Expt. No.1

CALIBRATION OF LOAD CELL

Aim: To calibrate given load cell by actual load.

Apparatus: Load cell of (10 kg capacity), dead weights and digital load indicator.

Theory: Weighing load/force using spring deflection is widely accepted one. But the deflection of spring reading mechanically is very tedious and time consuming. One of the most effective and accurate method is using strain gauge based load cells. Using the principle of deflection of high tensile strength material when load is applied on it and converting it into proportional electrical signal by using strain gauges will give accurate way of measuring load.

Strain gauges are bonded on the columns of corrosion resistance super tough alloy of high tensile strength steel that deforms very minutely under load. This deformation is converted to electrical signal through strain gauges bonded on the column and connected to form a wheat stone bridge. This electrical output is proportional to the load acting on the columns. The out put of the load cell is calibrated with reference to some standard i.e., primary standard i.e. dead weights.

A load cell is a transducer. In which the load is measured by subjecting a mechanical member to the load and measuring the strain developed in the mechanical member.

Procedure:

1. Connect the load cell to digital indicator inserting the corresponding colour codes.
2. Connect the digital indicator to mains and switch on the indicator.
3. Adjust the zero knob of the indicator to 0000.
4. Apply the weights up to 08 kg.
5. Apply the ‘Cal’ knob of the indicator to read 78.48 N. i.e. (9 x 9.81 N).
6. Remove weights form the load cell.
7. Set the zero knob to zero and repeat the calibration.
8. Now instrument is ready for measurement
9. Keep the weights one by one and take down the indicator reading.
10. Calculate the correction, error and % error.

Tabular Column

Sl. No	Actual Load in N	Indicated Load in N			% Error
		Increasing	Decreasing	Average	
1					
2					
3					
4					
5					
6					
7					
8					

Specimen calculation:

Correction = Actual Load - Indicated Load

Error = Indicated Load - Actual Load

$$\% \text{ Error} = \frac{\text{Actual Load} - \text{Indicated Load}}{\text{Actual Load}} \times 100$$

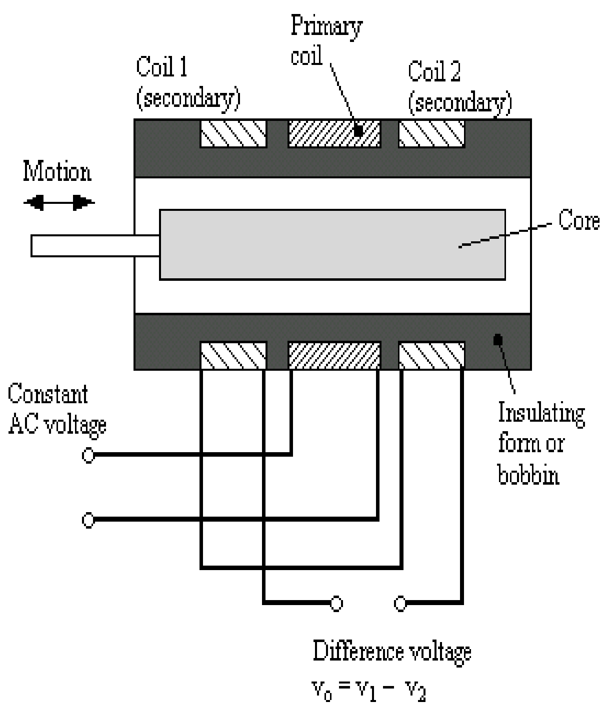
Graphs:

1. Indicated Load **v/s** Actual Load.
2. Indicated Load **v/s** % Error.

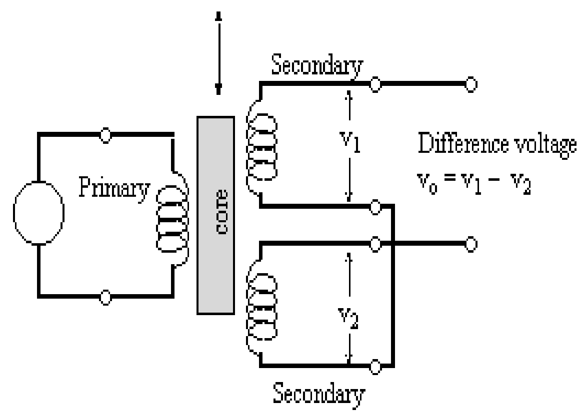
Results:

Working Sheet

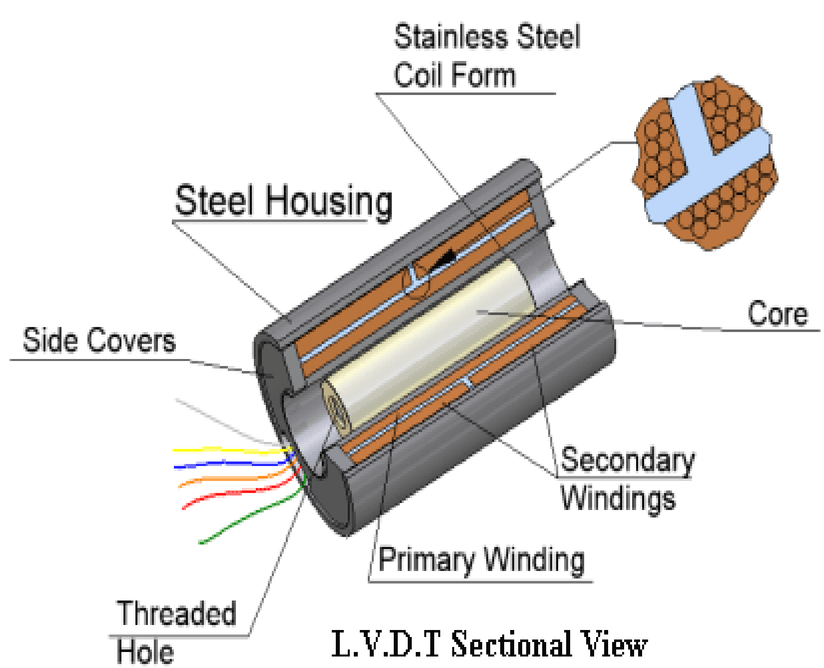
L . V . D . T



L.V.D.T Schematic Diagram



L.V.D.T Circuit



L.V.D.T Sectional View

Expt. No. 2

CALIBRATION OF L.V. D. T

Aim: To measure the displacement of core using linear variable differential transducer.

Apparatus: LVDT with Micrometer, (±10 mm Capacity) Digital displacement Indicator.

Theory: LVDT is a mutual inductance Transducer device which produces an A C Voltage output proportional to the displacement of a core passing through the windings. It consists of a primary A C Coil on each side of which are mounted to secondary coil wired in series opposition along the axis of three coils an iron core is mounted. The movement of the iron core causes the induced emf in the secondary coils to vary and because of their series opposition connection their combined output will be the difference of emf's induced. Thus the output voltage of the device is an indication of the displacement of the core. When operating in the linear range, the device is called L V D T.

Since the secondary coil is connected in series opposition, a null position exists at which the net output voltage is essentially zero. The out put voltage undergoes an 180^{O} phase shift from one side of the null position to the other.

In the practical differential transformer is always a capacitive effect between the primary and secondary coils which results in a small out put voltage even when the induced emf's in the secondary coils are in equal opposition. This is normally less than one percent of the maximum voltage. L V D T provides comparatively high out put and is also insensitive to temperature.

Procedure:

1. Connect the L V D T and Digital displacement meter to main supply.
2. Adjust the zero pot of the displacement indicator to indicate zero.
3. Connect the L V D T sensor to the displacement indicator through the cable.
4. Rotate the micrometer knob to clock wise or antilock direction, to bring the L V D T core to null position of the sensor. Where there is no induced emf. At this position indicator will read zero. Note down the micrometer reading. This is initial reading of micrometer.
5. Now move the core to any one side of the null position by slowly rotating the micrometer knob to clockwise or anti clock wise direction until it reads ±10 mm in the micrometer. Note down the reading and adjust the calibration of the instrument read 10 mm in the indicator

6. Repeat the above operation (4^{th} & 5^{th}) once more. Now the given L V D T is calibrated.
7. Now bring the LVDT to null position, rotate micrometer to clockwise or anticlockwise by 1mm or 2 mm and note down readings in the micrometer as well as of displacement indicator.
8. Repeat the experiment for different position of the core and note down the reading of micrometer and displacement indicator, simultaneously in every step.
9. Calculate the error if any and percentage error.

Tabular Column

SL No.	Micrometer Reading in mm	LVDT Reading (Positive)	LVDT Reading (Negative)	Percentage Error for $+^{ve}$ displacement	Percentage Error for $-^{ve}$ displacement
1					
2					
3					
4					
5					
6					
7					
8					

Specimen calculation:

$$\% \text{ Error} = \frac{\text{Micrometer Reading} - \text{LVDT Reading}}{\text{Micrometer Reading}} \times 100$$

Graph:

1. L V D T reading **v/s** Core displacement.
2. L V D T reading **v/s** % error.

Results:

Expt. No. 3

CALIBRATION OF PRESSURE CELL

Aim: To calibrate the given pressure cell.

Apparatus: Pressure cell, Dial type pressure cell indicator, Digital pressure Indicator.

Theory: Electro Mechanical Transducers are becoming very much popular in the measurement system. For pressure measurement barometer, manometer and Burden tube pressure gauges are analog type and pure mechanical type, unbounded resistance element type, bonded strain gauges type, inductive type, piezo electric type is the electromechanical type transducer.

Pressure cells, which are calibrating here is bonded strain gauges type. Strain gauges are bridged (wheat stone bridge) and supplied by excitation voltage, Strain gauges sense the deflection of diaphragm, this deflection is calibrating in terms of pressure using dead weight pressure gauge tester.

Procedure:

1. Make sure that dead weight pressure tester is filled with oil. To fill oil, fill the oil fully in the oil cup provided. Move the plunger to and fro so that all the air inside the reservoir will be filled with oil completely.
2. Connect the pressure cell to the pressure indicator through given cable.
3. Connect the instrument to mains i.e., 230 volts power supply and switch on the instrument.
4. Check up the dead weight pressure tester plunger is to the extreme end so that there should not be any load or pressure on the piston.
5. Now adjust the zero point of the indicator, to indicate zero.
6. Apply the load of 10kg on the piston.
7. Move the plunger to apply pressure on the piston. When applied pressure reaches 10 kg/cm^2, piston will start moving up.
8. Now read the pressure gauge reading and adjust the cal pot of the indicator to same pressure, as the analog reading. Now the given pressure cell is calculated.
9. Release the pressure fully by rotating the plunger.
10. Load the piston by one kg; apply the pressure by rotating the plunger. At a

Pressure of one kg /cm^2, piston starts lifting up. Note down the reading.

11. Repeat the experiment for different loads on the piston step by step, and note down the readings of dial gauge and pressure indicator, simultaneously in every step.

12. Calculate the percentage error and plot the graph.

Tabular Column:

SL No.	Actual Pressure in Newton's	Indicated Pressure in Newton's			% Error
		Increasing	Decreasing	Average	
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Specimen Calculation:

$$\% \text{ Error} = \frac{\text{Actual Pressure} - \text{Indicated Pressure}}{\text{Actual Pressure}} \times 100$$

Graphs:

1. Indicated Pressure **v/s** Actual Pressure
2. Indicated Pressure **v/s** Percentage error

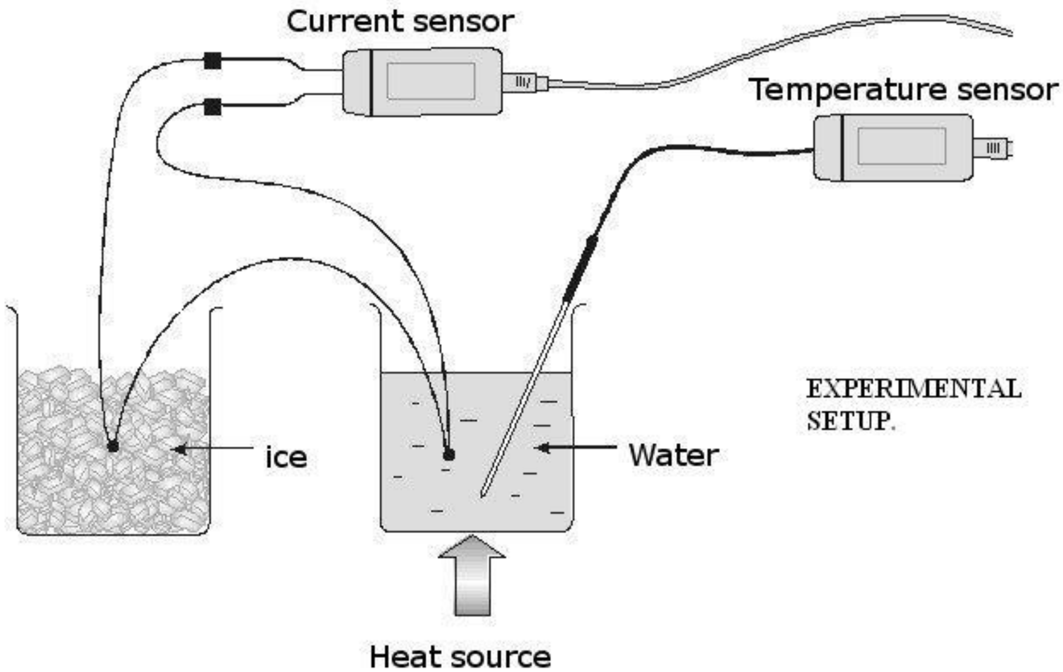
Specifications:

Capacity : 10 kg / cm$^{2.}$
Type : Strain gauge type.
Sensing Element : Foil type strain gauges.
Over Load : 10 % rated capacity.
Operating Temp : 10^0 C to 50^0 C.
Excitation : 10 volts D C.
Resistance in ohm's : 350 Ohms typical.

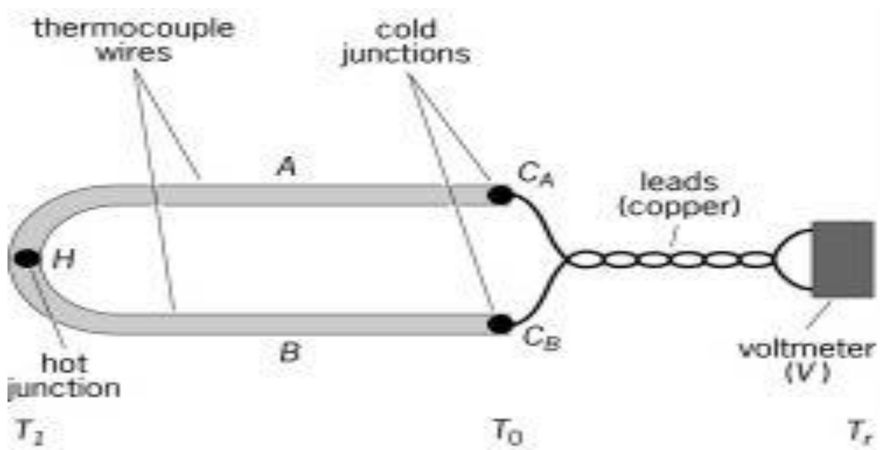
Results:

Working Sheet

THERMOCOUPLE



EXPERIMENTAL SETUP.



Expt. No. 4

CALIBRATION OF THERMO COUPLE

Aim: To calibrate the given thermo couple using Resistance thermometer.

Apparatus: Thermocouple, Resistance thermometer, Digital temperature Indicator, Water bath.

Theory: The common electrical method of temperature measurement uses the thermocouple, when two dissimilar metal wires are joined at both ends an emf will exist between the two junctions, if the two junctions are at different temperature this phenomenon is called set back effect. If the temperature of one junction is known then the temperature of the other junction may be easily calculated using the thermo electric properties of the materials. The known temperature is called reference temperature and is usually the temperature of ice. Potential electromotive force (emf) is also obtained if a temperature gradient exists along the metal wires. This is called Thomson effect and is generally neglected in the temperature measuring process. If two materials are connected to an external circuit in such a way that current is drawn, an emf will be produced. This is called as peltier effect. In temperature measurement set back emf is of prime concern since it is dependent on juncture temperature.

The thermocouple materials must be homogeneous. A list of common thermocouple materials in decreasing order of emf is chromel, iron, copper, platinum, 10 % rhodium, Alumel and constantan (60% copper & 40% nickel). Each material is thermoelectrically positive with respect to those below it and negative with respect to those above.

Specifications: The material used in the thermocouple probes are

1. Iron -Constantan ‘J’ type: 0 to 600^0 C
2. Copper -Constantan ‘T’ type: 0 to 400^0 C
3. Chromel- Alumel ‘K’ type: 0 to 1000^0 C

Procedure:

1. Turn the type selector to the desired position according to the given T.C. probe.
2. Connect the RTD (Resistence Temperature Detector) probe to the resistance temperature detector display.
3. Connect the given thermocouple to the thermocouple temperature display.
4. Place the thermocouple hot junction and the RTD probe into a beaker containing water at room temperature.
5. Connect the power supply to the temperature indicator.
6. Record the room temperature from the RTD temperature indicator.

7. Adjust the zero setting knob of the thermocouple temperature indicator until the display shows the room temperature.
8. Connect the power supply to heating coil & heat the water in the water bath.
9. Set the temperature of thermocouple to the temperature of RTD indicator when the Water is boiling, using CAL knob.
10. Now the given thermocouple is calibrated with reference to RTD.
11. Record the RTD and thermocouple temperature indicator reading simultaneously at regular intervals.

Observations and Tabular column:

RTD type:

Materials for thermocouples wires = ‘J’ type

SL No.	Temp of Water by RTD t_a (°C)	Temp of Water by Thermocouple t_m (°C)	Correction $t_a - t_m$	Error $t_m - t_a$	% Error
1					
2					
3					
4					
5					
6					

Specimen Calculation:

$$\% \text{ Error} = \frac{\text{RTD - Thermocouple}}{\text{RTD}} \times 100$$

Graphs: Draw the following graphs.

1. t_m **v/s** t_a
2. Correction **v/s** t_m
3. % Error **v/s** t_m

Results:

Expt. No. 5

MEASUREMENT OF STRAIN

Aim: To determine the elastic constant (modulus of elasticity) of a cantilever beam subjected to concentrated end load by using strain gauges.

Apparatus: Cantilever beam, Strain Gauges and strain indicator.

Theory: A body subjected to external forces is in a condition both stress and strain. Stress cannot be directly measured but its effects, i.e. change of shape of the body can be measured. If there is a relation ship between stress and strain, the stresses occurring in a body can be computed if sufficient strain information is available. The constant connecting the stress and strain in elastic material under the direct stresses is the modulus of elasticity. i.e. $E=\sigma /\varepsilon$

The principle of the electrical resistance strain gauge was discovered by Lord Kelvin, when he observed that a stress applied to a metal wire, besides changing its length and diameter, also changes its electrical resistance. Metallic electrical strain gauges are made in to two basic forms, bonded wire and bonded foil. Wire gauges are sand witched between two sheets thin paper and foil gauges are sand witched between two thin sheets of epoxy.

The resistance **R** of a metal depends on its electrical resistivityρ, its area **a** and the length **l** according to the equation. $R= \rho l / a$.

Thus to obtain a high resistance gauge occupying a small area the metal chosen has a high resistivity, a large number of grid loops and a very small cross sectional area. The most common material for strain gauges is a copper- nickel alloy known as advance.

The strain gauge is connected to the material in which it is required to measure the strain, with a thin coat of adhesive. Most common adhesive used is Eastman, duco cement, etc. As the test specimen extends are contracts under stress in the direction of windings, the length and cross sectional area of the conductor alter, resulting in a corresponding increase or decrease in electrical resistance.

Specification of Cantilever Beam

Capacity	: 1 kg.
Type	: Strain gauge based.
Strain Gauge	: Foil type, 120 ohms.
Gauge Factor	: 2
Weights	: 100 gms-10 Nos.
Beam width	: 40 mm.

Beam Thickness	: 2.5 mm.
Display	: 3.5 Digit LED displays.
Accuracy	: 1 %.
Resolution	: 1 μs.
Connection	: Through four cores shielded cables.
Power Required	: 230 */-10%. 50 Hz.

Strain Measurement in Four Arm Modes (Full bridge)

Procedure:

1. Switch on the instrument and leave 15 minutes to warm up.
2. Connect the respective colored wires of sensors to terminals in the indicator panel.
3. Keep the arm selector switch on 4.
4. Keep the function switch to gauge factor and adjust the gauge factor pot, to read 500 in display.
5. Select the function switch to cal and adjust the cal pot to read 1000.
6. Keep the function switch to read and adjust the display to read zero.
7. Apply load 100 gms step by step and note the readings.
8. Calculate the Young's Modulus and compare the value with theoretical value.

Observation:

Distance between gauge centers to the point application of load 1 mm = 280 mm.

Width of beam, b in mm = 40 mm.

Thickness of beam t = 2.5 mm.

Tabular Column:

SL No.	Load Applied W in (N)	Strain Indicator Reading ε micro strain	Measured strain $\varepsilon m = \varepsilon \times 10^{-6}$	Tensile Stress $\sigma = 6wl / bh^2$	Modulus of Elasticity $E = \sigma / \varepsilon m$ (N/nm^2)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Specimen calculation:

Load Applied, W = 200 x 9.81 / 1000 = 1.962 N.

Bending Stress, $\sigma = 6Wl / bt^2 = 6 \times 1.962 \times 280/40 \times 2.5^2 = 13.2$ N / mm^2

For Four Arm Modes, (Full Bridge)

Measured Strain, $\varepsilon m = \varepsilon \times 10^{-6}/4 = 264 \times 10^{6}/4 = 0.000066$

Young's modulus, $E = \sigma/\varepsilon m = 13.2/0.000066 = 200 \times 10^{5}$ N/mm^2

Results:

Strain Measurement in Two Arm Modes (Half bridge)

Procedure:

1. Switch on the instrument and leave 15 minutes to warm up.
2. Connect the respective colored wires of sensors to terminals in the indicator Panel.
3. Remove the center pin in the sensor part and green pin in the indicator panel.
4. Keep the arm selector switch on 2.
5. Keep the function to gauge factor and adjust the gauge factor pot to read 500 in display.
6. Select the function switch to cal and adjust the cal pot to read 1000.
7. Keep the function switch to read and adjust the display to read zero.
8. Apply load of 100 gms gradually and note down the reading.
9. Calculate the Young's Modulus and compare the value with theoretical value.

Observation and Tabular Column:

Distance between gauge centers to the point application of load 1 mm = 280 mm.

Width of beam, b in mm = 40 mm.

Thickness of beam t = 2.5 mm.

SL No.	Load Applied W in (N)	Strain Indicator Reading ε micro strain	Measured strain $\varepsilon m = \varepsilon \times 10^{-6}$	Tensile Stress $\sigma = 6wl/bh^2$	Modulus of Elasticity $E = \sigma/\varepsilon m$ (N/nm^2)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

For Two Arm Modes, (Half Bridge)

Measured Strain, $\varepsilon m = \varepsilon \times 10^{-6}/2 = 132 \times 10^{6}/2 = 0.000066$

Young's modulus, $E = \sigma/\varepsilon m = 13.2/0.000066 = 200 \times 10^{5}\ N/mm^2$

Strain Measurement in Two Arm Modes (Quarter Bridge)

Procedure: Remove the center pin in the sensor part and black pin in the indicator panel. Remaining is same as half bridge.

Observation and Tabular Column

Distance between gauge centers to the point application of load 1 mm = 280 mm.

Width of beam, b in mm = 40 mm.

Thickness of beam t = 2.5 mm.

SL No.	Load Applied W in (N)	Strain Indicator Reading ε micro strain	Measured strain $\varepsilon m = \varepsilon \times 10^{-6}$	Tensile Stress $\sigma = 6wl / bh^2$	Modulus of Elasticity $E = \sigma/\varepsilon m$ (N/nm^2)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

For Single Arm Modes, (Quarter Bridge)

Measured Strain, $\varepsilon m = \varepsilon \times 10^{-6} = 66 \times 10^{6} = 0.000066$

Young's modulus, $E = \sigma/\varepsilon m = 13.2/0.000066 = 200 \times 10^{5}$ N / mm^2

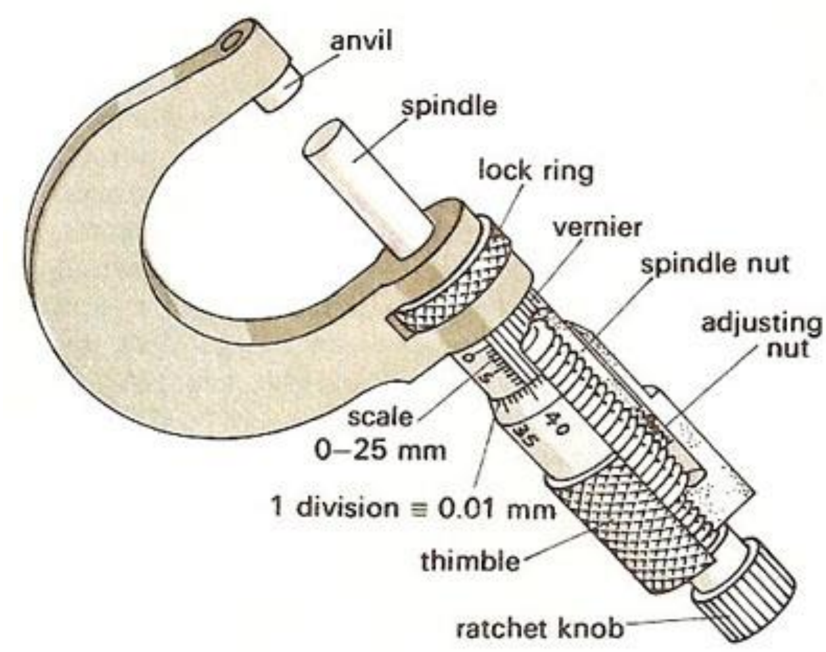
Graphs:

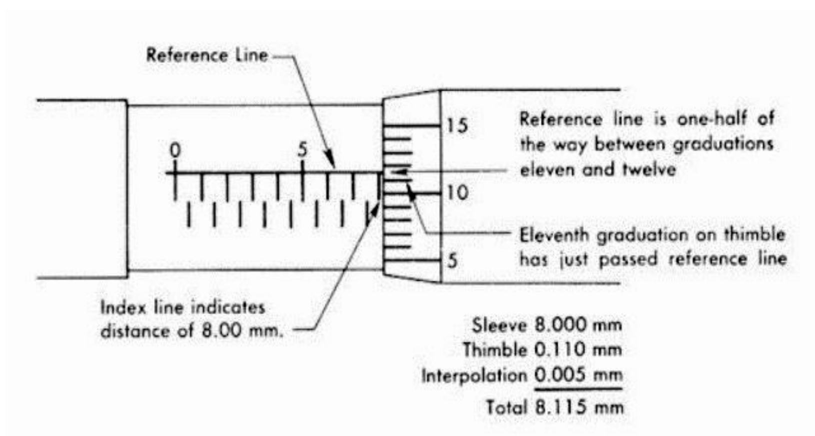
By plotting the graph, εm as the base and σ as the ordinate, a straight line is obtained from which the slope can be found.

Modulus of elasticity E = slope of the line

Results :

MICROMETER





Micrometer thimble reading 5.78mm

Expt. No. 6

CALIBRATION OF EXTERNAL MICROMETER

Aim: To calibrate the given micrometer for Progressive and periodic pitch errors by using slip gauge end standards.

Apparatus: Micrometer (0 - 25 mm range), micrometer holding device, slip gauge sets, clean dry soft cloth, cleaning agent like acetone or benzene.

Theory: In engineering measurements the values are needed to 3rd decimal place in the metric system. This cannot be obtained by ordinary rule. So to get précised readings micrometers are used. While manufacture of micrometers so many types of errors will occur, in that pitch errors are one of the known errors. Pitch errors are errors in the effective diameter. Helix measured parallel to the axis of the screw thread and are of three types namely

1. Progressive error
2. Periodic error
3. Erratic errors.

The method of manufacture of micrometer screws eliminates the last error. But three may be a progressive and periodic error.

Progressive Error: If the pitch of the thread is uniform but is longer or shorter than its nominal value. Such an error is called Progressive error. This type of errors occurs when

1. Tool work velocity ratio is incorrect
2. Change in length due to hardening by error in the pitch of the lead screw
3. Due to fault in the saddle guide ways
4. Due to the use of an incorrect gear train between work and tool. The Progressive errors are progressive in nature as the length of axis increases or almost obeys straight line path.

Periodic Error: Periodic errors are those, which vary in magnitude along the length of the thread and repeats at regular intervals. If the recur at every revolution the thread is called drunken and is shown in figure.

The deviation from true helix occurs on adjacent threads at the same fraction of a resolution, both the pitch remains constant and such an errors cannot be detected by measuring along a line parallel to the axis. Errors of these types are most frequently caused by lack of square ness in the thrust bearing of the lead screw used to produce the thread. If the pitch of screw being cut is not equal to that of lead screw this fault in the thrust bearing will cause a Periodic error. Recurring at other intervals, Periodic errors are also caused by the incorrect velocity ratio between work and the tool. Such an error is determined by measuring along a line parallel to helix. Other sources of Periodic errors are eccentric mounting of the gears, errors in the teeth of the gear etc.

Procedure:

1. Clamp the micrometer to the micrometer stand to avoid errors caused by expansion due to heat by handling.
2. Check for smooth running of micrometer spindle through its length. Note down the least count of the micrometer
3. Note down the Initial error in the Micrometer. This can be done by taking readings with measuring faces in contact.
4. Slip gauges are made ready 10 minutes before required and these can be held with the help of clean dry soft cloth during use.
5. For Progressive error take a reading of micrometer by placing slip gauges 2.5 to 25 mm in steps of 2.5 mm in between measuring faces of micrometer and tabulate in tabular column.
6. For Periodic error take a reading of micrometer by placing slip gauges 2.1 to 20.5 in steps of 0.1mm and 20 to 20.5 in steps of 0.1mm in between measuring faces.
7. The readings for periodic pitch errors are taken as two positions of the spindle one near each end of its travel.
8. Plot the following graphs
9. Progressive errors **v/s** Nominal slip gauges used
10. Periodic errors **v/s** Nominal slip gauges used

Observations:

1. Least count of the Micrometer __________________ mm

2. Initial error in the Micrometer __________________ mm

Tabular Column for Progressive Error

SL No.	Nominal size of slip gauge used in mm.	Actual size of slip gauges in micrometer in mm	Progressive error in mm
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

At nominal reading ____________________ mm
1. Progressive error ____________________mm
2. Periodic error ____________________ mm

Total error ____________________ mm

Tabular Column for Periodic Error

SL No.	Nominal size of slip gauge used in mm	Actual size of slip gauges in micrometer in mm	Periodic errors In mm
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Specimen calculation:
For SL No. __________

1. Actual size of slip gauge = MSR + VSR x LC ± Initial Error in mm.
2 Progressive / Periodic Error = Micrometer Reading - Nominal Slip Gauge used in mm.

Results:

MONOCHROMATIC LIGHT SOURCE

Expt. No. 7

MEASUREMENTS OF FLATNESS BY USING MONOCHROMATIC CHECK LIGHT

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

Apparatus: Optical flat, monochromatic light source, dry soft cloth, cleaning agent.

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

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

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

Procedure:

1. Clean the surface to be tested to become shiny and wipe if with dry clean cloth
2. Place the optical flat in between flatness of work piece to be tested and monochromatic sources of light i.e. on the work piece.
3. Both parts and flat must be absolutely clean and dry.
4. After placing optical flat over work piece switch on the monochromatic source of light and wait until getting yellowish or orange colour.
5. Apply slight pressure over optical and adjust until getting steady band approximately parallel to the main edges.

6. Count the number of fringes obtained on the flat with the help of necked eye and calculate the flatness error.

Observations:

1. Type of monochromatic source of light.
2. Wavelength of Monochromatic source of light.

$\lambda/2$ = __________ mm. Where $\lambda = 0.0002974$

Tabular Column:

SL No.	No. of fringes observed 'N'	Flatness error	Remark on type of surface with sketch

Calculations:

Flatness error= $N \times \lambda/2$

Results:

Expt. No. 8

STUDY OF MECHANICAL COMPARATOR

Aim: To compare the dimensions of given mass produced product with designed tolerance standard by using mechanical comparator.

Apparatus: 50 No's of product to be tested, Mechanical comparator with dial gauge and slip gauges for setting standard.

Theory: Comparator is the instrument used to compare the unknown dimension with one of the reference standard known as designed specification .the purpose of comparator is to detect and display the small difference between the unknown and the standard. The deviation in size is detected as the displacement of sensing device. The important and essential function of the instatement is to magnify the small input to displacement. The magnification required is greater than 1000: 1. The relationship between the input and output affected by the readings in the direction of input and this reveals that the movement should not have any backlash.
The major disadvantage of mechanical comparator is that, it is very difficult to recompute the arrangement for the adjustment of magnification.

Dial gauge is one of the Mechanical components which are used in laboratories. It has contact tip, graduated circular scale, plunger and clamp. Dial gauge works on the rack and pinion principle

Types: Mechanical, Electrical, Pneumatic and optical dial gauges

Procedure

1. Clean the sensors of the comparator and the surface table of the comparator.
2. Note down the actual measurement of each product by micrometer.
3. Slip gauge of specified basic size is placed on the surfaces of comparator table and here slip gauge serves as a setting standard have specified size.
4. Adjust the tolerance read needles to the specified size on either side of the zero reading by using screw knobs provided on the comparator.
6. Adjust the comparator needle, which is reading actual dimension to zero reading by using corresponding knobs (vertical movement)
7. After initial adjustment of comparator remove the setting standard.

8. Placethe given product for test in-between the sensors and surface of Comparator table.
9. Note down the readings of dial indicator provided in comparator. If the readings are within the tolerance needles the product can be accepted if it lies outside the tolerance needle the product can be rejected.
10. The product following within certain tolerance ranges are grouped together according to sequence of test and tabulated in the tabular column.
11. The above procedure is repeated for all products.
12. Plot the histogram and normal curve of frequency of product V/s group Nos.

Observations:

1. Name of the product to be tested = -------------------
2. Least count of the comparator = ---------------------- mm.
3. Specified designed dimensions with tolerance = ------------- mm ± ------ μ
4. No of product to be tested = ---------------------------
5. Size of setting gauge used = -------------------------mm

Tabular Column:

SL No.	Group range in Nos.	Error Frequency		Rejected
		Positive	Negative	
1	0 – 5			
2	6 – 10			
3	11– 15			
4	16 – 20			
5	21 – 25			
6	26 – 30			
7	31 – 35			
8	36 – 40			
9	41 – 45			
10	46 – 50			

No. of products rejected during the test =
Specified designed dimensions. = MSR + VSR x LC ± Initial error in mm ± ____ μ

Results:

Working Sheet

BEVEL PROTRACTOR

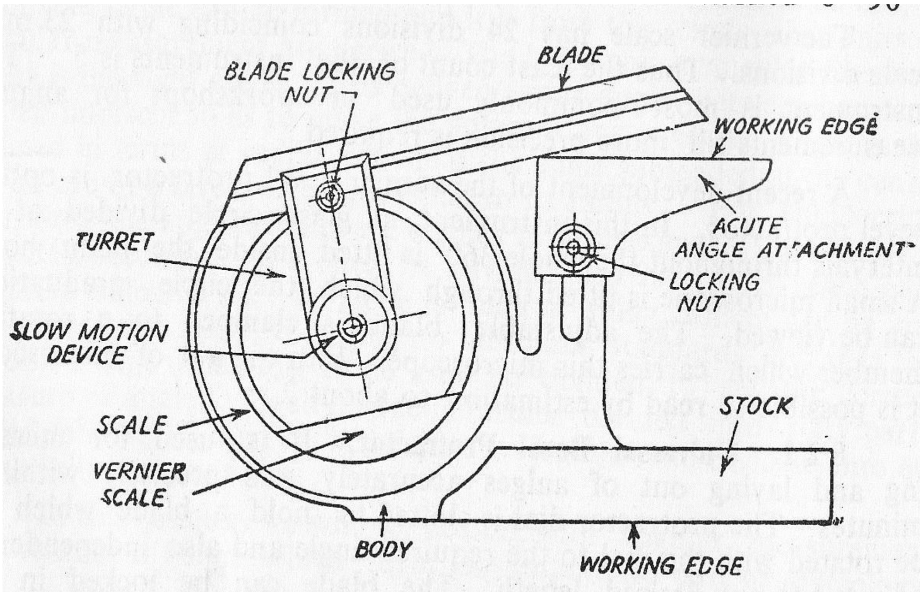


Fig. Mechanical Bevel Protractor with Vernier and acute angle attachment.

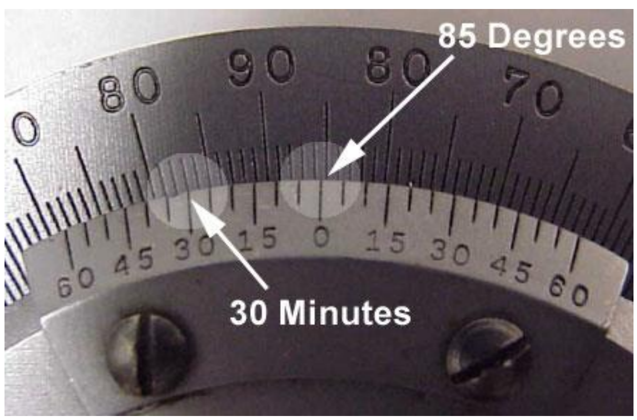


Figure: always read the vernier in the same direction that you read the dial

Expt. No. 9

MEASUREMENT OF TAPER ANGLE USING BEVEL PROTRACTOR

Aim: To find out the taper angle of given work piece by using Bevel Protractor.

Apparatus: Surface Plate, Bevel Protractor, Tapered work piece.

Theory: It is used for measuring and lying out of angles accurately and precisely within 5 minutes. The protractor dial is slotted to hold a blade which can be rotated with the dial to the required angle and also independently adjusted to any desired length. The blade can be locked in any position.

It is the simplest instrument for measuring the angle between two faces of component. It consists of base plate attached to the main body and an adjustable blade which is attached to a circular plate containing vernier scale. The adjustable blade is capable of rotating freely about the centre of the main scale engraved on the body of the instrument and can be locked in the any position. It is capable of measuring from zero to 360^0. The vernier scale has 24 divisions coinciding with 23 main scale divisions. Thus the least count of the instrument is 5^1.

This instrument is most commonly used in work shop for angular measurements.

Procedure:

1. Note down the least count of the Bevel Protractor.
2. Keep the work piece on the surface plate.
3. Fix the slide of Bevel Protractor to the Turret.
4. Keep one of the surfaces of the specimen on the working edge and rotate the turret. Remove the slide on to the other surface.
5. Fix the centre, after matching the both the faces and note down the reading.
6. Repeat the experiment for different faces

Observations:

Least count of the Bevel Protractor ___________________ mm

Initial error in the Bevel Protractor ___________________ mm

Least count = N/n = $\frac{\text{Value of 1 Main scale Division}}{\text{No of divisions on Vernier Scale}}$

L.C. $= 1^0/12$

L.C. $= 60^1/12$

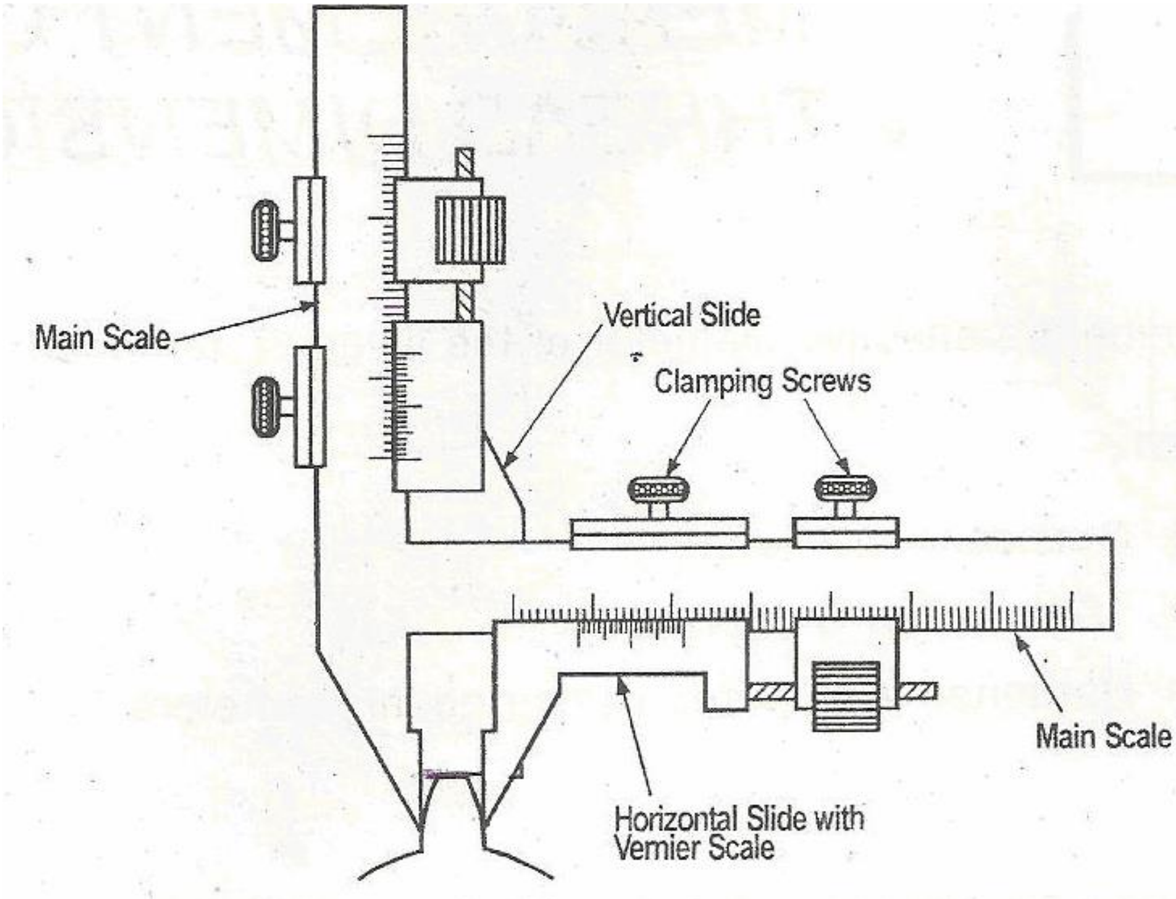
L.C. $= 5^1$

SL No.	Faces	Angles
1		
2		
3		
4		

Results:

Working Sheet

GEAR TOOTH VERNIER CALIPER



Expt. No. 10

MEASUREMENT OF GEAR TOOTH USING VERNIER CALIPER

Aim: To determine the tooth thickness and other parameters of a gear by using Gear tooth vernier caliper.

Apparatus: Gear Tooth vernier Caliper, vernier caliper, Spur gear preferably 50mm to 75 mm in dia. etc.

Theory: The measurement of element of Spur gear depend on the geometrical principle of the involute gear that the distance between parallel lines embracing several teeth is constant and is equal to the are on the base circle intersected by the extreme points.

The principle will naturally be strictly true only for a gear, which is perfect on tooth from, pitch concentricity etc. Therefore select precision gear, preferably ground and known to have only small errors in these elements. In measurements of gear tooth the following elements are checked.

Pitch circle diameter: It is the diameter of the pitch circle. Which by pure rolling action would produce the same motion as the toothed gear? The size of the gear usually specified by Pitch circle diameter

Module: It is the ratio of the Pitch circle diameter in a millimeter to the number of teeth or it is the length of the Pitch circle diameter per tooth. It is usually denoted by 'm'.

Addendum: It is the radial distance of the tooth from the pitch circle to the top or tip of the tooth.

Deddendum: It is the radial distance of the tooth from the pitch circle to the bottom of the tooth.

Tooth thickness: It is the width of the tooth measured along the pitch circle

Blank diameter: This is the diameter of the blank from which gear is cut.

Procedure:

1. Note down the least count of the gear tooth vernier caliper and vernier caliper
2. Measure the diameter of gear blank using vernier caliper also count the number of teeths on the gear blank.
3. Calculate the addendum of the gear tooth and fix the same dimension in vertical vernier scale and use the horizontal scale to measure the thickness of the gear tooth over the pitch line.
4. Measure the same parameters for different teeths.

5. Take the average of tooth thickness.
6. Calculate all other parameters using the formulae.

Observation:

1. Least count of the gear tooth caliper ________________ mm
2. Least count of the vernier caliper ________________ mm
3. Initial error in the caliper ________________ mm
4. Number of teeth on the gear Z = ________________

Calculations:

1. Diameter of gear blank, D = MSR + (VSR X LC) ± Initial Error in mm
2. Number of teeth's on gear Z = Z + 2
3. Module m = D/z
4. Theoretical thickness of tooth, W_t = Z x m x sin (90/Z) in mm
5. Cordal addendum d_a = Z x m/2 [1 + 2/Z – Cos (90/Z)] in mm

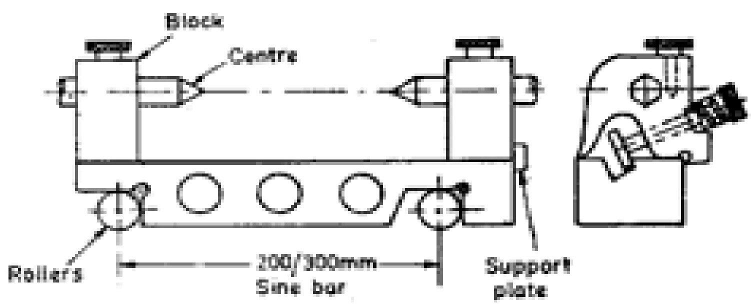
Tabular Column

SL No.	Tooth thickness measured 'mm'	Tooth thickness calculated 'mm'	Difference
1			
2			
3			
4			
5			

Results:

Working Sheet

SINE CENTRE



Expt. No. 11

MEASUREMENT OF TAPER ANGLE USING SINE CENTRE

Aim: To determine the taper angle of a given taper plug gauge by using sine centre.

Apparatus: Sine centre, Plug gauge, slips gauge, Surface Plate, Comparator with arrangement, cleaning agent with cotton.

Theory: The sine centers are used to measure the angles very accurately or for locating any work to a given angle within much closed limits. Sine centre are made from High Carbon, High Chromium corrosion resistant steel, hardened, ground and stabilized.

Two cylinders of equal diameter are attached at the ends, the axis of these two cylinders are mutually parallel to each other and also parallel to and equal distance from the upper surface of the sine center. The distance between the axes of the two cylinders is exactly 5^0 or 10^0 in British system and 100, 200, 300, mm in Metric system. Some holes are drilled in the body of the bar to reduce the weight and to facilitate handling. Sine centre itself is not a complete measuring instrument.

Another datum such as surface plate is used as well as auxiliary equipment notably slips gauges.

Procedure:

1. Note down the least count of the vernier caliper and dial gauge.
2. Measure the minimum, maximum diameter and axial length of taper plug gauge using vernier caliper.
3. Calculate approximate height of slip gauge using formula.
4. Build up the height using M-83 set of cleaning the surface of slip gauge using acetone liquid and use wringing technique to build the height.
5. Place the slips below one of the cylinder of sine centre which is placed above the surface plate.
6. Keep the plug gauge in between the sin centre.
7. Use the dial gauge with assembling to check the deviation from one end to other end of plug gauge and note down the deviations.
8. Add or subtract the value of the deviation to difference in dial gauge Reading (dh) and repeat the step 7 until zero reading occur in dial gauge and rebuilt the slips repeatedly.
9. Calculate the actual angle of taper plug gauge using actual slip heights.

Observations:

1. Least count of vernier caliper = __________ mm
2. Least count of dial gauge = __________ mm
3. Distance between the centre of rollers, L = ____________mm
4. Length of specimen (axial length), l = ____________ mm

Tabular Column

SL No.	Taper length of the specimen in mm 'l'	Initial reading of dial gauge 'h'$_1$ mm	Final reading of dial gauge 'h_2'in mm	Diff. of dial gauge reading $dh=(h_2-h_1)$	App. Ht. of slip gauge Read. H_{app}.	Actual Ht. of slip gauge Read. H_{act}	theoretical taper angle, θ_{th}	Actual taper angle, θ_{act}	Errors

Specimen Calculation:

1) Initial reading of dial gauge, h_1 = __________ mm
2) Final reading of dial gauge, h_2 = __________mm
3) Difference in dial gauge reading, $dh = (h_2 - h_1)$ in mm.
4) Approximate height of slip gauge used = h_{app}.

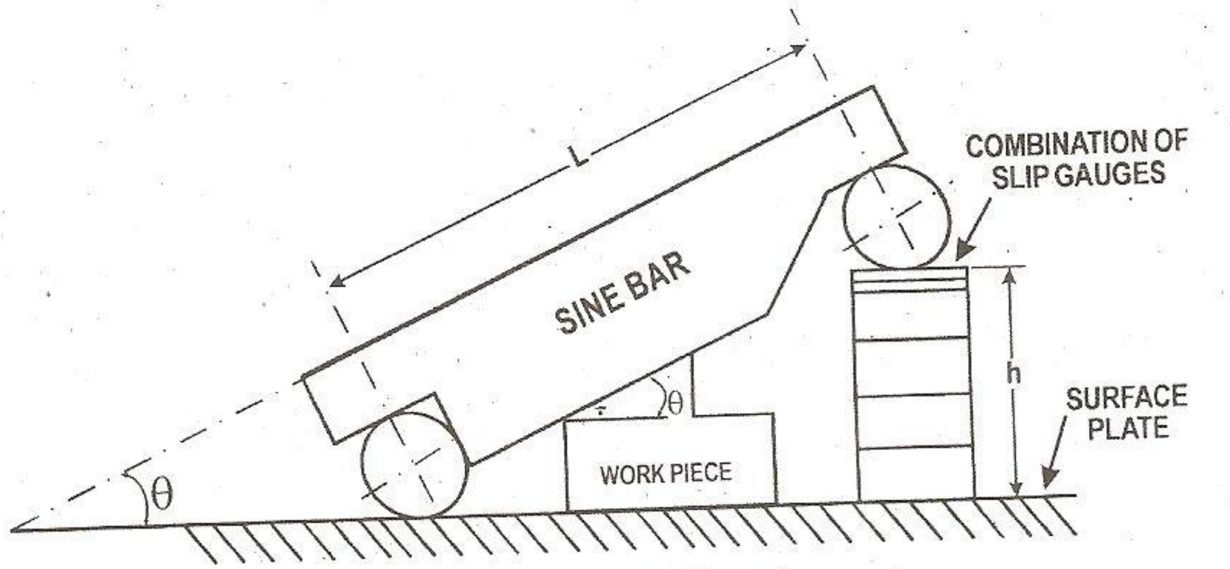
$$h_{app}. = \frac{dh \times L}{\sqrt{dh^2+l^2}} = \_\_\_\_\_\_\_\_\_\_ \text{ mm}$$

5) Theoretical taper angle, θ_{th} = tan-1(dh/l) = __________mm
6) Actual taper angle, θ_{act} = [sin-1 (H_{act})] /L = _________mm
7) Error θ_{act} - θ_{th} =___________mm

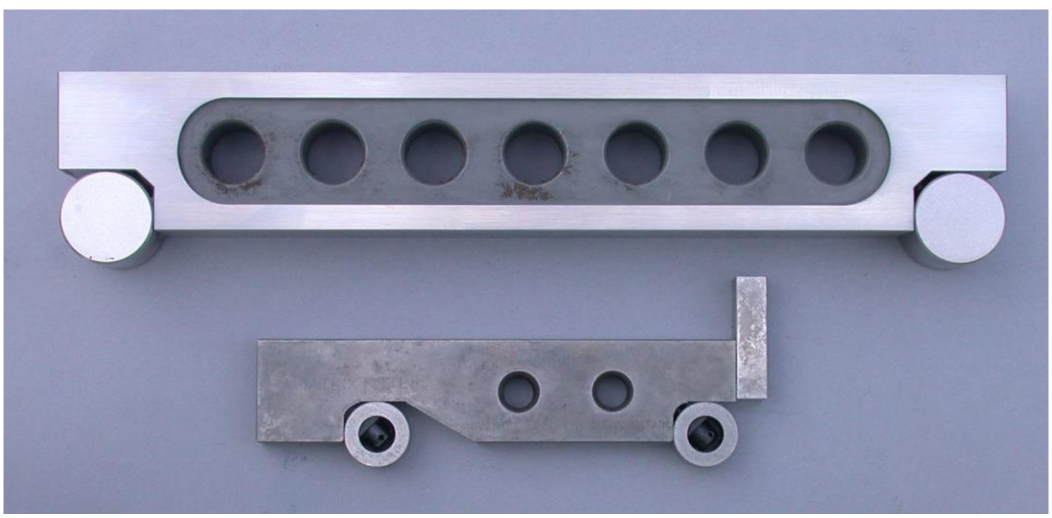
Results:

Working Sheet

SINE BAR



Measurement of angle
Using Sine bar



Expt. No. 12

MEASUREMENT OF TAPER USING SINE BAR

Aim: To determine the taper angle of the given work piece and compare it with theoretical value by using sine bar.

Apparatus: Surface plate, sine bar, slip gauge sets, Vernier caliper, cleaning agent, tapered work piece, clean dry soft cloth, clamping devices etc.

Theory: The angle is defined as the opening between the two lines or planes, which meet at a point. So angle is a thing which can be generated very easily requiring no absolute standard. Sinebars are used in junction with slip gauges constitute a very good device for the precision measurement of angles. Since sidebars are used either to measure angle very accurately or for locating any work to a given angle within very close limit. Sine bars are used only for measuring and setting any angle of the object having flat surface. Sine bars are also used to measure or set angle of the object not larger than the 45^0, if higher accuracy is demanded.
Sine bars are made from High Carbon, High Chromium corrosion resistant steel, hardened, ground and stabilized.

Procedure:

1. Set the sine bar on the surface plate.
2. Measure the distance between rollers of center of sine bar.
3. Mark the position of the rollers on the surface plate which is advantage if the position of sine bar is changed.
4. The axial length of taper under test is noted by use of vernier caliper.
5. The work piece whose taper is required to be known is fixed on the upper surface of the sinebar by means of clamp and so positioned that easily access whole length of the taper to the dial gauge.
6. The dial gauge is fixed on its stand which in term is fixed on the slide way.
7. Note down the least count of the dial gauge used.
8. Adjust the slip gauge height on the taper to be measure in such a way that it easily takes slip on the smaller end and note down dial gauge reading at the entry end.
9. By sliding the dial gauge across the work piece length take reading of the dial gauge on other end.

10. Calculate approximate height of slip gauge required at smaller dimension end in order to become an upper surface of the work piece parallel to the reference plane.
11. Without altering the position of the roller place the slip gauge pile under the roller of small size end of the sine bar set up toequal approximate height.
12. Then test with dial gauge for null deflection. If there is any slight deflection in dial gauge then alter slip gauges pile until getting null deflection.
13. With the help of formulas given in, calculate the acute angle and theoretical angle of taper and error in taper.

Observations:

1. Least count of vernier caliper = _____________ mm

2. Least count of dial gauge = _____________ mm

3. Distance between the centre of rollers & side bar L = _____________ mm

4. Length of specimen (axial length), l = _____________ mm

Tabular Column

SL No	Taper length of the specimen in mm 'l'	Initial reading of dial gauge 'h'$_1$ mm	Final reading of dial gauge 'h_2'in mm	Diff. of dial gauge reading $dh=(h_2-h_1)$	App. Ht. of slip gauge Read. H_{app}.	Actual Ht. of slip gauge Read. H_{act}	theoretical taper angle, θ_{th}	Actual taper angle, θ_{act}	Errors

Specimen Calculation:

1) Initial reading of dial gauge, h_1 = -------------- mm
2) Final reading of dial gauge, h_2 = --------------mm
3) Difference in dial gauge reading, $dh = (h_2- h_1)$ in mm.

4) Approximate height of slip gauge used = h_{app}.

$$h_{app.} = \frac{dh \times L}{\sqrt{dh^2+l^2}} \text{ -------------- mm}$$

5) Theoretical taper angle, θ_{th} = tan-1(dh/l) = ------------- mm

6) Actual taper angle, θ_{act} = [sin-1 (H_{act})] /L = ----------- mm

7) Error θ_{act} - θ_{th} =---------------mm

Results:

THREE WIRE METHOD

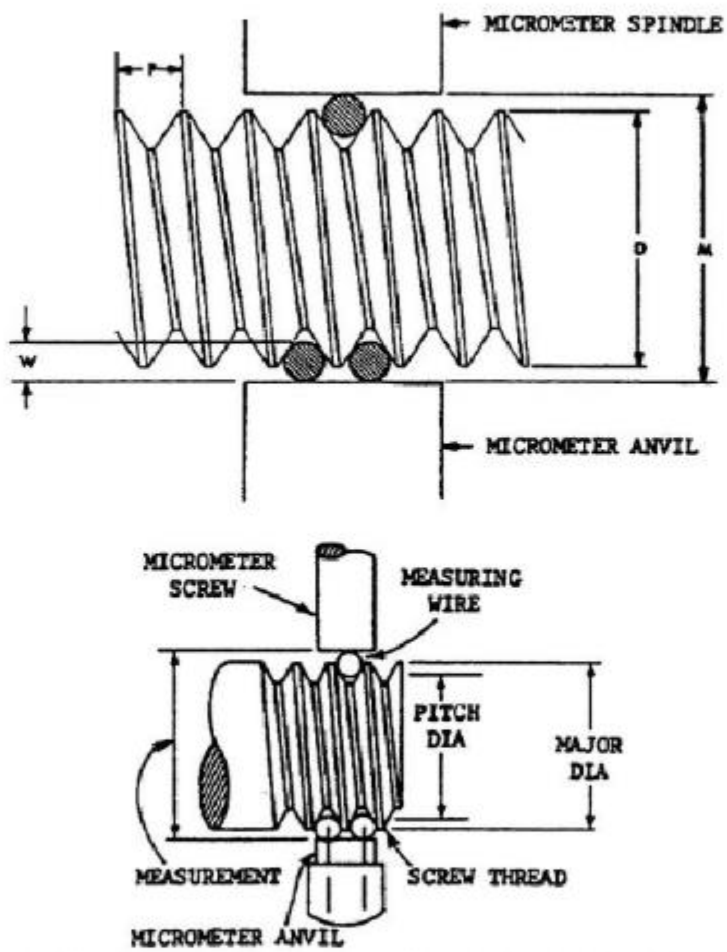


Fig: Holding Arrangement

Plugs

Expt. No. 13

THREE WIRE METHOD

Aim: To measure the effective diameter of a screw thread by using three wire method.

Apparatus: Micrometer, micrometer stand, a set of three wires, pitch gauge, and Screw thread specimen.

Theory: Effective diameter of screw thread is the diameter of pitch cylinder which is coaxial with the axis of the screw and intersects the flanges of the thread in such way as to make width of thread and the width of spaces between the threads equal. This is the most important dimension as it decides the quality of the fit between screw thread micrometer and two and three wire method.

Procedure:

1. Fix the given screw thread specimen to the arrangement block.
2. Measure the pitch of the given thread using pitch gauges and also note down the angle of the thread based on Metric or With Worth.
3. Measure the maximum diameter of the screw thread using micrometer.
4. Calculate the best wire to be used by using the given equation.
5. Consider the available wires and fix the two wires to one end on micrometer Anvil and one wire towards another anvil.
6. Measure the distance over the wire properly by using micrometer.
7. Calculate the effective diameter of the screw thread using the above equation.
8. Find out the error in effective diameter of the screw thread.

Observations:

1. Least Count of the Micrometer = ______________mm.
2. Initial error in the micrometer = ______________mm.

Calculations:

1. Pitch of the thread p = ______________mm.

2. Size of the best wire $db = \frac{p}{2\cos(x/2)}$ mm

Where x = 60^0 for Metric threads

db =

3. Best size of the wire used d = ____________mm.

4. Diameter of thread D = MSR+ (VSR x LC) + Initial error

5. Distance over the wire M = MSR+ (VSR x LC) + Initial error

6. Actual effective diameter

$$E_{act} = M - db\,[1+\text{cosec}(x/2)] + p/2 \text{ Cot } (x/2)$$

7. Theoretical effective diameter E_{the} = D - 0.649 X p

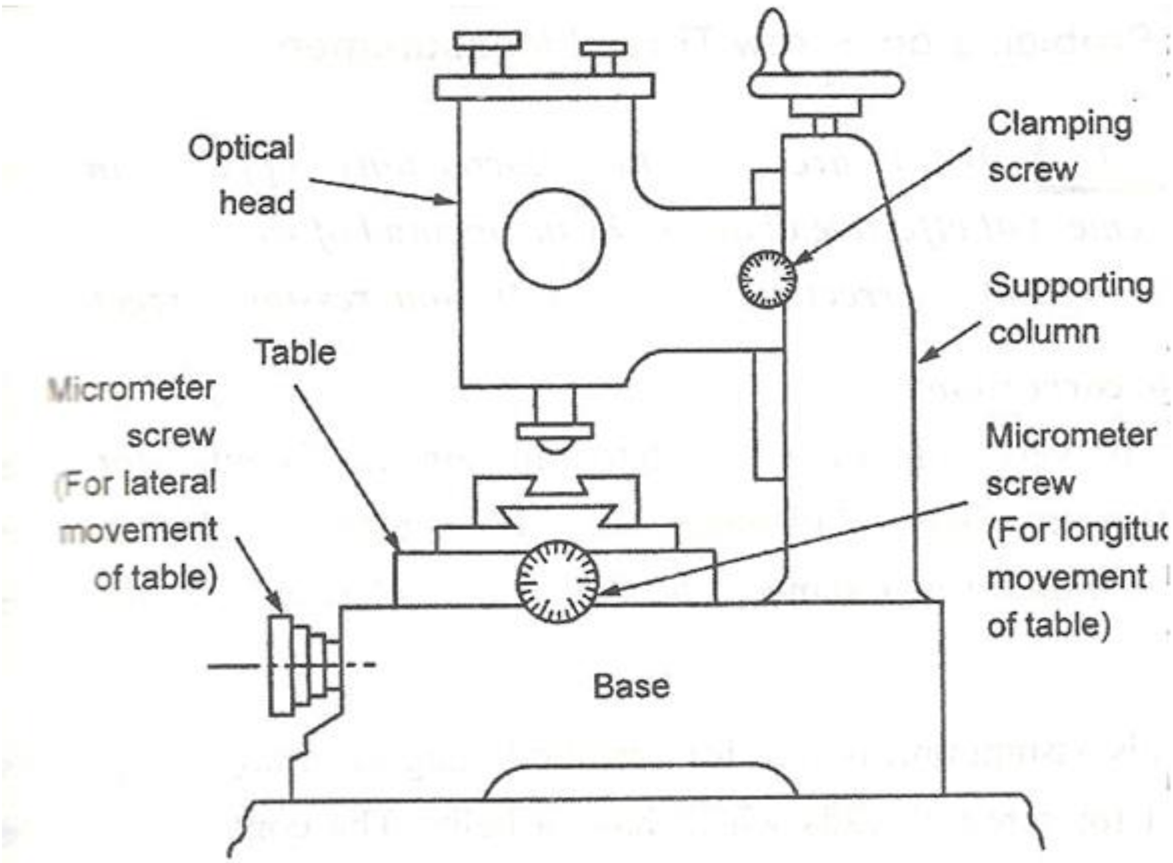
Tabular Column

SL No.	Pitch in mm	E_{act}	E_{the}	Error
1				
2				

Results:

Working Sheet

TOOLMAKERS MICROSCOPE



Expt. No. 14

TOOLMAKERS MICROSCOPE

Aim: Measurement of thread parameter using Tool maker's microscope.

Apparatus: Toolmaker's microscope, vernier caliper and pitch gauge.

Theory: Tool maker's microscope is versatile instrument that measures by optical means with no pressure being involved. It is thus a very useful instrument for making measurements of small and delicate parts.

Tool maker's microscope is designed for the following measurements

Measurements on parts of complex form, for example, the profile of external thread as well as for the tools, templates and gauges measuring.

Centre to centre distance of holes in any plane and other wide variety of linear measurements and accurate angular measurements. A Tool maker's microscope has optical head which can be moved up or down the vertical column and can be clamped at any height by means of a clamping screw. The table which is mounted on the base of the instruments can be moved in two mutually perpendicular horizontal directions (longitudinal and lateral) by means of accurate micrometers screws having thimble scale and vernier. A ray of light from light source is reflected by a mirror through 90^0. It is then passes through a transparent glass plate (on which flat parts may be placed). A shadow image of the outline or contour of the work piece passes through the objective of the optical head and is projected by a system of three prisms to a ground glass screen. The screen can be rotated through 360^0 the angle of rotation is read through an auxiliary eyepiece.

For taking linear measurements the work piece is placed over the table. The microscope is focused and one end of the work piece is made to coincide with cross line in the microscope (by operating micrometers screws). The table is again moved until the other end of the work piece coincide with the cross line on the screen and the final reading taken. From the final reading the desired measurement can be taken.

To measure the screw pitch, the screw is mounted on the table. The microscope is focused (by adjusting the height of the optical head) until a sharp image of the projected contour of the screw is seen on the ground glass screen. The contour is set so that some point on the contour coincides with the cross line on the screen.

Procedure:

1. Note the least count of the micrometers.
2. Dimensions of the screw thread whose elements have to be measured are noted.
3. Place or fix the screw thread on XY stage (stage glass) of the tool maker's microscope.
4. Align a measuring point on the work piece with one of the cross hairs.
5. Take the reading from the micrometer head.
6. Move the XY stage by turning the micrometer head and align another measuring point with the same cross hair and take the reading at this point.
7. Difference between the two readings represents the dimension between the two measuring points.
8. Repeat the experiment for different screw thread.

Angle Measurement*:*

Angles are measured with the angle dial using the following procedure

1. Align an edge of the work piece with the cross – hair reticle.
2. Align the end edge with the center of the cross – hair; turn the angle dial to align the cross – hair with the other edge of the work piece.
3. Take readings from the angle dial.

Observations:

1 Least Count of vertical slide micrometer = 1 MSD/ No. of divisions on thimble.

= ____________ mm

2 Least Count of horizontal slide micrometer = 1 MSD/ No. of divisions on thimble.

= ____________ mm

3 Initial error in the micrometer = _____________mm.

4 Least count of the angle dial = 1^0

1 MSD = 1^0

1 VSD =

$$\text{Least count} = N/n = \frac{\text{Value of One Main scale Division}}{\text{No of divisions on Vernier Scale}}$$

L. C. = $1^0/10$

L. C. = $60^1/10$ = 6^1

Tabular Column:

Sl. No	Parameters	Tool Makers Microscope Reading			Vernier Scale Reading(B)	Error
		Initial (a)	Final (b)	A = a - b		
1	Outside dia. (mm)					
2	inside dia. (mm)					
3	Pitch (mm)					
4	Helix angle (Degree)					

Calculation:

Error = Actual dial in vernier caliper − Actual reading using Tool Makers Microscope

Results:

Working Sheet

Expt. No. 15

DRILL TOOL DYNAMOMETER

Aim: Measurement of "Torque and Thrust" force by using Drill Tool Dynamometer.

Apparatus: Drill tool dynamometer, digital force indicator, work piece of any material and drilling machine.

.

Setup: Drill tool Dynamometer measures both the Thrust and Torque force of the drill bit and the torque produced on the work piece. It is used to establish drilling forces, study tool configuration and lubricant characteristics. This can be bolted directly on the bed of the machine using slots provided. The specimen is fixed using a vice or fixture.

The drill tool dynamometer provided load as well as torque output. The sensing portion of the drill dynamometer is bonded with two sets of strain gauge bridges one to sense the load and the other to sense the torque. Two out put sockets are provided for both the forces.

The instrument comprises of a digital displays calibrated to read two forces at a time. When used with the tool dynamometer keeping both the forces sensing Strain Gauge Bridge energized simultaneously. It has built in excitation supply with independent null balancing for respective strain gauge bridge independent signal processing system with digital display operated on 230V, S, .50c/s A.C. Mains.

Procedure:

1. Fix the drill Tool dynamometer on the work platform post using slot provided on the dynamometer. Ensure that the object being drilled is mounted on the top center of the drill tool dynamometer.
2. Plug the power cable to the 230V, 50Hz mains supply.
3. Connect the in put cable to the respectively thrust and Torque axis to the output socket of the dynamometer the other end to sensor socket on the front panel of the instrument.
4. Place the READ-CAL switch at READ position.
5. Switch ON the instrument by placing the POWER-ON switch at ON position.
6. Adjust the ZERO potentiometer such that the display reads Zero in both the display.

7. Place the READ-CAL switch to CAL position adjust CAL potentiometer until the display reads the range of force. This operation has to be conducted when the dynamometer does not have any load applied. This operation is conducted for both forces.
8. Turn back the READ – CAL switch to READ position. Now the instrument is calibrated to read force values up to calibrated capacity of the dynamometer in respective axis.

Tabular Column Materials used:____________________

Sl. No.	Torque in Kgm	Thrust Force in Kgs	Drill Bit Size in mm
1			
2			
3			
4			

SPECIFICATIONS:

Force : Thrust and Torque.

Range of Force : 200 kg thrust 20 kgm torques.

Bridge Resistance : 350 ohms.

Bridge voltage : 12 Volts maximum.

Results:

STUDY EXPERIMENT

STUDY OF DCC- CO-ORDINATE MEASURING MACHINE AND EXPLORING DIMENSIONAL FEATURES OF AN ARTEFACT

Aim:

- To study the functions of different parts of CMM.
- To study the conventions used for Machine Co-ordinate System and Work piece Co-ordinate System.
- To calibrate the probe tip at three different angles.
- To check different dimensional attributes like circularity, cylindrical, flatness, run out, etc and the corresponding tolerance values.

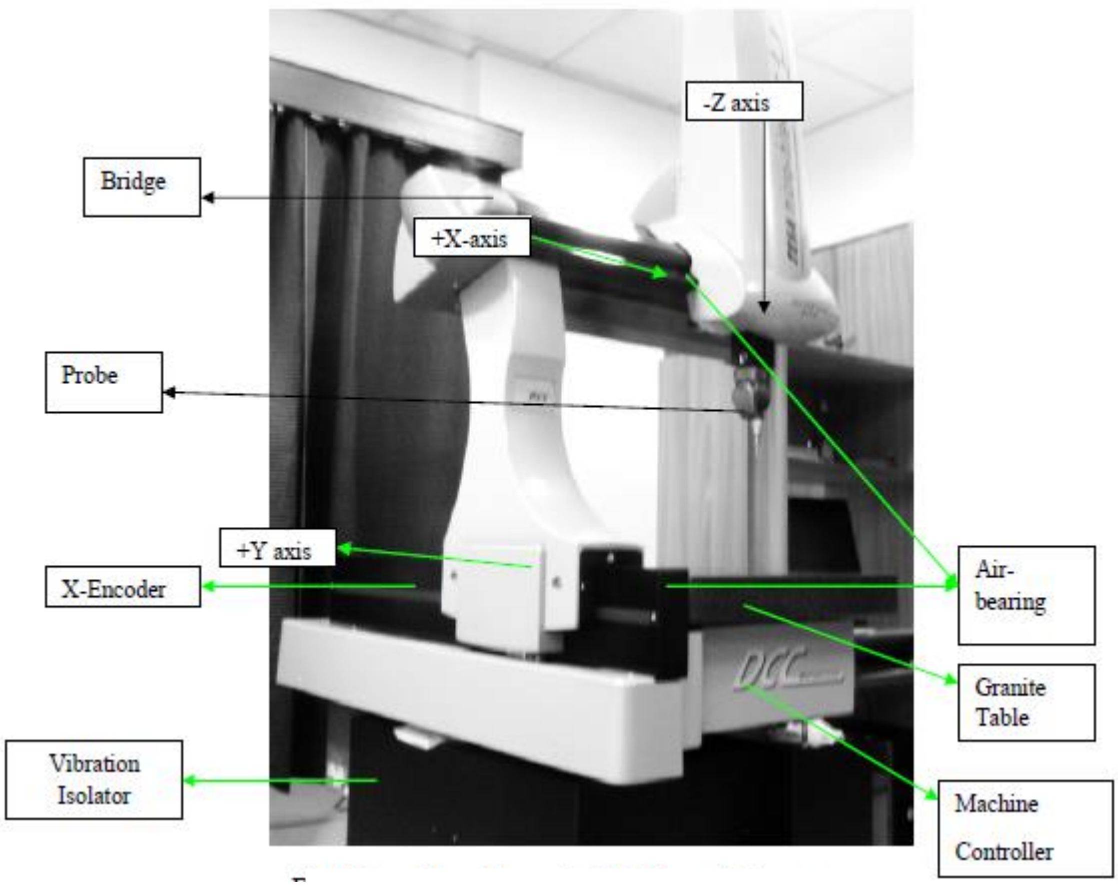


Fig 1: Co-ordinate Measuring Machine with its parts

It is used for geometrical feature measurement. The typical "bridge" CMM is composed of three axes, X, Y and Z. These axes are orthogonal to each other in a typical three dimensional coordinate system. Each axis has a scale system or encoder that indicates the translation of the axes. The machine will read the input points from the touch probe by touching the required location, as directed by the operator or programmer. The machine then uses the X, Y, Z coordinates of each of these points to determine size and position of the job. Then the measurands (e.g. length, diameter, angle, flatness, straightness etc.) can be determined by those points. A co-ordinate measuring machine **(CMM)** is also a device used in manufacturing and assembly processes to test a part or assembly against the design intent. By precisely recording the X, Y, and Z coordinates of the target, points are generated which can then be analyzed via regression algorithms for the construction of features. These points are collected by using a probe that is positioned manually by an operator or automatically via Direct Computer Control **(DCC).** DCC CMMs can be programmed to repeatedly measure identical parts; thus a CMM is a specialized form of industrial robot. In CMM there are mainly two major parts.

There are structural system and probing system. Machine structure, bridge, bearings for moving the bridge, granite table to support the work piece, vibration isolation system and are included in the structural systems. Air bearings are the chosen method for ensuring friction free travel. Compressed air is forced through a series of very small holes in a flat bearing surface to provide a smooth but controlled air cushion on which the CMM can move in a frictionless manner. In probing system one touch trigger probe is attached to the Z-axis quill of the bridge.

When probe is rotated about X-axis it is then called as angle A, and when the probe is rotated about Z-axis, then it is called as angle B.

Tesastar-p is the probe used in this machine. This probe can rotate in two directions via A & B.

A0B0:- Angle A= 0, and Angle B = 0

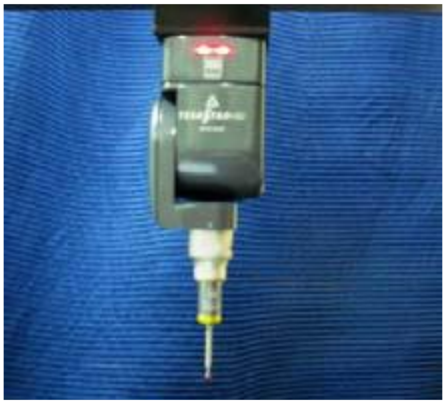


Fig 2: A0B0 position of probe

Fig 3: A90B90 position of probe

When rotation of probe is in CCW manner w.r.t. axis of rotation than it is considered positive else negative.

Range of angles:

Angle A: Probe can rotate from +90 to -115 about X-axis.

Angle B: Probe can rotate from +180 to -180 about Z- axis.

Measuring Mode: Manual Mode and Automatic Mode.

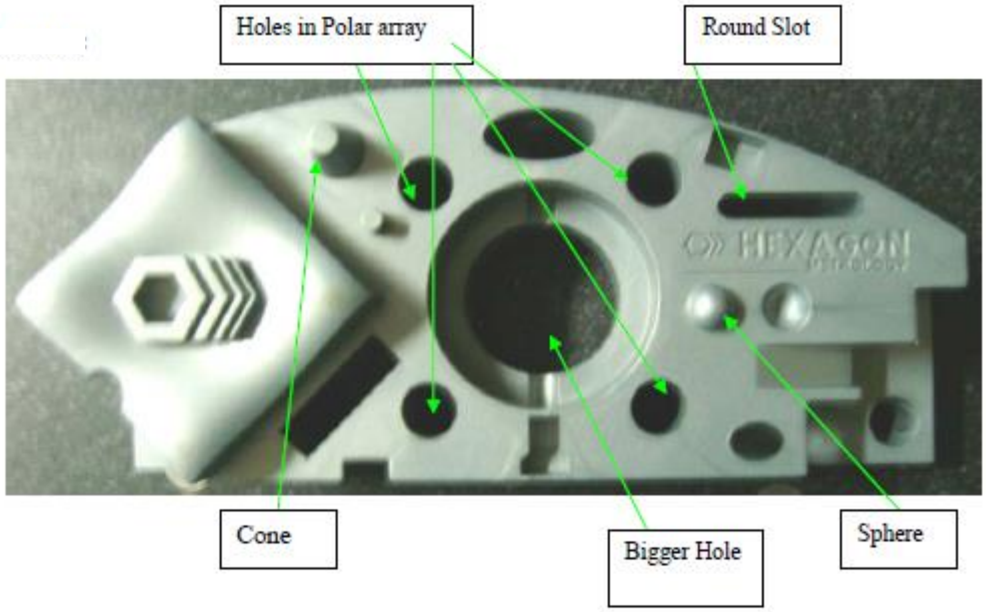


Fig 4: Job (Artifact supplied by TESA)

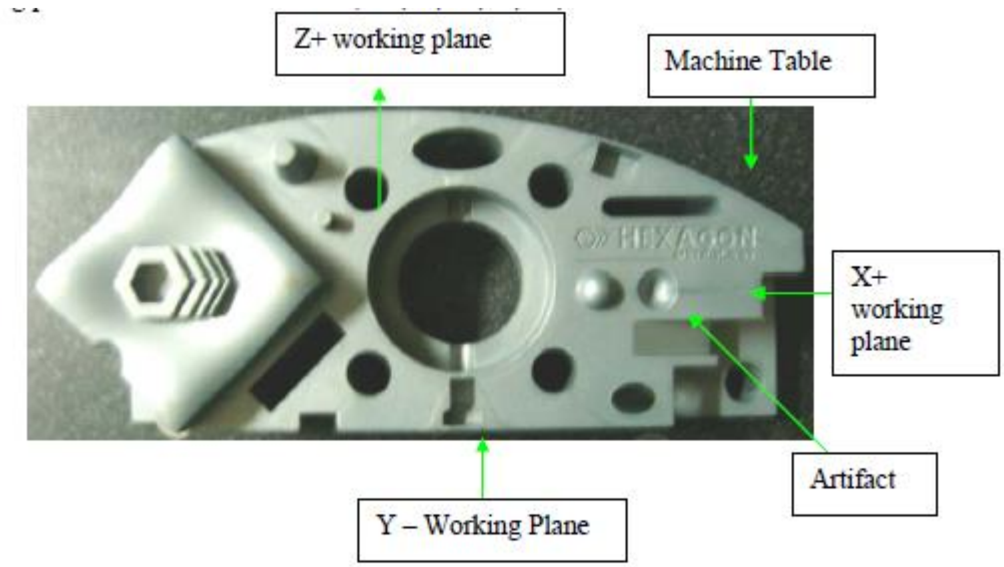
Job: Artifact supplied by TESA

1. Define plane, line and origin in manual mode.
2. Measure:
   - Inner diameter, circularity of the Bigger Hole
   - Height, cone angle and diameter of the Cone
   - Round slot
   - Measurement of all the holes in polar array in DCC mode
   - Sphere diameter

Feature	Dimension	1	2	3	Avg Value, mm
Bigger Hole	Inner diameter				
	Circularity				
Cone	Height				
	Cone angle				
	Diameter				
Round slot	Radius				
Holes in polar array	Diameter				
Sphere	Diameter				

Calibration and Measurement procedures:

Description of Working Plane:
There are 6 working plane in this machine such as, **Z+,Z-,Y+,Y-,X+,X-**.



Note: Z- will be in opposite direction of Z+ plane. Similarly, X- & Y+ will be in opposite directions of X+ and Y- Planes respectively.

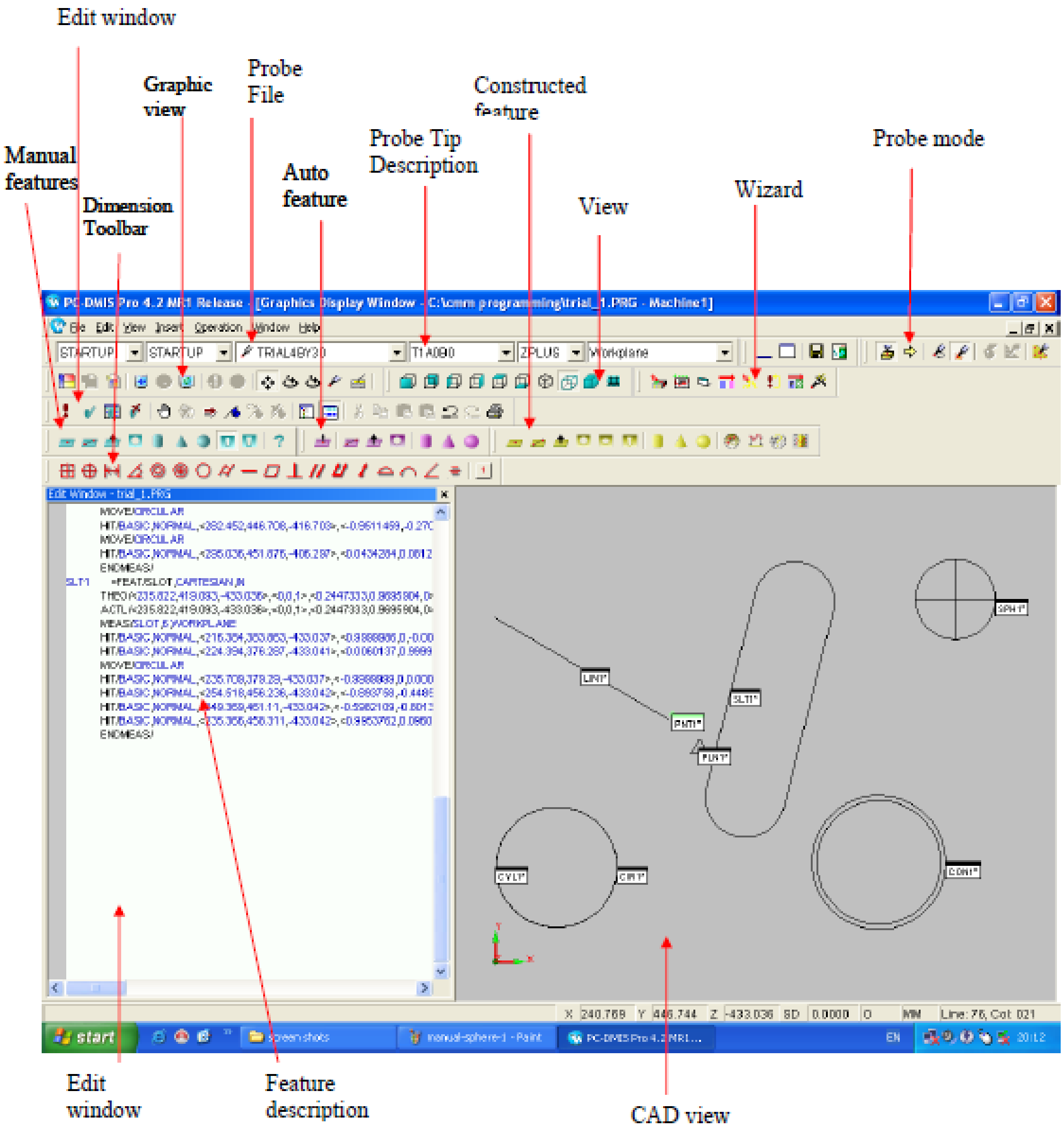
Orientation Concept of Probe:
When probe is rotated about X-axis it is then called as angle **A** and when probe is rotated about Z-axis, then it is called as angle **B.**

<u>Description of Remote Control Unit:</u>

<u>Specifications of CMM and probe used:</u>

Sl No	Items	Specifications
1	Bridge type CMM	Measuring Volume: 400 mm x 700 mm x 400 mm. TESA (Swiss Company): Model 4-7-4 Resolution: 0.1 µm
2	Qualification Sphere	Motorized Probing System Material of probe tip: Ruby Diameter of probe tip: 1/2/4 mm

Description of Graphics Display Window:



Results:

Viva questions

1. What is calibration?
2. What is a load cell?
3. Define an error. How is it classified?
4. Differentiate between primary & secondary standards.
5. What type of standards do you prefer in laboratory?
6. Define measurements. Mention different methods of measurements.
7. What is the necessity of measurement?
8. What are measurement systems?
9. What is the significance of Mechanical measurements?
10. What is L.V.D.T? What is its application?
11. Explain the principle of working of a L.V.D.T.
12. Comment on the characteristic curves of L.V.D.T.
13. List the instruments used for the displacement measurements.
14. List the various linear measuring instruments.
15. What is “Zero shift” & “scale error” with respect to measuring intstruments?
16. Define the following terms: Linearity,Sensitivityy,Repeatability,Hysteresis,Resolution, Accuracy, Readability & Threshold.
17. What is calibration? State its necessity & discuss how a pressure gauge is calibrated in the Laboratory?
18. Differentiate between stress & pressure.
19. Define absolute pressure, atmospheric pressure,gauge pressure,differential pressure& vaccum.
20. What are the methods of measuring pressure?
21. How do you define yard?
22. What is thermocouple? Where are they used? Which are the thermocouples you are using in the laboratory?
23. Name the different “thermocouple” materials
24. Explain the laws of thermocouples
25. What are the limitations of Mechanical measuring instruments over the electric type?
26. How do tou record the final readings or informations in the measurements?
27. Differentiate between progressive and periodic error
28. What are slip gauges? Name the different sets of slip gauges
29. What are the uses of slip gauge?
30. What is the ringing action of slip gauge?
31. What precautions should be taken while using micrometer?
32. Define the term back lash and measuring range in micrometer.
33. What are precision measuring instruments?
34. Explain Progressive and periodic pitch error.
35. Explain progressive and periodic pitch error.
36. What is optical flat?
37. What kind of light source is used to measure flatness in your job?
38. What type measurement is the optical flat best suited for?

39. What is comparator?
40. Name the different types of comparator?
41. What are advantages and disadvantages of mechanical comparator?
42. Difference between allowance and tolerance?
43. What is precision and accuracy?
44. What is surface plate? State its necessity and what are its uses?
45. What precautions should be tacken while using the surface plate?
46. What is an acute angle?
47. What is spur gear?
48. What is pitch gauge and feeler gauge? Where it is used?
49. Explain the different elements of screw thread.
50. What is a sine center?
51. How it is differ from sine bar?
52. What is metrology?
53. What are the objectives of metrology?
54. Metrological instruments are kept at 20° C. gives reason?
55. What is difference between metrology and measurement?
56. What is a sine bar?
57. What is the use of sine bar?
58. What are the limitations of sine bar?
59. What are the limitations of sine bar?
60. Explain working principle of sine bar? Name the different types of sine bar.

APPENDIX

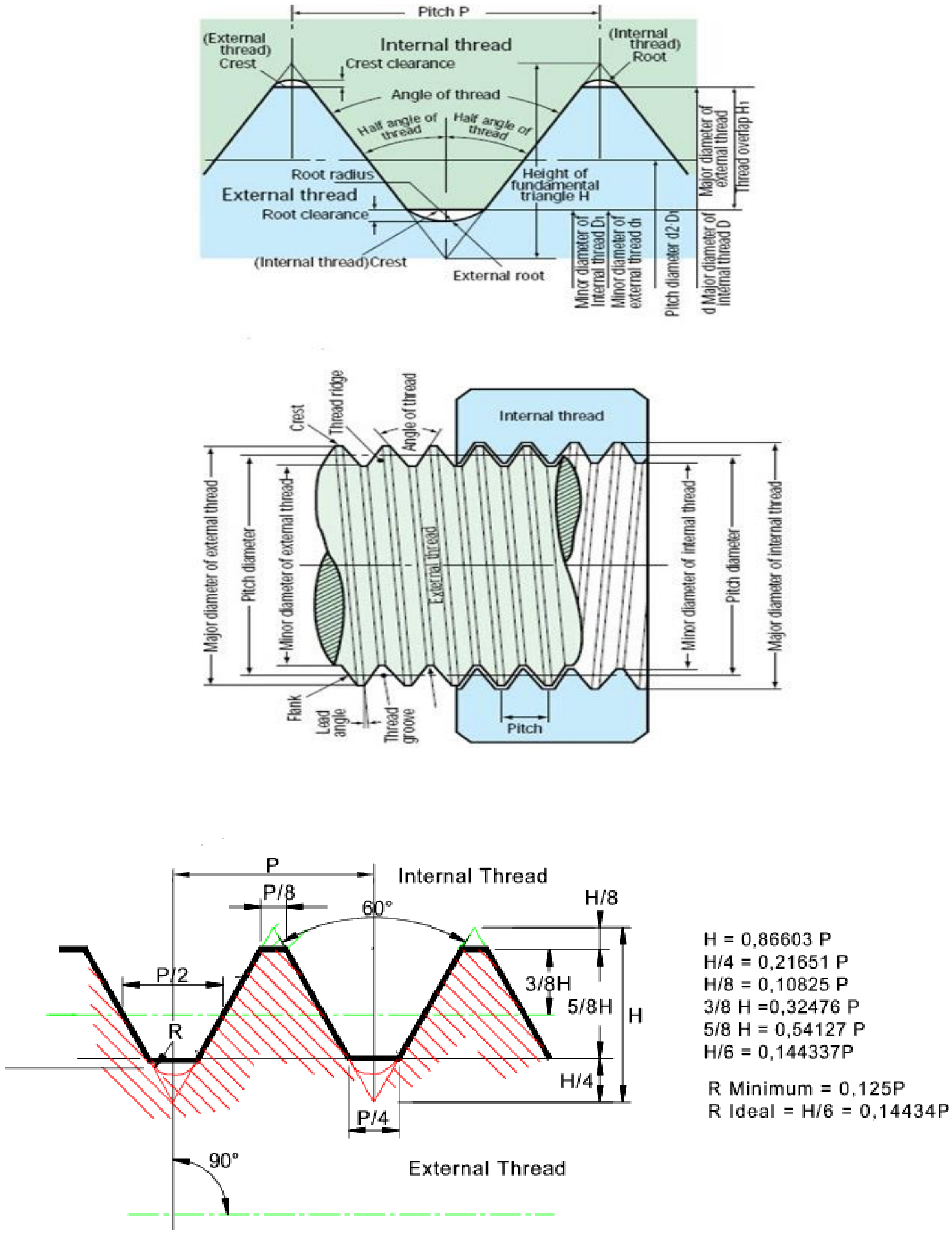


Fig: Nomenclature and Profile of Screw Thread

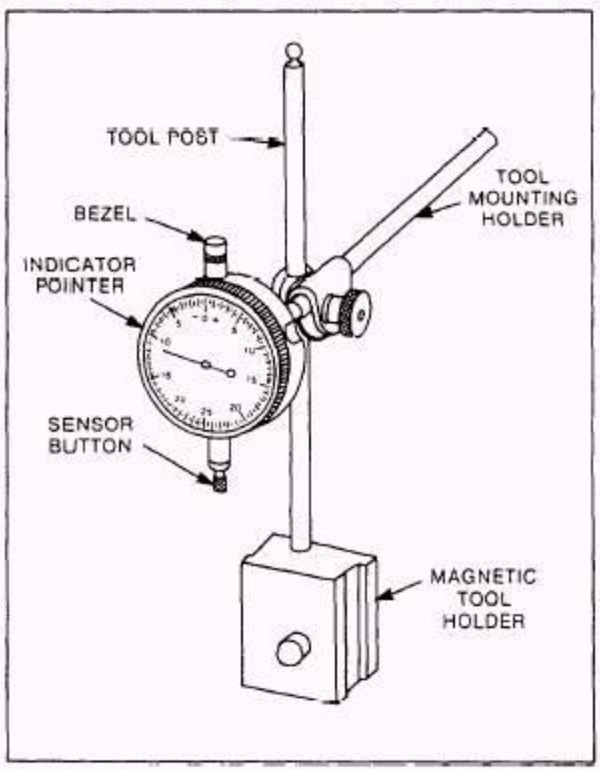


Fig: Dial Indicator

Fig: Thread Gauge & Slip Gauge

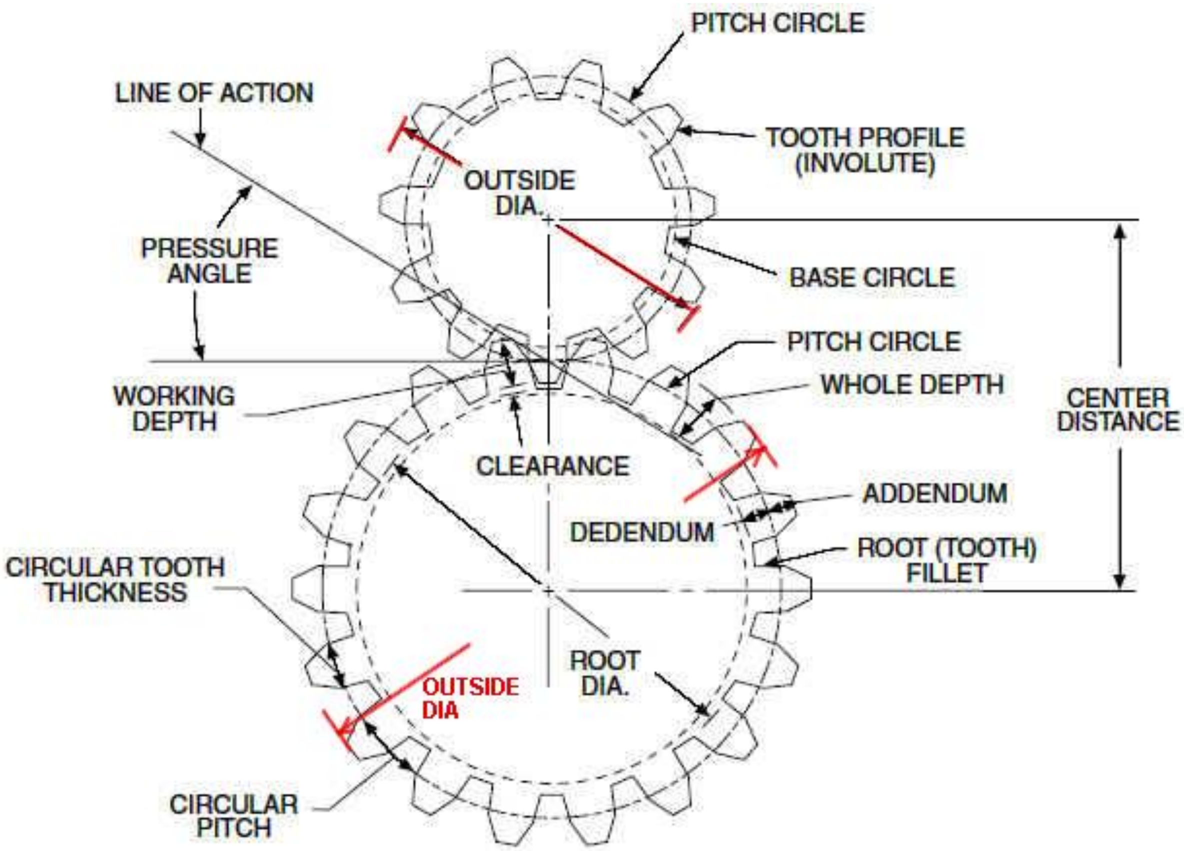


Fig: Gear Nomenclature

Fig: Gear Measurement

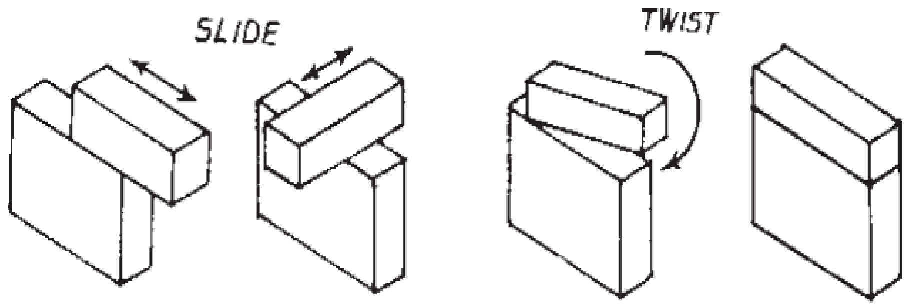


Fig: Wringing of slip gauges

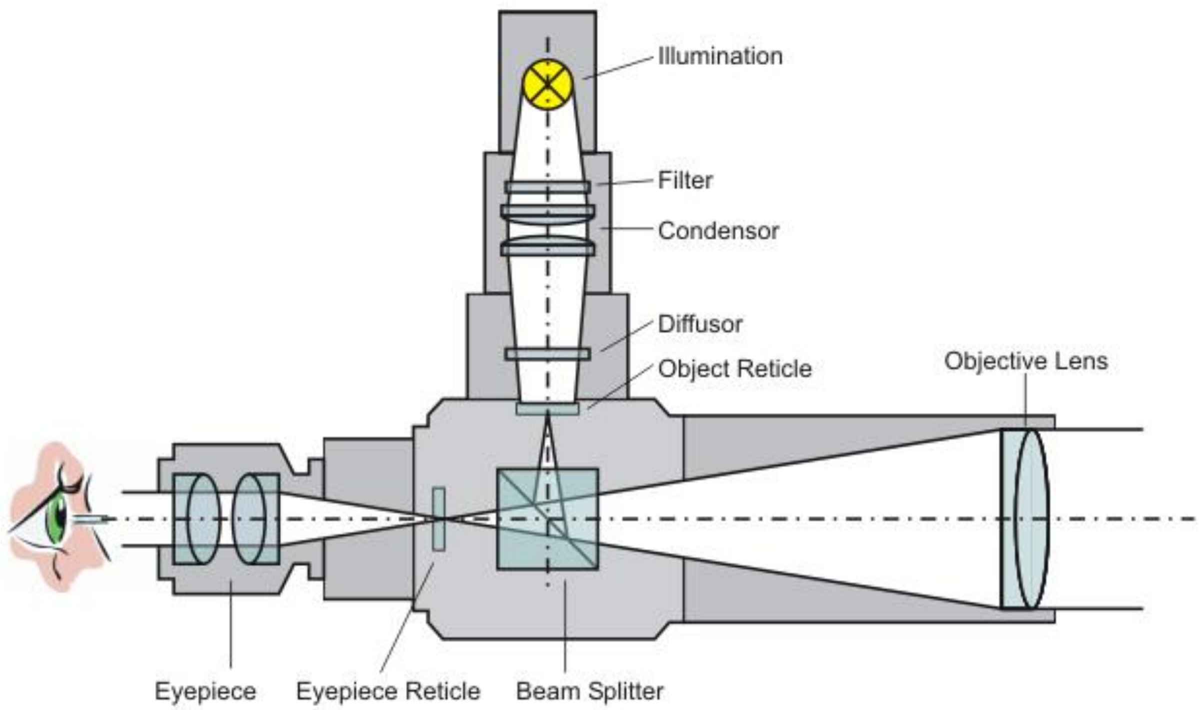


Fig: Autocollimator