



Balaji Institute of Technology & Science ^{Estd.: 2001}

Laknepally, NARSAMPET, Warangal – 506331

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LABORATORY MANUAL

Engineering Metrology

(B Tech III year Mechanical Engineering)



DEPARTMENT OF MECHANICAL ENGINEERING

INSTITUTE VISION

To be a centre for excellence in preparing the graduates professionally committed, intellectually adept and ethically balanced with high standards by imparting quality education with international standards to excel in their career to meet the challenges of the modern world and adapt to the technologically changing environment.

OUR MISSION

M1: To strive hard to produce technically trained human resources to serve the present and future global needs by providing quality education.

M2: To provide value based training in technological advancements and employment opportunities to students by strengthening institute's interaction with industries.

M3: To disseminate knowledge of need based technical education, innovative learning and research & development.

DEPARTMENT VISION

To excel in preparing mechanical engineering graduates with core knowledge, advanced skills and professional ethics in order to meet the ever changing industrial demands and social needs.

OUR MISSION

- M1:** To provide the students with the best of knowledge by imparting quality education in the area of Mechanical Engineering and allied fields.
- M2:** To facilitate the students by providing the interaction with Mechanical Engineering related companies to be part of technological advancements which enhances employment opportunities.
- M3:** To inculcate self learning abilities, leadership qualities and professional ethics among the students to serve the society.

PROGRAM EDUCATIONAL OBJECTIVES

- PEO1:** To make the graduates who are equipped with technical knowledge and engineering skills through the program to achieve a successful career in the field of mechanical engineering.
- PEO2:** To participate in ongoing developments of mechanical engineering to be strong with the fundamentals and relate it with the present trends.
- PEO3:** To gain the practical knowledge through the program by identifying, formulating and solving mechanical engineering related problems.

PROGRAM OUTCOMES

1. PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering Fundamentals and an engineering specialization to the solution of complex engineering problems.
2. PO2: Problem analysis: Identify, formulate, review research literature, and analyze complex Engineering problems reaching substantiated conclusions using first principles of Mathematics, natural sciences, and engineering sciences
3. PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. PO4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
5. PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
6. PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. PO9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. PO11: Project management and finance: Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments.
12. PO12: Life-long learning: Recognize the need for, and have the preparation and ability to Engage in independent and life-long learning in the broadest context of technological Change.

PROGRAM SPECIFIC OUTCOMES

PSO1: Identify and analyze the real time engineering problems in Manufacturing, Design and Thermal domains.

PSO2: Execute the work professionally as an employee in industries by applying manufacturing and management practices.

PSO3: Gain the knowledge of latest advancements in Mechanical Engineering using Computer Aided Design and Manufacturing.

COURSE OUTCOMES

Fluid Mechanics and Hydraulic Machines Lab	
After completion of the course students will be able to	
CO1	Explain the effect of fluid properties on a flow system.
CO2	Identify type of fluid flow patterns and describe continuity equation.
CO3	Analyze a variety of practical fluid flow, measuring devices and utilize fluid mechanics principles in design.
CO4	Select and analyze an appropriate turbine with reference to given situation in power plants.
CO5	Estimate performance parameters of a given centrifugal and reciprocating pump. Able to demonstrate boundary layer concepts.

METROLOGY LAB

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Introduction

In science and engineering, objects of interest have to be characterized by measurement and testing. Measurement is the process of experimentally obtaining quantity values that can reasonably be attributed to a property of a body or substance.

1. Metrology is the science of measurement.
2. Metrology is also a fine avenue for discussing accuracy, error, and calibration.

Testing is the technical procedure consisting of the determination of characteristics of a given object or process, in accordance with a specified method. In metrology (the science of measurement), a standard is an object, system, or experiment that bears a defined relationship to a unit of measurement of a physical quantity.

Metrology is mainly concerned with the following aspects

1. Unit of measurement and their standards.
2. Errors of measurement.
3. Changing the units in the form of standards.
4. Ensuring the uniformity of measurements.
5. New methods of measurement developing.
6. Analyzing these new methods and their accuracy.
7. Establishing uncertainty of measurement.
8. Gauges designing, manufacturing and testing.
9. Researching the causes of measuring errors.
10. Industrial Inspection.

Functions of metrology

1. To ensure conservation of national standards.
2. Guarantee the accuracy by comparison with international standards.
3. To organize training in this field.
4. Take part in the work of other National Organization.
5. To impart proper accuracy to the secondary standards.
6. Giving advice to repair of measuring instruments.

Applications of metrology

1. Industrial Measurement
2. Calibration and repair of instruments
3. Public health and human safety ensuring

Need of inspection

To determine the fitness of new made materials, components or products and to compare the materials, products to the established standard. It is summarized as

1. To conforming the materials or products to the standard.
2. To avoid fault product coming out.
3. To maintain the good relationship between customer and manufacturer.
4. To meet the interchange ability of manufacturer.
5. To maintain the good quality.

6. To take decision on the defective parts.
7. To purchase good quality raw materials.
8. To reduce the scrap

Need for measurement

1. To determine the true dimensions of a part.
2. To convert physical parameters into meaningful numbers.
3. Needed for ensuring public health and human safety.
4. To test if the elements that constitute the system function as per the design.
5. For evaluating the performance of a system.
6. For studying some basic laws of nature.
7. To ensure interchange ability with a view to promoting mass production.
8. To evaluate the response of the system to a particular point.
9. Check the limitations of theory in actual situation.
10. To establish the validity of design and for finding new data and new designs.

Methods of measurement

1. Direct comparison with Primary or Secondary Standard.
2. Indirect comparison with a standard through calibration system.
3. Comparative method.
4. Fundamental method.
5. Contact method.

1) Direct method: The value to be measured is directly obtained. Examples: Vernier calipers, Scales.

2) Indirect method: The value of quantity to be measured is obtained by measuring other quantities. Diameter measurement by using three wires.

3) Comparative method: In this method, the quantity to be measured is compared with other known value. Example: Comparators.

4) Fundamental method: Measuring a quantity directly in related with the definition of that quantity.

5) Contact method: The sensor or measuring tip of the instrument touches the area (or) diameter (or) surface to be measured. Example: Vernier calliper, micrometer, surface roughness tester.

A good measurement procedure is one which attempts to minimize the errors. An important part of this procedure is calibration— the procedure of verifying the accuracy of the measurement device itself by measuring known quantities and comparing the output of the measurement instrument to the expected values. These “known quantities” are called standards. The primary standard is the internationally accepted definition of the quantity of interest, such as mass and length. Secondary standards are copies of the primary standard that are more accessible than the primary standard.

Other than accuracy, the difference is a factor of ten in cost. Please note that this stated accuracy is an assessment of how closely these standards represent the true value relative to the primary standard.

MEASUREMENT OF GEAR ELEMENTS

Aim:

To determine the pressure angle, width and depth of tooth and to check the width and depth using gear tooth vernier callipers.

Apparatus:

Gear tooth Vernier Callipers - This is used to measure the thickness of gear tooth on the pitch circle. It consists of two beams, with line scalar squares with each other as shown in fig. There are two sliding vernier scales, which move along their respective beams, the tooth thickness on the pitch circle is measure by the jaws. This is similar to the ordinary vernier calliper, but having a second beam of right angles to the main beam as shown in fig.

The gear tooth vernier has two vernier scales and they are set for the width (W) of tooth and the depth (d) from the top at which width (w) occurs.

Theory:

There are various methods of measuring the gear tooth thickness they are

1. By gear tooth vernier calliper
2. Constant chord method
3. By Tangent Method
4. Measurement by dimensions over pins

The tooth thickness can be very conveniently measured by a gear tooth vernier shown in fig. The gear tooth vernier has two scales and they are set for the width (w) and depth (d) of tooth from top at which width occurs.

Considering one gear tooth, the theoretical value of w' and depth 'd' of tooth from at which width occurs.

Considering one gear tooth, the theoretical value of w' and 'd' can be found out which may be verified by the instrument. In fig it may be noted that 'w' is a chord ADB, but

Observations & Calculations:

1 Outside dia of gear wheel (OD) =

2 No of teeth on gear wheel (N) =

3. Dia of pitch (D.P) = $\frac{N + 2}{OD}$

4. Base pitch (BP) = $\frac{b - a}{y}$

Where a=distance of X no. Of teeth for(X=2) a=

b=distance of X+Y no. Of teeth for (Y=1) b=

5. Circumference of base circle = N× B.P. =

6. Base circle dia. (B.D) =N×B.P./π

7. Pitch circle dia (PCD) = N/ D.P

$$\text{module (M)} = \text{PCD} / N$$

$$\text{Pressure angle } \theta = \text{Cos}^{-1} \text{BD/PCD}$$

$$\text{Depth of tooth (d)} = \frac{Nm}{2} \times \left(1 + \frac{2}{N} - \cos\left(\frac{90}{N}\right) \right)$$

$$\text{Width of the tooth (w)} = NM \sin \frac{90}{N}$$

Measurement by gear tooth Vernier calliper

$$\text{Width of tooth (w}_1\text{)} =$$

$$\text{Depth of tooth (d}_1\text{)} =$$

$$\text{Error in width} = \text{Width of tooth by instrument (w}_1\text{)} - \text{Width of tooth by calculations (w)}$$

$$\% \text{ Error in width} = (w_1 - w) / w_1 \times 100 =$$

$$\text{Error in depth} = \text{Depth of tooth by instrument} - \text{Depth of tooth by calculations}$$

$$= d_1 - d$$

$$\% \text{ Error in depth} = (d_1 - d) / d_1 \times 100$$

tooth thickness is specified as an arc distance AEB, Also the distance d adjusted on instrument is slight greater than the addendum CE 'w' is therefore called chordal thickness and 'd' is called chordal addendum.

In fig.

$$W = AB = 2AD$$

$$\text{Now } \text{AOD} = 360/4N$$

Where, N = No of teeth

$$W = 2AD$$

$$= 2 \times AO \sin$$

$$= 2R \sin (360/4N), R \text{ Pitch circle radius}$$

$$\text{Module } M = \text{PCD} / \text{no. of teeth} = 2R/N$$

$$R = NM/2$$

$$W = 2 \times NM/2 \sin 360/4N$$

$$= NM \sin 360/4N$$

Also from fig (2)

$$D = OC = OD$$

But $OC = OE + \text{Addendum}$

$$= R + M$$

$$= (NM/2) + M$$

$$\text{And } OD = R \cos \theta$$

$$=(NM/2) \cos (90/N)$$

$$d = (NM/2)+M)-(NM/2) \cos (90/N)$$

$$=NM/2) (1+2/N-\text{Cos} (90/N)$$

Any error in the outside dia of the gear must be allowed for, when measuring tooth thickness.

Procedure:

- 1 Measure the outside dia of the gear wheel (O.D.) with the help of vernier calliper, at three points to ensure a reliable average value.
2. Count the number of teeth on gear wheel.
3. Measure the distance between opposite faces over different members of teeth of the gear using vernier callipers.
- 4 Calculate the chordal addendum (h) and the tooth thickness at the pitch circle using formula in observations and model calculations.
5. Check the value with the vernier depth gauge readings.

Precautions:

- 1.The surface must be horizontal
- 2.Care must be taken to see that the jaw does not make contact with the corner of the tooth tip or the root

Result:

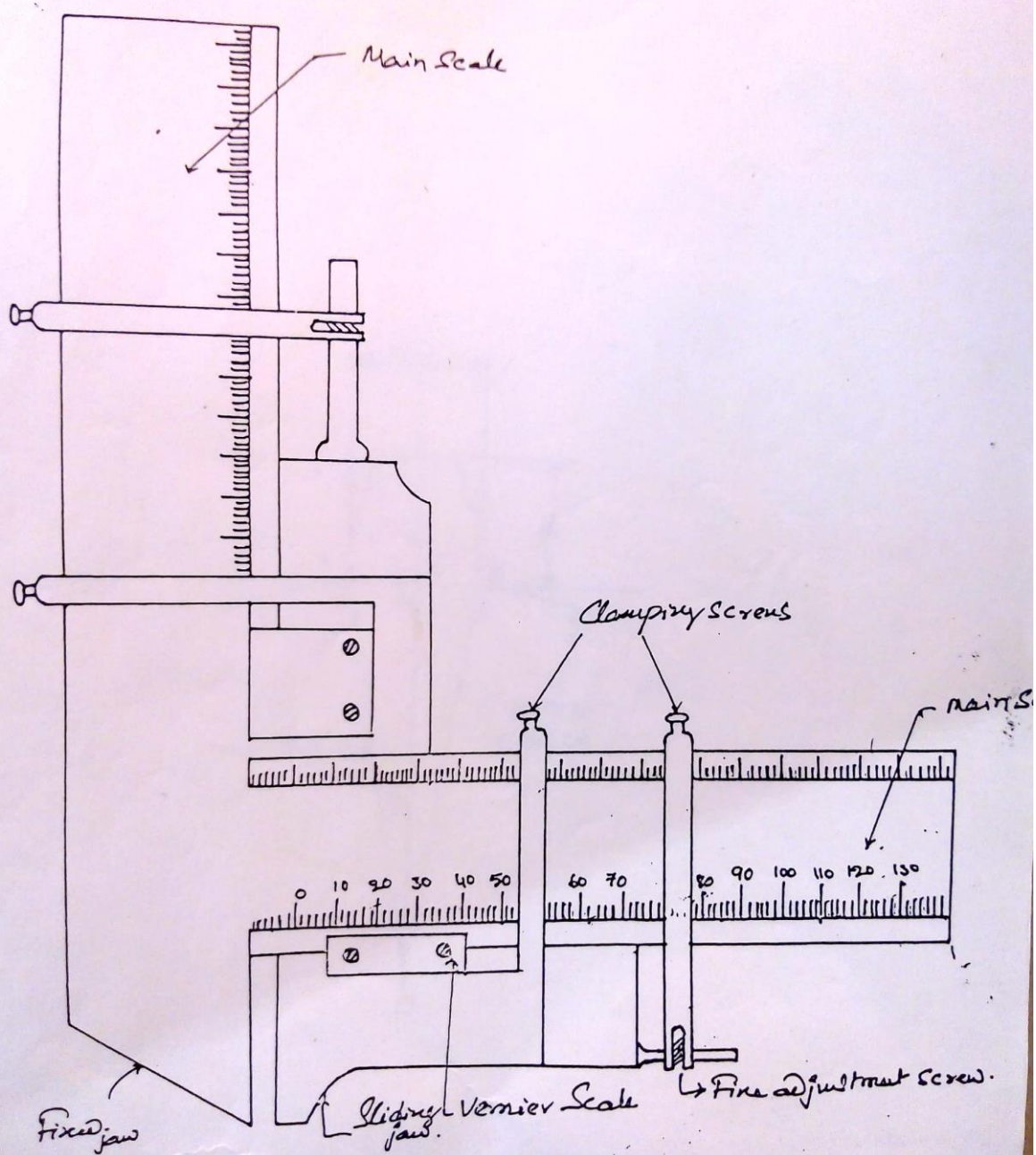
Pressure angle=

Width=

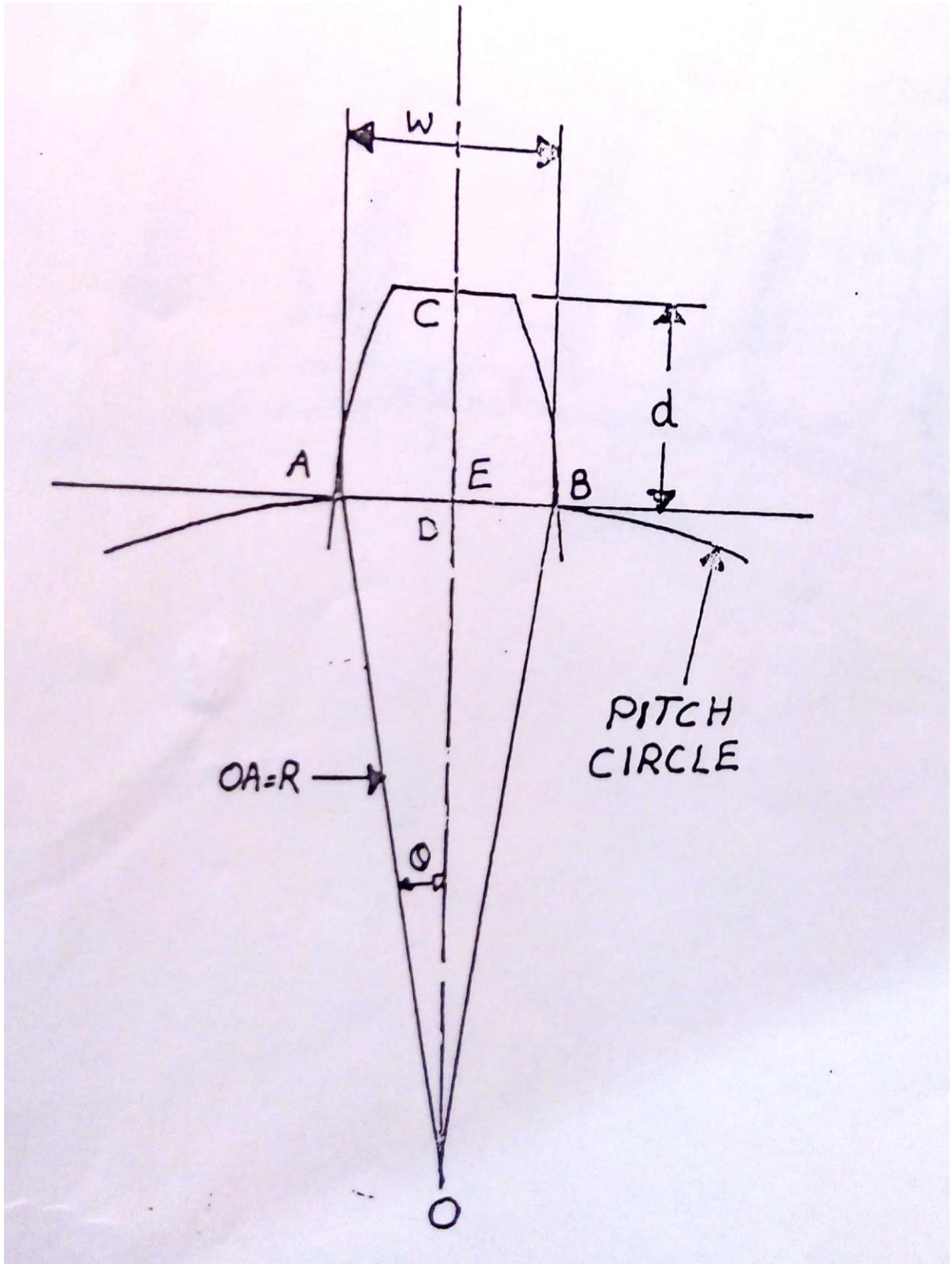
Depth=

% Error in width=

% Error in depth=



GEAR TOOTH VERNIER CALIPER.



Measurement of gear elements

Aim:

To measure spur gear tooth thickness by using Gear tooth vernier callipers.

Instruments and material required:

- a) Gear tooth Vernier callipers
- b) Spur gear

Specifications:

- a) Gear Tooth Vernier callipers – range 0-150 mm, LC = 0.02mm
- b) Spur gear size = Standard size
- c) Vernier callipers - range 0-150 mm, LC = 0.02mm

Terminology of gear tooth:

Pitch circle diameter (P.C.D): It is the diameter of a circle which by pure rolling action would produce the same motion as the toothed gear wheel.

Module (m): It is defined as the length of the pitch circle diameter per tooth. Thus if P.C.D of gear be 'D' and number of teeth 'N', then module (m) = D/N. it is generally expressed in mm.

Diametric pitch: It is expressed as the number of teeth per inch of the P.C.D.

Circular pitch: It is the arc distance measured around the pitch circle from the flank of one tooth to a similar flank in the next tooth. $P_c = \pi.D/N = \pi.m$

Addendum: This is the radial distance from the pitch circle to the tip of the tooth. Its value is equal to one module.

Clearance: This is the radial distance from the tip of a tooth to the bottom of a mating tooth space when the teeth are symmetrically engaged. Its standard value is 0.157 m.

Dedendum: This is the radial distance from the pitch circle to the bottom of the tooth space.
 $Dedendum = Addendum + clearance = m + 0.157 m = 1.157 m.$

Blank diameter: This is the diameter of the blank from which gear is cut. It is equal to P.C.D plus twice the addendum.

$$\text{Blank diameter} = P.C.D + 2m = mN + 2m = m(N+2)$$

Tooth thickness: This is the arc distance measured along the pitch circle from its intercept with one flank to its-intercept with the other flank of the same tooth.

Normally tooth thickness = $1/2 (C.P) = 1/2 (PII)$

But thickness is usually reduced by certain amount to allow for some amount of backlash and also owing to addendum correction.

Face of tooth: It is that part of the tooth surface which is above the pitch surface.

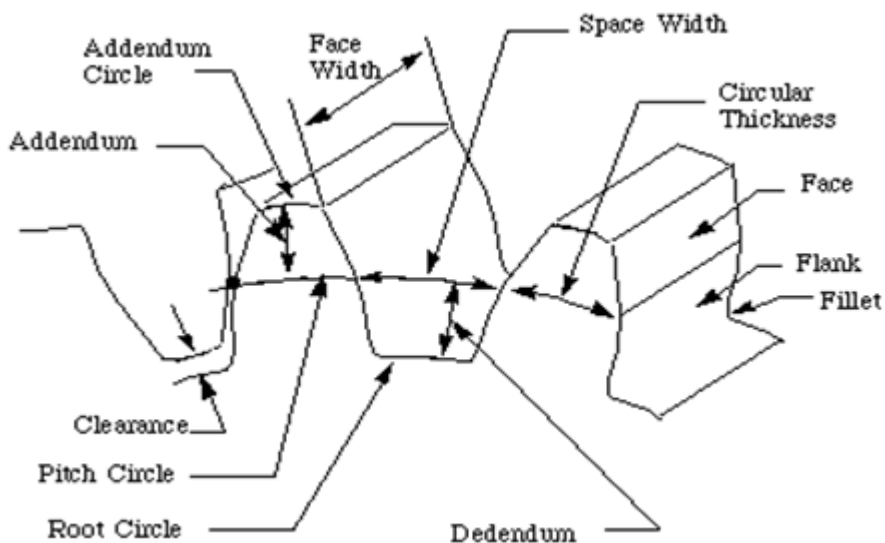
Flank of tooth: It is that part of the tooth surface which is lying below the pitch surface.

Principle:

Measurement of tooth thickness:

The permissible error or the tolerance on thickness of tooth is the variation of actual thickness of tooth from its theoretical value. The tooth thickness is generally measured at pitch circle and is therefore, the pitch line thickness of tooth i.e., length of an arc, which is difficult to measure directly. In most of the cases, it is sufficient to measure the chordal thickness i.e., the chord joining the intersection of the tooth profile with the pitch circle. Also the difference between chordal tooth thickness and circular tooth thickness is very small for gear of small pitch. The thickness measurement is the most important measurement because most of the gears manufactured may not undergo checking of all other parameters, but thickness measurement is a must for all gears.

The tooth thickness can be very conveniently measured by a gear tooth Vernier. Since the gear tooth thickness varies from the tip to the base circle of the tooth, the instrument must be capable of measuring the tooth thickness at a specified position on the tooth. Further this is possible only when there is some arrangement to fix that position where the measurement is to be taken. The gear tooth Vernier has two Vernier scales and they are set for the width (w) of the tooth and the depth (d) from the top, at which ' w ' occurs.



∴ 'W' is chordal thickness and 'd' is named as chordal addendum.

$$\text{So, } W = AB = 2AD$$

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

Where, $n = \text{Number of teeth.}$

$$W = 2AD = 2 \times AO \sin\theta$$

$$= 2R \sin \frac{360}{4n} \dots\dots$$

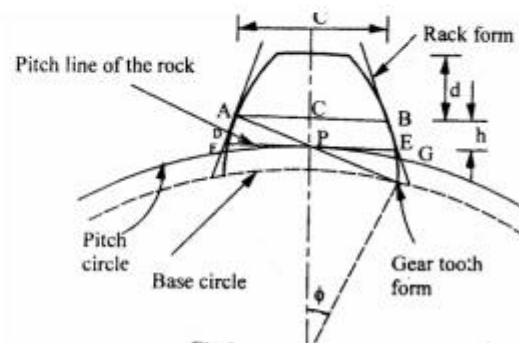
Where, $R = \text{Pitch circle radius}$

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

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

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

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



Procedure:

1. Find the number of teeth (N) of the gear.
2. Measure the outside diameter (Do) of the gear.
3. Calculate the module from the relation, $m = D_0 / (N + 2)$
4. Calculate the value of chordal addendum (d).
5. Set the gear tooth Vernier calliper for depth 'd' and measure 'w' i.e., chordal thickness of tooth.
6. Repeat the measurement on other teeth and determine an average value.

Observations:

- a) Number of teeth on gear, $N = \text{-----}$
- b) Outside diameter of gear (D_0) = -----

S.NO.	Chordal Addendum, (d) mm	Chordal thickness, (w) mm
1.		
2.		
3.		

4.		
5.		

Calculations:

i) Chordal addendum (d) = $\frac{N.m}{2} \left[1 + \frac{2}{N} - \cos \left[\frac{90}{N} \right] \right]$

ii) Chordal thickness (w) = $N.m \sin \left[\frac{90^\circ}{N} \right] = \text{—————}$

Ideal conditions / behaviour:

The instrument should be error free, Repeatability is required.

Precautions:

- i) Don't press the jaws too tight.
- ii) See the reading without parallax error.

Results:

The theoretical value of gear tooth thickness may differ from the measured value due to the manufacturing inaccuracies.

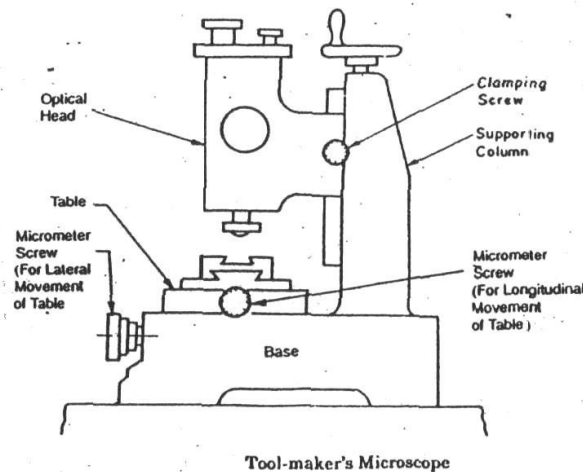
Measurement of linear and angular dimensions By tool maker's microscope

Aim: To measure the following parameters of threaded specimen of small magnitude

- (1) Major Diameter
- (2) Minor Diameter
- (3) Pitch
- (4) Included angle

Apparatus: Tool Maker's Microscope

Theory:

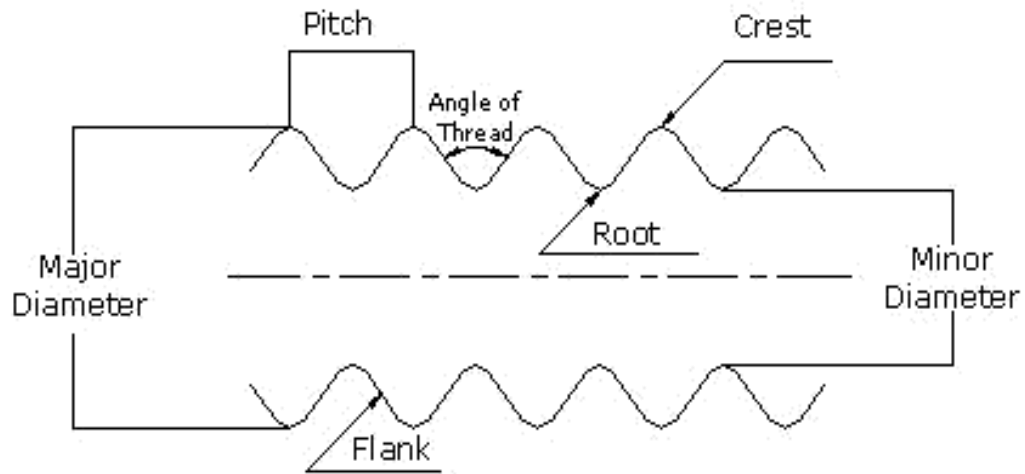


Tool Makers Microscope is an optical device used to view and measure very fine details, shapes and dimensions on small and medium sized tools, dies, and work pieces. It is equipped with a glass table that is movable in two principal directions and can be read to 0.01 mm. Microscope is also equipped with a protractor to measure the angular dimensions. It is also equipped with surface illumination. Provision is available to adjust the height of the viewing head to get a sharp image of the object.

Screw thread is a helical ridge produced by forming a continuous helical groove of the uniform section on the external or internal surface of a cylinder or cone. A screw thread formed on a cylinder is known as straight or parallel. Screw thread, while the one formed on a cone or frustum of a cone is known as tapered screw thread.

In the present experiment, parameters of a straight screw thread of small magnitude are measured. Parameters of small screws such as screws used in watches, electrical plugs, and toys cannot be measured using instruments like Vernier callipers or micrometers. Unless they are magnified it is not possible to measure all the parameters.

Some parameters of a straight screw thread are defined as follows:



Crest of a thread is defined as the prominent part of thread. Root of a thread is defined as the bottom of the groove between two flanks of thread.

Flanks of thread are straight edges which connect the crest with the root.

Angle of the thread also known as included angle is the angle between the flanks of the thread measured in axial plane.

pitch of a thread is the distance measured parallel to the axis of the thread, between corresponding points on adjacent thread forms in the same axial plane and on the same side of axis.

Major diameter is the diameter of an imaginary cylinder Co-axial with the screw which just touches the crests of an external thread or roots of an internal thread.

Minor Diameter is the diameter of an imaginary cylinder co-axial with the screw which just touches the roots of an external thread or the crest of an internal thread.

Procedure:

1. Determination of the major diameter:

Keep the specimen on the glass table. Here the given specimen is a thread. Switch on the light to get the silhouette of the thread. Adjust the height of the viewing head until a sharp image appears. Adjust the cross line of the instrument as shown in fig-1.

Now note-down the reading of the Micrometer. Now move cross line in such a way that, horizontal cross line occupies other sides of the crests as shown in fig-2. Again note-down the reading of the Micrometer. Difference of the two readings gives the major diameter of the thread.

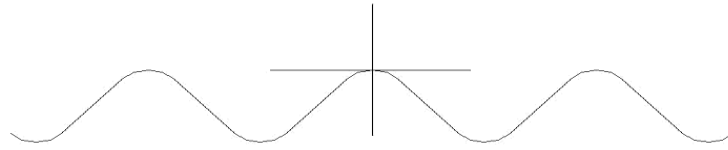


Fig. 1

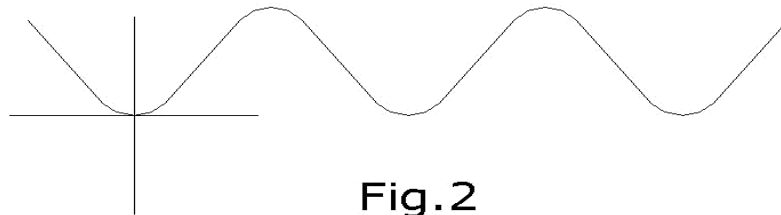


Fig. 2

2. Determination of the Minor diameter:

After obtaining the sharp image of the Threaded specimen let the horizontal cross line touch all the root points as shown in fig-3. At this position take the micrometer reading adjust the micrometer in such a way that, same horizontal line touches the other side of the root points as shown in fig-4. Again note-down the reading of the micrometer. Difference of the readings gives minor diameter.

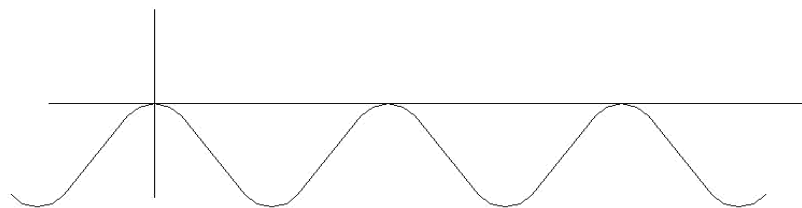


Fig.3

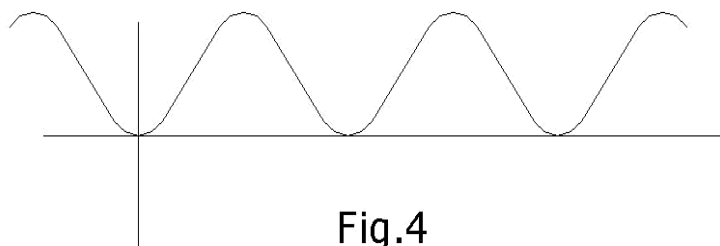


Fig.4

3. Determination of Pitch:

To measure pitch of the thread, align the centre of the cross lines at the peak of the crest as shown in the fig-5. At this position take the micrometer reading. Now move the micrometer in such a way that centre of the cross line align with the peak of the next thread as shown in fig-6. Again note-down the reading of the micrometer. Difference of the two readings gives the pitch of the thread.

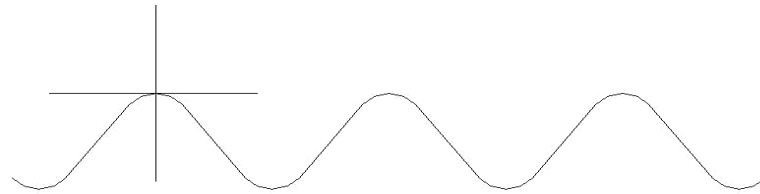


Fig.5

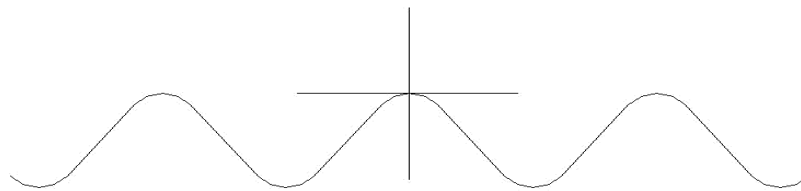


Fig.6

4. Determination of the angle:

To measure the included angle of the thread coincide one of the lines of the cross lines with the flank of the thread as shown in the fig-7. Note-down the reading of the protractor. Now rotate the protractor in turn the cross lines in such a way that same line coincides with the opposite flank as shown in fig-8. Note-down the reading of the protractor. Difference of the two reading gives the included angle of the thread.

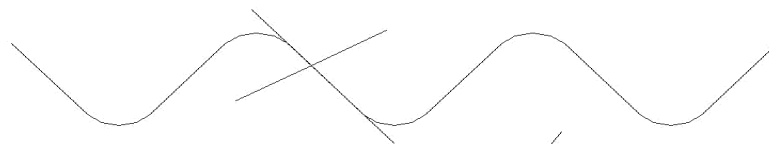


Fig.7

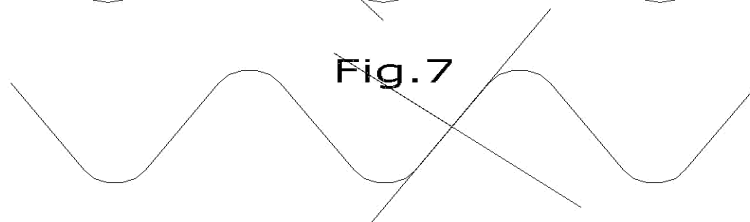


Fig.8

Precautions:

1. Students are advised to take readings without any parallax error.
2. Lens must be properly adjusted to get a sharp image.
3. Move the Microscope table by gently holding micrometer thimble.

Result:

Major diameter, Minor diameter, pitch and included angle of the screw thread are measured by tool makers microscope.

Angular Measurement by Bevel Protractor and Sine Bar

Aim:

1. To measure the angle between two faces of a given component using Bevel protractor.
2. To measure the taper angle of a given component using sine bar.

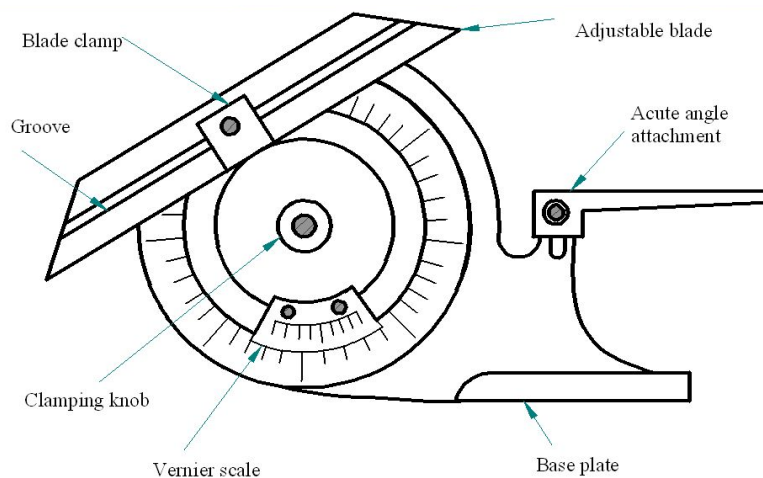
Equipment and accessories required:

1. Bevel protractor with Vernier and acute angle attachment (150/300 mm blades),
2. Sine bar (100 mm size)
3. Surface plate
4. Slip gauges
5. Dial gauge (0.01 mm least count),
6. Slotted angle plate,
7. Bolts for locking sine bar to angle plate
8. Clamps for locking component to sine bar.

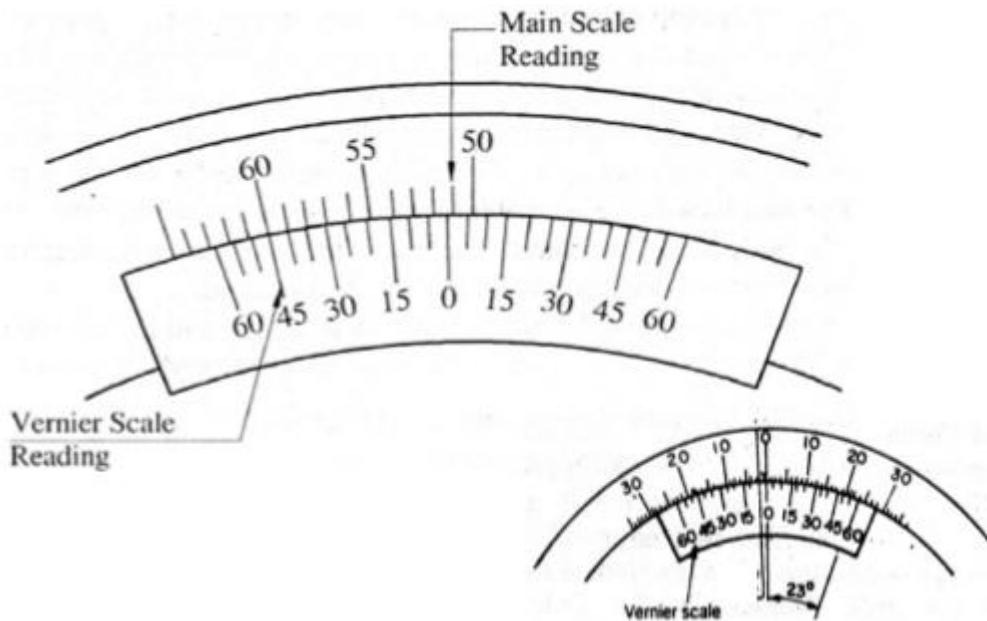
Theory and Description:

Bevel Protractor:

It is the simplest instrument for measuring angle between two faces of component. It consists of a base plate attached to the main body and an adjustable blade which is attached to a circular plate called turret containing Vernier scale. The adjustable blade is capable of rotating freely about the centre of the main scale (graduated around a complete circle from 0° to 90° , 90° to 0° and 0° to 90° , 90° to 0°) engraved on the body of the instrument and can be locked in any position. An acute angle attachment is provided at the top as shown in fig (4.1) to measure acute angles. The base of the base plate is made flat so that it could be laid flat upon the work and any type of angle measured. It is capable of measuring from 0° to 360° .



SCHEMATIC OF UNIVERSAL BEVEL PROTRACTOR



Magnified view of Vernier scale.

The Vernier scale has 24 divisions coinciding with 46 main scale divisions (23 on either side) as shown in fig. The Vernier scale is graduated to the right and left of zero up to 60 minutes, each of the 12 graduations representing 5 minutes. Since both the protractor dial and Vernier scale have graduations in both directions from zero, any angle can be measured, but it should be remembered that the Vernier must be read in the same direction from zero as the protractor either left or right. If the zero graduation on the Vernier scale coincides with a graduation on the protractor dial, the reading is in exact degrees, but if some other graduation on the Vernier scale coincides with a protractor graduation, the number of Vernier graduations multiplied by 5 minutes, must be added to the number of degrees read between the zeros on the protractor dial and Vernier scale. Magnified view of main scale is shown in fig.

Sine Principle and Sine bar:

The Sine principle uses the ratio of the length of two sides of a right angle triangle in deriving a given angle. The measurement is usually limited to 45° from loss of accuracy point of view. The accuracy with which the sine principle can be put to use is dependent in practice, on some form of linear measurement. The sine bar in itself is not a complete measuring instrument. Another datum such as a surface plate is needed, as well as other auxiliary equipment, notably slip gauges, and indicating device to make measurements. Sine bars used in conjunction with slip gauges constitute a very good device for the precise measurement of angles. Sine bars are used either to measure angles very accurately or for locating any work to a given angle within very close limits.

Sine bars are made from 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 5 inches or 10 inches in British System and 100, 200 and 300 mm in metric system.

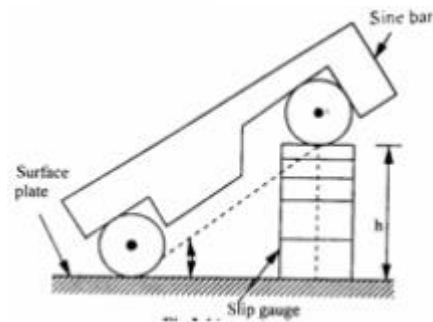
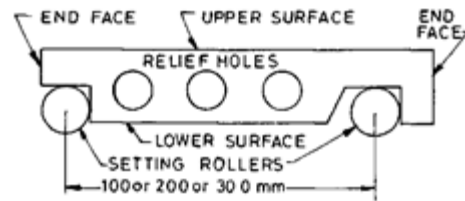
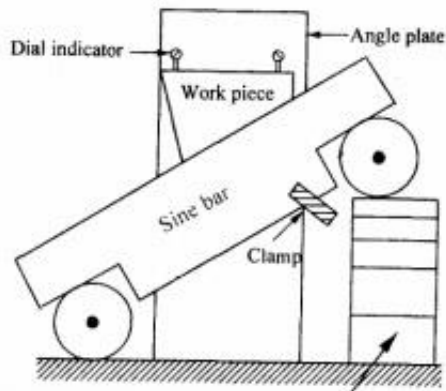


Fig 2.23 Work Location

(ii) To check unknown angles:



The Various parts are hardened and stabilized before grinding and lapping. All the working surfaces and the cylindrical surfaces of the rollers are finished to surface finish of $0.2 \mu\text{m Ra}$ value or better. Depending upon the accuracy of the centre distance, sine bars are graded as of A grade or B grade. B grade of sine bars are guaranteed accurate up to 0.02 mm/m of length and A grade sine bars are more accurate and guaranteed up to 0.01 mm/m of length. There are several forms of sine bars, but the one shown in fig (4.3) is most commonly used. Some holes are drilled in the body of the bar to reduce the weight and to facilitate handling.

The accuracy of sine bar depends on its constructional features:

1. The two rollers must have equal diameter and be true cylinders
2. The rollers must be set parallel to each other and to the upper face,
3. The precise centre distance between the rollers must be known
4. The upper face must have a high degree of flatness.

Use of Sine bar:

a) Measuring known angles or locating any work to a given angle:

For this purpose the surface plate is assumed to be having a perfectly flat surface, so that its surface could be treated as horizontal. One of the cylinders or rollers of sine bar is placed on the surface plate and other roller is placed on the slip gauges of height 'h' as shown in fig (4.4). Let the sine bar be set at angle θ . Then

$$\sin \theta = h/L$$

Where,

L = Distance between the centre of rollers.

Thus knowing θ , h can be found out and any work could be set at this angle as the top face of sine bar is inclined at angle θ to the surface plate. The use of angle plates and clamps could also be made in case of heavy components. For better results, both the rollers could also be placed on slip gauges of height h_1 and h_2 respectively. Then $\sin \theta = (h_2 - h_1)/L$

b) Checking of unknown angles:

Many a times, angle of a component to be checked is unknown. In such a case, it is necessary to first find the angle approximately with the help of a bevel protractor. Let the angle be θ . Then the sine bar is set at an angle θ and clamped to an angle plate. Next, the work is placed on sine bar and clamped to angle plate as shown in fig (4.5) and dial indicator is set at one end of the work and moved to the other, and deviation is noted. Again slip gauges are so adjusted that dial indicator reads zero across work surface.

If deviation noted down by the dial indicator is δh over a length of L of work, then height of slip gauges by which it should be adjusted is equal to $\delta h \times L/L$.

Procedure:

Angle measurement by Bevel protractor:

1. The base plate of the Bevel protractor is placed on the top horizontal surface of the component,
2. Blade locking nut is loosened and by rotating the blade about the centre of the main scale, the working edge of the blade is made to coincide with the inclined surface of the component,
3. Blade is locked in that position by tightening the nut.
4. Vernier scale division coinciding with main scale division is noted.

Inclination of the surface with respect to horizontal is calculated as follows:

Angular reading = (Vernier scale division x 5minutes) + Main scale division in degrees.

Angular measurement by sine bar:

1. The sine bar is made to rest on surface plate with rollers contacting the datum (surface plate)
2. Place the component on sine bar and lock it in position.

3. Lift one end (roller) of the 'sine bar and place a pack of slip gauges, underneath the roller. The height of the slip gauges (h) should be selected such that the top surface of component is parallel to the datum plate (surface plate).
4. The parallelism can be assessed by making the stylus of a dial indicator mounted on a dial gauge stand in contact with the upper surface of component and sliding the stylus along the component surface. If both the surfaces are perfectly parallel, the pointer on the dial gauge shows the same reading throughout the travel of the dial gauge stylus. If the surfaces are not parallel, then the height of the slip gauge pack (h) can be altered and procedure for checking parallelism can be repeated.)

Record the final height of slip gauge pack used for achieving parallelism.

Calculate inclination $\theta = \text{Sin}^{-1}(h/L)$

Precautions:

1. The sine bar should not be used for angle greater than 60° because any possible error in construction is accentuated at this limit.
2. Accuracy of sine bar should be ensured.
3. As far as possible longer sine bar should be used since many errors are reduced by using longer sine bars.

Measurement of finding flatness by optical flat

Aim:

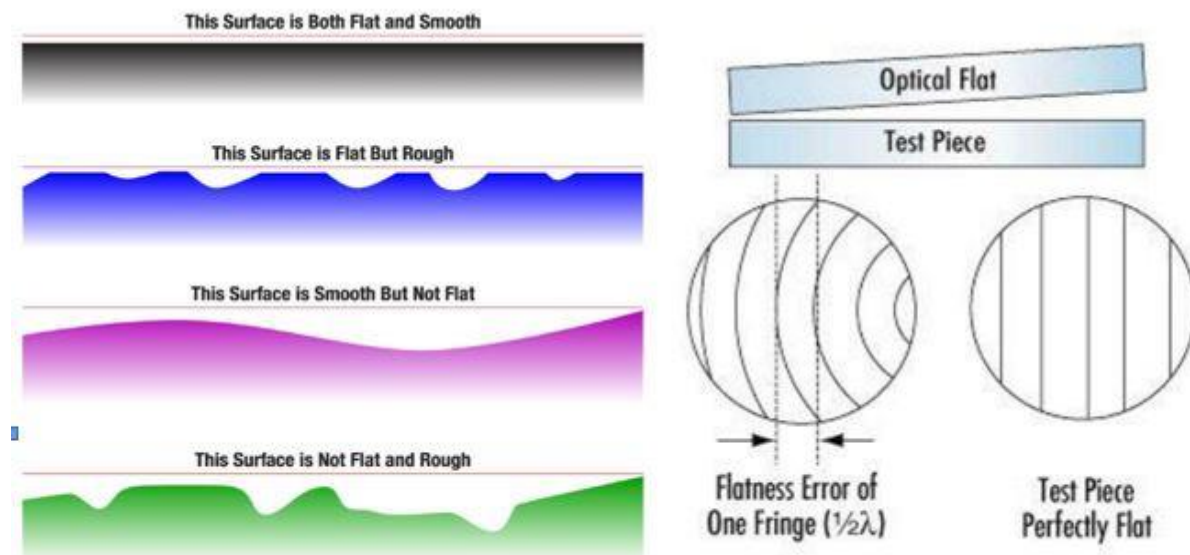
To measure the flatness of a given surface by using the optical flat.

Apparatus:

1. Optical flat,
2. monochromatic light source,
3. dry soft cloth,
4. Cleaning agent.

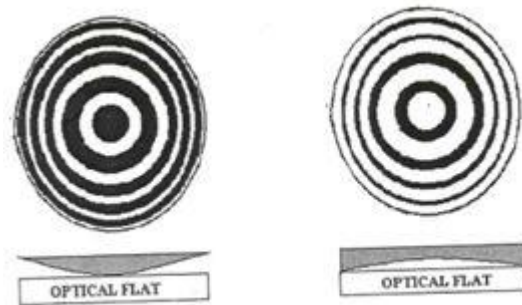
Theory:

Light band reading through an optical flat, using a monochromatic light source represent the most accurate method of checking surface flatness. The monochromatic light on which the diagrammatic interpretations of light wave readings are based comes from a source, which eliminates all colours except yellowish colour. The dark bands viewed under the optical flat are not light waves. They simply show where interference is produced by reflections from two surfaces. These dark bands are used in measuring flatness. The band unit indicates the level of the work that has risen or fallen in relation to the optical flat, between the centre of one dark band and the center of the next dark band.



The basis of comparison is the reflected line tangent to the interference band and parallel to the line of contact of work and the optical flat. The number of bands intersected by the tangent line indicates the degree of variation from the true flatness over the area of the piece. Optical flats are used to check flatness when surface to be tested shine and smooth i.e. Just like a mirror.

Optical flats are cylindrical piece made up of important materials such as quartz. Specification ranges from 25mm by 38mm (dia x Length) to 300mm by 70 mm. Working surface are finished by lapping and polishing process where as cylindrical surface are finished by grinding.



Applications:

1. Optical flats are used for testing the measuring surfaces of instruments like micrometers, measuring anvils & similar other devices for their flatness & parallelism.
2. These are used to calibrate the standard gauges, like slip gauges, angle gauges & secondary gauges in the workshops.
3. In measuring the curvatures like convex and concave for surfaces of the standard gauges.

	tolerance type	characteristic	symbol
individual features	form	straightness	—
		flatness	▭
		circularity	○
		cylindricity	⊘
for individual or related features	profile	profile of a line	⌒
		profile of a surface	⤿
related features	orientation	angularity	∠
		perpendicularity	⊥
		parallelism	∥
	location	position	⊕
		concentricity	⊙
	runout	circular runout	↗•
total runout		↘•	

Observations:

1. Monochromatic yellow light source is used for conducting this experiment.
2. Wavelength of Monochromatic source of light.

$$\lambda/2 = \text{_____ mm.}$$

$$\text{Where } \lambda = 0.0002974 \text{ mm}$$

Tabular column:

SL No.	Type of optical flats	No. of fringes observed =N'	Flatness error	Remark on type of surface with sketch
1	Straight (Slip gauge)			
2	Concave			
3	Convex			

Calculations:

$$\text{Flatness error} = N \times \lambda/2$$

Procedure:

1. Clean the surface to be tested to become shiny and wipe it with dry clean cloth.
2. Place the optical flat in between flatness of work piece to be tested and monochromatic Sources of light i.e. on the work piece.
3. Both parts and flat must be absolutely clean and dry.
4. After placing optical flat over work piece switch on the monochromatic source of light and Wait until getting yellowish or orange colour.
5. Apply slight pressure over optical and adjust until getting steady band approximately parallel to the main edges.
6. Count the number of fringes obtained on the flat with the help of naked eye and calculates the flatness error.

Results:

Flatness of a given specimen is measured by using the optical flats.

Machine tool alignment test on lathe

Aim:

To conduct various alignment test on the lathe machine.

Apparatus:

1. Spirit level test
2. Dial indicator
3. Test Mandrel
4. Magnetic stand

Various tests:

Various tests are performed on the lathe machine are:

1. Levelling of the machine.
2. True running of locating cylinder at main spindle.
3. Actual slip of main spindle and true running of shoulder face of spindle nose.
4. True running of head stock center.
5. Parallelism of the main spindle to saddle movement.
6. True running of head stock center.
7. Parallelism of tail stock guide ways with the movement of carriage.
8. Movement of upper slide parallel with main spindle in vertical plane.
9. Parallelism of tail stock sleeve to saddle movement.
10. Alignment of both the centers in vertical planes the various tests configurations.

Procedure:

Before the various tests to be carried out on any machine tool it is very essential that it should be installed on truly horizontal and vertical planes the following table shows the different test procedures and results.

Procedure of doing the test:

1. a) Level of directions is tested by a sensitive spirit level.
b) Saddle is kept in the center of bed support feed(approx)
c) Spirit level then placed to ensure that the level in the longitudinal direction.
d) Then it is traversed along the length of the bed and readings at various places are note down.
e) Take two readings in longitudinal and transverse directions simultaneously.
2. a) Locating cylinder is provided to locate the chuck or face plate thus the locator surface is cylindrical and this must be run truly for the only face plate etc can run true.
b) The dial indicator is fixed to the carriage and the feeler of the indicator touches the locating surface.
c) The surface is then rotated on its axis and indicator should not show any movement of needle.
3. a) Keep the feeler of dial gauge on the face of the locating spindle shoulder.
b) Clamp the magnetic stand, which holds the dial gauge on the bed.
c) The locating cylinder is then rotated and the change in reading note down.
d) The readings are taken at two diametrically opposite points.

4. a) Feeler of dial gauge is pressed perpendicular to the taper surface of the shoulder
b) And the spindle is rotated , the change in readings noted down
c) The deviation indicated by the dial gauge gives the trueness of the centers.
5. a) Mandrel is fitted in the taper socket of the spindle which is close fit to the spindle nose taper.
b) The feeler of dial indicator is pressed on the mandrel and the carriage is moved.
c) The indication in horizontal plane is given by dial (B) and in vertical plane by dial (A) and readings is noted down.
6. a) Mandrel is fitted into the tapered hole and readings at two extremes of the plane are taken by means of dial indicator.
7. a) A block is placed on the guide ways
b) The feeler of indicator is touched on the horizontal and vertical surfaces of the block.
c) The dial indicator is held in the carriage and the carriage is moved.
d) Any error is indicated by the pointer and dial indicator.
8. a) The dial indicator is fixed in the tool post.
b) Mandrel is fitted in the spindle.
c) The feeler gauge of dial gauge is pressed against the mandrel in vertical plane and upper slide is moved longitudinally.
9. a) Fix the dial indicator on the tool post and press the plunger against the sleeve first in vertical and then in horizontal plane.
b) The carriage is moved along the full length of the sleeve and derivations indicated by dial indicator are noted down.

Precautions:

1. Handle the dial indicator with more attention and set the indicator pointer to mark (indication) on dial scale.
2. Fix the dial gauge to magnetic stand approximately.
3. Place the magnetic stand at suitable location without slip.

Various alignment tests:

1. Levelling of the machine (Spirit level)

2. Axial slip of main spindle and true running of shoulder face of spindle nose

Max=

Min=

3. True running of taper socket on main spindle

Max=

Min=

4. True running of head socket center

Max=

Min=

5. True running of locating cylinder at main spindle

Max=

Min=

6. Parallelism of main spindle to saddle movement

Max=

Min=

7. Movement of compound slides parallel with main spindle in vertical plane

Max=

Min=

8. Alignment of both the centres in vertical plane

Max=

Min=

9. Parallelism of tail stock guide- ways with movement of carriage

Max=

Min=

10. Parallelism of tail stock sleeve to saddle movement

Max=

Min=

THREAD MEASUREMENT

Aim:

To measure (or) Check the major, minor diameters, pitch and effective diameter of a given threaded component by using

- a) Two wire method.
- b) Three wire method.

Description:

Screw pitch gauge fig1: there are sets of flat steel blades which are notched on one edge according to various thread pitches represented by the gauge. The blades are pivoted at the end of a holder. It is used to measure the pitch of the thread. To use it the blade with the required thread pitch is 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 gauges and thread profile.

Screw thread micrometer:

This is similar to the ordinary micrometer, but instead of usual flat measuring faces, it has specially designed anvil & spindle inserts as shown in fig(2). The inserts are interchangeable to suit the thread pitch. To check the minor dia of a screw, two v-shaped inserts are used so that their sharp apexes contact the roots of the screw thread.

Theory:

Three wire method: it is the more accurate method for checking the pitch diameter. This method consists in placing three small dia cylinders in the thread grooves of opposite side of a screw and measuring the distance w over the outer surface of the wires with an ordinary micrometer calliper having flat measuring faces fig(3). Three wires are required to prevent misalignment of the measuring faces on the micrometer calliper.

The pitch or effective dia is calculated from the value of w in the following manner

Procedure:

1. Keep the threaded component whose dimensions to be measured between the two centers of the bench centers.
2. Measure the outside dia by means of outside micrometer, which is equal to major dia.
3. Measure the root dia or cone dia of external threads by using vernier calliper, which is equal to minor dia.
4. Keep two wires made of hardened steel between the flank of the thread as shown in fig. (5) By means of either hand or by a stand.
5. Take the dia over the wire by means of micrometer & calculate the effective dia as per the formulae explained in theory.
6. The pitch & helix angle of the screw can be found by using screw pitch angle.
7. For three-wire method repeat the above procedure by keeping three wires instead of two wires & calculations as per theory.

Observations & Calculations:

The major diameter of external thread screw $D =$

The minor diameter of external thread screw $D_m =$

Pitch of thread screw (P) =

Helix angle or thread angle of thread screw $\theta =$

$$\text{Effective diameter or pitch diameter of thread screw (E)} = M - 2d + \frac{p}{2} \cot \frac{\theta}{2} - d(1 - \cos ec \frac{\theta}{2})$$

Where $M =$ distance over two wires =

$d =$ diameter of the wire

Best wire size diameter (d) = $P/2 \sec \theta/2 =$

Three wire method:

The major dia of external thread screw $D =$

The minor dia of external thread screw $D_m =$

Pitch of thread screw (P)

Helix angle or thread angle of thread screw $\theta =$

$$\text{Effective dia or pitch dia of thread screw (P)} = M - d(1 + \cos ec \frac{\theta}{2}) + \frac{p}{2} \cdot \cot \frac{\theta}{2}$$

Where $W =$ distance over three wires

$D =$ dia of the wire

$P =$ pitch of the screw

$\theta =$ Threaded angle = 60°

Best wire size dia (d) = $P/2 \sec \theta/2$

Two wire method:

The effective dia of screw thread can be obtained by placing two wires or rods of identical dia between the flanks of the thread as shown in fig. (5). and measuring the distance over the outside of three wires.

The effective dia $E = T + P$

Where $T =$ dimension under wires

$$= M - 2d$$

Where $M =$ dimension over the wires

$d =$ dia of each wire,

$P = 0.965p - 1.165d =$ whitworth thread,

$P = 0.866p - d =$ metric thread.

$P =$ the difference between the effective diameter and the diameter under the wires.

Wire of any diameter must take contact with the flanks of the thread at the pitch diameter

From fig (4), the point B, at which the wire touches the flank of the thread, lies on the pitch line i.e., BC lies on pitch line and AB is 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 dia, since such wires will be independent of any error in thread angle.

$$BC = P/4$$

from $\triangle ABC$, $AB = d/2 = BC \sec(\theta/2)$

$$d/2 = P/4 \sec(\theta/2)$$

Best size of the wire $d = p/2 \sec(\theta/2)$

For ISO metric threads

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

Precautions:

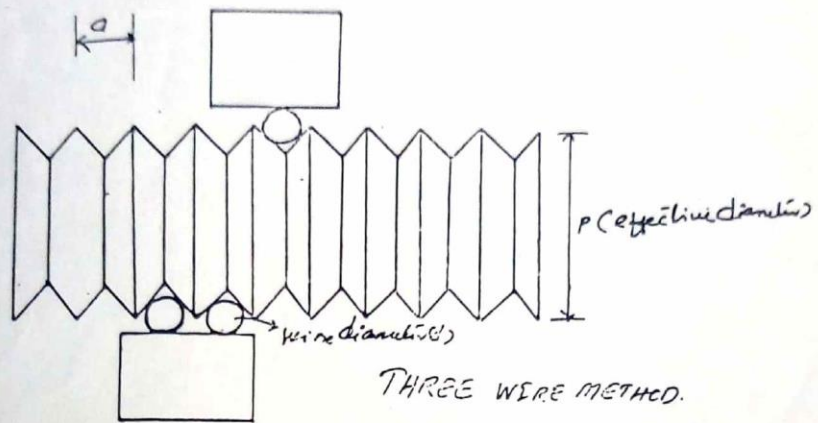
Fix the screwed post in between the canters perfectly.

Do not allow to turn, while doing the experiment.

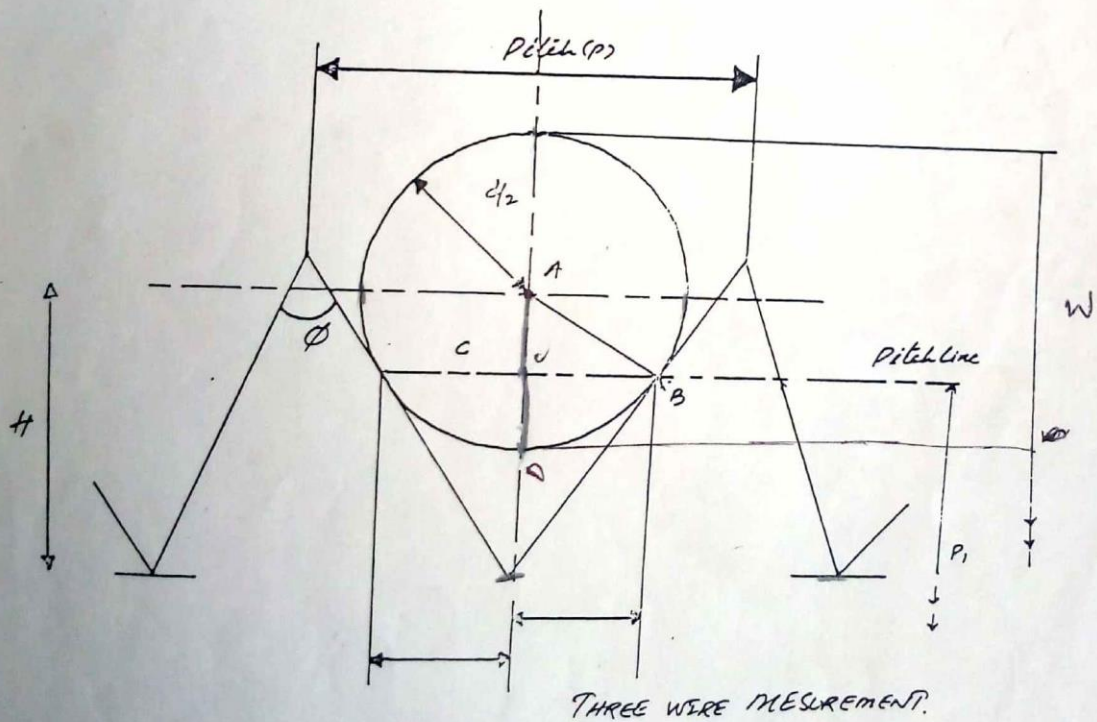
Take proper care while taking the reading with micrometers.

Result:

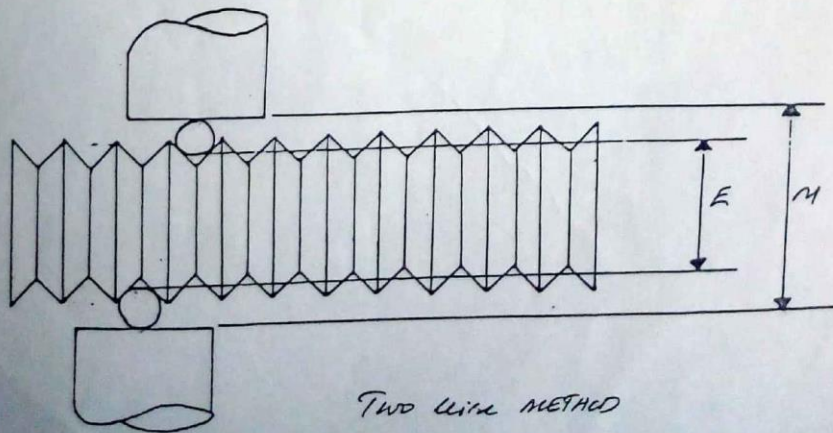
1. Major dia of screw =
2. Minor dia of screw =
3. Pitch of the screw =
4. Threaded angle =
5. Best wire size =
6. Effective diameter (d) or pitch diameter of screw =
 - a) By two wire method E =
 - b) By three wire method E =



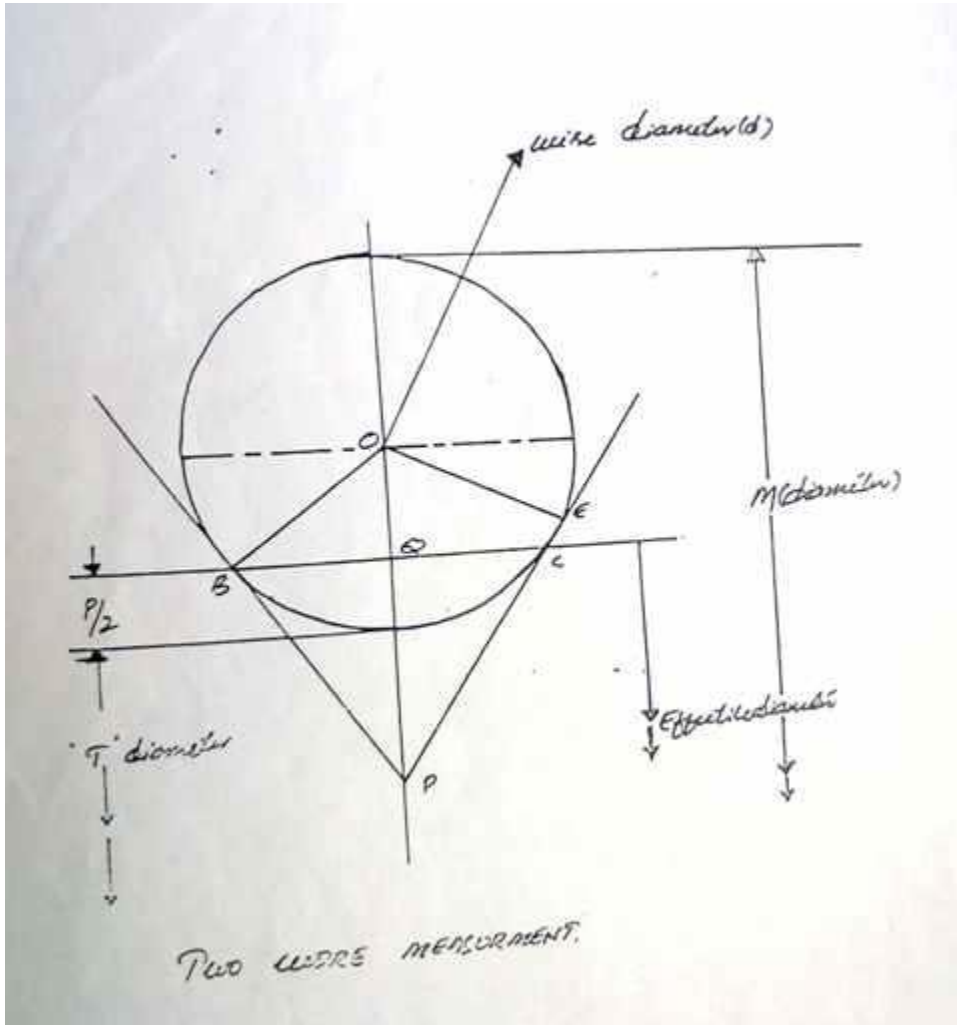
THREE WIRE METHOD.



THREE WIRE MEASUREMENT.



TWO WIRE METHOD



Measurement of effective diameter by two wire and three wire method

Aim:

To determine the major and effective diameter of the given threaded component.

Apparatus required:

1. Floating carriage machine
2. Standard wires
3. Standard cylinder

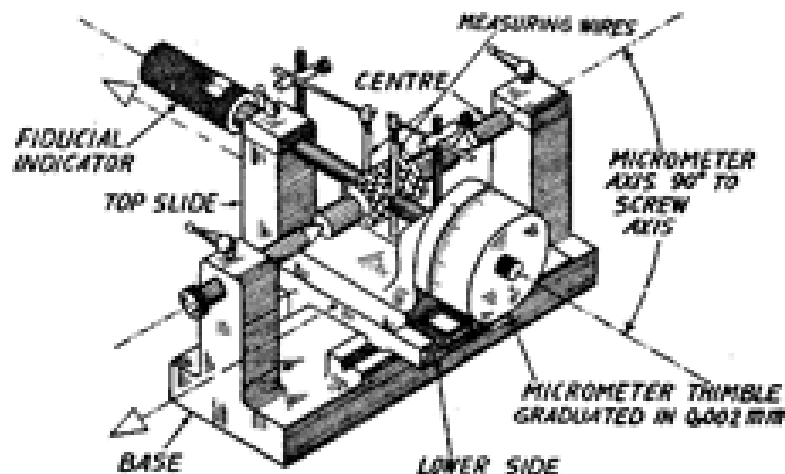
Theory:

1. Two wire and three method of effective diameter measurement.
2. Care to be taken while handling Floating Carriage Diameter Measuring Machine.
3. Best size of wires.

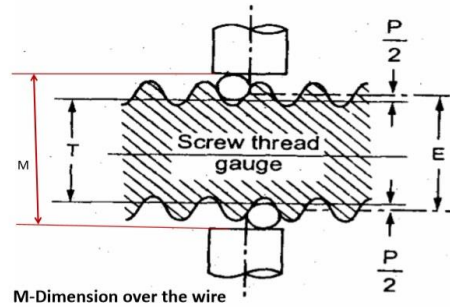
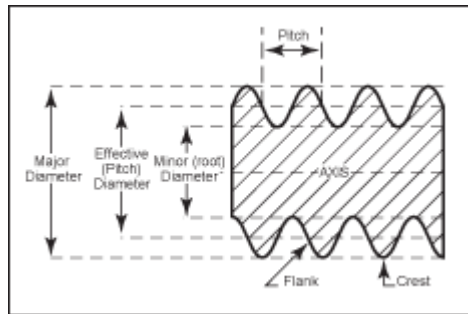
Floating Carriage Micrometer (FCM):

Effective Diameter Measuring Micrometer (EDMM) is also commonly known as FCM or Floating Carriage Micrometer. This instrument is used for accurate measurement of 'Thread Plug Gauges'. Gauge dimensions such as Outside diameter, Pitch diameter, and Root diameter are measured with the help of this instrument. In order to ensure the manufacture of screw threads to the specified limits laid down in the appropriate standard it is essential to provide some means of inspecting the final product. For measurement of internal threads thread plug gauge is used and to check these plug gauges Floating Carriage Micrometer is used for measuring Major, Minor and Effective diameter.

The pitch diameter is the diameter of an imaginary cylinder which passes through the thread profile at such points as to make the widths of thread groove and thread ridge equal. The correct pitch diameter assures that the threaded product or thread gauge is within required limits in producing interchange ability and strength. Periodic measurement of the pitch diameter is recommended to determine whether a thread gauge is worn below tolerance.



Two wire method:



- The effective diameter cannot be measured directly but can be calculated from the measurements made.
- Wires of exactly known diameters are chosen such that they contact the flanks at their straight portions
- If the size of the wire is such that it contacts the flanks at the pitch line, it is called the best size of wire which can be determined by the geometry of screw thread.

The screw thread is mounted between the centers and wires are placed in the grooves and reading is taken.

Procedure:

Principle of measurement:

The floating carriage diameter measuring machine is primarily used for measuring, major, and effective diameters of thread gauges and precision threaded components. The instrument has a meaning accuracy of 0.0002mm. It consists of a sturdy cast-iron base, two accurately aligned and adjustable centers. At right angles to the axis of centers, there is a freely moving measuring carriage mounted on V'-ways and carrying a micrometer and highly sensitive fiducial indicator. This carriage permits measurements to be taken along the center line and at right angles to the work. All measurements are made relative to a reference master gauge or plain cylinder standard. The diameter of the standard should be within 2.5mm of the effective diameter of the work to be measured. The reading is taken on the diameter over the standard with cylinders/prisms in position depending upon the thread element to be measured. The standard is then replaced by the work piece and the measurements are taken.

Major diameter measurement:

The instrument is first present using a suitable cylindrical standard and the reading (R) of the micrometer is noted. The standard is then replaced by the work piece and second reading is taken. The major diameter of the given specimen can be determined using the expression.

$$F = D \pm (R - R_1)$$

Where,

F = Major diameter.

D = Diameter of the cylindrical standard used.
 \pm = is determined by the relative size of the standard work piece.

Effective diameter measurement:

To determine the effective diameter of the thread, measurements are taken over the thread measuring wires which will be selected depending upon the size and form of thread by referring to the tables supplied.

The instrument is first present over a suitable cylindrical standard and selected thread measuring wires. The reading (R_s) of micrometer is noted.

Then the standard is replaced by the work piece along with the wires introduced in the thread form as shown in fig. The second reading (R_w) of the micrometer is noted.

The effective diameter can be determined using the relation,

$$E = D \pm [(R_s - P) \sim R_w]$$

Where,

E = the effective diameter.

D = Diameter of the standard cylinder.

P = A constant which is dependent on the diameter of cylinders and the form of thread to be measured. It is also defined as the difference between the effective diameter and the diameter under the standard wires.

The value of 'p' can be calculated using the expression,

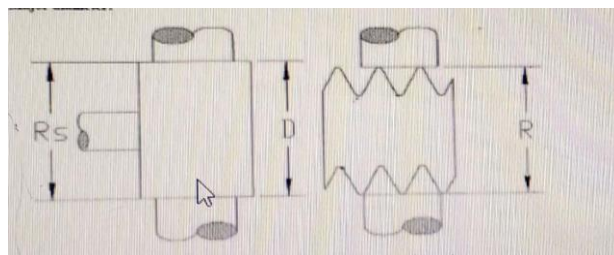
$$P = [(0.86602 * p) - d] \text{ for } 60 \text{ degree metric and unified threads.}$$

Where,

p = pitch of the threaded component.

d = mean diameter of the wires used.

1. Measurement of major diameter:



RS = Micrometer reading over setting Master/Standard.

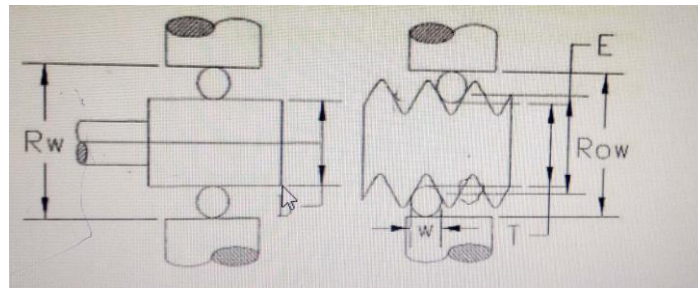
RW = micrometer reading over threaded work piece.

D = Standard cylinder diameter

$$\mathbf{RS} = \mathbf{MSR} + (\mathbf{HSR} \times \mathbf{LC}) + (\mathbf{CVD} \times \mathbf{LC})$$

$$\mathbf{RW} = \mathbf{MSR} + (\mathbf{HSR} \times \mathbf{LC}) + (\mathbf{CVD} \times \mathbf{LC})$$

2. Measurement of effective diameter:



Results:

1. Major Diameter = _____ mm
2. Minor Diameter = _____ mm
3. Effective Diameter = _____ mm

Linear Measurement of components by Vernier callipers, Micrometer.

Aim:

To measure length, width and diameter of given objects by using Vernier Callipers & Micrometer.

Apparatus:

1. Vernier Callipers,
2. Micrometer.

Description:

Pierre Vernier, a Frenchman, devised principle of Vernier for precise measurements in 1631. The Vernier Calliper consists of two scale one is fixed and the other is movable. The movable scale, called Vernier Scale. The fixed scale is calibrated on L-shape frame and carries a fixed jaw. The Vernier scale slides over the main scale and carries over the movable jaw. Also an arrangement is provided to lock the sliding scale on fixed main scale.

Principle of Vernier callipers:

The principle of Vernier is based on the difference between two scales or divisions, which are nearly, but not quite alike for obtaining small difference. It enables to enhance the accuracy of measurement.

Least Count:

Least count is the minimum distance which can be measured accurately by the Instrument.

Least Count of Vernier Caliper is the difference between the value of main scale division and Vernier Scale Division.

Thus Least Count = (Value of Smallest Division on Main Scale) - (Value of Smallest Division on Vernier Scale)

$$= 1 - \frac{49}{50}$$
$$= 0.02 \text{ mm.}$$

(Or)

$$\text{Least Count} = \frac{\text{(Value of Minimum Division on the Main Scale)}}{\text{(Number of Division on Vernier Scale)}} = \frac{1}{50} = 0.02 \text{ mm.}$$

Procedure:

The given component is fixed between the jaws firmly, i.e., in between fixed jaw and movable jaw.

The reading is to be noted down.

Procedure for taking the Reading:

1. After closing the jaws on the work surface, take the readings from the main as well as Vernier Scale. To obtain the reading, the number of divisions on the main scale is first read off. The Vernier Scale is then examined to determine which of its division coincide or most coincident with a division on the main scale.

2. Before using the instrument should be checked by zero error. The zero line on Vernier Scale should coincide with zero on the main scale.
3. Then take the reading in mm on main scale to the left of zero on sliding scale.
4. Now Count the no. of divisions on Vernier Scale from zero to a line which exactly Coincides with any line on the main scale.

Thus total reading = [Main scale reading] + [No. of divisions with a division on Main Scale] X Least Count.

(Or)

$$TR = MSR + VC \times LC$$

5. Take the reading for 4 times.

Diagram:

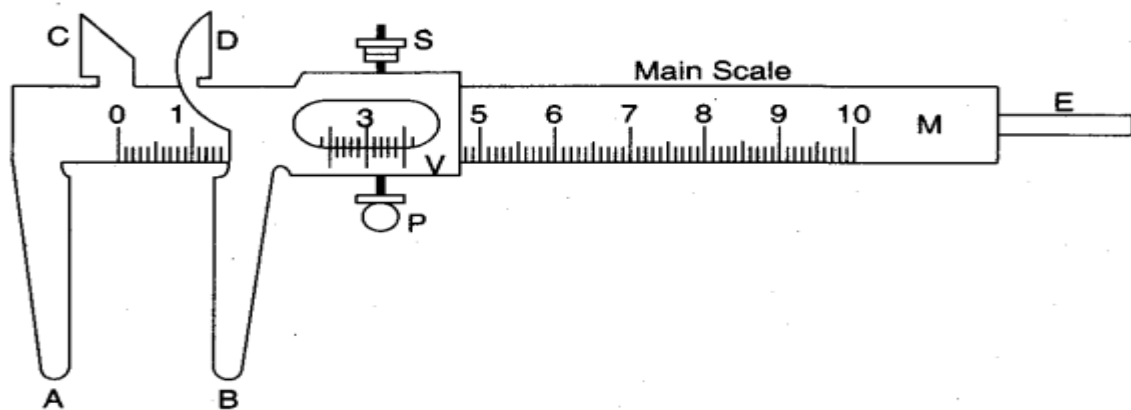


Fig. 2.05. Vernier callipers.

Tabular form:

S.NO.	MSR	VC	TR

MSR= Main Scale Reading; VC= Vernier coincidence; TR= Total reading

The length / diameter / height = Average of the readings = (Trial 1+2+3+4+5) / 5 =
----- mm

Result:

Length of the given component = ----- mm

Diameter of the given component = ----- mm

Width of the given component = ----- mm

Measurement of External diameters by the outside micrometer

Aim:

To find the outside diameters of rings, shafts, blocks, spheres and pipes etc.

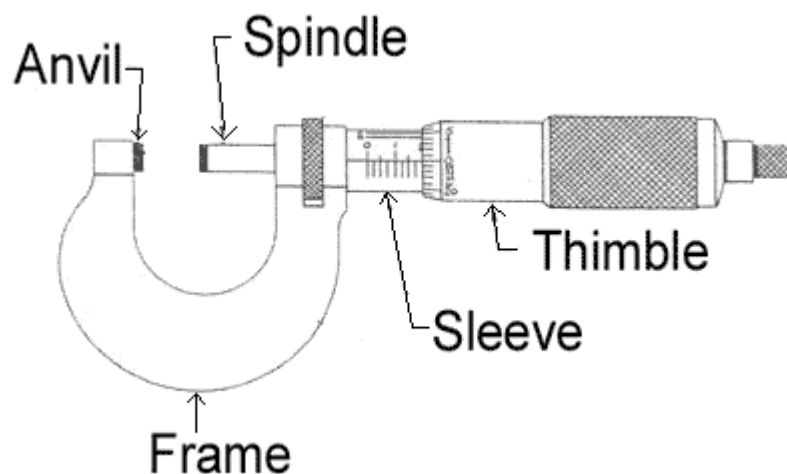
Description:

Micrometers are designed according to screw and nut principle where a calibrated screw thread and circular scale divisions are used to indicate the principle practical part of main scale divisions.

The semi circular frame carries a fixed anvil at one extremely and cylindrical barrel at the other end. A fine accurately cut screw of uniform pitch is machined on a spindle. The spindle passes through the barrel and its left hand side constitutes the movable anvil. A sleeve fits on the screw and carries on its inner edge a circular scale divided - into desired no. of divisions.

The spindle with its screw and thimble are in one piece and sleeve forms the nut. The thimble scale serves to measure the friction of its circular rotations. The number of complete rotations is read from main scale, which is graduated in 'mm' on nut parallel to axis of screw.

Diagram:



Procedure:

The work piece is held between the 2 anvils without undue pressure. This is accomplished by having a ratched drive to turn the thimble when the anvils contact each other directly or indirectly through work piece placed in between the ratchet tips over the screw cap without moving the screw forwards and thus avoids undue pressure.

Least Count = Pitch of the screw/ No. of Divisions on Circular Scale. If Pitch of screw is 0.5 mm and Circular Scale has 50 divisions on it, then

$$\text{Least Count} = 0.5 / 50 \sim 0.01 \text{ mm}$$

In measuring, the dimension of work piece the main scale up to the levelled edge of thimble and no. of divisions of thimble scale to axial line on barrel are observed addition of two given result.

Observations:

Measuring the given component within the range of 0-25mm, 0.01 mm is least count.

Sample calculations:

$$\text{TR} = \text{SR} + (\text{CSR} \times \text{LC})$$

TR = TOTAL READING

SR = SLEVE READING

CSR = CIRCULAR SCALE READING

LC = LEAST COUNT

Tabular form:

S.NO.	MSR	VC	TR

Precautions:

The thimble should be turned with ratchet only and to have standard condition and to prevent excess deformation of work piece.

Result:

The required outer diameter of the given components using outside micrometer is obtained.

Surface roughness measurement by Talysurf surface roughness tester

Aim:

1. To measure the surface roughness of the given specimens using surface roughness Tester.
2. To show the variation of surface roughness as a function of cutting conditions i.e., speed, feed, depth of cut and tool geometry etc.

Measuring instruments and material required:

1. Surface roughness tester (SJ - 201)
2. Precision roughness specimen, Test specimens, Calibration stage
3. Height gauge, Adapter for the height gauge, support feet
4. Nose pieces, Digimatic data processor (DP- 1 HS)

Terminology as per Indian standards:

Surface roughness: It concerns all those irregularities which form surface relief and which are conventionally defined within the area where deviations of form and waviness are eliminated.

Primary texture (Roughness): It is caused due to the irregularities in the surface roughness which results from the inherent action of the production process. These are deemed to include transverse feed marks and the irregularities within them.

Secondary texture (Waviness): It results from the factors such as machine or work deflections, vibrations, chatter, heat treatment or warping strains, waviness is the component of surface roughness upon which roughness is superimposed.

Centre line: The line about which roughness is measured.

Lay: It is the direction of the “predominant surface pattern: ordinarily determined by the method of production used.

Traversing length: It is the length of the profile necessary for the evaluation of the surface roughness parameters. The traversing length may include one or more sampling lengths.

Sampling length (l): Is the length of profile necessary for the evaluation of irregularities to be taken into account. This is also known as the cut - off length as regard to the measuring instruments. It is measured in a direction parallel to the general direction of profile.

Theory:

Surface texture is deemed to include all those irregularities which, recurring many times across the surface, tend to form on it a pattern or texture. The irregularities in the surface texture which result from the inherent action of the production process is called roughness or primary texture. That component of surface texture upon which roughness is super imposed is called waviness or secondary texture. This may result from such factors as machine or work deflections, vibrations, chatter, heat treatment or warping strains. The

direction of the predominant surface pattern, ordinarily determined by the production method used is called lay. The parameters of the surface are conveniently defined with respect to a straight reference line. The most widely used parameter is the arithmetic average departure of the filtered profile from the mean line. This is known as the CLA (Centre - Line - Average) or Ra (roughness average).

Arithmetic mean deviation of the Profile, Ra:

Ra is the arithmetic mean of the absolute values of the profile deviations (Y_i) from the mean line.

$$R_a = \frac{1}{N} \sum_{i=1}^N |y_i|$$

Root-mean-square deviation of the Profile, Rq:

Rq is the square root of the arithmetic mean of the squares of profile deviations (Y_i) from the mean line.

$$R_q = \sqrt{\frac{1}{N} \sum_{i=1}^N |y_i|^2}$$

Maximum height of the Profile, Ry:

Ry is the sum of height Y_p of the highest peak from the mean line and depth Y_v of the deepest valley from the mean line.

$$R_y = Y_p + Y_v$$

Outline of surf test SJ-201:

The surf test - 201 is a shop-floor type surface roughness measuring instrument, which traces the surfaces of various machines parts, calculates their surface roughness based on roughness standards, and displays the results.

Surf Test SJ-201 Surface roughness measurement principle:

A pick-up which is usually called as the “Stylus” attached to the detector unit of the surf test SJ-201 will trace the minute irregularities of the work piece surface. The vertical stylus displacement during the trace is processed and digitally displayed on the liquid crystal display of the surf test SJ-201. The instrument consists of the display unit and drive/detector unit. The drive/detector unit is designed to be removable from the display unit. Depending on the shape of the work-piece, it may be easier to perform measurement without mounting the drive/detector unit to the display unit. The detector in turn can be detached from the drive unit. Each time a measurement task has been completed with the surf test SJ-201, it is recommended that the detector be detached from the drive unit and stored in a safe place.

List of Surf Test SJ-201 Operation mode:

The surf test SJ-201 has various operation modes including the measurement mode, calibration mode, condition setting mode, RS-232 C communication mode, and detector retraction mode.

Measurement mode:

Starts and stops measurement, calculates and selects measurements parameters to be displayed, and performs SPC output.

Calibration mode:

Sets the calibration value prior to measurement and performs calibration measurement.

Condition setting mode:

Sets and modifies measurement conditions. This mode has 11 sub-modes.

RS-232C Communication mode:

Used for communication with a personal computer.

Detector retraction mode:

Retracts the detector as required.

Measurement of surface roughness:

Surface roughness measurement with the surf test SJ-201 includes

1. Mounting/dismounting the drive unit/detector, and cable connection, etc. according to the feature of the work piece to be measured,
2. Selection of power supply i.e., either the AC adapter or built-in battery,
3. Modifying the measurement conditions as necessary,
4. Calibrating surf test SJ-201 to adjust the detector gain for correct measurements,
5. Measuring the roughness specimen and display the result,
6. Outputting the measurement data or perform communication with a personal computer via the RS-232C interface.

Procedure:**Modifying measurement conditions:**

Table (6.C) shows the measurement conditions that can be modified by the user. If they are not modified, then measurement will be performed according to the default values, measurement conditions are modified according to the surface roughness parameters, the amplitude of roughness, the conditions of the objective area of measurement, etc.

Table – (6.A)

Table – (6.B)

Table – (6.C)

The surf test SJ-201 can obtain each roughness parameter based on the new JIS, old JIS, DIN ISO and ANSI standards. Evaluation according to any one of the standards may be obtained from Reference information (User's manual)

1. Calibration of measuring instrument:

The process of calibration involves the measurement of a reference work piece (precision roughness specimen) and the adjustment of the difference (gain adjustment), if

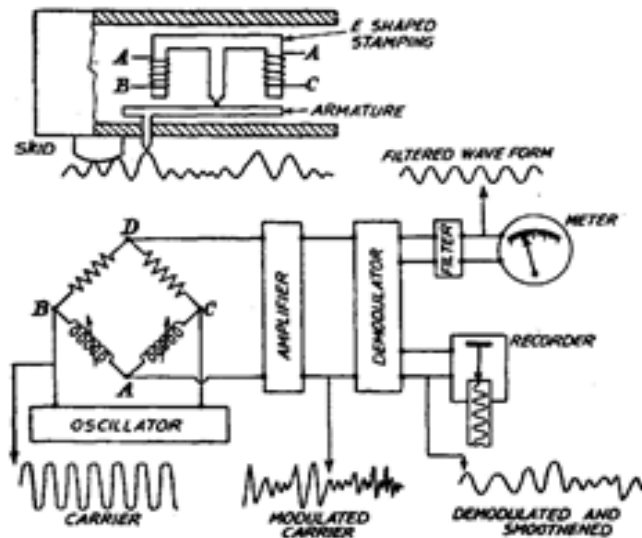
there is any between the measured value and the reference value (precision roughness specimen). Without properly calibrating the instrument, correct measurements cannot be obtained. Calibration of surf test SJ-201 with the supplied precision roughness specimen must be performed with the default values mentioned in Table (6.D).

1. Precision roughness specimen and calibration stage are placed on a level table.
2. Surf Test SJ-201 is mounted on the calibration stage.
3. Surf Test SJ-201 is set so that the detector traversing direction is perpendicular to the cutter mark of the precision roughness specimen. It should be confirmed that the detector is parallel to the measured surface as shown in fig (6.3).
4. If [CAL/STD/RANGE] key is pressed in the measurement mode, the calibration
5. Mode is entered and current calibration value is displayed. In this state the calibration value can be modified, if the displayed value is different from that marked on the precision roughness specimen. .
6. [n/Ent] key is pressed after confirming the displayed value, so that the entered calibration value is set.
7. [START/STOP] key is pressed to begin the calibration measurement. The symbol "--" is displayed while the detector is traversing and the measured value will be displayed when the measurement has been completed.
8. [n/Ent] key is pressed so that the calibration factor is updated, completing the entire calibration operation. viii) [MODE/ESC] key is pressed. This restores the measurement mode and retains the calibration factor obtained in the previous operation.

2. Actual measurement of roughness specimen:

Surf Test SJ-201 is placed on the work piece, if the work piece surface is large enough. For measurement to be successful, it should be performed on a firm base that is insulated as well as possible from all sources of vibration. If measurement is performed being subject to significant vibrations, results may be Unreliable.

- a) Work piece is positioned so that the measured surface is level.
- b) Surf Test SJ-201 is placed on the work piece, In this operation SJ-201 is supported by two reference surfaces at the bottom of driving unit. It must be confirmed that the stylus is in proper contact with the measured surface and the detector is parallel to the measured surface.



Relation between the operation mode and available keys:

Operation mode	Symbol(on LCD)	Key for mode switching
calibration mode	CAL	[CAL/STD/RANGE]
Surface roughness standard setup	STD	[CAL/STD/RANGE]
Filter setup mode	FIL	[FILTER/TOL/CUST]
GO/NG judgment function setup mode	TOL	[FILTER/TOL/CUST]
Parameter calculating condition setup mode	PAR	[FILTER/TOL/CUST]
Traversing speed setup mode	TSP	[MODE/ECE]
Pre-travel/post travel length setup mode	TRA	[MODE/ECE]
RS-232 C baud rate setup mode	SPD	[MODE/ECE]
Calibrating condition setup mode	CAL	[MODE/ECE]
Default value restoration INI mode	INI	Press [POWER/DATA] while simultaneously holding down [PARAMETER] and [STAR/STOP] during auto sleep
Rs-232 C communication	RMT	Press [POWER/DATA]

		While holding mode down [REMOTE] during auto sleep
Detector retraction mode	OFF ON	Retraction: press (POWER/DATA) while holding down (START/STOP) during auto sleep .Cancelling retraction. Press (START/STOP) if the detector is retracted and the power is on.

- c) [START/STOP] key is pressed in the measurement mode, the detector starts traversing to perform measurement,
- d) After the measurement has been completed, the measured value is displayed on the LCD. [PARAMETER] key is pressed until the desired parameter value is displayed on the LCD.

3. Outputting measurement result:

- a) The Surf Test SJ-201 is connected to a Digimatic data processor (DP - IHS) to output the measurement results (including the unit of measurement) as
- b) SPC data,
- c) DP-IHS is turned to 'ON' position,
- d) [PARAMETER] key is pressed until the objective parameter for output is displayed,
- e) [POWER/DATA] key is pressed so that the measurement result will be outputted from the Surf Test SJ-201 to the DP-1HS.

Precautions:

1. Never touch the stylus, otherwise it may be damaged.
2. Do not hold the detector when detaching the drive/detector unit. Otherwise, the detector may be damaged,
3. Confirm that the detector is parallel to the measured surface,
4. Confirm that the stylus is in proper contact with the measured surface,
5. Calibration of SJ - 201 with the precision roughness specimen must be performed with the default values that have been used for calibrating the roughness specimen.

9. Measurement of inside diameter by dial bore gauge

Aim: To measure inside diameters of given bores by using Dial bore gauge.

Apparatus and accessories required:

1. Dial bore indicator
2. Dial indicator
3. Specimen

Specification:

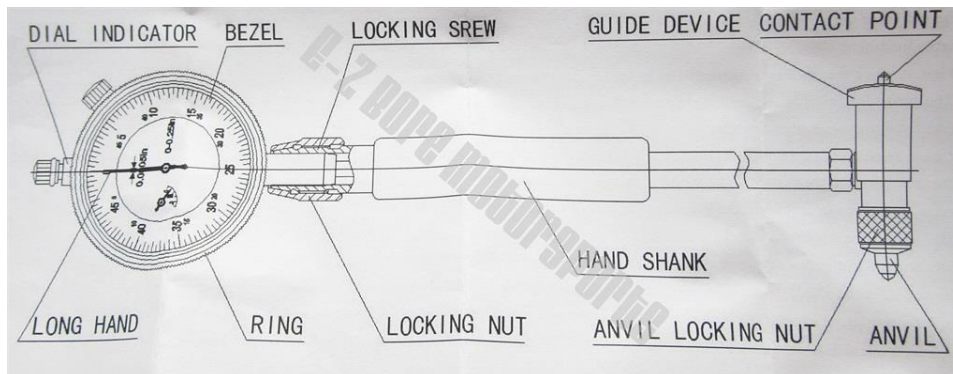
- a) Dial bore indicator :
Range 18-34 mm, Least count = 0.01 mm.
- b) Dial Indicator :
Range 0-10 mm, Least count = 0.01 mm.

Theory and description:

Dial bore indicator consists of measuring head and guide is attached with extension rod & collars for specific dimension chosen from the table in the instrument box, holder is assembled to the measuring head and dial indicator is fixed inside the holder during tightening. The condition is initially 1 kgf is applied to the dial indicator for getting exact reading.

Principle:

Dial bore indicator is works on comparator principle.



Procedure:

1. Once approximate bore is finding out by using inside micrometer.
2. Chose the same little more size extension rod & collar if necessary select and fit.
3. Keep the dial bore indicator into the specimen bore.

Tabular form:

S.NO.	Length of extension	Dial gauge reading	Total reading + spacing collar

Precautions:

- a) Thimble should be turned with ratchet only and to have standard condition and to prevent excess deformation of work piece.
- b) Only after checking the reading with inside micrometer, then use the dial bore gauge.
- c) The specimen measured surface should be smooth.
- d) See the reading without parallax error.
- e) Initially set the bezel of dial gauge to zero.

Result:

Inside diameter of given bore is ----- mm.

10. Measurement of inside diameter by Inside micrometer and depth of hole or recess of by Depth micrometer

Aim:

To measure bores of a given specimen by using Inside Micrometer and depth of hole or recess by depth micrometer.

Apparatus:

1. Inside micrometer.
2. Depth micrometers
3. Hollow cylinders.

Specification:

1. Inside micrometer: range 5-30 mm, Least count = 0.01 mm.

Theory and description:

A) Inside Micrometer :

This micrometer calliper has 'U' shape frame and spindle. The measuring tips are constituted by the jaws with contact surfaces which are hardened and ground to a radius. One of the Jaws is held stationary at the end and second one moves by the movement of thimble. A lock nut is provided to arrest the moment of movable right jaw.

Principle: Inside micrometer work on screw and nut principle.

Procedure:

1. Keep the inside micrometer Jaws in the work piece.
2. When two anvils touch the sides of bore, apply pressure with ratchet.
3. See the reading & note down.

Tabular form:

S.NO.	MSR	VC	TR

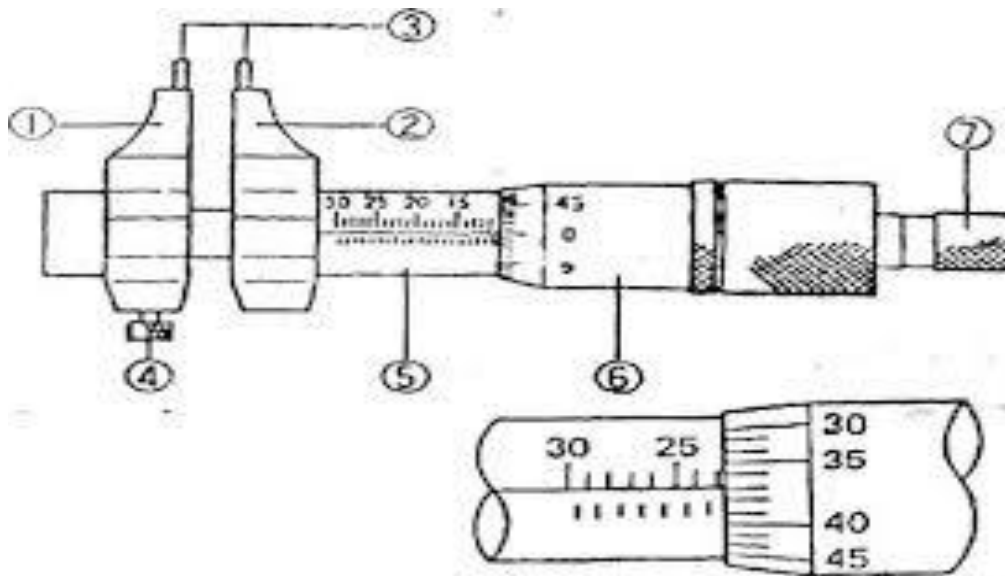
LC = Least Count

SR = Sleeve Reading

CR = Circular Scale Reading

TR = Total Reading = SR + CSR X L.C

Schematic diagram:



- | | |
|-------------------|-----------------|
| (1) Left jaw | Sleeve 22.5mm |
| (2) Right jaw | Thimble 37mm |
| (3) Contact point | Reading 22.87mm |
| (4) Clamping knob | |
| (5) Sleeve | |
| (6) Thimble | |
| (7) Ratchet stop | |

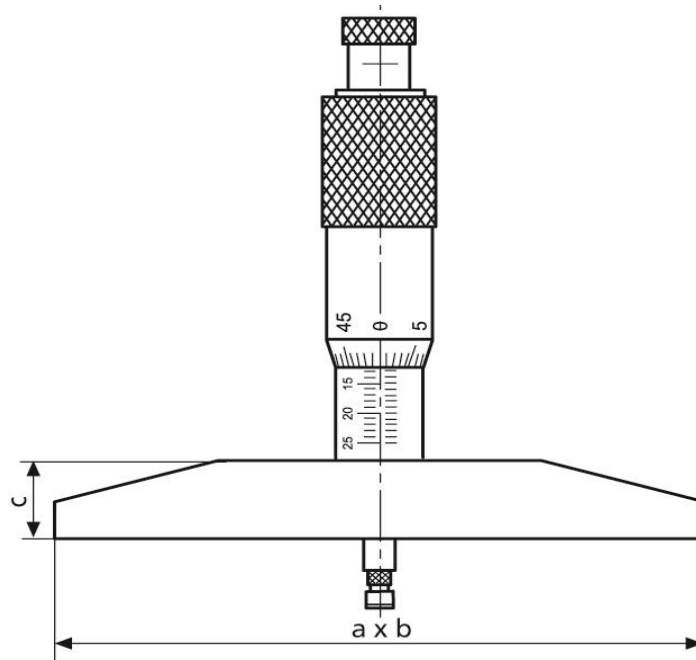
B) Depth micrometer:

Depth micrometer as the name indicates is used for measuring the depth of blind holes, slots and recesses. It has a shoulder which acts as a reference surface. The shoulder is held firmly and perpendicular to the center line of the hole. Extension rods or spindles in steps of 25mm may be used for longer range of measurement. The extension rod can easily be inserted by removing the thimble. The extension rods are marked with their respective capacity and are square with the base in any position. The measuring faces of the base and rods are hardened. IT should be noted that the scale of depth micrometer is calibrated in the reverse direction.

Procedure:

1. The appropriate length of extension rod is selected for required measurement.
2. The instrument should be checked for zero error before use.
3. The shoulder of the micrometer is placed on the measuring surface of hole.
4. The spindle is moved by rotating the ratchet until (the spindle touches the end of the hole) it gives sound.
5. Reading is taken on the main scale taking into account the division Above the Reference Line.
6. The thimble reading that coincides with the reference line on the sleeve is taken.
7. The total reading is calculated by using formula.

Schematic diagram:



Observations:

Total reading or depth of cylinder = M.S.R + L.C X V.C

MSR= Main scale reading

LC = Least count of the instrument.

VC = Vernier coincidence

Tabular column:

S.NO.	Basic length of the extension rod	M.S.R	V.C	Total Reading= M.S.R+L.CXV.C- Basic length

Precautions:

1. Micrometer should be cleaned by wiping of oil, dirt, dust, and grit.

2. The measuring faces of the anvil and spindle should be cleaned by clean piece of paper or cloth.
3. The zero reading on the instrument should be measured before measuring.
4. While measuring the circular objects, the micrometer must be moved carefully over the representative are so as not maximum dimension.

Result:

The depth of the given cylinder is measured with an accuracy of 0.01mm.