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GEAR MEASUREMENT

Introduction

Gear 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°.

Gear Measurement

The Inspection of the gears consists of determine the following elements in which manufacturing error may be present.

3. Runout.
4. Pitch
5. Profile
6. Lead
7. Back lash
8. Tooth thickness
9. Concentricity
10. Alignment

1. Runout:

It means eccentricity in the pitch circle. It will give periodic vibration during each revolution of the gear. This will give the tooth failure in gears. The run out is measured by means of eccentricity testers. In the testing the gears are placed in the mandrel and the dial indicator of the tester possesses special tip depending upon the module of the gear and the tips inserted between the tooth spaces and the gears are rotated tooth by tooth and the variation is noted from the dial indicator.

2. Pitch measurement:

There are two ways for measuring the pitch.

1. Point to point measurement (i.e. One tooth point to next toot point)
2. Direct angular measurement

1. Tooth to Tooth measurement

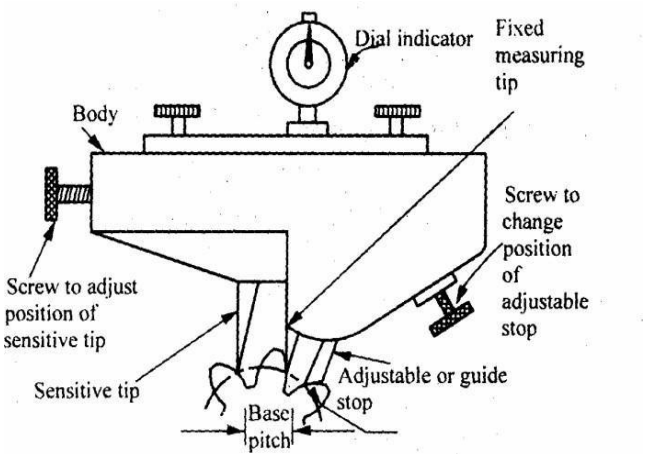


Fig 3.16 Tooth to tooth measurement

The instrument has three tips. One is fixed measuring tip and the second is sensitive tip, whose position can be adjusted by a screw and the third tip is adjustable or guide stop. The distance between the fixed and sensitive tip is equivalent to base pitch of the gear. All the three tips are contact the tooth by setting the instrument and the reading on the dial indicator is the error in the base pitch.

2. Direct Angular Measurement

It is the simplest method for measuring the error by using set dial gauge against a tooth. in this method the position of a suitable point on a tooth is measured after the gear has been indexed by a suitable angle. If the gear is not indexed through the angular pitch the reading differs from the original reading. The difference between these is the cumulative pitch error.

3. Profile checking

The methods used for profile checking is

1. Optical projection method.
2. Involute measuring machine.

1. Optical projection method:

The profile of the gear projected on the screen by optical lens and then projected value is compared with master profile.

2. Involute measuring machine:

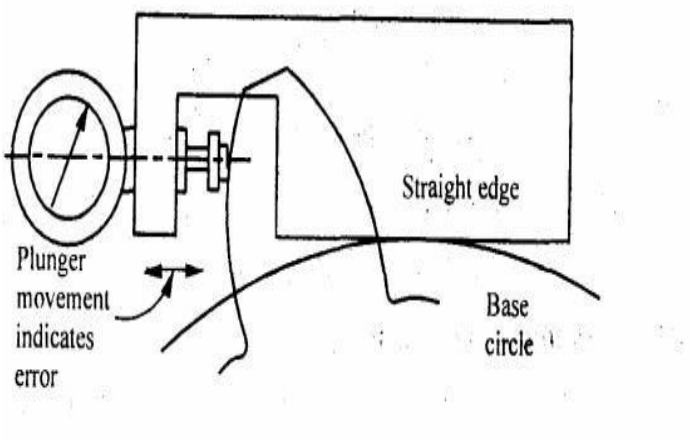


Fig 3.17 Involute Measuring Machine

In this method the gear is held on a mandrel and circular disc of same diameter as the base circle of gear for the measurement is fixed on the mandrel. After fixing the gear in the mandrel, the straight edge of the instrument is brought in contact with the base circle of the disc. Now, the gear and disc are rotated and the edge moves over the disc without sleep. The stylus moves over the tooth profile and the error is indicated on the dial gauge.

4. Lead checking:

It is checked by lead checking instruments. Actually lead is the axial advance of a helix for one complete turn. The lead checking instruments are advances a probe along a tooth surface, parallel to the axis when the gear rotates.

5. Backlash checking:

Backlash is the distance through which a gear can be rotated to bring its nonworking flank in contact with the teeth of mating gear. Numerical values of backlash are measured at the tightest point of mesh on the pitch circle.

There are two types of backlash

The determination of backlash is, first one of the two gears of the pair is locked, while other is rotated forward and backward and by the comparator the maximum displacement is measured. The stylus of comparator is locked near the reference cylinder and a tangent to this is called circular backlash.

6. Tooth thickness measurement:

Tooth thickness is generally measured at pitch circle and also in most cases the chordal thickness measurement is carried out i.e. the chord joining the intersection of the tooth profile with the pitch circle.

The methods which are used for measuring the gear tooth thickness is

a) Gear tooth vernier caliper method (Chordal thickness method)

b) Base tangent method.

c) Constant chord method.

d) Measurement over pins or balls.

a) Gear tooth vernier method

In gear tooth vernier method the thickness is measured at the pitch line. Gear tooth thickness varies from the tip of the base circle of the tooth, and the instrument is capable of measuring the thickness at a specified position on the tooth. The tooth vernier caliper consists of vernier scale and two perpendicular arms. In the two perpendicular arms one arm is used to measure the thickness and other arm is used to measure the depth. Horizontal vernier scale reading gives chordal thickness (W) and vertical vernier scale gives the chordal addendum. Finally the two values compared.

The theoretical values of W and d can be found out by considering one tooth in the gear and it can be verified. In fig noted that w is a chord ADB and tooth thickness is specified by AEB. The distance d is noted and adjusted on instrument and it is slightly greater than addendum CE.

$\therefore$ 'W' is chordal thickness and 'd' is named as chordal addendum.

So, $W = AB = 2AD$

And angle, $AOD = \theta = \frac{360}{4n}$

Where, n = Number of teeth.

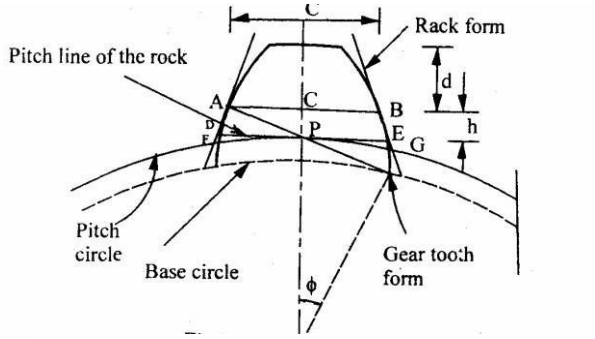
$W = 2AD = 2 \times AO \, Sin\theta$

$= 2R \, Sin \, 360/4n$ .....

Where, R = Pitch circle radius

Module, $m = \frac{P.C.D}{No.\,of\ teeth} = \frac{2R}{n}$

$\therefore R = \frac{nm}{2}$



And $OD = R \, Cos\theta = \frac{nm}{2} Cos\left(\frac{90}{n}\right)$

$$\boxed{OD = \frac{nm}{2} Cos\left(\frac{90}{n}\right)}$$

Vernier method like the chordal thickness and chordal addendum are dependent upon the number of teeth. Due to this for measuring large number of gears different calculations are to be made for each gear. So these difficulties are avoided by this constant chord method.

b) Measurement over Rolls or balls

A very good and convenient method for measuring thickness of gear. In this method two or three different size rollers are used for checkup the vibrations at several places on the tooth.

7. Measurement of concentricity

In setting of gears the centre about which the gear is mounded should be coincident with the centre from which the gear is generated. It is easy to check the concentricity of the gear by mounting the gear between centres and measuring the

variation in height of a roller placed between the successive teeth. Finally the variation in reading will be a function of the eccentricity present.

8. Alignment checking

It is done by placing a parallel bar between the gear teeth and the gear being mounted between centres. Finally the readings are taken at the two ends of the bar and difference in reading is the misalignment.

Parkinson Gear Tester

Working principle

The master gear is fixed on vertical spindle and the gear to be tested is fixed on similar spindle which is mounted on a carriage. The carriage which can slide either side of these gears are maintained in mesh by spring pressure. When the gears are rotated, the movement of sliding carriage is indicated by a dial indicator and these variations arc is measure of any irregularities. The variation is recorded in a recorder which is fitted in the form of a waxed circular chart. In the gears are fitted on the mandrels and are free to rotate without clearance and the left mandrel move along the table and the right mandrel move along the spring-loaded carriage.

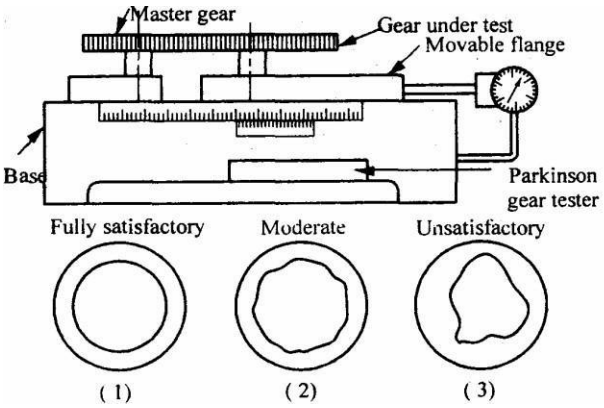


Fig 3.18 Parkinson Gear Tester

The two spindles can be adjusted so that the axial distance is equal and a scale is attached to one side and vernier to the other, this enables center distance to be measured to within 0.025mm. If any errors in the tooth form when gears are in close mesh, pitch or

concentricity of pitch line will cause a variation in center distance from this movement of carriage as indicated to the dial gauge will show the errors in the gear test. The recorder also fitted in the form of circular or rectangular chart and the errors are recorded.

- Limitations of Parkinson gear tester:
    1. Accuracy±0.001mm
    2. Maximum gear diameter is 300mm
    3. Errors are not clearly identified:
    4. Measurement dependent upon the master gear.
    5. Low friction in the movement of the floating carriage.