G.S. Mandal's
MAHARASHTRA INSTITUTE OF TECHNOLOGY, AURANGABAD
DEPARTMENT OF MECHANICAL ENGINEERING

NAME OF LABORATORY : METROLOGY & MECHANICAL MEASUREMENT		
LABORATORY MANUAL		
CLASS: SECOND YEAR	**PART:** I / ~~II~~	**COURSE CODE :**MED 223
NAME OF COURSE : METROLOGY AND QUALITY CONTROL		

INDEX

PREPARED BY: Er. P. T. Borlepwar	APPROVED BY: Dr., A. J. Keche (HMED)

Vision of the Institute: MIT aspires to be a leader in Techno-Managerial education at national level by developing students as technologically superior and ethically strong multidimensional personalities with a global mindset.

Mission of the Institute: We are committed to provide wholesome education in Technology and Management to enable aspiring students to utilize their fullest potential and become professionally competent and ethically strong by providing,

- Well qualified, experienced and Professionally trained faculty
- State-of-the-art infrastructural facilities and learning environment
- Conducive environment for research and development.
- Delight to all stakeholders.

Vision of Department: To be a center of excellence in the field of Mechanical Engineering where the best of teaching, learning and research synergize and serve the society through innovation and excellence in teaching.

Mission of Department: To provide world-class under-graduate and graduate education in Mechanical Engineering by imparting quality techno-managerial education and training to meet current and emerging needs of the industry and society at large.

Program Educational Objectives:

PEO-1: Graduates will apply the tools and skills acquired during their undergraduate studies either in advanced studies or as employees in engineering industries

PEO-2: Graduates of the program will have successful technical and professional career.

PEO-3: Graduates of the program will continue to learn to adopt constantly evolving technology.

PEO-4: Graduates will demonstrate sensitivity towards societal issues.

Program Outcomes

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

2. **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. **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. **Conduct investigations of complex problems:** Use research-based knowledge and search methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **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. **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. **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. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **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. **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. **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

PSO-I: Ability to design & analyse components & systems for mechanical performance

PSO-II: Ability to apply and solve the problems of heat power and thermal systems.

PSO-III: Ability to solve real life problems with the exposure to manufacturing industries

Course Objectives:

1) Selection of tool and techniques for determining geometry and dimensions.

2) Design and calibration of measuring tools and equipment's.

3) Application of Quality Control Techniques.

4) Application of Quality Management Concept.

Course Outcomes:

1. Recall the principles of engineering metrology, measurement standard and instruments
2. Explain quality control techniques and its applications in engineering industries.

3. Apply knowledge of various tools and techniques used to determine geometry and dimensions of components in engineering applications and use quality tools to produce quality products.
4. Analyze the data of measurement for understanding the concept of quality and SQC.
5. Examine the deviation and surface finish of the measured parts with measuring tools.
6. Discuss the principles of SQC, quality tools and acceptance sampling.

NAME OF LABORATORY : METROLOGY & MECHANICAL MEASUREMENT		
LABORATORY MANUAL		
CLASS: SECOND YEAR	**PART:** I / ~~II~~	**COURSE CODE :**MED 223
NAME OF COURSE : METROLOGY AND QUALITY CONTROL		

Dr. Babasaheb Ambedkar Marathwada University, Aurangabad
(Faculty of Science & Technology)
Syllabus of S. Y. B. Tech. (Mechanical Engineering) Semester-III

Course Code: MED223	Credits: 0-1-0
Course: Laboratory of Metrology & Quality Control	Term Work: 0 Marks
Teaching Scheme:	Practical: 25 Marks
Practical: 2 Hrs/week	

Objectives	:	1) Selection of tool and techniques for determining geometry and dimensions. 2) Design and calibration of measuring tools and equipment's. 3) Application of Quality Control Techniques. 4) Application of Quality Management Concept.
List of Practical	:	1. Determination of linear and angular dimensions of given composite part using precision/non precision measuring instruments. 2. Error determination with linear / angular measuring instruments. 3. Verification of dimensions & geometry of given components using Mechanical & Pneumatic comparator. 4. Identification of surfaces using optical flat/interferometers and measure surface roughness using surface roughness tester. 5. Determination of geometry & dimensions of given composite object using profile projector. 6. Measurement of various angles of single point cutting tool using tool maker's microscope. 7. Measurement of thread parameters using floating carriage diameter measuring machine. 8. Measurement of spur gear parameters using Gear Tooth Vernier, Span, Gear Rolling Tester. 9. Determination of given geometry using coordinate measuring machine (CMM) 10. Determination of process capability from given components and plot variable control chart / attribute chart.

The assessment of term work shall be done on the basis of the following.

- Continuous assessment
- Performing the experiments in the laboratory
- Oral examination conducted on the syllabus and term work mentioned above.

Lab Instructions

DOs

1. Conduct yourself in a responsible manner at all times in the laboratory
2. Observe good housekeeping practices.
3. Replace the materials in proper place after work to keep the lab area tidy.
4. Before starting Laboratory work follow all written and verbal instructions carefully
5. Before use equipment must be read carefully Labels and instructions. Set up and use the equipment as directed by your teacher.
6. If you do not understand how to use a piece of equipment, ASK THE TEACHER FOR HELP!
7. Students are not allowed to work in Laboratory alone or without presence of the teacher
8. Any failure / break-down of equipment must be reported to the teacher

DON'Ts

1. Don't talk aloud or crack jokes in lab
2. Do not wander around the room, distract other students, startle other students or interfere with the laboratory experiments of others
3. Students are not allowed to touch any equipment, other materials in the laboratory area until you are instructed by Teacher or Technician

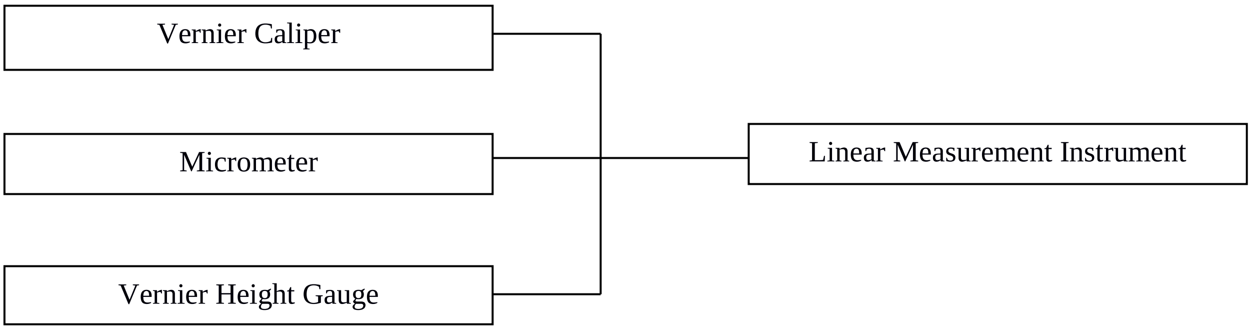
EXPERIMENT NO. 1

AIM: Study and demonstration of measuring instrument of linear measurement and angular measurement.

To measure the dimensions of a given component using Vernier caliper, Micrometer and Bevel protractor.

INTRODUCTION: These are the linear precision measuring instruments used for linear measurement in the workshop as well as standard room.

CONCEPT STRUCTURE:



VERNIER CALIPER

CONSTRUCTION:

- The Vernier caliper consists of two scales, one is fixed and other is movable.
- The fixed scale, called main scale is calibrated on L-shaped frame and carries a fixed jaw.
- The movable scale called Vernier scale slides over the main scale and carries a movable jaw.
- The movable jaw as well as the fixed jaw carries measuring tip.
- When the two jaw lock the sliding scale on the fixed main scales is closed the zero of the Vernier scale coincides with the zero of the main scale.
- For precise setting of the movable jaw an adjustment screw provided.
- Also an arrangement is provided to lock the sliding scale on the fixed main scale.
- Detail schematic diagram shown in Fig. 1.1

VERNIER PRINCIPLE:

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 measurements.

LEAST COUNT OF VERNIER CALLIPER:

- Vernier instrument have two scale, main scale and Vernier scale. Vernier scale slides on the main scale.
- When zero on the main scale coincides with the zero on the Vernier scale.
- The Vernier scale has one more division than that of the main scale with which it coincides.
- The value of a division on Vernier scale is slightly smaller than the value of a division on the main scale.
- The difference is the least count.

$$L.C. of\ vernier\ Instrument = The\ value\ of\ smallest\ division\ on\ the\ main\ scale - the\ value\ of\ the\ smallest\ division\ on\ the\ vernier\ scale.$$

- The value of smallest division on the main scale is 1.
- Vernier scale 50 division coincides with 49 division of main scale. So smallest division of Vernier scale is = 49/50mm.
- $\boldsymbol{L.C. = 1 - \frac{49}{50} = 0.02mm}$
- Also the least count can be calculated by the ratio of the value of minimum division on the main scale to the number of divisions on the Vernier scale. So least count is. $\boldsymbol{L.C. = \frac{1}{50} = 0.02mm.}$

READING:

- Read the position of the Vernier zero mark on the main scale reading to the nearest division on the low side.
- Look along the Vernier for a coincidence between graduations on the Vernier and the main scale. This number multiplied by the Vernier constant give the fraction to be added to the main scale reading.

$$Total\ Reading = Main\ scale\ reading + The\ number\ of\ the\ division\ which\ exactly\ coincides\ with\ a\ division\ on\ main\ scale \times L.C.$$

USES:

- Both used for internal and external measurement up to accuracy of 0.02 mm

Depth measurement. Etc.

MICROMETER

CONSTRUCTION OF OUTSIDE MICROMETER:

- It is used to measure the outside diameter, thickness and length of small parts to an accuracy of 0.01 mm.
- The main parts of micrometer are: Fig. 1.2

1. U shape steel frame
2. Anvil & Spindle
3. Lock Nut
4. Sleeve or Barrel
5. Thimble
6. Ratchet

1. **U shape Steel Frame:** outside micrometer has U shape or C shape frame; it holds all micrometer parts together. Gap of frame permits to maximum diameter or length of the job to be measured.

   Material: steel, cast steel, malleable C.I (white iron) or Light alloy.

2. **Anvil & Spindle:** on the left side of frame the anvil is fixed. The diameter of anvil is same as spindle. The anvil is accurately ground and lapped with its measuring faces flat and parallel to the spindle.

   Material: Hardened Steel or tungsten carbide.

   Spindle is the movable measuring face. The spindle engages with the nut. It should run freely and smoothly throughout the length of it travel.

3. **Lock Nut:** The knurled part (or lever) that one can tighten to hold the spindle stationary, such as when momentarily holding a measurement.

4. **Sleeve or Barrel:** the sleeve is accurately divided and clearly marked in 0.5mm division along its length which serves as a main scale. It chrome plated and adjustable for zero setting.

5. **Thimble:** the thimble can be moved over the barrel. It has 50 equal divisions around its circumference. Each division having a value of 0.01mm.

6. **Ratchet:** the ratchet is providing at the end of the thimble. It is used to insure accurate measurement, and to prevent too much pressure applied to the micrometer, when the both surface of spindle is tighten the ratchets automatically slip at correct pressure.

Micrometer available in measuring ranges: 0.25mm, 25to50mm, 125to150mm, 575 to 600mm etc.

PRINCIPLE OF MICROMETER:

- Micrometer work on the principle of screw and nut.
- When the screw is turned through the nut by one revolution, it advances by the pitch distance. i.e. one rotation of screw corresponds to a linear movement of a distance equal to pitch of the thread.
- Circumference of the screw is divided into number of equal parts say "n" so minimum length can be measured by such arrangement. (pitch/n)

LEAST COUNT:

- Pitch of the micrometer screw is 0.5.
- The circumference of screw or thimble graduated in 50 divisions to direct reading.

$$\boldsymbol{L.C. of\ Micrometer = \frac{Pitch\ of\ the\ spindle\ screw}{Number\ of\ division\ on\ the\ spindle} = \frac{0.5}{50} = 0.01mm}$$

READING:

- Select the micrometer with a desired range depending upon the size of work-piece.
- Check it's for zero error.
- In case of 0-25mm micrometer error checked by contacting of spindle and anvil faces.
- More than range 25-50mm or 125 to 150mm the zero error checked by placing of master gauge.

- Hold the work-piece between the faces of the anvil and spindle and then move the spindle by rotating the thimble until the anvil and spindle touches the work surfaces.
- Make the fine adjustment with the ratchet.
- Now take the reading on the main scale taken into account the divisions below the reference line.
- Take the thimble reading which coincides with the reference line on the sleeve.

$$\boldsymbol{Total\ reading = Main\ scale\ reading + L.C. \times Reading\ on\ the\ thimble}$$

Classification of Micrometer:

a. Outside micrometer
b. Inside micrometer
c. Screw thread micrometer
d. Depth gauge micrometer

OBSERVATION TABLE :

VERNIER CALLIPER:

Sr. No.	Main Scale Reading (mm)	Vernier Scale Reading (mm)	L.C.	Total Reading	Average Reading

MICROMETER:

Sr. No.	Main Scale Reading (mm)	Reading on Thimble (mm)	L.C.	Total Reading	Average Reading

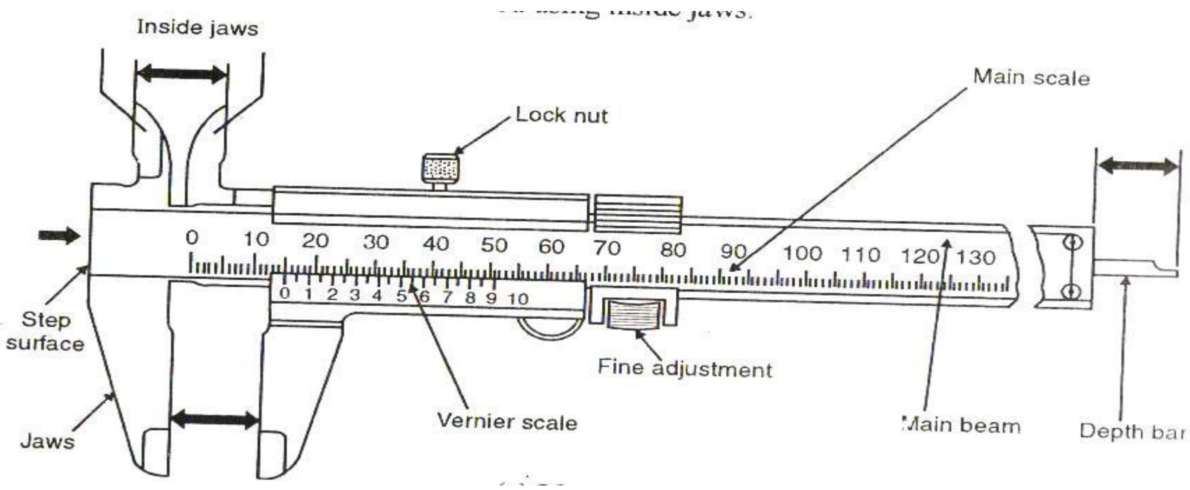


Fig. 1.1 Vernier Calliper

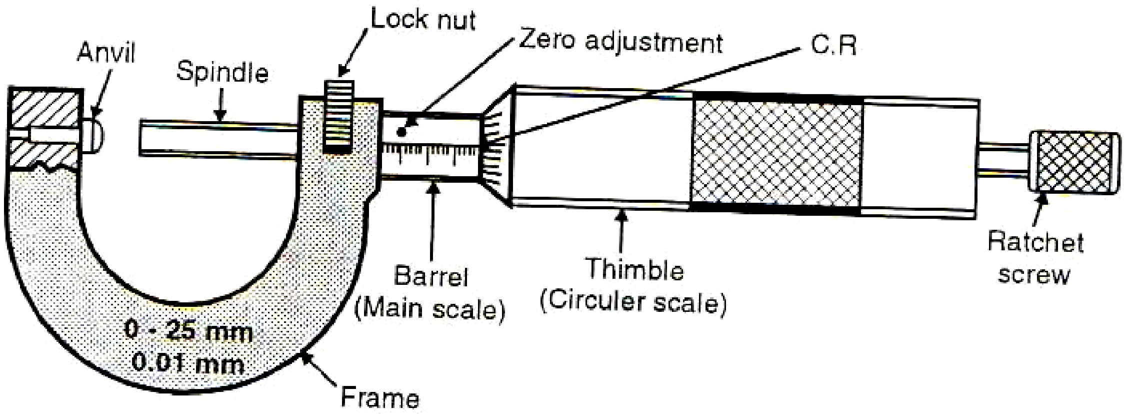


Fig. 1.2 Micrometer

READING OF VERNIER BEVEL PROTRACTOR: (Fig. 1.4)

Zero on the Vernier scale has moved 28 whole degrees to the right of the 0 on the main scale and the 3th line on the Vernier scale coincides with a line upon the main scale as indicated. Multiplying 3 by 5, the product, 15, is the number of minutes to be added to the whole number of degrees, thus indicating a setting of 28 degrees and 15 minutes.

USES OF VERNIER BEVEL PROTRACTOR: (Fig. 1.5)

- Inside beveled face of a ground surface
- For checking v blocks
- For measuring acute angle etc.

READING OF VERNIER BEVEL PROTRACTOR: (Fig. 1.4)

Zero on the vernier scale has moved 28 whole degrees to the right of the 0 on the main scale and the 3th line on the vernier scale coincides with a line upon the main scale as indicated. Multiplying 3 by 5, the product, 15, is the number of minutes to be added to the whole number of degrees, thus indicating a setting of 28 degrees and 15 minutes.

USES OF VERNIER BEVEL PROTRACTOR: (Fig. 1.5)

- Inside beveled face of a ground surface
- For checking v blocks
- For measuring acute angle etc.

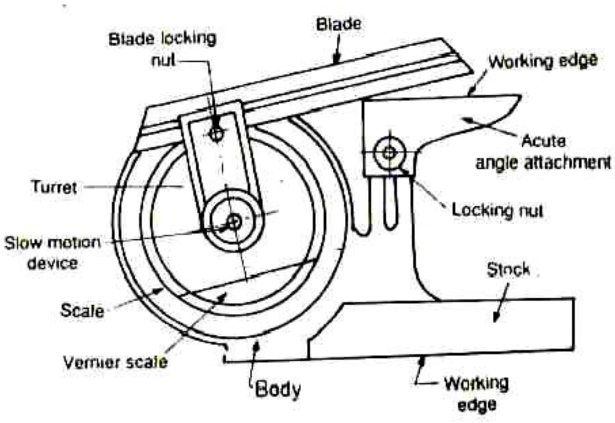


Fig. 1.3 Vernier Bevel Protractor **Fig. 1.4 Reading of Vernier Bevel Protractor**

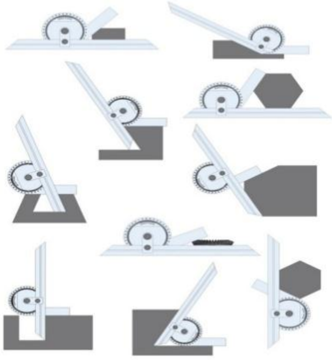


Fig. 1.5 Uses of Vernier Bevel Protractor

OBSERVATION TABLE:

VERNIER BEVEL PROTRACTOR:

Sr. No.	Main Scale Reading	Vernier Scale Reading	L.C.	Total Reading	Average Reading

Fig. 1.6 Bore Gauge

Sr. No.	Reading on dial Gauge	Diameter Measured	Remarks
1			
2			

Conclusion: We can measure the linear, angular and internal circular diameter using Vernier caliper, micrometer and bore gauge.

EXPERIMENT NO. 2

AIM: To determine error in measuring instrument of linear measurement and angular measurement.

To measure the dimensions of a given component using Vernier caliper, Micrometer, Bevel protractor and determine error in measurement.

Using the specimen given, the linear and angular measurements are to be carried out in the observation table of appropriate instrument shown below. After the actual measurements are taken, the error in the measurements is to be determined.

OBSERVATION TABLE :

VERNIER CALLIPER:

Sr. No.	Main Scale Reading (mm)	Vernier Scale Reading	L.C.	Total Reading	Average Reading	Error (Actual – Average)

MICROMETER:

Sr. No.	Main Scale Reading (mm)	Micrometer Scale	L.C.	Total Reading	Average Reading	Error (Actual –

VERNIER BEVEL PROTRACTOR:

Sr. No.	Main Scale Reading (mm)	Vernier Scale Reading	L.C.	Total Reading	Average Reading	Error (Actual – Average)

CONCLUSION:

From the observation table of each instrument, the percentage error can be calculated individually for each instrument.

Percent error for Vernier = error * 100 / Actual Length.

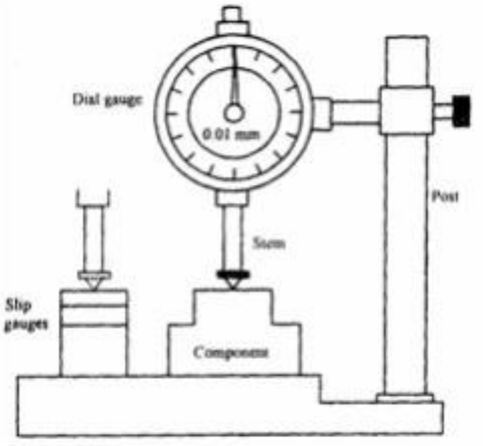
Percent error for Micrometer = error * 100 / Actual Length.

Percent error for Vernier Bevel Protractor = error * 100 / Actual Angle.

EXPERIMENT NO. 3

AIM: To compare the dimensions of given specimens with appropriate standards using mechanical and pneumatic comparators.

1.Dial indicator
2.Dial mounting stand with fine adjustments
3.Electrical comparator with probe and work table
4.Pneumatic comparator with measuring gauges
5.Vernier caliper
6.Micrometer



TO FIND:
1.Average size of the component.
2.To plot the graph of variations.
3.To determine the variation with respect to given tolerance value.
4.To segregate the component under heading oversize, undersize and correct size.

PROCEDURE: FOR USING MECHANICAL COMPARATOR:
1.First measure the dimension of given specimen using micro meter/Vernier caliper.
2.Select the appropriate standard/buildup the slip gauges to required height and place it below the plunger.
3.Set the reading of the dial indicator to zero. Thus the standard dimension is set on the dial indicator.

4.The standard component/pile of slip gauges is removed and the given specimen is introduced below plunger in place of the standard. Take the reading of the dial indicator at different point on the surface of the specimen. Then the average of all deviations is calculated and the correct size of the specimen is determined.

USE OF PNEUMATIC COMPATOR;

1.Before measurement make certain that the compressed air is passed through the system and freely escapes from the gauge head nozzles.

2.Use masterpiece and zero adjuster set the tolerance limits and initial reference reading in the indicator.

3.Now the standard gauge is introduced in the bore of the component to be compared and the reading are tabulated.

Conclusion: Hence we have studied functioning and use of mechanical and pneumatic comparator.

Questions

Q.1 what is comparator?

Q.2 what is the use of comparator?

Q.3 State & Explain the types of comparators.

Experiment No : 4
A. Interferometry Applied to Flatness Testing

AIM: Study of surface flatness using optical flat interferometer

INTRODUCTION: Optical flats are special pieces of glass that can be used to measure flatness of a surface. They are optical-grade glass polished to be extremely flat, usually to within 25 nanometers. When placed over surface to be tested, dark and white bands can be seen, indicating the contours of the surface.

THEORY:

Optical flats rely on a monochromatic light source which provides light of a single wavelength or color. The essential equipment for measurement by light wave interference is a monochromatic light source and a set of optical flats. If an optical flat is placed upon another flat reflecting surface (without pressure) it will not form an intimate contact, but will lie at some angle 0 making an inclined plane. If the optical flat be now illuminated by monochromatic source of light, the eye if placed in proper position, will observe a number of bands. These are produced by the interference of the light rays reflected from the lower surface of the top flat and the top surface of the lower flat through the very thin layer of air between the flats.

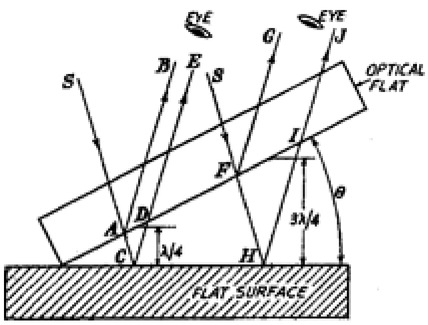


Fig : 4.1

As shown in figure S is the source of monochromatic light. At point A, the wave of incident beam from S is partially reflected along AB and is partially transmitted across the air gap along AC. At C, again the ray is reflected along CD and passes out towards the eye along CDE. Thus the two reflected components, reflected at A and C are collected and recombined by the eye, having travelled paths whose lengths differ by an amount ACD.

If the path lengths of the two components differ by an odd number of half wavelengths, then condition for complete interference is achieved. If the surface is perfectly flat, then condition of complete interference is satisfied in a straight line across the surface as the surface at right-angles to the plane of the paper is parallel to the optical flat. Therefore, a straight dark line will be seen passing through point C. Thus, in case of a perfectly flat surface, we will have pattern of alternate light and dark straight lines on the surface. When surface is not flat we will have other than straight lines patterns for example when the surface is spherical then we get fringe pattern with concentric circles.

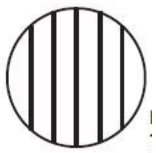


Fig 4.2 : Fringe pattern for flat surface

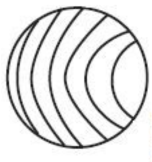


Fig 4.3 : Fringe pattern for not flat surface

CONCLUSION: Hence we have studied about surface flatness using optical flat for different surfaces.

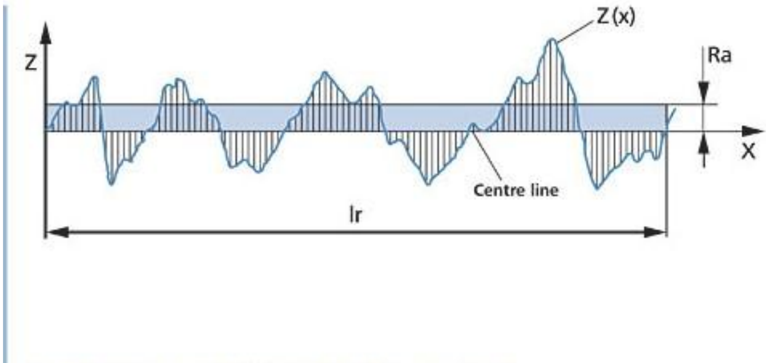
B. Study of Surface Finish Measuring Instrument.

AIM: Study and demonstration of surface finish measuring instrument.

INTRODUCTION: Surface roughness is an important parameter in order to decide whether a surface is suitable for a certain applications or not. Rough surfaces often wear out more quickly than smoother surfaces. Rougher surfaces are normally more vulnerable to corrosion and cracks, but they can also aid in adhesion. A roughness tester is used to quickly and accurately determine the surface texture or surface roughness of a material. A roughness tester shows the measured roughness depth (Rz) as well as the mean roughness value (Ra) in micrometers or microns (µm).

THEORY:

The irregularities on the surface are in the form of succession of hills and valleys varying in height and spacing. These irregularities are termed as surface roughness, surface finish, surface texture or surface quality. 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 R_a (roughness average).



Ra – arithmetical mean deviation of the assessed profile

Arithmetic mean deviation of the Profile, R_a:

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

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

R_q is the square root of the arithmetic mean of the squares of profile deviations (Yi) from the mean line.

SURF TEST SJ-201

The surftest - 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 :

The Surftest SJ-201P is a shop-floor type surface-roughness measuring instrument, which traces the surfaces of various machine parts, calculates their surface roughness based on roughness standards, and displays the results

A "stylus" is attached to the detector unit of the SJ-201P will trace the minute irregularities of the workpiece surface. The vertical stylus displacement during the trace is processed and digitally displayed on the liquid crystal display of the SJ-201P.

Procedure/Working:

1. The detector stylus traces the workpiece surface (measurement surface) .
2. The vertical stylus displacement produced during tracing the workpiece surface is converted into electrical signals.
3. The electrical signals are subject to various calculation processes inside the SJ 201P.
4. The calculation results (measurement results) are displayed on the LCD. It is in the form of average roughness value Ra.
5. Measurement result can be saved and later printed with the help of a printer.
6. First check accuracy of inst rument by checking roughness of standard specimen supplied with the SJ 201P.
7. Take 3-4 readings using different test surfaces and different values of sampling lengths.

CONCLUSION:

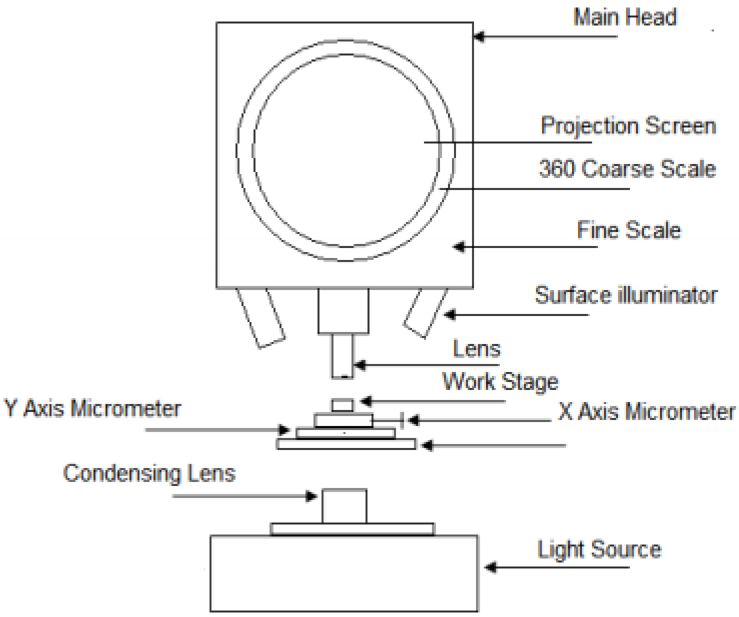
Thus we have studied surface roughness measurement using electronic surface roughness tester (i .e. SJ 201P)

Experiment 5

AIM: To determine the diameters of the holes and the angle of bevel edge of the given specimen using profile projector.

APPARATUS: Profile projector.

THEORY:



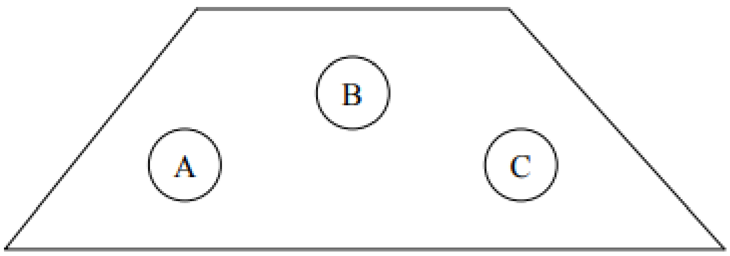
PROFILE PROJECTOR

Profile projector is a device which displays the magnified image of the object on an appropriate viewing screen. The magnified image serves as an aid to more precise determination of dimension, form etc. The objects like screws, gears used in wrist watches and small templates having holes, bevel edges will not lend themselves to carryout measurements using instruments like Vernier Calipers and micrometers. Measurements of dimensions on such small objects can be accomplished using profile projector.

The profile projector consists of a glass table the object to be projects is to be placed on the glass table either directly or with the help of a suitable fixture depending upon the type of job. The table is equipped with two micrometers. With the help of micrometers the movement of the glass table in turn image can be precisely registered. Below the glass table a light source and condensing or collimating lens system exists. It also consists of a screen where the image of the work piece is projected with the help of mirrors and lenses. The optical system of the profile projector is shown in the figure.

PROCEDURE:

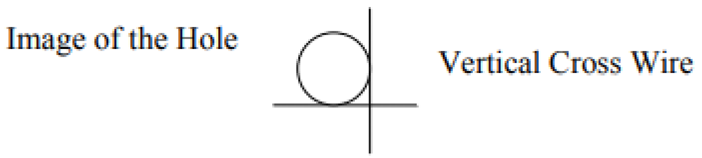
The specimen along with the features to be measured is shown in the figure.



The task is to determine the diameters of the holes A, B, C and to determine angles of beveled edges θ1 and θ2

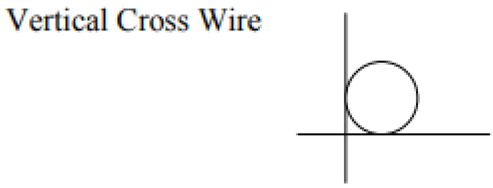
To determine the diameters of the holes following steps may be followed.

1. Keep the specimen on the glass table and switch on the bulb
2. Adjust the height of the table until; a sharp image of contour of the specimen appears on the screen.
3. Now arrange the image of the hole tangential to one of the cross lines as shown in the figure image of the hole.



4. The above arrangement is to determine the diameter of the hole in x-direction.

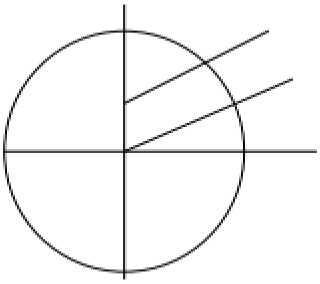
5. In this position note down the reading of the micrometer.
6. Rotate the micrometer thimble until same Vertical cross line occupies diametrically opposite point as shown below.



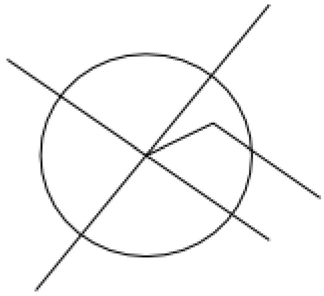
7. In this position again note down the reading of micrometer.
8. Difference of the readings in the steps (7) and (5) gives the diameter of the hole in x – direction.
9. To determine the diameter of the hole in y – direction horizontal cross line may be made tangential to the image of the hole.
10. Repeat the above procedure for other holes also.

To determine the angles of the beveled edges following steps may be followed:

1. First get the sharp images of the specimen.
2. Coincide one of the lines of cross line with one side of the bevel edge image as shown in the figure. In this position note down the reading of the protractor.



3. Rotate screen in such a way that same line coincides with other side of the beveled edge, as shown in the figure. In this position again note down the reading of the protractor.



4. Difference of the readings of the protractor in steps (2) and (3) gives the angle of the beveled edge.
5. Same procedure may be implemented for other beveled edge to get the angle.

OBSERVATIONS: Determination Diameters of Holes:

X – Direction

S.No.	Initial Reading R_1= M.S.R.+L.C x T.R	Final Leading R_2 = M.S.R. + L.C x T.R	Dia of the hole R_1-R_2
1			
2			
3			

Y – Direction

S.No.	Initial Reading R_1= M.S.R.+L.C x T.R	Final Leading R_2 = M.S.R. + L.C x T.R	Dia of the hole R_1-R_2
1			
2			
3			

Average

Determination of Angles of Bevel Edge:

Sl No.	Initial Reading θ_1	Final Reading θ_2	θ_1- θ_2

PRECAUTIONS:
1. Students are advised to take readings without any parallax error.
2. For each feature at least two readings must be taken and average is to be presented.
3. Table must be properly adjusted to get a sharp image.

RESULT:

Feature	X-Direction	Y-Direction
Diameter of the hole A		
Diameter of the hole B		
Diameter of the hole C		

Angle of the Beveled Edge 1 θ_1 =

Beveled Edge 2θ_2 =

Conclusion: Hence, we have studied the construction and working of Profile Projector

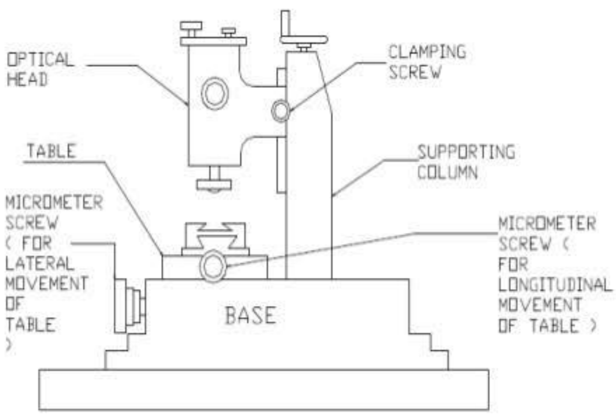
Experiment No 6

Aim: Measurement of various angle of single point cutting tool using Tool maker's microscope.

Instruments used: Tool maker's microscope, measuring work piece (Single point cutting tool).

Theory:

- The 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 foot screws by means of which the equipment can be leveled with reference to the built-in spirit 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. The slides run on precision balls in hardened guide ways warranting reliable travel.



❑ Tool Maker's Microscope

Fig. 6.1 Tool maker's microscope

- The rotary table has been provided with 360 degrees graduation and with a 60 minute vernier. The rotary motion is initiated by activation of knurled knob. Slots in the rotary table serve for fastening different accessories and completing elements. The sighting microscope has been fastened to column with a carrier arm. The carrier arm can be adjusted in height by means of a rack. The main lighting unit has been arranged in the rear of the cast base and equipped with projection lamp where rays are directed via stationary mounted mirror through table glass plate into the sighting microscope.

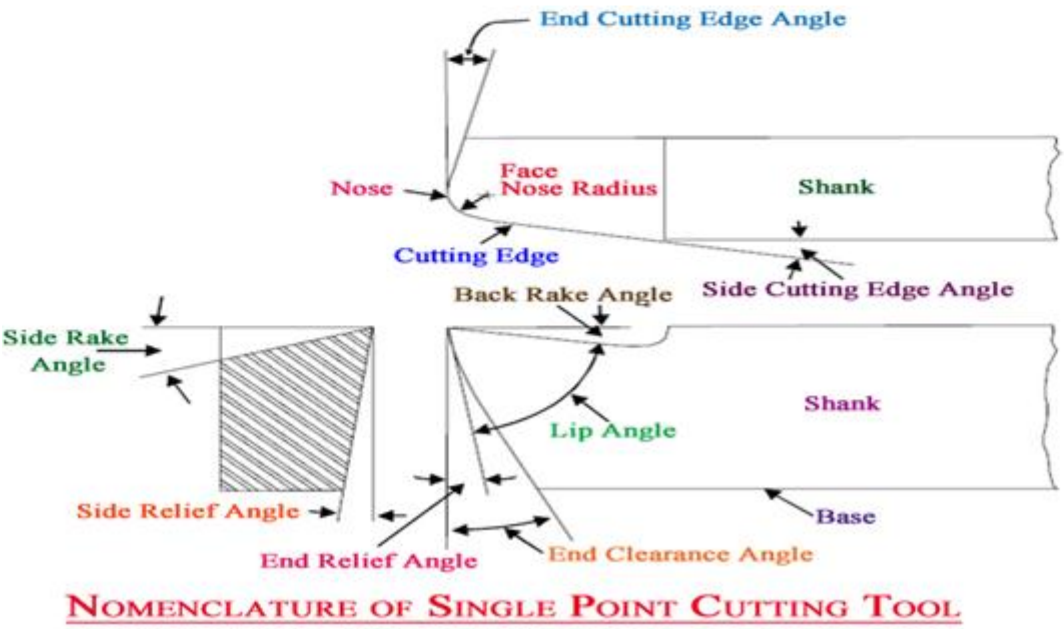


Fig.6.2 Single point cutting tool

Measuring principle:

- Tool Maker's Microscope is a precision Optical Microscope that consists of single or multiple objective lenses, which magnifies the object under observation and by the help of eyepiece lens the object is focused and viewed. A high precision micrometric X-Y stage and the Z axis travel are used to measure the three dimensions [Length (X), Width (Y), and Depth (Z)]. The angle is measured with the help of a rotating stage and eyepiece graduation.

Applications:

- The tool maker's microscope is an essential part of engineering inspection, measurement and calibration in metrology labs. Hence is used to the following,
- Examination of form tools, plate and template gauges annular grooved and threaded hobs etc.
- Elements of external thread forms of screw plug gauges, taps, worms and similar components.

Procedure:

- Switch on the projection lamp. Get familiar with the least count, linear and angular readings of the tool maker's microscope and nomenclature of the thread. Place the given specimen on the glass table plate. Viewing through the eyepiece, rotate the knob for moving carrier arm on column to get the sharp image of the specimen kept on the glass plate. Position the specimen such that the table movement in the X direction is parallel to the direction of the pitch measurement.
- This is checked by ensuring the crosswire touching the adjacent sides of single point cutting tool during table movement.

To measure the angles:

To measure the angles of single point cutting tool match the cross wire with side of cutting tool between which angle need to measure.

- Observe the reading and find the value of unknown angle directly on engraved scale.
- **Observations:-**
- Side cutting edge angle=
- End cutting edge angle=
- Back rack angle=
- End relief angle=

Conclusion:- Hence we have measured the various angle of single point cutting tool

NAME OF LABORATORY : METROLOGY & MECHANICAL MEASUREMENT		
LABORATORY MANUAL		
CLASS: SECOND YEAR	**PART:** I / ~~II~~	**COURSE CODE :**MED 223
NAME OF COURSE : METROLOGY AND QUALITY CONTROL		

Experiment No: 7

Aim: - Measurement of thread parameters using a floating carriage diameter measuring machine.

Objective: - Selection of tools and techniques for determining dimensions.

Apparatus/Equipment: - Floating Carriage Diameter Measuring Machine, Thread measuring wires, Prisms, Sample thread, fiducial indicator.

Theory: - Floating Carriage Micrometer 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. Floating Carriage Micrometer is used for measuring Major, Minor and Effective diameter. The instrument has an 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 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 interchangeability and strength. Periodic measurement of the pitch diameter is recommended to determine whether a thread gage is worn below tolerance. 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.

Schematic diagram

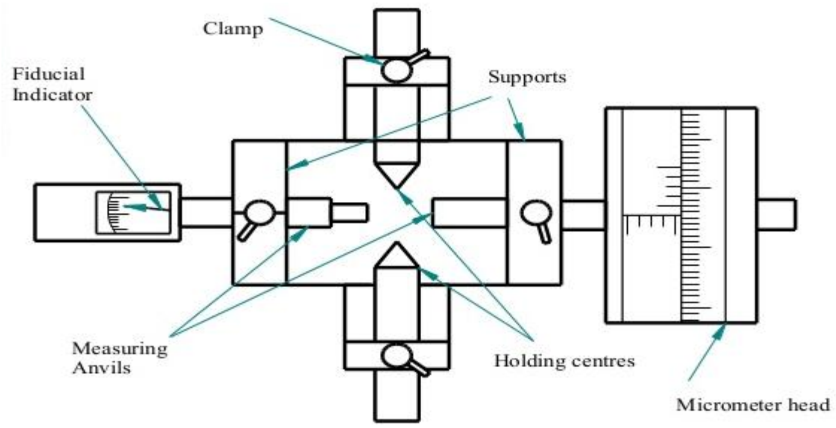
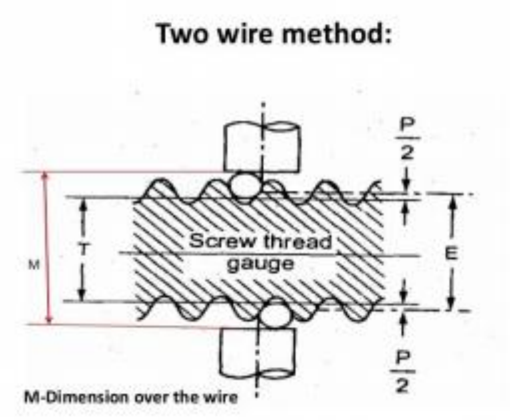
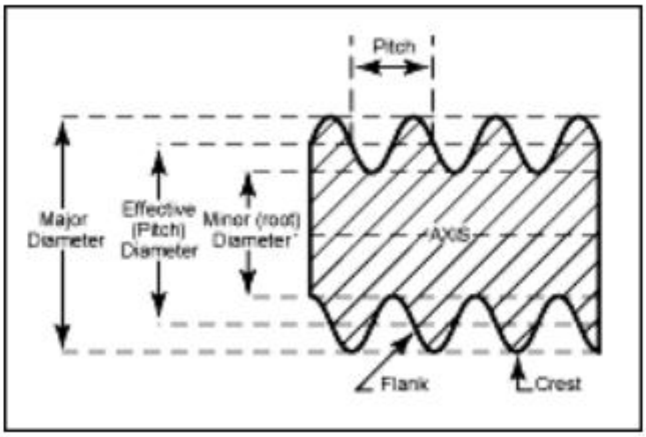


Fig.7.1 - Floating Carriage Micrometer





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.

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 workpiece 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 workpiece and second reading is taken. The major diameter of the given specimen can be determined using the expression. $F = D \pm (R \sim R1)$ where,

F = Major diameter.

D = Diameter of the cylindrical standard used.

± = is determined by the relative size of the standard workpiece.

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 (Rs) of micrometer is noted.

Then the standard is replaced by the workpiece along with the wires introduced in the thread form as shown in fig. The second reading (Rw) of the micrometer is noted. The effective diameter can be determined using the relation,

$E = D \pm [(Rs - P) \sim Rw]$

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, $P = [(0.86602 * p) - d]$ for 60 degree metric and unified threads where, p = pitch of the threaded component. d = mean diameter of the wires used.

Procedure:

1. The reading is taken on the diameter over the standard with cylinders/prisms in position depending upon the thread element to be measured.
2. The standard is then replaced by the workpiece and the measurements are taken.
3. The instrument is first to present using a suitable cylindrical standard and the reading (R) of the micrometer is noted. The standard is then replaced by the workpiece and second reading is taken.
4. The major diameter of the given specimen can be determined using the expression.
   F = D ± (R~R1) where,

   F = Major diameter.

   D = Diameter of the cylindrical standard used.

   ± = is determined by the relative size of the standard workpiece.

5. Measurement of Effective diameter: 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.
6. The instrument is first present over a suitable cylindrical standard and selected thread measuring wires. The reading (Rs) of the micrometer is noted.
7. Then the standard is replaced by the workpiece 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 = Effective diameter.

   D = Diameter of the standard cylinder.

P is a constant which is dependent on the diameter of cylinders and the form of thread to be measured.

8. 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] for 60-degree metric and unified threads where p = pitch of the threaded component. d = mean diameter of the wires used.

Observation Table:-

Parameters	**MSR**	**VSR**	**Measurement=(MSR+VSR*LC)**
Major Diameter			
Minor Diameter			
Effective Diameter			

Sample Calculations: -

Precautions: - 1) Fudicial indicator should not get disturbed once it is set to zero.

2) Ensure Micrometer and thread are making perfect contact.

3) Ensure wires and prism are aligned properly with respect with thread

Results: - 1) Major Diameter =................................mm

2) Minor Diameter =................................mm

3) Effective Diameter =..............................mm

Conclusions: - Hence we have studied the floating carriage micrometer and found out thread parameters of given threaded specimen.

Questions

Q1. Explain floating carriage micrometer with neat sketch

Experiment No: 8

Aim: - Measurement of spur gear parameters using Gear Tooth Vernier, Span, Gear Rolling Tester.

Objectives: - Selection of tool and techniques for determining geometry and dimensions.

Apparatus/Equipment: - Gear Tooth Vernier, Spur gear of known module

Theory:-

Gear tooth Vernier is used to measure the depth and thickness of the tooth. It is based on the principle of vernier scale Gear tooth Vernier consists of a horizontal and a vertical vernier scale. The thickness of a tooth at pitch line and the addendum is measured by an independent tongue each of which is adjusted independently by adjusting the slide screws on graduated beams.

The caliper consists of two adjustable Vernier's

Vertical scale: Measures the depth of the teeth from the top of the pitch line.

Horizontal Scale: This is used to measure the Chordal Thickness of the gear tooth

Schematic Diagram

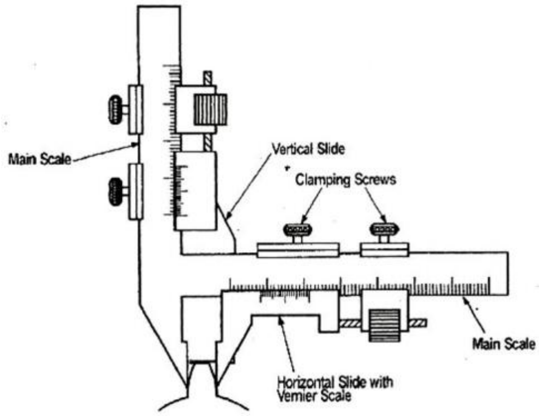


Fig. 8.1 Gear Tooth Vernier

Procedure:-

1. The vertical blade should be moved and then the gear tooth vernier caliper is placed on the gear tooth
2. The horizontal movable jaw of the horizontal scale should be adjusted and then thickness can be measured.
3. The reading on horizontal scale i.e. tooth thickness is noted down
4. The jaws are made to have contact with the tooth on either side by adjusting the knob
5. The above procedure is repeated number of times and readings are noted.

Observation Table:-

For tooth thickness

Sr. No.	M.S.R	V.S.D.	V. S. R = (V.S.D x L.C.)	Total Reading = (M.S.R + V.S.R.)

Depth of the teeth

Sr. No.	**M.S.R**	**V.S.D.**	**V. S. R = (V.S.D x L.C.)**	**Total Reading = (M.S.R + V.S.R.)**

Gear rolling tester

This gear rolling tester is designed to measure the double-flank total composite deviation and the tooth-to-tooth composite deviation of cylindrical gears and worm-gear pairs. It can also be used for checking the error of reference cone apex of bevel gears at right shaft angle.

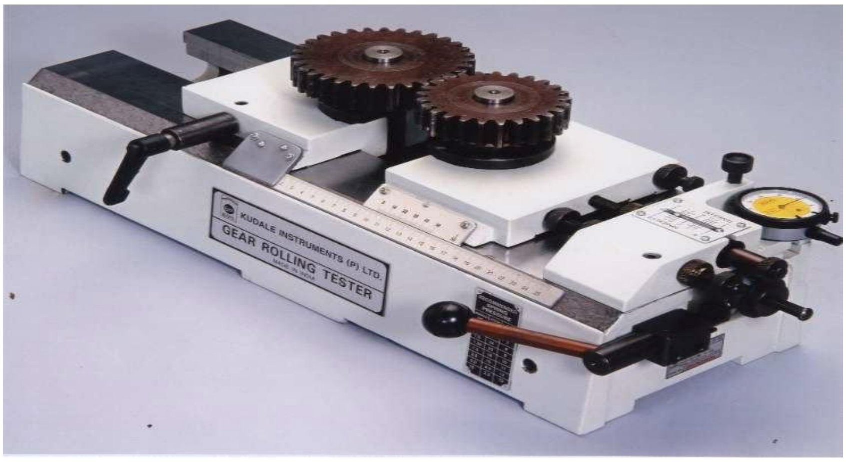


Fig. 8.2 Gear rolling Tester

Sr. No.	**Teeth No**	**Lead Error**

Precautions: -

1. Set the zero reading of the instrument to before measuring.
2. Clean the measuring faces of tooth caliper

Results:-

1. **Tooth Thickness = ………**
2. **Depth of the teeth = …………**

Conclusions: - Hence we have measured various parameters of gear using Gear Tooth Vernier and Gear Rolling Tester

Experiment No: 9

Aim: After studying this instrument, the student should be able to familiarize themselves with parts of a CMM, and understand the principle and the working of a CMM.

Coordinate Measuring Machine

DESCRIPTION OF PARTS: Co-ordinate Measuring Machines are built rigidly and are very precise. They are equipped with digital readout or can be linked to computers for online inspection of parts. These machines can be placed close to machine tools for efficient inspection and rapid feedback for correction of processing parameter before the next part is made. They are also made more rugged to resist environmental effects in manufacturing plants such as temperature variations, vibration and dirt. Important features of the CMMs are :

(i) To give maximum rigidity to machines without excessive weight, all the moving members, the bridge structure, Z-axis carriage, and Z-column are made of hollow box construction. (ii) A map of systematic errors in machine is built up and fed into the computer system so that the error compensation is built up into the software. (iii) All machines are provided with their own computers with interactive dialogue facility and friendly software. (iv) Thermocouples are incorporated throughout the machine and interfaced with the computer to be used for compensation of temperature gradients and thus provide increased accuracy and repeatability.

A CMM consists of four main elements:

Main Structure

The machine incorporates the basic concept of three coordinate axes so that precise movement in x, y, and z directions is possible. Each axis is fitted with a linear measurement transducer. The transducers sense the direction of movement and gives digital display. Accordingly, there may be four types of arrangement :

Cantilever: The cantilever construction combines easy access and relatively small floor space requirements. It is typically limited to small and medium sized machines. Parts larger than the machine table can be inserted into the open side without inhibiting full machine travel. Figure 8.1 shows a

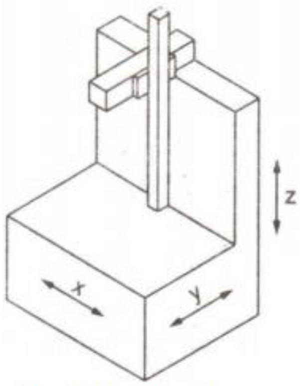


Figure 8.1 : Cantilever Structure

Probing System: It is the part of a CMM that sense the different parameters required for the calculation. Appropriate probes have to be selected and placed in the spindle of the CMM. Originally, the probes were solid or hard, such as tapered plugs for locating holes. These probes required manual manipulation to establish contact with the work piece, at which time the digital display was read. Nowadays, transmission trigger-probes, optical transmission probes, multiple or cluster probes, and motorized probes are available.

They are discussed in brief below:

Inductive and Optical Transmission Probes Inductive and optical transmission probes have been developed for automatic tool changing. Power is transmitted using inductive linking between modules fitted to the machine structure and attached to the probe. Figure 8.6 shows a schematic of the inductive transmission probe. The hard-wired transmission probe shown is primarily for tool setting and is mounted in a fixed position on the machine structure.

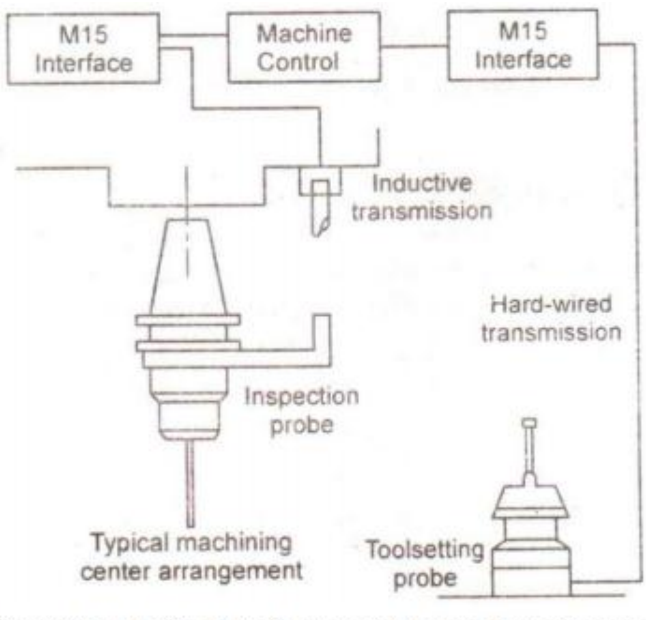


Figure 8.6 : Inductive Probe System and Automatic Probe Changing

Machine Control and Computer Hardware

The control unit allows manual measurement and self teach programming in addition to CNC operation. The control unit is microprocessor controlled. Usually a joystick is provided to activate the drive for manual measurement.

Software for Three-dimensional Geometry Analysis

In a CMM, the computer and the software are an inseparable part. They together represent one system. The efficiency and cost effectiveness of a CMM depend to a large extent on the software. The features that the CMM software should include:

- Measurement of diameter, center distances, lengths, geometrical and form errors in prismatic components, etc.
- Online statistics for statistical information in a batch.
- Parameter programming to minimize CNC programming time of similar parts.
- Measurement of plane and spatial curves
- Data communications
- Digital input and output commands for process integration
- Program for the measurement of spur, helical, bevel and hypoid gears
- Interface to CAD software

Conclusion: Hence, we have got introduced to elements of CMM and its working.

Experiment No: 10

AIM: Determination of process capability from given components and plot variable control chart/ attribute chart.

INTRODUCTION:

Process Capability: Process Capability (Cp) is a statistical measurement of a process's ability to produce parts within specified limits on a consistent basis. To determine how our process is operating, we can calculate Cp (Process Capability), Cpk (Process Capability Index). The Cp and Cpk calculations use sample deviation or deviation mean within rational subgroups. Process capability indices Cp and Cpk evaluate the output of a process in comparison to the specification limits determined by the target value and the tolerance range. Cp tells you if your process is capable of making parts within specifications and Cpk tells you if your process is centered between the specification limits. The Cp index is a fundamental indication of process capability. The Cp value is calculated using the specification limits and the standard deviation of the process. Most companies require that the process Cp = 1.33 or greater.

Control charts: Control charts are used to routinely monitor the quality. The types of charts are often classified according to the type of quality characteristic that are supposed to monitor, there are quality control charts for variables (X-bar chart, R chart) and control charts for attributes(P chart).

X-bar chart: In this chart, the sample means are plotted in order to control the mean value of a variable

R chart: In this chart, the sample ranges are plotted in order to control the variability of a variable

P chart: In this chart, we plot the percent of defectives (per batch, per day, per machine, etc.)

A) Construct an X-Bar and R Control Chart

To construct an X-Bar and R Chart, follow the process steps below

1. Record subgroup observations, consider subgroup size n=5
2. Calculate the average (X-Bar) and range (R) for each subgroup
3. Calculate the average R value, or R-bar, and plot this value as the centerline on the R chart.
4. Based on the subgroup size, select the appropriate constant, called D4 (for n=5, D4 = 2.115), and multiply by R-bar to determine the Upper Control Limit for the Range Chart. There is no Lower Control Limit for the Range Chart if the subgroup size is 6 or less.(D3 =0) Plot the Upper Control Limit and lower control limit on the R chart
5. Using the X-bar values for each subgroup, compute the average of all Xbars, or X-bar-bar (also called the Grand Average). Plot the X-bar-bar value as the centerline on the X Chart.
6. Calculate the X-bar Chart Upper Control Limit, or upper natural process limit, by multiplying R-bar by the appropriate A2 factor (for n=5, A2 = 0.577) and adding that value to the average (X-bar-bar). Plot the Upper Control Limit on the X-bar chart.
7. Calculate the X-bar Chart Lower Control Limit, or lower natural process limit, for the X-bar chart by multiplying R-bar by the appropriate A2 factor (for n=5, A2 = 0.577) and subtracting that value from the average (X-barbar). Plot the Lower Control Limit on the X-bar chart.
8. Plot the X-bar and R values for each subgroup in time series

$$UCL = \bar{R}D_4$$

$$LCL = \bar{R}D_3$$

UCL and LCL for R chart

$$UCL = \bar{\bar{X}} + A_2\bar{R}$$

$$LCL = \bar{\bar{X}} - A_2\bar{R}$$

UCL and LCL for X-bar chart

OBSERVATION TABLE :

X-bar and R Chart Case Study Data

Sub group no	Sample readings					Average	Range
	1	2	3	4	5	X-bar	R
1							
2							
.							
.							
.							
n							

CONCLUSION : Hence we studied process capability from given components and plotted variable control chart and attribute charts.