EXPERIMENT: 1

MEASUREMENT OF LENGTH, AND DIAMETER BY VERNIER CALIPER, VERNIER HEIGHT GAUGE, AND MICROMETER

AIM:

To determine the length, height and diameter of the given work piece using vernier caliper, vernier height gauge, and micrometer.

INSTRUMENTS USED: - 1) VERNIER CALIPER

2) VERNIER HEIGHT GAUGE

3) MICROMETER

SPECIFICATIONS: -

VERNIER CALIPER: Range: 0-200mm

Least count: 0.02 mm

VERNIER HEIGHT GAUGE: Range: 0-300mm

Least count: 0.02 mm

MICROMETER: Range: 0-25mm and 25-50mm

Least count: 0.01 mm

WORKING PRINCIPLE:

VERNIER CALIPER: The principle of vernier is that when two scales slightly different in length are placed one below the other, the deference between them can be utilized to enhance the accuracy of measurement. The veriner caliper essentially consists of two steel rules and these can slide along each other. One of the scales, i.e. the main scale is engraved in mm and partly in 1mm. the sliding scale, called the vernier scale consists of 50 divisions engraved on a length of 49mm. hence the least count which is the main significant value that can be measured further to the main scale reading is (1-49/50)=0.02mm. The graduation divisions and the L.C may vary from the type of vernier to another based on the range of measurement.

VERNIER HEIGHT GAUGE: Vernier height gauge also works on the same principle on which vernier caliper works. Hence this also has two scales one of which is so arranged to move vertically up and down, a thick beam frimly fixed to the base and on which the main scale is marked.

MICROMETER: Micrometer works on the principle of screw and nut. When a screw is turned one revolution through a fixed nut, the screw moves by one pitch of the thread A Circular scale marked with 'n' equal parts is attached to the screw and each division on it measures a length equal to (pitch/n).A linear scale with graduations in mm and 0.5mm is engraved on the barrel. This is the Main scale a circular scale with 50 divisions is engraved on the beveled surface of the thimble, this is vernier scale. If the micrometer screw has a pitch of 0.5 mm, those one turn of thimble makes it to travel by 0.5mm. as there are 50 equal divisions on the beveled edge of the thimble, the axial movement of the spindle connected to the thimble per division value and is known as the least count of micrometer.

DESCRIPTION:

VERNIER CALIPER: The three elements of vernier viz. the beam, the fixed jaw and the sliding jaw permit substantial improvements over direct measurement with graduated rules. Asliding jaw which moves along the guiding surface provided by the main scale is coupled to a vernier scale. The sliding jaw at its left extremity contains another measuring tip juxtaposed against the tip of the fixed jaw. When two measuring tip juxtaposed against the tip of the fixed jaw. When two measuring tip surfaces are in contact with each other, scale shows zero reading. The finer adjustment of the movable jaw can be done by adjusting screw on the vernier scale and on the support bracket are provided to ensure no disturbance of the scale.

VERNIER HEIGHT GAUGE: the main features of this instrument are the main scale and vernier scale, flat, lapped base block and other attachments which make the instrument suitable for height measurements. Along with the sliding jaw assembly, arrangement is provided to carry a marker knife or a dial indicator by means of a clamp. The upper and lower surfaces of the measuring jaw are parallel to the base, so that it can be used for measurements over or under a surface. The vernier height gauge is mainly used on a surface plate or a machine bed which form the reference plane.

MICROMETER: the micrometer consists of frame, a barrel, fixed and moving anvils, a thimble and an accurate screw having 20 threads per cm which revolves in a fixed nut. The nut is fixed in the barrel also called the sleeve. One end of the screw forms one measuring tip called the moving anvil or spindle and the other measuring tip is constituted by a stationary anvil fixed in the frame. The spindle is advanced or retracted for locking the spindle at any dimension and preventing disturbance of the spindle. Ratchet stop which ensures uniform application of measuring force on the part, consists of an overriding clutch held by a weak spring.

PROCEDURE:

VERNIER CALIPER

1. When two measuring tip surfaces are in contact with each other, check for zero error and also check if the surface are not unduly worn out or bent or any dirt collected on them.
2. The object must be held as close to the main scale bar as possible to avoid error due to deflection of tips. The axis of vernier should be perpendicular to the axis of the object. This ensures the correct dimension of the part to measure.
3. Do not apply to much pressure while measuring. First make the measuring jaws to light contact the surfaces of the work piece. Then slightly retract the left jaw and clamp the support bracket at its place.
4. Now rotate the micro adjustment knurled knob to advance the left jaw to contact the work piece surface edge.

5. Read the measurements as below

a) Main Scale rating = A (i.e reading on the main scale which is behind the zero of the vernier scale)
b) Vernier scale reading (which is coinciding with any division on the main scale)×least count = B
   Final reading =A+B

6. Take the reading at a number of positions (minimum 10) and tabulate them.

7. Find mean of the readings, mean = X= (X1+X2……Xn)/n

8. Find the standard deviation σ= $\pm \frac{\sqrt{\sum Xi-X}}{n-1}$

Where n is number of readings.

8a). calculate the range of X for 95% confidence using‘t’ factor (see table attached)

9. Mark ±1σ, ±2σ and ± 3σ limits from the mean on X- axis.

10. Plot X1, X2, X3 ……. X10 as frequencies.

11. Determine the nature of the measurement i.e. precision, accurate or both, for the experiment where an already known value of dimension, such as length of slip gauge are measured.

VERNIER HEIGHT GAUGE:

1. The base of the height gauge is first wiped clean and placed on a flat surface such as a surface plate and is checked for error, by observing that zero of the vernier coincides with the zero of the main scale when the measuring pointer just touches the reference surface.
2. The workpiece is then placed on the surface plate and the slider is moved with the help of slider clamping screw and the measuring jaw is placed on the surface of the specimen, so that it just touches the surface of the workpiece whose height is to be measured. Employ the same precautions as in vernier caliper experiment to ensure application of correct measuring force.
3. Now the measuring jaw is firmly clamped.
4. Read the measurements as below-
   a. Main scale reading = A
   b. Vernier scale reading ×least count = B

   Final reading = A+B

5. Take the reading at a number of positions (minimum 10) and tabulate them. Before taking any reading slide out the measuring tip or pointer from the surface of the work piece and slide block to the same point to ensure application of correct measuring force.

6. Find mean of the reading, mean = X = (X1+X2+………Xn)/n.

7 .Find standard deviation $\sigma = \pm\frac{\sqrt{\sum(Xi-X)2}}{n-1}$

8. Mark ±1σ, ±2σ, and ±3σ limits from the mean on X-axis.

9. Plot X1, X2, X3… Xn as frequencies.

10. Determine the nature of the measurement i.e. precision, accurate or both, by knowing the value of the already calibrated value of the work piece (Eg. Slip gauge or length bar.).

11. The calculations to be made using height gauge differ from work piece to work piece depending on the complexity of work piece.

MICROMETER:

1. Select the correct range of micrometer which will be good enough to measure the dimension.
2. Check for zero error by bringing the anvil and spindle into contact, after wiping both flat surfaces clean.
3. Retract the spindle to create a gap between the fixed anvil and the spindle tip so that the micrometer can be easily applied to the work piece dimension.
4. The work piece is placed between the anvil and spindle; ensure that the dimension to be measured is along the axis of the spindle. Let the spindle make contact with the work piece. Use only the ratchet and not the thimble.
5. When the spindle is brought into contact with the work at the correct measuring pressure, the clutch starts slipping and no further movement of the spindle takes place by rotation of ratchet. Now lock the spindle using the locking knob.
6. Now the reading on the barrel is noted down which corresponds to the main scale reading that is just cleared by the edge of the thimble.
7. Then the reading on the thimble corresponding to the pitch scale reading is noted, which is that value on the thimble scale which is coinciding with the reference line on the barrel.
8. Then the final reading is calculated using the main scale reading +pitch scale reading ×least count of the micrometer (least count is 0.01mm).
9. Take the reading at a number of positions to ensure that the measurement is made with sufficient confidence. (Minimum 10) and tabulate them.
10. Find mean of the reading, mean =X= (X1+X2+ …… Xn)/n.
11. Find the standard deviation $\sigma = \pm\frac{\sqrt{\sum(Xi-X)2}}{n-1}$

    Where n is no of readings taken.
12. Mark ±1σ, ±2σ, ±3σ limits from the mean on X-axis.
13. Plot X1, X2, X3 ……. Xn as frequencies.
14. Determine the nature of the measurement i.e. precision accurate or both by taking reading on an already established value such as slip gauge.

VERNIER CALIPER TABLE.1

s.no	MSR	VSR	LC	TR=MSR+(VC*LV)	MEAN X= (X1+X2+ …… Xn)/n.	STANDARD DEVIATION
1						
2						
3						
4						
5						

VERNIER HEIGHT GAUGE TABLE.2

s.no	MSR	VSR	LC	TR=MSR+(VC*LV)	MEAN X= (X1+X2+ …… Xn)/n.	STANDARD DEVIATION $\sigma = \pm\frac{\sqrt{\sum(Xi-X)2}}{n-1}$

MICROMETER TABLE.3

s.no	MSR	VSR	LC	TR=MSR+(VC*LV)	MEAN X= (X1+X2+ …… Xn)/n.	STANDARD DEVIATION $\sigma = \pm\frac{\sqrt{\sum(Xi-X)2}}{n-1}$
1						
2						
3						
4						
5						

GRAPH: Dimension Vs frequency

PRECAUTIONS:

VERNIER CALIPER

1. Do not apply excessive force to the work piece. Excessive measuring force will develop instrument error because of the positional deviation of the jaw or deformation of the work piece.

2. Take reading on the vernier / main scale in a viewing direction perpendicular to the measured point on the scales.

3. Do not use the vernier as a stick or screw driver. Do not throw it on the table .

VERNIER GEIGHT GAUGE:

1. Every care should be taken, particularly in case of long height gauges, to avoid its heating by warmth from the hands.
2. The height gauges are generally kept in their cases when not in use.

3. The springing of the measuring jaws should always be avoided.

MICROMETER:

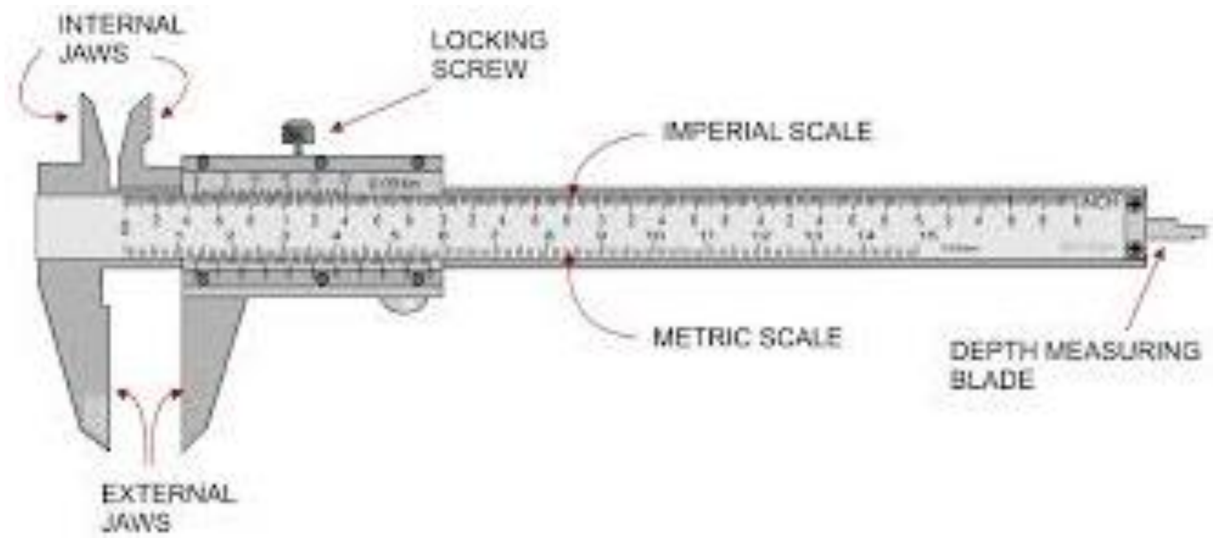
1. The port whose dimension is to be measured must be held in left hand or firmly on a surface and the micrometer in right hand, and i such a way that the forefinger and the thumb will be able to rotate the thimble and ratchet.

2. Micrometer should be cleaned of any dust and spindle should move freely.

3. Do not drop the micrometer or throw it on the table. Keep it in the case when not in use.

REVIEW QUESTIONS:

1. State the advantages and limitations of vernier caliper.
2. State the advantages and limitations of micrometer.
3. What do you mean by precession?
4. Difference between accuracy and precession.
5. State the accuracy of calipers and micrometer.



VERNIER CALIPER

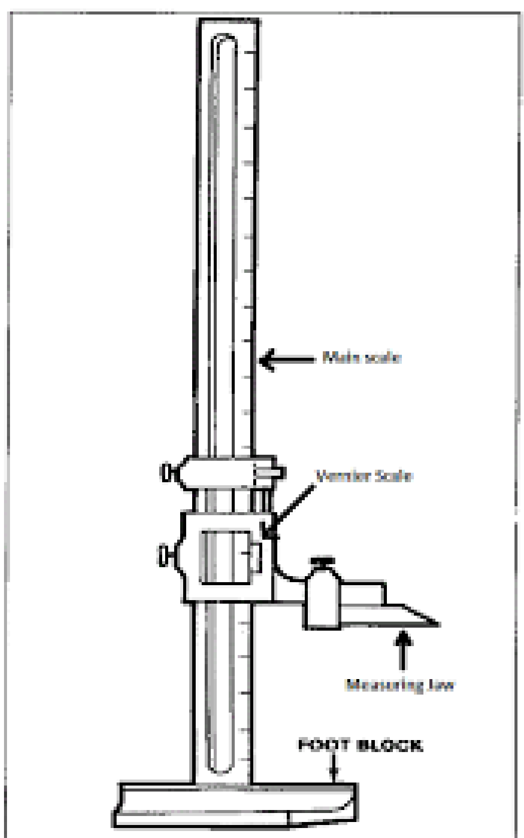
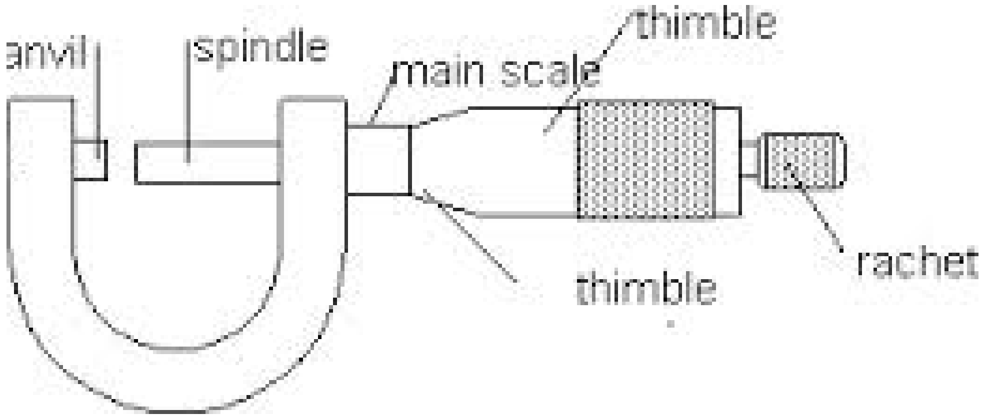


Figure 1-15. Vernier height gage.

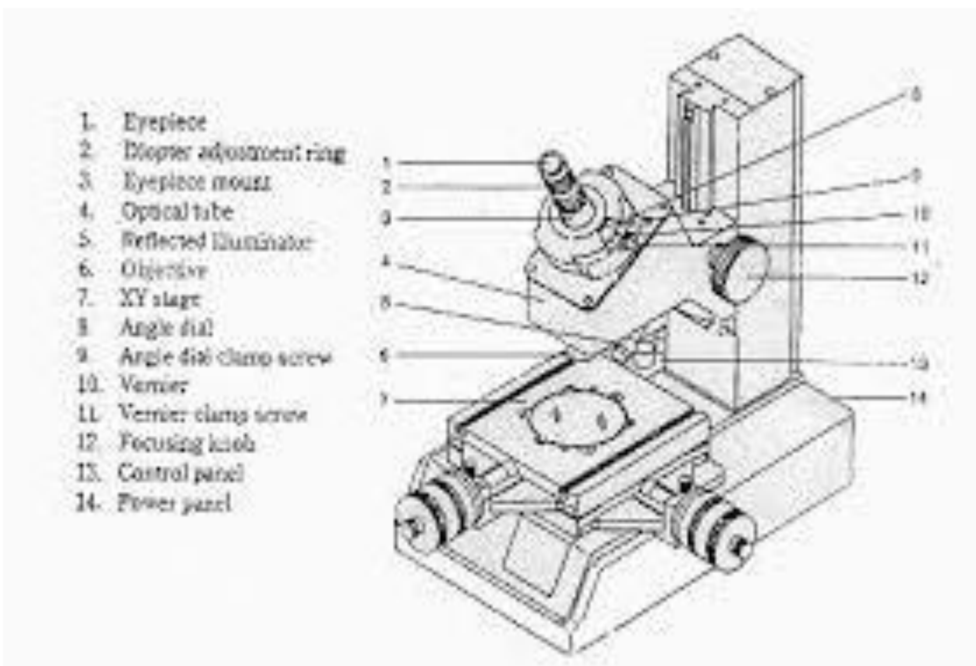
VERNIER GEIGHT GAUGE



MICROMETER

TOOL MAKERS MICROSCOPE

The large tool maker’s microscope (TMM) essentially consists of the cast base, the main lighting unit, the upright with carrying arm and the sighting microscope. The rigid cast base is resting on three foots screw by means of which the equipment can be leveled with reference to the build in box level . the base carries the co- ordinate measuring table, consists of two measuring slides ;one each for directions X and Y and a rotary circular table provided with the glass plate (fig.1). The slides are running on precision balls in hardened guide ways warranting reliable travel. Two micrometer screw each of them measuring range of 0 to 25 mm permit the measuring table to be displaced in the directions X and y. the range of movements of the carriage can be widened up to 150 m in the X direction and up to 50 mm in the Y direction with the use of gage blocks.



The rotary table has been provided with 360 degrees graduation and with a three minute vernier. The rotary motion is initiated by activation of knurled knob and locked with star handle screw. Slots in the rotary table serve for fastening different accessories and completing elements.
The sighting microscope has been fastened with a carrier arm to column. The carrier arm can be adjusted in height by means of a rack and locked with star handle screw. Thread measuring according to the shadow image permits the column to be tilted in X direction to either side about an axis on center plane level . the corresponding swivel can be adjusted with a knurled knob with a graduation celler. The main lighting unit has been arranged in the rear of the cast base and equipped with projection lamp where rays are directed via station mounted mirror through table glass plate into the sighting microscope.

MEASURING PRINCIPLE:

The work piece to be checked is arranged in the path of the rays of the lighting equipment. it produces a shadow image , which is viewed with the microscope eyepiece having either a suitable mark for aiming at the next points of the objects or in case of often occurring profiles . e.g threads or rounding – standard line pattern for comparison with the shadow image of the text object is projected to a ground glass screen. The text object is shifted or turned on the measuring in addition to the comparison of shapes.

The addition to this method (shadow image method), measuring operations are also possible by use of the axial reaction method, which can be recommended especially for thread measuring. This involves approached measuring knife edges and measurement in axial section of thread according to definition. This method permits higher precision than shadow image method for special measuring operations.

APPLICATIONS:
The large tool maker's microscope is suitable for the following fields of applications;
Length measurement in Cartesian and polar co-ordinates.
Angle measurements i.e., profile major and minor diameters, height of lead, thread angle, profile position with respect to the thread axis and the shape of thread. (Rounding, flattering, straightness of flanks)
Comparison between centers and drawn patterns and drawing of projected profiles

Single point lathe tool angle measurements

The various tool angles as per machine reference system (American system of tool nomenclature-ASA) are as follow;

Back rake angle ( ) is the angle between the tool face and the Ym axis and is measured In Ym – Zm plane (fig. 2) side rake angle ( )is the angle between the tool face and the Xm axis measured in Xm – Zm plane. End relief angle ( ) is the angle between the end flank and the side flank of the tool and the angle between the trailing edge of the tool and the Xm axis and is measured in Xm – Ym plane. Side cutting edge and is measured in the Xm – Ym plane.

Procedure of measurement with TMM

Place the tool bit on the glass stage so as to obtain a clear image on which angular measurements are done. Focus the microscope to get a real image super imposed on the graticule pattern of the eye piece. Tilt the graticule pattern so as to align the shank edge with the reference hair line. Read microscope angle scale. Tilt the angle so as to bring the cutting edge of the tool to align with the reference hairline. If necessary X,Y movements may be made to retain the edge in the field of view. A typical field of vision before and after adjustment is shown in fig.3

Different nomenclature systems for face and flank orientations

The commonly used nomenclature system for face and flank orientations are American System of Tool nomenclature (ASA system which follow machine reference system),orthogonal rake system (ORS – which follow tool reference system). The different angles and their plane of measurement are depicted in fig. 4. A comparison of the various systems and their interrelations are given in table. The graphical method of conversion between ASA and orthogonal system is explained in fig.5 the common wear patterns on tool flank and crater surface is shown in fig.6.

EXPERIMENT-1

AIM: To find the angle of thread.

TOOLS REQUIRED: Tool Makers Microscope And Accessories.

PROCEDURE:

1. Keep the specimen (thread) whose angle of thread to be found on the table.

2. Rotate the eye piece such that one of cross hair coincides the one of the flank.

3. Note the angle the eyepiece as θ_1.

4. Note the angle the eyepiece such that the same line of cross hair coincides with the other flank.

5. Note the angle the eyepiece as θ_2.

6. The difference in the angles of $\theta_1$and θ_2 is the measure of the angle of thread.

To find θ_1

S.N	MSR=a	VSR	VSR X LC =b	TOTAL READING (a+b)IN DEGREE

To find θ_2

S.N	MSR=a	VSR	VSR X LC =b	TOTAL READING (a+b)IN DEGREE

Angle of the thread= θ_1- θ_2

EXPERIMENT-2

AIM: To find the screw thread pitch.

TOOLS REQUIRED: Tool Makers Microscope And Accessories.

PROCEDURE:

1. Keep the specimen (thread) whose angle of thread to be found on the table.

2. Rotate the eye piece such that one of cross hair coincides the one of the flank.

3. Note the reading of the longitudinal micrometer as R_1

4. Rotate the longitudinal micrometer such that of cross hair coincides the same point on the profile of next thread.

5. Note the reading of longitudinal micrometer as R_2.

6. The difference in the angles of $R_1$and R_2 is the measure of the angle of thread.

To find R_1

S.N	MSR=a	VSR	VSR X LC =b	TOTAL READING (a+b)IN DEGREE

To find R_2

S.N	MSR=a	VSR	VSR X LC =b	TOTAL READING (a+b)IN DEGREE

Pitch of the thread= $R_1 - R_2$

EXPERIMENT-3

AIM: To find the Major diameter of thread.

TOOLS REQUIRED: Tool Makers Microscope And Accessories.

PROCEDURE:

1. Keep the specimen (thread) whose angle of thread to be found on the table.

2. Rotate the eye piece such that one of cross hair coincides the one of the flank.

3. Note the reading of the longitudinal micrometer as R_1

4. Rotate the longitudinal micrometer such that of cross hair coincides the same point on the profile of next thread.

5. Note the reading of longitudinal micrometer as $R_{2.}$

6. The difference in the angles of $R_1$and R_2 is the measure of the angle of thread.

To find R_1

S.N	MSR=a	VSR	VSR X LC =b	TOTAL READING (a+b)IN DEGREE

To find R_2

S.N	MSR=a	VSR	VSR X LC =b	TOTAL READING (a+b)IN DEGREE

Major diameter of thread = R_{1}- R_2

EXPERIMENT-4

AIM: To find the Manor diameter of thread.

TOOLS REQUIRED: Tool Makers Microscope And Accessories.

PROCEDURE:

1. Keep the specimen (thread) whose angle of thread to be found on the table.

2. Rotate the eye piece such that one of cross hair coincides the one of the flank.

3. Note the reading of the longitudinal micrometer as R_1

4. Rotate the longitudinal micrometer such that of cross hair coincides the same point on the profile of next thread.

5. Note the reading of longitudinal micrometer as R_2.

6. The difference in the angles of $R_1$and R_2 is the measure of the angle of thread.

To find R_1

S.N	MSR=a	VSR	VSR X LC =b	TOTAL READING (a+b)IN DEGREE

To find R_2

S.N	MSR=a	VSR	VSR X LC =b	TOTAL READING (a+b)IN DEGREE

Major diameter of thread = $R_2 - R_1$

EXPERIMENT: 2

MEASURMENT OF BORES BY INSIDE MICROMETER AND DIAL BORE GAUGE

AIM:

To determine the inner diameter of the given work piece by using micrometer and dial bore gauge.

INSTRUMENT USED: 1) Inside micrometer

2) Dial bore gauge

SPECIFICAUTION:

Inside micrometer: Range: 5-30 mm

Least count: 0.01mm

Dial bore gauge: Range: 18-35 mm

Least count: 0.01mm

WORKING PRINCIPLE:

INSIDE MICROMETER:

Micrometer works on the principle of screw and nut when a screw is turned one revolution through a fixed nu , the screw moves by one pitch of the thread . a circular scale marked with 'n' equal parts is attached to the screw and each division on it measures a length equal to (pitch/n). A linear scale with graduations in mm and 0.5 mm is engraved on the barrel .this is the main scale a circular scale with 50 divisions engraved on the beveled surface of the thimble . this is thimble scal .if the micrometer screw has a pitch of 0.5mm , then one turn of the thimble makes it to travel by 0.5m.as there are 50 equal divisions on the beveled edge of the thimble , the axial movement of the spindle connected to the thimble per division of the thimble scale will be equal to 0.5/50=0.01mm . This is the scale division value and is known as the least count of the micrometer.

DIAL BORE GAUGE:

Dial bore gauge works on the principle of mechanical movement and amplification by rack and pinion and gears is moving anvil actuates an L-liver is hinged at the corner there for any movement of one leg of L-liver results in corresponding movement without magnification of the other leg . Attached to the other leg is spring loaded plunger which moves in a direction perpendicular to the movement of moving anvil. The movement of plunger is transferred to, directly the plunger of dial indicator. There is a plunger which is a perfect sliding fit in its own bearings. This carries a rack which is accurately meshes with a pinion A. The rotation of the plunger about its own axis is prevented by a pin attached to it, which is located in a slot in a rack guide G. In order to keep the plunger in an extended or normal position a light coil spring Sis employed. a small movement of the contact point causes the rack to turn the pinion . A with which is it meshed. A larger gear B is attached to the small spindle as pinion A. The gear B is further meshed with a pinion C, which thus magnifies the movement of pinion A. Attached to the second pinion C is another gear D which enmeshes with a third pinion E mounted on the same spindle as the indicator pointer . The overall magnification of final pinion is thus = (TD/TE×TB/TC).Where TB, TC etc represent the number of teeth of gears B and C respectively. This magnification is further enlarged at the tip of the pointer by an amount dependent upon its length. The overall magnification for any dial gauge may be thus calculated by measuring the distance between divisions on the scale and dividing this dimension by the equivalent movement of the measuring plunger. A small movement of anvil is amplified and shows by the dial indicator can be graduated in L.C of 0.01or0.05mm.

DESCRIPTION:

INSIDE MICROMETER:

Inside micrometer consist of 5 parts 1) left and right jaw pins 2) sleeve or barrel 3) thimble 4) ratchet stop 5) clamping knob .This micrometer caliper has no U-shape frame and spindle . The measuring tips are constituted by the jaw pins with contact surfaces which are hardened and ground to a radius. One of the jaws is held stationary at the end second one moves by the movement of the thimble. a locknut is provided to arrest the movement of the movable jaw , at any position . Note that the main scale does not start with zero when the jaws are closer. Also the clockwise direction of thimble moves the jaws away from each other. There is no zero of the main scale but only the minimum value of 5 which is the least bore diameter that can be measured using this micrometer.

DIAL BORE GAUGE:

It consists of a dial indicator or dial gauge which is sensitive to the change in dimensions. These are designed for checking bore diameter by the comparative method. The instrument basically consists of a hollow tube in which is contained a lever pivoted about its intermediate support. One end of the lever is linked to the movable contact of the instrument and other end of the lever actuates the pointer .the three contacts bears against the internal surface of the part and properly center the instrument in a relation to the axis of the bore being checked . The contacts are interchangeable with extension rods in order to broaden the range of measurement. the range , the instrument available in the lab can check is 18 to 35 mm in diameter , without an extension rod and 18 to 400 mm with extension rod . There are other similar bore gauges available to check 6 to 10 and 10 to 18.5 mm range.

PROCEDURE:

INSIDE MICROMETER

1. Firstly the diameter of bore is measured approximately by vernier caliper.
2. Before measurement, wipe clean the contact points with cloth.
3. Before measurement, check the datum point; measure a master gauge with the micrometer. if the micrometer does not read the size of the master gauge and if any deviation is there then datum point adjustment is required .
   A) Deviation within ±0.01 mm: tighten the clamping knob. Rotate the sleeve with the wrench set in the hole behind the reference line on the sleeve until of the micrometer becomes the same with the size of the master gauge.
   B) Deviation out of ±0.01 mm: tighten the clamping knob. Loosen the ratchet stop by rotating it with the wrench set in the hole on the ratchet stop. Push the thimble to the ratchet stop, and rotate the thimble until the reading of the micrometer becomes the same with the size of the master gauge. Set the ratchet stop in place, and tighten it there.
4. The micrometer is then adjusted at a distance slightly smaller than the diameter of the bore.
5. Apply constant measuring force by rotating the ratchet stop. Any excessive force will cause the indication error.
6. Contact point must always be moved sideways up and down in an arc in order to ensure that diameter is being measured and not chord. Lock the reading.
7. The micrometer is then removed and reading is taken.
8. Take reading of the thimble / sleeve carefully.
   Reading on the micrometer = reading uncovered on the barrel +0.01×number of divisions on thimble scale which coincides with horizontal line on the barrel.
9. Take the reading at a number of positions (minimum 10) and tabulate them.
10. Find mean on the readings, mean = X=(X1+X2+……. Xn)/n.
11. Find the standard deviation $\sigma=\pm\frac{\sqrt{\sum(Xi-X)2}}{n-1}$
12. Mark ±1σ, ±2σ, and ± 3σ limits from mean on X-axis.
13. Plot X1, X2, X3… Xn as frequencies.
14. Determine the nature of the measurement I.e. precision, accurate or both, by trying the instrument on an already known (to a better accuracy then 0.01) bore.

DIAL BORE GAUGE

1. Firstly the diameter of bore is measured approximately by vernier caliper.
2. Dial indicator is attached to bore gauge as follows :
   Set the dial indicator by inserting its spindle in the holder so that the indicator reads at least 0.3mm. Secure the dial indicator with the clamp screws.
   Use limit hands as per the requirement.
3. Datum point adjustment is done with a setting ring or master gauge , whose dimension is known accurately.
4. For the required measuring dimension (which we got from the vernier caliper) select the appropriate interchangeable rod, interchangeable washers and sub anvils and set them on the main nut.
5. Set the bore gauge to a dimension about 0.5 mm more than the dimension to be measured, using a micrometer which is set to an operating of dimension to be measured +0.5 mm. Rock the bore gauge slightly in an arc to get the pointer of dial start moving in both the directions for a slight change in the tilt angle of the handle. Now turn the bezel of the indicator to bring the zero of the dial under the pointer. At this dimension also note the position of the small pointer, which should be within the 1mm mark.
6. The movable contact is pressed when the measuring head is inserted into the bore .whose diameter is to be measured then certain pressure is created and by this the dial gauge indicator moves. Rock the handle slightly so that the axis of the measurement is perpendicular to the bore axis.
7. By knowing the direction of the deviator of the dial gauge, pointer from zero add or subtract the value to the actual value at zero. Correct reading is obtained at A and E position.
8. Take the readings at a number of positions (minimum 10) and tabulated them.
9. Find mean of the readings, mean =X=(X1+X2+…… Xn)/n.
10. Find the standard deviation $\sigma = \pm\frac{\sqrt{\sum(Xi-x)2}}{n-1}$
11. Mark ±1σ, ±2σ, and ±3σ limits from the mean on X-axis.
12. Plot X1, X2, X3… X10 as frequencies.
13. Determine the nature of the measurement on a bore whose value is precisely known and whose accuracy is better than 0.01.

INSIDE MICROMETER TABLE: 1

s.no	MSR	VSR	LC	TR=MSR+(VC*LV)	MEAN X=(X1+X2+ …… Xn)/n.	STANDARD DEVIATION $\sigma = \pm\frac{\sqrt{\sum(Xi-X)2}}{n-1}$
1						
2						
3						
4						
5						

DIAL BORE GAUGE TABLE: 2

s.no	MSR	SR	LR	RR	VSR=SR+(LR-RR)	LC	TR=MSR+(VC*LV)	MEAN X=(X1+X2+ …… Xn)/n.	STANDARD DEVIATION $\sigma = \pm\frac{\sqrt{\sum(Xi-X)2}}{n-1}$
1									
2									
3									
4									
5									

GRAPH: Dimension Vs frequency

RESULT:

PRECAUTIONS:

INSIDE MICROMETER

1. The port whose dimension is to be measured must be held in left hand and the micrometer in right hand, so that rotation of thimble or ratchet is effected by the forefinger and the thumb.
2. Micrometer should be cleaned of any dust and spindle should move freely

3. Do not over tighten the thimble at the end positions .carefully note the correct direction of rotation when retracing the spindle from an already contacted position

DIAL BORE GAUGE

1. Do not push the dial indicator stem too much into the bore gauge holder. The pointer should move only about 0.3mm to 0.4mm.
2. DO not disassemble the instrument beyond the needed stage to fit extension rod or change of anvil.
3. Do not apply too much torque to fix the interchangeable anvil.
4. Do not bump the instrument on any other object.
5. After use cleans the interchangeable anvil, washer etc stores them in their respective containers.

REVIEW QUESTIONS:

1. What is the other instrument used for measurement of bore?
2. What do you mean by least count of the instrument?
3. Explain the principle of inside micrometer and bore gauge?
4. Explain the advantages and limitation of bore gauge.

INSIDE MICROMETER

DIAL BORE GAUGE

EXPERIMENT: 3

USE OF GEAR TOOTH VERNIER CALIPER FOR CHECKING THE CHORDAL ADDENDUM AND CHORDAL THICKNESS OF SPUR GEAR

AIM:

To determine the chordal addendum and chordal thickness of the given spur gear by gear tooth vernier caliper.

INSTRUMENT USED: Gear tooth vernier caliper

SPECIFICATIONS:

Gear tooth vernier caliper: Range a) vertical beam: 0-80 mm

b) Horizontal beam: 0-100 mm

Least count: 0.02 mm

WORKING PRINCIPLE

GEAR TOOTH VERNIER CALIPER:

The principle of vernier is that when two scales slightly different in length are placed on below the other, the difference between them can be utilized to enhance the accuracy of measurement. The vernier caliper essentially consists of two steel rules and these can be slide along each other. One of the scales, i.e. the main scale is engraved in mm and partly in 1mm. The sliding scale, called the vernier scale consists of 50 divisions engraved on a length of 49 mm. hence the least count which is the minimum significant value that can be measured further to the main scale reading is (1-49/50) = 0.02 mm . the graduation divisions and the L.C . May vary from the type of vernier to another based on the range of measurement. Further, gear tooth vernier works on the principle that when the jaws are set to the chordal thickness then the vertical scale should measure the chordal height (or chordal addendum) when its moving blade (tongue) touches the tooth outer surface.

DISCRIPTION:

GEAR TOOTH VERNIER CALIPER:

Gear tooth vernier caliper is used to measure the chordal thickness of the gear tooth at the pitch line or chordal thickness of the tooth and the chordal addendum is. The chordal thickness of a tooth at pitch line and chordel addedum is measured by an adjustable touge, each of which is adjusted independently by adjusting screw on graduated bars. The effect of zero error should be taken into considerations. This method is simple and inexpensive. However it needs different setting for every change in the number of teeth for a given pitch and accuracy is limited by the least count of instrument. Since the wear during use is concentred on the two jaws, the caliper has to be calibrated at regular intervals to maintain the accuracy of measurement.

Where w- chordel thickness or width

d- chordel addendum

Directly the value of w can be found out the formula.

w- Nm sin (90/N)

Where N-total no of teeth of the given gear

m- Module (which is given or determined)

Once this value is known then directly we can find the value of chordel addendum with the help of gear tooth vernier caliper (by setting the value of w in the caliper).

The formula to find out theoretical chordel addendum is

D= Nm /2 {1+2/N-COS (90/N)}

PROCEDURE:

1. When two measuring tip surfaces are in contact with each other, check for zero error.
2. Count the number of teeth on gear wheel.
3. The chordel thickness or width of the gear is calculated by using the formula for w. module ‘m’ is to be obtained either by design specification or by trial and error. Bear in mind that module will be usually a whole integer 3 to 10 or at most 0.5 more than a whole number .To arrive at correct ‘m’ first approximately measure w at about the pitch circle and calculate ‘m’ using the formula for w .now round off the value for ‘m’ and recalculate ‘w’ with this new ‘m’.
4. The value of chordel thickness is set on caliper (on horizontal beam) and chordel addendum is measured by using gear tooth vernier (on vertical beam).
5. Thus the chordal addenda of several teeth are measured and their average is taken as the actual value of the chordel addendum for the gear along with the σ for the variation of the average.
6. If any error in the instrument is found then it is added to the obtained value accordingly.
7. The measured value is compared with the calculated value . if the difference is within limits the chordel addendum is accepted .
8. Where thickness correction has been indicated in the design this should be considered when calculating ‘m’ by using the actual value of ‘w’.

CHORDAL ADDENDUM OF SPUR GEAR

TABLE: 1

s.no	MSR	VSR	LC	TR=MSR+(VC*LV)	MEAN X= (X1+X2+ …… Xn)/n.	STANDARD DEVIATION $\sigma = \pm\frac{\sqrt{\sum(Xi-X)2}}{n-1}$
1						
2						
3						
4						
5						

CHORDAL THICKNESS OF SPUR GEAR

TABLE: 2

s.no	MSR	VSR	LC	TR=MSR+(VC*LV)	MEAN X= (X1+X2+ …… Xn)/n.	STANDARD DEVIATION $\sigma = \pm\frac{\sqrt{\sum(Xi-X)2}}{n-1}$
1						
2						
3						
4						
5						

GRAPH: Dimension Vs frequency

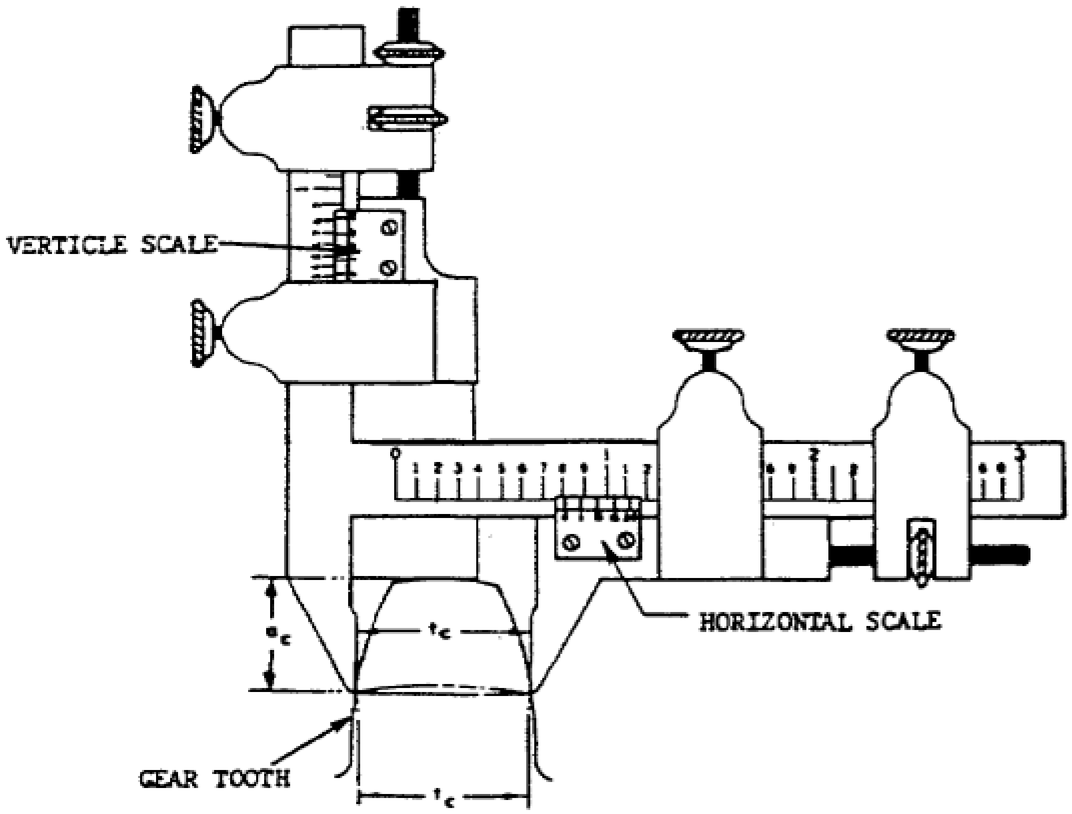
PRECAUTIONS:

1. Take the value of cordel thickness correctly in the gear tooth vernier caliper and then accordingly find the value of chordel addendum.
2. Thickness may change along the face of the gear tooth .hence on each tooth take measurements at 3 places, namely front, middle and rear.
3. Take precaution not to drop the vernier or use it badly and roughly.
4. When not in use, store it in the case.

RESULT:

REVIEW QUESTIONS:

1. What is meant by addendum and why is it important?
2. What is module and how do we choose its value?
3. What are the other methods of measuring chordel thickness?
4. What is a pitch circle and what is its role in the proper functioning of the gear?



GEAR TOOTH VERNIER CALIPER

EXPERIMENT: 4
ANGLE AND TAPER MEASUREMENT BY VERNIER BEVEL PROTRACTOR AND SINE BAR

AIM:
To measure the angle of the given work piece by using venire bevel protractor and sine bar.

INSTRUMENTS USED: 1) Venire bevel protractor

2) Sine bar.

SPECIFICATIONS:-

Venire bevel protractor: Range 0-360°

Least count: 5'

Sine bar Length: 100 mm

WORKING PRINCIPLE:

VERNIER BEVEL PROTRACTOR:

This instrument works on the principle of venire. Two scales marked in angles and differing slightly are arranged to slide past each other. The venire scale which is marked in 5' and covering only a small part of the main scale slide over the main scale. The vernier scale has 24 divisions coinciding with 23 main scale divisions .(So 1-23/24= 1/24x60'=2.5',in order to avoid cluttering of too many lines the vernier scale is marked with 5' internal division i.e., 2.5' internal lines are omitted). Thus the least count of the instrument is 5 minutes. It is capable of measuring from 0 to 360°. It is probably the simplest instrument for measuring the angle between two faces of component.

SINE BAR:

The sine bar uses sine principle i.e., the ratio of the length of hypotenuse of right angle triangle in finding out the angle of work piece. The measurement is usually limited to 45°from the accuracy point of view. The accuracy with which the sine principle can be put to use is dependent in practice on some form of liner measurement.

DESCRIPTION:

VERNIER BEVEL PROTRACTOR:

Generally it consists of three parts: i) body, ii) stock and, iii) blade. Body is designed in such a way that its back is flat and there are no projections beyond its back so that when the bevel protractor is placed on its back on a surface plate there shall be no perceptible rock. The flatness of the working edge of the stock and body is tested by checking the squareness of blade with respect to stock when blade is set at 90^o. The working edge of the stock is about 90 mm in length and 7 mm thick. It is very essential that the working edge of the stock be perfectly straight and if at all departure is there, it should be in the form of concavity and of the order of 0.01mm maximum over the whole span. Blade can be moved along the turret throughout its length and can also be reversed. It is about 150 or 300mm long, 3mmwide and 2mm thick and ends beveled at angles 45 and 60 within the accuracy of 5 minutes of arc. It is capable of measuring from 0 to 360. Acute angle attachment can be readily fitted into the body and clamped in any position. Its working edge should be flat to within 0.005 mm over the entire length of attachments.

SINE BAR:

Sine bars are used either to measure angles very accurately or for locating any work to a given angle with very close limits. The sine bar in itself is not a complete measuring instrument. Another datum such as a surface plate is needed, as well as auxiliary equipment, notably slip gauges are used. Sine bars used in conjunction with slip gauges constitute a very good device for the precise measurements of angles. Sine bars are used either to measure to measure angles very accurately or for locating any work to a given angle within the close limits. Sine bars are made of high carbon, high chromium, corrosion resistant steel, Hardened, ground and stabilized. Two cylinders of equal diameter are attached at the ends. The axes of these two cylinders are mutually parallel to each other and also parallel to and at equal distance from the upper surface of the sine bar. The distance between the axes of the two cylinders is exactly 150 mm.

The angle is given as $\sin \Theta = h/L$ so $\Theta = \sin^{-1}(h/L)$

Where $h = h1 - h2$

SLIP GAUGES:

Slip gauges are high accuracy end standards in length measurement. They are manufactured to an accuracy of ±0.01L microns. Where L is the length of slip gauge. The gauge are made of high grade steel hardened and tempered to 800 HV. Each slip gauge is engraved for its length from one face to another. Slip gauges are manufactured in sets to enable combining the gauges to develop a length which is very accurate and ranging from 1.001 mm to 100mm, when developing any desired length using many pieces of slip gauges. Care should be taken to wring the gauges properly and also not to writing the unpolished faces by mistake.

PROCEDURE:

VERNIER BEVEL PROTRACTOR:

Study the parts of the bevel protractor and the leastcount of the instrument and understand its construction.
Study the work piece whose angle is to be measured. Study the diagram shown on the page attached. By comparison conclude which method of measuring the angle by bevel protractor will be most appropriate.
Place the work piece securely either on reference surface (surface plate, m/c table) or if the work piece is small enough, between the blade and base frame.
Step i) initially makes the blade to rest on the work piece such that no light passes between them and rotate the knob to clamp the main scale.

Step ii) Use fine adjusting knob to completely make sure that the blade is in fully contact with the surface of work piece.

Step iii) In this position make sure that the surface base frame (or the acute angle attachment) is also in good contact with work piece surface or reference surface as the case may be.

Step IV) use the blade clamp to overcome the difficulties in the long length of blade.

Step V) if necessary fix the base frame to the height gauge using the clamp and the bracket provided.

This method is employed for measuring angles on heavy workpiceces when no reference surface is available itself.

After doing all the adjustment take out the bevel protractor and read the angle correctly using both the main scale and Venire scale.
Express the angle properly by adding or subtracting 90^{o}properly, whenever the same is called for.
Take measurement at number of places on the surface and report the reading as an average along with confidence level.

SINE BAR :

Firstly the angle of the work piece is measured by bevel protractor. The required height of the slip gauges (h) is calculated using the above formula.

Stack the slip gauges whose height is approximately equal to h. set up the sine bar such that the end of the sine bar which has a L-frame is kept on the top of slip gauge. The roller of the sine bar should rest on the slip gauge stack.
The complete set up is kept on the surface plate.
The work piece is kept over or under the sine bar, as per the shape of work piece and weight of the work piece.
By means of height gauge and dial indicator traverse the length of work piece kept on sine bar to ascertain if both the ends of the surface are parallel to the reference plane (i.e., surface plate).
If the entire surface is not parallel to the base plate determine which end of the surface is above (or below) the other end of the surface. If one end of the surface is higher than the other end, it is obvious that the height of slip gauge is more than the correct height.
Try another combination of slip gauge whose height is less than the previous height by 0.1 mm.
Repeat steps from 5to 7 to make sure the surface is parallel when traversed by the dial indicator fixed to the height gauge. Surface is said to be parallel when the pointer in the dial indicator will not move by more than 0.05mm.
Same procedure is followed if one of the surfaces is below the other end in which case the height of slip gauge stack requires to be increased in steps of 0.1 mm.
Take measurement at number of places on the surface and report the reading as an

s.no	MSR	VSR	LC	TR=MSR+(VC*LV)	MEAN X= (X1+X2+ …… Xn)/n.	STANDARD DEVIATION $\sigma = \pm\frac{\sqrt{\sum(Xi-X)2}}{n-1}$
1						

average along with confidence level.

VERNIER BEVEL PROTRACTOR TABLE:

2						
3						
4						
5						

RESULTS:

GRAPH: Dimension Vs frequency

PRECAUTIONS:

VERNIER BEVEL PROTRACTOR:

1. Do not over tighten main scale knob.
2. Keep the overhang of blade as a ruller or screw driver.
3. Do not use the blade as a ruller or screw driver.
4. The magnifying glass should be ensured not to be scratched by mis- handling.

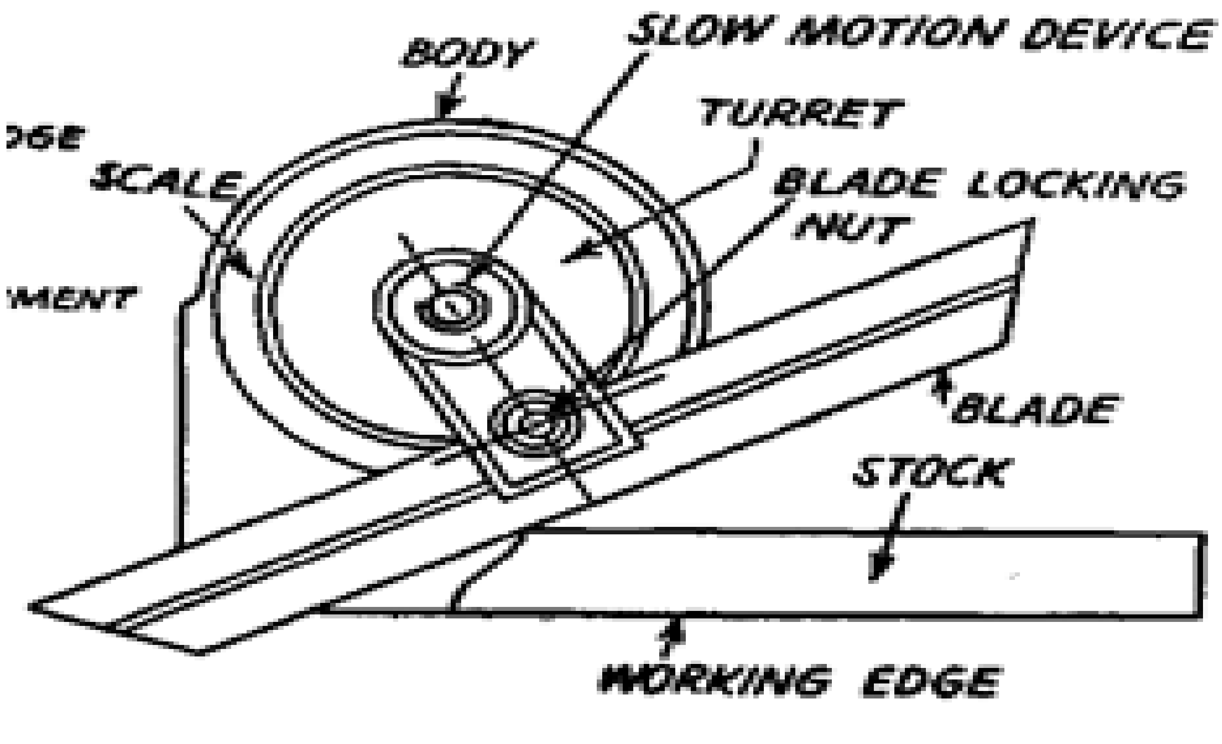
SINE BAR:

1. The surface plate must be flat and horizontal.
2. Slip gauges must be perfectly in touch with the roller of sine bar.
3. The slip gauges must be held with care and must be placed sequentially one over the other.
4. Also take care to handle slip gauges with at most quotation not to drop it, not to rub it unnecessarily and hold the gauges for as little time as possible to avoid unnecessary expansion due to increase in temperature. After developing a required length the gauge set must be allowed to attain room temperature before using them as high accuracy length.

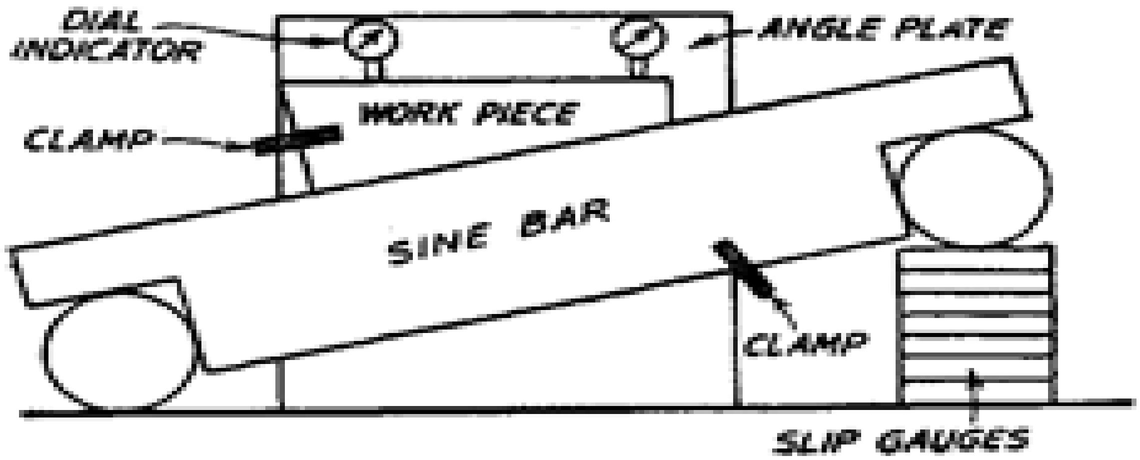
REVIEW QUESTIONS:

List out the various instruments used for angle measurement according to their accuracy.
Explain the principle of sine bar.
Differentiate between sine bar and vernier bevel protractor in terms of accuracy.

VERNIER BEVEL PROTRACTOR



SINE BAR:


DIAL INDICATOR
ANGLE PLATE
WORK PIECE
CLAMP
SINE BAR
CLAMP
SLIP GAUGES

EXPERIMENT: 5
MEASUREMENT OF STREIGHTNESS OF EDGES AND FLATNESS OF SURFACES

AIM:

1) To determine straightness of a given edge, namely the lathe bed.
2) To determine the flatness of given surface, namely the surface plate.

EQUIPMENTS USED: 1) Precision spirit level of L. C. 4 sec of arc.

2) Long scale or a straight edge to align the spirit level.

3) Given lathe bed, cleaned and cleared of all attachments and obstacles.

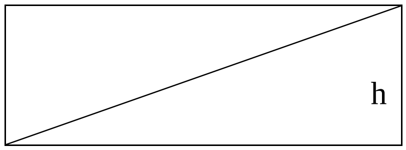
4) Given surface plate well cleaned and leveled.

THEORETICAL BACK GROUND AND ANALYSIS:

Straightness of an edge is defined as the distance between two imaginary parallel lines so drawn that they encompass all the actual (real) points on the straight edge.

It is to be noted that on the straight edge of any physical object, no matter how well it is made all points do not lie on a theoretically straight line .fig. below shows the points on edge in a much exaggerated manner. The experiment is conducted to measure the distance (between the two parallel lines) which gives the straightness of the edge. Alternatively, we can draw a single imaginary line to pass somewhat in between the end points a and h and measure the distance of each real point, with the proper sign, and indicate the straightness as + x and –y microns. Such a line would be a line which is called the least square line because the sum of the square of the distances of all the points from it would be the least and other line would give the same sum always more.

The theory of the working of spirit level is not covered here. It is to be noted that each division on the sprit level corresponds to a tilt of 4 seconds of an arc. This means that means that if the bubble of the spirit Level (S.L., kept centrally on a bridge with its feet at a distance of 100 mm and the bridge is initially so leveled as to make the bubble rest centrally) moves to the right by one division when the right foot of the bridge is slightly raised then it is at a higher level by 4 x 0.000005 x 100 = 0.0020 mm or 2 micron above the left foot, as shown below. (Exaggerated). Because, rise h = r. ϴ, when ϴ is small and expressed in radians. (180 x 3600 secs of arc = π/ (180 x 3600) = 0.00050mm. for 4 secs of arc it is 2μm.



Rise h per sec of arc (100 mm base) = 0.5μ

The whole length of the straight edge of the bed is traversed by the S.L in steps of 100 mm and the rise or fall of the points carefully noted. A graph of the reading converted to mm is plotted and the end points are joined. From the graph one can determine the straightness of the edge.

Flatness of any given surface is defined as the distance between two imaginary parallel planes which just encompass all the points of the given surface. Therefore, we carry out the measurements of straightness along several generator lines as shown below on the given surface, and by successive manipulations, determine the relative heights of all the points chosen to lie at a spacing distance of 100 mm, or any other spacing depending on the size of the given surface. Now we can imagine two planes parallel and passing through the lowest and the highest point and containing all the real points of the given surface. The distance between these two planes is, as per definition, the flatness of the given surface.

Alternatively, we may calculate the equation to that plane which passes through the centroid of the values x ,y ,and z, x and y being the coordinates of the points in the horizontal plane and z being the height of points of the given surface. This imaginary plane which gives the least sum of the squares of the deviations of the observed points, is expresses by the equation, $Z = ax + by + c$. The values of a, b, and c are given by the following equations.

Let all the points of the given surface be denoted by (X_1, Y_1, Z_1), (X_2, Y_2, Z_2), (X_3, Y_3, Z_3),………..etc. In these sets, x and y are the grid points and z are the heights a observed by the tilt of the S.L . let x,y,z be the mean of these readings in x, y, and z axis . i.e., $x = (X_1 + X_2 + X_3 + \ldots\ldots)/n$.

$a = \sum Ym^2 \cdot \sum Xm \cdot Zm - \sum XmYm \cdot \sum Ym \cdot Zm) / (\sum Ym^2 \cdot \sum Xm^2 - (\sum Ym \cdot Xm)^2)$

$b = \sum Xm^2 \cdot \sum Ym \cdot Zm - \sum XmYm \cdot \sum Ym \cdot Zm) / (\sum Ym^2 \cdot \sum Xm^2 - (\sum Ym \cdot Xm)^2)$

Note: only Ym^2 is changed to Xm^2 to get the value of Xm = reading along x axis w.r.t.x. i.e., $(X_1 - X)$, $(X_2 - X)$,($X_3 - X$) etc. similarly Ym and Zm are also obtained by similar equations .

$c = z - ax - by$

PROCEDURE:

Using a maker (not chalk piece because its dust is sufficiently big to introduce errors in the level readings) and a straight edge (a steel rule may also be good) draw a straight line adjacent, parallel and close to the edge of the lathe bed. Mark out short lines perpendicular to the edge of the edge of the lathe bed at intervals of 100 mm, starting from a point 20 mm away from the end of the bed. Also leave out the last 20 mm from the other end. (This will exclude points which may have been badly dented etc due to usage.) Name these points as a, b, c, d… etc.

Keep the bridge (with the level mounted on it) on the first two points, a-b. Note the division nearest to the edge of the bubble. It is advised to estimate the fraction of a division by observing the position of the bubble's end directly from above. (No parallax error). Enter the value in secs of arc in a table against position a-b.

Lift and move the bridge carefully to the next position, namely, b-c. Note the reading and the direction of the bubble movement. If point c is higher than b, the bubble moves to the right. Enter the value in the table. Continue to move the bridge along the straight lines till all the marked spans are covered.

Repeat the above procedure in the reverse order of spacing and note the reading against corresponding spans. Take the average of the two reading as the mo0st probable position of the bubble and enter these reading in the final table below.

Now complete the calculations as shown in the table till the last column is filled.

Position 1	Mean reading (sec of arc 2	Diff. from the first sec of arc 3	Rise or fall per 100mm in the position (μ) 4	Cumulative rise or fall (μ) 5	**Adjustment to make both ends zero (μ) 6**	**Deviation from the ends line. (μ) + or – 7**
a-b	θ_1	0	0	0	**-L / n**	**-L / n**
b-c	θ_2	$\theta_2 - \theta_1$	$(\theta_2 - \theta_1)0.5\mu$	$(\theta_2 - \theta_1)0.5\mu$	**-2L / n**	**Col .5 + col.6 in this R**
c-d	θ_3	$\theta_3 - \theta_1$	$(\theta_2 - \theta_1)0.5\mu$	Value above +col 4 value in this row	**-3L / n**	**Col .5 + col.6 in this R**
….						
….						
…						
h-i	θ π	θ π- θ_1	$(\theta_2 - \theta_1)0.5\mu$	Value above +col 4 value in this row = L	**-L**	**Col .5 + col.6 in this R = 0**

Now plot the values in col. 7 as ordinates (y axis values) vs. spacing as abscissa (x axis values). Draw two lines parallel to x- axis and passing through the highest and lowest points of the graph . The distance between them is the straightness error, in microns, of the given lathe bed edge.

If the cumulative values are plotted on y – axis against the spacing on x- axis and the ends of the curve are joined by a straight line, we can easily measure the deviations of the real points from this line without having to make calculations in columns 6 and 7.

PRECAUTIONS:

1) Exclude any dents, scored areas, heavily damaged places from the measurement.
2) Do take care not to be very near the edge and in the process drop the S. L.

QUESTIONS: -

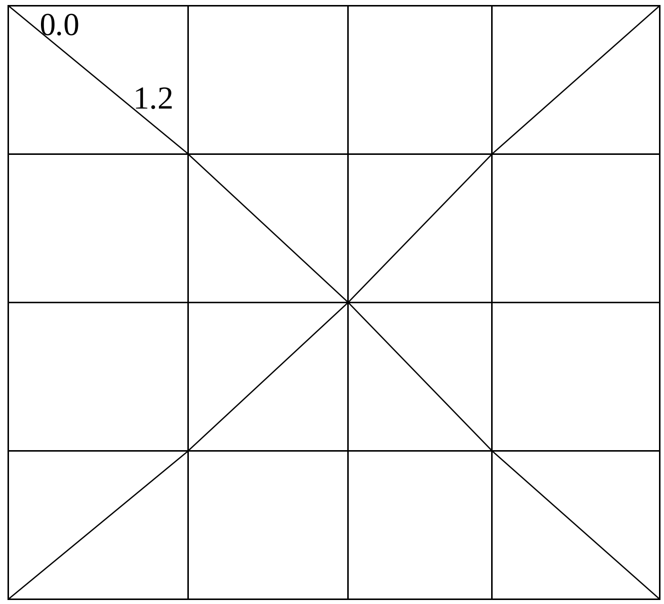
1) What other method are used for measuring straightness? How do the compare with this method by S.L.?
2) What is meant by calibration? How often is the straight edge in machine shop calibrated?
3) When using straight edge, what precaution do you take to increase the accuracy of measurement?

PROCEDURE FOR FLATNESS TESTING: -

1) Mark out the grid points with a span of 100mm on the given surface (leaving out the margins of 50mm from the ends) as shown in the fig below . Do not use chalk Use marker pen.

2) Traverse the lines with the bridge (with the S.L. strapped to it) along the four sides and the diagonals and note the readings in a tabular from for each of the sides and the diagonals separately.

3) Treating them as cases of straight edges, calculate the values up to cumulative rise or fall column,(col.no.5 in the previous experiment)



4) Apply correction to the lines AB,AD and DB so that the ends of these lines are made to lie on an imaginary plane

ABD.While so doing, all the intermediate points along these lines also get proportionately corrected. Separate table for these values. Example of doing this correction for one set of data shown in the fig. is shown below. All in μm.

First, make D zero. This means lowering the line graph by adding-1.6 to all the intermediate values. This gives a new line:

A (2.4-1.6=0.8) (4.6-1.6=3.0) (3.2-1.6=1.6) (2.4-1.6=0.8) (1.6-1.6=0)D

With this A is0.8 above D and located four spans away from D. now swing the chain of lines with D held at 0 and let A become 0.this means adding-0.8/2=-0.2 per span, starting from D. now the corrected plot of AD is as below:

A(0.8-0.2x4spans=0)(3.0-0.2x3spans=2.4) (1.6-0.2x2 spans=1.2) (0.8-0.2x1 span=0.6) (0.-0.2x –span=0)D or more elegantly,

A0 2.4 1.2 0.6 0D

Similarly, let the readings along AB (starting from A and having four equal spans) be: A3.0 2.4 1.2 1.8 0.6B.

First make B to become zero. This means lowering the line graph by adding-0.6 to all the intermediate values. This gives a new line:

A (3.0-0.6=2.4) (2.4-0.6=1.8) (1.2-0.6=0.6) (1.8-0.6=1.2) (0.6-0.6=0)B

Now swing the chain of lines with B as fulcrum and to make A become zero. This means to subtract the difference in the heights of B and A (which is 2.4, over four spans) at A. proportionately, we should subtract 2.4 /4 = 0.6 from 1.8 which is one span away from Band 0.6 x2 = 1.2 from 0.6 which is two spans away and 0.6 x3 = 1.8 from 1.8 which is three spans away from B hence we get the following new line A b in which both A and B are at zero.

A (2.4-2.4 = 0.0) (1.8-1.8 = 0.0) (0.6 - 1.2 = - 0.6) (1.2-0.6=+0.6) (0.0) B

A (0.0) (0.0) (-0.6) (+0.6) (0.0) B

Now take line BD. This has the values D (1.0) (2.8) (2.2) (7.0) (6.6) B

Since D is already made zero on the line AD, we should make D zero on this line DB also. This means adding -1 to all the values to get a revised line as below:

D (1.0-1.0 = 0) (2.8-1.0 = 1.8) (2.2-1.0 = 1.2) (7.0-1.0 = 6.0) (6.6-1.0 = 5.6) B . now B is 5.6 higher than D on this line DB. To make B to become zero, swing the graph line keeping D at zero, such that B which is 4 spans away is brought down to zero. Hence the proportionate deduction per span is 5.6 /4 = 1.4.Hence, starting from D, deduct 1.4 from 1.8, 2.8 from 1.2, 4.2 from 6.0 and finally 5.6 from 5.6 at B. we get a new line DB.

D (0.0) (0.4) (-1.6) (1.8) (0.0)B

Now, we have A, B &D at zero and we can assume a plane to be passing through these three points. A'1 other points on the surface can now be measured w.r.t this imaginary plane. Already the points lying on AD, DB, BA have been normalized.

Let us normalize the points on other lines now. Take the line AC.

A(0.0) (1.2) (3.0)E (1.4) (4.2)C

On this line point E is at 3.0 above A, while the same point is at -1.6 on line DB. Hence, we should swing line AC with A as fulcrum (A is already at 0.0 on this line) so as to bring E on this line to -1.6. This requires adding -4.6 to E which is two spans away from A. hence, a proportionate amount of -2.3 per span. This means adding -2.3 to1.2, -4.6 to 3, -6.9 to 1.4 and -9.2 to 4.2 C, resulting in the following line.

A (0.0) (-1.1) (-1.6) E (-5.5) (-5.0)C

In this way, line BC is normalized keeping B as fulcrum and line dc is normalized keeping D as fulcrum. This gives a new array of points on the surface with A,D & B at zero and all other points at the corrected heights or depths w.r.t the plane passing through A,D,&B .this is shown below.it can now be seen that the highest point is at 2.4 and the lowest point is at -5.5. hence the flatness error is the distance these points which is 7.9µm.

QUESTIONS:

1) How do you achieve higher accuracy of flatness mmt.in the above example?
2) The span distance along AD is different from that along AC> how do you take mmt?
3) Which is another instrument that has more accuracy and ideally suited to this task?

EXPERIMENT: 6
THREAD MEASUREMENT BY THREE WIRE METHOD

AIM:
To measure the major and minor diameters, pitch diameter and pitch of a given threaded component using three wire methods.

INSTRUMENTS USED: 1) screw pitch gauge.

2) Three wires of equal diameters

3) Outside micrometer

4) Vernier caliper

WORKING PRINCIPLE:

OUTSIDE MICROMETER:

The micrometer screw essentially consists of an accurate screw having 10 or 20 threads per cm and revolutions in a fixed nut. The end of the screw forms one measuring tip and the other measuring tip is constituted by stationary anvil in the base of the frame. The screw is threaded for certain length and is having plain portion after words. The plain portion is called sleeve and its end is the measuring surface. The spindles advanced or retarded by turning a thimble correct to the spindle. A locknut is provided for locking a dimension by preventing motion of the spindle. Ratchet stop consist of an overriding clutch held by a weak spring. The material used for thimble, barrel, ratchet and all other locking and clamping devices for all sizes of micrometer should be of suitable quality wear resistant steel.

VERNIER CALIPER:

The principle of vernier is that when two scales slightly different in length are placed one below the other , the difference between them can be utilized to enhance the accuracy of measurement. The vernier caliper essential consists of two steel rules and these can slide along each other. One of the scales, i.e the main scale is engraved in mm and partly in 1 mm. the slide scale, called the vernier scale consists of 50 divisions engraved on the length of 49 mm. hence the least count which is the minimum significant value that can be measured further to the main scale reading is (1-49/50)=0.02mm. The graduation divisions and the L.C. may vary from the type of vernier to another based on the range of measurement.

DESCRIPTION:

SCREW PITCH GAUGE:

The pitch of a thread is usually measured with screw pitch gauge. Screw pitch gauges are sets of steel blades (similar to feeler gauges), which are notched no one edge according to various thread pitches represented by the gauge. The blades are applied to the thread being checked at the radial plane. If the pitch is correct, the gauge will fit tightly to the thread profile and no light will pass between the gauge and the thread profile.

THEORY:

THREE WIRE METHOD: it is the most accurate method for checking the pitch diameter. This method consists of placing three small diameter cylinders (three wires of equal and precise diameter) in the thread grooves at opposite sides of screw and measuring the distance W over the outer surfaces of the wires with an ordinary outside micrometer having flat measuring faces on the micrometer. The pitch or effective diameter is calculated from the value W in the following manner

$W = P + 2AC + 2 \times (d/2)$ ------------- (1)

Where P= pitch or effective diameter

D = wire size

Now AC = AD- CD

$= (d/2) \operatorname{cosec} (\alpha/2) - (p/4) \cot (\alpha/2)$

Where α= thread angle

P = pitch of threads

After simplification,

$W = P + d (1+ \operatorname{cosec} \alpha/2) - p/2 \cot \alpha/2$ ------- (2)

In the case of I.SO. Metric threads, $\alpha = 60°$

$W = P + 3d - 0.866p$

$P = W – 3d + 0.866p$ ------- (3)

Here the pitch diameter lines 0.328P inside the crest of the thread that is,

$P = D – 0.6496p$ --------- (4)

Where D = outside diameter, from equations (3) and (4) it is

$D = W – 3d + 1.5156p$ -------- (5)

Where d = wire diameter in mm

P =thread pitch in mm

W = distance over wire in mm.

WIRE SIZE:

Wire of any diameter can be used to measure the pitch diameter, provided it makes contact on the true flank of the thread and provided the thread angle is correct. A wire of best size is the one that makes contact with the help of any wire touching the true flank of the thread will differ from that obtained by using a wire of best size if any there is an error in the angle or from of the thread. In the case of best size wire of best size wire, the point B at which the wire touches the flank of the thread lies on the pitch line, that is , BC lies on the pitch line and that AB is perpendicular to the flank position of the thread. If there is a possibility of the thread angle being Incorrect, the wire of best size should be used to determine effective diameter, science such wires will be independent of any error in thread angles.

Now $BC=p/4$

From triangle ABC, $AB = d/2 = BC \sec \alpha/2 = p/4 \sec \alpha/2$

Best wire size, $d= p/2 \sec \alpha/2$

For I.S.O. metric tread,

$$d = p/2 \sec 30 = 0.5774p$$

PROCEDURE:

1. Measure the outside diameter of the given thread component by means of outside micrometer, which is equal to major diameter.
2. Measure the pitch of the given threaded component by using the pitch gauge.

3. Measure the root diameter of the component by using a vernier caliper, which is equal to minor diameter.
4. To find the pitch or effective diameter, keep the three wires made of hardened steel between the flanks of the thread as shown in fig.
5. Take the diameter over the wires with the help of outside micrometer, which is held with micrometer holder on the anvil and spindle of the micrometer. Now calculate the pitch or effective diameter as per the formula explained in the theory.

OBSERVATIONS AND CALCULATIONS:

THREE WIRE METHOD:

1. the major diameter (D1) =
2. the minor diameter (D2) =
3. pitch (p) =
4. pitch of effective diameter (P) =

$$P=W-d\ (1+\operatorname{cosec}\alpha/2)+p/2\cot\alpha/2$$

Where,

W= Distance over the three wires

d= diameter of wire = 1.10mm.

p= pitch of thread

α = thread angle = 60

RESULT:

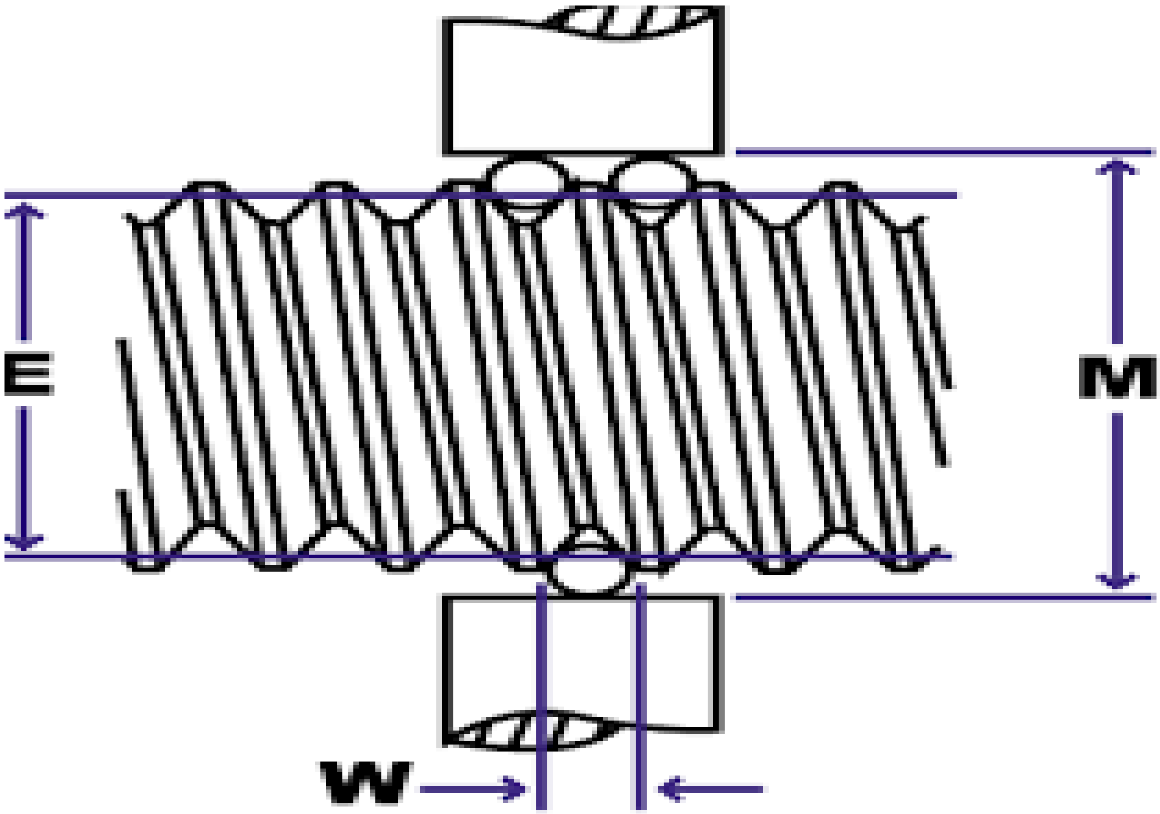
1. the major diameter (D1) =
2. the minor diameter (D2) =
3. pitch (p) =
4. pitch of effective diameter (P) =

PRECUATIONS:

1. Do not use the vernier as a stick or a screw driver. Do not throw it on the table.
2. Micrometer should be cleaned of any dust and spindle should move freely.
3. Do not drop the micrometer or throw it on the table. Keep it in the case when not in use.

REVIEW QUESTIONS:

1. What is pitch?
2. What is major diameter?
3. What is minor diameter?
4. What is root and crest?



THREE WIRE METHOD

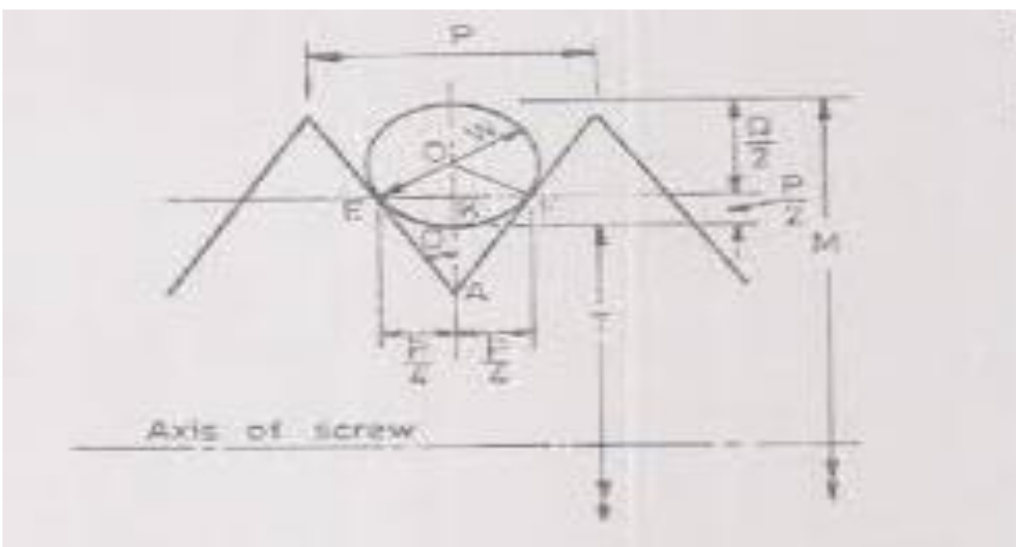


Fig. 11.13 Measuring effective diameter using the wires

THREE WIRE MEASUREMENT