SIR C.R.REDDY COLLEGE OF ENGINEERING
ELURU-534007

METROLOGY LABORATORY MANUAL

III/IV B.TECH (Mechanical): II SEMESTER

DEPARTMENT OF MECHANICAL ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

METROLOGY LAB

LIST OF EXPERIMENTS

1. CALIBRATION OF MICROMETER

AIM: To calibrate the given micrometer with respect to a standard reference i.e. slip gauge set and to draw the calibration curve.

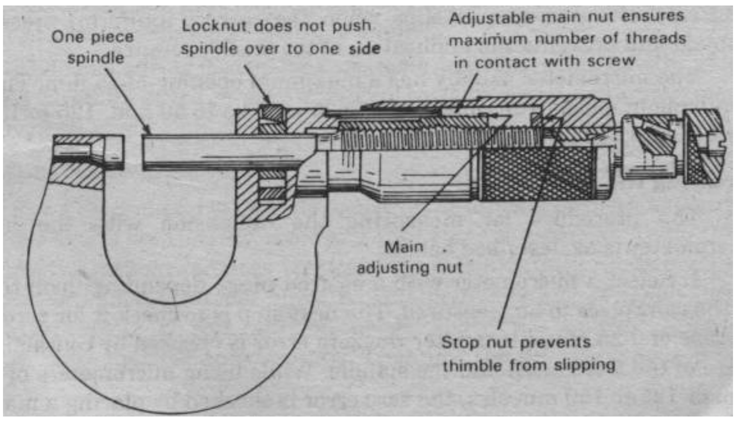
MEASURING INSTRUMENTS & TOOLS:

1. Micrometer
2. Slip gauge set

THEORY: Measuring instruments in usage will acquire certain errors due to wear and tear. So every instrument should be checked periodically to find out the errors and to assess the accuracy. Comparing the reading of the instrument with a standard reference does this. This type of inspection is known as calibration. Depending on the type of instrument the standard reference is selected, against which the error of the instrument is evaluated. Since the error cannot be eliminated from the instrument, corresponding correction is applied to the measured reading of the instrument. Since the wear and tear of the instrument is not uniform, the error in the measured value will be different at different ranges of the instrument. To apply correction for the various readings in the range of the instrument, a calibration curve is to be drawn. Calibration curve is the curve drawn between the error and the instrument reading. The error at any stage of the instrument can be either positive or negative. The correction to be applied for a positive error is negative and vice–versa.

CONSTRUCTIONAL DETAILS & APPLICATIONS: Refer any text book

FIGURE:



PROCEDURE:

1. The least count of the micrometer was found.

2. The two jaws were cleaned and the micrometer was checked for zero error.

3. The given set of slip gauges, which is used as standard reference, was cleaned.

4. A slip gauge was placed in between the two jaws of micrometer and was adjusted.

5. The slip gauge size and corresponding micrometer reading were noted down. The difference between micrometer reading and slip gauge size is the error.

6. The experiment was repeated with slip gauges of different sizes within the range of the micrometer and the readings are tabulated and corresponding errors were found.

7. A graph is plotted against micrometer reading and error / correction obtained.

PRECAUTIONS:

1. Slip gauges should be degreased properly.

2. While taking the reading of the micrometer over tightening should be avoided.

3. Slip gauges should be increased in size with regular increments and wringing should be done properly to get the required size.

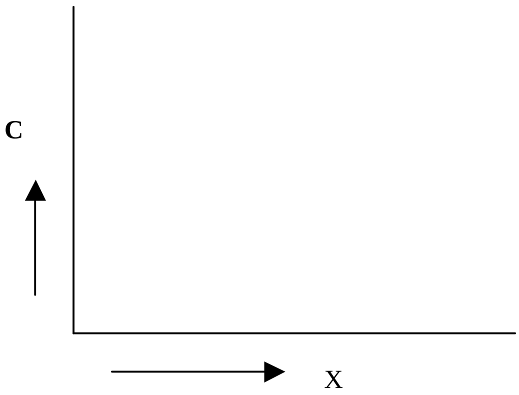
OBSERVATIONS:

Least count of micrometer =

S.No	Micrometer reading X mm	Slip gauge reading Y mm	Error E = X - Y	Correction C mm

GRAPH:

Calibration Curve



VIVA QUESTIONS

1. What is Calibration?
2. What is Measurement?
3. What is instrument?
4. Explain accuracy and write about Micrometer accuracy?
5. What is least count?
6. Explain least count for micrometer.
7. What is basic principle of the micrometer?
8. Main scale is measured on?
9. Thimble contains (or) divided into how many equal parts?
10. How final diameter is measured in micrometer?

2. CALIBRATION OF VERNIER CALIPERS

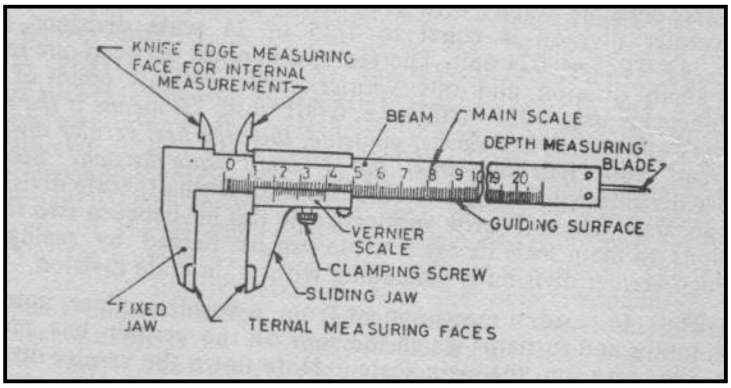
AIM: To calibrate the given vernier calipers with respect to a standard reference i.e. slip gauge set and to draw the calibration curve.

MEASURING INSTRUMENTS & TOOLS:

3. Vernier calipers (Range:)
4. Slip gauge set

THEORY: Measuring instruments in usage will acquire certain errors due to wear and tear. So every instrument should be checked periodically to find out the errors and assess the accuracy. Comparing the reading of the instrument with a standard reference does this. This type of inspection is known as calibration. Depending on the type of instrument the standard reference is selected, against which the error of the instrument is evaluated. Since the error cannot be eliminated from the instrument, corresponding correction is applied to the measured reading of the instrument. Since the wear and tear of the instrument is not uniform, the error in the measured value will be different at different ranges of the instrument. To apply correction for the various readings in the range of the instrument, a calibration curve is to be drawn. Calibration curve is the curve drawn between the error and the instrument reading. The error at any stage of the instrument can be either positive or negative. The correction to be applied for a positive error is negative and vice–versa.

CONSTRUCTIONAL DETAILS & APPLICATIONS:



PROCEDURE:

8. The least count of the Vernier calipers was found.
9. The two jaws of the Vernier calipers were cleaned and vernier was checked for zero error by bringing the two jaws close at each other.
10. The given set of slip gauges, which is used as standard reference, was cleaned.
11. A slip gauge was placed in between the two jaws of Vernier calipers and was adjusted.
12. The slip gauge size and corresponding Vernier calipers reading were noted down. The difference between Vernier calipers reading and slip gauge size is the error.
13. The experiment was repeated for slip gauges of different sizes within the range of the Vernier calipers and the readings were tabulated and corresponding errors were found.
14. A graph is plotted against Vernier calipers reading and error / correction obtained.

PRECAUTIONS:

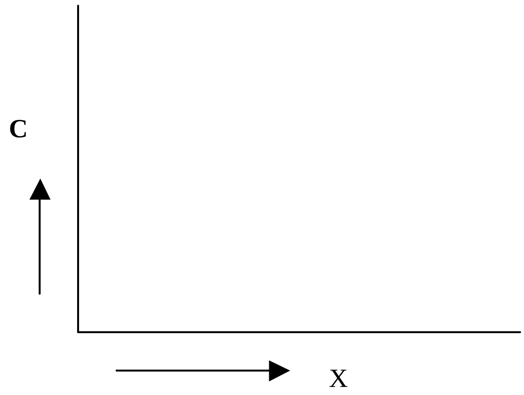
4. Slip gauges should be degreased properly.
5. Vernier reading should be taken without parallax error.
6. Slip gauges should be increased in size with regular increments with in the range of the Vernier and wringing should be done properly to get the required size.
7. Over tightening of the slip gauge in between the jaws of the instrument should be avoided.

OBSERVATIONS:

Least count of Vernier calipers =

S.No	Vernier calipers reading X mm	Slip gauge reading Y mm	Error E = X - Y	Correction C mm

GRAPH:



VIVA QUESTIONS

1. Vernier Callipers contains how many scales?
2. What is repectability?
3. How much Vernier callipers least count?
4. Internal dimensions are measured using Vernier Callipers is it true (or) not?
5. How internal dimensions are measured using Vernier Callipers?
6. Vernier scale is ****** fixed (or) Movable scale?
7. Explain about slip gauges?
8. What Error measures in Measurement?
9. Vernier Callipers is useful for depth measurement (or) not how?
10. Which material is used for slip gauge manufacturing?

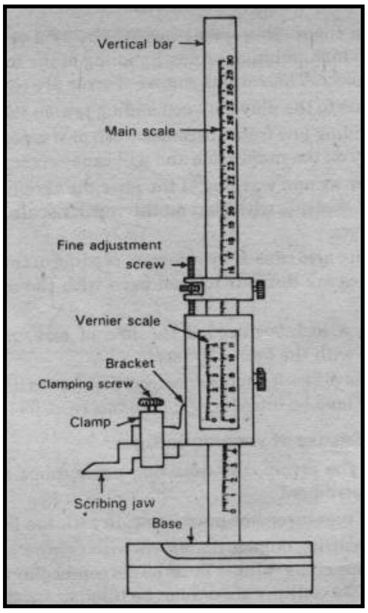
3. CALIBRATION OF VERNIER HEIGHT GAUGE

AIM: To calibrate the given vernier height gauge with respect to a standard reference i.e. slip gauge set and to draw the calibration curve.

MEASURING INSTRUMENTS & TOOLS:

5. Vernier height gauge (Range)
6. Slip gauge set

THEORY: Measuring instruments in usage will acquire certain errors due to wear and tear. So every instrument should be checked periodically to find out the errors and assess the accuracy. Comparing the reading of the instrument with a standard reference does this. This type of inspection is known as calibration. Depending on the type of instrument the standard reference is selected, against which the error of the instrument is evaluated. Since the error cannot be eliminated from the instrument, corresponding correction is applied to the measured reading of the instrument. Since the wear and tear of the instrument is not uniform, the error in the measured value will be different at different ranges of the instrument. To apply correction for the various readings in the range of the instrument, a calibration curve is to be drawn. Calibration curve is the curve drawn between the error and the instrument reading. The error at any stage of the instrument can be either positive or negative. The correction to be applied for a positive error is negative and vice – versa.



CONSTRUCTIONAL DETAILS & APPLICATIONS:

ROCEDURE:

1. The given vernier height gauge was mounted on a leveled surface plate.
2. Before placing the height gauge the surface plate should be degreased and free from dust.
3. Slip gauge set was degreased.
4. The scriber was clamped to the measuring jaw of the height gauge.
5. Measuring jaw was moved down so that the scriber touch the surface plate and the scale is adjusted to read ‘0’.

6. Measuring jaw was lifted and adjusted so that the scriber just touch on the top surface of the slip gauge placed bellow it.

7. The reading of the vernier height gauge and the size of the slip gauge were noted down. The difference between the height gauge reading and slip gauge size will be error in the instrument.

8. The procedure was repeated for different sizes of the slip gauges with in the range of vernier height gauge and reading were tabulated and corresponding errors were found.

9. A graph is plotted against vernier height gauge reading and error / correction

PRECAUTIONS:

1. Slip gauges should be degreased properly before use

2. Vernier reading should be taken with out parallax error using the magnifying glass provided.

3. The scriber should just touch the slip gauge. Any pressure on the slip gauge may lift the entire height gauge.

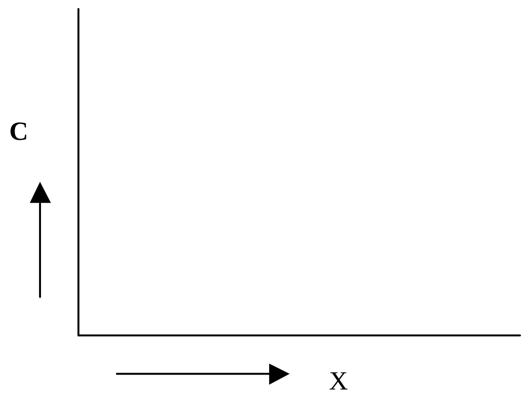
4. Slip gauges should be increased in size with regular increments with in the range of height gauge and if required the wringing should be done properly to get required size.

OBSERVATIONS:

Least count of Vernier height gauge =

S.No	Vernier height gauge reading X mm	Slip gauge reading Y mm	Error E = X - Y	Correction C mm

GRAPH:



VIVA QUESTIONS

1. Explain about precission?
2. What are difference between precission and accuracy?
3. What are difference between accuracy and precission?
4. Explain about correction?
5. How hight is measured using Vernier height gauge?
6. Explain about static Error?
7. Explain about relative Error?
8. What is relation between static error and correction?
9. Least count for height gauge?
10. In this experiment graph is drawn in between which ******?

4. CALIBRATION OF MECHANICAL COMPARATOR

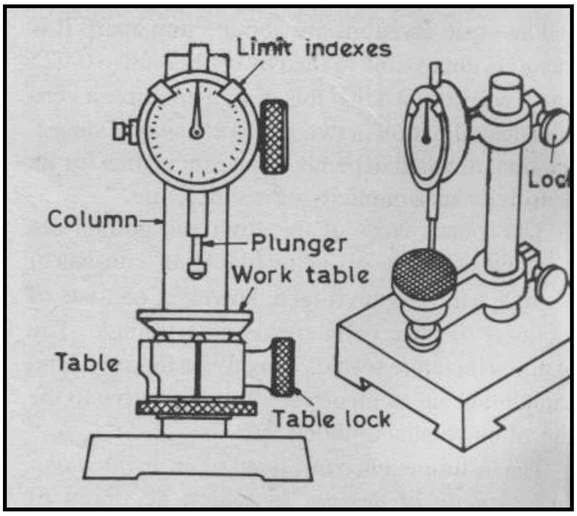
AIM: To calibrate the given mechanical comparator with respect to a standard reference i.e. slip gauge set and to draw the calibration curve.

MEASURING INSTRUMENTS & TOOLS:

1. Mechanical comparator (Range:)
2. Slip gauge set
3. Comparator stand
4. Surface plate

THEORY: Measuring instruments in usage will acquire certain errors due to wear and tear. So every instrument should be checked periodically to find out the errors and assess the accuracy. Comparing the reading of the instrument with a standard reference does this. This type of inspection is known as calibration. Depending on the type of instrument the standard reference is selected, against which the error of the instrument is evaluated. Since the error cannot be eliminated from the instrument, corresponding correction is applied to the measured reading of the instrument. Since the wear and tear of the instrument is not uniform, the error in the measured value will be different at different ranges of the instrument. To apply correction for the various readings in the range of the instrument, a calibration curve is to be drawn. Calibration curve is the curve drawn between the error and the instrument reading. The error at any stage of the instrument can be either positive or negative. The correction to be applied for a positive error is negative and vice – versa.

CONSTRUCTIONAL DETAILS & APPLICATIONS:



PROCEDURE:

1. The comparator was mounted securely in the stand and the base of the stand is cleaned.
2. Free movement of the comparator plunger was ensured.
3. The slip gauge set was degreased and an initial reading is set by selecting a suitable slip gauge and so that the plunger of the comparator just slide on the top surface and the comparator reads zero.
4. A small increment was given to the initial size of the slip gauge and the corresponding comparator reading was noted down.
5. The procedure was repeated for various slip gauge sizes within the range of the comparator so as to have the deflection on either side of zero reading.
6. The reading were tabulated and corresponding errors were found.
7. A graph is plotted against the comparator reading and error obtained.

PRECAUTIONS:

1. The slip gauge set should be degreased properly before use.
2. The initial setting of the comparator should be done carefully so as to have zero reading.
3. Slip gauges should be increased in size with regular increments with in the range on either side of zero reading.
4. Slip gauges should be wringing properly for various combinations.

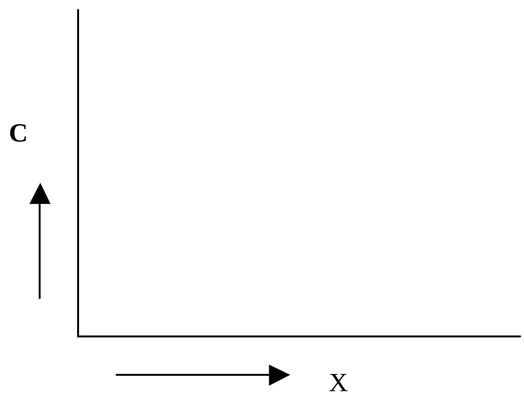
OBSERVATIONS:

Least count of Mechanical comparator =

S.No	Mechanical comparator reading X mm	Slip gauge reading Y mm	Error E = X - Y	Correction C mm

GRAPH:

Calibration Curve



VIVA QUESTIONS

1. Explain about Linear measurement?
2. What is difference between accuracy and repeat which?
3. What is the use of comparator?
4. Classify comparators?
5. Explain tolerance?
6. Explain limits?
7. What is surface plate?
8. Comparators are used in which type of production?
9. What is the basic comparator?

5. CALIBRATION OF DIAL GAUGE

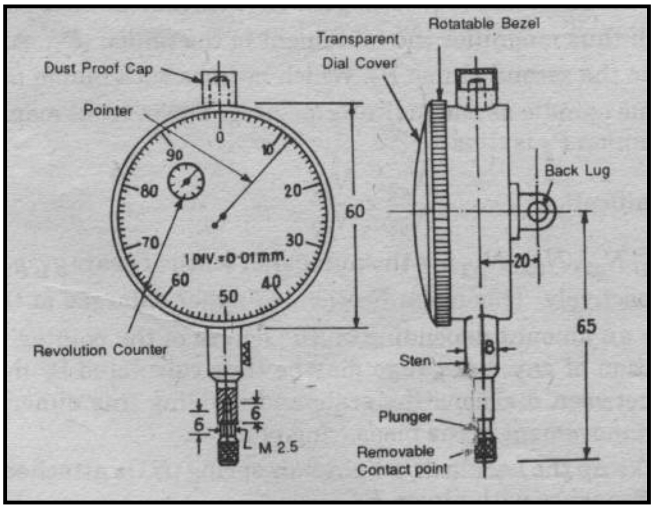
AIM: To calibrate the given dial gauge with respect to a standard reference i.e. slip gauge set and draw the calibration curve

MEASURING INSTRUMENTS & TOOLS:

1. Dial gauge (Range**:**)
2. Dial gauge stand with magnetic base
3. Slip gauge set
4. Surface plate

THEORY: Measuring instruments in usage will acquire certain errors due to wear and tear. So every instrument should be checked periodically to find out the errors and assess the accuracy. Comparing the reading of the instrument with a standard reference does this. This type of inspection is known as calibration. Depending on the type of instrument the standard reference is selected, against which the error of the instrument is evaluated. Since the error cannot be eliminated from the instrument, corresponding correction is applied to the measured reading of the instrument. Since the wear and tear of the instrument is not uniform, the error in the measured value will be different at different ranges of the instrument. To apply correction for the various readings in the range of the instrument, a calibration curve is to be drawn. Calibration curve is the curve drawn between the error and the instrument reading. The error at any stage of the instrument can be either positive or negative. The correction to be applied for a positive error is negative and vice – versa.

CONSTRUCTIONAL DETAILS & APPLICATIONS:



PROCEDURE:

1. The dial gauge was mounted securely on the stand.
2. The base of the stand was cleaned and free movement of the dial gauge plunger was ensured.
3. Slip gauges are degreased and an initial reading was set by selecting a suitable slip gauge so that the plunger of the dial gauge just slide on the top surface.
4. Dial gauge reading with initial set up was adjusted to read zero
5. A small increment was given to the initial size of the slip gauge by combination of slip gauges and was placed under the dial gauge plunger by lifting it. The corresponding reading is noted down.
6. The procedure was repeated for different sizes of slip gauges within the range of the dial gauge and reading were tabulated and corresponding errors were found.
7. A graph is plotted against dial gauge reading and error obtained

PRECAUTIONS:

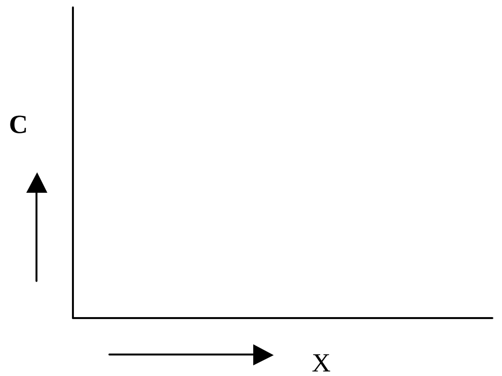
1. The dial gauge should be clamped to the stand properly so that the plunger is vertical to the base.
2. The slip gauge set should be degreased properly.
3. The plunger of the dial gauge should be handled gently.
4. The dial gauge reading was set to zero after giving slight initial compression to the plunger.
5. Slip gauges should be increased in size with regular increments with in the range of dial gauge.
6. Slip gauges should be wringing properly for various combinations.

OBSERVATIONS:

Least count of Dial gauge =

S.No	Dial gauge reading X mm	Slip gauge reading Y mm	Error E = X - Y	Correction C mm

GRAPH:



6. MEASUREMENT OF ANGLES – UNIVERSAL BEVEL PROTRACTOR

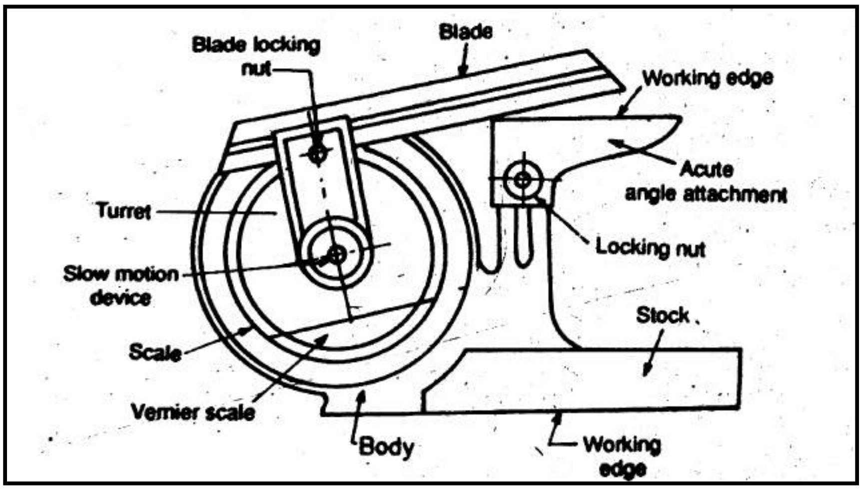
AIM: To find out the various angles of the given specimen using universal bevel protractor

MEASURING INSTRUMENTS & TOOLS:

Universal bevel protractor with accessories

THEORY: The bevel protractor is used to measure the various angles of both small and large components with accuracy up to 5 minutes. The design of the universal bevel protractor type had considerably increased the scope of angular measurement with the adjustable blades and the protractor can be indexed through 360^0. The same basic principle as in the other vernier scales was used in this instrument.

CONSTRUCTIONAL DETAILS & APPLICATIONS:



LEAST COUNT: The vernier scale of the protractor had 24 equal divisions with 12 divisions on each side of zero. On each side 12 divisions are marked from 0-60 and occupying 23 divisions on the main scale. Each division on vernier scale measures $23/12^o$. There fore least count is the difference between one main scale division and one vernier scale division [$2^o – 23/12^o = 1/12^o = 5'$] Once the least count was known the method of taking the reading is as usual.

PROCEDURE:

1. The appropriate size blade to suit the given job was fixed and locked.
2. The job / component was placed by touching the reference face and the movable blade.
3. The blade was locked after ensuring the proper contact on the two faces of the job.
4. The reading was noted down corresponding to the zero of the vernier scale.
   (M.S.R + V.S.C x 1/12)
5. The procedure was repeated to find out all the required angles.

PRECAUTIONS:

1. The blades should be fined tightly without any play.
2. Blade should be clamped only after ensuring the contact of the blade over the entire length of the component.
3. The instrument should be cleaned before and after use.
4. Vernier coincidence should be taken without parallax error

OBSERVATIONS:

SPECIMEN – 1:

θ_1 =

θ_2 =

θ_3 =

SPECIMEN – 2:

θ_1 =

θ_2 =

θ_3 =

RESULT:
The angles of the various corners of the given specimen were found to be as follows.

θ_1 =

θ_2 = , θ_3 =

7. MEASUREMENT OF TAPER ANGLES – SINE BAR

AIM: To find out the taper angle of a given specimen using sine bar

MEASURING INSTRUMENTS & TOOLS:

1. Sine bar (Specification:)
2. Dial gauge
3. Dial gauge stand
4. Slip gauge set
5. Surface plate

THEORY & PRINCIPLE: The high degree of precision available for linear measurement in the form of slip gauges can be utilised for the measurement of angles with the aid of a very simple and best measuring tool known as sine bar. The principle involved in this measurement was that the sine bar, slip gauges and the datum surface i.e. surface plate on which they lay form a right-angled triangle. The sine bar forms as hypotenuse of the right angled triangle and the slip gauges form the side opposite to the required angle. If θ is the angle to be measured and if H is the height of slip gauge and L is the length of the sine bar, from the right-angled triangle.

$$Sin\theta = \frac{H}{L}$$

CONSTRUCTIONAL DETAILS & APPLICATIONS: Sine bar (Refer any text book)

PROCEDURE:

1. The surface plate was considered as the datum to conduct the experiment.

2. The component whose angle is to be checked was mounted securely on the sine bar and both are placed on the surface plate.

3. The sine bar along with the component was set at an approximate angle by placing a known size of slip gauge at one end of the sine bar, so that the tapered side of the component is made parallel to the surface plate.

4. The dial gauge mounted on a suitable stand was placed adjacent to the sine bar so that the plunger just slides on the surface of the component. At one end the dial gauge was adjusted to read zero.

5. The same dial gauge was placed at the other end of the component and the reading is noted.
6. The height of slip gauges under the sine bar was adjusted until the dial gauge read zero at both ends of the component and the corresponding slip gauge size was noted down.

7. The acute angle made by the sine bar with the surface plate is the taper angle of the component, which was measured by using the following formula.

$$\theta = Sin^{-1}\frac{H}{L}$$

PRECAUTIONS:

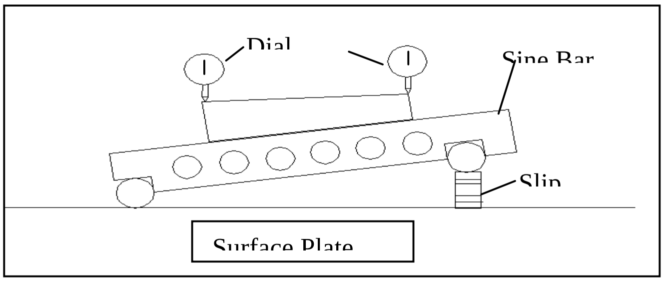
1. The surface plate, slip gauge set and sine bar should be degreased properly.

2. The dial gauge should be clamped to the stand properly so that the plunger is vertical to the base.

3. The dial gauge plunger should be handled gently and the gauge was set to zero after giving slight initial compression to the plunger.

4. The slip gauges should be placed gently under the roller of the sine bar.

EXPERIMENT SETUP FIGURE:



OBSERVATIONS:

Length of the sine bar = L mm
Height of the slip gauges = H mm

CALCULATIONS:

$$The Taper Angle\,\theta = Sin^{-1}\frac{H}{L}$$

RESULT:

Taper angle of the specimen " θ " =

8. V – GROOVE ANGLE MEASUREMENT

AIM: To measure the angle of V-groove of a given V-block by using two cylindrical rollers of different diameters.

MEASURING INSTRUMENTS & TOOLS:

1. V- Block with clamps (Specification:)
2. Surface Plate
3. Vernier Height Gauge
4. Vernier Calipers
5. Rollers of three different diameters

THEORY: Many methods were available to measure the angle of V- groove depending up on the size of the groove, location and accuracy of the groove. Two rollers of different diameters should be used for the measurement of the angle. This roller method is suitable to measure if the component height is with in the range of vernier height gauge. The accuracy of measurement in this method depends up on the roller sizes and type of V-groove surface. The parameters required were roller dimensions and the heights of those rollers from the reference when they were placed in the V-groove. An expression was derived for the V-groove angle θ in terms of the roller diameters and heights of those rollers from reference plane.

$$\theta = 2Sin^{-1}\left[\frac{d_2 - d_1}{2(h_2 - h_1) - (d_2 - d_1)}\right]$$

θ = V-groove angle

d_2 & d_1 = Diameters of the two rollers

h_2 & h_1 = Height of the rollers

PROCEDURE:

1. The diameters of the three rollers were found using the vernier calipers (i.e. d_1, d_2 & d_3 mm)

2. The components with V-groove were placed on a properly cleaned and dust free surface plate.

3. The rollers with diameter ‘d_1’ was clamped in V-groove.

4. The vernier height gauge was placed on the surface plate and was adjusted to read zero when the scriber is touching the surface plate.

5. The height of the roller was measured using vernier i.e. ‘h_1’

6. The roller with diameter ‘d_1’ was replaced by roller with diameter ‘d_2’ and the height ‘h_2’ was found.

7. The procedure was repeated for roller with diameter d_3 and height h_3 was found.

8. The reading related to all the three rollers were tabulated.

9. The v-groove angle θ was calculated thrice with the three possible combinations of the three rollers.

10. The average of the three values of θ was calculated.

PRECAUTIONS:

1. The rollers in the V-groove should not move while the height is measured.

2. The scriber edge of the vernier height gauge should just touch the surface of the roller while measuring the height.

3. The diameters and height of the rollers were found at three different places and the average diameter and height were found.

4. The readings should be taken with out parallax error.

RESULT: Average angle of the V-groove of the given V-block was found to be.

OBSERVATIONS:

Least count of the vernier calipers =

Least count of the vernier height gauge =

MEASUREMENT OF ROLLER DIAMETERS:

S.No	Roller diameter	Trial – 1 mm	Trial – 2 mm	Trial – 3 mm	Average mm
1 2 3	d1 d2 d3				

ROLLER HEIGHT MEASUREMENT:

S.No	Roller diameter	Trial – 1 mm	Trial – 2 mm	Trial – 3 mm	Average mm
1 2 3	h1 h2 h3				

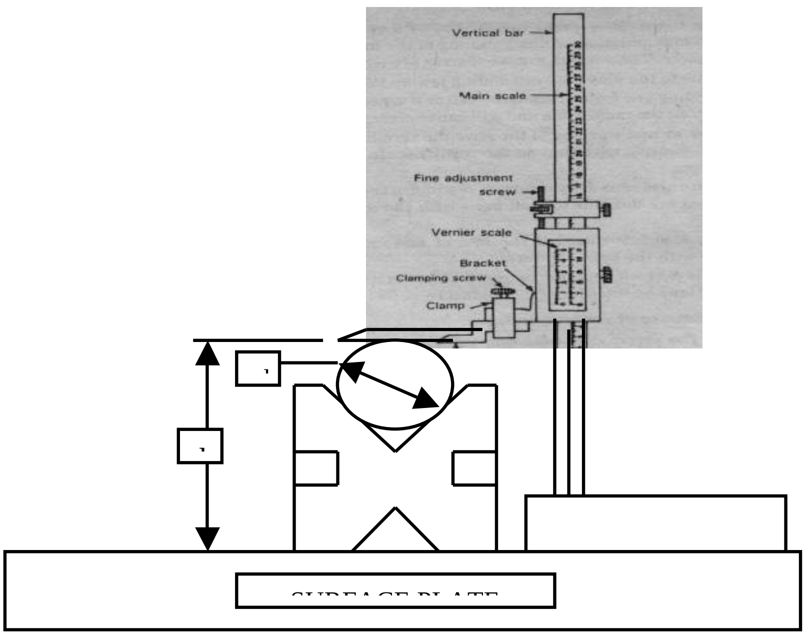
CALCULATIONS:

$$\theta_1 = 2Sin^{-1}\left[\frac{d_2 - d_1}{2(h_2 - h_1) - (d_2 - d_1)}\right]$$

$$\theta_2 = 2Sin^{-1}\left[\frac{d_3 - d_2}{2(h_3 - h_2) - (d_3 - d_2)}\right]$$

$$\theta_3 = 2Sin^{-1}\left[\frac{d_3 - d_1}{2(h_3 - h_1) - (d_3 - d_1)}\right]$$

V-GROOVE ANGLE MEASUREMENT SETUP FIGURE:



9. MEASUREMENT OF RADIUS OF CURVATURE

AIM: To measure the radius of curvature of a given component by using two cylindrical rollers of same diameter when the center of arc is not accessible.

MEASURING INSTRUMENTS AND TOOLS:

1. Surface plate (Specification:)
2. Vernier calipers (Specification:)
3. Two rollers of same diameter – 3 sets
4. V-block with clamp
5. Curved Specimen

THEORY: In practice, for various reasons, the components made will be provided with different curvatures. The measurement of the radius of these curvatures is a part in the quality control. The centers of the curvature provided for the components are not accessible and hence the measurement of radius of curvature is not possible. In such cases the option is indirect method. Indirectly the curvature can be measured by using two cylindrical rollers of same diameter and accuracy in the method depends on the diameter and accuracy of the rollers. The setup required for the measurement is as shown in the figure. For the known values of diameter of the rollers and the distance between the end points of the rollers i.e. 'd' and 'm' respectively an expression was desired for the radius of curvature 'R' in terms of 'd' and 'm'. It is given by

$$R = \frac{(m-d)^2}{8d}$$

PROCEDURE:

1. The diameters of the three sets of rollers were measured using vernier calipers. In each case the diameter was measured at three different places and the average was considered.
2. The component was placed securely on the surface plate so that it rests on its curvature with a line contact with the surface plate.
3. The first set of rollers was placed on the surface plate i.e. one on either side of the component so that the rollers have line contact with the curved surface of the component. Using two supports, one on either side of the roller, made the setup.
4. The horizontal distance 'm' between the end supports of the rollers was measured using vernier calipers and noted down.
5. The procedure was repeated using the remaining two sets of rollers and in each the distance 'm' is measured.
6. The reading were tabulated for the three sets of the rollers and in each case the radius of curvature was calculated and the average was declared as the radius of curvature.

7. The radius of curvature so measured is compared with that measured by chord-method using Vernier Depth Gauge.

$$\text{Radius of curvature } (R) = \frac{M^2 + 4h^2}{8h}$$

Where M = Length of the chord

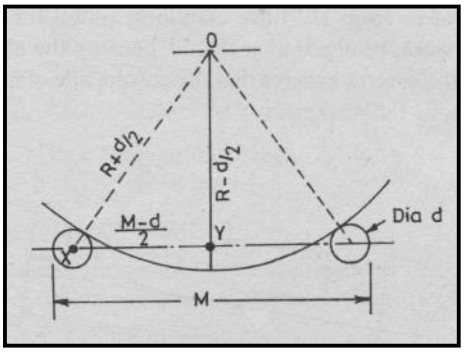
h = Depth of the curve

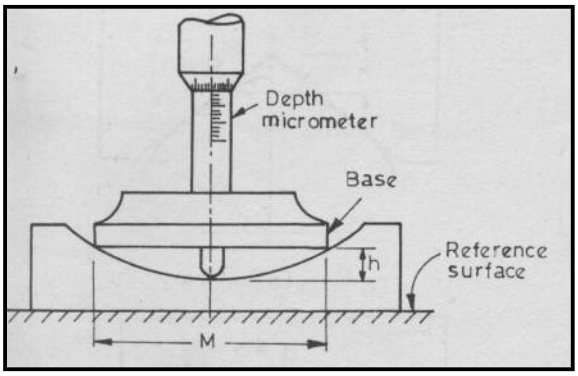
PRECAUTIONS:

1. The surface plate should be free from dust.
2. While taking the reading 'm' care should be taken that rollers has proper contact with component and the component rests on the surface plate.
3. All readings should be taken without parallax error.

RESULT: The radius of circular arc of the given component was found to be _______ mm

MEASUREMENT OF RADIUS OF CURVATURE EXPERIMENT FIGURE:





VIVA QUESTIONS

1. Explain how radius of convecture is measured using Vernier Callipers?
2. What is the importance of “V-Block” in Radius of Convecture measurement?
3. Give an expression for Radius of Convecture?
4. Radius of Convecture is mainly depend on?
5. Diameter of the rollers used in experiment are equal (or) not?

10. MEASUREMENT OF SPUR GEAR PARAMETERS

AIM: To determine the gear tooth thickness and pressure angle for the given spur gear using gear tooth micrometer / David brown base tangent micrometer.

MEASURING INSTRUMENTS AND TOOLS:

1. Base tangent micrometer
2. Vernier caliper

THEORY: Spur gear is a machine element, which is used to transmit both motion and power between two shafts whose axis are parallel. The nomenclature of a spur gear can be explained with help of the figure and is as follows.

1. Pitch circle
2. Pitch point
3. Pressure angle
4. Circular pitch
5. Tooth thickness
6. Diameteral pitch

For definitions refer any Text book.

SIGNIFICANCE OF PRESSURE ANGLE: When a pair of gear wheels are in mesh the teeth on two gears will have contact along a common tangent to their base circles, which is refered as line of contact or line action. Since this line of contact is the common generator of involute profile for both gears, the load or pressure between the gears will be transmitted along this line. The angle between this line of action and the common tangent to the pitch circles at the pitch point is called pressure angle. The standard values for pressure angle ϕ are $14\frac{1}{2}^{o}$ and 20^{o}.

PRINCIPLE: The principle involved in this experiment was the principle of base tangent method. This is the popular method for checking the gear wheel parameters. In this method the length of the base tangent was measured covering different numbers of teeth i.e 2, 3 and 4 nos. of teeth. If x, y and z are the lengths of the base tangents corresponding to different nos. of teeth i.e. l, m and n, then the base circular pitch can be calculated. Further the pitch circle diameter was found with an assumption that the gear has addendum equal to one module. Knowing the base circle diameter and pitch circle diameter, both pressure angle and tooth thickness was calculated using relevant formula.

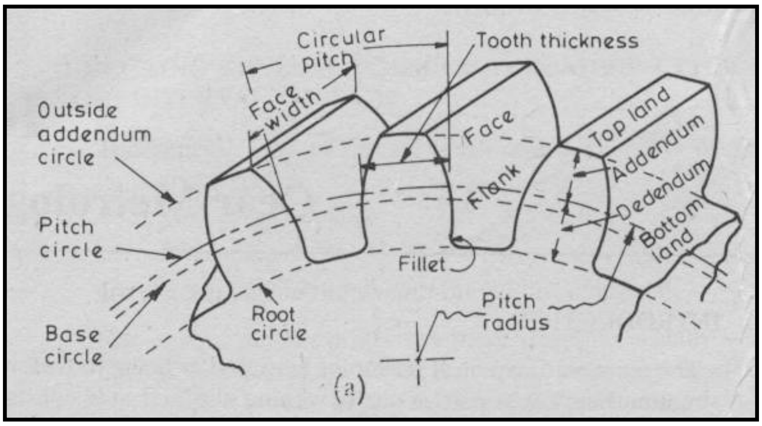
PROCEDURE:

1. The spur gear to be checked was cleaned.
2. The no. of teeth on the spur gear were counted i.e. ‘N’
3. The outer diameter of the gear was found using vernier caliper (D_o)
4. Using the base tangent micrometer the distance covered by 2, 3 and 4 nos. of teeth was found i.e. x, y and z respectively.
5. The readings were tabulated and the calculations were done to find the pressure and ‘ϕ’ and gear tooth thickness ‘W’.

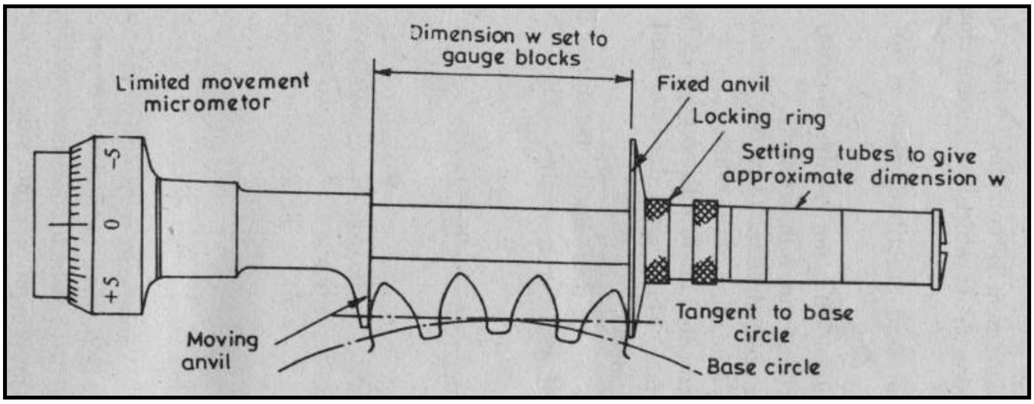
PRECAUTIONS:

1. The base tangent micrometer should be handled properly so that the flanged anvil had contact on the tooth profile close to the pitch circle.
2. The readings should be taken without parallax error.

GEAR PROFILE FIGURE:



EXPERIMENTAL SETUP:



OBSERVATIONS:

Least count of vernier caliper =

Outer Circular diameter of gear (D_o) =

No of teeth on gear N =

No. of teeth	**Tangent length**
l	x
m	y
n	z

Base circular pitch $P_{b1} = \frac{x - y}{l - m}$; $P_{b2} = \frac{y - z}{m - n}$; $P_{b3} = \frac{z - x}{n - l}$

1.The average base circular pitch was $P_b = \frac{P_{b1} + P_{b2} + P_{b3}}{3}$

2.Base Circular Diameter $D_b = \frac{P_b * N}{\pi}$

3. Do = Dp + 2m (Assume addendum = module) = mN + 2m = m(N+2)

4. m= $\frac{D_o}{N+2} \Rightarrow P_d = \frac{N+2}{D_o}$

5.Diametral pitch $P_d = \frac{N+2}{D_o}$

6.Pitch circular diameter $D_p = \frac{N}{P_d}$

7.Pressure angle $\phi = \text{Cos}^{-1}\left(\frac{D_b}{D_p}\right)$

8.Tooth thickness W = $D_p \text{Sin}\left(\frac{90}{N}\right)$

VIVA QUESTIONS

1. Explain Different important parameters in spar gear?
2. Define pitch circle and Explain procedure to measure pitch circle?
3. Define **** angle and explain procedure to measure **** angle?
4. Define circular pitch and explain procedure to measure circular pitch?
5. Define tooth thickness and explain procedure to measure tooth thickness?
6. How profile of the spar gear is measured?
7. ***** angle in spar gear is cont (or) ****?
8. Explain addendem and redendem?
9. Explain black lash?
10. What is face and flank?
11. Which instrument issued to measure tool thickness?

11. MEASUREMENT OF SCREW THREAD PARAMETERS BY OPTICAL PROJECTOR

AIM: To measure the screw thread parameters of the given grub screw viz. Pitch, root diameter, thread angle and major diameter using optical profile projector.

MEASURING INSTRUMENTS AND TOOLS:

1. Profile projector
   Specification: Screen diameter = 300 mm
   Magnification = 20X
   Table travel = 25 x 25 mm
   Screen rotation L.C = 2 min

THEORY: Profile projectors are precision inspection and measuring machines that provide fast, simple reliable quality control. The profile projector utilizes the principle of optical projection to form an image of the illuminated object at the desired magnification. The projection lens renders geometrically accurate & bright image on a ground glass serving as a screen.

CONSTRUCTION DETAILS: The system consists of a projection lens in combination with a condenser unit, micro stage and grounded glass as viewing screen as shown in figure. The illuminating system consists of a light source and a collimating optics, which are free from spherical aberration. The micro control stage below the condenser unit was provided with X and Y displacements to an accuracy of ten microns. The projection lens fixed below the micro stage has 20X magnification and is designed for distortion free image. Moving the stage up and down will do focusing of the object placed on the stage. The clear image of the object will be seen on the projection screen with the help of a front-coated reflecting glass provided in the projection system.

PROCEDURE:

1. The power supply to the profile projector was switched on.
2. The micro stage was made free from dust and the given grub screw was placed on it.
3. The height of the micro stage was adjusted to focus the object to get clear and sharp image on the projection screen.
4. The micrometer heads of the stage were adjusted to have the image at the center of the projection screen.
5. The screw thread parameters are found by adjusting the micrometer heads provided for the table movement and the protractor fitted to the projection screen.

6. The image on the screen was traced on a tracing paper or graph sheet.
7. Knowing the magnification, the parameters, pitch, thread angle, root diameter and major diameter were found from the drawing.
8. Both the readings are compared and noted down.

PRECAUTIONS:

1. The specimen should be cleaned before placing
2. The specimen axis should be parallel to stage surface
3. The tracing paper should be fixed securely on the screen
4. On the sharp image after proper focusing should be traced.

RESULT:

Pitch

Thread angle

Root diameter
Major diameter

VIVA QUESTIONS

1. What is optical projection?
2. Explain construction of optical projector?
3. Thread is specified with which diameter?
4. Explain pitch?
5. Explain thread angle?
6. Discuss thread classification according to thread angle?
7. What is Root diameter?
8. What is Mafer diameter?
9. What is error commonly encounted in screw threads?

12.DETERMINATION OF OUT OF ROUNDNESS

AIM: To check the given cylindrical specimen for roundness and find the run out from the graphical representation.

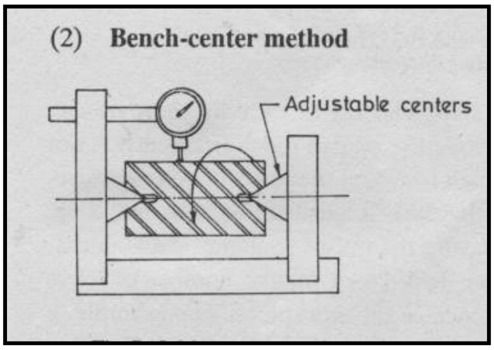
MEASURING INSTRUMENTS AND TOOLS:

1. Bench centers
2. Dial indicator
3. Dial indicator stand

THEORY: In any manufacturing industry the accuracy and precision of the assemblies made will depend on the geometrical tolerance and dimensional tolerance of the various components involved in the assembly. Geometrical tolerances are related to the shape of the component and dimensional tolerances are related the size of the components. Some of the geometrical tolerances are : 1) Straightness 2) Roundness 3) Parallelism 4) Squareness 5) Flatness. For cylindrical elements and shafts roundness and parallelism are more important. Hence cylindrical components should be checked for roundness and parallelism and run out should be found. The reference that was considered is intrinsic datum.

ROUNDNESS: It is the condition of surface of revolution. An element is said to be round if all the points on the surface intersecting with any plane perpendicular to a common axis and passing through a common center are equidistant from the axis.

EXPERIMENTAL SETUP:



PROCEDURE:

1. The cylindrical mandrel was set on the bench centers and free rotation was ensured.
2. The dial gauge was fixed to the magnetic stand and was placed behind the specimen so that the probe just touch the surface of the specimen at the highest point by having initial compression.
3. At least 5 circles were marked along the length of the specimen to check roundness.
4. At each circle after adjusting the dial gauge to read to zero with initial compression the specimen is rotated once and change in the dial gauge reading was noted at 4 to 6 different points.
5. The procedure was repeated at all the 5 circles and the readings were tabulated to find the out of roundness.
6. For all the 5 circles the readings of dial gauge were plotted graphically and the run out was found. The maximum run out of the 5 circles will be the run out of the specimen.

RESULT: Run out of the given specimen was found to be ____________

VIVA QUESTIONS

1. Define Random?
2. What is Dial indicator?
3. Explain working principle of dial indicator?
4. What is Straight ness?
5. What is parallelism?
6. What is squareness?
7. For cylindrical elements which parameters are most important?

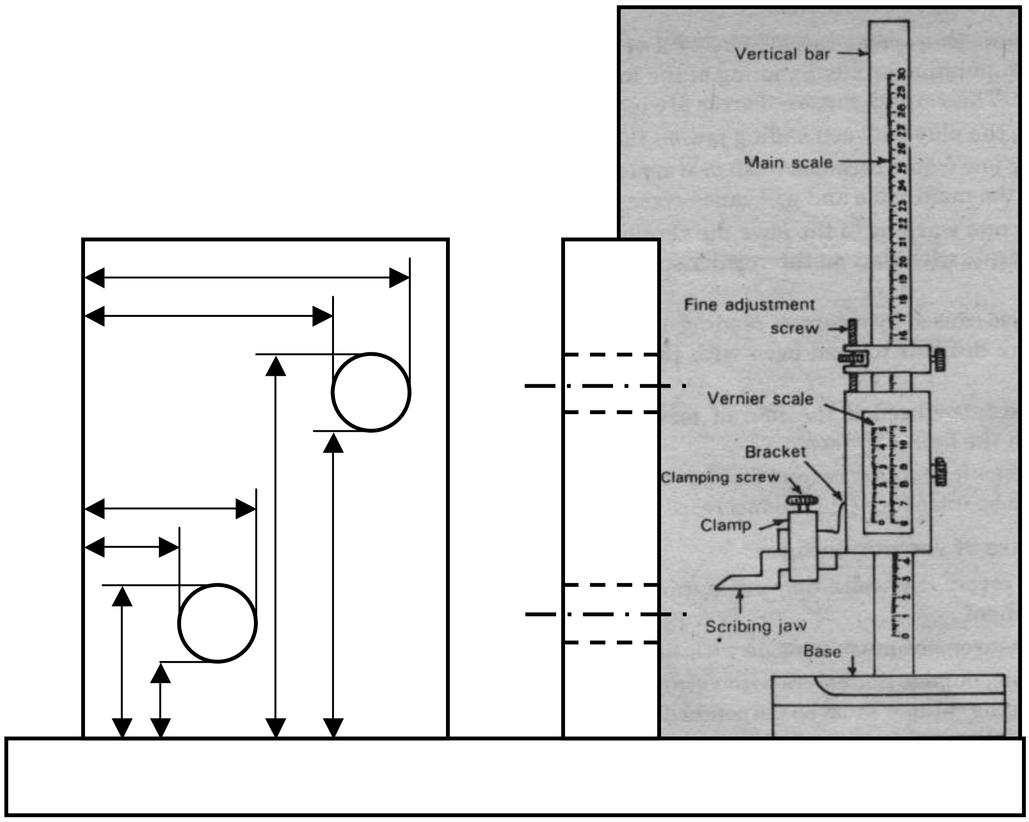
13. MEASUREMENT OF CENTRAL DISTANCE BETWEEN TWO HOLES

AIM: To measure the central distance between the two holes of the template using vernier height gauge.

MEASURING INSTRUMENTS & TOOLS:
Vernier height gauge
Surface plate
Angle plate with clamps
Bevel protractor

THEORY: Vernier height gauge will be used to measure and mark vertical distances above a reference surface with the help of knife edge or lever type dial indicator fitted to the measuring jaw. With this capability the utility of vernier height gauge can be extended to measure the central distance between the two holes of a template. The template should have two adjacent sides corrected to right angle accurately, which will be the reference sides.

FIGURE:



PROCEDURE:

1. The template sides were checked for 90^o angle using a bevel protractor.
2. Any two sides at right angle were selected and the template was fixed to the angle plate so that one of the sides under consideration touching the surface plate.
3. The heights of the lowest and highest points of the two holes under consideration were found using vernier height gauge with reference to the surface plate.
4. The procedure was repeated and the heights of the same holes were measured with reference to the second side of the template.
5. All the readings were tabulated and central distance between the two holes was found by finding the coordinates of the same holes.

PRECAUTIONS:

1. Vernier height gauge should be set to read zero on the surface plate.
2. The template should be clamped properly to angle plate to ensure the plan of the plate perpendicular to the surface plate.
3. Care should be taken while seeing the coincidence of the knife edge with the edges of the holes.

OBSERVATIONS:

L.C of the vernier height gauge =

REFERENCE SIDES OF TEMPLATE:

S. No	Reference side	x_1 mm	x_2 mm	x_3 mm	x_4 mm	X_1 mm	X_2 mm	y_1 mm	y_2 mm	y_3 mm	y_4 mm	Y1 mm	Y2 mm

$$X_1 = \frac{x_1 + x_2}{2} \qquad Y_1 = \frac{y_1 + y_2}{2}$$

$$X_2 = \frac{x_3 + x_4}{2} \qquad Y_2 = \frac{y_3 + y_4}{2}$$

$$Distance = \sqrt{(X_2 - X_1)^2 + (Y_2 - Y_1)^2}$$

VIVA QUESTIONS

1. What is angular plate?
2. What are applications of angular plate?
3. Explain expression for centre distance between two holes?
4. Explain using by affective slip gauge?
5. Using effect is desirable (or) not?

14. MEASUREMENT OF STRAIGHTNESS / FLATNESS OF A SURFACE BY AUTO COLLIMATOR

AIM: To check the flatness or straightness of a given surface plate using Auto – Collimator

MEASURING INSTRUMENTS & TOOLS:

Auto-collimator

Specification:

Objective focal length	:	220 mm
Clear aperture	:	40 mm
Magnification	:	11X
Measuring range	:	60' – 0 60' – 60' on x-y axis
L.C	:	2'
Length of test block	:	78 mm

THEORY: Auto-collimator is basically a telescope permanently focused for infinity. This is a sensitive extremely accurate optical instrument which is used in work shops for inspecting straightness, squareness and parallelism. The instrument uses the basic principle of reflection. A plane parallel beam of light projected on to a plane reflecting surface placed normal to the beam is reflected back along the same path. When the surface is slightly tilted the reflected beam returns but in deviated path. The angle of direction is taken as a measure to check the straightness.

CONSTRUCTION: A collimator is a tube used for projecting parallel rays of light. It consists of a light source and a collimating lens. Auto-collimator consists of a collimator and telescope in one units with an eyepiece provided with a micrometer. Auto-collimator along with a test block can be used for inspection of straightness. The base of the test block is flat with its working surface vertical, flat and highly polished to form a reflecting surface.

In principle if 'θ' is the angle of deviation of the reflection surface then 2 θ will be the angle of deviation of the reflected beam of the light.

If ‘d’ be deviation of the reflected beam;

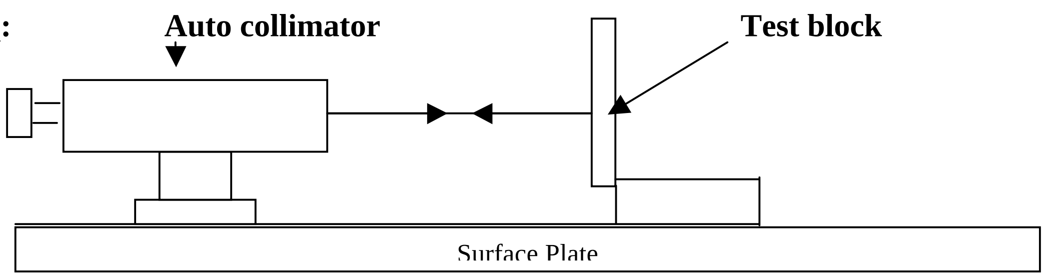
f = focal length of the lens and

θ = angle of tilt of the test block. Then $d = 2f\theta$

Let ‘l’ be the length of the test block and h be the vertical deviation of the surface over a length ‘l’ then

$h = l \tan\theta$

FIGURE:



Experimental setup

PROCEDURE:

1. The surface to be checked is cleaned and made free of dust and grease.
2. Auto-collimator is mounted on a rigid stand. So that the axis of Auto-collimator is parallel to the test surface.
3. As per the length of the test block distances are marked on the test surface parallel to the axis collimator.
4. The points are marked with numbers starting from ‘0’.
5. The test block is placed on the test surface at 0-1 marks with its reflecting surface normal to the collimator axis.
6. The collimator is adjusted until the cross wire and its reflected image are coincident as seen through the eye piece.
7. The test block is then moved to another position 1 –2 on the test surface keeping its reflecting surface perpendicular with the direction of movement.
8. The non coincidence of cross wire and image will confirm that the test surface is uneven. The scale in collimator will give the direct measure of angle of deviation of the reflected surface of the test block (i.e.$\pm\theta$).
9. Repeat the procedure along the entire length of the test surface and angles at every point are noted down.
10. The deviation from straightness or flatness at every point with reference to the 1st point is found by $h = l \tan\theta$ and are plotted to find the error in straightness.

PRECAUTIONS:

1. The surface to be checked should be free of dust.
2. Auto-collimator position should not be disturbed until the inspection is completed.
3. The micrometer of the collimator should be at mean position when the cross wire and image are coincident.

VIVA QUESTIONS

1. What is straight ness?
2. Explain about auto colliometer?
3. What is the basic principle involves in this experiment?

15. MEASUREMENT OF CUTTING TOOL ANGLES BY TOOL MAKER'S MICRO SCOPE

AIM: To measure the cutting tool angles of a single point cutting tool viz. Rake angle, Relief angle, wedge angle etc using a tool maker's micro scope.

MEASURING INSTRUMENTS & TOOLS :

Tool maker's microscope
Specification:

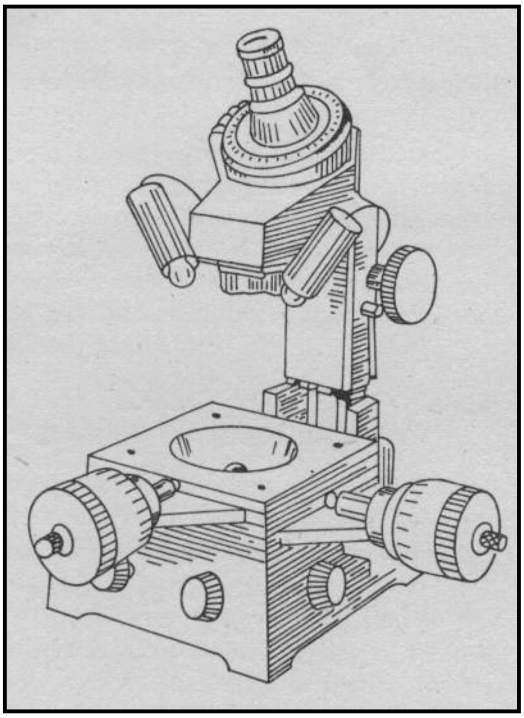
Magnification	30X
Objective	2X or 3X
Eye piece	10X
Measuring stage	150 x 150 mm
Micro meter head L.C	0.001 mm
Eye piece protractor	0 – 360^{o} with L.C 6'

Swiveling centre support L.C

THEORY: A Tool maker's microscope is a highly versatile instrument and is used in the tool room and inspection areas. It is specially useful in checking from tools, tool angles, shoulder distances, radius and teeth profile etc. A tool makers microscope provides direct reading measurement of angles and linear dimensions by means of eye piece protractor and x – y sliding table.

CONSTRUCTION DETAILS: The tool maker's microscope consists of an optical head fitted to a vertical column. Optical head consists of eye piece and objective with a suitable magnification. By moving the optical head up and down the objects that are placed on the table can be focused. The table consists of a glass plate and is provided with back ground illumination system to enable the inspection of the contours. Two micrometer heads provided to the table will enable the movement of the job in x – y direction. Further for surface illumination of job spot lights are provided on either side of the optical head. Eye piece with the protractor and cross wires will enable the angular measurements directly. In between the head and the table a swiveling center support is provided to hold the jobs between centres for angular measurements.

FIGURE:



PROCEDURE:

1. The rigidity of the tool maker's microscope placed on the work bench has to be ensured.
2. The job is either placed on the glass plate or held between the centres of the swiveling support based on the parameters to be measured.
3. The job is perfectly focused by adjusting the height of the optical head.
4. The object is illuminated by surface light or background based on the need.
5. Linear measurements are made by the movement of micrometer heads.
6. Angular measurements are made by the movement of eye protractor.
7. For a given single point cutting tool, rack angle, relief angle, wedge angle and tool depth are found.

PRECAUTIONS:

1. The specimen and the stage are to be cleaned before taking the measurement.
2. The axis of the specimen should be parallel to the movement of the stage.
3. Measurements are to be made only after ensuring a clear and sharp image of the object.

VIVA QUESTIONS

1. What is cutting tool?
2. Define Race angle?
3. Define relief angle?
4. Define wedge angle?
5. Explain working principle of tool makers's microscope?
6. What is single point cutting tool?
7. What is multi point cutting tool?