K.L.N. College of Engineering

(An Autonomous Institution, Affiliated to Anna University, Chennai)

Pottapalayam – 630 612

Accredited by National Assessment and Accreditation Council (NAAC)

Department of Mechanical Engineering

Accredited by NBA, New Delhi

Approved Research Center by Anna University, Chennai

REGULATIONS 2020

20ME404

METROLOGY AND MEASUREMENT PRACTICES

MANUAL

Lab In charge

Dr. N. NAGASUBRAMANIAN, M.E., Ph.D.

Prepared by

Dr. N. Nagasubramanian, M.E., Ph.D.

Assistant Professor / Mech. Engg.

Approved by

Dr. P. Udhayakumar

HOD / Mech. Engg.

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

To become a Centre of excellence for Education and Research in Mechanical Engineering.

MISSION

- Attaining academic excellence through effective teaching learning process and state of the art infrastructure.
- Providing research culture through academic and applied research.
- Inculcating social consciousness and ethical values through co-curricular and extra-curricular activities.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO I	Graduates will have successful career in Mechanical Engineering and service industries.
PEO II	Graduates will contribute towards technological development through academic research and industrial practices.
PEO III	Graduates will practice their profession with good communication, leadership, ethics and social responsibility.
PEO IV	Graduates will adapt to evolving technologies through lifelong learning.

PROGRAM SPECIFIC OBJECTIVES (PSOs)

PSO I	Derive technical knowledge and skills in the design, develop, analyze and manufacture of mechanical systems with sustainable energy, by the use of modern tools and techniques and applying research based knowledge.
PSO II	Acquire technical competency to face continuous technological changes in the field of mechanical engineering and provide creative, innovative and sustainable solutions to complex engineering problems.
PSO III	Attain academic and professional skills for successful career and to serve the society needs in local and global environment.

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Dr. N. NAGASUBRAMANIAN, M.E., Ph.D.

Name : ***Roll No. :***

Year / Sem. / Sec : ***Reg. No :***

20ME404 METROLOGY AND MEASURMENT PRACTICES L T P C
3 0 2 4

OBJECTIVES

- To make the students, familiar with characteristics of generalized measurement system limits, fits and tolerances.
- To relate various types of comparators, linear and angular measurement of part.
- To understand the principles of interference, principles of form measurement.
- To understand the methods of measurements of power, flow, temperature, speed, acceleration.
- To gain practical knowledge on dimensional measurement techniques such as linear and angular measurement of part, and physical measurement techniques such as force, torque, temperature, surface finish measurements and inspection methods using calipers, comparators, gauges and measuring machines.

PREREQUISITE: NIL

UNIT – I BASICS OF METROLOGY 9

Basics of Measurement- significance, generalized measuring system, Standards, Precision, Accuracy, Sensitivity, Repeatability, Reproducibility, Linearity, Calibration, Errors- Systematic and Random, Uncertainty of Measurement, Limits, fits and tolerances, Tolerance grades, Types of fits, IS919, GO and NO GO gauges (plug, ring, snap)- Taylor's principle, design of GO and NO GO gauges,

LAB COMPONENT 6

1. Calibration and use of Vernier caliper, Micrometer.
2. Calibration and use of Vernier height gauge.

UNIT – II LINEAR AND ANGULAR MEASUREMENT 9

Linear Measuring Instruments –Types, procedure, Comparators - mechanical, optical, electrical/electronic and pneumatic comparators, advantages, limitations and field of applications. Angular measuring instruments – Types – Bevel protractor clinometers, angle gauges, spirit levels, sine bar, Angle alignment telescope, Angle dekkor, Autocollimator – Applications.

LAB COMPONENT 6

1. Measurement of linear dimensions using comparators.
2. Measurement of angles using Bevel protractor and Sine bar.

UNIT – III FORM MEASUREMENT 9

Principles and methods of straightness, flatness, roundness and roughness measurement, Screw Thread Measurement, Gear Measurement. Principles of measurement using Tool Maker's microscope, profile projector.

LAB COMPONENT 6

1. Measurement of screw thread parameters using Three wire method (floating carriage micrometer).

2. Measurement of screw thread parameters using Profile Projector, Tool Maker's Microscope

3. Measurement of gear parameters using Gear tooth Vernier caliper.

UNIT – IV SPECIAL MEASURING EQUIPMENTS 9

Principles of interference, optical flats, optical interferometer and laser interferometer, coordinate measuring machine – Construction, types, accessories and applications, machine vision. 3D Scanning metrology

LAB COMPONENT 6

1. Testing of straightness of a machine tool guide way using Autocollimator.

2. Measurement of features in a prismatic component using Coordinate Measuring Machine (CMM).

UNIT – V MISCELLANEOUS MEASUREMENT 9

Measurement of Force, Torque, Power : mechanical , Pneumatic, Hydraulic and Electrical type

Measurement of Flow: Differential Pressure Meters, Rotameter, Turbine Meters, Electromagnetic Flow meters, Ultrasonic Flow meters

Measurement of Temperature: Bimetallic strip, Resistance Temperature Detectors, Thermistor, Thermocouples, Pyrometers.

Measurement of Speed: Contact & non- contact type, Measurement of acceleration

LAB COMPONENT 6

1. Measurement of force
2. Measurement of temperature
3. Measurement of torque

TOTAL : 75 PERIODS

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

- Design tolerances and fits for a selected product quality.
- Select a suitable comparator/ angular measuring device for inspecting the products in a given industry.
- Choose appropriate method and instruments for inspection of various forms.
- Select suitable advanced measuring instruments for special requirement in the industries.
- Choose appropriate method for the measurement of power, flow for a given application.
- Conduct experiments on various dimensional/physical measuring instruments and determine the parameters like diameter, angle, straightness, force, temperature, torque etc.,

LIST OF EXPERIMENTS

1. Calibration and use of Vernier caliper, Micrometer.
2. Calibration and use of Vernier height gauge.
3. Measurement of linear dimensions using comparators.
4. Measurement of angles using Bevel protractor and Sine bar.
5. Measurement of screw thread parameters using Three wire method (floating carriage micrometer).
6. Measurement of screw thread praameters using profile projector, Tool maker's Microscope.
7. Measurement of gear parameters using Gear tooth Vernier caliper.
8. Testing of straightness of a machine tool guide way using Autocollimator.
9. Measurement of features in prismatic component using Coordinate Measuring Machine (CMM).
10. Measurement of Force
11. Measurement of temperature.
12. Measurement of torque

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS

S.No.	NAME OF THE EQUIPMENT	Qty.
1	Micrometer	5
2	Vernier Caliper	5
3	Vernier Height Gauge	2
4	Vernier depth Gauge	2
5	Slip Gauge Set	1
6	Gear Tooth Vernier	1
7	Sine Bar	1
8	Floating Carriage Micrometer	1
9	Profile Projector / Tool Makers Microscope	1
10	Parallel / counter flow heat exchanger apparatus	1
11	Mechanical / Electrical / Pneumatic Comparator	1
12	Autocollimator	1
13	Temperature Measuring Setup	1
14	Force Measuring Setup	1
15	Torque Measuring Setup	1
16	Coordinate measuring machine	1
17	Surface finish measuring equipment	1
18	Bore gauge	1
19	Telescope gauge	1

CONTENTS

Date :

Introduction

Aim:

To study about basic measuring needs and instruments.

<u>Measuring needs</u>

Surface Plate

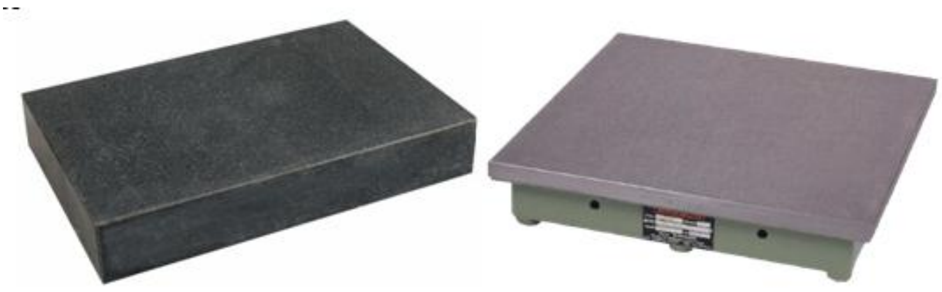


Fig.1. Surface plates

Surface plate is a solid, flat plate used as the main horizontal reference plane for precision inspection, marking out (layout), and tooling setup. The surface plate is often used as the baseline for all measurements to the work-piece. The plate is usually made with materials like granite, cast iron and glass which provide greater accuracy. The surface plate is used in conjunction with accessories such as a square, straight edge, gauge blocks, sine bar, sine plate, dial indicator, parallels, angle plate and height gauge.

Spirit Level

Fig.2. Spirit level

Spirit level or Bubble level is an instrument designed to indicate whether a surface is horizontal (level) or vertical (plumb). In the 1920s Henry Ziemann, the founder of Empire Level Mfg. Corp., invented the modern level with a single vial. These vials, common on most ordinary levels today, have a slightly curved glass tube which is incompletely filled with a liquid, usually a colored spirit or alcohol, leaving a bubble in the tube. At slight inclinations the bubble travels away from the center position, which is usually marked.

Angle Plate

Fig.3. Angle plate

An angle plate is a work holding device used as a fixture in metalworking. The angle plate is made from high quality material (generally spheroidal cast iron) that has been stabilized to prevent further movement or distortion. Slotted holes or T bolt slots are machined into the surfaces to enable the secure attachment or clamping of work piece to the plate, and also of the plate to the worktable.

V-Block

V-Blocks are precision metal working fixture typically used to hold round metal rods or pipes for performing drilling or milling operations. They consist of a rectangular steel or cast iron block with a 90-degree channel rotated 45-degrees from the sides, forming a V-shaped channel in the top. A small groove is cut in the bottom of the "V". They often come with screw clamps to hold the work. There are also versions with internal magnets for magnetic work holding. V-blocks are usually sold in pairs.

Fig.4. V-Block

Combination Set

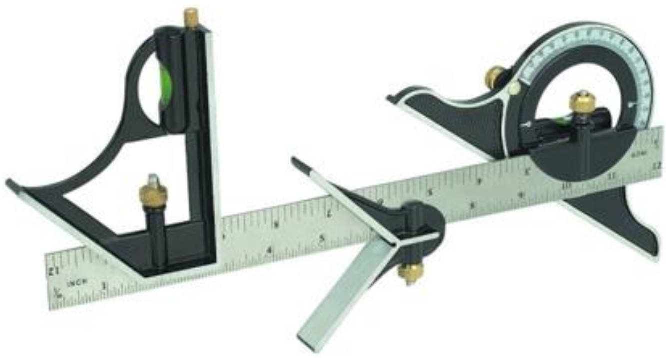


Fig.5. Combination set

A combination square is a tool used for multiple purposes in woodworking, stonemasonry and metalworking. It is composed of a ruled blade and one or more interchangeable heads that may be affixed to it. The most common head is the standard or square head which is used to lay out or check right and 45° angles. In metalworking, it is useful for a wide variety of layout and setup tasks. When used correctly, a fairly high degree of precision can be achieved. One use would be setting large items at the required angle in machine vices, where the long reach of the ruler and firm, heavy base aid the process.

Feeler Gauge

Feeler gauge is a tool used to measure gap widths. Feeler gauges are mostly used in engineering to measure the clearance between two parts. They consist of a number of small lengths of steel of different thicknesses with measurements marked on each piece. They are flexible enough that, even if they are all on the same hinge, several can be stacked together to gauge intermediate values.

Fig. 6. Feeler gauge

Screw Thread Pitch Gauge

Thread pitch gauges are used as a reference tool in determining the pitch of a thread that is on a screw or in a tapped hole. This tool is not used as a precision measuring instrument. This device allows the user to determine the profile of the given thread and quickly categorize the thread by shape and pitch.

Fig.7. Screw Thread Pitch Gauge

<u>Measuring instruments:</u>

Dial gauge

It is a gauge consisting of a circular graduated dial and a pointer actuated by a member that contacts with the part being calibrated. It is a precision measurement commonly used to measure machined parts for production tolerances or wear. Measurement inputs are transferred to the gauge via a plunger or the jaws of a vernier. In first case, a spring loaded plunger or lever at the bottom of the gauge transfers workpiece surface height deviations to the gauge. Plunger instruments are generally used in conjunction with a clamp or stand which holds the gauge in a fixed position in relation to the workpiece. The workpiece is then rotated or moved to take the measurements. Dial gauges are available with analog needle and dial indicators or digital liquid crystal displays (LCDs). The second type is the vernier dial gauge which receives its measurement input from the movement of the jaws of a conventional vernier.

Fig.8. Dial gauge

Uses:

By mounting a dial gauge on any suitable base and with various attachments, it can be used for variety of purposes as follows

1. Determining the errors in geometrical forms (ovality, out of roundness, taper etc.)
2. Determining positional errors of surfaces, (squareness, parallelism, alignment etc.)
3. Taking accurate measurement of deformation (extension or compression) in tension and compression testing of materials.
4. Comparing two heights or distances between the narrow limits (as a comparator)

Vernier Caliper

A vernier caliper consists of a steel beam ending in the double fixed jaw with the measuring face 1. It is graduated in the main scale divisions. The fixed jaw is either integral with or welded to the beam. The head slides along the beam and carries the integral double sliding jaw whose measuring face is parallel to that of the fixed jaw. The sliding head carries a vernier plate with the vernier scale. When the fixed jaws and the sliding jaws are closed, the zero on the vernier scale coincides with zero on the main scale.

Fig.9. Vernier caliper

The micrometric adjustment, consisting of a micrometric screw, secured to the head, a nut and an auxiliary scale, is used for accurate adjustment of the sliding jaw. A thumb screw is used to clamp the head on the beam to fix the measurement made. Internal measurements are taken by the external measuring faces 2 of the jaws.

Micrometer

The micrometer is a precision measuring instrument, used by engineers. The object to be measured is placed between the anvil face and the spindle face. Each revolution of the rachet moves the spindle face 0.5mm towards the anvil face. The rachet is turned clockwise until the object is 'trapped'

Fig.10. Micrometer

between these two surfaces and the rachet makes a 'clicking' noise. This means that the rachet cannot be tightened anymore and the measurement can be read. This instrument is highly heat sensitive and should be stored at room temperature. When storing the measuring contacts points should be left away from each other (open) so that temperature variations do not stress the device.

Slip gauges

Slip gauges are rectangular blocks of high-grade steel with exceptionally close tolerances. These blocks are suitably hardened throughout to ensure maximum resistance to wear. The cross sections of these gauges are 9mm x 30mm for sizes upto 10mm and 9mm x 35mm for larger thickness. Any two slips, when perfectly clean may be wrung together. The dimensions are permanently marked on one of the measuring faces of gauge block.

Fig.11. Slip gauge set

Slip gauges are available in sets both in inch units and in metric units. The five most usual sets available in inch units contain 81, 49, 41, 35 and 25 pieces respectively, e.g. in the 81-piece set, the slip gauges are arranged in the following order:

9 pieces from 0.1001″, to 0.1009″ in steps of 0.0001″.

49 pieces from 0.101″ to 0.149″ in steps of 0.001″

19 pieces from 0.050″ to 0.950″ in steps of 0.050″.

4 pieces of 1.000″, 2.000″, 3000″, 4.000″.

In metric units, sets of 103, 76, 48 and 31 pieces are available. Metric unit sets of 103 pieces are made up as follows:

49 pieces with a range of 1.01 mm to 1.49 mm in steps of 0.01 mm.

49 pieces with a range of 0.50 to 24.50 mm in steps of 0.50 mm.

4 pieces of 25, 50, 75 and 1000 mm respectively and 1 piece extra of 1.005 mm.

Slip gauges with three basic forms are commonly found. These are rectangular, square with centre hole, and square without centre hole. Rectangular form is the more widely used because rectangular blocks are less expensive to manufacture, and adapt themselves better to applications where space is restricted or excess weight is to be avoided. For certain applications, square slip gauges, though expensive, are preferred. Due to their large surface area, they wear longer and adhere better to each other when wrung to high stacks. Square blocks with centre holes are used to permit the use of tie rods as an added assurance against the wrung stocks falling apart while handling.

Precautions:

1. Slip gauges should be used in an atmosphere free from dust.
2. Before wringing the slip gauges together ensure their faces are perfectly clean.
3. Minimum number of slip gauges should be used for building up the require size.
4. The slip gauges should never be dropped or struck with other metallic objects.
5. When the slip gauges are not in use they should be kept in their case.

Vernier height gauge

This is also a sort of vernier caliper equipped with a special base block and other attachments, which make the instrument suitable for height measurements. Along with the sliding jaw assembly, arrangement is provided to carry a removable clamp. The upper and lower jaws are parallel to the base, so that it can be used for measurements over or under a surface. The vernier height gauge is mainly used in the inspection of parts and lay out work. With a scribing attachment in place of measuring jaw, this can be used to scribe lines at certain distance over the surface. However dial indicators can also be attached in the clamp and mainly useful measurements made as it exactly gives indication when the dial tips touch the surface. For all these measurements, use of surface plates as datum surface is very essential.

Fig.12. Vernier height gauge

Experiments

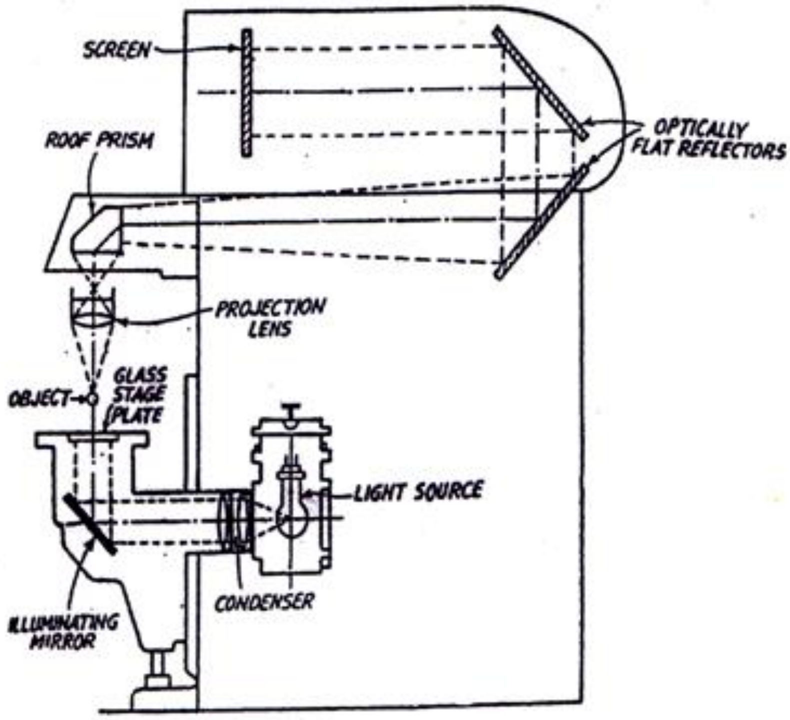


Fig. 1.1 Profile Projector

Ex No : 1.a) ***Date :***

Measurement of Thread Parameters Using Profile Projector

Aim:

To find the Pitch, major diameter, minor diameter and angle of thread of the given thread using Profile Projector.

Apparatus Required:

Profile Projector

Specimen Required:

Screw thread

Procedure:

1. Place the screw thread on the measuring stage of profile projector.
2. For major diameter measurement, bring the cross wire to one outer end of the specimen. Note down the readings and move it to another outer end by rotating the Vernier scale knob. Note down the readings. The difference between these two readings gives the major diameter.
3. Similarly calculate the minor diameter from the difference between two inner ends of the specimen.
4. For thread angle measurement, make the cross hair to coincide with one taper side of the thread. Note down the reading. Then rotate the protractor and make the same cross hair to coincide with the other taper side of the thread. The difference between these two readings gives the angle of thread.
5. For pitch measurement, make the cross hair to coincide with crest or root of a thread. Note down the micrometer reading. After that, make the same cross hair to coincide with crest or root of an adjacent thread. The difference between the two micrometer readings gives the pitch of thread.

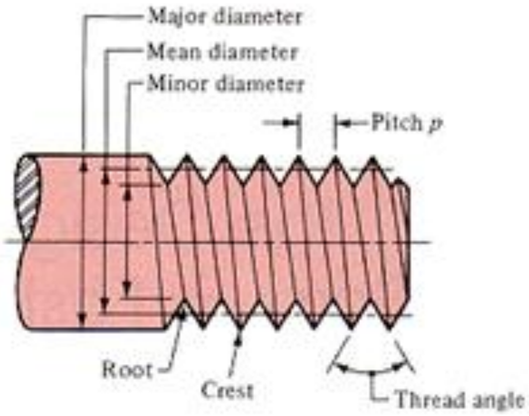


Fig. 1.2 Screw thread

Observation and Tabulation:

Least count in micrometer = 0.01mm

Least count in protractor = 2‘

S.No.	Parameter	Initial reading	Final reading	Result (Final – Initial)
1.	Pitch of thread (p) in mm			
2.	Internal Diameter (d_i) in mm			
3.	External diameter (d_o) in mm			
4.	Angle of thread (θ) in °			

Pitch of thread (p) =

Internal Diameter (d_i) =

External diameter (d_o) =

Angle of thread (θ) =

Result:

Thus the following thread parameters are measured.

Pitch of thread (P) = mm

Minor diameter (d_I) = mm

Major diameter (d_o) = mm

Angle of thread (θ) = °

Inference:

I have gained hands on experience in the measurement of various parameters of external thread.

Applications:

Profile projectors are widely used in machine shops for routine inspection of machined parts especially for small components. These are being used for routine inspection of medical device manufacturing, ultrasonic machining, tool & die industries etc.

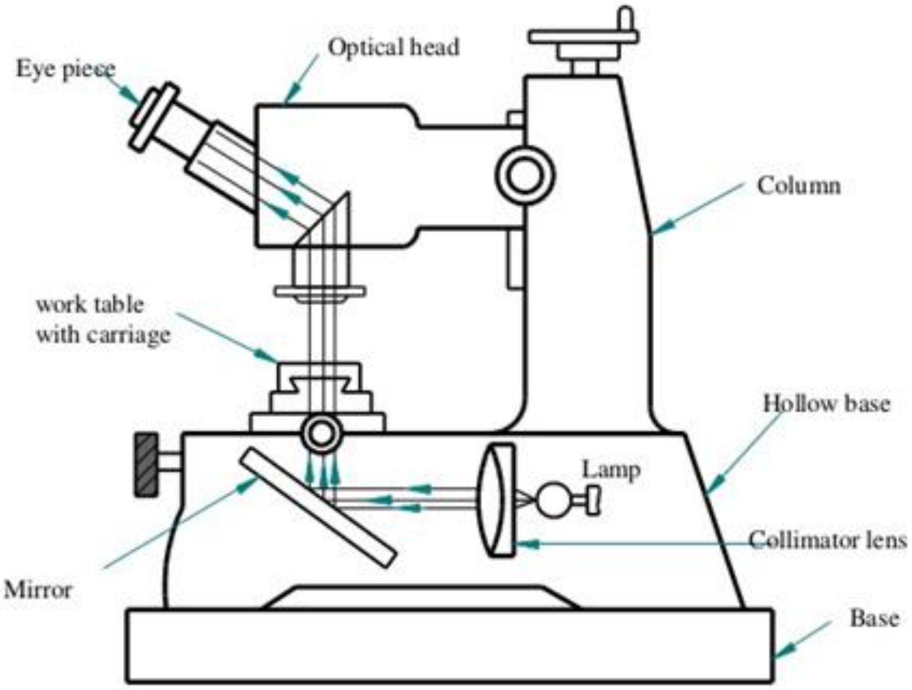


Fig. 1.3 Tool room microscope

Ex No : 1.b) ***Date :***

Measurement of Thread Parameters Using Tool Room Microscope

Aim:

To find the Pitch, major diameter, minor diameter and angle of thread of the given thread using Tool Room Microscope.

Apparatus Required:

Tool room microscope

Specimen Required:

Screw thread

Procedure:

1. Place the screw thread on the measuring stage of Tool Room Microscope.
2. For major diameter measurement, bring the cross wire to one outer end of the specimen. Note down the readings and move it to another outer end by rotating the vernier scale knob. Note down the readings. The difference between these two readings gives the major diameter.
3. Similarly calculate the minor diameter from the difference between two inner ends of the specimen.
4. For thread angle measurement, make the cross hair to coincide with one taper side of the thread. Note down the reading. Then rotate the protractor and make the same cross hair to coincide with the other taper side of the thread. The difference between these two readings gives the angle of thread.
5. For pitch measurement, make the cross hair to coincide with crest or root of a thread. Note down the micrometer reading. After that, make the same cross hair to coincide with crest or root of an adjacent thread. The difference between the two micrometer readings gives the pitch of thread.

Observation and Tabulation:

Least count of micrometer = 0.005mm

Least count of protractor = 6‘

S.No.	Parameter	Initial reading	Final reading	Result (Final – Initial)
1.	Pitch of thread (p) in mm			
2.	Internal Diameter (d_i) in mm			
3.	External diameter (d_o) in mm			
4.	Angle of thread (θ) in °			

Pitch of thread (p) =

Internal Diameter (d_i) =

External diameter (d_o) =

Angle of thread (θ) =

Result:

Thus the following thread parameters are measured.

Pitch of thread	(P)	=	mm
Minor diameter	(d_I)	=	mm
Major diameter	(d_o)	=	mm
Angle of thread	(θ)	=	°

Inference:

I have gained hands on experience in the precise measurement of various parameters of external thread.

Applications:

Tool room microscopes are widely used for linear as well as angular measurements. These are also used for measuring the shape of different components like formed cutter, milling cutter, punching die, and cam.

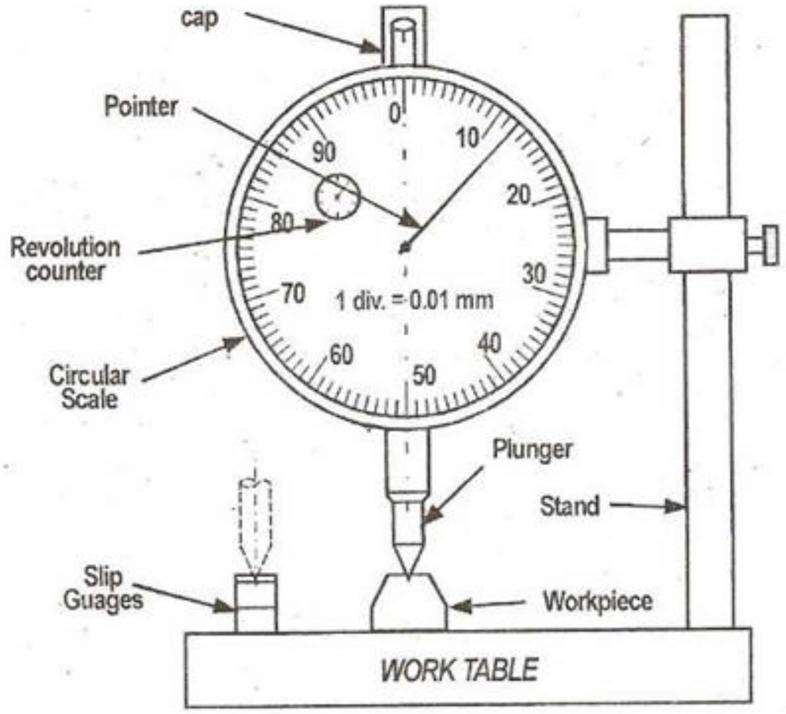


Fig. 2.1 Dial gauge

Observation and tabulation:

S. No.	Specimen under test	Details of slip gauge (mm)	Final dimension of the Specimen (mm)
1.	Specimen-I		
2.	Specimen-II		
3.	Specimen-III		
4.	Specimen-IV		

Ex No : 2.a) ***Date :***

Checking Dimension of Part Using Mechanical Comparator

Aim:

To check the dimensions of part using mechanical comparator.

Apparatus Required:

1. Slip gauge set
2. Surface plate
3. Dial gauge

Specimen Required:

Cylinders (4 Numbers)

Procedure:

1. Place the part to be measured and dial gauge in the surface plate.
2. Place the plunger of the dial gauge over the part and fix the dial gauge on the stand.
3. Adjust the circular scale of the dial gauge to show zero reading.
4. Then remove the part and place the slip gauges one over another on the surface plate below the plunger until the dial gauge shows zero reading.
5. Continue the step 4 till the variation is nil. Then add the slip gauge values and it gives the height of the job.

Result:

The height of

Specimen – I is = _________mm, Specimen – II is = _________mm,

Specimen – III is =_________mm, Specimen – IV is =_________mm.

Inference:

I have gained hands on experience in measuring the dimension of the given object using mechanical comparator.

Applications:

1. To check for run-out when fitting a new disc to an automotive brake.
2. In metal engineering workshops, where a typical application is the centering of a lathe's work-piece in a four jaw chuck.

Observation and Tabulation:

Standard value	(mm)
Low set value	(mm)
High set value	(mm)

S.No	**Standard value (mm)**	**Measured value (mm)**	**Error**	**Status**
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

Ex No : 2.b) ***Date :***

Checking the Limits of Dimensional Tolerance Using Electrical Comparator

Aim:

To determine the accuracy of the given specimens using electrical comparator

Apparatus Required:

1. Electrical comparator
2. Dial gauge
3. Slip gauge

Specimen Required:

Hollow cylinders (10 Numbers)

Procedure:

1. First place a standard specimen (slip gauge) under the plunger of probe.
2. After that adjust the resistance of Wheatstone bridge so that the scale reading shows zero.
3. Then remove the specimen.
4. Now introduce the specimen to be tested under the plunger one by one.
5. If height variations of work present, it will move the plunger up or down. The corresponding movement of the plunger is first amplified then it is transferred to the meter to show variations.

Result:

Thus the accuracy of the given specimens is determined using electrical comparator.

Inference:

I have gained hands on experience to find the deviation of in the dimension of the given component from standard dimension.

Applications:

1. Attached with some machines, comparators can be used as working gauges to maintain required tolerances at all stages of manufacturing.
2. In selective assembly of parts, where parts are graded in three or more groups depending upon their tolerance.

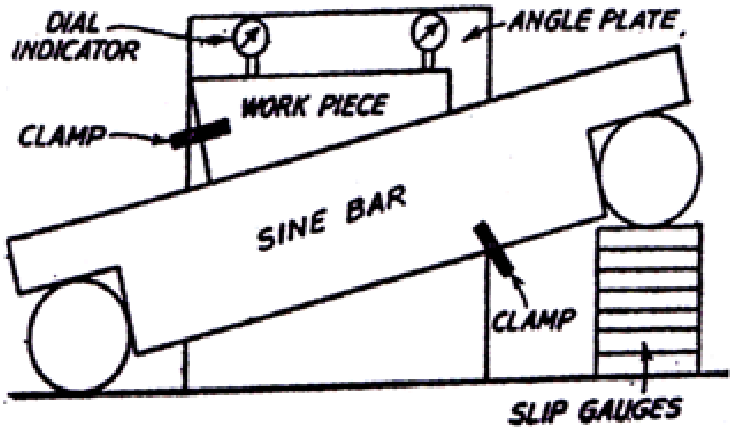


Fig. 3.1 Measurement of taper angle using sine bar

Ex No : 3 ***Date :***

Measurement of Taper Angle Using Sine Bar

Aim:

To measure the taper angle of the given job using the Sine bar.

Apparatus Required:

1. Sine bar
2. Dial gauge
3. Slip gauges
4. Bevel protractor
5. V- block

Specimen Required:

Truncated cone

Formula used:

$$\sin\theta = \frac{h_2 - h_1}{l}$$

Alternation in slip gauge height = $\frac{dh \times l}{l_1}$

where,

h_1 - Height of slip gauge in lower part in mm

h_2 - Height of slip gauge in higher part in mm

l - Distance between two rollers of the Sine bar in mm

dh - Difference in dial gauge reading

l_1 - Distance between two points marked on the work piece

θ - Taper angle of the given job.

Observation and Tabulation:

S.No	Difference in dial reading	Alternation in slip gauge	Height of slip gauge in "mm"	Details of slip gauge in "mm"
1.				
2.				
3.				
4.				
5.				

Model calculation:

Alternation in slip gauge = $\frac{dh \times l}{l_1}$ =

Taper angle of the given job = $\theta = \sin^{-1}\left(\frac{h_2 - h_1}{l}\right) =$

$\theta =$

Procedure:

1. Measure the length of the sine bar using veriner caliper.
2. Measure the angle of the given job using the bevel protractor in the following manner.
    i. Make the fixed blade of the bevel protractor to coincide with the reference surface of work piece.
    ii. Adjust the movable blade of protractor to coincide with taper surface
    iii. Note down the angle between the blades
3. Calculate initial height setup for the measured angle using the above formula.
4. Then held the job in the sine bar using v- block. Choose the slip gauges for this height and place below the one end roller of sine bar. The measuring set up is as shown in the figure.
5. Move the dial gauge over tapered surface of the job to measure height variation from one end to other end.
6. If there is any variation, then measure the alternation height.
7. For this alteration height, choose the slip gauges and add it to the existing slip gauges and continue the step 4 till the variation is nil.
8. Calculate the angle of given job using above formula.

Result:

The taper angle of given job $\theta =$ ^{o}

Inference:

I have gained hands on experience in measurement of angle of a given job and setting a desired angle.

Applications:

Sine bars are used to check the unknown angles of small as well as large components and also to locate any work to a given angle.

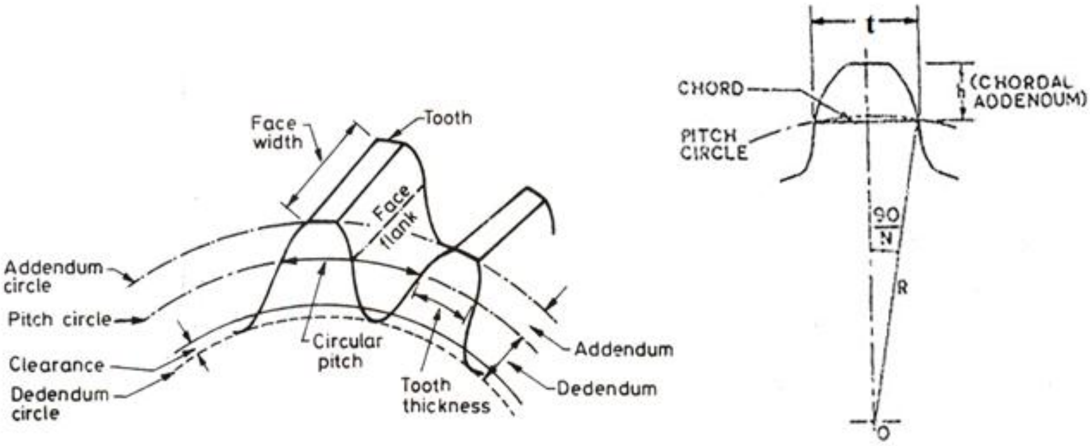


Fig. 4.1 Nomenclature of spur gear

Ex No : 4 ***Date :***

Gear Tooth Vernier Caliper

Aim:

To measure the parameters of given gear wheel using gear tooth Vernier.

Apparatus Required:

1. Gear tooth Vernier
2. Vernier caliper

Specimen Required:

Spur gear

Procedure:

Calculation of pitch circle diameter, module, addendum and clearance.

1. Measure the outside diameter (D_o) of the blank with the help of vernier caliper.
2. Count the number of teeth (N) on the spur gear.
3. Calculate the various gear elements as follows:

$$\text{Pitch circle diameter (D)} = \frac{(N \times D_o)}{(N + 2)}$$

$$\text{Module(m)} = \frac{D}{N}\ \text{mm}$$

$$\text{Addendum (h)} = \left(\frac{Nm}{2}\right)\left[1 + \left(\frac{2}{N}\right) - \cos\left(\frac{90}{N}\right)\right]$$

$$\text{Dedendum} = Nm \sin\left(\frac{90}{N}\right)$$

$$\text{Circular pitch} = \pi\, m$$

$$\text{Clearance} = 0.25m$$

Measuring chordal thickness by using gear tooth Vernier.

1. Set the addendum on the vertical side of gear tooth vernier and then insert the jaw of the instrument on the tooth to be measured.
2. Slide the horizontal jaw so that the jaw first touches the tooth.

Observation and Tabulation:

Least count = 0.02mm

S.No.	Parameters of gear	Values
1.	Outside diameter (D_o)	mm
2.	Dedendum	mm
3.	Number of teeth (N)	
4.	Pitch circle diameter (D)	mm
5.	Clearance	mm
6.	Addendum	mm
7.	Module	mm
8.	Percentage of error	

3. Get the observations similar to as done in case of vernier caliper
4. Repeat the observations and get the average value. Let this be t. The theoretical value (standard value of thickness),

$$t_s = D\sin\left(\frac{90^\circ}{N}\right)$$

   Hence, calculate the value of t_s

5. Compare the observed value with standard value and get the % of error as follows:

$$\text{Percentage of error} = \left[\frac{(t_s - t)}{t}\right] \times 100$$

Result:

Thus Gear elements / parameters are measured; percentage of error in tooth thickness measurement =

Inference:

I have gained hands on experience in measurement of tooth thickness of gear.

Applications:

Gear tooth Vernier can be used for measuring hobs, form and thread tools.

Observations:

Least count of micrometer = 0.0002mm

S. No.	Parameter	FCM reading for master cylinder (mm)			FCM reading for Screw thread (mm)		
		Main scale reading (MSR)	**Vernier scale reading (VSR)**	**Measured reading**	**Main scale reading (MSR)**	**Vernier scale reading (VSR)**	**Measured reading**
1.	Major diameter			R =			R1=
2.	Minor diameter			RP =			R2=
3.	Effective diameter			RW=			R3=

Ex No : 5 **Date :**

Floating Carriage Micrometer

Aim:

To measure the major diameter, minor diameter & Effective diameter of thread by using floating carriage micrometer.

Apparatus Required:

1. Floating carriage micrometer.
2. Prism
3. Wire
4. Cylinder.

Specimen Required:

1. Screw thread

Procedure:

Major diameter measurement

1. To determine the major diameter, first preset the instrument using a suitable master cylinder and note down the reading R of the micrometer.
2. Then replace the master cylinder by the threaded work piece and note the second reading R1.
3. The major diameter of work piece is then determined as follows.

If, Micrometer reading over master cylinder		=	R
Micrometer reading over threaded work piece		=	R1
Diameter of master cylinder		=	D
Then major diameter of work piece	(OD)	=	D ± (R ~ R1).

The + or – is determined by relative size of master & work piece.

Minor diameter measurement

1. To determine the minor diameter, take a measurement over a pair of prism lying in the thread form.
2. Place the master cylinder between the centre, insert the prism between the measuring anvils and standards and note down the reading RP of micrometer.
3. Then replace the master cylinder by the threaded work piece with the prisms inserted in the thread form and note the second reading R2.

Model Calculation:

Diameter of master cylinder	=	D	=	mm
Pitch of thread	=	p	=	mm
Mean diameter of cylinder wire used	=	d	=	mm

Measured reading = MSR + (VSR x L.C) =

Major diameter of work piece (OD) = D ± (R ~ R1) =

Minor diameter of work piece (ID) = D ± (RP ~ R2) =

P = 0.86602p - d =

Effective diameter of work piece (E) = D ± [(RW-P) ~ R3].

4. The minor diameter of work piece is then determined as follows.

If, Micrometer reading over master cylinder = RP

Micrometer reading over threaded work piece = R2

Diameter of master cylinder = D

Then minor diameter of work piece (ID) = D ± (RP ~ R2).

The + or – is determined by relative size of master & work piece.

Measurement of effective diameter by using 2 wire method

1. Place the master cylinder between the centre, insert the measuring cylinder or wire between the measuring anvils and standards and note down the reading RW of micrometer.
2. Then replace the master cylinder by the threaded work piece with the wires inserted in the thread form and note the second reading R3.
3. The effective diameter of work piece is then determined as follows.

Micrometer reading over master cylinder = RW

Micrometer reading over threaded work piece = R3

Diameter of master cylinder = D

If P is the difference between the effective diameter and diameter of cylinder wire, then

P = 0.96049p−1.16568d (for Whitworth thread).

P = 0.86602p—d (for ISO metric thread).

p = Pitch of thread

d = Mean diameter of cylinder wire used

Then effective diameter of work piece (E) = D ± [(RW-P) ~ R3].

The + or – is determined by relative size of master & work piece.

Result:

Thus the thread parameters of a screw thread are measured using floating carriage micrometer.

Inference:

I have gained hands on experience in measurement of Major, Minor and Effective diameter of thread.

Applications:

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. All these dimensions have a vital role in the thread plug gauges, since the accuracy and interchangeability of the component depends on the gauges used.

Observation and Tabulation:

S.No.	**R_a (Microns)**	**R_q (Microns)**	**R_z (Microns)**
1.			
2.			
3.			
4.			
5.			

where,

R_a (Microns) = Arithmetic mean deviation of the profile.

R_q (Microns) = Root mean square deviation of the profile.

R_z (Microns) = Maximum height of the profile.

Ex No : 6 ***Date :***

Surface Finish Measuring Equipment

Aim:

To measure the surface roughness of a given specimen

Apparatus Required:

1. Surf tester 301

Procedure

1. Set the required roughness parameters of the given work piece in SJ-301 surface roughness tester.
2. Then set the sampling length to be measured of the given work piece and Stylus of the surface roughness tester touch over the given work piece.
3. Determine the surface roughness by traversing the Stylus over the surface irregularities.
4. The measurement results are displayed digitally/graphically on the touch panel, and output can be printed with the help of the built in printer.

Result:

Thus the various roughness parameters for different specimens are measured and tabulated.

Inference:

I have gained hands on experience in measuring the surface roughness of the given object using Surface Finish Measuring Equipment

Applications:

This instrument is used to measure the roughness (Closely spaced irregularities such as cutting tool marks), waviness (Widely spaced irregularities) and flaws (Surface cracks and scratches) on the machined surface.

Observation and Tabulation:

Least Count :0.02mm

S.No.	Main scale reading (MSR) in mm	Vernier scale reading (VSR) in mm	Measured reading = MSR+(VSR x LC) in mm
1.			
2.			
3.			
4.			

Ex No : 7 **Date :**

Measurement of Dimension Using Vernier Height Gauge

Aim:

To measure the height of the object using Vernier height gauge.

Apparatus Required:

1. Surface Plate
2. Vernier height gauge

Specimen Required:

Cylinders and hollow cylinders

Formula used:

1. Least Count = $\frac{\text{Value of the smallest division on man scale}}{\text{Number of divisions on vernier scale}}$

2. Height = Main scale reading + (Vernier scale division × Least count)

Procedure:

1. Place the object and the Vernier height gauge on the surface plate.
2. Make sure that the Vernier and main scale coincide at zero when the sliding jaw is touching the bottom of the object.
3. Move the sliding jaw to the top of the object and tighten the screw.
4. Note down the main scale and Vernier scale reading.
5. Height of the object can be obtained by adding MSR with VSR × L.C

Result:

The height of

Specimen-I is = ____________________mm, Specimen-II is = ____________________mm.

Specimen-III is = ____________________mm, Specimen-IV is = ____________________mm.

Inference:

I have gained hands on experience in measuring various heights of components using height gauge.

Applications:

Vernier height gauge is used for marking and measuring work for molds, jigs and tooling.

Observation and Tabulation:

Least count: mm

S.No.	Main scale reading (MSR) in mm	Vernier scale reading (VSR) in mm	Measured reading = MSR+(VSR x LC) in mm

Ex No : 8 ***Date :***

Bore Diameter Measurement Using Telescope Gauge

Aim:

To measure the diameter of the bore using telescope gauge.

Apparatus Required:

1. Surface Plate
2. Telescope gauge set

Specimen Required:

1. Hollow cylinders and bearings

Procedure:

1. Place the object and the gauges on the surface plate.
2. Lock the gauges by twisting the knurled end of the handles.
3. Once gently locked to a size slightly larger than the bore, insert the gauges at an angle to the bore and slowly bring to align themselves radially, across the hole. This action compresses the two anvils where they remain locked at the bore's dimension after being withdrawn.
4. Then remove the gauge and measure with the aid of a micrometer or Vernier caliper which gives the diameter of bore.

Result:

The bore diameter of

Specimen-I is = ________________mm, Specimen-II is = ________________mm.

Specimen-III is = ________________mm, Specimen-IV is = ________________mm.

Inference:

I have gained hands on experience in measuring inner diameters of various holes using telescopic gauge set.

Applications:

Inside micrometers are used for measuring the interior radius of the bore or cylinder of a crank case in which the cylinder's pistons would extend and retract. For internal combustion and diesel engines to work properly, absolutely no air can pass out of the cylinder when the piston extends, compressing the combustible gases within. This means that the circumference and radius of the piston head must match the circumference and radius of the cylinder as closely as possible. This means that precision indirect measuring tools such as telescoping gauges are an absolute necessity.

Observations:

Least count : 0.01 mm

S.No.	Main scale reading (MSR) in mm	Vernier scale reading (VSR) in mm	Measured reading = MSR+(VSR x L.C) in mm
1.			
2.			
3.			
4.			

Ex No : 9 ***Date :***

Bore Diameter Measurement Using Micrometer

Aim:

To measure the diameter of the bore using inside micrometer.

Apparatus Required:

1. Surface Plate
2. Inside micrometer

Specimen Required:

1. Hollow cylinders and bearings

Formula used:

1. Least Count $= \frac{\text{Value of the smallest division on man scale}}{\text{Number of divisions on vernier scale}}$
2. Height = Main scale reading + (Vernier scale division × Least count)

Procedure:

1. Place the object and the inside micrometer on the surface plate.
2. Make sure that the Vernier and main scale coincide at zero
3. If it coincides at 0, then the value of measurement is 25mm. Because its range of measurement is 25 – 50mm.
4. Insert the measuring end of micrometer into the work piece and move it into the bore.
5. If it moves freely, then adjust the thimble scale until the measuring end moves tightly.
6. Measure the main scale and Vernier scale reading.
7. Diameter of the bore can be obtained by adding MSR with VSR × L.C

Result:

The bore diameter of

Specimen-I is = ________________mm, Specimen-II is = ________________mm.

Specimen-III is = ________________mm, Specimen-IV is = ________________mm.

Inference:

I have gained hands on experience in measuring inner diameters of various holes using inside micrometer.

Applications:

Inside micrometers are used for measuring inside dimensions such as pump casing wearing rings, cylinders, bearings and bushings.

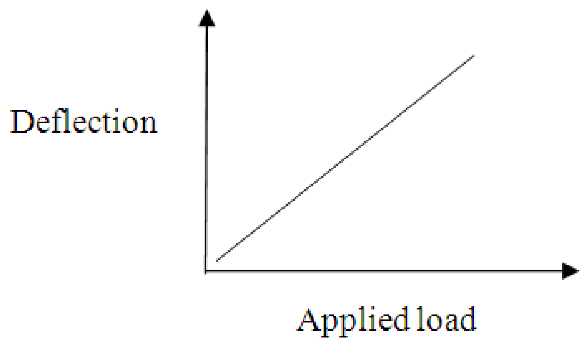
Observation and Tabulation:

1 division = 0.002mm

S. No	Actual load applied (kg)	Deflection (div) in mm
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Graph:

Deflection (div) Vs Applied load (kg)



Ex No : 10 ***Date :***

Force Measurement

Aim:

To measure the force using load cell.

Apparatus Required:

1. Proving Ring
2. Load cell
3. Force indicator
4. Screw jack
5. Dial gauge.

Specimen required:

1. Wooden beam

Procedure:

1. Ensure that proving ring along with load all are perfectly in vertical position.
2. Check and ensure that the axes of screw jacks are perfectly aligned with load cell.
3. Ensure that load cell with socket is connected to the rear side of the load indicator.
4. Apply a small load without any slip in the system.
5. Note down the reading of dial gauge of force indicator.

Result:

Thus the force has been measured using load cell.

Inference:

I have gained hands on experience in accurate measuring of large static loads such as pushing or pulling forces based on deflection of proving ring.

Applications:

Proving rings are often used to calibrate the amount of force used within various force-testing devices. Once the calibration is set, other materials are placed in the devices, and it is possible to see if they can withstand the same force that was being applied to the proving ring. In this way, exact strengths of various materials are determined.

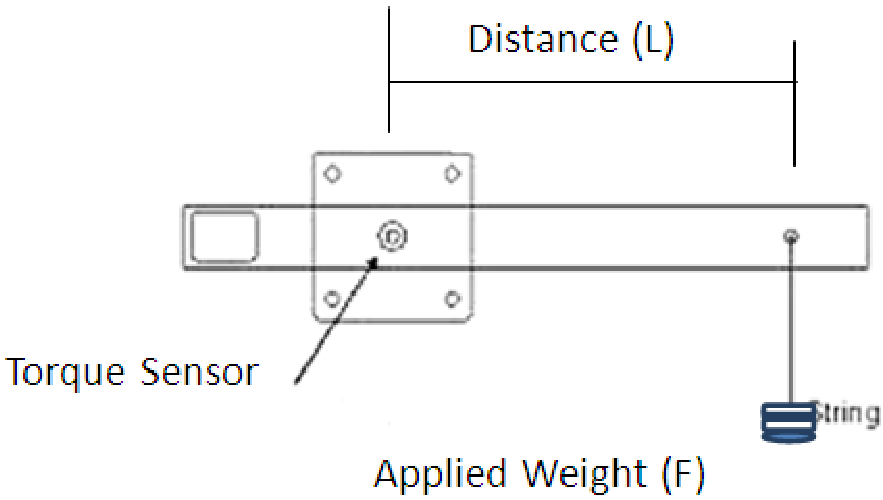


Fig. 11.1 Torque Measurement setup

Observation and Tabulation:

S. No.	Load in kg	1m		0.75m		0.5m		1m % error	0.75m % error	0.5m % error
		actual	Theoretical	Act	Theo	Act	Theo			
1.										
2.										
3.										
4.										
5.										

Ex No : 11 ***Date :***

Torque Measurement

Aim:

To measure torque using a torque measurement trainer

Apparatus Required:

1. Digital torque indicator
2. 1 kg mass (5 Numbers)
3. Hanger to hold the weight
4. Lever of 1 m length

Formula Used:

Torque = Load x Distance (kg-m)

Error = Theoretical torque ~ Actual torque

$$\% \text{ Error} = \left(\frac{\text{Error}}{\text{Theoretical torque}}\right) \times 100$$

Procedure:

1. Switch ON the instrument and adjust the potentiometer in front panel till the display reads "0.00"
2. Set the distance as 1m and weigh loads and take torque values.
3. Also for distance 0.75m and 0.5m, add loads and take torque values respectively.
4. The indicated and calculated readings are tabulated and percentage of error is calculated.

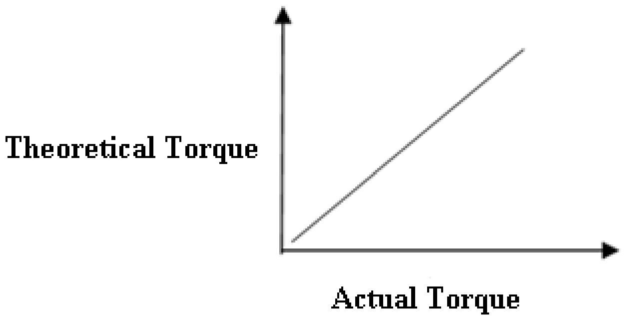
Model Calculation:

Error = Theoretical torque ~ Actual torque

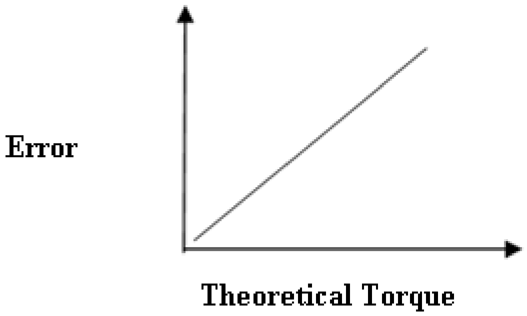
$$\% \text{ Error} = \left(\frac{\text{Error}}{\text{Theoretical torque}}\right) \times 100$$

Graphs:

Theoretical Torque Vs ActualTorque



Theoretical Torque Vs % Error



Result:

Thus torque is measured at various distances by torque measurement trainer and its performance is also evaluated.

Inference:

I have gained hands on experience in measuring the turning force in mechanical systems.

Applications:

Torque is a measure of the turning force on an object such as a bolt or a flywheel. For example, pushing or pulling the handle of a wrench connected to a nut or bolt produces a torque (turning force) that loosens or tightens the nut or bolt. Torque measurement is often associated with determination of mechanical power, either power required to operate a machine or power developed by the machine. The power is calculated from $P = 2\pi NT$

Where N is the angular speed in revolutions per second.

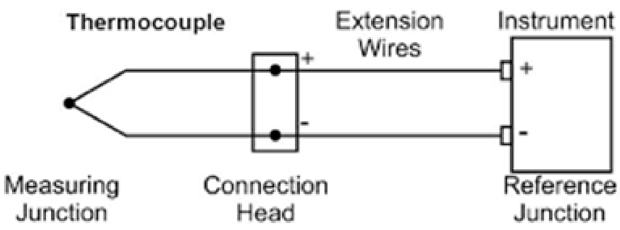


Fig. 12.1 Thermocouple

Observation and Tabulation:

S.No.	Thermocouple reading (°C)	Thermometer reading (°C)	Error %
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

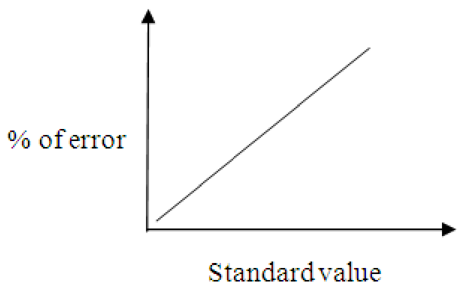
Model calculation:

Thermocouple:

$$\% \text{ Error } = \left(\frac{\text{Standard value} - \text{Observed value}}{\text{Standard value}}\right) \times 100$$

Graph:

Thermocouple reading Vs % of error of Thermometer



Ex No : 12 **Date :**

Temperature Measurement

Aim:

To measure the temperature by using thermometer and thermocouple.

Apparatus required:

1. Thermocouple
2. Thermometer

Formula used:

$$\% \text{ Error} = \left(\frac{\text{Standard value} - \text{Observed value}}{\text{Standard value}}\right) \times 100$$

Procedure:

1. Heat the liquid (water) above 90°C nearer to its boiling point.
2. After reaching the steady state temperature, immerse the thermocouple and thermometer in the liquid.
3. During cooling, for every 5°C reduction in temperature shown by the thermocouple, note the corresponding thermometer reading. Take the thermocouple reading as the standard value.
4. Tabulate the thermometer and thermocouple readings and calculate the percentage of error.
5. Continue this process until the liquid reaches the room temperature.

Result:

The temperature was determined by using thermometer and thermocouple.

Inference:

I have gained hands on experience in measuring the temperature by different measuring instruments and comparing their outputs.

Applications:

Thermocouples withstand high temperatures, extreme pressures and high flow velocities in both standard and demanding applications with harsh environmental conditions.

Observation and Tabulation:

Parallel to the Axis

Least count : 1”

S. No.	Distance of reflector (mm)	Micrometer reading (sec)		Tanθ (sec)	Level in Microns
		Initial	Final		
1.					
2.					
3.					
4.					
5.					

Perpendicular to the Axis

S. No.	Distance (mm)		Micrometer reading (sec)		Tanθ (sec)	Level in Microns
	Prism (mm)	Reflector (mm)	Initial	Final		
1.	100	100				
2.		200				
3.		300				
4.	200	100				
5.		200				
6.		300				
7.	300	100				
8.		200				
9.		300				

Ex No : 13 ***Date :***

Measurement of Straightness and Flatness Using Autocollimator

Aim:

To determine the straightness and flatness of the given surface.

Apparatus Required:

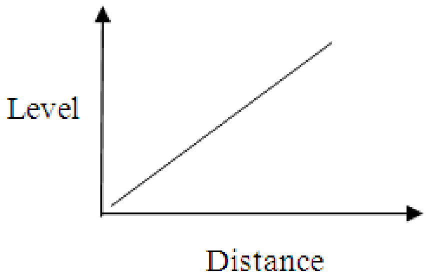
1. Autocollimator
2. Reflector
3. Prism
4. Specimen Required:
5. Surface plate

Procedure:

1. Place the Autocollimator on a surface plate to be inspected.
2. To measure the straightness, place the reflector along the axis of the Autocollimator.
3. Switch on the light and observe the measuring graticule through eyepiece and adjust the micrometer so that the eyepiece graticule horizontal line is made to coincide with the horizontal line of image of the target graticule.
4. Note the readings on the micrometer drum. This reading is the reference for all subsequent observations. (Position "A")
5. Move the reflector to position "B" say by 100mm away along the same axis from the earlier position "A".
6. Observe through the eyepiece. If the surface plate is perfectly flat, then the two horizontal lines will coincide each other. If there is a level difference between the position A&B, then there is a gap between the two horizontal lines.
7. By means of the micrometer move the horizontal line to coincide again.
8. Note the micrometer readings at position B.
9. The difference in the readings for Position A & B refers to the angular tilt at position B.

Graph:

Distance (mm) Vs Level (microns)



10. (Difference in Micrometer readings gives the angular tilt between two positions in seconds). The angles are then converted in microns as given below.

    $\text{Tan } \theta = X / 100$

    $X = (100 \times \text{Tan } \theta) \times 1000$ in microns

    X represents the level at Position B with respect to position A.

11. This procedure is carried out by varying the distances of reflector along the axis of the Autocollimator on the surface plate.
12. To measure the flatness, the prism is placed along the axis of the Autocollimator and the reflector is placed perpendicular to the axis of the prism.
13. The above steps are carried out for various distances of prism.

Result:

Thus the straightness and flatness of surface plate are determined using autocollimator.

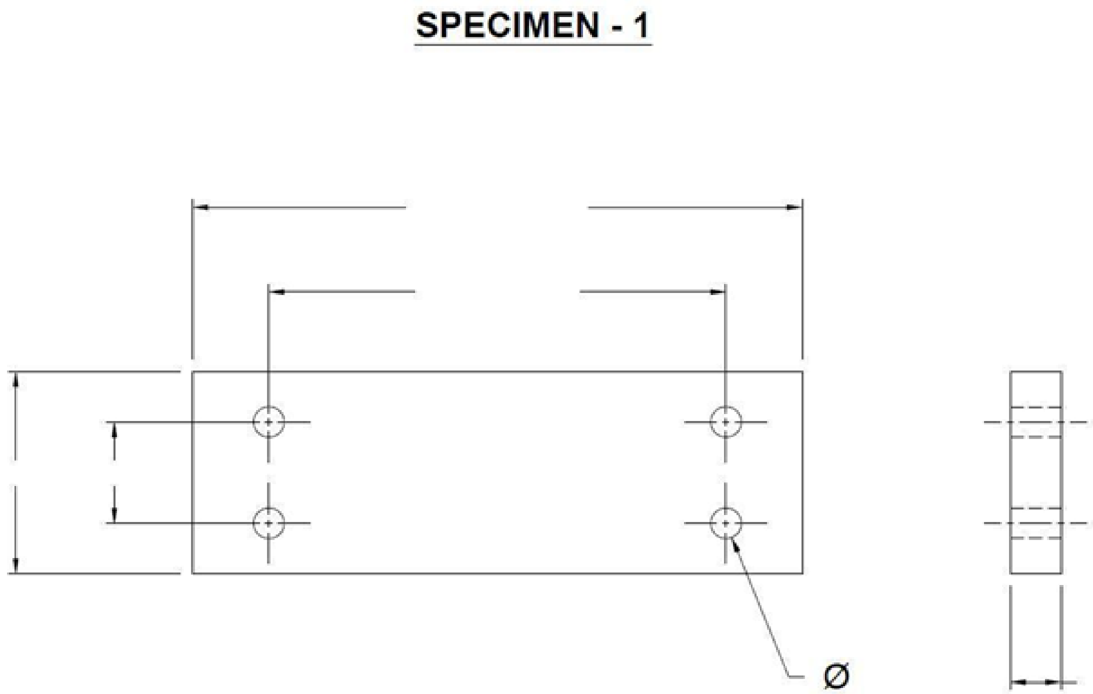
Inference:

I have gained hands on experience in determining straightness and flatness of mechanical systems.

Applications:

Autocollimator is an optical instrument used for the measurement of small angular differences. It is used for checking the face parallelism of optical windows and assessment of squareness and parallelism of components.

Observation and Tabulation:



All dimensions are in mm

Fig. 14.1 Rectangular specimen with holes

S. No.	Dimensions	Values (mm)
1.	Length of the specimen (l)	
2.	Breath of the specimen (b)	
3.	Thickness of the specimen (t)	
4.	Diameter of hole (d)	
5.	Centre distance between i) Holes nearer to length side ii) Holes nearer to breath side	

Ex No : 14 ***Date :***

Co-ordinate Measuring Machine

Aim:

To measure the required dimensions of the given specimen.

Apparatus Required:

1. Co-ordinate Measuring Machine
2. Calibrating sphere
3. Supporting stands

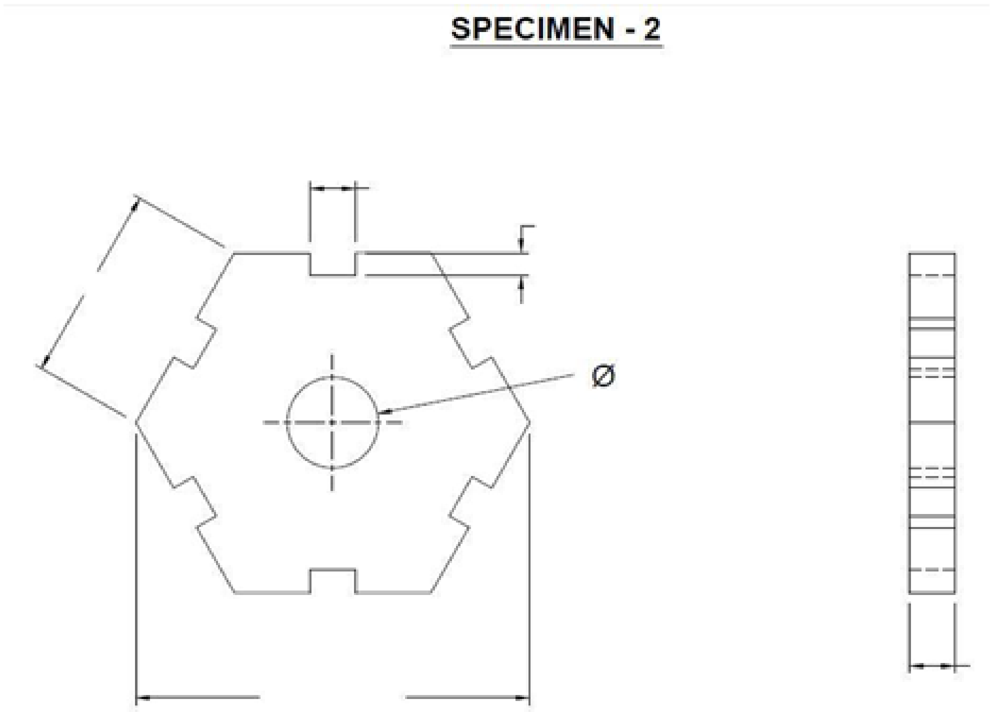
Specimen Required:

1. Rectangular bar with holes at nearer to each corner
2. Hexagonal prism with hole at centre.

Procedure:

1. Qualify the probe by using calibrating sphere.
2. Fix the supporting stands on the granite table and adjust them according to the size of specimen.
3. Place the specimen on the supporting stands such a way that completely arresting its movement.
4. Set the reference plane, reference line and reference point for the given specimen.
5. Based on these references, measure the required dimensions of the given specimen.

Observation and Tabulation:



All dimensions are in mm

Fig. 14.2 Hexagonal specimen with centre hole

S.No.	Dimensions	Values (mm)
1.	Side of the specimen (a)	
2.	Diameter of centre hole (d)	
3.	Thickness of the specimen (t)	
4.	Distance between straight opposite corners	
5.	Slot length	
6.	Slot breath	

Result:

Thus the required dimensions of the given specimen are measured using Co-ordinate Measuring Machine.

Inference:

I have gained hands on experience in measuring the various dimensions of the given specimen using Co-ordinate Measuring Machine.

Applications:

A coordinate measuring machine (CMM) is a device for measuring the physical geometrical characteristics such as geometric dimensioning and tolerancing (GD&T), parallelism, perpendicularity, circularity, cylindricity etc. of an object. It is also used in manufacturing and assembly processes to test a part or assembly against the design intent.

PROGRAM OUTCOMES (POs)

Mechanical Engineering Graduates will be able to

1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to 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 research 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 modeling 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 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.

K.L.N. COLLEGE OF ENGINEERING

VISION

To become a Centre of Excellence in Technical Education and Research in producing Competent and Ethical professionals to the Society.

MISSION

To impart Value and Need based curriculum to the students with enriched skill development in the field of Engineering, Technology, Management and Entrepreneurship and to nurture their character with social concern and to pursue their career in the areas of Research and Industry.

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