Lecture - 2

Design of a Helical-Bevel Gear Box

Part-II

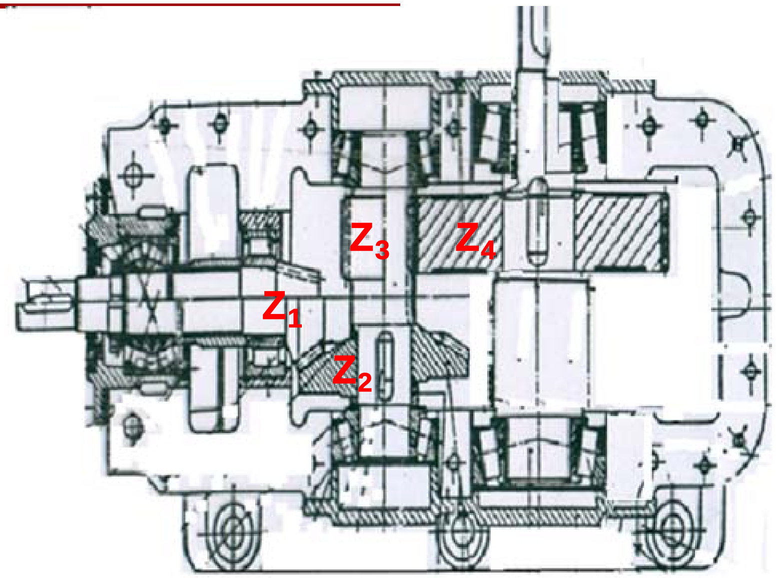
(March 20, 2017)

Design of Helical & Bevel Gears and Layout of Gear Box

Design of an Industrial General Purpose Reduction Gear Unit :

Tasks (contd....) :

Data: The TWO- stage (1st stage Bevel and 2nd. Stage helical) reduction gear box has the following specifications.
(20 to 22 different problems).



Assembled plan view
(Not of the same one as below)

GROUP	POWER (kW)	INPUT RPM	OUTPUT RPM	DUTY		OVERHAUL TIME	LUBRICATION
				Sub Group	Description		
I A, B, C, D,	12	1500	170	A,E,I,M, Q, U	Precision, Intermittent, No shock	2 years	Forced
I I E, F,G,H	10	1800	200	B,F,J,N,R	General, Continuous, Medium shock		Oil Sump
I I I I, J, K, L	09	1450	125	C,G,K,O, S, V	General, Intermittent, Heavy Shock		Oil Sump
IV M,N,O,P	07	1200	125	D,H,L,P,T	Precision, Continuous, Medium Shock		Forced
V Q,R,S,T	05	1500	140				
VI U, V	06	950	100	Horizontal input and vertical output (Forced Lubrication)			

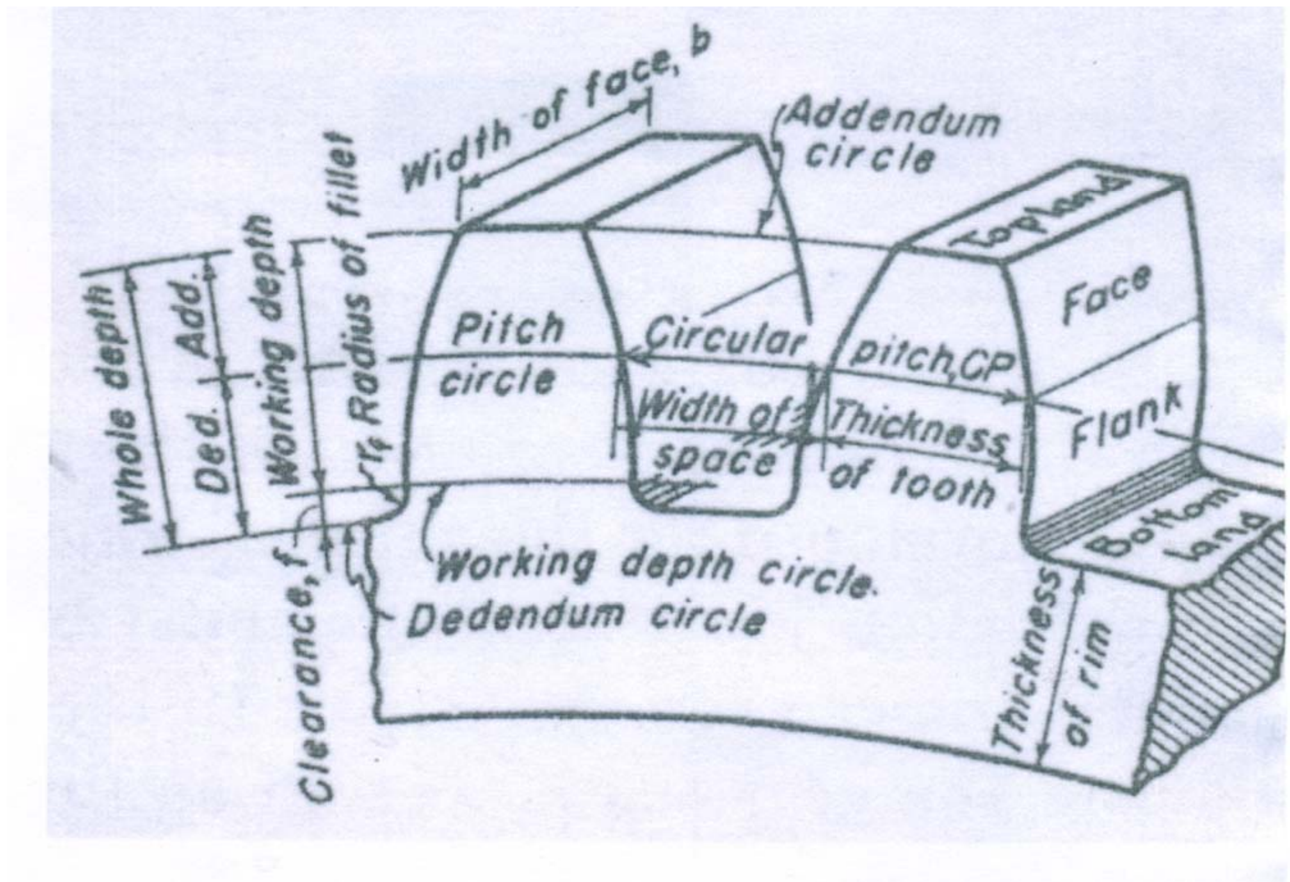
Photographic view of 2-stage (Bevel Helical) gear box.
(Top cover open)

Horizontal Input-Output.

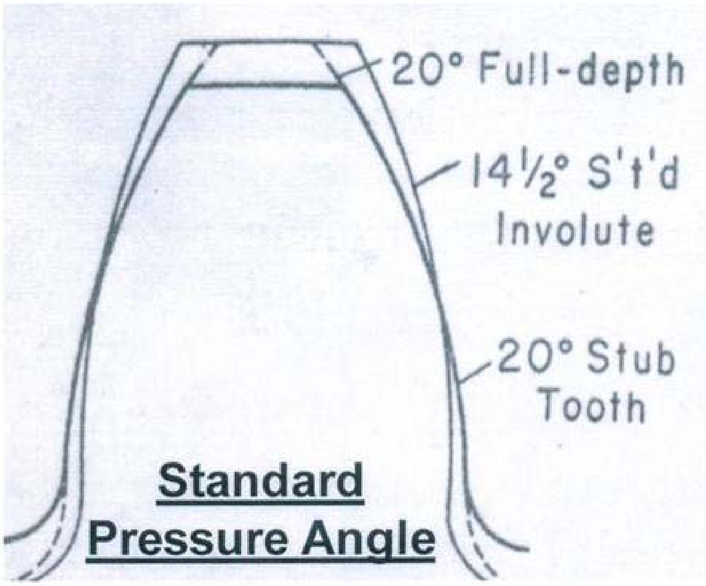
1st. stage ratio should not exceed 3.

In general non co-axial horizontal input and output (except otherwise mentioned).

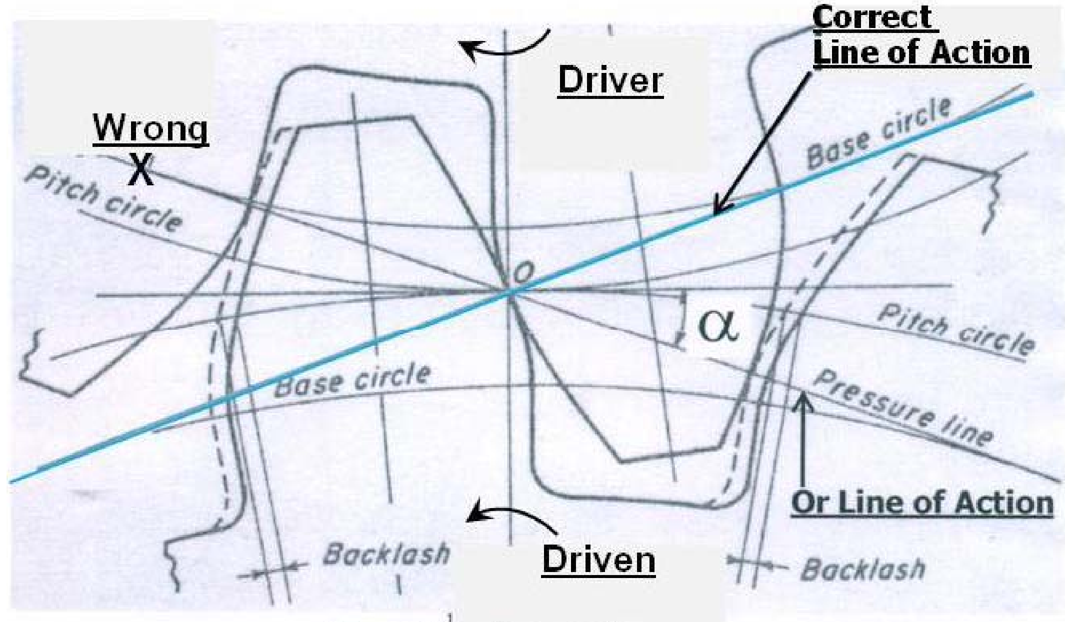
Gear Tooth Terminology



Gear Tooth Terminology (Contd.)



An Involute Tooth



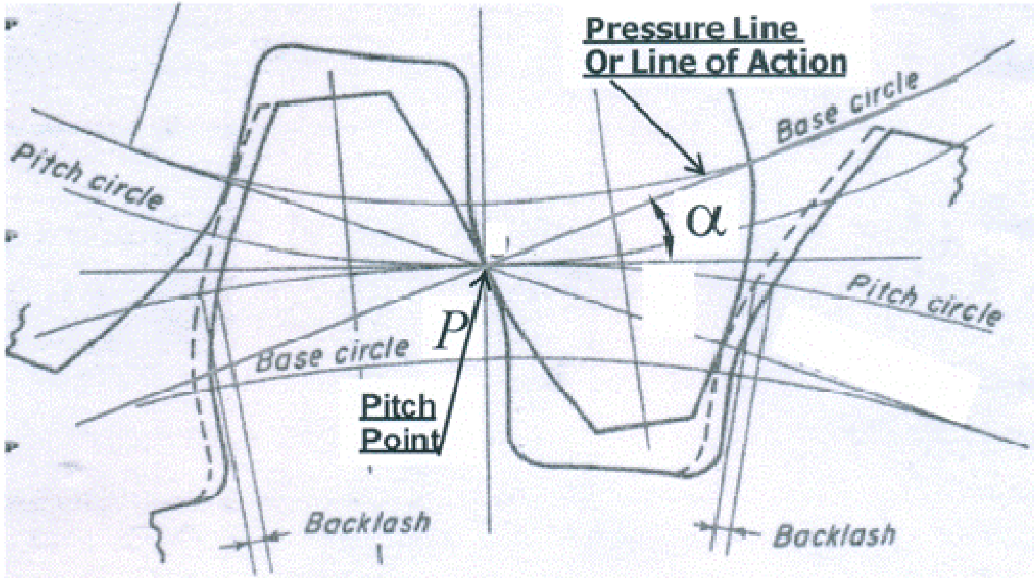
Gear Tooth mesh

<u>Pressure Angle</u> (α) : Also known as 'angle of obliquity', is the inclination of the "line of action" of the contact force between a pair of meshing teeth with respect to a line drawn tangent to pitch circles at pitch point.

[Note- Working pressure angle may be different from standard pressure angle].

Direction of 'line of action' depends on driver & driven gears and their directions of rotation.

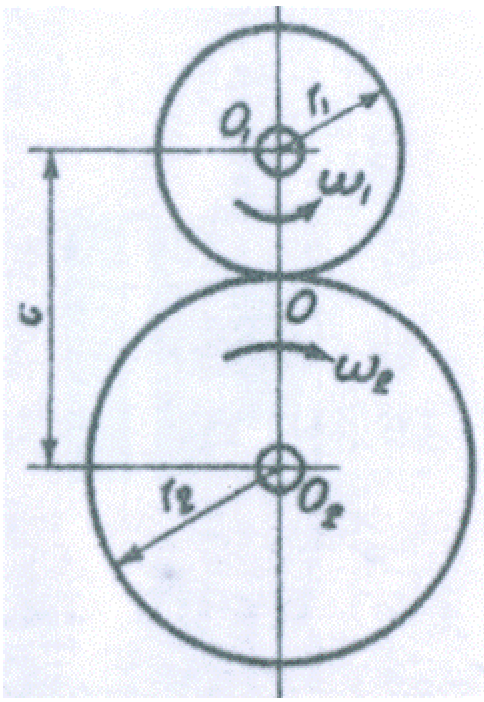
Gear Tooth Terminology (Contd.)



Base Circle: It is an auxiliary circle used in involute gearing to generate tooth profiles.

Line of actions a common tangent, which passes through the pitch point, both base circles.

[Note: *For a particular generated involute gear the base circle remains fixed and can be considered as reference.*]



Pinion & Gear: In a pair of gears in mesh smaller one is called 'Pinion' and the bigger one is called 'Gear' irrespective of any of them is driver or driven.

Gear Tooth Terminology (Contd.)

Module (m) : **Pitch circle diameter / Number of teeth.**

It is standardized and expressed in mm.

[Note: In case of helical teeth 'normal module' m_n (i.e., module in normal direction is standard one].

It is followed in Metric and SI unit system.

Standard Module: 1, (1.25), 1.5, 2, 2.5, 3, 3.5, 4, 4.5
5 6 7 8 10 12 15 17 20 25

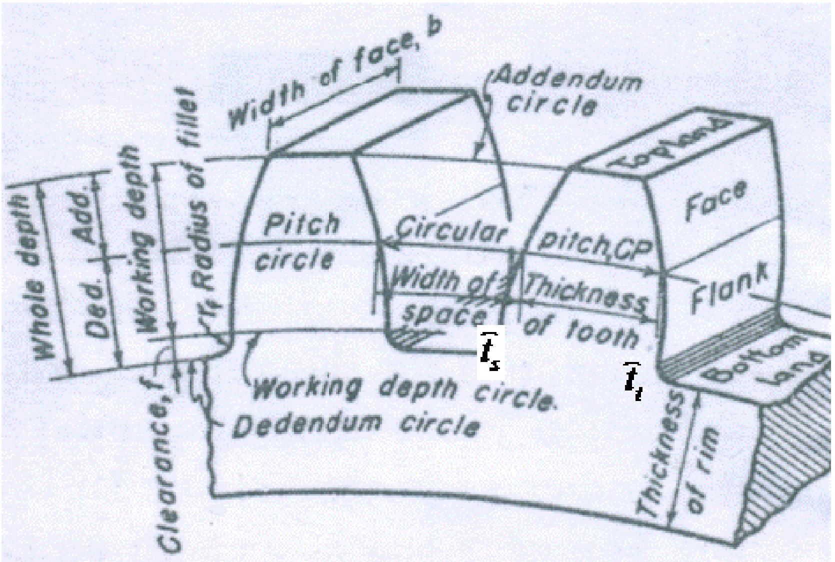
Diametral Pitch (DP) : **Average number of teeth per unit length (inch) of pitch circle diameter.**

To compare with module system 1"/DP i.e., 25.4/DP gives a value close to a standard module.

Standard **1, 2, 3, 4, ... 25**

Involute Toothed Gear : Fundamental Relations :

Referring to straight tooth spur Gear:



Pitch diameter

$$d_p = 2r_p = Z \times m$$

Circular pitch (arc)

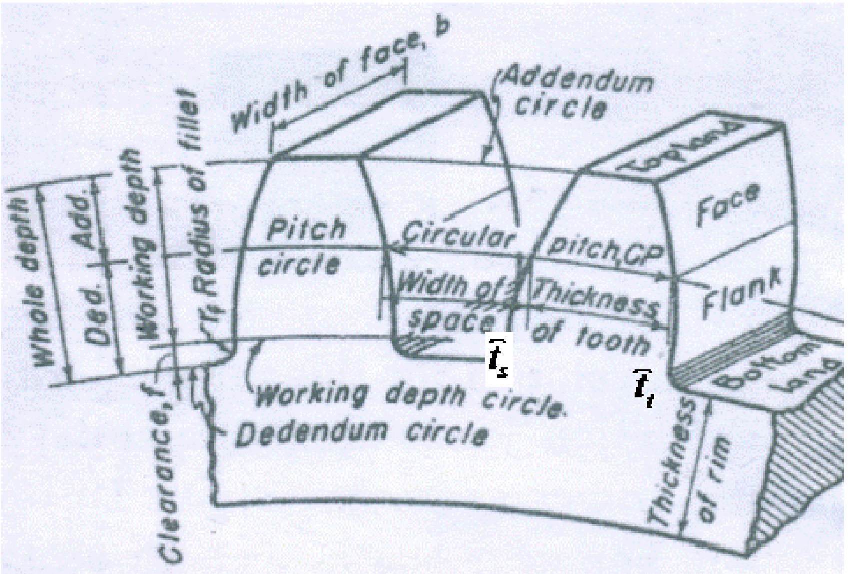
$$\widehat{p}_c = 2\pi r_p / Z = \pi m$$

Base circle radius

$$r_b = r_p \cos \alpha$$

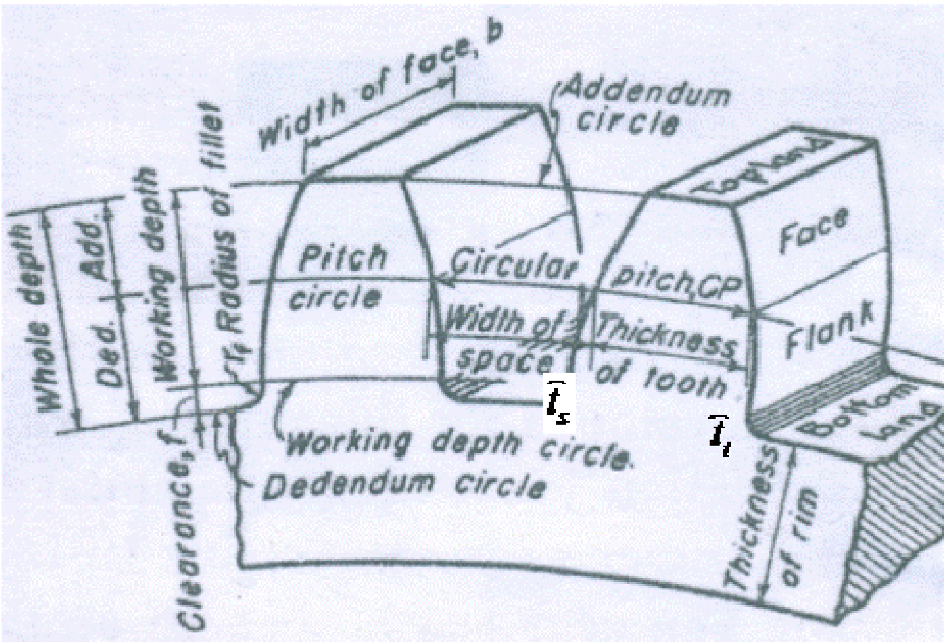
Involute Toothed Gear : Fundamental Relations (Contd.):

Referring to straight tooth spur Gear:

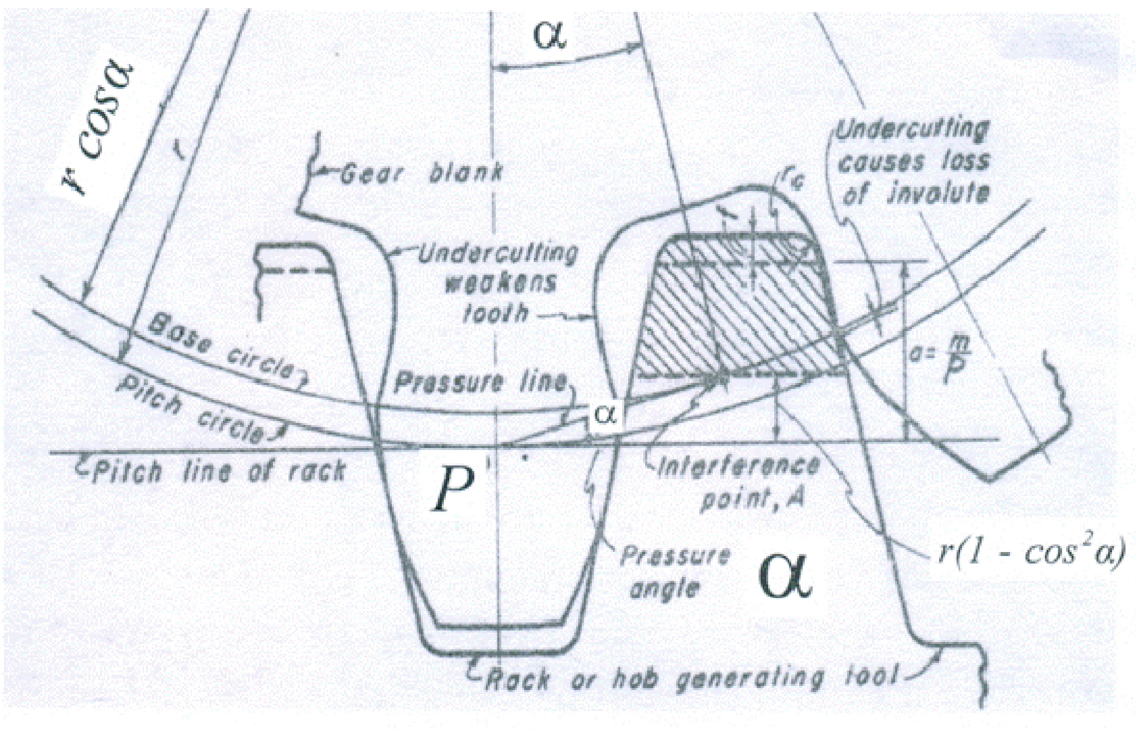


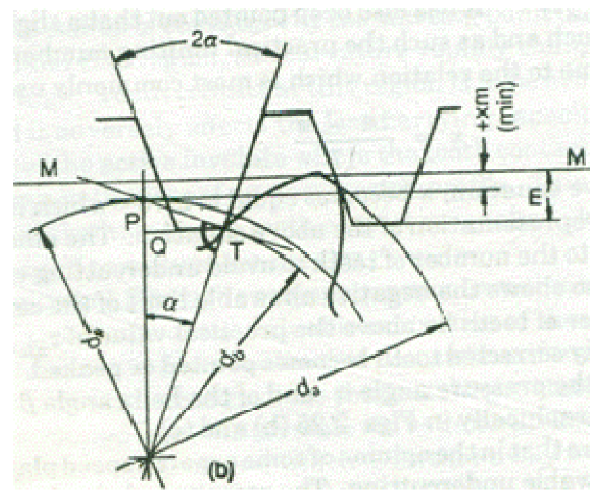
Involute Toothed Gear : Fundamental Relations (Contd.): Recapitulation :

Referring to straight tooth spur Gear:



Minimum Number of Teeth in a Gear, Interference and Undercut



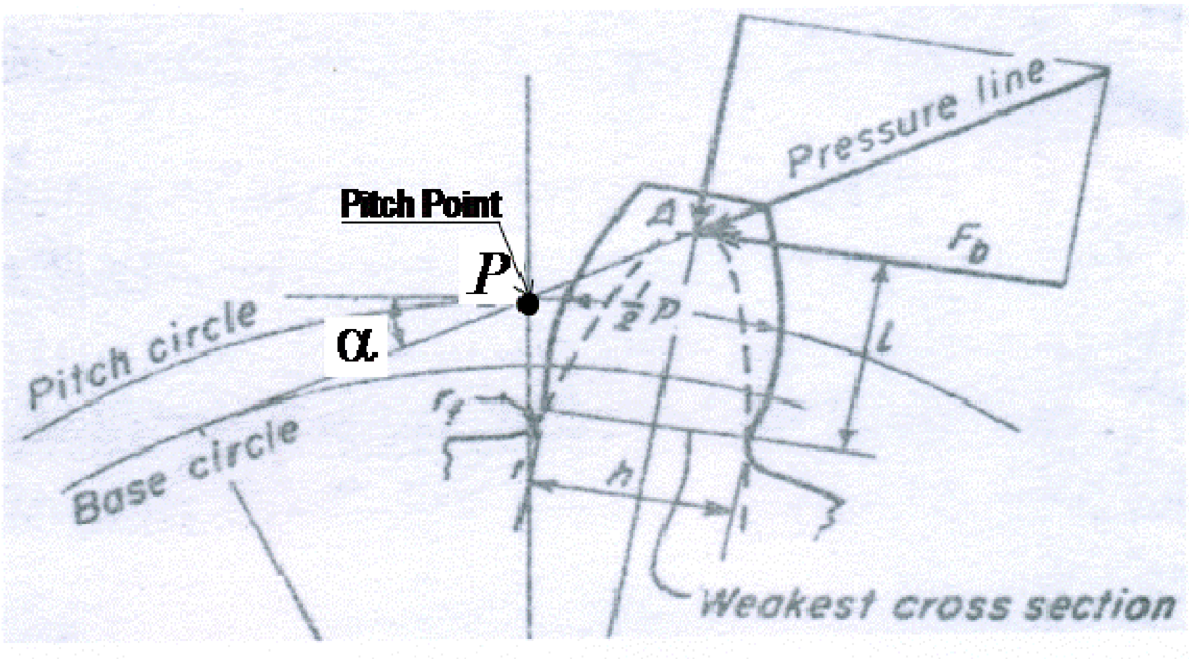


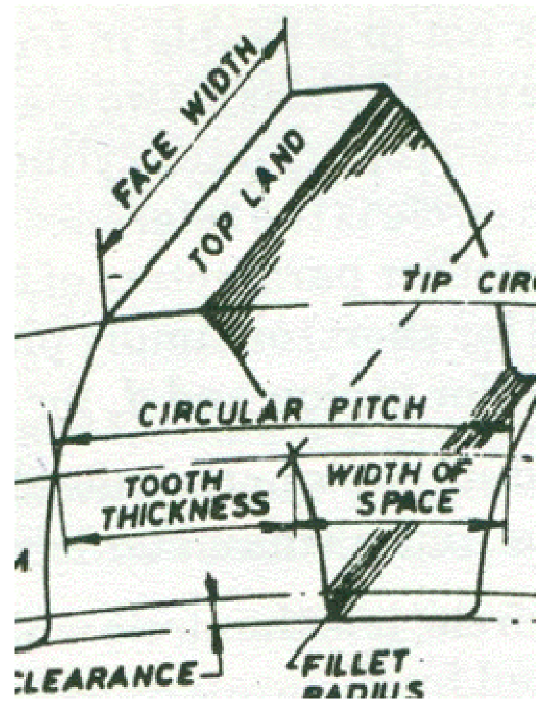
$$Z_c = \frac{2a_f}{\sin^2 \alpha}$$

Gear Design

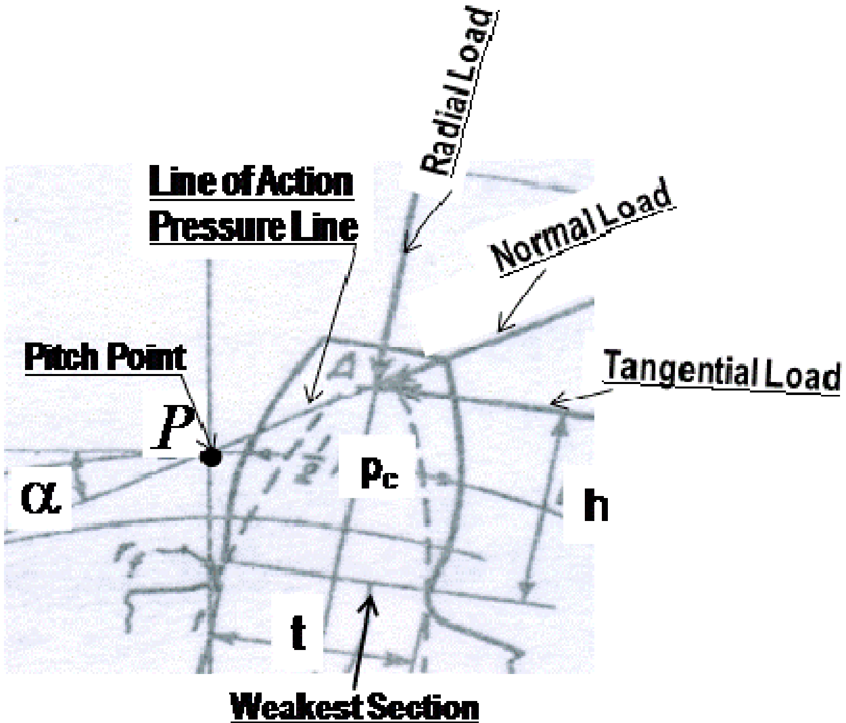
Straight Tooth Spur Gear

Strength of gear teeth-Lewis equation





Strength of gear teeth-Lewis equation



Stress at root

$$\sigma = \frac{6M}{bt^2} = \frac{6F_t h}{bt^2}$$

Where, b is the width of gear.

$$\frac{t^2}{6h} = Ym$$

Y is called the Lewis form factor

Strength of gear teeth-Lewis equation

Y Lewis form factor

$$Y = 0.484 - 3.28 / Z'$$

Z' Formative number of teeth.

$$F_t = \sigma b Y m$$

Introducing Allowable Strength
And velocity factor

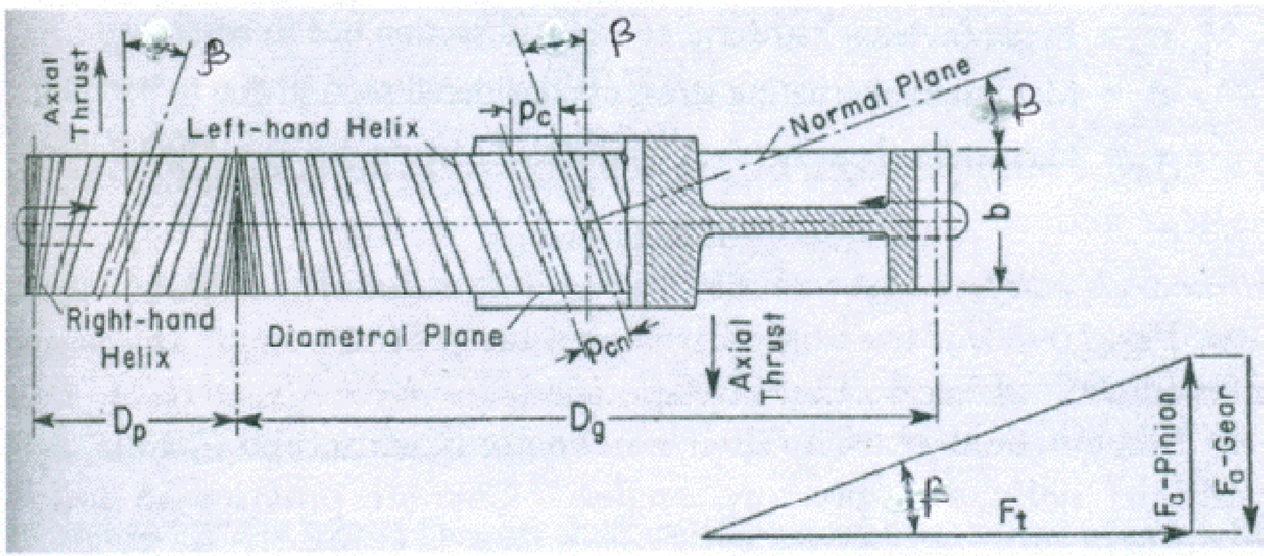
$$F_t = S_o c_v b Y m$$

Gear Design

Helical Tooth Spur Gear

Design of Helical Gear

Pitch Diameter of Helical Gear



Plan view of a Helical Gear Pair in Contact

Z' Formative number of teeth is expressed as:

$$Z' = \frac{Z}{\cos^3 \beta}$$

Design of Helical Gear

Design of first stage gear set:

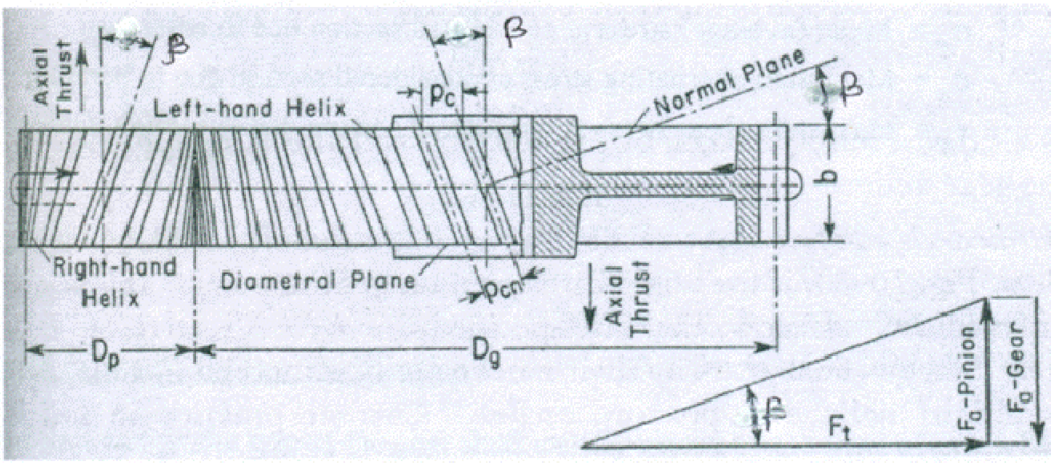
Module on the basis of bending strength:

The Lewiss Formula for module calculation.

$$m_n = \sqrt[3]{\frac{2T\cos\beta}{\frac{S_d}{c_v c_w}\psi Y Z}}$$

Design of Helical Gear

Centre Distance of Mating Helical Gear Pair



Plan view of a Helical Gear Pair in Contact

$$D_p = \frac{Z_p p_c}{\pi} = \frac{Z_p p_n}{\pi \cos \beta}$$

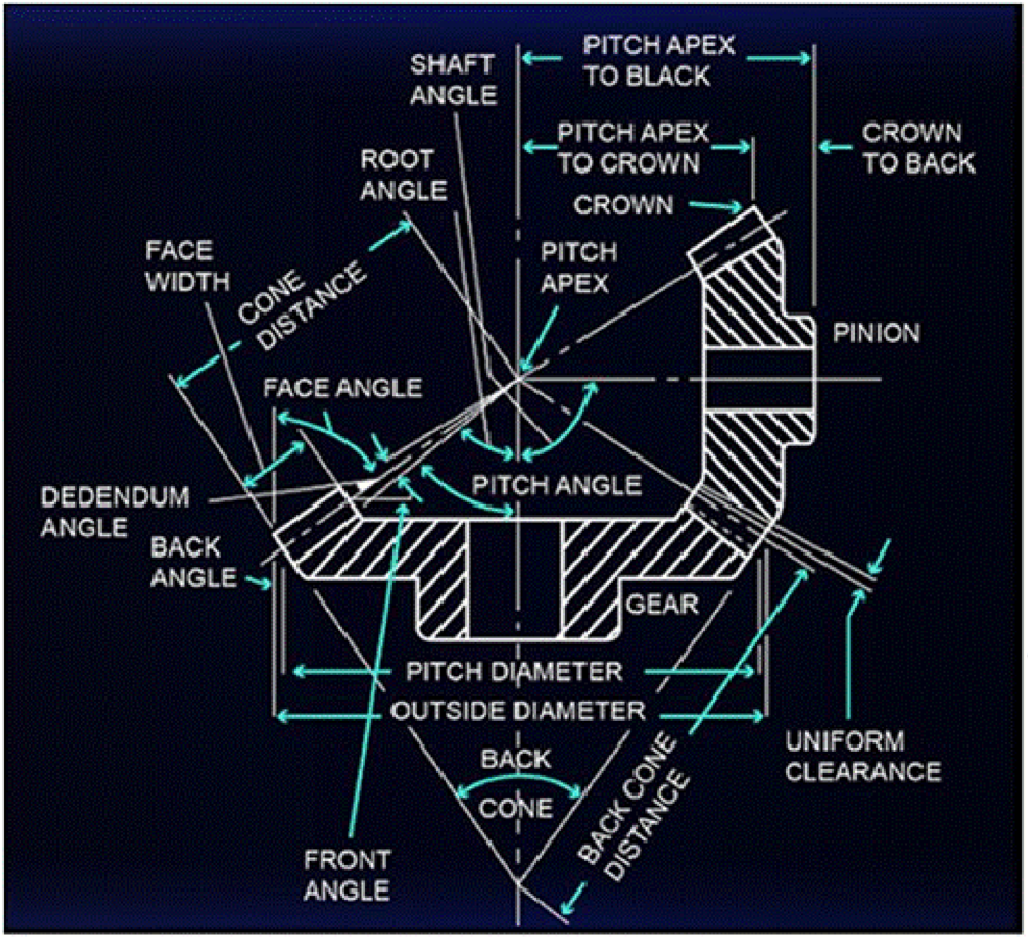
$$D_g = \frac{Z_g p_c}{\pi} = \frac{Z_g p_n}{\pi \cos \beta}$$

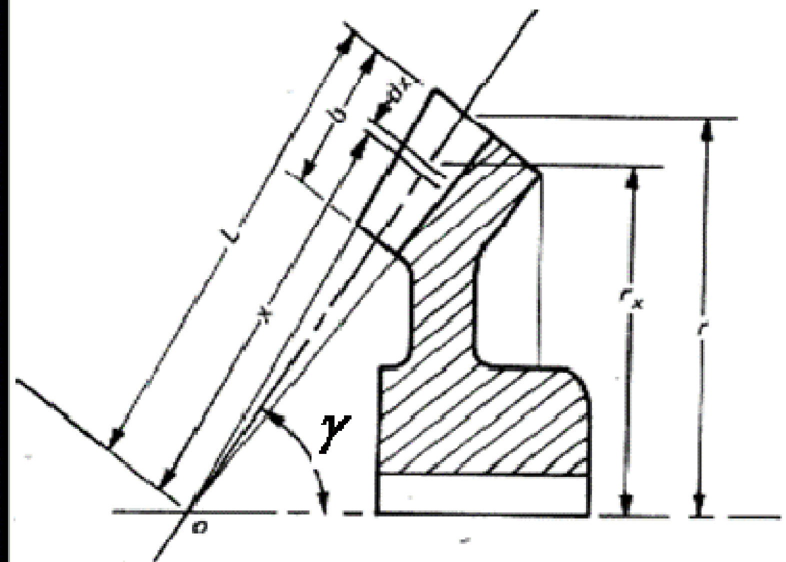
$$A = (D_p + D_g)/2 \qquad A = \frac{m_n}{2 \cos \beta}\left(Z_p + Z_g\right)$$

Gear Design

Straight Tooth Bevel Gear

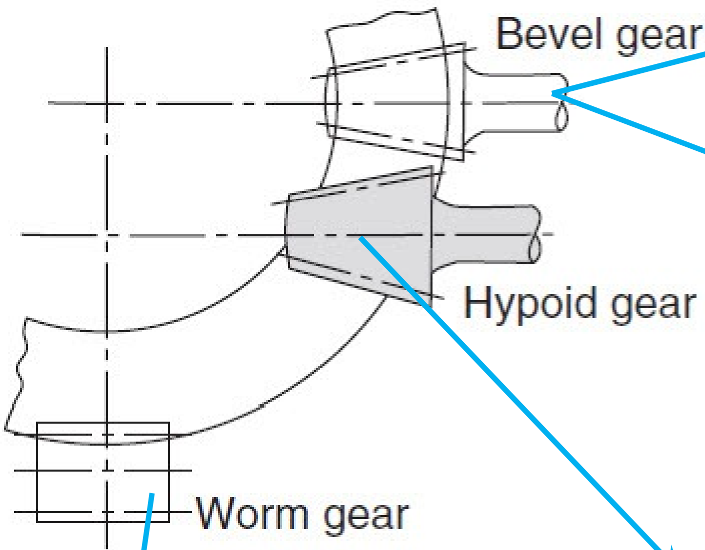
Bevel Gear Nomenclature & Terminology :



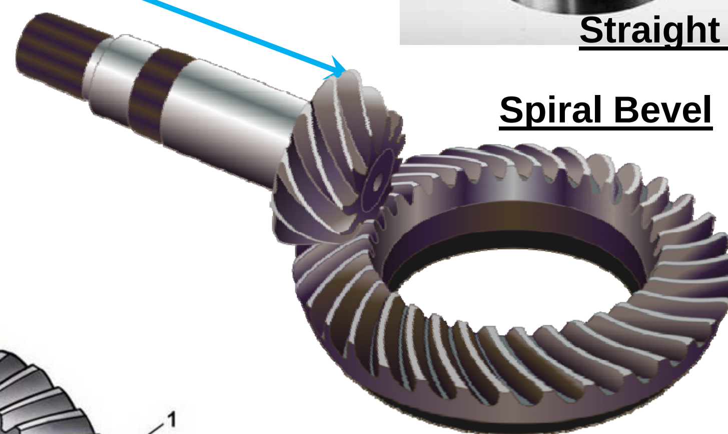


Straight Tooth Bevel Gear.

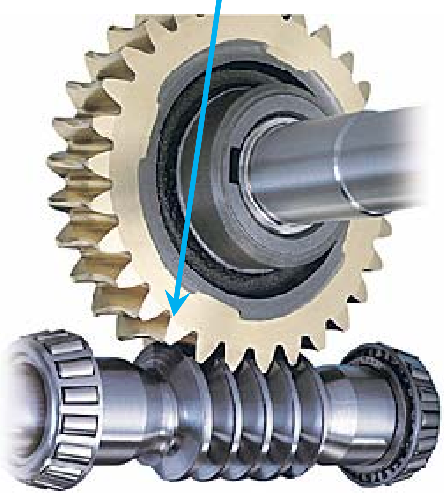
Different Type of Bevel Gears:



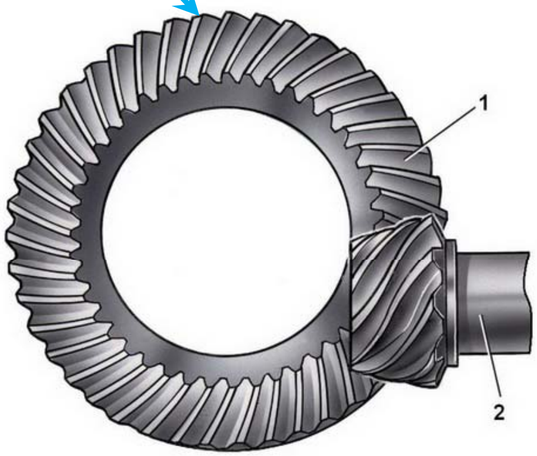
Straight Bevel



Spiral Bevel



Worm & Worm Wheel



Hypoid Bevel

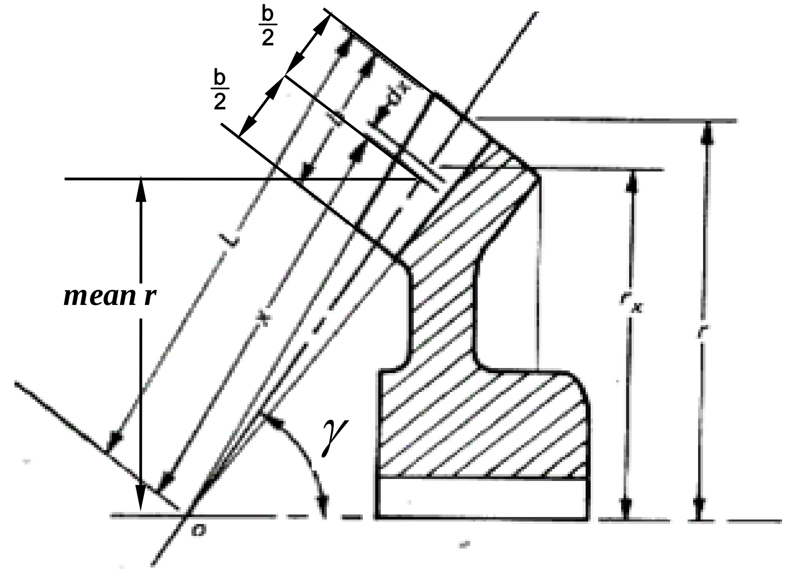
Herringbone Bevel

Straight Bevel Gear Design:

Module (m, in meter) can be estimated as:

For straight tooth bevel gear:

$$m_{bevel} = \sqrt[3]{\frac{2T}{\frac{S_d}{c_v c_w} ZY\psi(1-\psi_o)}}$$



Mean PCD (Straight Bevel)

$$= 2 \times mean\ r = Z \times m_{bevel}$$

Other relations.

$$\gamma_p + \gamma_g = 90^o$$

And,

$$\sin\gamma_p / \sin\gamma_g = Z_p / Z_g$$

Straight Tooth Bevel Gear.

Design of a Bevel- Helical Two Stage Gear Box:

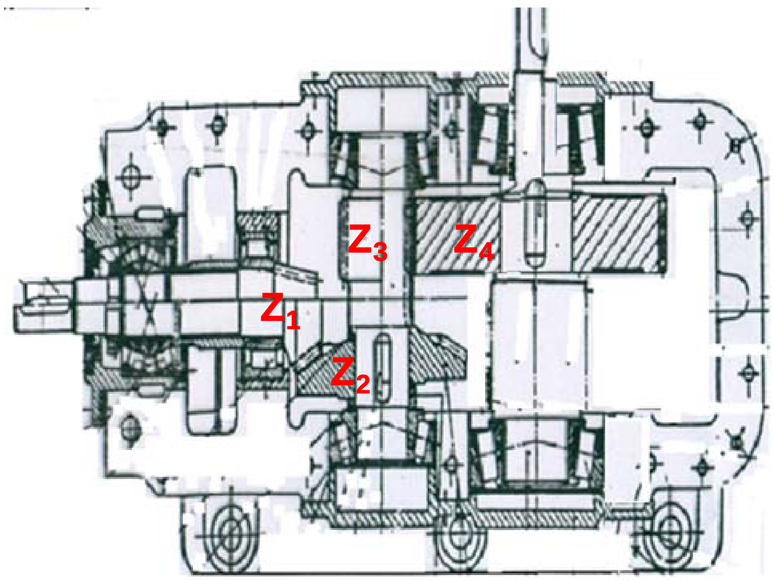
IMPORTANT:

Complete the Gear Design Part

and

Draw the layout of gears

on 27 March, 2017



Assembled plan view
(Not of the same one as below)

IMPORTANT:

Also Submit a freehand sketch of plan view (one copy per group).

of 2-stage (Bevel-Helical) gear box.
(Top cover open)