4.6 Roundness measurement

Roundness is defined as a condition of a surface of revolution. Where all points of the surface intersected by any plane perpendicular to a common axis in case of cylinder and cone.

Roundness is a geometric aspect of surface metrology and is of great importance because the number of rotational bearings in use is much more than that of linear bearings. Many machine parts, such as a machine spindle or the hub of a gear, have circular cross sections; these parts should have roundness with a very high degree of accuracy.

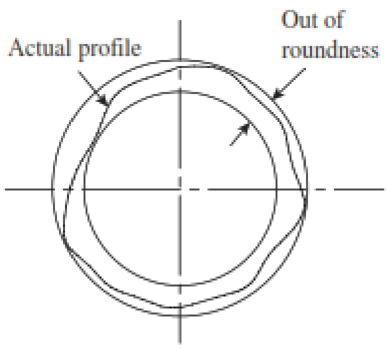

Fig. 4.45 Out of roundness

[source: Engineering Metrology and Measurements, N.V. Raghavendra, Pg. No 243]

Roundness is defined as a condition of surface of revolution where all points of the surface intersected by any plane perpendicular to a common axis are equidistant from the axis. It is obvious that any manufactured part cannot have perfect roundness because of limitations in the manufacturing process or tools; we need to determine how much deviation from perfect roundness can be tolerated so that the functional aspects of the machine part are not impaired. This leads to the definition of out of roundness as a measure of roundness error of a part. It is the radial distance between the minimum circumscribing circle and the maximum inscribing circle, which contain the profile of the surface at a section perpendicular to the axis of rotation.

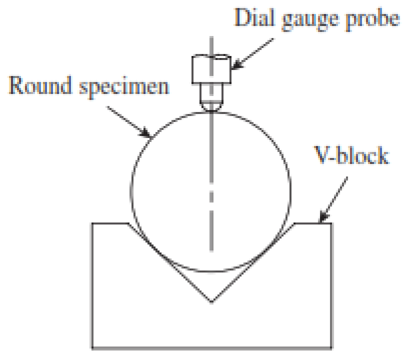

Fig. 4.46 Use of a V-block for measuring out of roundness

[source: Engineering Metrology and Measurements, N.V. Raghavendra, Pg. No 243]

Roundness error can be measured in various ways. Accessories required for the measurement comprise a surface plate, a V-block, and a dial gauge with a stand. The V-block is kept on the surface plate, and the cylindrical work part is positioned on the V-block. Care should be taken to ensure that the axis of the work part is parallel to the edges of the 'V' of the V-block. The dial gauge is mounted on its stand and the plunger is made to contact the surface of the work part. A light contact pressure is applied on the plunger so that it can register deviations on both the plus and minus sides. The dial gauge reading is set to zero. Now the work part is slowly rotated and the deviations of the dial indicator needle on both the plus and minus sides are noted down. The difference in reading for one complete rotation of the work part gives the value of out of roundness.

4.6.1 Devices used for measurement of roundness

1) Diametral gauge.

2) Circumferential conferring gauge => a shaft is confined in a ring gauge and rotated against a set indicator probe.

3) Rotating on center

4) V-Block

5) Three-point probe.

6) Accurate spindle.

4.6.1.1. Diametral method:

- The measuring plungers are located 180° a part and the diameter is measured at several places.
- This method is suitable only when the specimen is elliptical or has an even number of lobes.
- Diametral check does not necessarily disclose effective size or roundness.
- This method is unreliable in determining roundness.

4.6.1.2. Circumferential confining gauge:

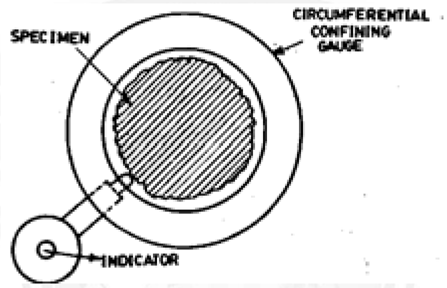

Fig. 4.47 Circumferential confining gauge

[source: http://what-when-how.com/metrology/measurement-of-circularity-metrology/]

- It is useful for inspection of roundness in production.
- This method requires highly accurate master for each size part to be measured. The clearance between part and gauge is critical to reliability.
- This technique does not allow for the measurement of other related geometric characteristics, such as concentricity, flatness of shoulders etc.

4.6.1.3. Rotating on centers:

- The shaft is inspected for roundness while mounted on center.
- In this case, reliability is dependent on many factors like angle of centers, alignment of centres, roundness and surface condition of the centres and centre holes and run out of piece.
- Out of straightness of the part will cause a doubling run out effect and appear to be roundness error,

4.6.1.4. V-Block:

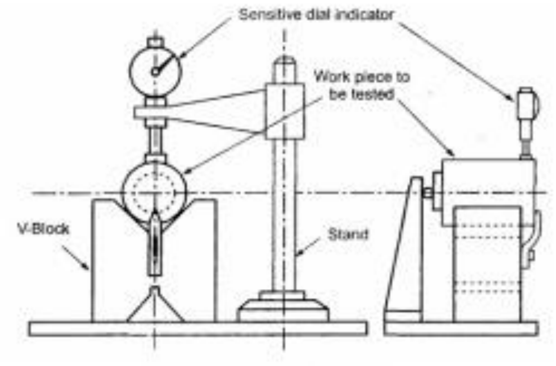

Fig. 4.48 V-Block

[source: https://www.brainkart.com/article/Roundness-Measurement_5856/]

- The V block is placed on surface plate and the work to be checked is placed upon it.
- A diameter indicator is fixed in a stand and its feeler made to rest against the surface of the work. The work is rotated to measure the rise on fall of the work piece.
- For determining the number of lobes on the work piece, the work piece is first tested in a 60° V-Block and then in a 90° V-Block.
- The number of lobes is then equal to the number of times the indicator pointer deflects through 360° rotation of the work piece.

Limitations:

a) The circularity error is greatly by affected by the following factors.

(i) If the circularity error is i\e, then it is possible that the indicator shows no variation.

(ii) Position of the instrument i.e. whether measured from top or bottom.

(iii) Number of lobes on the rotating part.

b) The instrument position should be in the same vertical plane as the point of contact of the part with the V-block.

c) A leaf spring should always be kept below the indicator plunger and the surface of the part.

4.6.1.5. Three-point probe

- The fig. shows three probes with 120° spacing is very, useful for determining effective size they perform like a 60° V-block.
- 60° V-block will show no error for 5 a 7 lobes magnify the error for 3-lobed parts show partial error for randomly spaced lobes.

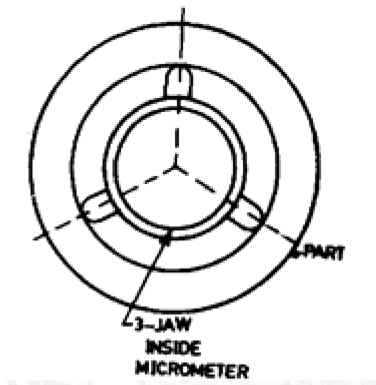

Fig. 4.49 Three point probe

[source: https://www.brainkart.com/article/Roundness-Measurement_5856/]

4.6.1.6 Roundness measuring spindle

There are following two types of spindles used.

4.6.1.6.1. Overhead spindle:

- Part is fixed in a staging plat form and the overhead spindle carrying the comparator rotates separately from the part.
- It can determine roundness as well as camming (Circular flatness). Height of the work piece is limited by the location of overhead spindle.
- The concentricity can be checked by extending the indicator from the spindle and thus, the range of this check is limited.

4.6.1.6.2. Rotating table:

Spindle is integral with the table and rotates along with it. The part is placed over the spindle and rotates past a fixed comparator

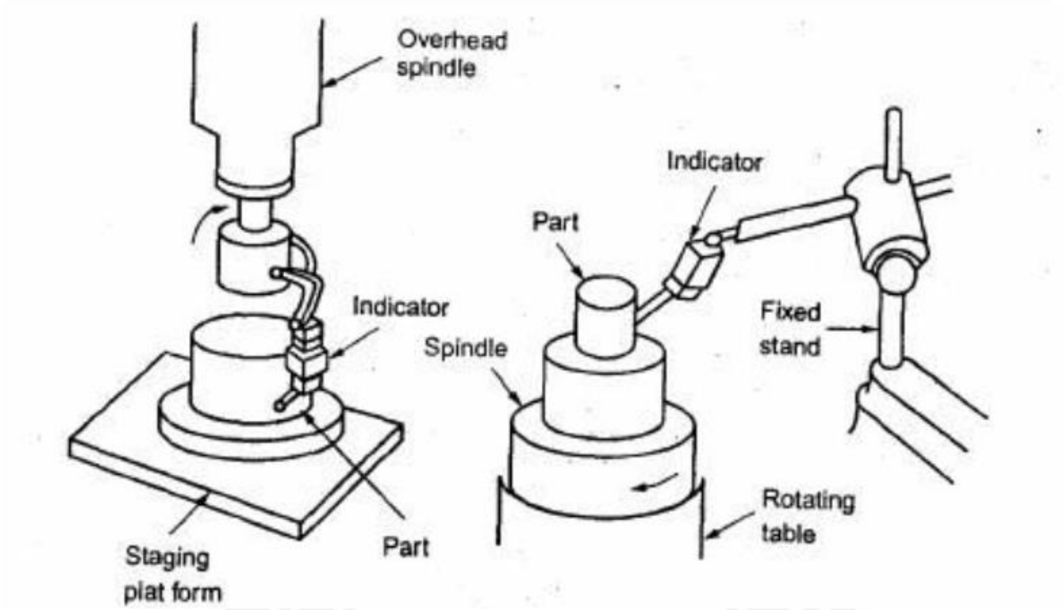

Fig. 4.50 Roundness measuring spindle Rotating table

[source: https://www.brainkart.com/article/Roundness-Measurement_5856/]

4.6.2 Modern Roundness Measuring Instruments

- This is based on use of microprocessor to provide measurements of roundness quickly and in a simple way; there is no need of assessing out of roundness. Machine can do centering automatically and calculate roundness and concentricity, straightness and provide visual and digital displays.
- A computer is used to speed up calculations and provide the stand reference circle.

(i) Least square circle:

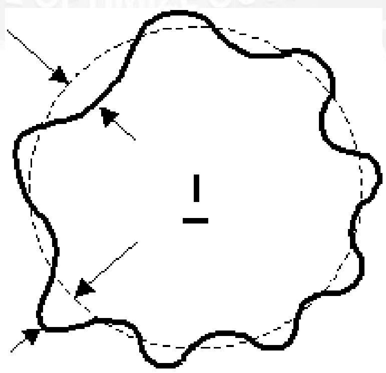

Fig. 4.51 Least square circle

[source: https://www.taylor-hobson.com/resource-center/faq/what-reference-circles-are-there]

- The sum of the squares of a sufficient no. of equally spaced radial ordinates measured from the circle to the profile has minimum value.
- The center of such circle is referred to as the least square center. Out of roundness is defined as the radial distance of the maximum peak from the circle (P) plus the distance of the maximum valley from this circle

(ii) Minimum zone or Minimum radial separation circle:

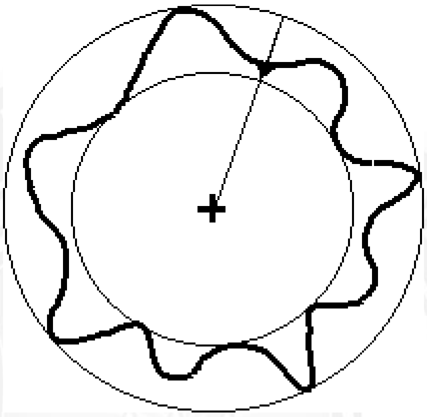

Fig. 4.52 Minimum zone circle

[source: https://www.taylor-hobson.com/resource-center/faq/what-reference-circles-are-there]

- These are two concentric circles. The value of the out of roundness is the radial distance between the two circles.
- The center of such a circle is termed as the minimum zone center. These circles can be found by using a template.

(iii) Maximum inscribed circle:

- This is the largest circle. Its center and radius can be found by trial and error by compare or by template or computer. Since V = 0 there is no valleys inside the circle.

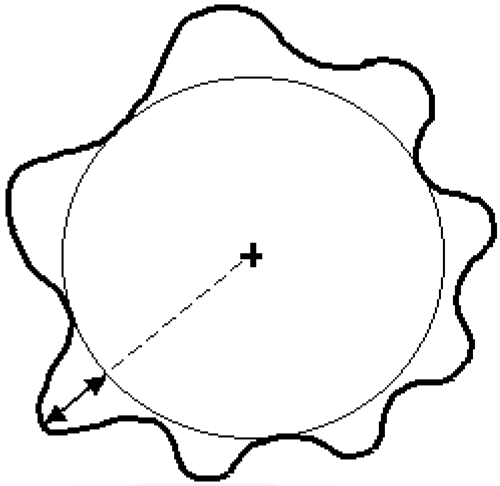

Fig. 4.53 Maximum inscribed circle

[source: https://www.taylor-hobson.com/resource-center/faq/what-reference-circles-are-there]

(iv) Minimum circumscribed circles:

- This is the smallest circle. Its center and radius can be found by the previous method since P = 0 there is no peak outside the circle.
- The radial distance between the minimum circumscribing circle and the maximum inscribing circle is the measure of the error circularity. The fig shows the trace produced by a recording instrument.

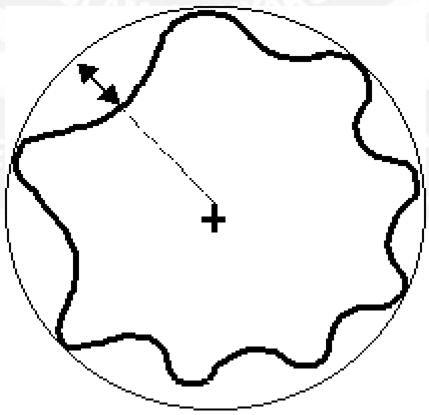

Fig. 4.54 Minimum circumscribed circles

[source: https://www.taylor-hobson.com/resource-center/faq/what-reference-circles-are-there]

- This trace to draw concentric circles on the polar graph which pass through the maximum and minimum points in such way that the radial distance be minimum circumscribing circle containing the trace or the n inscribing circle which can fitted into the trace is minimum.
- The radial distance between the outer and inner circle is minimum is considered for determining the circularity error.
- Assessment of roundness can be done by templates.
- The out off roundness is defined as the radial distance of the maximum peak (P) from the least square circle plus the distance of the maximum valley (V) from the least square circle.
- All roundness analysis can be performed by harmonic and slope analysis.