Helical Gears

- For parallel shafts, opposite hand gears are needed.
- For perpendicular shafts, same hand gears are needed.

Advantages of Helical Gears Over Spur Gears

- Smoother engagement of the gear teeth.
- More teeth carry load at a given time so they are more efficient – carry more load for a given size.

Geometry

Tangent Plane
Transverse Plane
Normal Plane

$$\psi = \text{Helix angle} \quad 15^\circ - 45^\circ$$

$$\phi_t = \text{Transverse Pressure angle}$$

$$\phi_n = \text{Normal Pressure angle}$$

$$\tan \phi_n = \tan \phi_t \cdot \cos \psi$$

Pitches

- **Circular Pitch** – distance from a point on a tooth to corresponding point on next tooth
  \[ p = \pi \frac{D}{N} \]
- **Normal Circular Pitch** – distance between corresponding points on adjacent teeth measured on pitch surface in normal direction
  \[ p_n = p \cos \psi \]
- **Diametral Pitch** – ratio of number of teeth in the gear to the pitch diameter.
  \[ P_d = \frac{N}{D} \]

More Pitches

- **Normal Diametral Pitch** – diametral pitch in normal direction
  \[ P_{nd} = P_d / \cos \psi \]
- **Axial Pitch** – distance between corresponding points on adjacent teeth measured in the axial direction. Need \( P_x \geq 2 \) for full helical action.
  \[ P_x = \frac{p}{\tan \psi} = \frac{\pi}{P_d \tan \psi} \]

Forces on Helical Gear Tooth

\[ W_t = \frac{33000(P)}{v_t} \]

- **Tangential Load**
- **Power transmitted (hp)**
- **Pitch line speed (ft/min)**

\[ W_x = W_t \tan \psi \]

\[ W_e = W_t \tan \phi_t \]
Forces on Helical Gear Tooth

**Driving Gear**

- \( W_t \) from the pinion on the gear pushes the gear in the driven direction.
- \( W_t \) from the gear on to the pinion is a reaction force.

**Driven Gear**

- \( W_x \) is ALWAYS perpendicular to the tooth.

Biggest Disadvantage of Using Helical Gears

- Axial Force, \( W_x \) – called axial thrust load

Helical Gear Design

- Everything for helical gear design is essentially the same as it was for spur gears. The fundamental difference is the \( J \) and \( I \) factors.
Gear Design Problem w/ Helical Gears

- Parameters:
  \[ P_d = 6 \text{T/in} \]
  \[ N_p = 24 \text{T} \quad N_G = 138 \text{T} \]
  \[ F = 2.00 \text{ in} \]

- Spur Gear Results:
  \[ S_{ap} = 22710 \text{ psi} \]
  \[ S_{acp} = 123053 \text{ psi} \]
  Assume helix angle = 15 deg.

New J-Factor for Pinion

- Fig. 10-6a, Pg 457
  \[ J = 0.48 \]

- Fig. 10-6b, Pg 457
  \[ J = 1.017 \times 0.48 = 0.49 \]

Tooth Bending Stress in Pinion

\[
S_{ip} = \frac{W_i P_d K_s K_b K_n K_v}{F J_p} \\
= \frac{(970 \text{ lbs})(6 \text{ T/in})}{(2.00^\circ)(0.49)} \\
= 16823 \text{ psi}
\]

\[ \frac{16823}{22710} = 74\% \]

Pitting Resistance Factor, I

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<thead>
<tr>
<th>Gear teeth</th>
<th>Pinion teeth</th>
</tr>
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<tbody>
<tr>
<td>17</td>
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</tbody>
</table>

\[ S_c = C_r \sqrt{\frac{W_i K_s K_b K_n K_v}{F D_i}} \]

\[ S_c = 2300 \sqrt{\frac{970 \text{ lbs})(1.75)(1)(1.2)(1.349)}{(2.00^\circ)(4.00^\circ)(0.24)}} \]

\[ = 86830 \text{ psi} \]

\[ \frac{86830}{123053} = 71\% \]