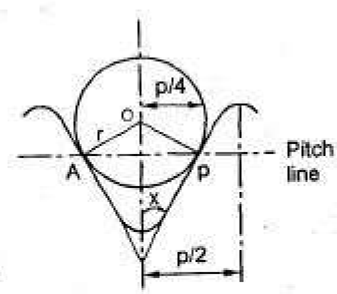


$$db = 2Ap\ sec x$$

Where, db = Wire diameter

x = Included angle

$AP = p/4$

$\therefore db = 2\ p/4\ sec\ x$

$$\boxed{db = p_2\ sec x}$$

2.11 GEAR MEASUREMENT

2.11.1 GEAR TERMINOLOGY

Each gear has a unique form or geometry. The gear form is defined by various elements. An illustration of the gear highlighting the important elements is referred to as 'gear terminology'. This section explains the types of gears and their terminology.

2.11.1.1 Introduction

- Gears is a mechanical drive which transmits power through toothed wheel.
- In this gear drive, the driving wheel is in direct contact with driven wheel.
- The accuracy of gearing is the very important factor when gears are manufactured.
- The transmission efficiency is almost 99 in gears. So, it is very important to test and measure the gears precisely.
- For proper inspection of gear, it is very important to concentrate on the raw materials, which are used to manufacture the gears, also very important to check the machining the blanks, heat treatment and the finishing of teeth.
- The gear blanks should be tested for dimensional accuracy and tooth thickness for the forms of gears.
- The most commonly used forms of gear teeth are

  1.Involute

  2. Cycloidal

- The involute gears also called as straight tooth or spur gears.
- The cycloidal gears are used in heavy and impact loads.

- The involute rack has straight teeth.
- The involute pressure angle is either 20° or 14.5°.

2.11.2 Types of Gears

The common types of gears used in engineering practices are described in this section. The information provided here is very brief, and the reader is advised to read a good book on 'theory of machines' to understand the concepts better.

2.11.2.1 Spur gears These gears are the simplest of all gears. The gear teeth are cut on the periphery and are parallel to the axis of the gear. They are used to transmit power and motion between parallel shafts.

Fig. 2.104 Spur gears

2.11.2.2 Helical gears The gear teeth are cut along the periphery, but at an angle to the axis of the gear. Each tooth has a helical or spiral form. These gears can deliver higher torque since there are more number of teeth in a mesh at any given point of time. They can transmit motion between parallel or non-parallel shafts.

Fig. 2.105 Helical gears

2.11.2.3 Herringbone gears These gears have two sets of helical teeth, one right-hand and the other left-hand, machined side by side.

Fig. 2.106 Herringbone gears

2.11.2.4 Worm and worm gears A worm is similar to a screw having single or multiple start threads, which form the teeth of the worm. The worm drives the worm gear or worm wheel to enable transmission of motion. The axes of worm and worm gear are at right angles to each other.

Fig. 2.107 Worm and worm gears

2.11.2.5 Bevel gears These gears are used to connect shafts at any desired angle to each other. The shafts may lie in the same plane or in different planes.

Fig. 2.108 Bevel gears

2.11.2.6 Hypoid gears These gears are similar to bevel gears, but the axes of the two connecting shafts do not intersect. They carry curved teeth, are stronger than the common types of bevel gears, and are quiet-running. These gears are mainly used in automobile rear axle drives.

2.11.3 Gear terminology

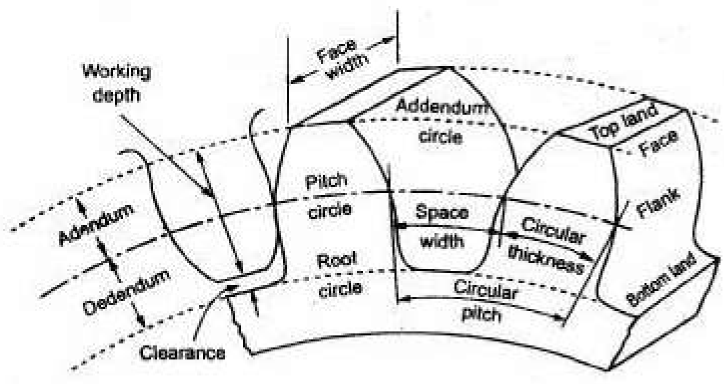


Fig. 2.109 Spur gear terminology

1. Tooth profile:

It is the shape of any side of gear tooth in its cross section.

2. Base circle:

- It is the circle of gear from which the involute profile is derived.
- Base circle diameter Pitch circle diameter x Cosine of pressure angle of gear

3. Pitch circle diameter (PCD):

The diameter of a circle which will produce the same motion as the toothed gear wheel.

4. Pitch circle:

It is the imaginary circle of gear that rolls without slipping over the circle of its mating gear.

5. Addendum circle:

The circle coincides with the crests (or) tops of teeth.

6. Dedendum circle (or) Root circle:

This circle coincides with the roots (or) bottom on teeth.

7.Pressure angle (a):

It is the angle making by the line of action with the common tangent to the pitch circles of mating gears.

$\alpha = 14\ 1/2°$ or $20°$.

8.Module(m):

`It is the ratio of pitch circle diameter to the total number of teeth.

$$m = \frac{d}{n}$$

Where, d = Pitch circle diameter.

n = Number of teeth.

9. Circular pitch:

It is the distance along the pitch circle between corresponding points of adjacent teeth.

$$P_C = \frac{\pi d}{n} = \pi m$$

10. Addendum:

Radial distance between tip circle and pitch circle. Addendum value = 1 module.

11 Dedendum:

Radial distance between itch circle and root circle, Dedendum value = 1 .25module.

12 Clearance (C):

A mount of distance made by the tip of one gear with the root of mating gear.

Clearance = Difference between Dedendum and addendum values.

13 Blank diameter:

The diameter of the blank from which gear is out. Blank diameter = PCD + 2m

14. Face:

Part of the tooth in the axial plane lying between tip circle and pitch circle.

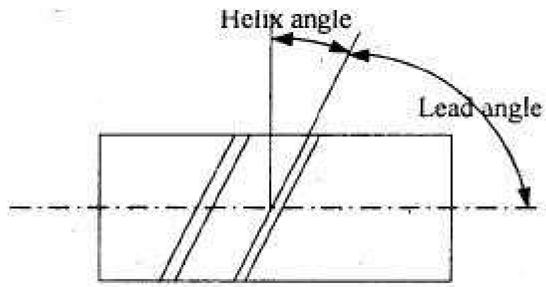
15. Flank:

Part of the tooth lying between pitch circle and root circle.

16. Top land:

Top surface of a tooth.

17. Helix angle:



The angle between the tangents to helix angle.

18. Lead angle:

The angle between the tangent to the helix and plane perpendicular to the axis of cylinder.

19. Backlash:

- The difference between the tooth thickness and the space into which it meshes.
- If we assume the tooth thickness as t and width ‘t then

Back lash $= t_2 - t_1$

2.11.4 ERRORS IN SPUR GEARS

A basic understanding of the errors in spur gears during manufacturing is important before we consider the possible ways of measuring the different elements of gears. A spur gear is a rotating member that constantly meshes with its mating gear. It should have the perfect geometry to maximize transmission of power and speed without any loss. From a metrological point of view, the major types of errors are as follows:

1. Gear blank runout errors
2. Gear tooth profile errors
3. Gear tooth errors
4. Pitch errors
5. Runout errors
6. Lead errors
7. Assembly errors

2.11.4.1 Gear blank runout errors Gear machining is done on the gear blank, which may be a cast or a forged part. The blank would have undergone preliminary machining on its outside diameter (OD) and the two faces. The blank may have radial runout on its OD surface due to errors in the preliminary machining. In addition, it may have excessive face runout. Unless these two runouts are within prescribed limits, it is not possible to meet the tolerance requirements at later stages of gear manufacture.

2.11.4.2 Gear tooth profile errors These errors are caused by the deviation of the actual tooth profile from the ideal tooth profile. Excessive profile error will result in either friction between the mating teeth or backlash, depending on whether it is on the positive or negative side.

2.11.4.3 Gear tooth errors This type of error can take the form of either tooth thickness error or tooth alignment error. The tooth thickness measured along the pitch circle may have a large amount of error. On the other hand, the locus of a point on the machined gear teeth may not follow an ideal trace or path. This results in a loss in alignment of the gear.

2.11.4.4 Pitch errors Errors in pitch cannot be tolerated, especially when the gear transmission system is expected to provide a high degree of positional accuracy for a machine slide or axis. Pitch error can be either single pitch error or accumulated pitch error. Single pitch error is the error in actual measured pitch value between adjacent teeth. Accumulated pitch error is the difference between theoretical summation over any number of teeth intervals and summation of actual pitch measurement over the same interval.

2.11.4.5 Runout errors This type of error refers to the runout of the pitch circle. Runout causes vibrations and noise, and reduces the life of the gears and bearings. This error creeps in due to inaccuracies in the cutting arbour and tooling system.

2.11.4.6 Lead errors This type of error is caused by the deviation of the actual advance of the gear tooth profile from the ideal value or position. This error results in poor contact between the mating teeth, resulting in loss of power.

2.11.4.7 Assembly errors Errors in assembly may be due to either the centre distance error or the axes alignment error. An error in centre distance between the two engaging gears results in either backlash error or jamming of gears if the distance is too little. In addition, the axes of the two gears must be parallel to each other, failing which misalignment will be a major problem.

2.11.5 MEASUREMENT OF GEAR ELEMENTS

A number of standard gear inspection methods are used in the industry. The choice of the inspection procedure and methods not only depends on the magnitude of tolerance and size of the gears, but also on lot sizes, equipment available, and inspection costs. While a number of analytical methods are recommended for inspection of gears,