameter.

7, Decide the Corrected Centre distance

8, Determine the face width of gear teeth

9, Check the induced Compressive Stress and bending Stress with there design value as give in table 7.10

10, Find the essential Parameters of gear drucks

11, Draw the schematic Sketch of helical gear drive heatly.

Problem:

A pair of helical gear is to be designed to transmit 30kw at a pinion speed of 1500rpm. The velocity ratio is 3, selecting suitable materials determine the dimension of the gears

Given Data

Power $P = 30kw$

Pinion Speed $n_1 = 1500 rpm$

Velocity ratio $i = 3$

material for pinion Gear as 15Ni2 Cr1 Mo 15 Steel.

$[\sigma_c] = 950 N/mm^2$

$[\sigma_b] = 320 N/mm^2$

① Minimum Centre distance

$$a \geq (i+1) \sqrt[3]{\left(\frac{7}{\sigma_b}\right)^2 \frac{E(M)}{i_4}}$$

table 7.8

$M_t = M_t \, k \, k_d.$

$$M_t = \frac{60P \times 10^6}{2\pi N}$$

$$= \frac{60 \times 30 \times 10^6}{2\pi \times 1500}$$

$k k_d = 1.3$

$M_t = M_t k k_d$

$= 191 \times 10^3 \times 1.3$

$= 248 \times 10^3 \ N \cdot mm$

$\psi = \frac{b}{a} = 0.5$ and $E = 2.15 \times 10^3 \ N/mm^2$

$$a \geq 3+1 \sqrt{\left(\frac{7}{950}\right)^2 \times \frac{2.15 \times 10^3 \times 248 \times 10^3}{3 \times 0.5}}$$

$\geq 108 \ mm$

To find module

$$m_n \geq 1.15 \cos\beta \sqrt[3]{\frac{M_t}{y(\sigma_b)\psi_n z_1}}$$

$Z_1 = 20$

$\psi_m = \frac{b}{m} = 10$ Assumed.

β = helix angle $= 20°$

$$Z = \frac{Z_1}{\cos^3\beta} = \frac{20}{\cos^3 20} = 24.1$$

y_v for $Z_{v_1} = 24 = 0.414$

$$m_n \geq 1.15 \cos 20 \times \sqrt{\frac{248 \times 10^3}{414 \times 320 \times 10 \times 20}}$$

$\geq 2.3 \ mm$

To find out the number of teeth of Pinion and gear

$$Z_1 = \frac{2a \cos\beta}{m_c (C+1)}$$

$$= \frac{2 \times 108 \times \cos 20'}{2.5(3+1)}$$

$$= 20.3 = 22$$

$$Z_2 = i Z_2 = 3 \times 22 = 66$$

To find Corrected Centre distance

$$a = \frac{m_n}{\cos \beta}\left(\frac{z_1 + z_2}{2}\right) = \frac{2.5}{\cos 20}\left(\frac{22+66}{2}\right)$$

$$= 1107 \text{ mm}$$

Since this Corrected Centre distance is more than its minimum Value are design is Centre

To Check Induced Stress

$$\sigma_c = 7\left(\frac{i+1}{a}\right)\sqrt{\frac{1+C}{ib} \times E (m_t)}$$

$$b = \psi\ a = 0.5 \times 117 = 58.5 \text{mm}$$

$$b = \psi_m\ m_n = 10 \times 2.5 = 25 \text{mm}$$

$$\sigma_c = 7\left(\frac{3+1}{1107}\right)\sqrt{\frac{3+1}{3 \times 60} \times 2.15 \times 10^6 \times 248 \times 10^3}$$

$$= 824 \text{N/mm}^2 < \sigma_c = 950 \text{N/mm}^2$$

$$\sigma_c = \frac{7(i+1) m_t}{a b m_n \psi_n}$$

$$z_1 = 28.5 \text{ is } 0.427$$

$$\sigma_b = \frac{7 \times (3+1) \times 248 \times 10^3}{117 \times 60 \times 2.5 \times 0.427}$$

$= 92.7\ N/mm^2 \leq \sigma_b\ 320\ N/mm^2$

Pitch Circle dia of Pinion

$$d_1 = \frac{m_n}{\cos\beta} \times Z_1 = \frac{2.5}{\cos 20} \times 22 = 58.5mm$$

$$d_2 = \frac{m_n}{\cos\beta} \times Z_2 = \frac{2.5}{\cos 20} \times 66 = 175.5mm$$

Addendum $h_a = m_n = 2.5mm$

Deddendum $h_f = 1.25 m_n = 1.25 \times 2.5$

$= 3.125mm$

T. P Circle dia of

$d_{a_1} = d_1 + 2h_a$

$= 58.5 + (2 \times 2.5)$

$= 63.5mm$

$d_{a_2} = d_2 + 2h_a$

$d_{a_2} = 180.5mm$

Root Circle dia of Pinion $d_1 = d_1 - 2h_f$

$= 38.5 - (2 \times 3.125)$

$= 52.25$

$d_1 = d_1 - 2h_f$

$= 58.5 - 2 \times 3.125$

$= 52.25$

$d_2 = d_2 - 2h_f$

$= 175.5 - (2 \times 3.125)$

$= 169.25mm$

Result:

Sl No	Description	Pinion	Gear
1,	Material	13 Ni2Cr1mo15	15Ni2Cr1 mo15
2,	No. of teeth	22	66
3,	Pitch Circle dia	58.5mm	175.5 mm
4,	Tip Circle dia	63.5mm	180.5mm
5,	Root Circle dia	52.25mm	169.25 mm
6,	Face Width	60mm	60mm
7,	Normal module	2.5	2.5

8, Centre distance = 117mm

9, Helix angle = 20°

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