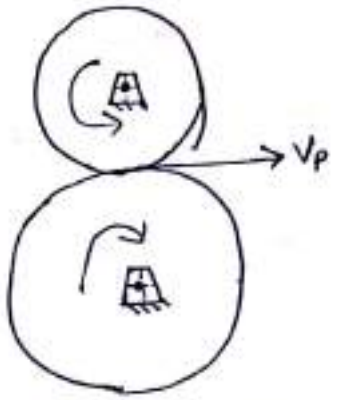
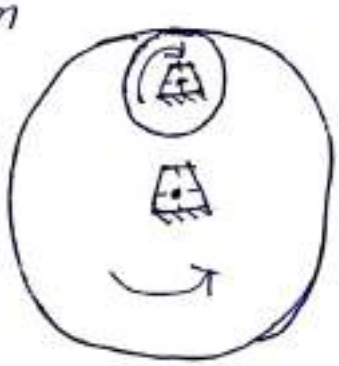
Theory of Gearing :-

⇒ Rolling Cylinders :- The simplest means of transferring rotary motion from one shaft to another is a pair of rolling cylinder. They may be an external set of rolling cylinder (fig. a) or internal set (fig. b). This mechanism will work quite well, provided that sufficient friction is available at the rolling interface. There will be no slip between the cylinders until the maximum available frictional force at the joint is exceeded by the demands of torque transfer.



(a) External set



(b) Internal Set

The principal drawbacks to rolling cylinder drives mechanism are its relatively low toorque capability and the possibility of slip. Some drives requires absolute phasing of the input and output shaft for timing purposes. A common example is the valve train drive in an automobile engine. The valve cams must be kept in phase with the piston motion or the engine will not work properly. A rolling cylinder drive from crankshaft to camshaft would not guarantee correct phasing. In this case some means of preventing slip is needed.

This can be achived by adding some meshing teeth

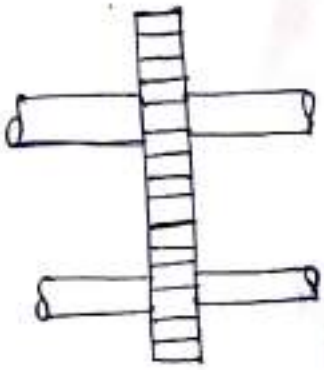
to the rolling cylinder. Then they becomes gear. When two gears are placed in mesh it is called as gear set. It is conventional to refer to the smaller of the two gears as the pinion and to the other as the gear.

⇒ Type of gears :-

1) According to position of axes of the shafts :- The axes of two shafts between which the motion is to be transmitted may be.
   a) Parallel
   b) Intersecting
   c) Non parallel and non intersection

a) Parallel shaft :-

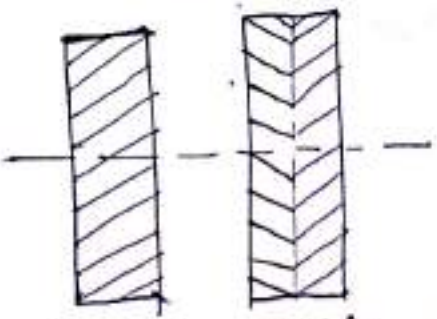
i) Spur gear :- Spur gear have straight teeth parallel to the axes and thus are not subjected to any axial thrust due to tooth load. (Fig. a). These are simplest form of gear.



(a)

At the time of engagement of the two gears, the contact extends across the entire width on a line parallel to the axis of rotation.

ii) Helical gear :- In helical gears teeth are curved i.e. part of helix instead of straight teeth. The mating gears will have same helix angle but



Single helical gear | Double helical gear

in opposite direction for proper mating.

At the beginning of engagement, contact occurs only at the points of leading edge of the curved teeth. As the gear rotate, the contact extends along a digonal line across the teeth. Thus, the load application is gradual which results in low impact stresses and reduction in noise.

Double helical and herringbone gears :— A double helical gear is equivalent to a pair of helical gears secured together, one having right hand helix and other having left hand helix. The teeth of the two rows are seperated by a groove used for tool run out. Axial thrust which occurs in case of single-helical gears is eliminated in double helical gears. This is because the axial thrusts of the two rows of teeth cancel out each other. These can be run at high speeds with less noise and vibration.

If the left and right inclinations of a double helical gear meet at the common apex and there is no groove in between the gear is known as herringbone gear.

iii) Rack and Pinion :- In these the rack is considered to be spur gear of infinite pitch radius. In this pinion rotates while the rack translate.

b) Gears for intersecting shafts :- The motion between two intersecting shaft is equivalent to the rolling of two cones. The gears used for intersecting shaft are called bevel gears. Gears under this category are following!

i) Straight bevel gear :- When teeth on the cones are straight and radial to the point of intersection of the shaft axes, the gears are known as straight bevel gear. Usually, these are used to connect shafts at right angles which runs at low speed.

* Gears of the same size and connecting two shafts at right angle are known as mitre gears.

ii) Spiral bevel gears :- When the teeth of a bevel gear are inclined at an angle to the face of bevel, they are known as spiral bevel or helical bevel gears. These are smoother in action and quieter than straight bevel gear as there is gradual load application and less impact stresses.

Application :- These are used for the drive to the differential of an automobile.

iii) Zero bevel gear :- Spiral bevel gears with curved teeth but with a zero spiral angle are known as zero bevel gears.

c) Gears for skew shafts :- The following gears are used to join two non-parallel and non-intersecting shafts.

i) Worm gear :- Worm gear is a special case of a spiral gear in which the larger wheel, usually has a hollow or concave shape such that a portion of the pitch diagmeter of the ~~larger~~ other gear is enveloped on it. The smaller of the two wheels is called the worm which also has a larger spiral angle.

Worm gear are made in the following form :—

1) Non throated :- the contact between the teeth is concentrated at a point.

2) Single throated :- Gear teeth are curved to envelop the worm. there is line contact between the teeth.

3) Double throated :- There is area contact between teeth. A worm may be cut with a single or multible thread cutter.

ii) Hypoid gear :- Hypoid gears are made of the frusta of hyperboloid of revolution. A hypoid pinion is larger and stronger than a spiral bevel pinion.

2) According to the pheripheral velocity of the gears :-

a) Low velocity gear

b) Medium velocity gear

c) High velocity gear

The gears having velocity less than 3 m/s are termed as low velocity gears and gears having velocity in between 3 to 15 m/s are known as medium velocity gears. If the velocity of gears is more than 15 m/s. then these are called as high speed gears.

3) According to the type of gearing :-

a) Internal gearing

b) External gearing

c) Rack and pinion

In internal gearing the gears of the two shaft mesh internally with each other. The larger of these two wheels is called annular wheel and the smaller wheels is called pinion. In an internal gearing, the motion of two wheels is always in the same direction.

In external gearing, the gear of two shafts mesh externally with each other. The larger of

these two wheels is called spur wheels and the smaller wheel is called pinion. In an external gearing, the motion of two wheels is always in opposite direction.

Sometimes, the gear of a shaft meshes externally and internally with the gear in a straight line. Such type of gear is called rack and pinion. The straight line gear is called rack and the circular wheel is called pinion. With the help of a rack and pinion, we can convert linear motion into into rotary and vice-versa.

⇒ Gear Terminology :-

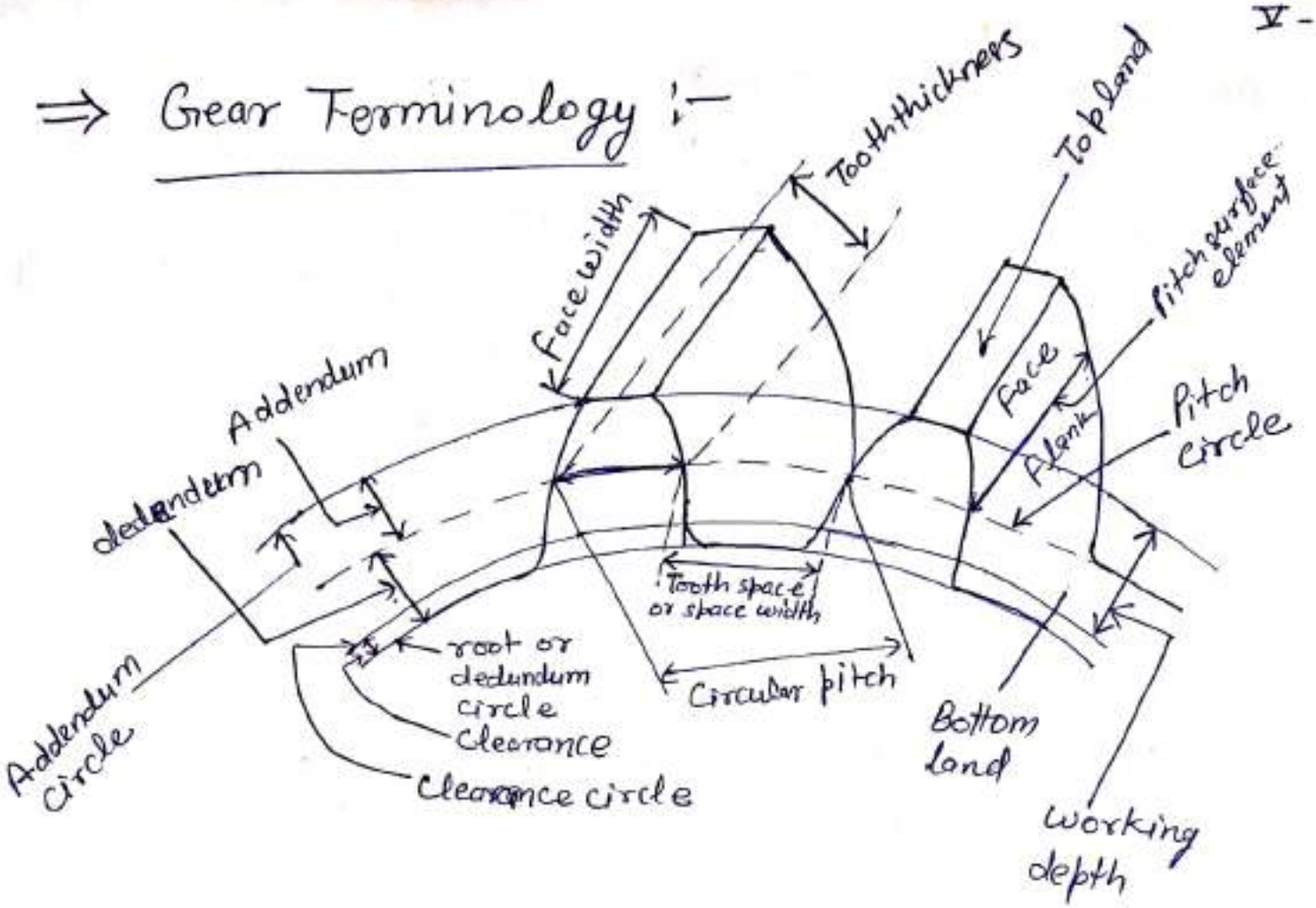


Fig. : Term used in gears

Pitch Circle :- It is an imaginary circle which by pure rolling action, would give the same motion as the actual gear. It is a theoritical circle upon which all calculations are usually based.

Circular pitch :- The circular pitch is the distance measured on the pitch circle, from a point on one tooth to a corresponding point on an adjecent tooth.

Circular pitch $\boxed{P_c = \frac{\pi D}{T}}$

where

D = Pitch circle diameter

T = Number of teeth on the wheel.

★ The two gears will mesh together correctly, if two wheels have the same circular pitch.

If D_1 and D_2 are the diameters of the two meshing gears having no. of teeth T_1 and T_2 respectively, then for them to mesh correctly,

$$P_c = \frac{\pi D_1}{T_1} = \frac{\pi D_2}{T_2} \Rightarrow \boxed{\frac{D_1}{D_2} = \frac{T_1}{T_2}}$$

Pitch circle diameter :- It is the diameter of pitch circle. The size of the gear is usually specified by the pitch circle diameter. It is also known as pitch diameter.

Pitch point :- It is a common point of contact between two pitch circles of mating gears.

Addendum :- It is the radial distance of a tooth from the pitch circle to the top of the tooth.

Dedendum :- It is a radial distance of tooth from the pitch circle to the bottom of the tooth.

Addendum Circle :- It is the circle drawn through the top of the teeth and is concentric with the pitch circle.

Declendum circle :— It is the circle drawn through the bottom of the tooth and also called the root circle.

Root circle diameter = Pitch circle dia. × $\cos\phi$

where $\phi \rightarrow$ Pressure angle.

Pressure angle or Angle of obliquity :— It is the angle between the common normal to two gear teeth at the point of contact and the common tangent at the pitch point and usually denoted by ϕ. The standard pressure angles are $14\frac{1}{2}°$ and $20°$.

Diametral pitch :— It is the ratio of no. of teeth to the pitch circle diameter in millimeters.

Diametral pitch $\boxed{P_d = \frac{T}{D} = \frac{\pi}{P_c}}$

Module :— It is the ratio of the pitch circle dia. in mm to the no. of teeth.

Module $\boxed{m = \frac{D}{T}} = \frac{P_c}{\pi}$

Clearance :— It is the radial distance ~~between the addendum~~ from the top of the tooth to the bottom of the tooth, in a mating gear.

Or The clearance (c) is the amount by which the

the dedendum in a given gear exceeds the addendum of its mating gear.

Clearance circle :- A circle passing through the top of the tooth ~~tooth bottom~~ in a mating gear is known as clearance circle.

Total depth :- The radial distance between the addendum circle and dedendum circle of a gear is known as total depth. It is the sum of addendum and dedendum.

Working depth :- It is the radial distance from the addendum circle to the clearance circle. It is equal to sum of the addendum of two mating gears.

Tooth thickness :- Width of the tooth measured along the pitch circle is known as tooth thickness.

Tooth space :- Width of the space between the two adjacent teeth measured along the pitch circle.

Backlash :- The backlash is the amount by which the width of a tooth space exceeds the thickness of the engaging tooth on the pitch circle.

Theoritically, the backlash should be zero, but in actual practice some backlash mush be allowed to prevent jamming of the teeth due to tooth error and thermal expansion.

Path of contact :- Path traced by the point of ~~two~~ pitch circles contact of two teeth from the begning to the end of engagement.

Length of path of contact :- The length of the common normal cut-off by the addendum circles of the wheel and pinion.

Arc of contact :- It is the path traced by a point on the pitch circle from the begining to the end of engagement of a given pair of teeth. The arc of contact consist of two parts :

a) Arc of approach :- It is the portion of the path of contact from the begning of engagement to the pitch point.

b) Arc of recess :- It is the portion of path of contact from the pitch point to the end of the engagement of a pair of teeth.