MECHANICAL MEASUREMENTS AND
METROLOGY LAB [AS PER CHOICE ASED
CREDIT SYSTEM (CBCS) SCHEME]
SEMESTER -III/IV

Subject Code	18MEL47A	IA Marks	20
Number of Lecture Hrs / Week	01	Exam Marks	80
No of Practical Hours / Week	02	Exam Hours	03
CREDIT S – 02			

COURSE OBJECTIVES:

1. To illustrate the theoretical concepts taught in Mechanical Measurements & Metrology through hexperiments.
2. To illustrate the use of various measuring tools measuring techniques.
3. To understand calibration techniques of various measuring devices.

COURSE OUTCOMES

At the end of the course, the students will be able to

	Description	CL	POs
CO1	To calibrate pressure gauge, thermocouple, LVDT, load cell, micrometer.	U	PO1, PO6
CO2	To measure angle using Sine Center/ Sine Bar/ Bevel Protractor, alignment using Autocollimator/ Roller set.	U	PO1, PO6
CO3	To demonstrate measurements using Optical Projector/Tool maker microscope, Optical flats.	U	PO1, PO6
CO4	To measure cutting tool forces using Lathe/Drill tool dynamometer.	U	PO1, PO6
CO5	To measure Screw thread parameters using 2-Wire or 3-Wire method, gear tooth profile using gear tooth vernier/Gear tooth micrometer.	U	PO1, PO6
CO6	To measure surface roughness using Tally Surf/ Mechanical Comparator.	U	PO1, PO6

PART-A: MECHANICAL MEASUREMENTS

1. Calibration of Pressure Gauge
2. Calibration of Thermocouple
3. Calibration of LVDT
4. Calibration of Load cell
5. Determination of modulus of elasticity of a mild steel specimen using strain gauges.

PART-B: METROLOGY

1. Measurements using Optical Projector / Toolmaker Microscope.
2. Measurement of angle using Sine Center / Sine bar / bevel protractor
3. Measurement of alignment using Autocollimator / Rolle set
4. Measurement of cutting tool forces using
   a) Lathe tool Dynamometer OR
   b) Drill tool Dynamometer.
5. Measurements of Screw thread Parameters using two wire or Three-wire methods.
6. Measurements of Surface roughness, Using Tally Surf/Mechanical Comparator
7. Measurement of gear tooth profile using gear tooth Vernier /Gear tooth micrometer
8. Calibration of Micrometer using slip gauges
9. Measurement using Optical Flats

Scheme of Examination:

ONE question from part -A: 25Marks

ONE question from part-B: 40Marks

Viva-Voice: 15Marks

Total: 80Marks

CONTENTS

Expt. No.	Title of the Experiment
	PART A
1	Calibration of Pressure Gauge
2	Calibration of Thermocouple
3	Calibration of LVDT
4	Calibration of Load cell
5	Determination of modulus of elasticity of a mild steel specimen using strain gauges
	PART B
1	Measurement of thread parameters using Optical Projector / Toolmaker Microscope
2A	Measurement of angle using Sine center
2B	Measurement of angle using Sine bar
2C	Measurement of angle using bevel protractor
3	Measurement of alignment using Autocollimator
4A	Measurement of cutting tool forces using Lathe tool Dynamometer
4B	Measurement of torque & thrust force using Drill tool Dynamometer.
5	Measurement of Screw thread parameters using two wire or Three-wire method
6	Measurements of Surface roughness using Taly Surf
7	Measurement of gear tooth profile using gear tooth vernier /Gear tooth micrometer
8	Calibration of Micrometer using slip gauges
9	Measurement of surface flatness using Optical Flats
	VIVA QUESTIONS AND ANSWERS

EXPERIMENTAL SET UP FOR PRESSURE GAUGE EXPERIMENT

Specifications :

Capacity	: 10 kg / $cm^{2.}$
Type	: Strain gauge type.
Sensing Element	: Resistances 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

PART - A

ExperimentNo:1 Date:

CALIBRATION OF PRESSURE GAUGE

Aim: To calibrate the given pressure gauge or pressure cell.

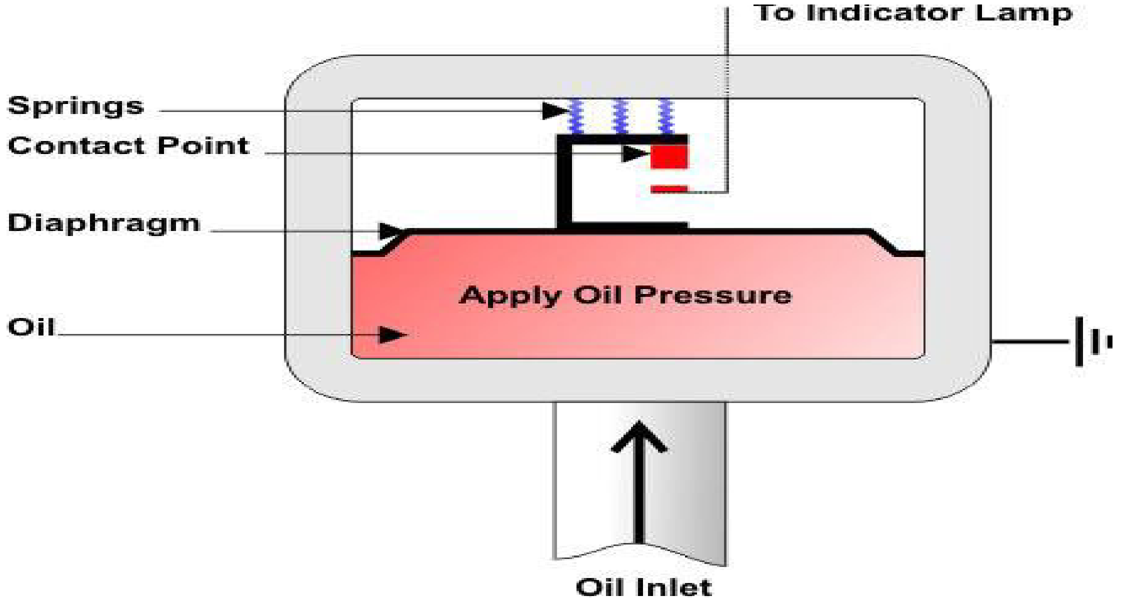
Apparatus:
Pressure cell / sensor/ gauge, Dial type pressure cell indicator, Digital pressure Indicator, weight pan, compressor to create pressure

Theory: Many techniques have been developed for the measurement of pressure and vacuum. Instruments used to measure pressure are called **pressure gauges** or **vacuum gauges**. A '*manometer*' is an instrument that uses a column of liquid to measure pressure, although the term is often used nowadays to mean any pressure measuring instrument. A **pressure sensor / gauges** measures pressure, typically of gases or liquids. Pressure is an expression of the force required to stop a fluid from expanding, and is usually stated in terms of force per unit area. A pressure sensor usually acts as a transducer; it generates a signal as a function of the pressure imposed. Pressure sensors are used for control and monitoring in thousands of everyday applications. Pressure sensors can also be used to indirectly measure other variables such as fluid/gas flow, speed, water level, and altitude. Pressure sensors can alternatively be called **pressure transducers**, **pressure transmitters**, **pressure senders**, **pressure indicators**, **pyrometers** and **manometers**, among other names.

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 researches 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 threading.
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 (P_a) (kg/cm^2)	Pressure shown in digital indicator (P_i) (kg/cm^2)	Error $P_i - P_a$	% Error $\frac{P_i - P_a}{P_a} \times 100$
1				
2				
3				
4				
5				
6				
7				
8				
9				

10				

Calculation:

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

Plot the Graphs as follows:

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

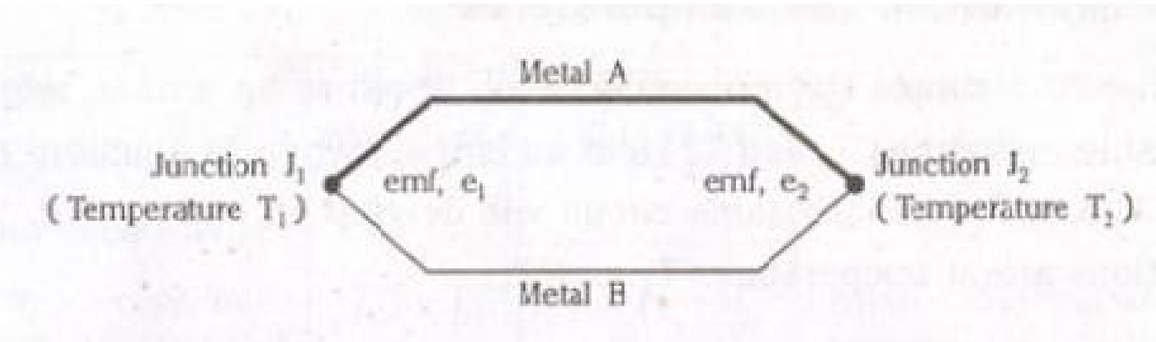
Applications:

- Pressure gauges are used for variety of industrial and application-specific pressure- monitoring applications. Their uses include visual monitoring of air & gas pressure for compressors, vacuum equipment, process lines & specialty tank applications such as medical gas cylinders & fireextin guishers.
- Fluid pressure industrial hydraulic circuits.
- Measurement of steam pressure in power plants &boilers.
- Measurement of pressure in large pumping stations/ water works/ or minor/major irrigations.

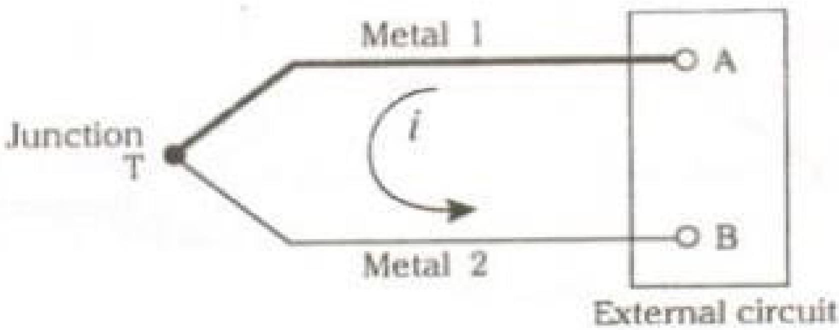
Results:

- The given Pressure gauge was calibrated and the average percentage of error is found to be………………..%

EXPERIMENTAL SET UP FOR THERMOCOUPLE EXPERIMENT



Basic Thermocouple Circuit



Junction of Two Dissimilar Metals

ExperimentNo.2: Date:

CALIBRATION OF THERMO COUPLE

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

Apparatus: Thermocouple, RTD, Digital temperature Indicator, Water bath

Theory:

Temperature measurement is the most common and important measurement in controlling any process. **Temperature** may be defined as an indication of intensity of molecular kinetic energy within a system. It is a fundamental property similar to that of mass, length and time & hence it is difficult to define. Temperature cannot be measured using basic standards through direct comparison. It can only be determined through some standardized calibrated device. Change in temperature of a substance causes a variety of effects such as: i) Change in physical state ii) Change in chemical state iii) Change in physical dimensions iv) Change in electrical properties and v) Change in radiating ability. And any of these effects may be used to measure the temperature **Temperature Measurement by Electrical Effects, Thermo resistive Elements, Electrical Resistance Thermometers, Electrical Resistance Thermometers, Instrumentation for Resistance Thermometers and Thermocouple.**

The electrical resistance of most materials varies with temperature. Resistance elements which are sensitive to temperature are made of metals and are good conductors of electricity. Examples are nickel, copper, platinum and silver. Any temperature-measuring device which uses these elements are called resistance thermometers or resistance temperature detectors (RTD). If semiconducting materials like combination of metallic oxides of cobalt, manganese and nickel having large negative resistance co- efficient are used then such devices are called ther mistors.

When two dissimilar metals are joined together as shown in the Fig. electromotive forces (emf) will exists between the two points A and B, which is primarily a function of the junction temperature. This phenomenon is called the **see beck effect**. If the two metals are connected to an external circuit in such a way that a current is drawn, the emf may be altered slightly owing to a phenomenon called the **peltier effect**. Further, if a temperature gradient exists along either or both of the metals, the junction emf may undergo an additional slight alteration. This is called the **Thomson effect**. Hence there are, three emf's present in a thermoelectric circuit: i) The See beck emf, caused by the junction of dissimilar metals ii) The Peltier emf, caused by a current flow in the circuit and iii) The Thomson emf, resulting from a temperature gradient in the metals. The See beck emf is important since it depends on the junction temperature. If the emf generated at the junction of two dissimilar metals is carefully measured as a function of temperature, then such a junction may be used for the measurement of temperature. The above effects form the basis for a thermocouple which is a temperature measuring element.

Procedure:

1. Turn the type selector to the desired position according to the given T.C.probe.
2. Connect the RTD (Resistance 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 temperate eradicator.
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: Resistance Temperature Detector 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)	Error $t_m - t_a$	% Error $\frac{t_m - t_a}{t_a} \times 100$
1				
2				
3				
4				

Calculation for J type

$$\%Error = \frac{Thermocouple - RTD}{RTD} X100$$

Materials for thermocouples wires = _K' type

SL No.	Temp of Water by RTD t_a (°C)	Temp of Water by Thermocouple t_m (°C)	Error $t_m - t_a$	% Error $\frac{t_m - t_a}{t_a} \times 100$
1				
2				
3				
4				

Calculation for K type

$$\%Error = \frac{Thermocouple - RTD}{RTD} X100$$

Materials for thermocouples wires = _T' type

SL No.	Temp of Water by RTD t_a (°C)	Temp of Water by Thermocouple t_m (°C)	Error $t_m - t_a$	% Error $\frac{t_m - t_a}{t_a} \times 100$
1				
2				
3				
4				

Calculation for T type

$$\%Error = \frac{Thermocouple - RTD}{RTD} X100$$

Plot the Graphs:

1. t_m v/s t_a
2. % Error v/s t_m

Advantages:

1. Thermocouples are cheaper than the resistance thermometers.
2. Thermocouples follow the temperature changes with small time lag thus suitable for recording rapidly changing temperatures.
3. They are convenient for measuring the temperature at a particular point.

Disadvantages:

1. Possibility of inaccuracy due to changes in the reference junction temperature hence they cannot be used in precision work.
2. For long life, they should be protected to prevent contamination and have to be chemically inert and vacuum tight.
3. When thermocouples are placed far from the measuring systems, connections are made by extension wires. Maximum accuracy is obtained only when compensating wires are of the same material as that of thermocouple wires, thus the circuit becomes complex.

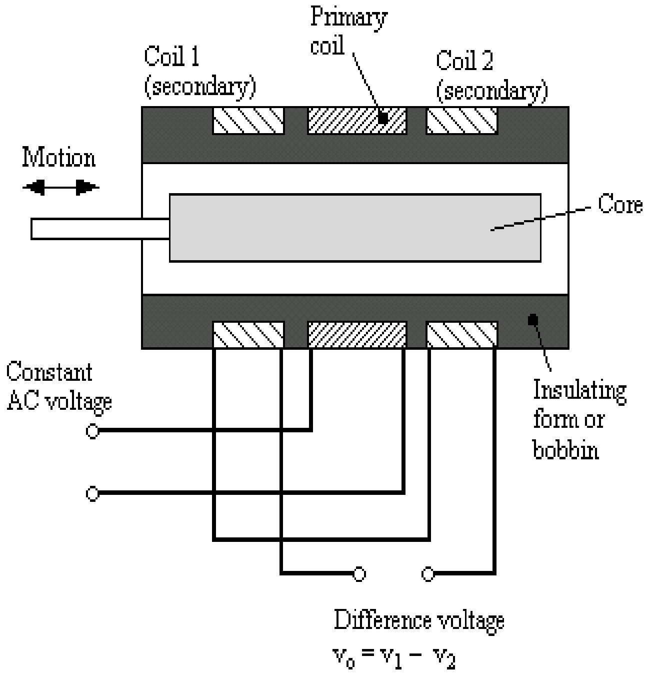
Applications:

- Thermocouples are used in big blast furnaces.
- Thermocouples are used intrans formers
- Thermocouples are used in automobiles, diesel electrical railways and large motors.
- In pressure vessel temperature controls in petrochemical and chemical industries thermocouples have been used.
- In steel melting & rolling mills for temperature control, these are used.

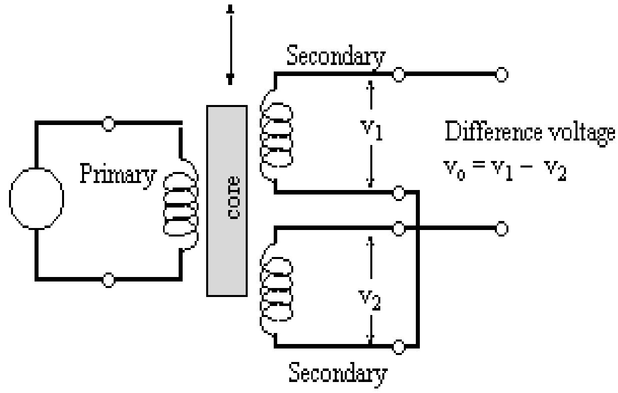
Results:

The given thermocouple is calibrated Using RTD.

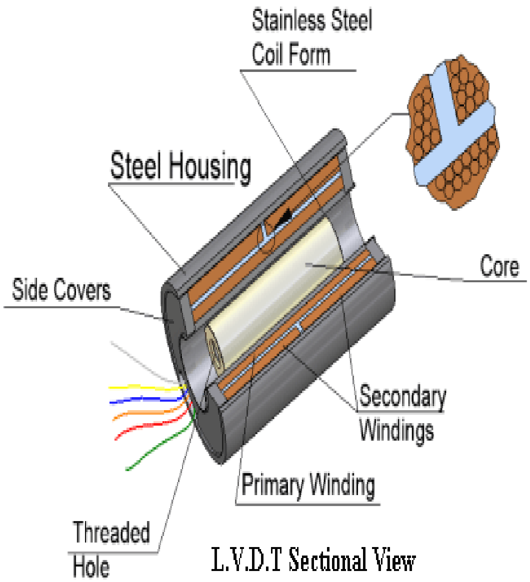
EXPERIMENTAL SET UP FOR THE LVDT EXPERIMENT



L.V.D.T Schematic Diagram



L.V.D.T Circuit



L.V.D.T Sectional View

Experiment No.3: Date:

CALIBRATION OF L.V. D. T

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

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 operatinginthelinearrange,thedeviceiscalledLVDT.Sincethesecondarycoilis 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.

Tabular Column

SL No.	Core Position	Digital Displacement Reading S_i In mm	Micrometer Reading S_a In mm	Error $S_i - S_a$	% Error $\frac{S_i - S_a}{S_a} \times 100$
1	Moving the core towards left of null position				
2					
3					
4					
5					

Tabular Column

SL No.	Core Position	Digital Displacement Reading S_i In mm	Micrometer Reading S_a In mm	Error $S_i - S_a$	% Error $\frac{S_i - S_a}{S_a} \times 100$
1	Moving the core towards right of null position				
2					
3					
4					
5					

Calculation: for left of null position

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

Calculation: for right of null position

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

Applications

- LVDT's are used in position control in machine tools.
- To measure the furnace tilting position in steel melting shops.
- To check the position of an Ailerons in the wing assemble lyinaero space.
- In landing gear position, LVDT's are used.
- LVDT are suitable for use in applications where the displacements are too large for strain gauge to handle. There are often employed together other transducers for measurement of force, weight & pressure etc.

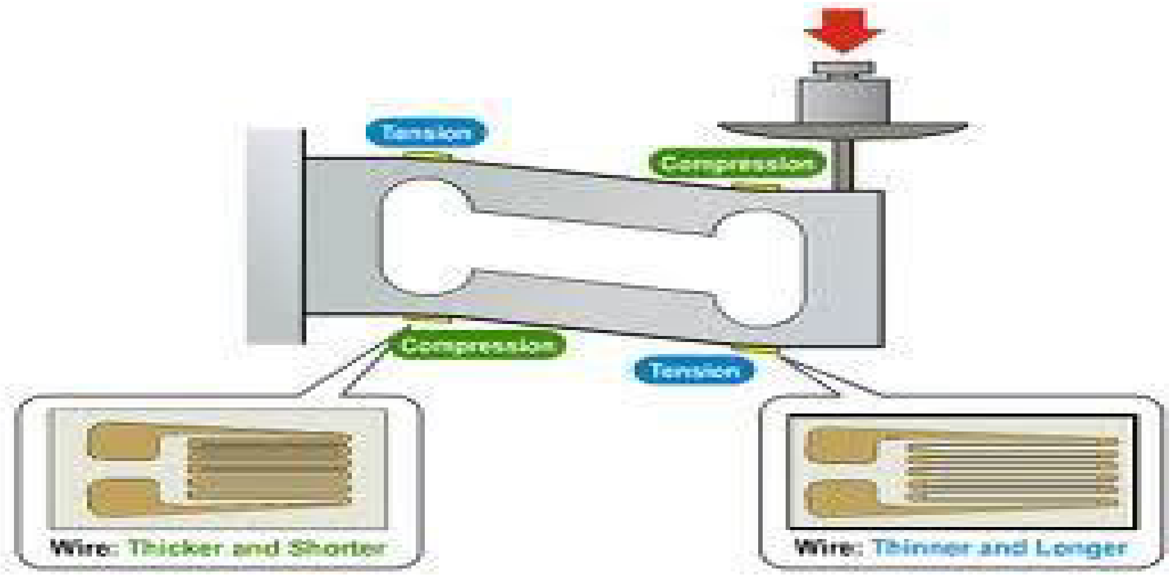
Plot the Graphs:

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

Results:

Calibration of LVDT is performed and percentage error was found to be …………………and……………… when core move towards right side and left side respectively.

EXPERIMENTAL SET UP FOR THE EXPERIMENT OF LOAD CELL



ExperimentNo.4: Date:

CALIBRATION OF LOAD CELL

Aim: To calibrate given load cell and plot a graph of indicated value to actual value.

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 & 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 output of the load cell is calibrated with reference to some standard i.e., primary standard i.e. deadweights.

Procedure:

1. Connect the load cell to digital indicator inserting the corresponding color codes.
2. Connect the digital indicator to mains and switch on the indicator.
3. Adjust the zero knob of the indicator to0000.
4. Apply the weights up to 08kg.
5. Applythe_Cal'knoboftheindicatortoread78.48N.i.e.(9x9.81N).
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 L_a in Kg	Indicated Load L_i in Kg	Error $L_i - L_a$	% Error $\frac{L_i - L_a}{L_a} x100$
1				
2				
3				
4				
5				

Calculation:

Error = Indicated Load - Actual Load

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

Plot the Graphs:

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

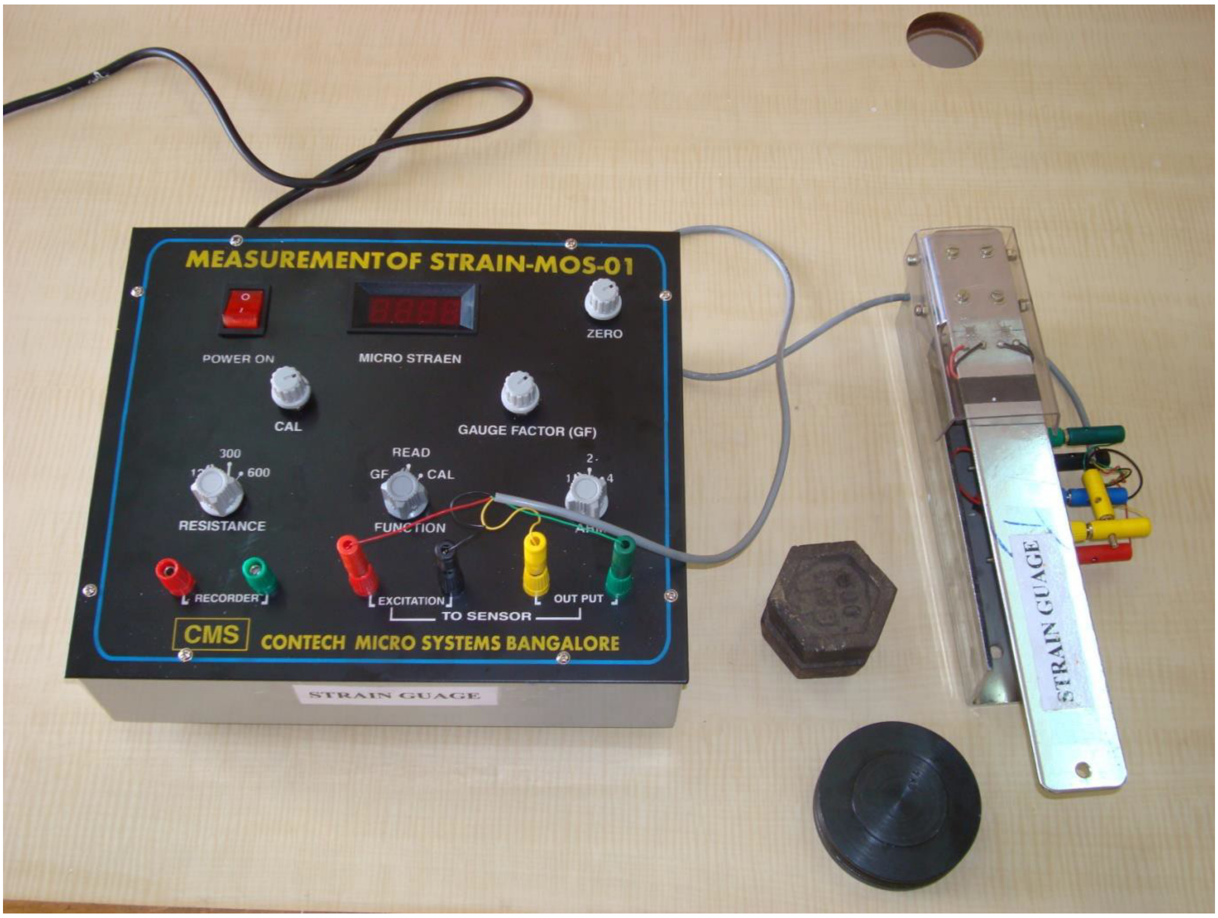
Applications

1. Weighing systems are used in both static and dynamic applications.
2. In road and railway weighbridges.
3. In electrical overhead travelling cranes.
4. Roll force measurement in steel plants/rolling mills.
5. Weigh bridges in conveyers &bunker

Result:

The given Load cell is calibrated and percentage error was found to be ………………. %

EXPERIMENTAL SET UP FOR STRAIN GAUGE



Specification:

Type	: Strain gauge based.
Range	: 10Kg.
Gauge Resistance	: 350ohms.
Max Excitation	: 12 Volt DC.
Insulation Resistance	: 1000 mega ohms @ 25degrees measured at 30 volt DC.
Combined Error	: + or – 0.5 % of the F.5.
Operating Temperature	: 0 degree to50degree.
Safe over load	: 10 % of the rated load.

ExperimentNo.5: Date:

DETERMINATION OF MODULUS OF ELASTICITY OF A MILD STEEL SPECIMEN USING STRAIN GAUGES

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 , strain indicator, weights, weighing pan,

Theory:

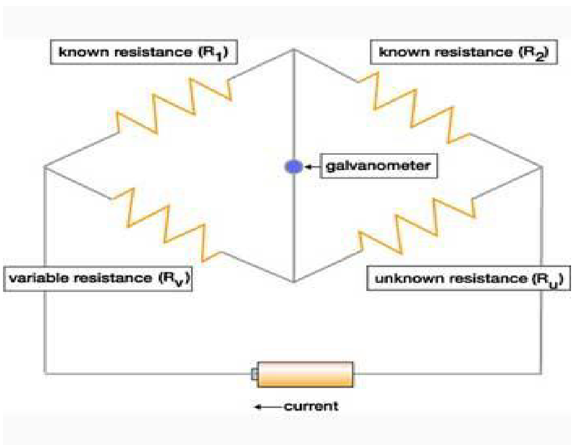
A body subjected to external forces is in a condition both stress and strain. Stress cannot be directly measured but its effects, i.e. change of shape of the body can be measured. If there is a relationship between stress and strain, the stresses occurring in a body can be computed if sufficient strain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

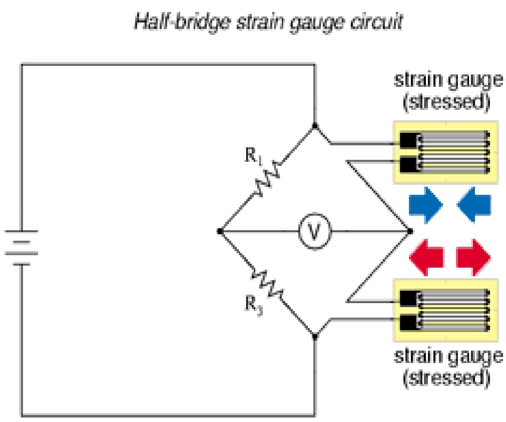
The principle of the electrical resistance strain gauge was discovered by Lord Kelvin, when he observed that a stress applied to a metal wire, besides changing its length and diameter, also changes its electrical resistance. Metallic electrical strain gauges are made in to two basic forms, bonded wire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

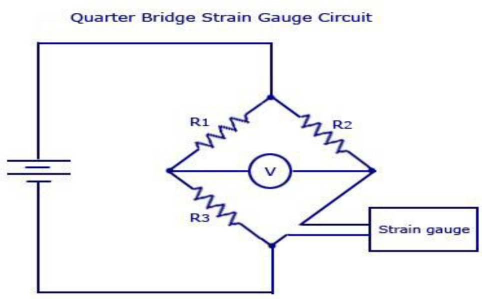
The strain gauge is connected to the material in which it is required to measure the strain, with a thin coat of adhesive. Most common adhesive used is Eastman, duco cement, etc. As the test specimen extends are contracts under stress in the direction of windings, the length and cross sectional area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

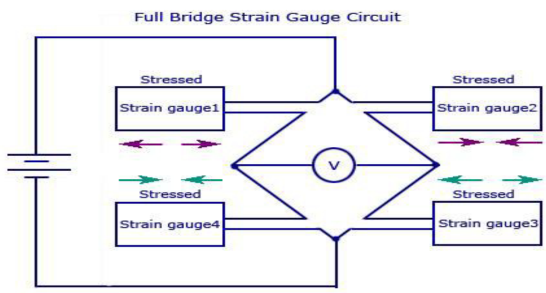
A strain gauge is a device used to measure strain on an object. Invented by Edward E. Simmons and Arthur C. Ruge in 1938, the most common type of strain gauge consists of an insulating flexible backing which supports a metallic foil pattern. The gauge is attached to the object by a suitable adhesive, such as cyanoacry late. As the object is deformed, the foil is deformed, causing its electrical resistance to change. This resistance change, usually measured using a Wheatstone bridge, is related to the strain by the quantity known as the *gaugefactor.*

A strain gauge takes advantage of the physical property of electrical conductance and its dependence on the conductor's geometry. When an electrical conductor is stretched within the limits of its elasticity such that it does not break or permanently deform, it will become narrower and longer, changes that increase its electrical resistance end-to-end. Conversely, when a conductor is compressed such that it does not buckle, it will broaden and shorten changes that decrease its electrical resistance end-to-end. From the measured electrical resistance of the strain gauge, the amount of applied stressmay be inferred. A typical strain gauge arranges a long, thin conductive strip in a zigzag pattern of parallel lines such that a small amount of stress in the direction of the orientation of the parallel lines results in a multiplicatively larger strain measurement over the effective length of the conductor surfaces in the array of conductive lines and hence a multiplicatively larger change in resistance than would be observed with a single straight-line conductive wire.









www.InstrumentationToday.com

A **Wheatstone bridge** is an electrical circuit used to measure an unknown electrical resistance by balancing two legs of abridge circuit, one leg of which includes the unknown component. Its operation is similar to the original potentiometer. It was invented by Samuel Hunter Christie in 1833 and improved and popularized by Sir Charles Wheatstone in 1843. One of the Wheatstone bridge's initial uses was for the purpose of soils analysis and comparison. In the figure, R_x is the unknown resistance to be measured R_1 , R_2 and R_3 are resistors of known resistance and the resistance of R_2 is adjustable. If the ratio of the two resistances in the known leg (R_2/R_1) is equal to the ratio of the two in the unknown leg (R_x/R_3), then the voltage between the two midpoints (B and D) will be zero and no current will flow through the galvanometer V_g If the bridge is unbalanced, the direction of the current indicates whether R_2 is too high or too low. R_2 is varied until there is no current through the galvanometer, which then reads zero. Detecting zero current with a galvanometer can be done to extremely high accuracy. Therefore, if R_1 R_2 and R_3 are known to high precision, then R_x can be measured to high precision. Very small changes in R_x disrupt the balance and are readily detected. At the point of balance, the ratio of

$$\frac{R_2}{R_1} = \frac{R_x}{R_3}$$

$$\Rightarrow R_x = \frac{R_2}{R_1} \cdot R_3$$

Alternatively, if R_1 , R_2 , and R_3 are known, but R_2 is not adjustable, the voltage difference across or current flow through the meter can be used to calculate the value of R_x, using Kirchhoff's (also known as Kirchhoff's rules). This setup is frequently used in strain gauge and resistance thermometer measurements, as it is usually faster to read a voltage level off a meter than to adjust a resistance to zero the voltage.

Significance: The Wheatstone bridge illustrates the concept of a difference measurement, which can be extremely accurate. Variations on the Wheatstone bridge can be used to measure capacitance, inductance, impedanceand other quantities, such as the amount of combustible gases in a sample, with an explosimeter. The Kelvin Bridge was specially adapted from the Wheatstone bridge for measuring very low resistances. In many cases, the significance of measuring the unknown resistance is related to measuring the impact of some physical phenomenon (such as force, temperature, pressure, etc.) which thereby allows the use of Wheatstone bridge in measuring those elements indirectly. The concept was extended to alternating current measurements by James Clerk Maxwell in 1865 and further improved by Alan Blumleinaround1926.

Observations:

Distance between gauge centers to the point application of

load Length in mm L = 250mm.

Width of beam, bin mm =42 mm.

Thickness of beam, h in mm = 3mm.

I. Strain Measurement in Four Arm Modes (Fullbridge)

Procedure:

1. Switch on the instrument and leave 15 minutes to warm up.

2. Connect the respective colour wires of sensors to terminals in the indicat or panel.

3. Keep the arm selector switch on4.

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 read1000.

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 the oretical value.

Gauge Factor or Strain Sensitivity

For a given amount of unit strain (ΔL/L), the gauge will undergo a corresponding change in resistance (ΔR/R). The ratio of the unit change in the resistance to the unit change in the length is known as gauge factor. where *R* is the nominal resistance of the gauge

$$G_F = \frac{dR/R}{dL/L}$$

conventional foil gauges have standardized nominal resistance values of 120 &350ohms&typicallyexhibitgaugefactorsbetween1.5&3.5.intypicaltransducer applications, they are subjected to full scale design strain levels ranging from 500 to 2000 micro strain.

Results:

Using the strain gauges, Young's Modulus of the given mild steel specimen has been determined for full bridge

Tabular Column (Full Bridge):

SL No.	Load Applied W in (N)		Strain Indicator Reading ε micro strain	Measured strain $\varepsilon m = \overline{\varepsilon \times 10^{-6}}$ 4	Bending Stress $\sigma = 6wl / bh^2$	Modulus of Elasticity $E = \sigma / \varepsilon m$ (N/mm²)
	gms	N				
1	200					
2	400					
3	600					
4	800					
5	1000					

Calculation:

Load Applied, W = 0.2 x 9.81 (200g / 1000) = 1.962 N

Bending Stress, $\sigma = 6WL / bh^2 = (6 \times 1.962 \times 250) / (42 \times 3^2) = 7.78$ N / mm²

For Four Arm Modes, (Full Bridge)

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

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

Tabular Column (for Half Bridge):

SL No.	Load Applied W in (N)		Strain Indicator Reading ε micro strain	Measured strain $\varepsilon m = \frac{\varepsilon \times 10^{-6}}{2}$	Bending Stress $\sigma = 6wl / bh^2$	Modulus of Elasticity $E = \sigma / \varepsilon m$ (N/mm^2)
	gms	N				
1	200					
2	400					
3	600					
4	800					
5	1000					

II. 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 colour 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 on2.
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 read1000.
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.

Tabular Column (for Quarter Bridge):

SL No.	Load Applied W in (N)		Strain Indicator Reading ε micro strain	Measured strain $\varepsilon m = \overline{\varepsilon \times 10^{-6}}$ 1	Bending Stress $\sigma = 6wl / bh^2$	Modulus of Elasticity $E = \sigma / \varepsilon$ m (N/mm²)
	gms	N				
1	200					
2	400					
3	600					
4	800					
5	1000					

III. Strain Measurement in one Arm Modes (QuarterBridge)

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

Applications:

1. Wherever load cells are using there is a strain gauge embedded in it.
2. Estimation of structural strength in steel & concrete structures, bridges & hydraulic structures.
3. In large machineries, pipelines & pressure reversals.
4. Estimation of remaining life of old & huge structures like civil engineering structures, rail bridges & electrical towers.
5. Strain gauges are used for the stress analysis without any experiments.
6. Strain gauges are also used in measuring the stress developed in the moving parts of the engine. Ex: piston.

Graphs:

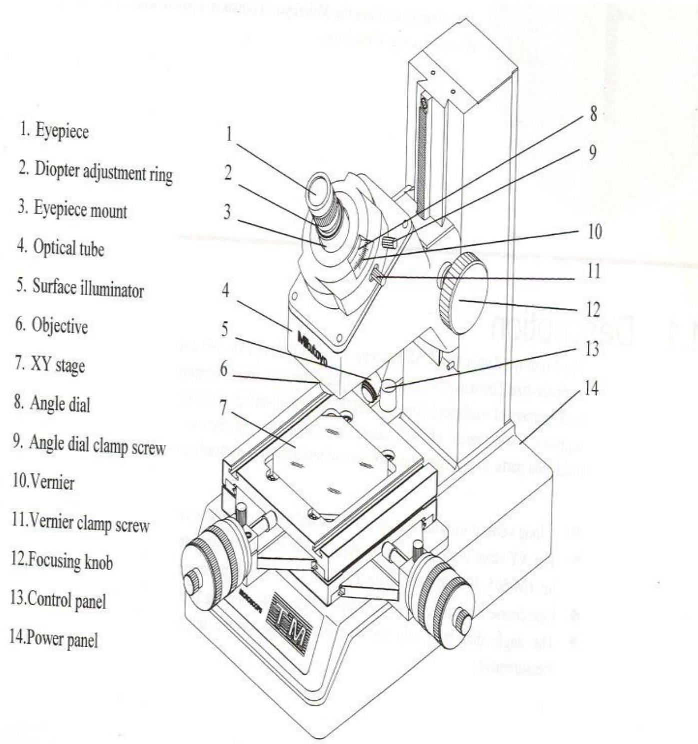
By plotting the graph, εm as the base and σ as the ordinate, a straight line is obtained from which the slope can be found.

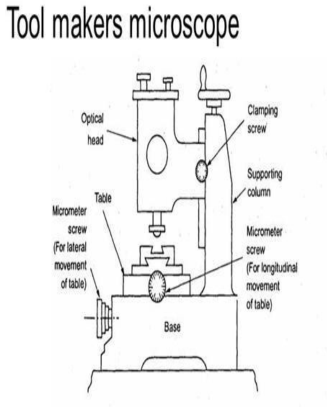
Modulus of elasticity E = slope of the line

Results:

Using the strain gauges, Young's Modulus of the given mild steel specimen has been determined for half and quarter bridges.

EXPERIMENTAL SET UP FOR TOOL MAKER MICROSCOPE





ExperimentNo.6: Date:

MEASUREMENT OF THREAD PARAMETERS BY USING TOOL MAKER MICROSCOPE

Aim: Measurement of thread parameters by using Tool maker microscope.

Apparatus: Toolmaker microscope, vernier calliper 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. 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 crosshairs.
5. Take the reading from the micro meterhead.
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.

Observations:

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

= 0.0005 mm or 5 microns.

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

= 0.0005 mm or 5 microns.

Tabular Column:

Sl. No	Parameters	Tool Maker Microscope Reading		
		Initial (a)	Final (b)	Total A = a - b
1	Outside dia. (mm)			
2	inside dia. (mm)			
3	Effective diameter (mm)			
4	Pitch (mm)			
5	Helix angle (Degree)			

Calculations:

Initial reading = MSR+(CVD×LC)
Final reading =MSR+(CVD×LC)
Total reding= initial reading-final reading

Angle Measurement:

Angles are measured with the angle dial using the following procedure

1. Align an edge of the work piece with the cross – hairreticle.
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.

Objectives:

1. After performing this experiment, you should be able to
2. appreciate the importance of precision measurement,
3. know how precise measurements can be taken with this instrument,
4. explain the field of application/working of this in strumpet, and
5. understand the principle of working of tool room microscope.

Results:

The following parameters are found that;

1. Outsidedia. =______________mm

2. Insidedia. =______________mm

3. Effective dia. =_____________mm

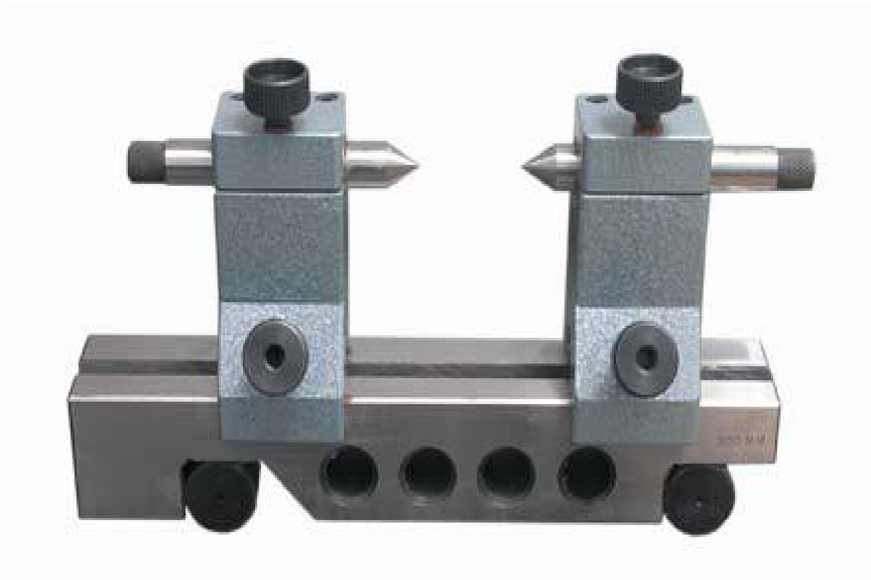
4. Pitch =______________mm

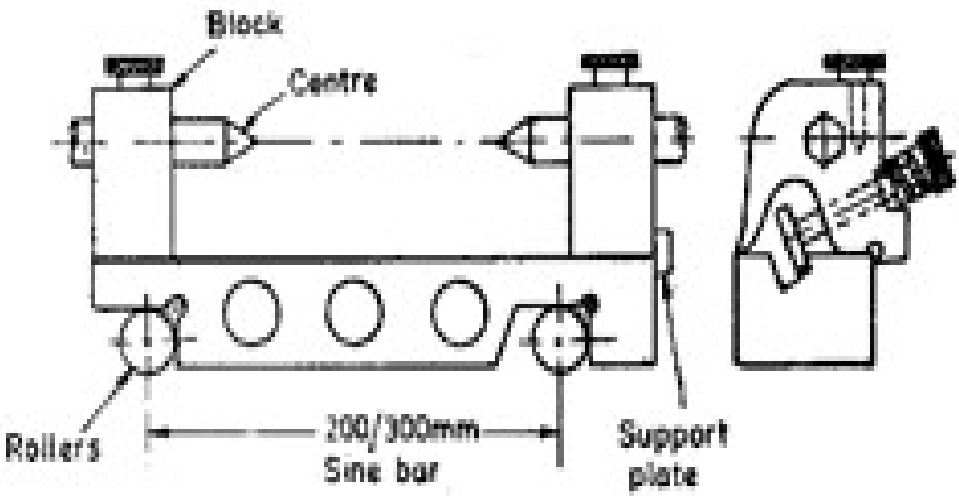
5. Helix angle =______________Degrees

Applications:

1. Precision tools making of cutting tools.
2. In jigs and fixtures for accuracy measurement, this can be used.
3. In assembly & matching of components.
4. In Precision machining
5. In jewelleries applications.

EXPERIMENTAL SET UP FOR SINE CENTER





ExperimentNo.7A: Date:

MEASUREMENT OF TAPER ANGLE USING SINE CENTRE

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

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

Theory:

The sine centres 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.

A special type of sine bar is sine centre which is used for conical objects. It cannot measure the angle more than 45 degrees. 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 hole sare drilled in the body of the bar to reduce the weight and to facilitate and ling.

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.

Sine centre is basically a sine bar with block holding centers which can be adjusted and rigidly clamped in any position. These are used for inspection of conical objects between centers. These are used up to inclination of 60°. Rollers are clamped firmly to the body without any play. This is a very useful device for testing the conical work cantered at each end. The principle of setting is same as of sine table.

Procedure:

1. Note down the least count of the venire caliper and dial gauge.

2. Measure the minimum, maximum diameter and axial length of taper plug gauge using Vernier calliper.

3. Calculate approximate height of slip gauge using formula.

4. Build up the height using M-87 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 verniercalliper =_____________mm
2. Least count of dial gauge =_____________mm
3. Distance between the centre of rollers, L =200_______mm
4. Length of specimen(taper length), l =_____________mm

Calculations:

1) Height for one side of the work piece H = -------------mm
2) Actual taper angle, θ_{act} = [sin-1 (H_{act})] /L

=_________Degrees

Results:

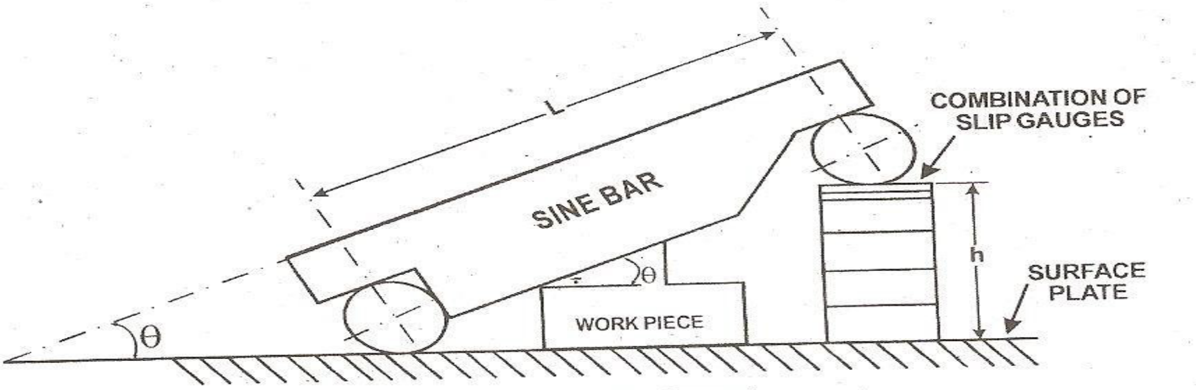
The unknown angle of the given conical specimen was detected and found to be…………… degree

Applications:

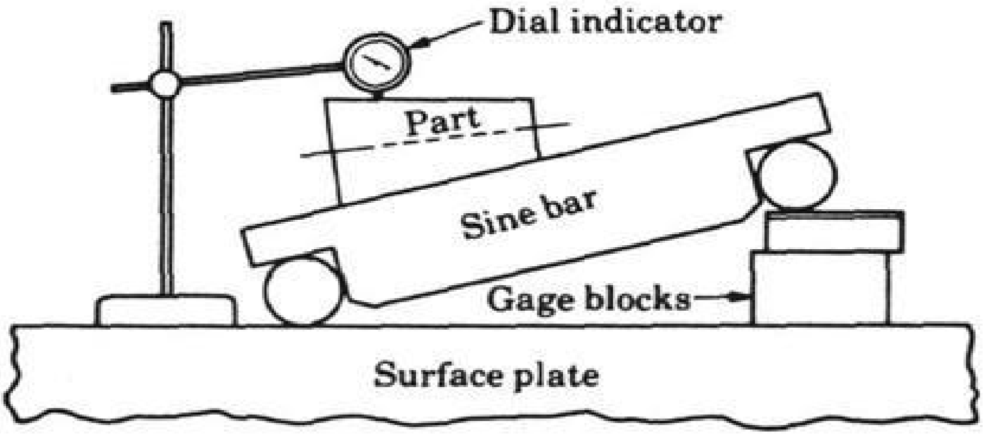
1. In workshops, assembly shops, precision machining.
2. Checking of existing machine components.
3. Precision machining in aerospace industries & quality control departments.
4. These are used in situations where it is difficult to mount the component

on the sine bar.

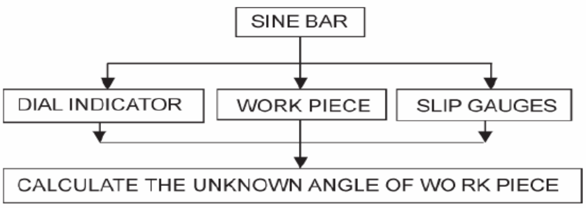
EXPERIMENTAL SET UP FOR THE SINE BAR



Measurement of angle Using Sine bar



Concepts and objectives of the Sine bars as follows:



Objectives:

Students will be able to know

i. Understand different parts of sine,

ii. Know the principle, use and working of sine bar

ExperimentNo.7B: Date:

MEASUREMENT OF TAPER ANGLE USING SINE BAR

Aim:To determine the taper angle of the given work piece using sine bar.

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

Theory:

Sine bar is a precision instrument used along with slip gauges for accurate angle measurements or angle setting. Sine bar consists of an accurate straight bar in which two accurately lapped cylindrical plugs or rollers are located with extreme position. The straight bar are made of high carbon, high chromium, corrosion resistant steel and the surfaces are hardened, grounded and lapped. Ends of the straight bar are stepped so that the plugs can be screwed at each step. Plugs are the two rollers of same diameter fixed at a distance L between them and is called as length of the bar. This distance L is the centre to centre distance of plugs is which is generally 100, 200 and 300 mm and soon.

Use of Sine bar: The work piece whose angle is to be measured is placed on sine bar. Below one roller of sine bar, slip gauges are placed. Slip gauges are added till the work piece surface is straight. Dial indicator is moved from one end of work piece till another end. Slip gauges are added till dial pointer does not move from zero position. The use of sine bar is based on the laws of trigonometry. When sine bar set up is made for the purpose of angle measurement, sine bar itself forms hypotenuse of right angle triangle and slip gauges form the side opposite to the required angle. **Sin θ= (h/L),** Therefore θ= sin-1(h/L), Angle θ is determined by an indirect method as a function of sine so this device is called as sine bar. Sine bar is always used in conjunction with slip gauge and dial indicator for the measurement of angle.

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. Sine bars are used in junction with slip gauges constitute a very good device for the precision measurement of angles. Since sine bars 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 measuringandsettinganyangleoftheobjecthavingflatsurface.Sinebarsarealsousedto measure or set angle of the object not larger than the 45^0, if higher accuracy is demanded.

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 calliper.
5. The work piece whose taper is required to be known is fixed on the upper surface of the sine bar 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 sideway.
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 to equal 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 actual angle and theoretical angle of taper and error in taper.

Observations:

1. Least count of vernier calliper =___________ mm
2. Least count of dial gauge = ____________ mm
3. Distance between the centre of rollers & side bar L = 200mm
4. Length of specimen(taper length), l = ______________mm

Calculations:

1) Height for one side of the work piece H = -------------mm
2) Actual taper angle, θ_{act} = [sin-1 (H_{act})] /L =__________Degrees

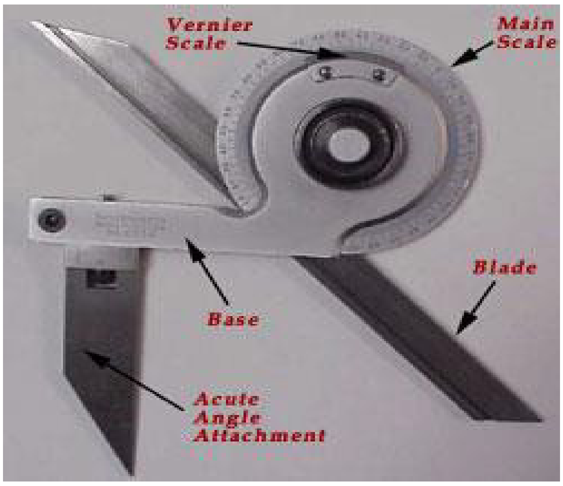
Results:

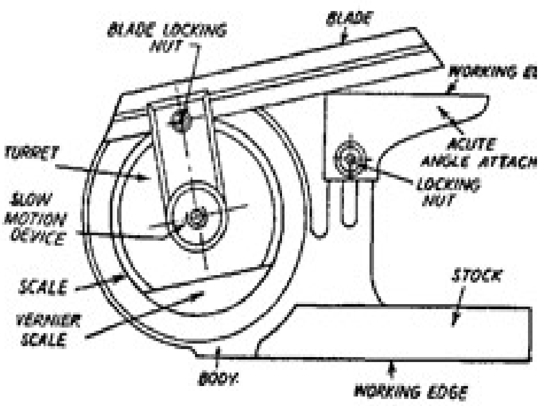
The unknown angle of the given conical specimen was detected and found to be…………… degree

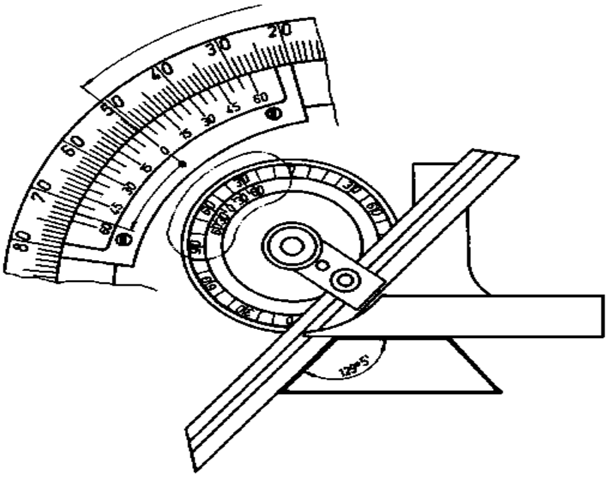
Applications:

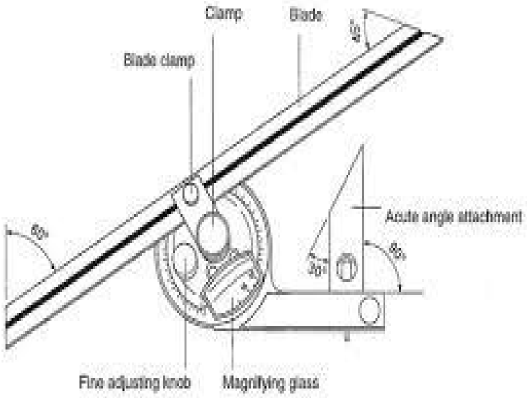
1. To measure and/ or set the angle accurately using a sine bar, the main requirement is that it must be accurate.
2. To check the flat surfaces in industry machine tools like lathe beds, milling machines columns, tables, apron & also saddle in lathe.
3. Rolling mills housing can be checked by sine bars.

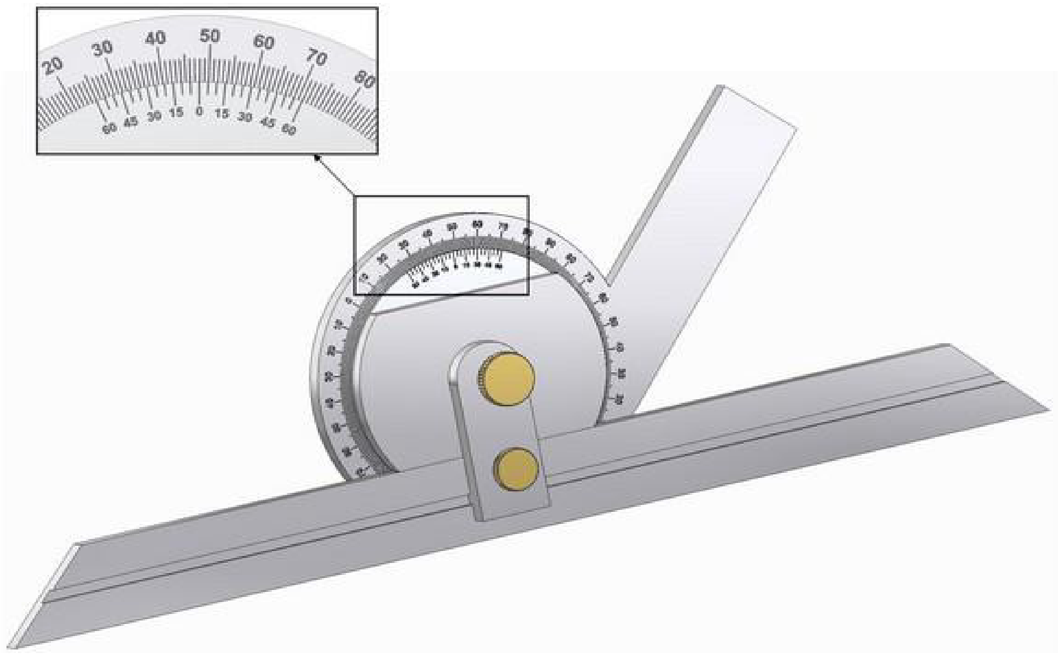
EXPERIMENTAL SET UP FOR BEVEL PROTRACTOR











ExperimentNo.7C: Date:

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.

Objectives:

Students will be able to know

- Understand different parts of vernier bevel protractor,
- Know the use and working of bevel protractor,
- Understand the use of vernier bevel protractor.

Theory:

Main parts of bevel protractor are

1. Fixed Base blade and a circular body is attached to it.
2. Adjustable blade.
3. Blade clamp.
4. Scale magnifier lens.
5. Acute angle attachment.

Bevel protractor 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.

Note the reading, magnifying lens has been provided for easy reading of the instrument. Main scale is circular and is graduated in degrees on the circular body. Main scale graduations are all around the circular body which is attached to fixed base blade. Fixed base blade also called as stock is attached to circular body of bevel protractor as shown in figure. Once the reading is fixed, blade clamp fixes the reading. Blades are about 150 mm long or 300mm long, 13mm wide and 2mm thick. Its ends are beveled at angles of 45 degree and 60 degree. Vernier scale is also marked on turret which can rotate all over the fixed body. Adjustable blade can pass through the slot provided in turret. So as the turret rotates, adjustable blade also rotates full 360 degrees. There are 12 graduations of Vernier scale starting from 0 to 60o on both sides of zero of Vernier scale as shown in figure.

$$\text{Least count of Vernier bevel protractor} = \frac{\text{smallest division on main scale}}{\text{Total no of divisions on Vernier scale}}$$

$$= 1^{o}\ (\text{equal to } 60') \text{ i.e. } \frac{60}{12}$$

$$= 5 \text{ minutes (written as } 5')$$

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____________________minutes

Tabular Column:

SL No.	Faces/Sides	Angles
1		
2		
3		
4		

Applications:

1. To measure the acute & obtuse angles in case of flat & circular objects with large radius.
2. In machining processes like production of flat surfaces.
3. For checking the_ V 'block, it is used.

Results:

By using the bevel protractor, the taper angle of the given specimen is calculated and they were found to be

1)

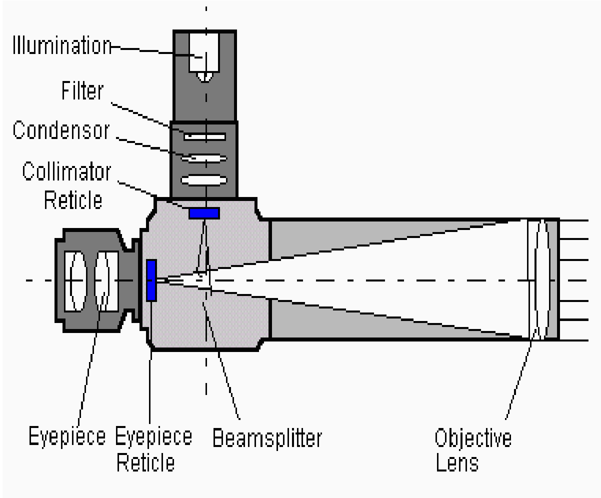
2)

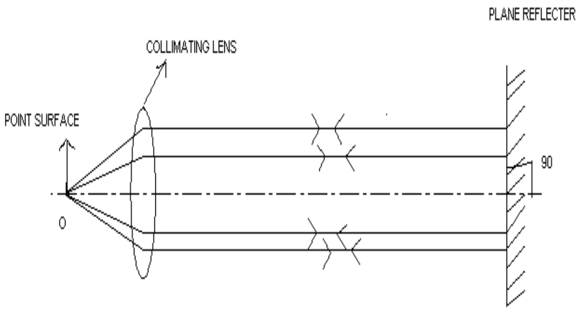
3)

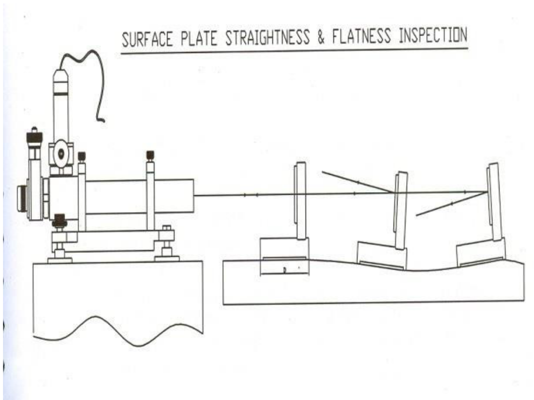
4)

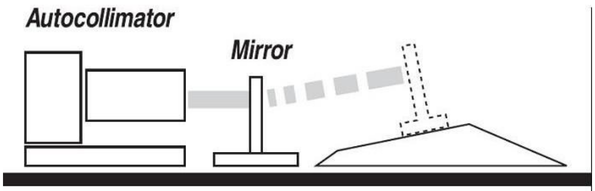
5)

EXPERIMENTAL SET UP FOR AUTOCOLLIMATOR









Measuring straightness.

Experiment No.8: Date:

MEASUREMENT OF ALIGNMENT USING AUTOCOLLIMATOR

Aim: To check the Straightness & flatness of the given component by using Autocollimator.

Apparatus: Autocollimator, work piece/ object to be tested.

Theory:

Definition of straightness-a plane is to be said straight over a given length. If the variation or distance of its point from two planes perpendicular to each other and parallel to the generation direction at of the line remain within specified tolerance limits. The reference planes being so chosen that there intersection is parallel to the straight line joining two points suitably located on the line to be tested and two points being close ends of the length to be measured.

Principle of the Autocollimator: A cross line -target‖graticule is positioned at the focal plane of a telescope objective system with the intersection of the cross line on the optical axis, i.e. at the principal focus. When the target graticule is illuminated, rays of light diverging from the intersection point reach the objective via a beam splitter and are projected- from the objective as parallel pencils of light. In this mode the optical system is operating asa *–collimator‖.*

A **flat reflector** placed in front of the objective and exactly normal to the optical axis reflects the parallel pencils of light back along their original paths. They are then brought to focus in the plane of the target graticule and exactor coincident with its intersection. A proportion of the returned light passes straight through the beam splitter and the return image of the target cross line is therefore visible through the eyepiece. In this mode, the optical system is operating as a telescope focused at infinity.

If the reflector is tilted through a small angle the reflected pencils of light will be deflected by twice the angle of tilt (principle of reflection) & will be brought to focus in the plane of target graticule but linearly displaced from the actual target cross lines by an amount 2θ* *f.*

An optical system of an auto collimator consists of a light source, condensers, semi-reflectors, target wire, collimating lens and reflector apart from microscope eyepiece. A target wire takes place of the light source into the focal plane of the collimator lenses. Both the target wire and the reflected image are seen through a microscope eyepiece. The eyepiece incorporates a scale graduated in 0.05mm interval and a pair of parallel setting wires which can be adjusted. Movements of wires are effected through a micrometer, one rotation of the drum equals to one scale division movement of the wires. The instrument is designed to be rotated through 90 degrees about its longitudinal axis so that the angles in both horizontal & vertical planes are measured.

Autocollimators: *It is an instrument designed to measure small angular deflections*

& may be used in conjunction with a plane mirror or other reflecting surface. An automaton is essentially an infinity telescope & a collimator combined into one instrument. This is an optical instrument used for the measurement of small angular differences. For small angular measurements, autocollimator provides a very sensitive and accurate approach. Auto- collimator is essentially an infinity telescope and a collimator combined into one instrument. The principle on which this instrument works is given below. O is a point source of light placed at the principal focus of a collimating lens. The rays of light from O incident on the lens will now travel as a parallel beam of light. If this beam now strikes a plane reflector which is normal to the optical axis, it will be reflected back along its own path and refocused at the same point O. If the plane reflector be now tilted through a small angle 0, then parallel beam will be deflected through twice this angle, and will be brought to focus at O' in the same plane at a distance x from O. Obviously

OO'=x=2θ.f, where *f* is the focal length of the lens.

Procedure:

(1) Make the distance of 100mm internal on the work piece.

(2) Set the cross wire so that two cross will coincide.

(3) Set the mirror so that the cross wire will be visible

(4) Move the reflector on next 100mm mark and adjust it to see reflection of crosswire.

(5) Take the reading of reflected crosswire deviated or moved up or down. Measure the distance between two crosswire.

Tabular Column:

SL No	Bridge Length (Base length of the reflector)	Cumulative Bridge length (Position of the reflector)	Micrometer final reading (Autocollimator)	Difference from previous Position (X in seconds)	Deviation for each 100mm (Θ in degrees)
1					
2					

3					
4					

Calculation:

Tan θ = X / 100

X = (100 x Tan θ) x 1000 in Microns

Where X = Level at position B with respect to position A

θ = Angle/Deviation in degrees/ Seconds (1 Degree = 60 Minutes, 1 Minute = 60 Seconds).

Result:

The values are analyzed and necessary modification of the surface may be recommended based on the accuracy required on flatness. If the values observed from the micrometer are varying linearly then straightness/flatness can be judged.

Applications:

1. To find the control line & alignment of circular & flat surfaces in machining.
2. Alignment of beams & columns in construction buildings / industries, steel structures.
3. In measuring the straightness, flatness and parallelism, these can be used.

EXPERIMENTAL SET UP FOR LATHE TOOL DYNAMOMETER

SPECIFICATIONS:

CAPACITY	: X, Y, Z - Force 500Kg
EXCITATION	: 10VDC
LINEARITY	:2%
ACCURACY	:2%
CROSS-SENSITIVITY	:5%
MAX.OVER LOAD	: 150 %

ExperimentNo.9A: Date:

MEASUREMENT OF CUTTING TOOL FORCES BY USING LATHE TOOL DYNAMOMETER

Aim: To measure the cutting tool forces by using lathe Tool Dynamometer.

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

Applications:

1. To determine the cutting forces in all the directions in cutting tools mounted on a machine like lathe, milling etc.
2. In metal forming operations, like to find out the forces on punch press tools.

Theory: The dynamometers being commonly used now-a-days for measuring machining forces desirably accurately and precisely (both static and dynamic characteristics) are either a strain gauge type or a piezoelectric type. Strain gauge type dynamometers are inexpensive but less accurate and consistent, whereas, the piezoelectric type are highly accurate, reliable and consistent but very expensive for high material cost and stringent construction.

Turning/Lathe Dynamometer: Turning dynamometers may be strain gauge or piezoelectric type and may be of one, two or three dimensions capable to monitor all of PX, PY and PZ. For ease of manufacture and low cost, strain gauge type turning dynamometers are widely used and preferably of 2 – D (dimension) for simpler construction, lower cost and ability to provide almost all the desired force values. Pictorially shows use of 3 – D turning dynamometer having piezoelectric transducers inside.

Procedure: **Lathe Tool Dynamometer** is a cutting force measuring instrument used to measure the cutting forces coming on the tool tip on the Lathe Machine. The sensor is designed in such a way that it can be rigidly mounted on the tool post, and the cutting tool can be fixed to the sensor directly. This feature will help to measure the forces accurately without lose of the force. The sensor is made of single element with three different wheat stones strain gauge bridge. Provision is made to fix 1/2" size Tool bit at the front side of the sensor. The tool tip of the tool bit can be grind to any angle required. Forces in X - Y - Z directions will be shown individually & simultaneously in three digital Indicators Supplied

Tabular Column:

Material used:____________________ Depth of Cut:__________________mm

Sl. No.	Depth of cut feed in mm	Forces in Kg-f		
		F_X	F_Y	F_Z
1				
2				
3				
4				

Result:

The resultant forces are found out for different speeds (V) by lathe tool dynamometer

1) Fx=……………..kgF
2) Fy=……………..kgF
3) Fz=………………kgF

EXPERIMENTAL SET UP FOR DRILL TOOL DYNAMOMETER

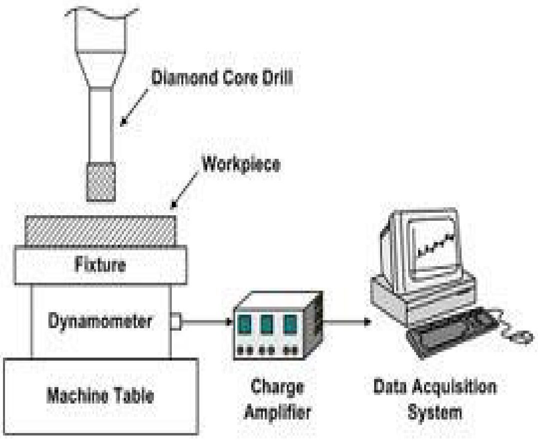


FIGURE 1. Structure of experimental setup

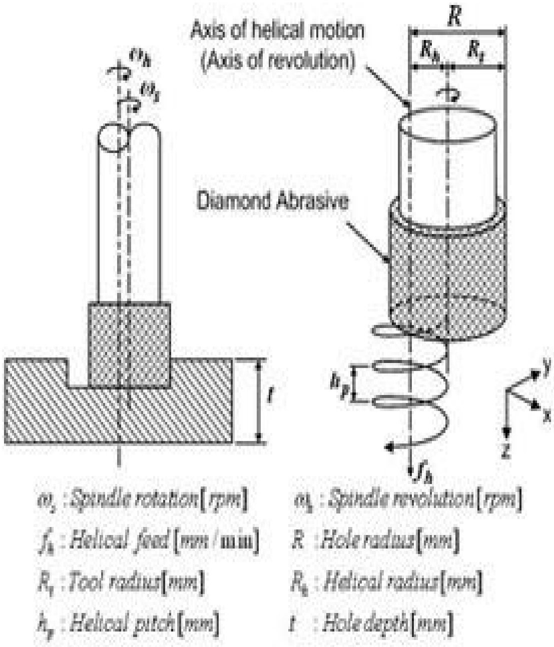


FIGURE 2. Illustration of helical-feed drilling

ExperimentNo.9B: Date:

MEASUREMENT OF THRUST FORCE AND TORQUE BY USING DRILL TOOL DYNAMOMETER

Aim: Measurement of -Torque and Thrust‖ forces by using Drill Tool Dynamometer.

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

Theory:

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 output 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.

SPECIFICATIONS:

Force	: Thrust force and Torque.
Range of Force	: 200 kg-f thrust 20 kg-m torque
Bridge Resistance	: 350ohms
Bridge voltage	: 12 Volts maximum

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.

TabularColumn Material used:

Sl. No.	Drill bit size	Depth of cut in mm	Thrust Force in Kg-f	Drill Bit Size in mm
1				
2				
3				

4				

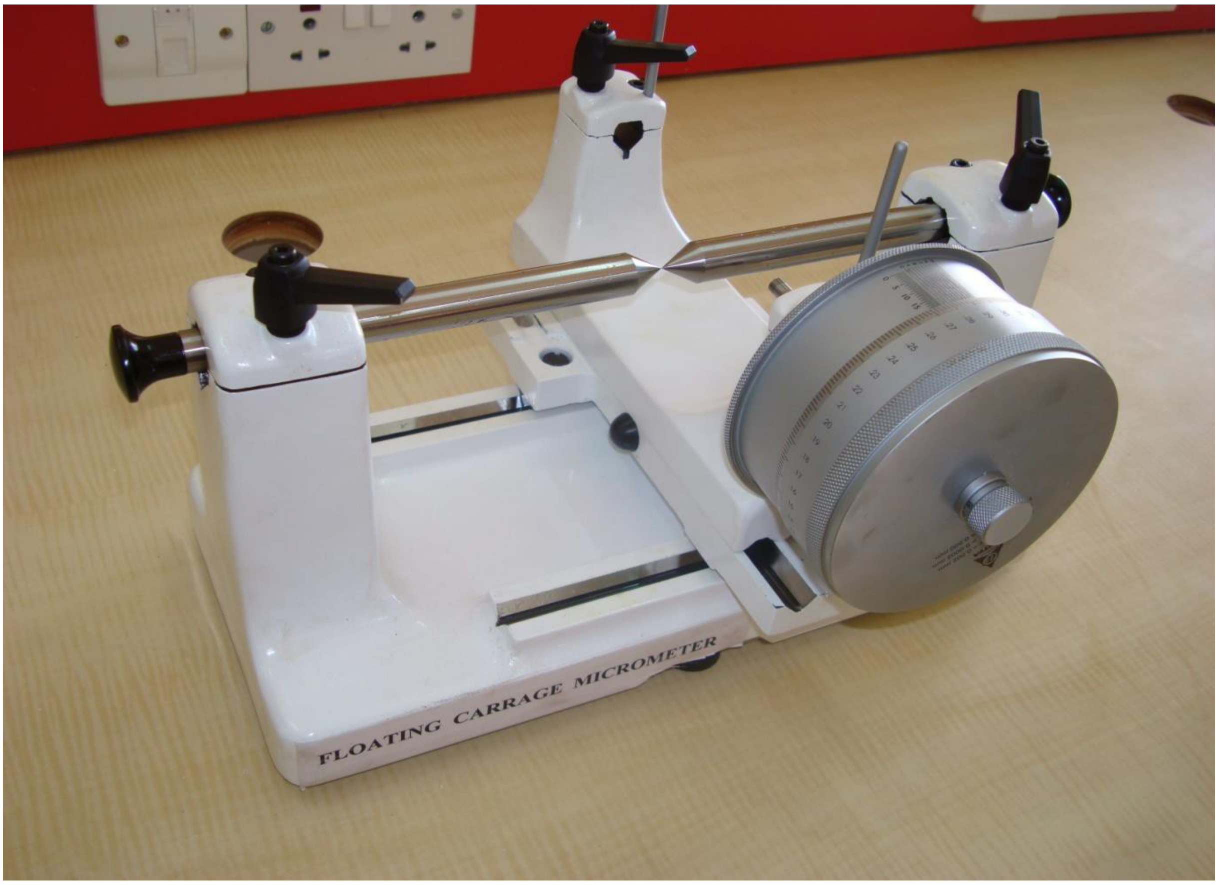
Results:

The thrust force and torque force acting on work piece are detected and they are found to be …………….kgF nd …………….kgf respectively

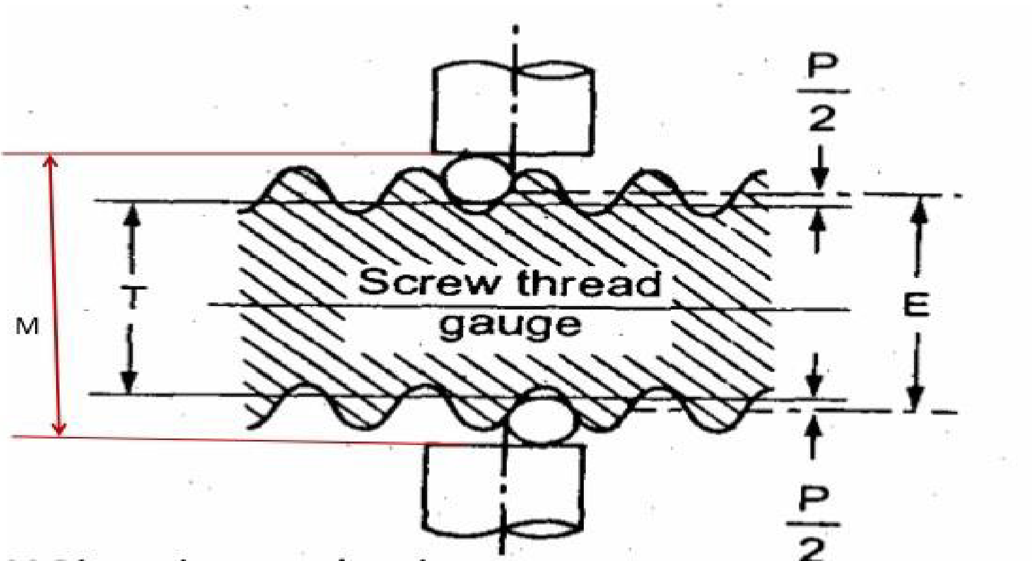
Applications:

1. To estimate the torque required & tool & thrust force requirements in drilling operations.
2. In boring and trepanning operations to find torque and thrustforce

EXPERIMENTAL SET UP FOR TWO WIRE METHOD



Two wire method:

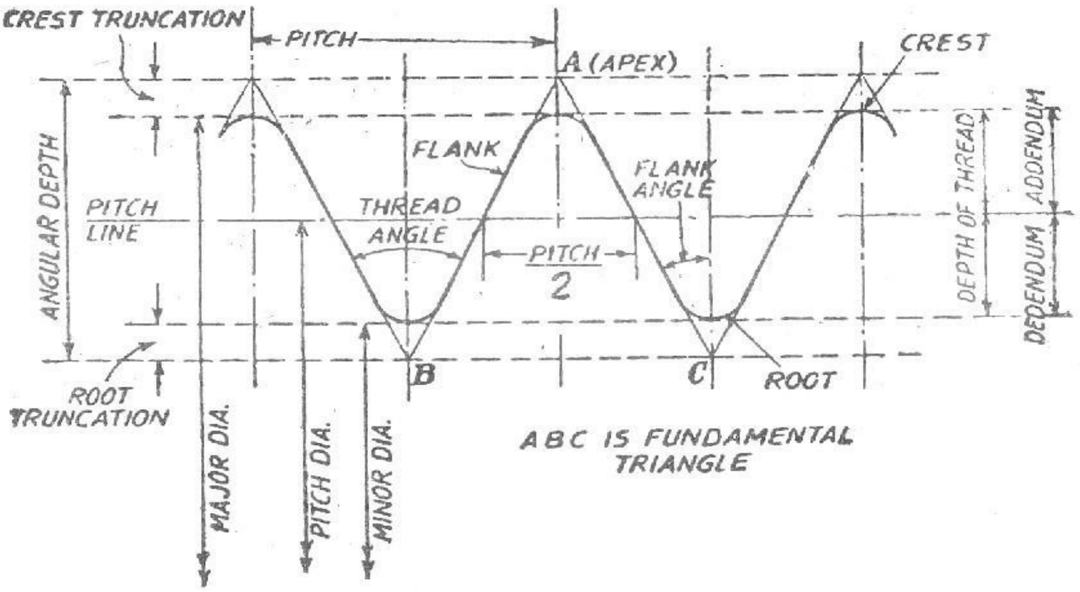


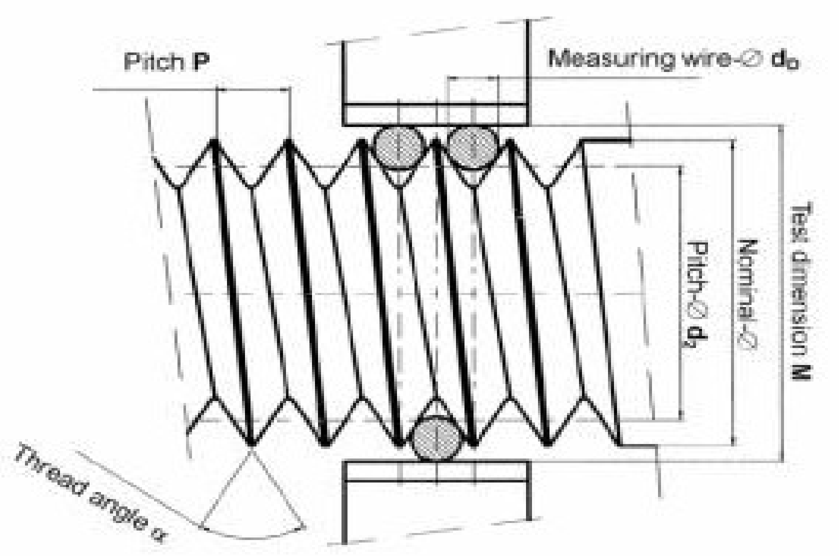
ExperimentNo.10: *Date:*

MEASUREMENT OF SCREW THREAD PARAMETERS USING TWO WIRE METHOD BY FLOATING CARRIAGE MICROMETER

Aim: To measure the screw thread parameters using two wire method by Floating carriage micrometer.

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





Screw Threads Terminology:

1. **Screw thread.** A screw thread is the helical ridge produced by forming a continuous helical groove of uniform section on the external or internal surface of a cylinder or

cone. A screw thread formed on a cylinder is known as straight or parallel screw thread, while the one formed on a cone or frustum of a cone is known as tapered screw thread.

2. **External thread.** A thread formed on the outside of a work piece is called external thread e.g., on bolts or studs etc.

3. **Internalthread.**Athreadformedontheinsideofaworkpieceiscalledinternalthread e.g. on a nut or female screw gauge.

4. **Multiple-start screw thread.** This is produced by forming two or more helical grooves, equally spaced and similarly formed in an axial section on a cylinder. This gives a _quick traverse' without sacrificing core strength.

5. **Axis of a thread.** This is imaginary line running longitudinally through the centre of the screw.

6. **Hand (Right or left hand threads).** Suppose a screw is held such that the observer is looking along the axis. If a point moves along the thread in clockwise direction and thus moves away from the observer, the thread is right hand; and if it moves towards the observer, the thread is left hand.

7. **Form, of thread.** This is the shape of the contour of one- complete thread as seen in axial section.

8. **Crest of thread.** This is defined as the prominent part of thread, whether it is external or internal.

9. **Root of thread.** This is defined as the bottom of the groove between the two flanks of the thread, whether it be external or internal.

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

11. **Angle of thread {Included angle).** This is the angle between the flanks or slope of the thread measured in an axial plane.

12. **Flank angle.** The flank angles are the angles between individual flanks and the perpendicular to the axis of the thread which passes through the vertex of the fundamental triangle. The flank angle of a symmetrical thread is commonly termed as the half- angle of thread.

13. **Pitch.** The pitch of a thread is the distance, measured parallel to the axis of the thread, between corresponding points on adjacent thread forms in the same axial plane and on the same side of axis. The basic pitch is equal to the lead divided by the number of thread starts. On drawings of thread sections, the pitch is shown as the distance from the centre of one thread crest to the centre of the next, and this representation is correct for single start as well as multi-start threads.

14. **Lead.** Lead is the axial distance moved by the threaded part, when it is given one complete revolution about its axis with respect to a fixed mating thread. It is necessary to distinguish between measurements of lead from measurement of pitch, as uniformity of pitch measurement does not assure uniformity of lead. Variations in either lead or pitch cause the functional or virtual diameter of thread to differ from the pitch diameter.

15. **Thread per inch.** This is the reciprocal of the pitch in inches.

16. **Lead angle**. On a straight thread, lead angle is the angle made by the helix of the thread at the pitch line with plane perpendicular to the axis. The angle is measured in an axial plane.

17. **Helix angle.** On straight thread, the helix angle is the angle made by the helix of the thread at the pitch line with the axis. The angle is measured in an axial plane.

18. **Depth of thread**. This is the distance from the crest or tip of the thread to the root of the thread measured perpendicular to the longitudinal axis or this could be defined as the distance measured radially between the major and minor cylinders.

19. **Axial thickness.** This is the distance between the opposite faces of the same thread measured on the pitch cylinder in a direction parallel to the axis of thread.

20. **Fundamental triangle**. This is found by extending the flanks and joining the points B and C. Thus in Fig. 13.2, triangle ABC is referred to as fundamental triangle. Here BC=pitch and the vertical height of the triangle is called the angular or theoretical depth. The point A is the apex of the triangle ABC.

21. **Truncation.** A thread is sometimes truncated at the crest or at the root or at both crest and root. The truncation at the crest is the radial distance from the crest to the nearest apex of the fundamental triangle. Similarly the truncation at the root is the radial distance from the root to the nearest apex.

22. **Addendum.** For an external thread, this is defined as the radial distance between

the major and pitch cylinders. For an internal thread this is the radial distance between the minor and pitch cylinders.

23. **Dedendum.** This is the radial distance between the pitch and minor cylinder for external thread, and for internal thread, this is the radial distance between the major and pitch cylinders.

24. **Major diameter.** In case of a straight thread, this is the diameter of the major cylinder (imaginary cylinder, co-axial with the screw, which just touches the crests of an external thread or the root of an internal thread). It is often referred to as the outside diameter, crest diameter or full diameter of external threads.

25. **Minor diameter.** In case of straight thread, this is the diameter of the minor cylinder (an imaginary cylinder, co-axial with the screw which just touches the roots of an external thread or the crest of an internal thread). It is often referred to as the root diameter or cone diameter of external threads.

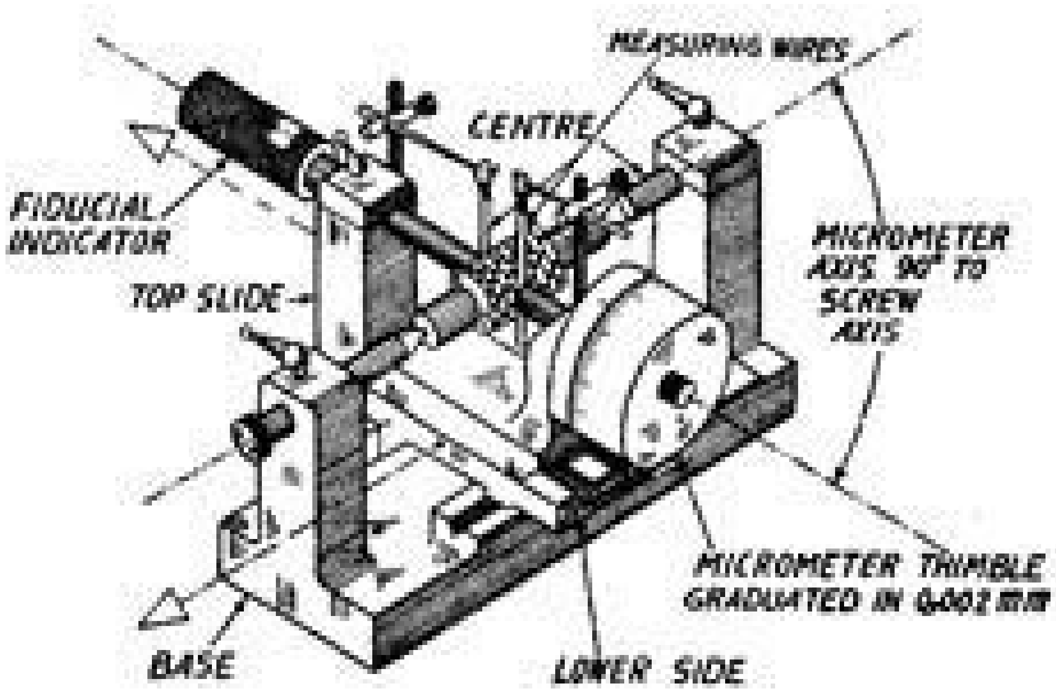
26. **Effective diameter or pitch diameter.** In case of straight thread, this is the diameter of the pitch cylinder (the imaginary‘ cylinder which is co-axial with the axis of the screw, and intersects the flank of the threads in such a way as to make the width of threads and width of the spaces between the threads equal). If the pitch cylinder be imagined as generated by a straight line parallel to the axis of screw, that straight line is then referred to as the pitch line. Along the pitch line, the widths of the threads and the widths of the spaces are equal on a perfect thread. This is the most important dimension at it decides the quality of the fit between the screw and the nut.

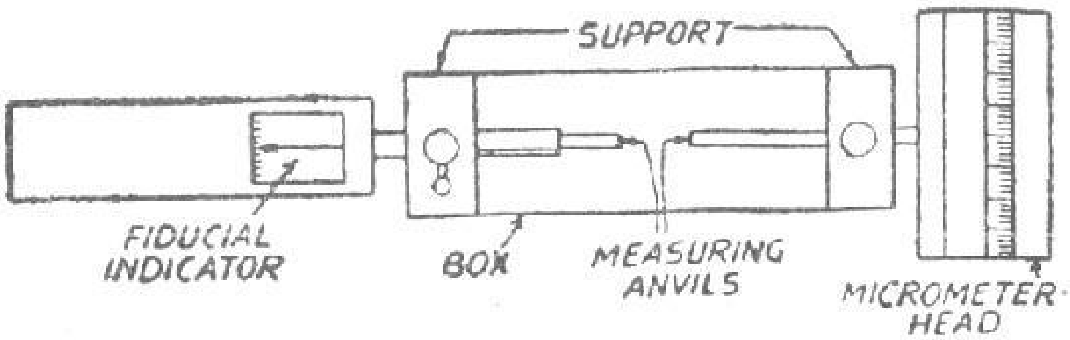
27. **Functional (virtual) diameter.** For an external or internal thread, this is the pitch diameter of the enveloping thread of perfect pitch, lead and flank angles having full depth of engagement but clear at crests and roots. This is defined over a specified length of thread. This may be greater than the simple effective diameter by an amount due to errors in pitch and angle of thread. The virtual diameter being the modified effective diameter by pitches and angle errors, is the most important single dimension of a screw thread gauge. In the case of taper screw thread, the cone angle of taper, for measurement of effective diameter, and whether pitch is measured along the axis or along the pitch cone generator also need to be specified.

Applications of Measurement of screw thread parameters using two wire methods

1. By using floating carriage micrometer the minor, major and effective diameters are to be determined.

Measurement of screw threads- principles of floating carriage micrometer





Bench Micrometer.
Fig. 13·8

If D_1=diameter of setting cylinder.
R_1=reading of micrometer on setting cylinder.
R_2=micrometer reading on thread,

It consists of three main units. A base casting carries a pair of centres, on which the threaded work-piece is mounted. Another carriage is mounted on it and is exactly at 90° to it. On this is provided another carriage capable of moving towards the centres. On this carriage one head having a large thimble enabling reading up to 0.002 mm is provided. Just opposite to it is a fixed anvil which is spring loaded and its zero position is indicated by a fiducial indicator. Thus the micrometer elements are exactly perpendicular to the axis of the centers as the two carriages are located perpendicular to each other. On the fixed carriage the centers are supported in two brackets fitted on either end. The distance between the two centres can be adjusted depending upon the length of tie threaded job. After job is fitted between the centres the second carriage is adjusted in correct position to take measurements and is located in position, the third carriage is then moved till the fiducial indicator is against the set point.

The readings are noted from the thimble head. It is now obvious that the axis of the indicator and micrometer head spindle is same and is perpendicular to the line of two centres. The indicator is specially designed for this class of work and has only one index line, against which the pointer is always to be set. This ensures constant measuring pressure for all readings. Sufficient friction is provided by the conical pegs to restrain the movement of carriage along the line of centres. The upper carriage is free to float on balls and enables micrometer readings to be taken on a diameter without restraint. Squareness of the micrometer to the line of centre can be adjusted by rotating the pegs in the first carriage which is made eccentric in its mounting. Above the micrometer carriage, two supports are provided for supporting the wires and Vee pieces for measurement of effective diameter etc.

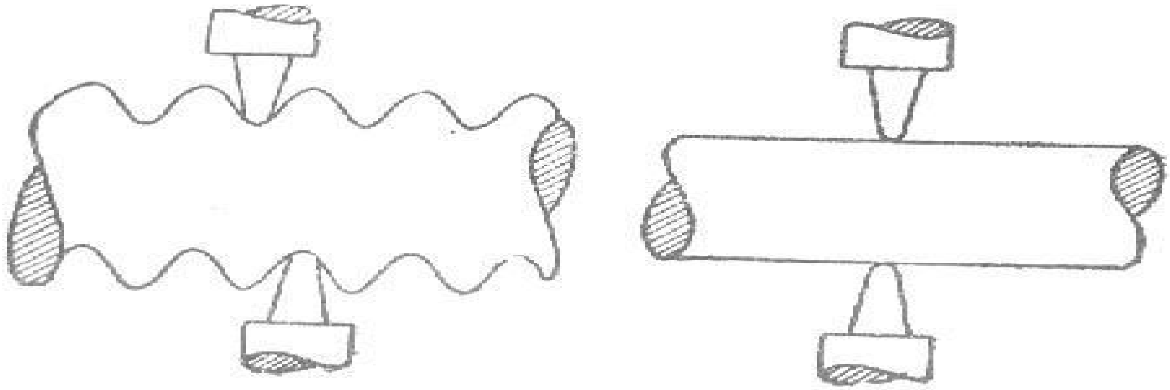
(i) Measurement of Major Diameter.

For the measurement of major diameter of external threads, a good quality hand micrometer is quite suitable. In taking readings, a light pressure must be used as the anvils make contact with the gauge at points only and otherwise the errors due to compression can be introduced. It is, however, also desirable to check the micrometer reading on a cylindrical standard of approximately the same size, so that the zero error etc., might not come into picture. For greater accuracy and convenience, the major diameter is measured by bench micrometer. This instrument was designed by N.P.L. to estimate some deficiencies inherent in the normal hand micrometer. It uses constant measuring pressure and with this machine the error due to pitch error in the micrometer thread is avoided. In order that all measurements be made at the same pressure, a fiducial indicator is used in place of the fixed anvil. In this machine there is no provision for mounting the work piece between the centres and it is to be held in hand. This is so, because, generally the centers of the work piece are not true with its diameter. This machine is used as a comparator in order to avoid any pitch errors of micrometers, zero error setting etc. A calibrated setting cylinder is used as the setting standard. The advantage of using cylinder as setting standard and not slip gauges etc., is that it gives greater similarity of contact at the anvils. The diameter of the setting cylinder must be nearly same as the major diameter. The cylinder is held and the reading of the micrometer is noted down. This is then replaced by threaded work piece and again micrometer reading is noted for the same reading of fiducial indicator. Thus, if the size of cylinder is approaching, that of major diameter, then for a given reading the micrometer thread is used over a short length of travel and any pitch errors it contains are virtually eliminated.

Then major diameter=D1+ (R2−R1). In order- to determine the amount of taper, the readings should‘ be taken at various positions along the thread and to detect the ovality, two or three readings must be taken at one plane in angular positions.

(ii) Measurement of MinorDiameter

This is also measured by a comparative process using small Vee-pieces which make contact with a root of the thread. The Vee-pieces are available in several sizes having suitable radii at the edges. The included angle of Vee-pieces is less than the angle of the thread to be checked so that it can easily probe to the root of the thread. To measure the minor diameter by Vee- pieces is suitable for only Whitworth and B.A. threads which have a definite radius at the root of the thread. For other threads, the minor diameter is measured by the projector or microscope.



The measurement is carried out on a floating carriage diameter measuring machine in which the threaded work-piece is mounted between centres and a bench micrometer is constrained to move at right angles to the axis of the centre by a Vee-ball slide. The method of the application of Vee-pieces in the machine is shown diagrammatically in Fig. The dimensions of Vee-pieces play no important function as they are interposed between the micrometer faces and the cylindrical standard when standard reading is taken. It is important while taking readings, to ensure that the micrometer be located at right angles to the axis of the screw being measured. The selected Vees are placed on each side of the screw with their bases against the micrometer faces. The micrometer head is then advanced until the pointer of the indicator is opposite the zero mark, and note being made of the reading. The screw is then replaced by standard reference disc or a plain cylindrical standard plug gauge of approximately the core diameter of the screw to be measured and second reading of the micrometer is taken.
If reading on setting cylinder with Vee-pieces in position=R1 and reading on thread =R2 & diameter of setting cylinder=D1 Then minor diameter =D1+ (R2—R1)
Readings may be taken at various positions in order to determine the taper and ovality.

(iii) Effective Diameter Measurements.

The effective diameter or the pitch diameter can be measured by . any one of the following methods :
(i) The micrometer method
(ii) The one wire, two wires, or three wire or rod methods.

<u>Theory</u>: 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.

Two Wire Method.

The effective diameter of a screw thread may be ascertained by placing two wires or rods of identical diameter between the flanks of the thread, as shown in Fig. 13.15, and measuring the distance over the outside of these wires. The effective diameter E I s then calculated as E=T+P, Where T= Dimension under the wires = M—2d, M=dimension over the wires, d= diameter of each wire

$$E = T + P$$

Where T = Dimension under the wires

$= M - 2d$

M = dimension over the wires, d = diameter of each wire

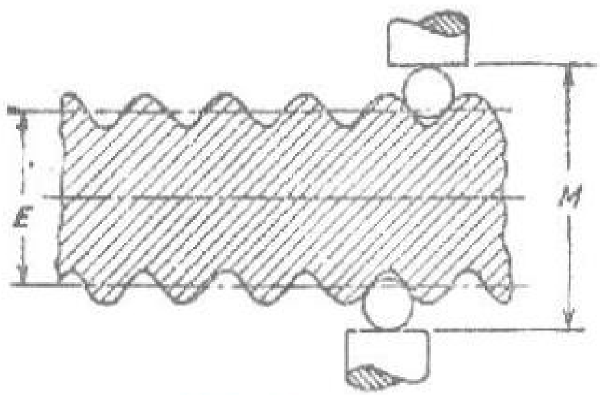


Fig (a)

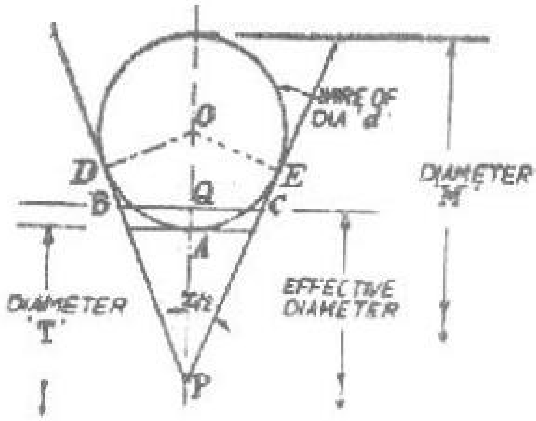


Fig (b)

The wires used are made of hardened steel to sustain the wear and tear in use. These are given a high degree of accuracy and finish by lapping to suit different pitches. Dimension T can also be determined by placing wires over a standard cylinder of diameter greater than the diameter under the wires and noting the reading R1 and then taking reading with over the gauge, say R2. ThenT=S—(R1—R2).

P=It is a value which depends upon the diameter of wire and pitch of the thread.

If P= pitch of the thread, then

P= 0.9605p−1.1657d (for Whitworth thread).

P= 0.866p—d (for metric thread).

Actually P is a constant Value which has to be added to the diameter under the wires to give the effective diameter. The expression for the value of P in terms of p (pitch), d (diameter of wire) and x (thread angle) can be derived as follows:

In Fig.13.15 (b), since BC lies on the effective diameter line

BC= ½ pitch=½ p

OP=d cosec x/2/2

PA=d

(cosecx/2-1)/2

PQ=QC cot x/2=p/4 cot x/2

AQ=PQ-AP=p cot x/2/4 – d (cosec x/2

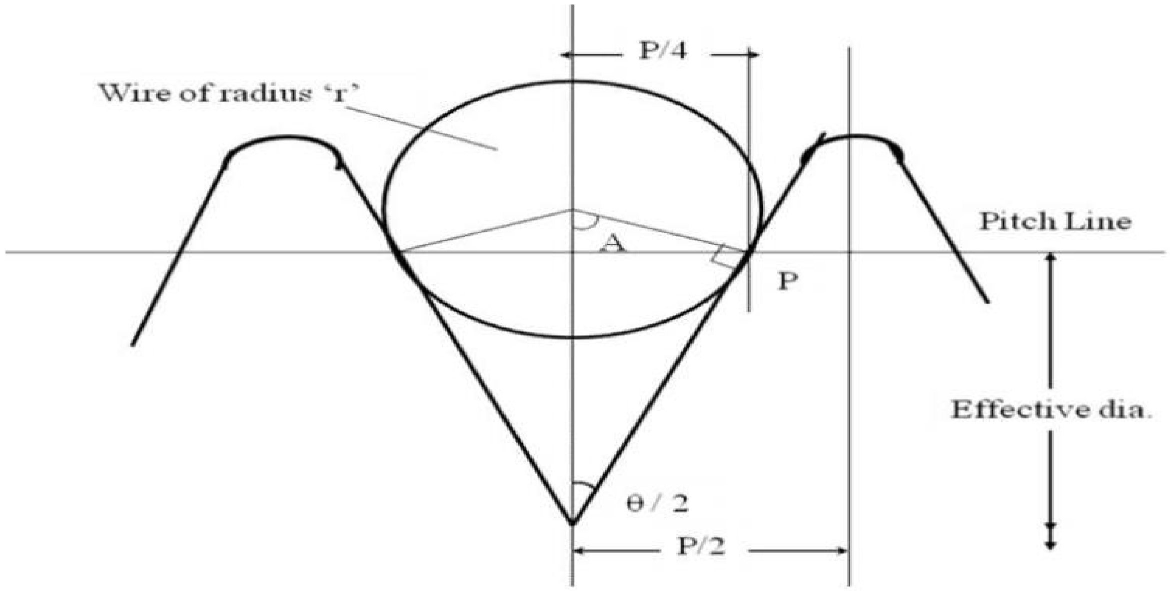
-1)/2 AQ is half the value of P

.'. P value=2AQ =p/2 cot x/2 -d (cosecx/2-1)

Two wire method can be carried out only on the diameter measuring machine described for measuring the minor diameter, because alignment is not possible by 2 wires and can be provided only by the floating carriage machine. In the case of three wire method, 2 wire, on one side help in aligning the micrometer square to the thread while the third placed on the other side permits taking of readings.

Best size wire Method:

This wire is of such diameter that it makes contact with the flanks of the thread on the effective diameter or pitch line. The effective diameter can be measured with any diameter wire which makes contact on the true flank of the thread, but the values so obtained will differ from those obtained with ‗best size' wires if there is any error in angle or form of thread. t is recommended that for measuring the effective diameter, always the best size wire shouldbeusedandforthisconditionthewiretouchestheflankatmeandiameterlinewithin ±1/5 of flank length



Let the thread angle be $\frac{\theta}{2}$

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 an other anvil.
6. Measure the distance over the wire properly by using micrometer.
7. Calculate the effective diameter of the screw thread.
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.
3. Pitch of the thread p =_____________mm.
4. Best size of the wire used d=___________mm.

Calculation:

1) Major diameter = D ± (D - R_1)

   D = Diameter of master specimen =………………mm

   R_1 = MSR+((CHSD×LC)+ (CVSD× LC)) =………………mm

2) Minor diameter = D ± (Rp - R_3)

   D = Diameter of master specimen =………………mm

   Rp = size of first prism + size of second prism +D

   R_3 = MSR+((CHSD×LC)+ (CVSD× LC)) =………………mm

3) Effective diameter = D ± (Rw – P - R_2)

   D = Diameter of master specimen =………………mm

   Rw = (2×size of wires) + D = ……………………..mm

   P = pitch value for the pitch 1mm

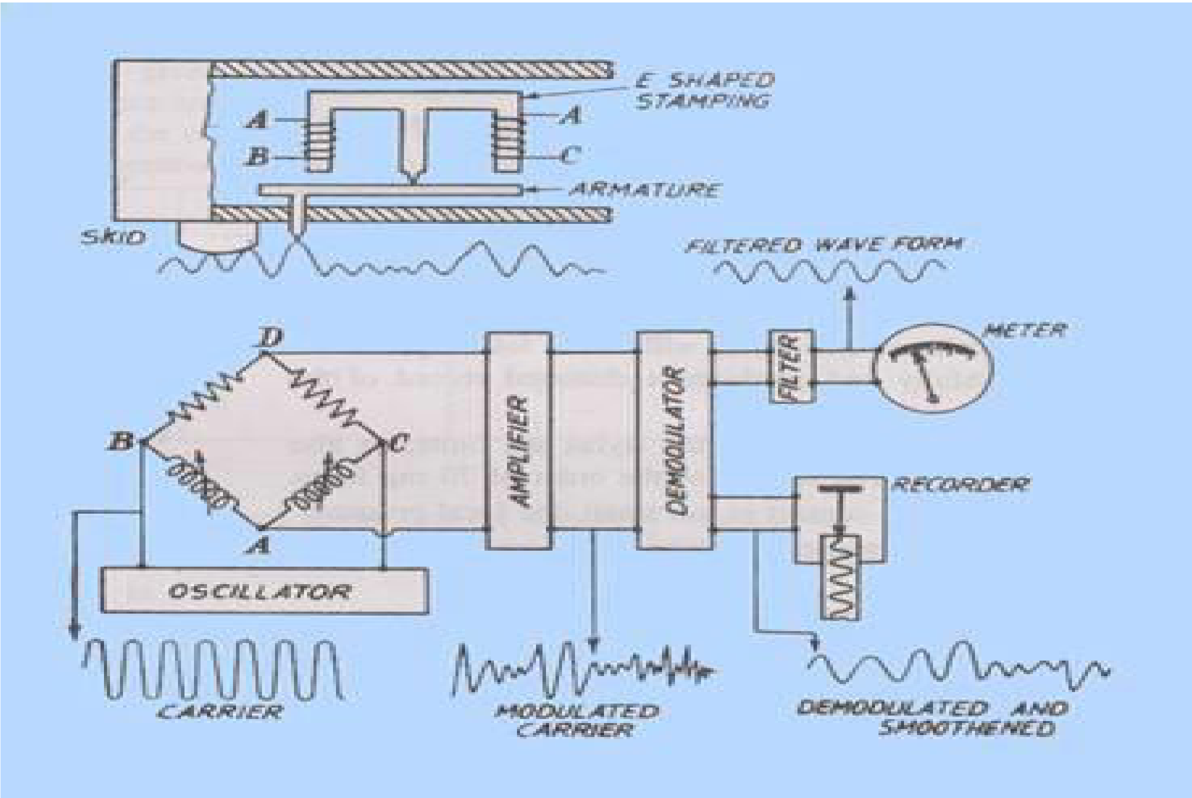
   R_2 = MSR+((CHSD×LC)+ (CVSD× LC)) =………………mm

Results:

The given threaded parameters are detected and they are found to be

1. Major Diameter =_______________mm
2. Minor Diameter =_______________mm
3. Effective Diameter=_______________mm.

EXPERIMENTAL SET UP FOR TALY SURF



ExperimentNo.11: Date:

MEASUREMENT OF SURFACE ROUGHNESS (TALYSURF)

Aim: To measure surface roughness parameter using surface roughness indicator.

Apparatus: Mitituyo make surface roughness tester, Calibrated specimen, Surface plate, Specimen

Procedure:

1. Connect Ac adopter to the measuring instrument & Switch on the power supply

2. Attach the drive detector unit & connect to all the cable connection as shown when mounting the detector to the drive unit, take care not to apply excessive force to the drive unit.

3. Adjust or modify the measurement condition such as sample length, number samples, Standard required for the measurement

4. Calibrate the instrument using standard calibration piece

5. Carefully place the detector on the work piece. Care should be taken to see that work piece & detector are aligned properly

6. Press the start button to measure the work piece & result are displaced on the console

7. Press print button to take the printout.

Applications:

1. Taly surf is the dynamic electronic instrument used on the factory floor as well as in the laboratory.
2. To find out the surface roughness of the machines &components.
3. To check the accuracy of the cast iron, granites used in workshops for checking the surface finish &flatness.

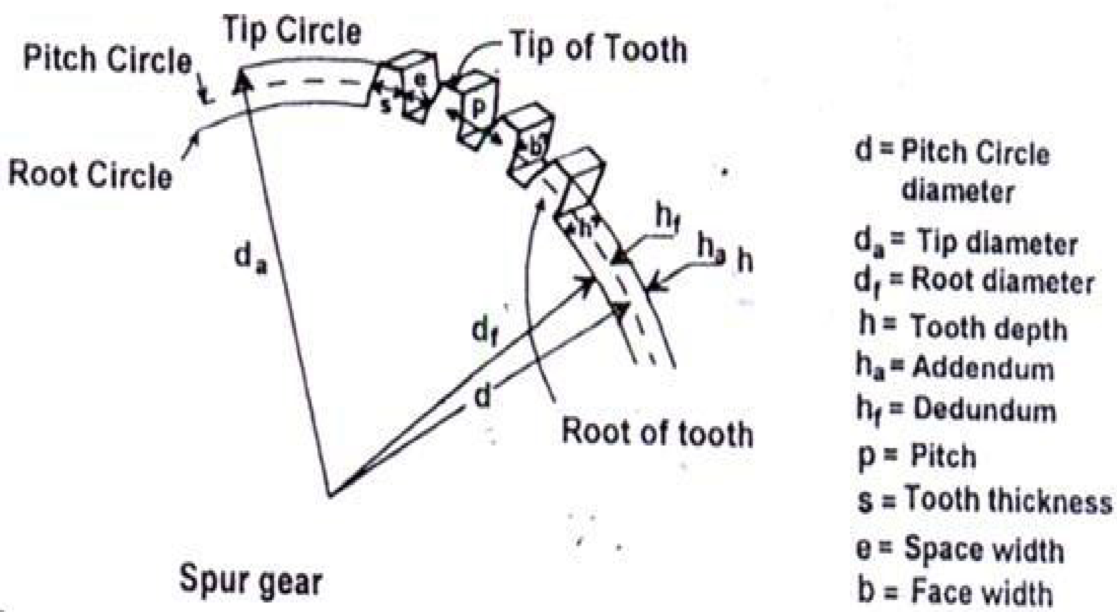
Tabular column:

Sl. no	Λ c in mm	N Number of intervals	Total length in mm	Ra value	Rz value	Rq value
1						
2						
3						
4						

Results: Surface roughness checked for different specimens by Tally surf.

EXPERIMENTAL SET UP FOR GEAR TOOTH MICROMETER

DIMENSIONS OF A SPUR GEAR



ExperimentNo.12: Date:

MEASUREMENT OF GEAR TOOTH PROFILE BY USING GEAR TOOTH MICROMETER

Aim: To determine the tooth thickness and other parameters of the given specimen using gear tooth vernier caliper

Apparatus: Gear Tooth Micrometer, 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 involutes 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.

Dedendum: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 micrometer
2. Measure the diameter of gear blank using vernier calliper also count the number of teeth on the gear blank.
3. Calculate the addendum of the gear tooth and fix the same dimension in gear tooth micrometer
4. Measure the same parameters for different teeth.
5. Take the average of tooth thickness.

Observation:

Least count of the gear tooth micrometer__________________mm

Least count of venire caliper =____________mm

Error In the gear tooth micrometer _____________mm

Calculations:

1) Pitch circle diameter (D) $= \frac{\text{outside dia.} + \text{inside dia.}}{2}$
2) No. teeth (Z) =…………..
3) Module (M) = D/2= …………………mm
4) Thickness of teeth = Z×Msin(90/2) = ……………….mm
5) Cordial addendum $= \frac{(Z \times M)}{2} \times (1 + (Z/2) - \cos(90/2))$ =……………mm
6) Height of teeth = MSR+ (CVSD×LC) − Error =…………………mm
7) Width of the teeth = MSR+ (CVSD×LC) = ……………mm

Rresult:

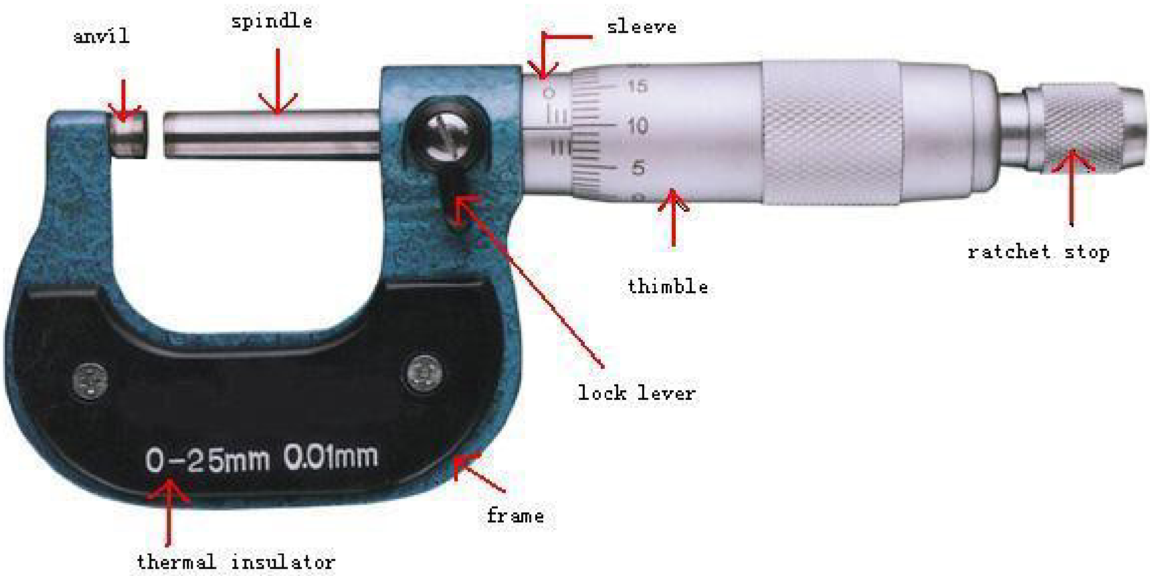
The different parameters of spur gear were detected and were found to be

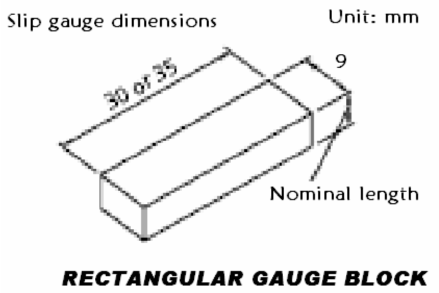
1) Pitch circle dia =………………mm
2) No. of teeth =…………………..
3) Module =……………..
4) Thickness of teeth =………….mm
5) Cordial addendum = ………….mm
6) Height of teeth =…………….mm
7) Width of teeth =……………mm

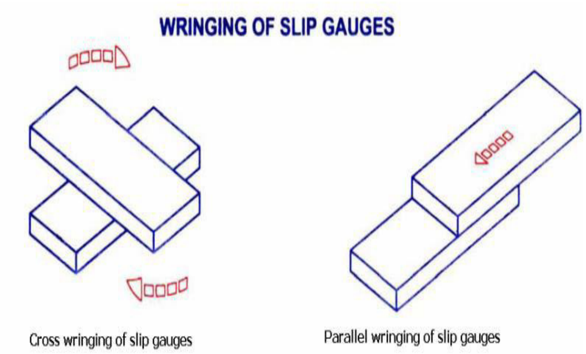
Applications:

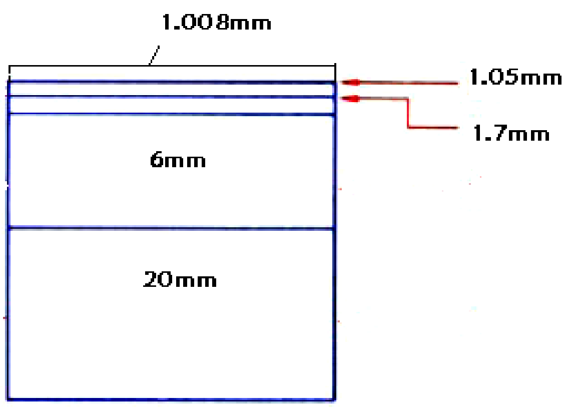
1. Gear tooth vernier is an instrument & is used for measuring pitch line tooth thickness. But this does not give a very accurate result, so base tangent length method has been used to away that difficulties by measuring the span of convenient number of teeth between the two parallel planes, which are tangential to the opposite tooth flanks. The span length is a tangent to the base circle. This distance is known as base tangent length.
2. Gear tooth micrometer
3. In finding out the dimensions of the gears & gear terminologies like pitch circle, addendum & deddundum etc.
4. To find out the in volute profiles of hypoidal gears, helical, bevel, warm & planetary gears.

EXPERIMENTAL SET UP FOR MICROMETER CALIBRATION









ExperimentNo:13 Date:

CALIBRATION OF MICROMETER USING SLIP GAUGES

Aim: To calibrate the micrometer for a progressive error and periodic error using slip gauges.

Apparatus: Micrometer, slip gauges, cotton cloth, benzene or petrol.

Objectives:

Students will be able to know 1. To know the use and working of slip gauges 2. To know the classification and working of slip gauges

Theory: Slip gauges are end standards used in linear measurements. They are used in workshop for work where a tolerance as low as 0.001mm is needed. Slip gauges were invented by Swedish engineer, C.E. Johnson, so they are also called Johnson gauges. Slip gauges are rectangular blocks, made of high grade steel, having cross section about 30mm X10mm. These blocks are made into required sizes and hardened to resist wear and allowed to stabilize so as to relieve internal stresses. This prevents occurrence of size and shape variations. After hardening the blocks, measuring faces are carefully finished to fine degree of surface finish, flatness and accuracy. This high grade surface finish is obtained by super finishing process known as lapping.

Wringing of slip gauges:

The measuring face of the gauges is flat and it possesses high surface finish. If two slip gauges are forced against each other on measuring faces, because of contact pressure, gauges stick together and considerable force is required to separate these blocks. This is known as wringing of slip gauges. Thus, wringing refers to condition of intimate and complete contact and of permanent adhesion between measuring faces. Slip gauges are wrung to build desired dimension. Slip gauges are wrung together by hand and no other external means. Figure shows 1) Parallel wringing of slip gauges and 2) Cross wringing of slip gauges.

In cross wringing – the two slip gauges are first cleaned to remove dirt and then they are placed together at right angles in the form of cross and then rotated through 90o, while being pressed together. This method causes less rubbing of surfaces. Almost any dimension may be built by suitable combination of gauges. Wringing phenomenon is purely due to surface contact and molecular adhesion of metal of blocks. Hence, ―wringing is defined as the property of measuring faces of gauge blocks of adhering, by sliding or pressing the gauge against measuring faces of other gauge blocks or reference faces or datum surfaces without the use of external means.‖

Uses/Applications of slip gauges

1. as a reference standard.
2. for verification and calibration of measuring apparatus.
3. for adjustment of indicating devices.
4. for direct measurement.
5. for setting of various types of comparators.
6. Micrometers are used to measure the small or fine measurements of length, width, thickness and diameter of the job.

Observation table:

Range: Least count: Make:

Sr. No	Slip gauges in combination	Micrometer reading in mm				
		Increasing	Decreasing	Average	Error	Correction
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Determining the dimension of 29.758mm by M45 slip gauge set:
Rule 1:-Minimum number of slip gauges should be used to build dimension.
Rule 2:- Always start with the last decimal place.

Procedure	Last decimal	Calculation
a) Write the required dimension		29.758
b) Starting with last decimal place i.e. 0.008 But we can use 1.008 as to follow rule 1.	0.008	- 1.008
c) After subtraction the value remaining is 28.75. Here the last decimal place is 0.05 but we can use 1.05 slip gauge set so as to follow rule 1	0.05	28.75 - 1.05
d) Value remaining is 27.7 i.e last decimal place is 0.7 But we can use 1.7mm slip gauge so as to follow rule 1.	0.7	27.7 - 1.7
e) Now the value remaining is 26 mm and we have 6mm gauge block available.	6.0	26.0 - 6.0
f) Final value is 20mm and this gauge is available. Remainder should always be zero	20mm	20.0 - 20.0 = 0.0

Hence to build the dimension of 29.758 we need slip gauges of 20mm, 6mm, 1.7mm, 1.05mm and 1.008mm.

Procedure of performing experiment:

(1) Clean the fixed vice and micrometer
(2) Clamp the micrometer in vice putting cushioning material between micrometer and jaws of vice to protect the micrometer from probable damage due to clamping force.
(3) Make pile of gauge blocks and insert between two anvils of the micrometer and take reading.
(4) Increase the value of gauge blocks pile and take next few readings.
(5) Then decrease the value of gauge blocks pile and take same readings in decreasing order.
(6) Tabulate the readings

(7) After cleaning the place the gauge blocks should be placed in their respective places.

Particulars of M87 and M45 slip gauge set.

M87 is a special set of slip gauges.

Range (mm)	Steps	Pieces
1.001 to 1.009	0.001	9
1.01 to 1.49	0.01	49
0.5 to 9.5	0.5	19
10 to 90	10	0
1.005	-	1

M45 is a normal set of slip gauges.

Range (mm)	Steps	Pieces
1.001 to 1.009	0.001	9
1.01 to 1.09	0.01	9
1.1 to 1.9	0.1	9
1 to 9	1	9
10 to 90	10	9
		Total 45

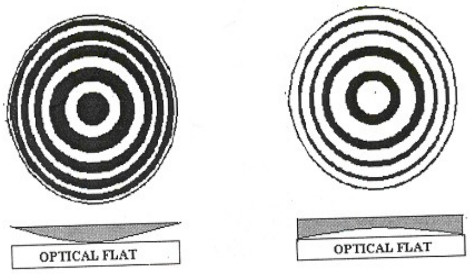
Plot the Graphs:

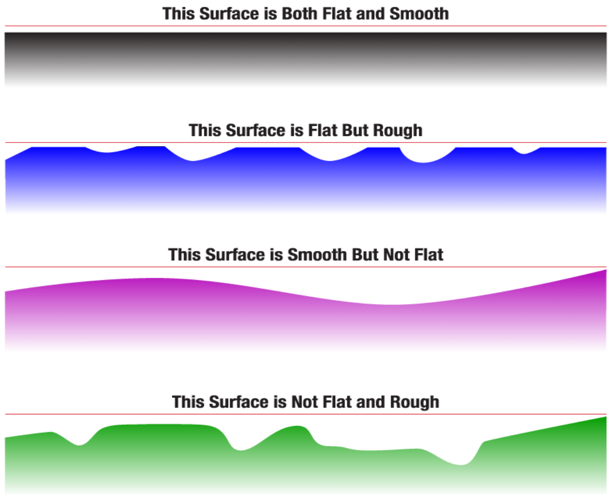
(1) Slip gauges combination – Micrometer average
(2) Slip gauges combination –Error
(3) Micrometer average reading –correction

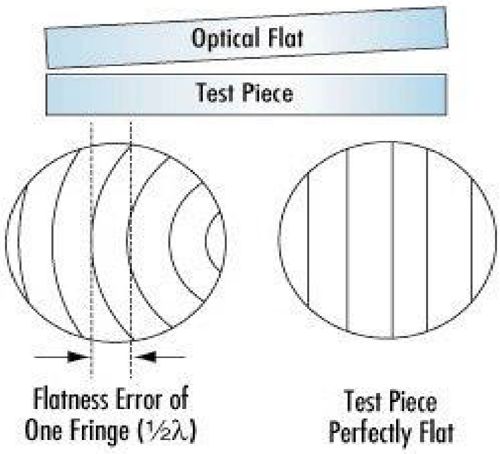
Result:

The given micrometer has been calibrated using M87 slip gauge set.

EXPERIMENTAL SET UP FOR OPTICAL FLAT







	tolerance type	characteristic	symbol
individual features	form	straightness	⏤
		flatness	⏥
		circularity	○
		cylindricity	⌭
for individual or related features	profile	profile of a line	⌒
		profile of a surface	⌓
related features	orientation	angularity	∠
		perpendicularity	⊥
		parallelism	//
	location	position	⌖
		concentricity	◎
	runout	circular runout	↗
		total runout	⌰

ExperimentNo14: Date:

MEASUREMENTS OF SURFACE FLATNESS BY USING MONOCHROMATIC LIGHT SOURCE

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 colours except yellowish colour. The dark bands viewed under the optical flat are not light waves. They simply show where interference is produced by reflections from two surfaces. These dark bands are used in measuring flatness. The band unit indicates the level of the work that has risen or fallen in relation to the optical flat, between the centre of one dark band and the center of the next dark band.

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

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

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 naked eye and calculates the flat nesserror

Observations:

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

$\lambda/2$ =___________mm. Where λ = 0.0002974 mm

Tabular Column:

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

.

Calculations:

Flatness error = N x $\lambda/2$

Results:

Flatness of a given surface by using the optical flats are observed

Applications:

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

3. In measuring the curvatures like convex and concave for surfaces of the standard gauges.

VIVA QUESTIONS WITH ANSWERS

1. What is metrology?

   Metrology is the science of measurement. Metrology includes all theoretical and practical aspects of measurement. **Metrology** is the process of making extremely precise measurements of the relative positions and orientations of different optical and mechanical components. **Metrology** is concerned with the establishment, reproduction, conservation and transfer of units of measurement & their standards.

2. What are the objectives of metrology?
   - To provide accuracy at minimum cost.
   - Thorough evaluation of newly developed products, and to ensure that components are within the specified dimensions.
   - To determine the process pabilities.
   - To assess the measuring instrument capabilities and ensure that they are adequate for their specific measurements.
   - To reduce the cost of inspection & rejections and rework.
   - To standardize measuring methods.
   - To maintain the accuracy of measurements through periodical calibration of the instruments.
   - To prepare designs for gauges and special inspection fixtures

3. What is calibration?

   Calibration is the comparing of an unknown measurement device against equal or better known standard under specified conditions. Every measuring system must be provable. The procedure adopted to prove the ability of a measuring system to measure reliably is called **'calibration'**.

4. Give the importance of calibration.
   - Assurance of accurate of measurements
   - Ability to trace measurements to international standards
   - International acceptance of test/calibration reports
   - Consumer protection (legal metrology)
   - Correct diagnosis of illness (medical reports)
   - Meeting the requirements of ISO 9000 &17025

5. What is a load cell?

   A Load cell is a transducer that is used to convert a force into an electrical signal. This conversion is indirect and happens in two stages. Through a mechanical arrangement, the force being sensed deforms a strain gauge. The strain gauge measures the deformation (strain) as an electrical signal, because the strain changes the effective electrical resistance of the wire.

6. List the various linear measuring instruments.

   a)Scale b) Vernier Calipers c)HeightGauge d) Micrometeretc.

7. Define an error.
   Error may be defined as the difference between the best measured or indicated value and the true or actual value. No measurement can be made without errors at all times i.e. 100% accurate measurements cannot be made at all the times. Classified in different ways, they are: Systematic error, Random errors and illegitimate errors.

8. Define Standard with an example.
   "Something that is set up & established by an authority as a rule of the measure of the quantity, weight, extent, value or quality" Ex: A meter is a standard established by an international organization for the measure of length.

9. Define measurements. Mention different methods of measurements.
   Measurement is a process or an act of comparing a quantitatively an unknown magnitude with a predefined standard. For Example, consider the measurement of a length of a bar. We made use of a scale/ steel rule (i.e. a standard). It is a collection of quantitative data. A **measurement** is a process of comparing a quantity with a standard unit. Since this comparison cannot be perfect, measurements inherently include error. There are two methods of measurement: 1) direct comparison with primary or secondary standard & 2) indirect comparison through the use of calibrated system.

10. What is L.V.D.T? What is its application?
    The **linear variable differential transformer** (LVDT) (also called just a **differential transformer**) is a type of electromechanical transformer used to convert linear displacement into electrical signal. Although the LVDT is a displacement sensor, many other physical quantities can be sensed by converting displacement to the desired quantity via thoughtful arrangements.

11. Explain the principle of working of a L.V.D.T
    The LVDT converts a position or linear displacement from a mechanical reference (zero, or null position) into a proportional electrical signal containing phase (for direction) and amplitude (for distance) information.

12. What is Precision?
    Precision of an instrument indicates its ability to reproduce a certain reading with a given accuracy. It is the degree of agreement between repeated results.

13. Define sensitivity.
    Sensitivity is the ratio of the magnitude of the output quantity (response) to the magnitude of input quantity. Ex: 1 mV recorder might have a 10 cm scale. Its sensitivity would be a 10 cm/mV. Assuming that measurement is linear all across the scale.
14. Define Linearity.
    A measuring system is said to be a **linear** if the output is linearly proportional to the input.

15. Define Repeatability.
    Repeatability is defined as the ability of a measuring system to reproduce output

readings when the same input is applied to it consecutively under the same conditions & in the same directions.

16. Define Hysteresis.
    An instrument is said to exhibit **hysteresis** when there is a difference in readings depending on whether the value of the measured quantity is approached from higher value or from a lower value. **Hysteresis** is a phenomenon which depicts different output effects when loading and unloading.

17. Define Resolution or Discrimination.
    Resolution is defined as the smallest increment of input signal that a measuring system is capable of displaying or Measurement resolution which is the smallest change in the underlying physical quantity that produces a response in the measurement.

18. Define Accuracy.
    Accuracy of an instrument indicates the deviation of the reading from a known input.

19. Define least count.
    It is the smallest difference between two indications that can be detected on the instrument scale.

20. Define Readability &Threshold.
    Readability indicates the closeness with which the scale of the instrument may be read. Ex: an instrument with 30 cm scale has a higher readability than that of a 15 cm scale. **Threshold**: If the instrument input is increased very gradually from zero, there will be some minimum value of input below which no output change can be detected. This minimum value defines the threshold of the instrument.

21. Define system response.
    System response: Response of a system may be defined as the ability of the system to transmit & present all the relevant information contained in the input signal & to exclude all others. If the output is faithful to input, i.e. the output signals have the same phase relationships as that of input signal, the system is said to have good *System response.* If there is a lag or delay in output signal which may be due to natural inertia of the system, it is known as *'measurement lag'.* "Rise time" is defined as the time taken for system to change from 5% to 95% of its final value. It is measure of the speed of response of a measuring system and a short rise time is desirable.

22. Define Discrepancy.
    The difference between two indicated values or results determined from a Supposedly fixed time value.

23. True value (v_t) or Actual value (v_a)
    It is the actual magnitude of the input signal to a measuring system which may be approximated but never truly be determined.

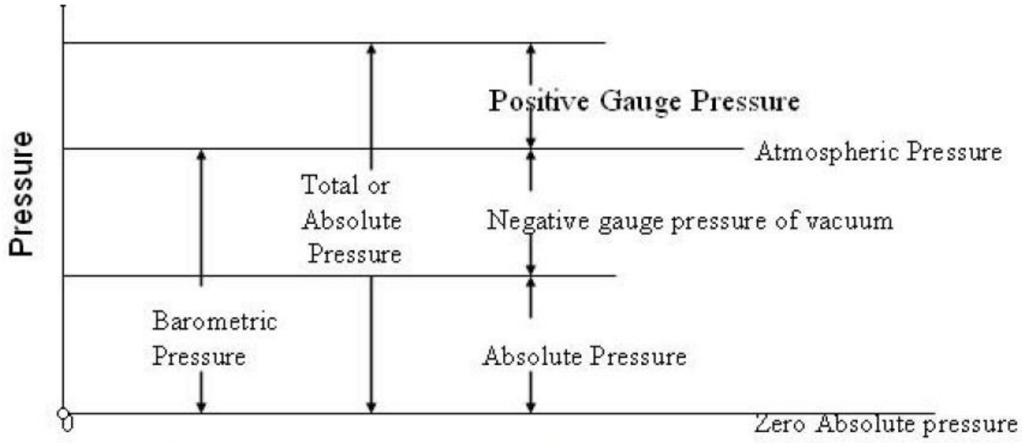
24. Indicated value (v_i) or Measured value (v_m)

The magnitude of the input signal indicated by a measuring instrument is known as a indicated value.

25. Define measure.
    It means, to determine the dimension, quantity or capacity of something.

26. Define result.
    It is obtained by making all known corrections to the indicated value.

27. Give the relationship among the different types of pressures and its definitions.



Relationship between Pressure Terms

Atmospheric Pressure It is the pressure exerted by the earth's atmosphere and is usually measured by a barometer. At sea level. Its value is close to 1.013 x 105 N/m2 absolute and decreases with altitude. **Gage Pressure** It represents the difference between the absolute pressure and the local atmosphere pressure **Vacuum** It is an absolute pressure less the atmospheric pressure i.e. a negative gage pressure.

Static and Dynamic pressures

If a fluid is in equilibrium, the pressure at a point is identical in all directions and independent of orientation is referred as pressure. In dynamic pressure, there exists a pressure gradient within the system. To restore equilibrium, the fluid flows from regions of higher pressure t regions of lower pressure. **Pressure** is the force per unit area. **Gauge pressure**: It is the system pressure which is measured with the pressure gauge, a device to measure the pressure. **Atmosphere pressure**: It is the pressure exerted by the air molecules on the object. This atmospheric pressure is measured with the help of Barometer. **Absolute Pressure**: It is the pressure measured with reference to the Zero pressure or perfect vacuum. It represents the summation of atmospheric pressure and gauge pressure. Hence, Absolute pressure = Gauge pressure + Atmospheric pressure

28. How do you define yard?
    Yard is defined as distance between the two central traverse lines of the gold plug when the temperature of the bar is at 62° F (Imperial Standard yard).

29. What is thermocouple? Where are they used?
If two dissimilar metals are joined, an emf exists which is a function of several factors including the temperature. When junctions of this type are used to measure temperature, they are called as thermocouples.

30. What are slip gauges?
Slip gauges a very accurately ground block of hardened steel used to measure a gap with close accuracy: used mainly in tool-making and inspection.

31. What is Tolerance?
It is the difference between the upper limit and the lower limit of a dimension. It is impossible to make anything to an exact size, therefore it is essential to allow a definite tolerance. It is also the maximum permissible variation on every specified dimension.

32. What are Limits?
The maximum and minimum permissible sizes within which the actual

size of a Component lies are called Limits.

33. Define fits.
The relationship existing between two parts, shaft and hole, which are to be assembled, with respect to the difference in their sizes is called fit.

34. What is Range?
Range represents the highest possible value that can be measured by an instrument *or* Range is the difference between the largest & the smallest results of measurement.

35. What is loading effect?
Loading effect: The presence of a measuring instrument in a medium to be measured will always lead to extraction of some energy from the medium, thus making perfect measurements theoretically impossible. This effect is known as 'loading effect' which must be kept as small as possible for better measurements. For ex, in electrical measuring systems, the detector stage receives energy from the signal source, while the intermediate modifying devices and output indicators receive energy from auxiliary source. The loading effects are due to impedances of various elements connected in a system.

36. What is comparator?
Comparator is a precision instrument used for comparing dimensions of a part under test with the working standards. It is an indirect type of instrument and used for linear measurement. If the dimension is less or greater than the standard, then the difference will be shown on the dial. It gives only the difference between actual and standard dimension of the work piece.

37. Name the different types of comparator?
Mechanical Comparator, Pneumatic Comparator, Optical Comparator, Electrical Comparator, Electronic Comparator and Combined Comparator (ex: mechanical

–optical comparator).

38. What are advantages and disadvantages of mechanical comparator?

Advantages of Mechanical Comparator

1. They do not require any external source of energy.

2. These are cheaper and portable.

3. These are of robust construction and compact design.

4. The simple linear scales are easy to read.

5. These are unaffected by variations due to external source of energy such air, electricity etc.

Disadvantages

1. Range is limited as the pointer moves over a fixed scale.

2. Pointer scale system used can cause parallax error.

3. There are number of moving parts which create problems due to friction,and ultimately the accuracy is less.

4. The instrument may become sensitive to vibration due to high inertia.

39. What is a sine bar?

Sine bar is a high precision & most accurate angle measuring instrument. It is used for measurement of an angle of a given job or for setting an angle. They are hardened and precision ground tools for accurate angle setting. It can be used in conjunction with set of angle gauges and dial gauge for measurement of angles and tapers from horizontal surface.

40. What is a sine center?

These are used in situations where it is difficult to mount the component on the sine bar. It is basically used for conical work pieces. It is the extension of sine bars where two ends are provided on which centers can be Clamped. These are useful for testing of conical work centered at each end, up to60°.