Engineering Information

Helical Gears

Gear Nomenclature

The information contained in the Spur Gear section is also pertinent to Helical Gears with the addition of the following:

HELIX ANGLE (ψ) is the angle between any helix and an element of its cylinder. In helical gears, it is at the pitch diameter unless otherwise specified.

LEAD (L) is the axial advance of a helix for one complete turn, as in the threads of cylindrical worms and teeth of helical gears.

NORMAL DIAMETRAL PITCH (P_n) is the Diametral Pitch as calculated in the normal plane.

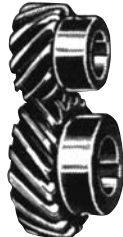HAND – Helical Gears of the same hand operate at right angles, see Fig. 1
Helical Gears of opposite hands run on parallel shafts. Fig. 2

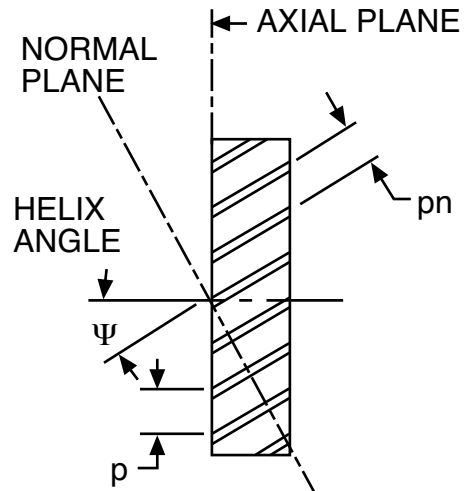| TWO RIGHT-HAND HELICAL GEARS	TWO LEFT-HAND HELICAL GEARS	LEFT-HAND AND RIGHT-HAND HELICAL GEARS
Figure 1		**Figure 2**

Helix Angle—

p = AXIAL CIRCULAR PITCH
pn = NORMAL CIRCULAR PITCH

All Boston Helicals are cut to the Diametral Pitch system, resulting in a Normal Pitch which is lower in number than the Diametral Pitch.

INVOLUTE—The Helical tooth form is involute in the plane of rotation and can be developed in a manner similar to that of the Spur Gear. However, unlike the Spur Gear, which may be viewed as two-dimensional, the Helical Gear must be viewed as three-dimensional to show change in axial features.

Helical gears offer additional benefits relative to Spur Gears, those being:
- Improved tooth strength due to the elongated helical wrap-around.
- Increased contact ratio due to the axial tooth overlap.
- Helical Gears thus tend to have greater load carrying capacity than Spur Gears of similar size.
- Due to the above, smoother operating characteristics are apparent.

LEFT HAND HELICAL GEAR

The teeth of a LEFT HAND Helical Gear lean to the left when the gear is placed flat on a horizontal surface.

RIGHT HAND HELICAL GEAR

The teeth of a RIGHT HAND Helical Gear lean to the right when the gear is placed flat on a horizontal surface.

Helical Gear Formulas

To Obtain	Having	Formula
Transverse Diametral Pitch (P)	Number of Teeth (N) & Pitch Diameter (D)	$P = \dfrac{N}{D}$
	Normal Diametral Pitch (P_n) Helix Angle (ψ)	$P = P_N Cos\psi$
Pitch Diameter (D)	Number of Teeth (N) & Transverse Diametral Pitch (P)	$D = \dfrac{N}{P}$
Normal Diametral Pitch (P_N)	Transverse Diametral Pitch (P) & Helix Angle (ψ)	$P_N = \dfrac{P}{Cos\psi}$
Normal Circular Tooth Thickness (τ)	Normal Diametral Pitch (P_N)	$\tau = \dfrac{1.5708}{P_N}$
Transverse Circular Pitch (p_t)	Diametral Pitch (P) (Transverse)	$p_n = \dfrac{\pi}{P}$
Normal Circular Pitch (p_n)	Transverse Circular Pitch (p)	$pt = p_t Cos\psi$
Lead (L)	Pitch Diameter and Pitch Helix Angle	$L = \dfrac{\pi D}{Tan\psi}$

Transverse Vs. Normal Diametral Pitch for Boston 45° Helical Gears

P Transverse Diametral Pitch	P_N Normal Diametral Pitch
24	33.94
20	28.28
16	22.63
12	16.97
10	14.14
8	11.31
6	8.48

Helical Gear Lewis Formula

The beam strength of Helical Gears operating on *parallel shafts* can be calculated with the Lewis Formula revised to compensate for the difference between Spur and Helical Gears, with modified Tooth Form Factors Y.

$$W = \frac{SFY}{P_N} \left(\frac{600}{600 + V} \right)$$

W = Tooth Load, Lbs. (along the Pitch Line)
S = Safe Material Stress (static) Lbs. per Sq. In. (Table III)
F = Face Width, Inches
Y = Tooth Form Factor (Table IV)
P_N = Normal Diametral Pitch (Refer to Conversion Chart)
D = Pitch Diameter
V = Pitch Line Velocity, Ft. Per Min. = .262 x D x RPM

Table III – Values of Safe Static Stress (s)

Material	(s) Lb. per Sq. In.
Bronze	10000
Cast Iron	12000
Steel { .20 Carbon (Untreated)	20000
.20 Carbon (Case-hardened)	25000
.40 Carbon (Untreated)	25000
.40 Carbon (Heat-treated)	30000
.40 C. Alloy (Heat-treated)	40000

Table IV – Values of Tooth Form Factor (Y)

FOR 14-1/2°PA—45° HELIX ANGLE GEAR			
No. of Teeth	Factor Y	No. of Teeth	Factor Y
8	.295	25	.361
9	.305	30	.364
10	.314	32	.365
12	.327	36	.367
15	.339	40	.370
16	.342	48	.372
18	.345	50	.373
20	.352	60	.374
24	.358	72	.377

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Horsepower and Torque

Max. allowable torque (T) that should be imposed on a gear will be the safe tooth load (W) multiplied by $\dfrac{D}{2}$ or $T = \dfrac{W \times D}{2}$

The safe horsepower capacity of the gear (at a given RPM) can be calculated from $HP = \dfrac{T \times RPM}{63,025}$ or directly from (W) and (V);

$$HP = \frac{WV}{33,000}$$

For a known HP, $T = \dfrac{63025 \times HP}{RPM}$

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Helical Gears

When Helical gears are operated on other than Parallel shafts, the tooth load is concentrated at a point, with the result that very small loads produce very high pressures. The sliding velocity is usually quite high and, combined with the concentrated pressure, may cause galling or excessive wear, especially if the teeth are not well lubricated. For these reasons, the tooth load which may be applied to such drives is very limited and of uncertain value, and is perhaps best determined by trial under actual operating conditions. If one of the gears is made of bronze, the contact area and thereby the load carrying capacity, may be increased, by allowing the gears to "run-in" in their operating position, under loads which gradually increase to the maximum expected.

Thrust Loads

As a result of the design of the Helical Gear tooth, an axial or thrust load is developed. Bearings must be adequate to absorb this load. The thrust load direction is indicated below. The magnitude of the thrust load is based on calculated Horsepower.

$$\text{Axial Thrust Load} = \frac{126,050 \times HP}{RPM \times Pitch\ Diameter}$$

Boston Helicals are all 45° Helix Angle, producing a tangential force equal in magnitude to the axial thrust load. A separating force is also imposed on the gear set based on calculated Horsepower.

Separating Load = Axial Thrust Load x .386

Above formulae based on Boston 45° Helix Angle and 14-1/2° Normal Pressure Angle.
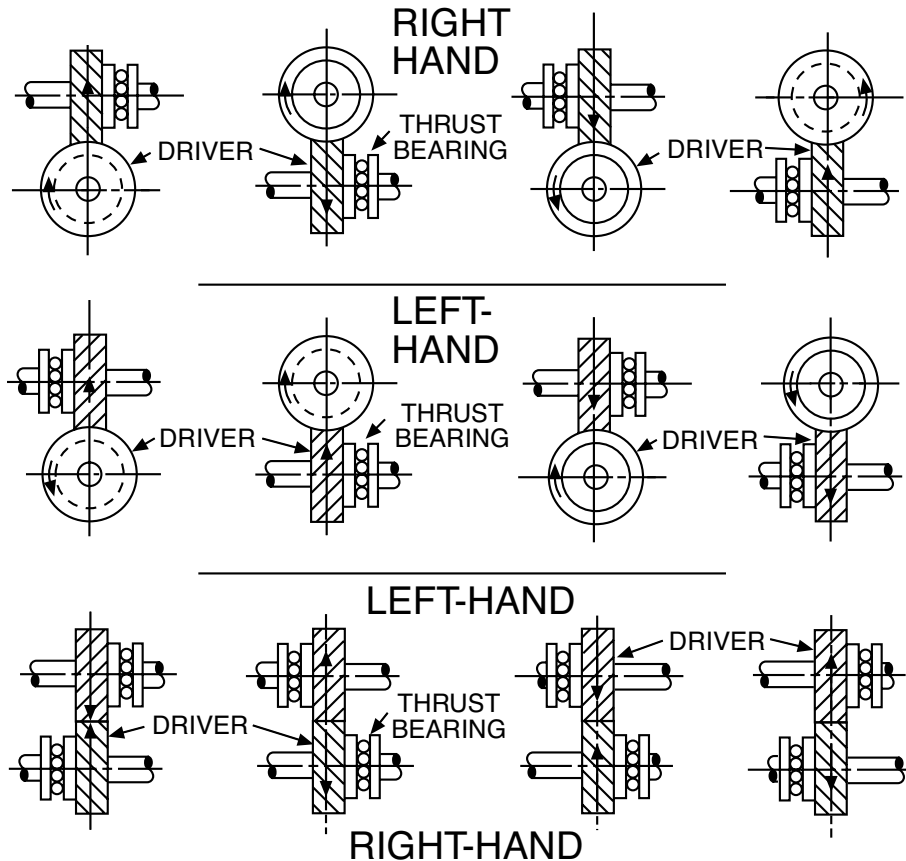
See page 118 for hardened and ground Thrust Washers.