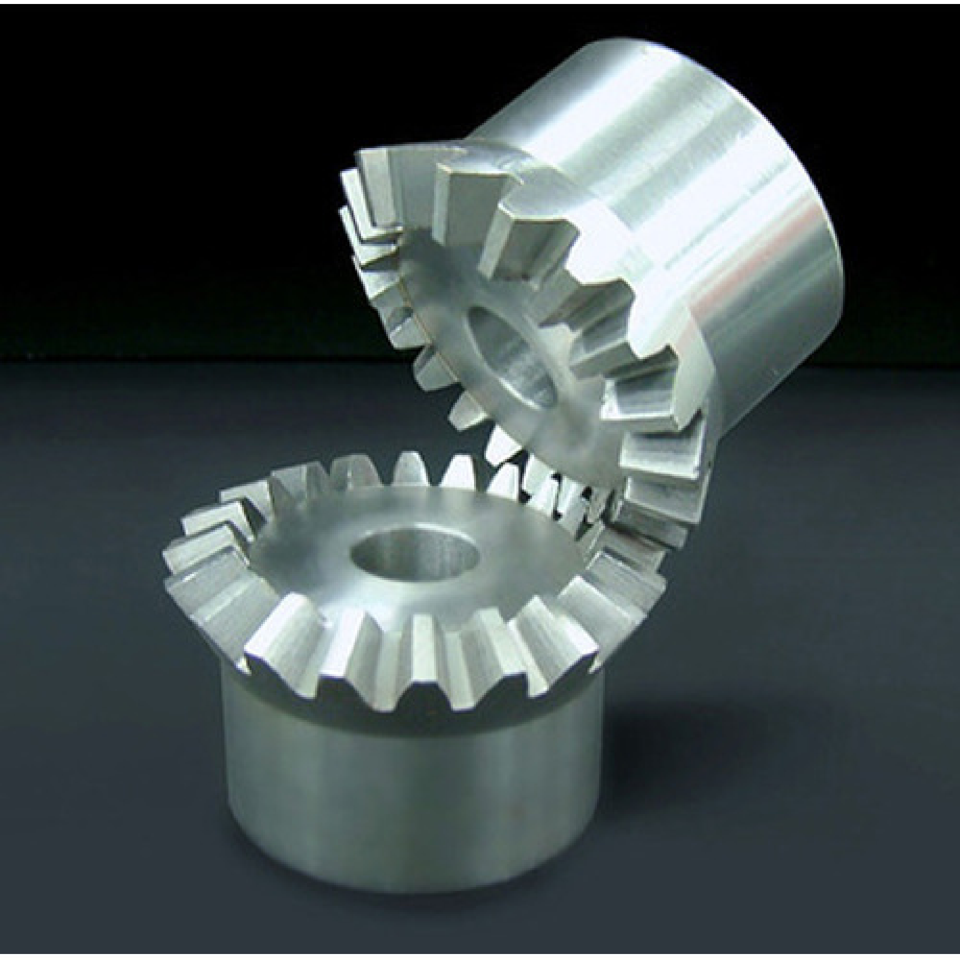


Ex. 1 : A pair of cast iron bevel gears connect two shafts at right angles. The pitch diameters of the pinion and gear are 80 mm and 100 mm respectively. The tooth profiles of the gears are of 14 1/2^{o} composite form. The allowable static stress for both the gears is 55 MPa. If the pinion transmits 2.75 kW at 1100 r.p.m.,

find the module and number of teeth on each gear from the standpoint of strength and

check the design from the standpoint of wear.

Take surface endurance limit as 630 MPa and modulus of elasticity for cast iron as 84 KN/mm^2.

Ex. 1 A 35 kW motor running at 1200 r.p.m. drives a compressor at 780 r.p.m. through a 90° bevel gearing arrangement. The pinion has 30 teeth. The pressure angle of teeth is 14 1/2° . The wheels are capable of withstanding a dynamic stress, σ_w = 140 (280/(280+v)) MPa, where v is the pitch line speed in m / min.

The form factor for teeth may be taken as

$$0.124 - \frac{0.686}{T_E}$$

,where TE is the number of teeth equivalent of a spur gear. The face width may be taken as ¼ of the slant height of pitch cone. Determine for the pinion, the module pitch, face width, addendum, dedendum, outside diameter and slant height.

Ex. 2 A pair of 20º full depth involute teeth bevel gears connect two shafts at right angles having velocity ratio 3 : 1. The gear is made of cast steel having allowable static stress as 70 MPa and the pinion is of steel with allowable static stress as 100 MPa. The pinion transmits 37.5 kW at 750 r.p.m. Determine : 1. Module and face width; 2. Pitch diameters; and 3. Pinion shaft diameter.

Assume tooth form factor, $$y = 0.154 - \frac{0.912}{T_E}$$

T_E is the formative number of teeth, width = 1/3 rd the length of pitch cone, and pinion shaft overhangs by 150 mm. Consider T_p = 20 .

EX. 3 A pair of bevel gears connect two shafts at right angles and transmits 9 kW.
Determine the required module and gear diameters for the following specifications :

Particulars	Pinion	Gear
Number of teeth	21	60
Material	Semi-steel	Grey cast iron
Brinell hardness number	200	160
Allowable static stress	85 MPa	55 MPa
Speed	1200 r.p.m.	420 r.p.m.
Tooth profile	14 1/2° composite	14 1/2° composite

Check the gears for dynamic and wear loads.

Ex. 1 : A pair of cast iron bevel gears connect two shafts at right angles. The pitch diameters of the pinion and gear are 80 mm and 100 mm respectively. The tooth profiles of the gears are of 14 1/2^{o} composite form. The allowable static stress for both the gears is 55 MPa. If the pinion transmits 2.75 kW at 1100 r.p.m.,

find the module and number of teeth on each gear from the standpoint of strength and

check the design from the standpoint of wear.

Take surface endurance limit as 630 MPa and modulus of elasticity for cast iron as 84 KN/mm^2.

Design of Bevel Gear

The bevel gears are used for transmitting power at a constant velocity ratio between two shafts **whose axes intersect at a certain angle**.

The elements of the cones, as shown in Fig. 1 intersect at the point of **intersection of the axis of rotation**.

In Fig. 2, the elements of both cones **do not intersect** at the point of shaft intersection.

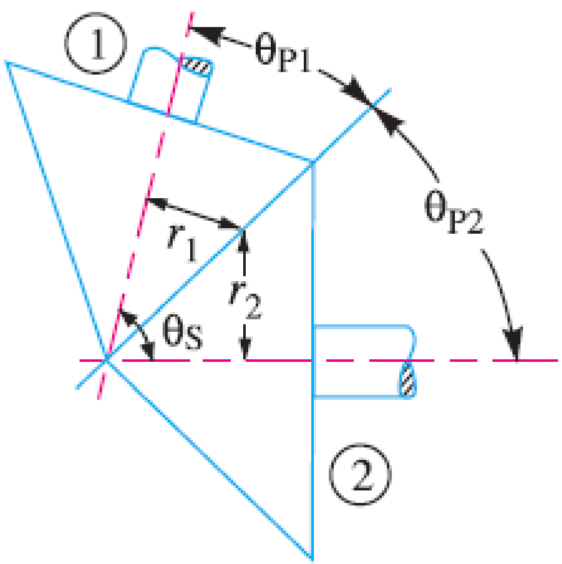


Fig. 1

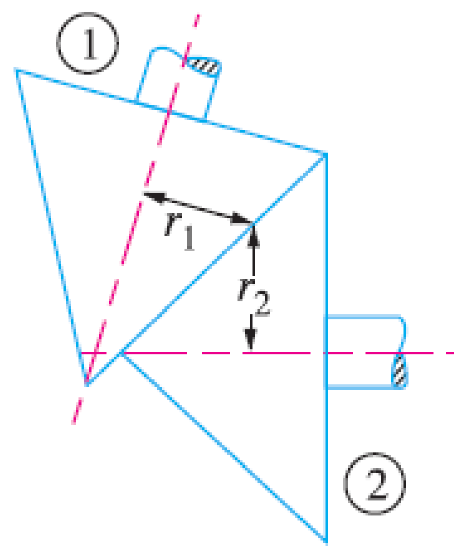
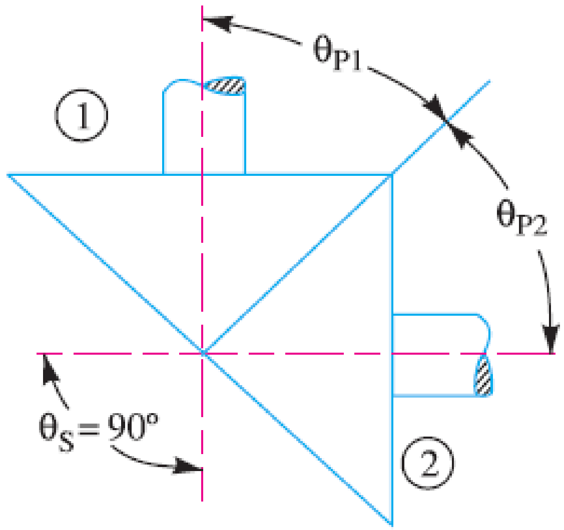


Fig. 2

Classification of Bevel Gears

(a) Mitre gears. When equal bevel gears (having equal teeth and equal pitch angles) connect two shafts whose axes intersect at right angle, as shown in Fig. (a), then they are known as **mitre gears.**



(*a*) Mitre gears.

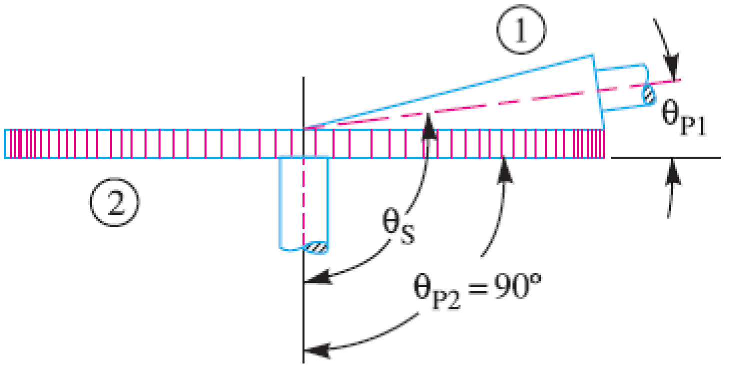
(b) Angular bevel gears. When the bevel gears connect two shafts whose axes intersect at an angle other than a right angle, then they are known as **angular bevel gears.**

Mitre gears

Angular bevel gears

(c) Crown bevel gears.

When the bevel gears connect two shafts whose axes intersect at an angle
greater than a right angle and one of the bevel gears has a pitch angle of 90º, then it is known as a crown gear.

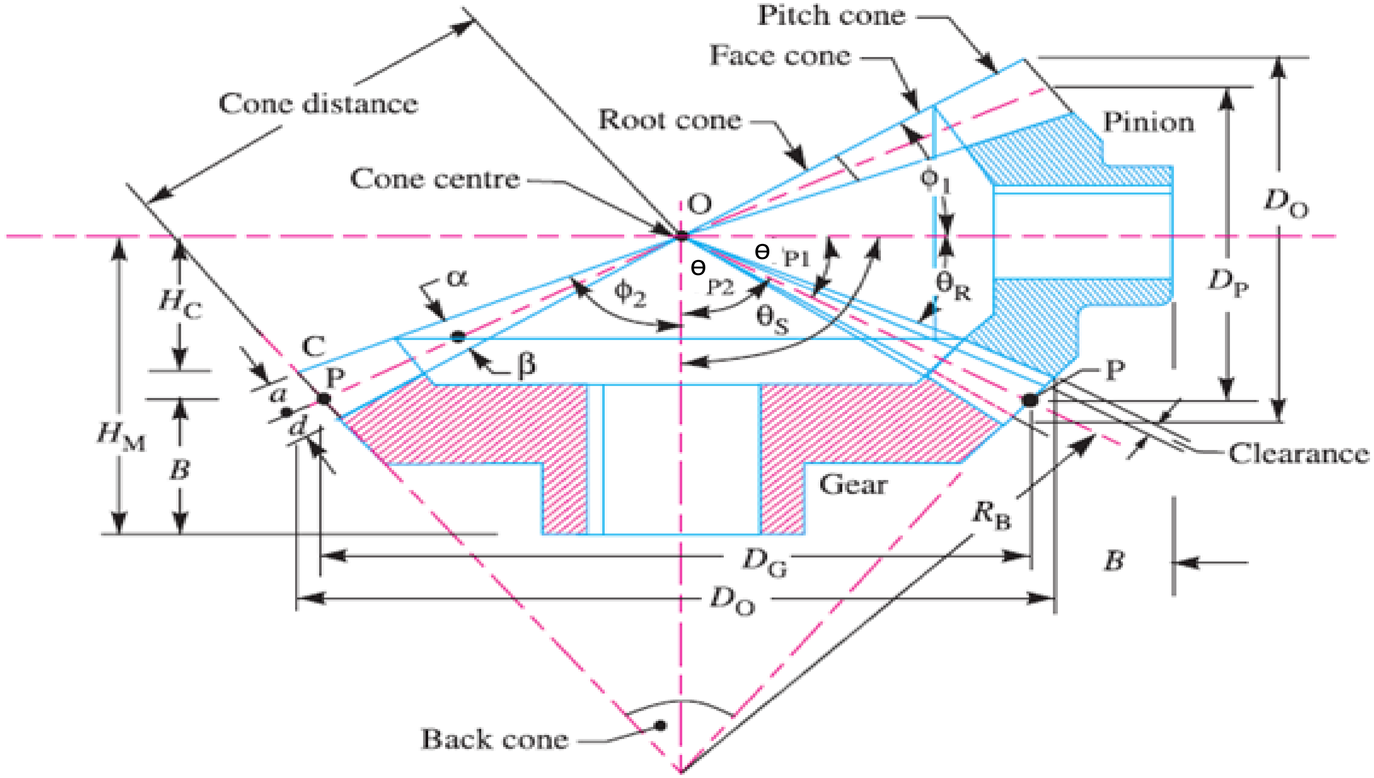


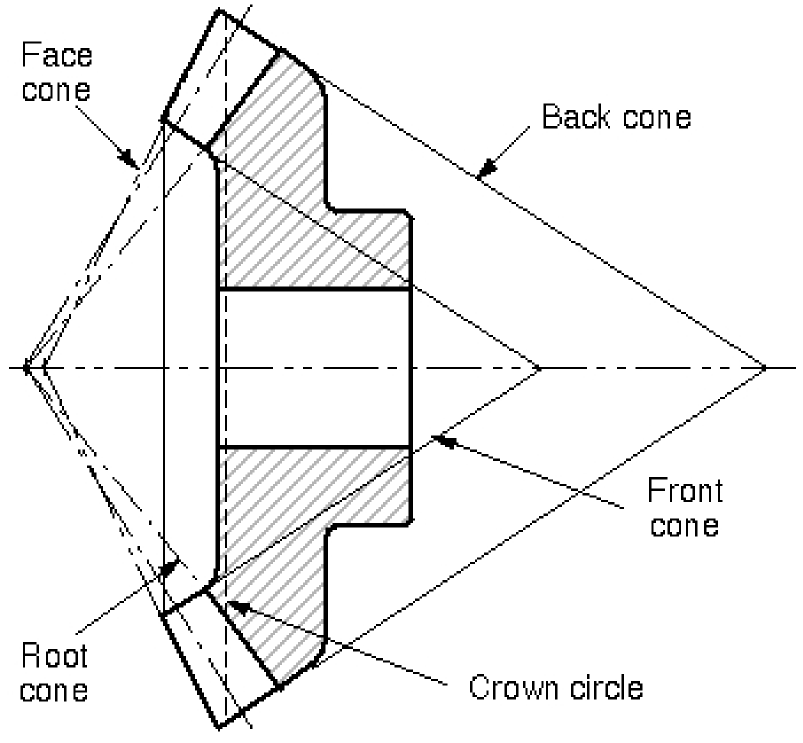
(b) Crown bevel gear.

(d) Internal bevel gears.

When the teeth on the bevel gear are cut on the inside of the pitch cone, then they are known as internal bevel gears.

Terms used in Bevel Gears

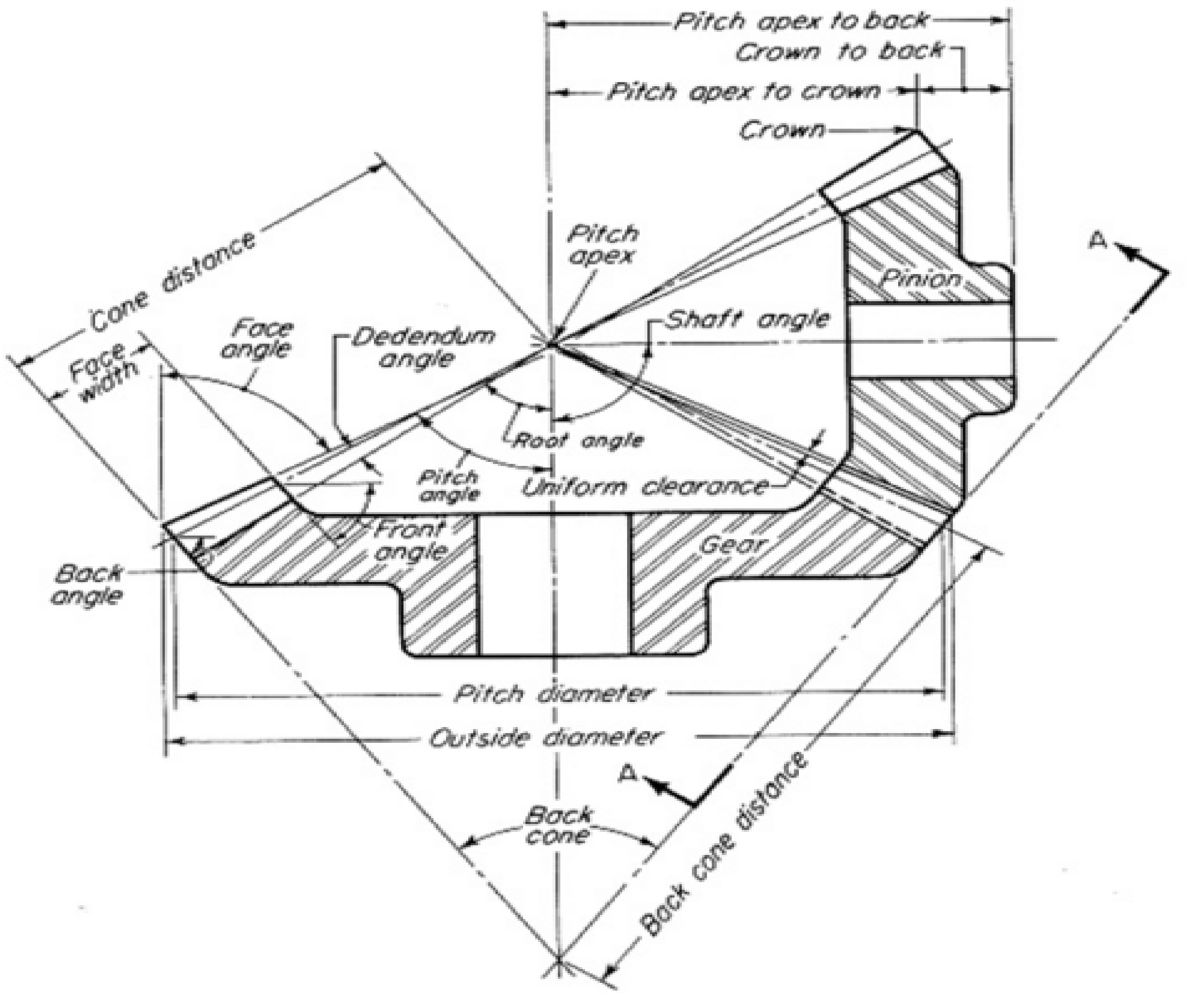




A **pitch cone** is the imaginary cone in a bevel gear that rolls without slipping on a pitch surface of another gear.

The **root cone** is the imaginary surface that coincides with the bottoms of the tooth spaces in a bevel gear.

The **face cone**, also known as the **tip cone** is the imaginary surface that coincides with the tops of the teeth of a bevel gear.

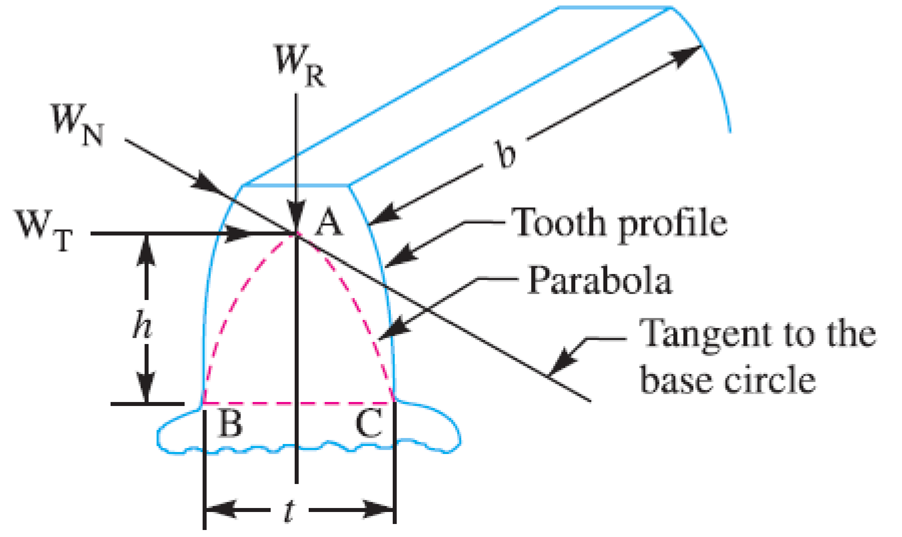

Pitch apex to back
Crown to back
Pitch apex to crown
Crown
Pitch apex
Pinion
A
Shaft angle
Cone distance
Face angle
Dedendum angle
Face width
Root angle
Pitch angle
Uniform clearance
Front angle
Gear
Back angle
Pitch diameter
Outside diameter
A
Back cone
Back cone distance

C_v = Velocity factor,

$= \dfrac{3}{3+v}$, for teeth cut by form cutters,

$= \dfrac{6}{6+v}$, for teeth generated with precision machines,

Beam Strength of Gear Teeth – Lewis Equation
Tooth form Factor



$$y = 0.124 - \frac{0.684}{T}, \text{ for } 14\tfrac{1}{2}^\circ \text{ composite and full depth involute system.}$$

$$= 0.154 - \frac{0.912}{T}, \text{ for } 20^\circ \text{ full depth involute system.}$$

$$= 0.175 - \frac{0.841}{T}, \text{ for } 20^\circ \text{ stub system.}$$

Proportions for Bevel Gear

The proportions for the bevel gears may be taken as follows :

1. Addendum, a = 1 m

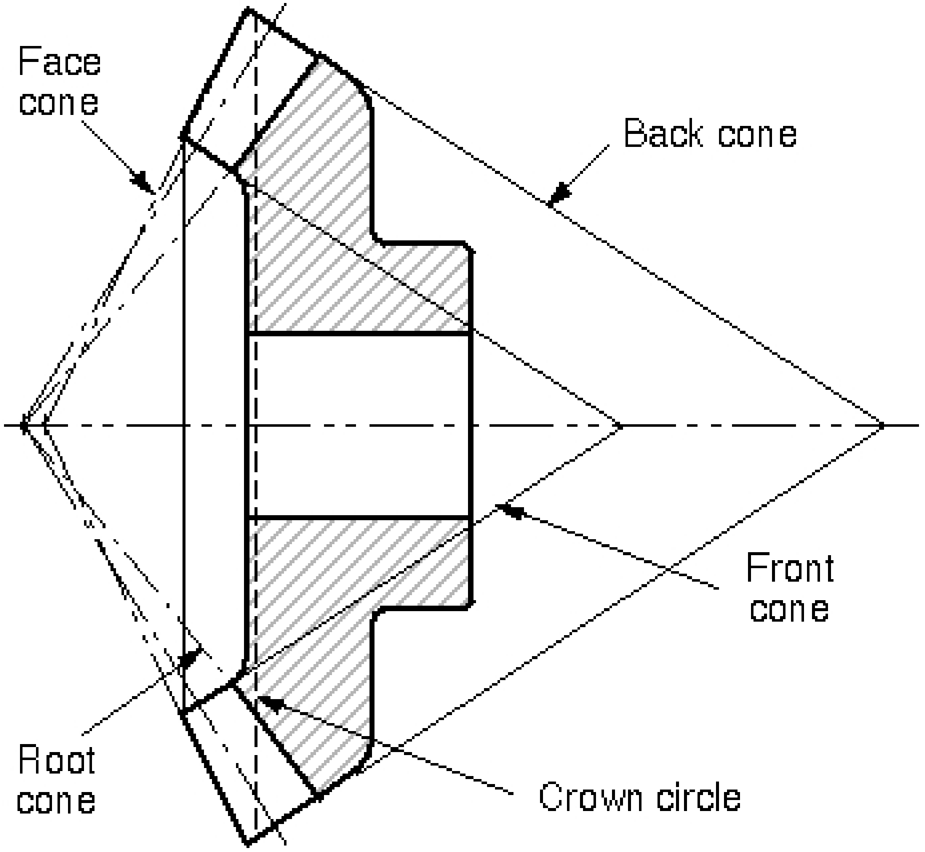
2. Dedendum, d = 1.2 m

3. Clearance = 0.2 m

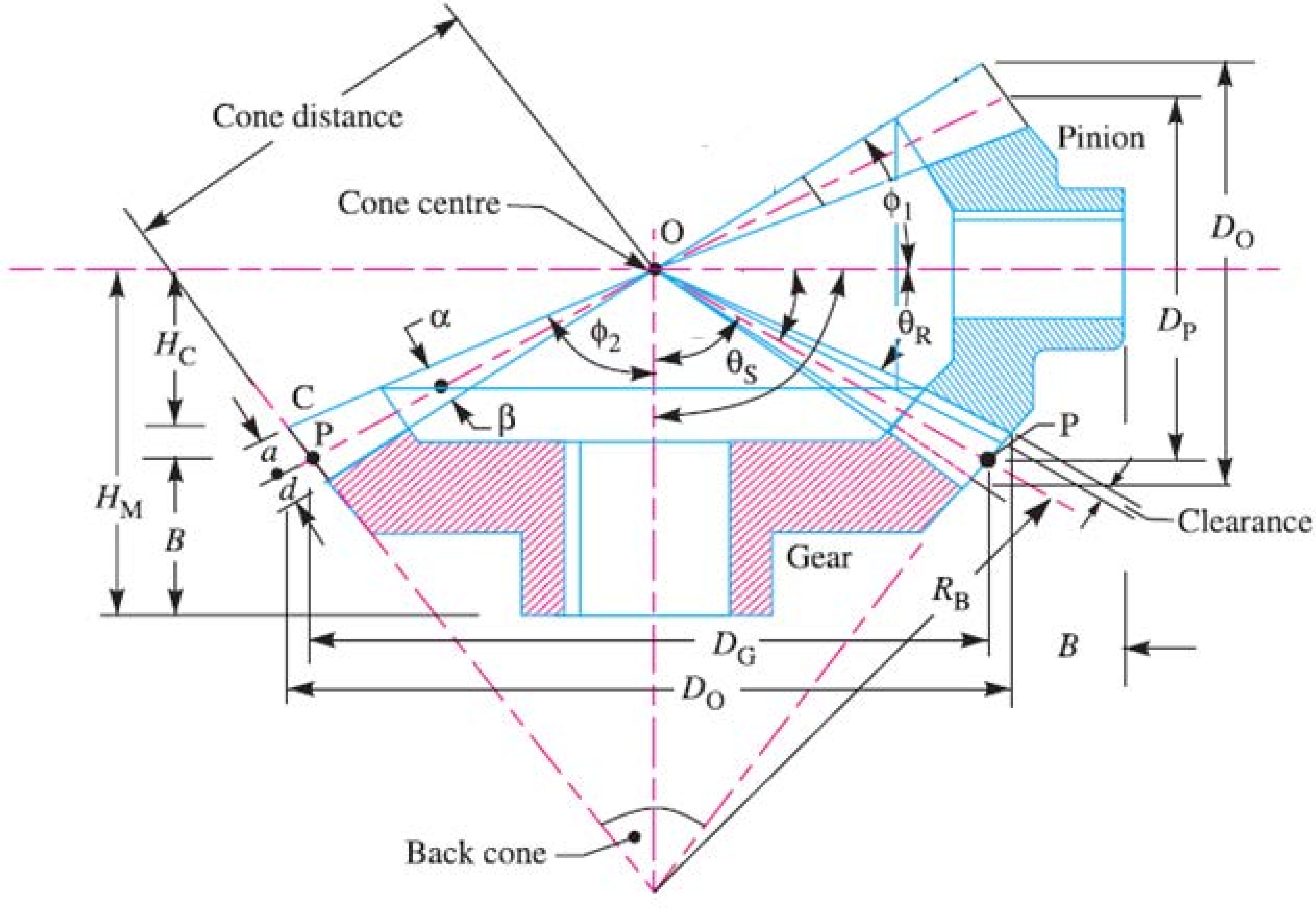
4. Working depth = 2 m

5. Thickness of tooth = 1.5708 m

where m is the module.


Face cone
Back cone
Front cone
Root cone
Crown circle

Types of Gears


Cone distance
Cone centre
O
Pinion
ϕ_1
D_O
D_P
θ_R
H_C
α
ϕ_2
θ_S
C
β
P
P
a
d
H_M
B
Clearance
Gear
R_B
D_G
B
D_O
Back cone

Basic of Worm Gears

Types of Worm Gears

The following three types of worm gears are important from the subject point of view :

1. Straight face worm gear, as shown in Fig.(*a*),

2. Hobbed straight face worm gear, as shown in Fig. (*b*),

3. Concave face worm gear, as shown in Fig. (*c*).

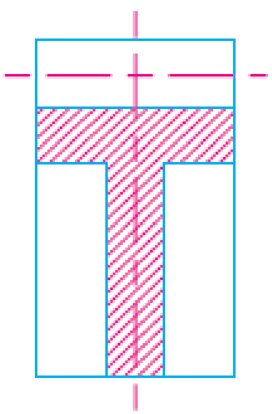


Fig.(*a*)

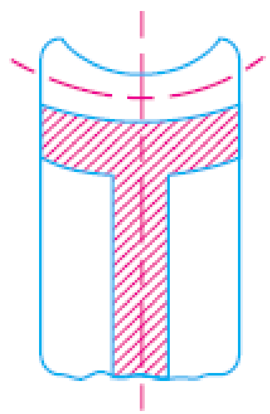


Fig.(*b*)

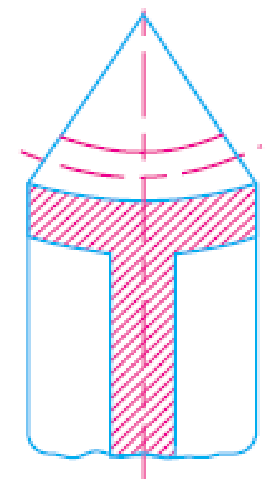
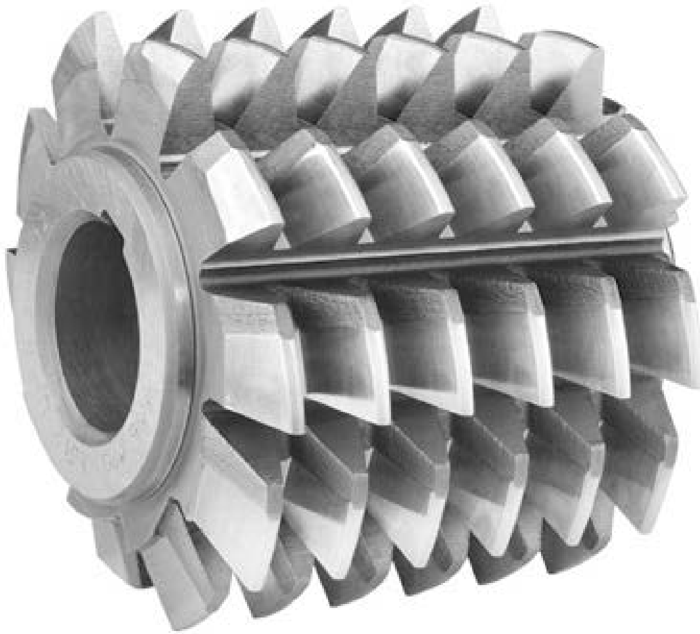


Fig.(*c*)

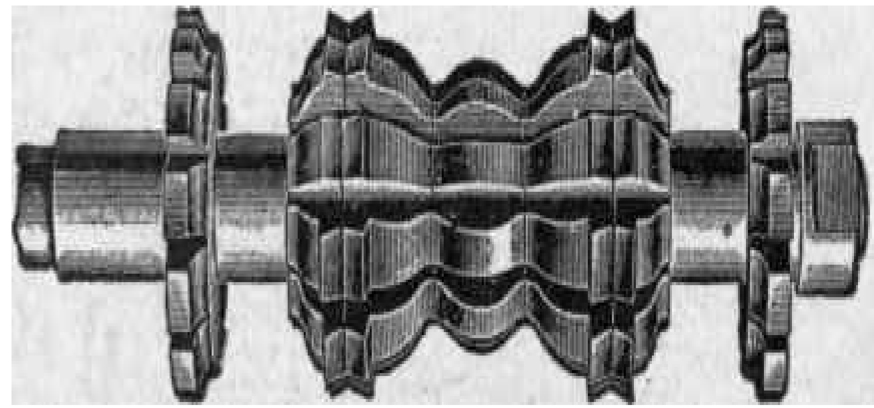
The **straight face worm gear** is like a helical gear in which the straight teeth are cut with a form cutter.
Since it has only point contact with the worm thread, therefore it is used for **light service**.

The **hobbed straight face worm gear** is also used for light service but its teeth are cut with a hob, after which the outer surface is turned.

The concave face worm gear is the accepted standard form and is used for all heavy service and general industrial uses.
The teeth of this gear are cut with a hob of the same pitch diameter as the mating worm to increase the contact area.



Hob Cutter



Form Cutter

Worm gears can be classified into:

(a) Single envelope/single start worm gear set; and
(b) Double envelope/double start worm gear set.

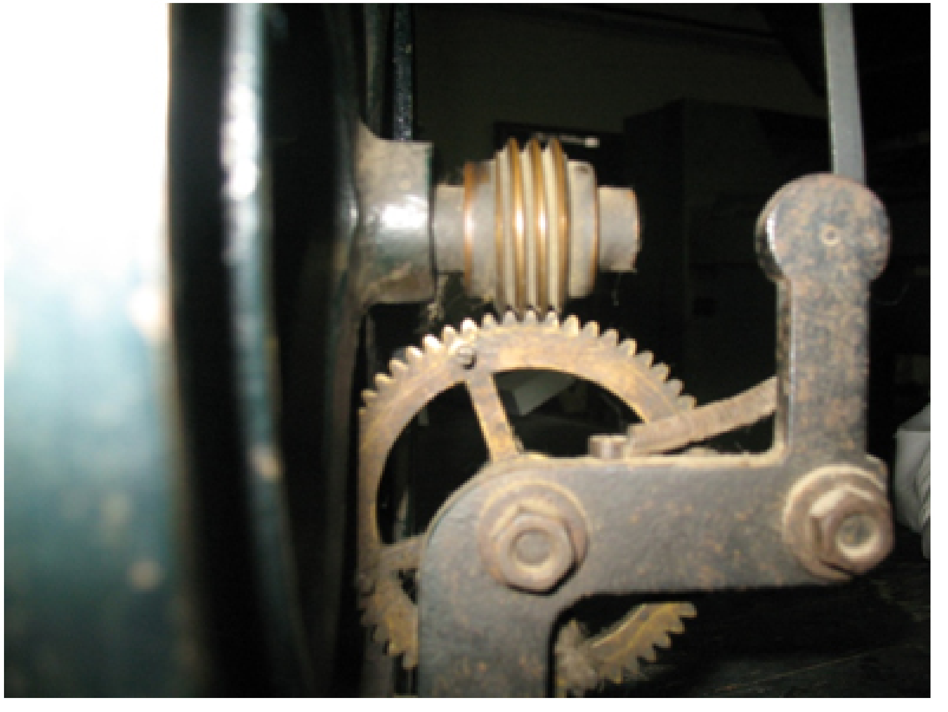
In the former, a single spiral starts from one end of worm (left) and finishes at other end (right), forming the threads. In the later, two spirals with phase difference of 180° start at one end and finishes at other end, forming the threads. Both the set of threads maintain the phase difference all around.

Single envelop worm gear

In a single enveloping set, the width of worm gear is cut into concave surface,

thus partially enclosing the worm in meshing as shown in Fig.

They are used in applications requiring a **high speed reduction and low load transmission.**



Double envelop worm gear

In double envelope worm gear set, both the width of the helical gear and the length of the worm are cut concavely as shown in **Fig.**.

These results in both the worm and gear partially enclose each other.

The double envelop worm set have more teeth in contact; and area contact rather than line contact, thus permitting greater load transmission.

The double enveloping gears are difficult to mount compared with single envelope gears. They are used for higher load transmission compared with single start gears.

Double envelope worm gear set on ring spinning machine

Worms and worms gear: Advantage

1. Higher speed reduction could be secured; speed reduction could be secured up to 300: 1
2. Worm and worm gears operate silently
3. Worm and worm gears will have one characteristics i.e. **self locking**. Reverse movement will be restricted but this characteristic depends on lead angle and friction angle,
4. Worm and worm gear unit will be preferred to use if space is restricted. worm and worm gear unit could be used for heavy speed reduction in compact space also.
5. output torque will be secured here with the application of worm and worm gear.

Worms and worms gear: Disadvantage

1. Manufacturing cost is heavy as compared with manufacturing cost of bevel gear
2. Cost of raw material to manufacture the worm and worm gear set will be quite high
3. Worm and worm gear set will have heavy power losses.
4. Efficiency will be low
5. If speed reduction ratio is large, worm teeth sliding action will create lots of heat
6. Lubrication scheduled must be strictly maintained for healthiness of worm and
7. worm gear as this unit requires much lubrication for smooth working of gearbox.