QMP 7.1 D/F

Channabasaveshwara Institute of Technology

(Affiliated to VTU, Belgaum & Approved by AICTE, New Delhi)

(**NAAC Accredited & ISO 9001:2015 Certified Institution**)

NH 206 (B.H. Road), Gubbi, Tumakuru – 572 216. Karnataka

Department of Mechanical Engineering

Mechanical Measurements and Metrology

Lab Manual

BME404

B.E – IV Semester

Name:____

USN:____

Batch: __________________ Section: _____________

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Department of Mechanical Engineering

Mechanical Measurements and Metrology

BME404

Lab Manual

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DEPARTMENT OF MECHANICAL ENGINEERING

Mechanical Measurements & Metrology Lab

CONTENTS

College Vision

To create centres of excellence in education and to serve the society by enhancing the quality of life through value based professional leadership.

College Mission

To provide high quality technical and professionally relevant education in a diverse learning environment.

- To provide the values that prepare students to lead their lives with personal integrity, professional ethics and civic responsibility in a global society.
- To prepare the next generation of skilled professionals to successfully compete in the diverse global market.
- To promote a campus environment that welcomes and honors women and men of all races, creeds and cultures, values and intellectual curiosity, pursuit of knowledge and academic integrity and freedom.
- To offer a wide variety of off-campus education and training programmes to individuals and groups.
- To stimulate collaborative efforts with industry, universities, government and professional societies.
- To facilitate public understanding of technical issues and achieve excellence in the operations of the institute.

Vision of the Department

To create state of the art learning environment to nurture the learning, blending human values, academic professionalism and research process in the field of mechanical engineering for the betterment of society.

Mission of the Department

The mission of the department is to

- Provide requisite foundation to our students in Mechanical Engineering
- Provide cutting edge laboratory resources to bridge the gap between theoretical and practical concepts
- Provide exposure to various mechanical industries through periodic industrial visits
- Enhance our students skill set and to make them industry ready by systematic skill development program.

Department of Mechanical Engineering

MECHANICAL MEASUREMENTS AND METROLOGY LAB		Semester	4th
Course Code	**BME404**	CIE Marks	***50***
Teaching Hours/Week (L:T:P:S)	**0:0:2:0**	SEE Marks	***50***
Total Hours of Pedagogy	**15 sessions**	Total Marks	***100***
Credits	***01***	Exam Hours	***03***
Examination nature (SEE)	***Practical***		

**** Additional one hour may be considered for instructions, if required***

Course objectives:

- To illustrate the theoretical concepts taught in Mechanical Measurements & Metrology through experiments.
- To illustrate the use of various measuring tools & measuring techniques.
- To understand calibration techniques of various measuring devices.

Modern computing techniques are preferred in estimation and analysis.

Sl. No.	Experiments
	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
	METROLOGY
6	Measurements using Optical Projector / Toolmaker Microscope
7	Measurement of angle using Sin Centre / Sine bar / Bevel Protractor
8	Measurement of alignment using Autocollimator / Roller set
	Demonstration Experiments (For CIE)
9	Measurement of cutting tool forces using a) Lathe Tool Dynamometer OR b) Drill Tool Dynamometer
10	Measurement of Screw thread parameters using Two wire or Three wire methods.
11	Measurements of Surface roughness using Tally Surf / Mechanical Comparator
12	Measurement of gear tooth profile using Gear tooth Vernier / Gear tooth micrometer

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

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

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation (CIE):

CIE marks for the practical course are 50 Marks. The split-up of CIE marks for record/ journal and test are in the ratio 60:40.

- Each experiment is to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments are designed by the faculty who is handling the laboratory session and are made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled down to 30 marks (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct a test of 100 marks after the completion of all the experiments listed in the syllabus.
- In a test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The marks scored shall be scaled down to 20 marks (40% of the maximum marks). The Sum of scaled-down marks scored in the report write-up/journal and marks of a test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

- SEE marks for the practical course are 50 Marks.
- SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the Head of the Institute.
- The examination schedule and names of examiners are informed to the university before the conduction of the examination. These practical examinations are to be conducted between the schedules mentioned in the academic calendar of the University.
- All laboratory experiments are to be included for practical examination.
- (Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. OR based on the course requirement evaluation rubrics shall be decided jointly by examiners.
- Students can pick one question (experiment) from the questions lot prepared by the examiners jointly.
- Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 15% of Marks allotted to the procedure part are to be made zero.

The minimum duration of SEE is 02 hours

Suggested Learning Resources:

Engineering Metrology and Measurements,
N.V.Raghavendra and L. Krishnamurthy, Oxford University Press

DEPARTMENT OF MECHANICAL ENGINEERING

Mechanical Measurement & Metrology Lab

OBJECTIVES

The objectives of Mechanical Measurements & Metrology lab is

- ✓ To demonstrate the theoretical concepts taught in Mechanical Measurements & Metrology.
- ✓ To understand and use various measuring tools.
- ✓ To understand calibration of various measuring devices.

OUTCOMES

The expected outcome of Mechanical Measurements & Metrology lab is that the students will be able

- ✓ To understand the basic measurement units and able to calibrate various measuring devices.
- ✓ To express error and correction factors of various measuring devices.
- ✓ To use measuring tools such as Sine Bar, Sine Centre, Bevel Protractor, Tool Maker Microscope, Gear Tooth Micrometer, Optical Flats etc.

DEPARTMENT OF MECHANICAL ENGINEERING

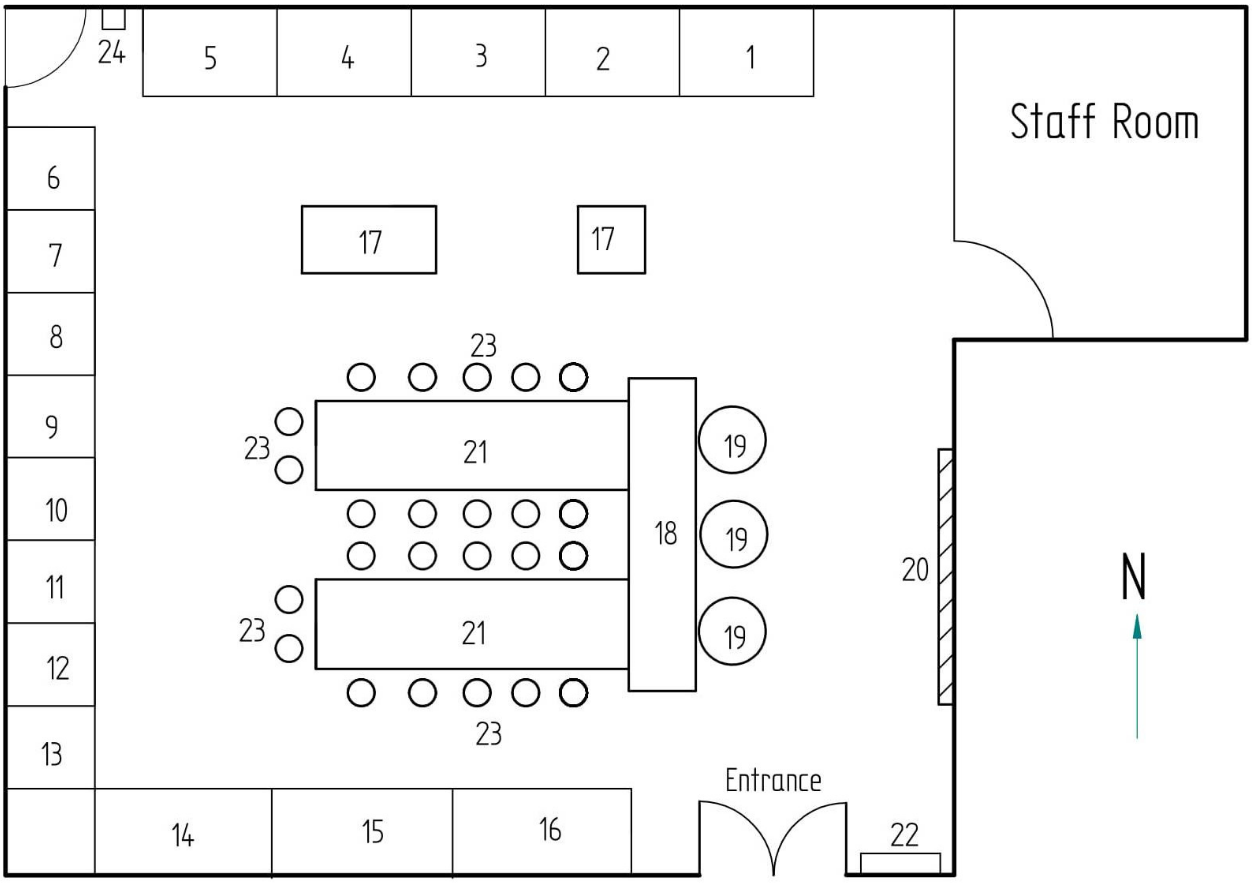
Mechanical Measurement & Metrology Lab

Safety measures to the students

- ✓ Laboratory uniform, shoes & safety glasses are compulsory in the lab.
- ✓ Do not touch anything with which you are not completely familiar. Carelessness may not only break the valuable equipment in the lab but may also cause serious injury to you and others in the lab.
- ✓ Please follow instructions precisely as instructed by your supervisor. Do not start the experiment unless your setup is verified & approved by your supervisor.
- ✓ Do not leave the experiments unattended while in progress.
- ✓ Do not crowd around the equipment's & run inside the laboratory.
- ✓ During experiments material may fail and disperse, please wear safety glasses and maintain a safe distance from the experiment.
- ✓ If any part of the equipment fails while being used, report it immediately to your supervisor. Never try to fix the problem yourself because you could further damage the equipment and harm yourself and others in the lab.
- ✓ Keep the work area clear of all materials except those needed for your work and cleanup after your work.

DEPARTMENT OF MECHANICAL ENGINEERING

Mechanical Measurement & Metrology Lab



1. Pressure Gauge.
2. Thermo Couples.
3. L.V.D.T
4. Load Cell.
5. Strain Gauge.
6. Auto Collimator.
7. Optical Flats.
8. Sine Center.
9. Sine Bar.
10. Mechanical Comparator.
11. Bevel Protractor.
12. Tally Surf.
13. Floating Carriage Micrometer.
14. Tool Makers Microscope.
15. Drill Tool Dynamometer.
16. Lathe Tool Dynamometer.
17. Surface plates.
18. Staff Table.
19. Staff Chairs.
20. Green Board.
21. Instructions Tables.
22. Students Bag Rack.
23. Students Stool
24. First Aid Box

Total Area: (10.0 X 8.0) + (2.94 X 3.81) = **91.20 M^2**

Department of Mechanical Engineering

LECTURE PLAN

Faculty Name(s):

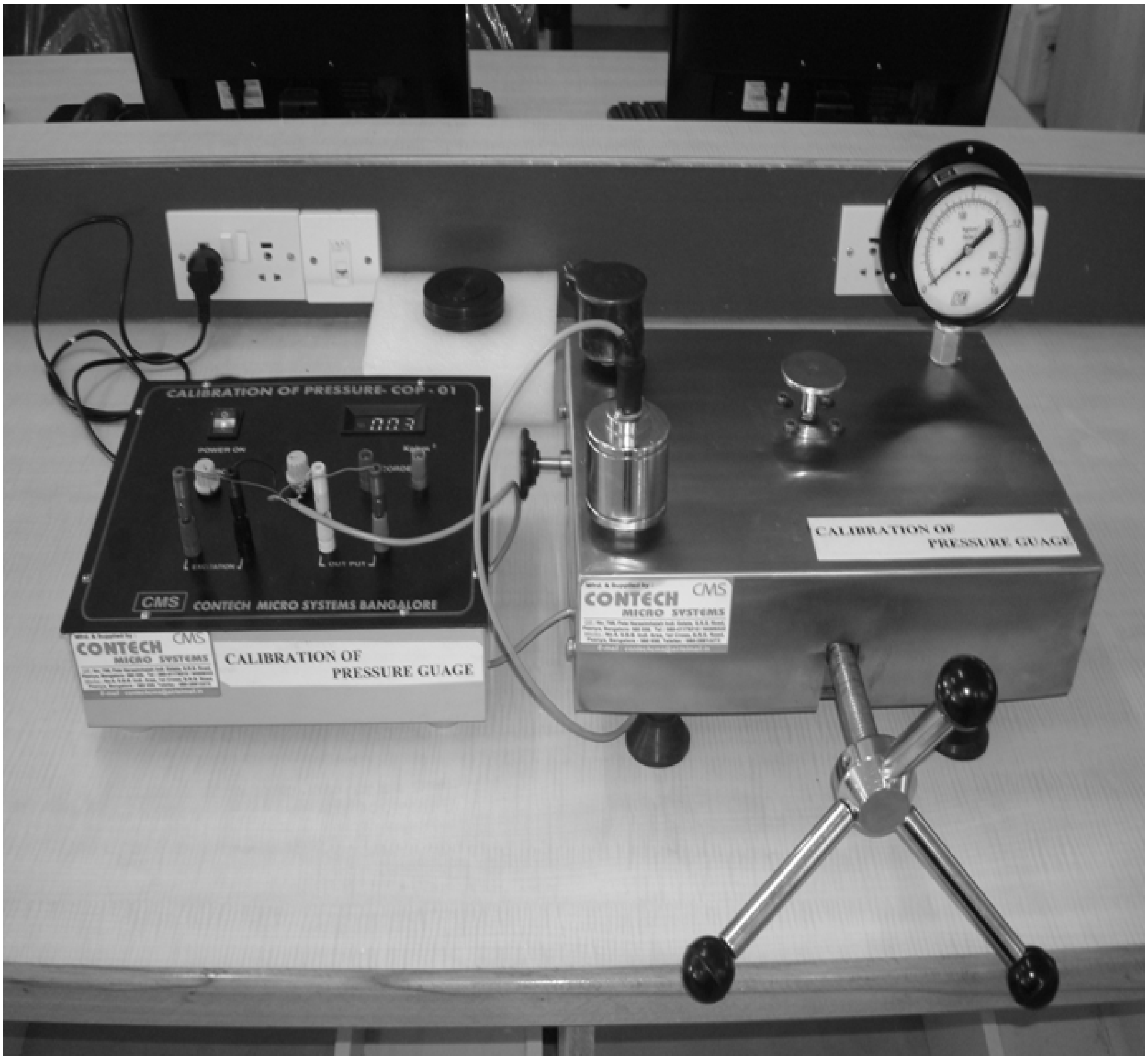
Semister: **4th Semister** Subject: **MMM Lab** Course Code: **BME404**

Sl. No.	Date	Lesson Plan	Name of the Experiment	Remarks
MECHANICAL MEASUREMENTS				
1		LP. 1	Calibration of Pressure Gauge	
2		LP. 2	Calibration of Thermocouple	
3		LP. 3	Calibration of LVDT	
4		LP. 4	Calibration of Load cell	
5		LP. 5	Determination of modulus of elasticity of a mild steel specimen using strain gauges	
METROLOGY				
6		LP. 6	Measurements using Toolmaker Microscope	
7		LP. 7	Measurement of angle using Sin Centre/ Sine bar/ Bevel Protractor	
8		LP. 8	Measurement of alignment using Autocollimator	
Demonstration Experiments				
9		LP. 9	Measurement of cutting tool forces using a) Lathe Tool Dynamometer OR b) Drill Tool Dynamometer	
10		LP. 10	Measurement of Screw thread parameters using two wire or Three-wire methods.	
11		LP.11	Measurements of Surface roughness using Tally Surf / Mechanical Comparator	
12		LP.12	Measurement of gear tooth profile using Gear tooth micrometer	
13		LP.13	**Test**	
Additional Experiments				
14		LP. 14	Calibration of Vernier caliper using Slip Gauges	
15		LP. 15	Calibration of Micrometer using Slip Gauges	

DEPARTMENT OF MECHANICAL ENGINEERING

Mechanical Measurement & Metrology Lab

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

Experiment No: 01

CALIBRATION OF PRESSURE GAUGE

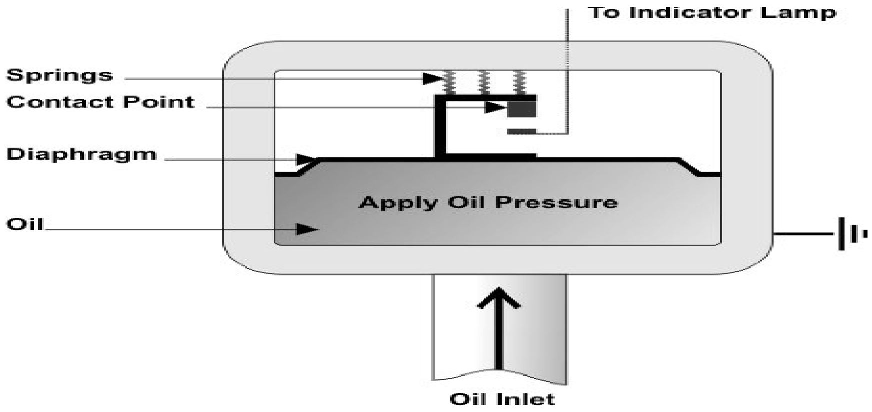
Aim: To calibrate the given pressure gauge

Apparatus: Pressure cell / sensor/ gauge, Dial type pressure cell indicator, Digital pressure Indicator

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, piezometers 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 reaches 10 kg/cm^2, piston will start moving up.
8. Now read the pressure gauge reading and adjust the cal pot of the indicator to same pressure, as the analog reading. Now the given pressure cell is calculated.
9. Release the pressure fully by rotating the plunger.
10. Load the piston by one kg; apply the pressure by rotating the plunger. At a Pressure of one kg /cm^2, piston starts lifting up. Note down the reading.
11. Repeat the experiment for different loads on the piston step by step, and note down the readings of dial gauge and pressure indicator, simultaneously in every step.
12. Calculate the percentage error and plot the graph.



Tabular Column:

SL No.	Actual Pressure (P_a) (kg/cm²)	Pressure shown in digital indicator (P_i) (kg/cm²)	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:

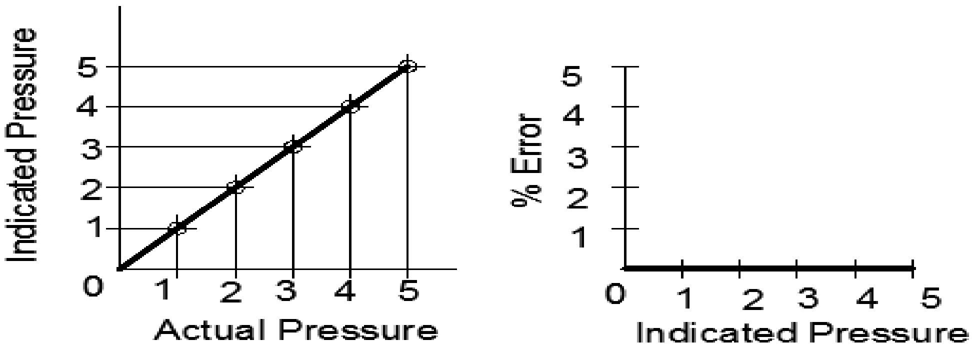
$$\% \text{ Error} = \frac{\text{Indicated Pressure} - \text{Actual Pressure}}{\text{Actual Pressure}} \text{ X } 100$$

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 & fire extinguishers.
- 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.

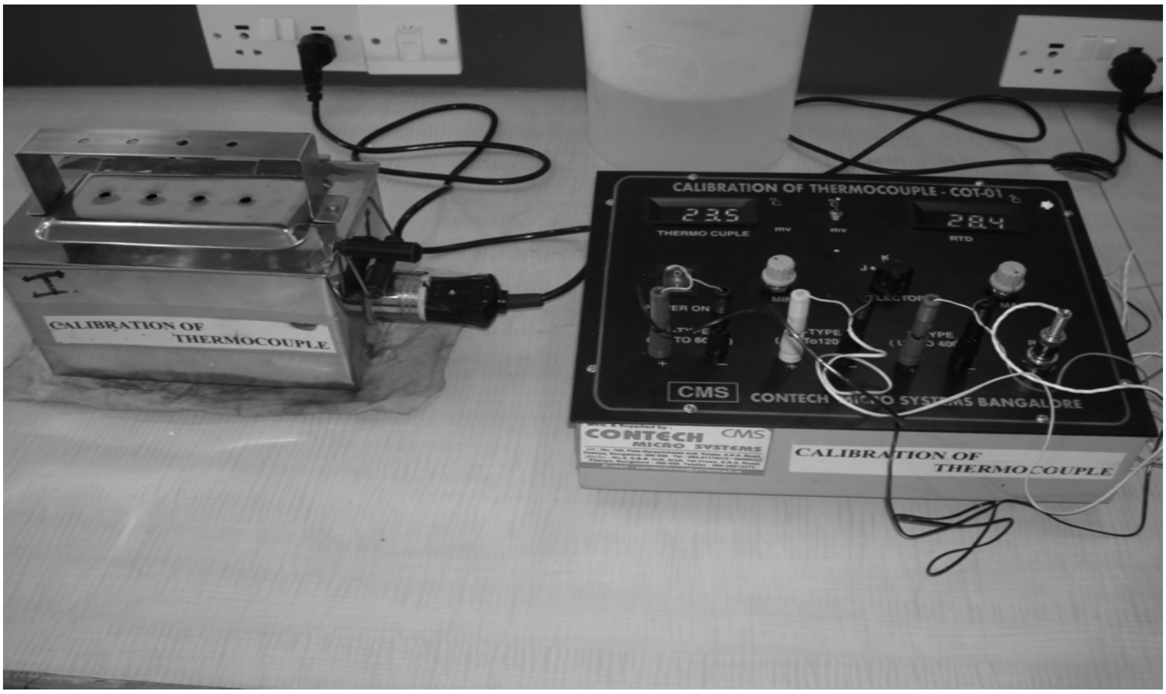


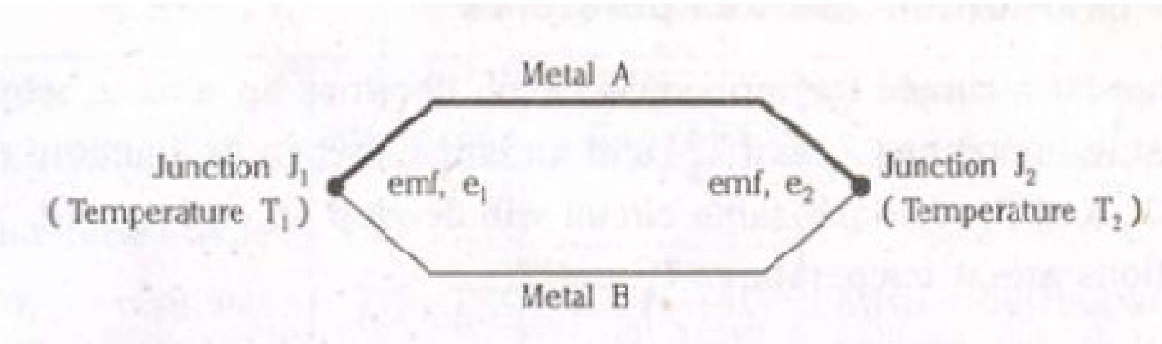
(Under Ideal Conditions)

Result:

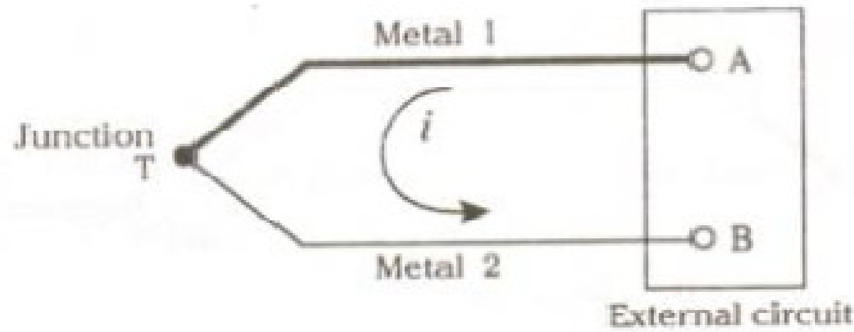
Finally the pressure gauge has been calibrated.

EXPERIMENTAL SET UP FOR THERMOCOUPLE EXPERIMENT





Basic Thermocouple Circuit



Junction of Two Dissimilar Metals

Experiment No: 02

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 standard s 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:
1 Change in physical state 2. Change in chemical state 3. Change in physical dimensions.
4. Change in electrical properties and 5. 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 Thermometer sand 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 thermostats.

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 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.

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 (^oC)	Temp of Water by Thermocouple t_m (^oC)	Error $t_m - t_a$	% Error $\frac{t_m - t_a}{t_a} \times 100$
1				
2				
3				
4				

Calculation for J type

% Error = $\frac{Thermcouple\ Reading - RTD\ Reading}{RTD\ Reading} \times 100$

Thermocouple:

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 thermocouples. The principle of a thermocouple is that if two dissimilar metals *A* and *B are* joined to form a circuit as shown in the Fig. It is found that when the two junctions J_1 and J_2 are at two different temperatures T_1 and T_2, small emf's e_1 and e_2 are generated at the junctions. The resultant of the two emf causes a current to flow in the circuit. If the temperatures T_1 and T_2 are equal, the two emf will be equal but opposed, and no current will flow. The net emf is a function of the two materials used to form the circuit and the temperatures of the two junctions. The actual relations, however, are empirical and the temperature-emf data must be based on experiment. It is important that the results are reproducible and therefore provide are liable method for measuring temperature. It should be noted that two junctions are always required; one which senses the desired one known temperature is called the **hot** or **measuring** junction. The other junction maintained at a known fixed temperature is called the **cold** or **reference** junction.

Thermocouple materials and Construction

Any two dissimilar metals can be used to form thermocouple, but certain metals and Combinations are better than others. The desirable properties of thermocouple materials are: i) Linear temperature-emf relationship ii) High output emf iii) Resistance to chemical change when in contact with working fluids iv) Stability of emf v) Mechanical strength in their temperature range and vi) Cheapness. The thermocouple materials can be divided into two types1. Rare-metal types using platinum, rhodium, iridium etc 2. Base-metal types as given in the table.

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

Materials for thermocouples wires = ‘K’ type

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

Calculation for K type

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

Materials for thermocouples wires = ‘T’ type

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

Calculation for T type

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

Plot the Graphs:

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

Table Thermocouple Ranges and Characteristics

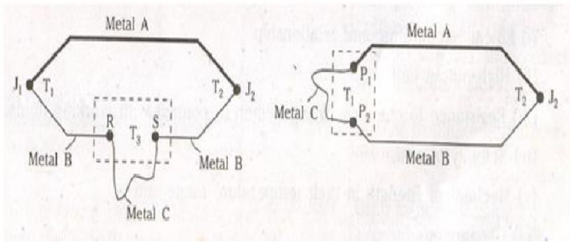
Type	ANSI Standards	Temperature Range °C	Characteristics
A. Base-metal type			
1. Copper-constantan (40% Ni 60%Cu)	Type – T	-250 to + 400	Resists oxidizing and reducing atmospheres, and requires protection from acid fumes.
2. Iron Constantan	-	-200 to + 850	Low cost, corrodes in the presence of moisture, oxygen and sulphur bearing gases, suitable for reducing atmospheres
3. Chromel (90% Cr, 10% Ni) - Alumel (94% Ni, 2%Al + Si and Mn)	Type K	-200 to + 1100	Resistant to oxidizing but not to reducing atmospheres. Susceptible to attack by carbon-bearing gases, sulphur and cyanide fumes.
4. Chromel –Constantan	Type – E	-200 to + 850	Similar to Chromel Alumel

Laws of Thermocouples

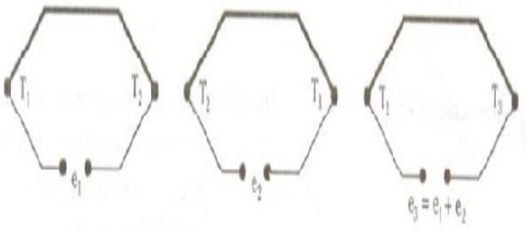
The two laws governing the functioning of thermocouples are:

i) Law of Intermediate Metals:

It states that the insertion of an intermediate metal into a thermocouple circuit will not affect the net emf, provided the two junctions introduced by the third metal are at identical temperatures. Application of this law is as shown in Fig. In Fig. (a), if the third metal C is introduced and the new junctions R and S are held at temperature T_3, the net emf of the circuit will remain unchanged. This permits the insertion of a measuring device or circuit without affecting the temperature measurement of the thermocouple circuit **Circuits illustrating the Law of Intermediate Metals** In the Fig. (b) The third metal is introduced at either a measuring or reference junction. As long as junctions P_1 and P_2 are maintained at the same temperature TP the net emf of the circuit will not be altered. This permits the use of joining metals, such as solder used in fabricating the thermocouples. In addition, the thermocouple may be embedded directly into the surface or interior of a conductor without affecting the thermocouple's functioning.



Circuits illustrating the Law of Intermediate Metals



Circuits illustrating the Law of Intermediate Temperatures

ii) Law of Intermediate Temperatures:

It states that "If a simple thermocouple circuit develops an emf, e_1 when its junctions are at temperatures T_1 and T_2, and an emf e_2, when its junctions are at temperature T_2 and T_3. And the same circuit will develop an emf $e_3 = e_1 + e_2$, when its junctions are at temperatures T_1 and T_3. This is illustrated schematically in the above Fig. This law permits the thermocouple calibration for a given temperature to be used with any other reference temperature through the use of a suitable correction. Also, the extension wires having the same thermo-electric characteristics as those of the thermocouple wires can be introduced in the circuit without affecting the net emf of the thermocouple. **Circuits illustrating the Law of Intermediate Temperatures**

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.

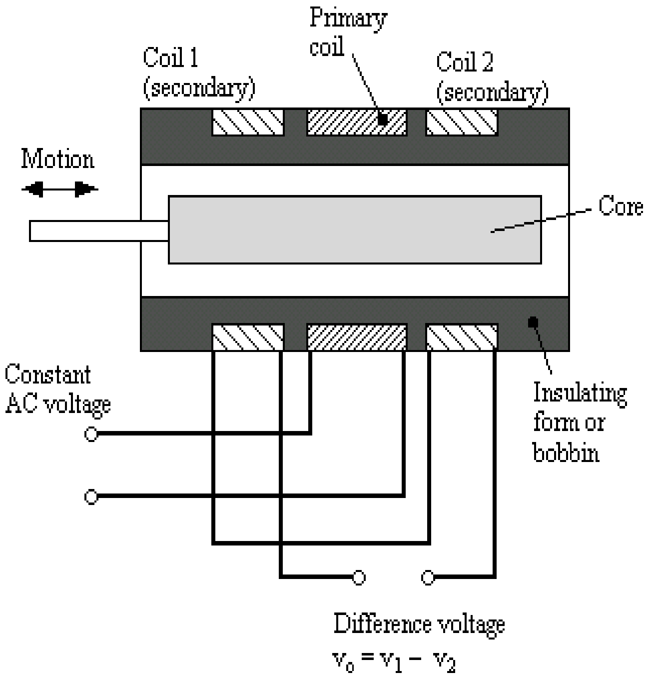
Applications:

- Thermocouples are used in big blast furnaces.
- Thermocouples are used in transformers
- 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.

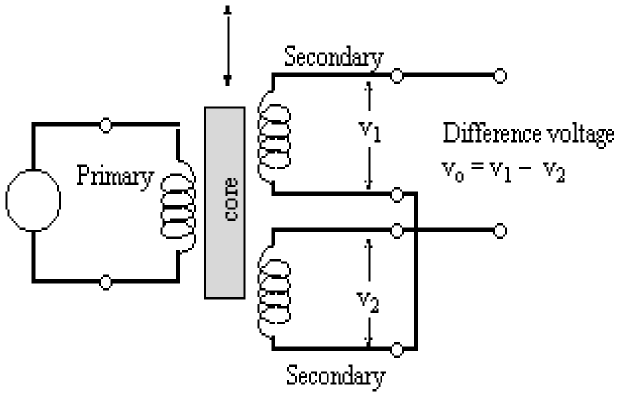
Result:

The given thermocouple is calibrated using RTD.

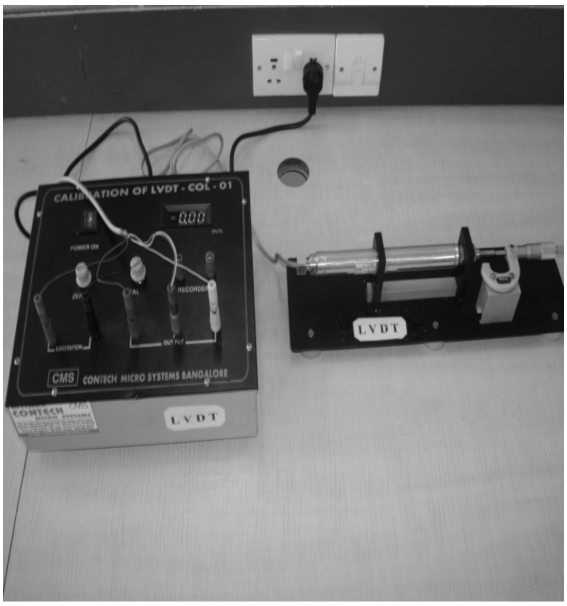
EXPERIMENTAL SET UP FOR THE LVDT EXPERIMENT

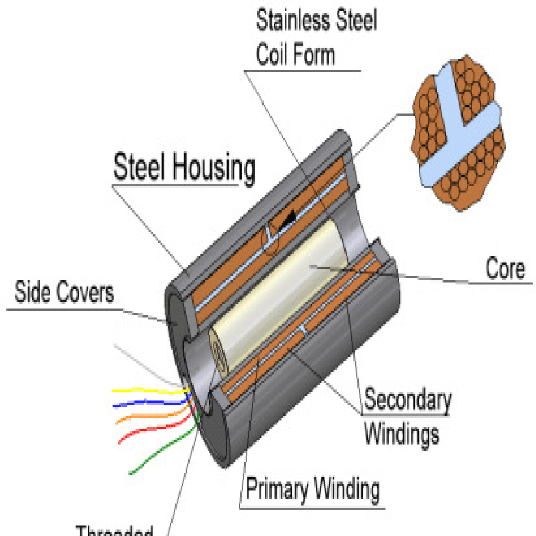


L.V.D.T Schematic Diagram



L.V.D.T Circuit





L.V.D.T Sectional View

Fig. Experimental Se up for the LVDT

Experiment No.: 03

CALIBRATION OF L.V. D. T

(Linear Variable Differential Transformer)

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 operating in the linear range, the device is called L V D T. Since the secondary coil is connected in series opposition, a null position exists at which the net output voltage is essentially zero. The out put voltage undergoes an 180^0 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 output 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 output 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	Micrometer Reading S_a In mm	Digital Displacement Reading S_i 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	0			
2		2			
3		4			
4		6			
5		8			
6		10			

Tabular Column

SL No.	Core Position	Micrometer Reading S_a In mm	Digital Displacement Reading S_i 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	0			
2		2			
3		4			
4		6			
5		8			
6		10			

Calculation: for left of null position

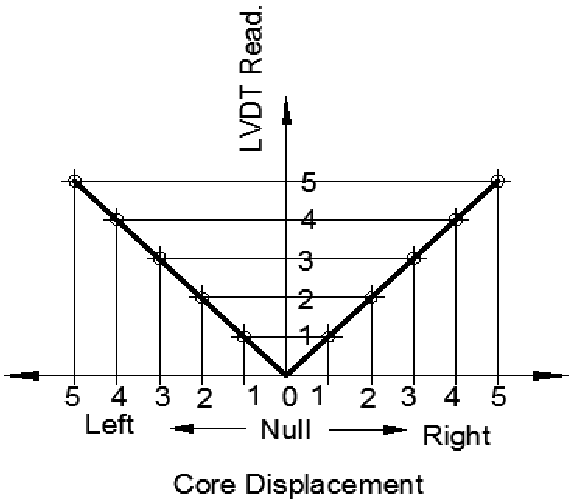
$$\% \text{ Error} = \frac{LVDT\ Reading - Micrometer\ Reading}{Micrometer\ Reading} X100$$

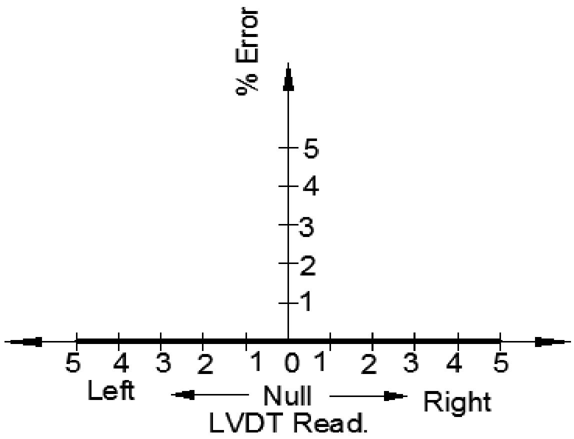
Calculation: for right of null position

$$\% \text{ Error} = \frac{LVDT\ Reading - Micrometer\ Reading}{Micrometer\ Reading} X100$$

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 Alerons in the wing assembly in aerospace.
- 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.



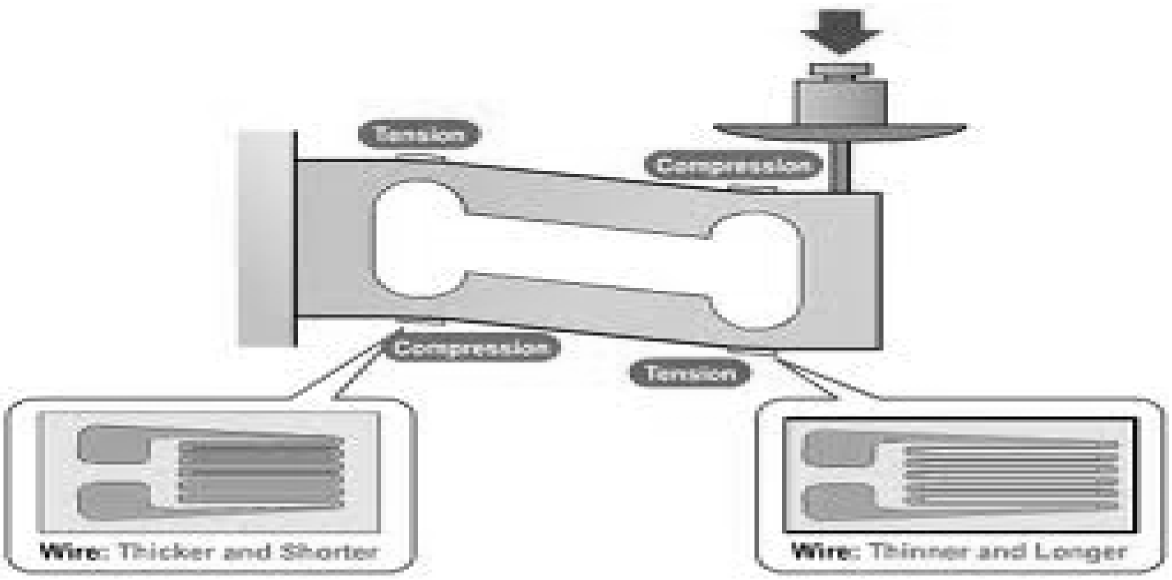


Plot the Graphs:

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

Result:
Calibration of LVDT is performed.

EXPERIMENTAL SET UP FOR THE EXPERIMENT OF LOAD CELL



Experiment No.: 04

CALIBRATION OF LOAD CELL

Aim: To calibrate given load cell by actual load.

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

Theory: Weighing load/force using spring deflection is widely accepted one. But the deflection of spring reading mechanically is very tedious and time consuming. One of the most effective & 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 gauge**s 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. dead weights.

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 to 0000.
4. Apply the weights up to 08 kg.
5. Apply the 'Cal' knob of the indicator to read 78.48 N. i.e. (9 x 9.81 N).
6. Remove weights form the load cell.
7. Set the zero knob to zero and repeat the calibration.
8. Now instrument is ready for measurement
9. Keep the weights one by one and take down the indicator reading.
10. Calculate the correction, error and % error.

Tabular Column:

Sl. No	Actual Load L_a in Kg	Indicated Load L_i in Kg	Error $L_i - L_a$	% Error $\frac{L_i - L_a}{L_a} \times 100$
1	0			
2	1			
3	2			
4	3			
5	4			
6	5			
7	6			
8	7			
9	8			
10	9			
11	10			

Calculation:

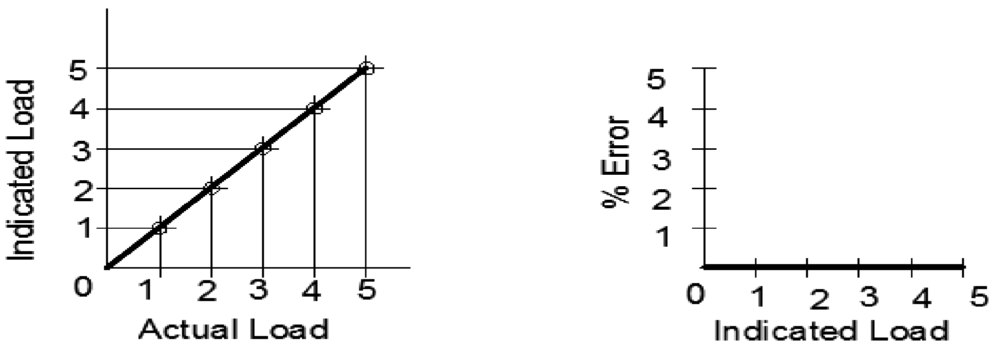
$$\% \text{ Error} = \frac{Indicated\ Load - Actual\ Load}{Actual\ Load} \text{ x } 100$$

Applications:

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

Plot the Graphs:

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

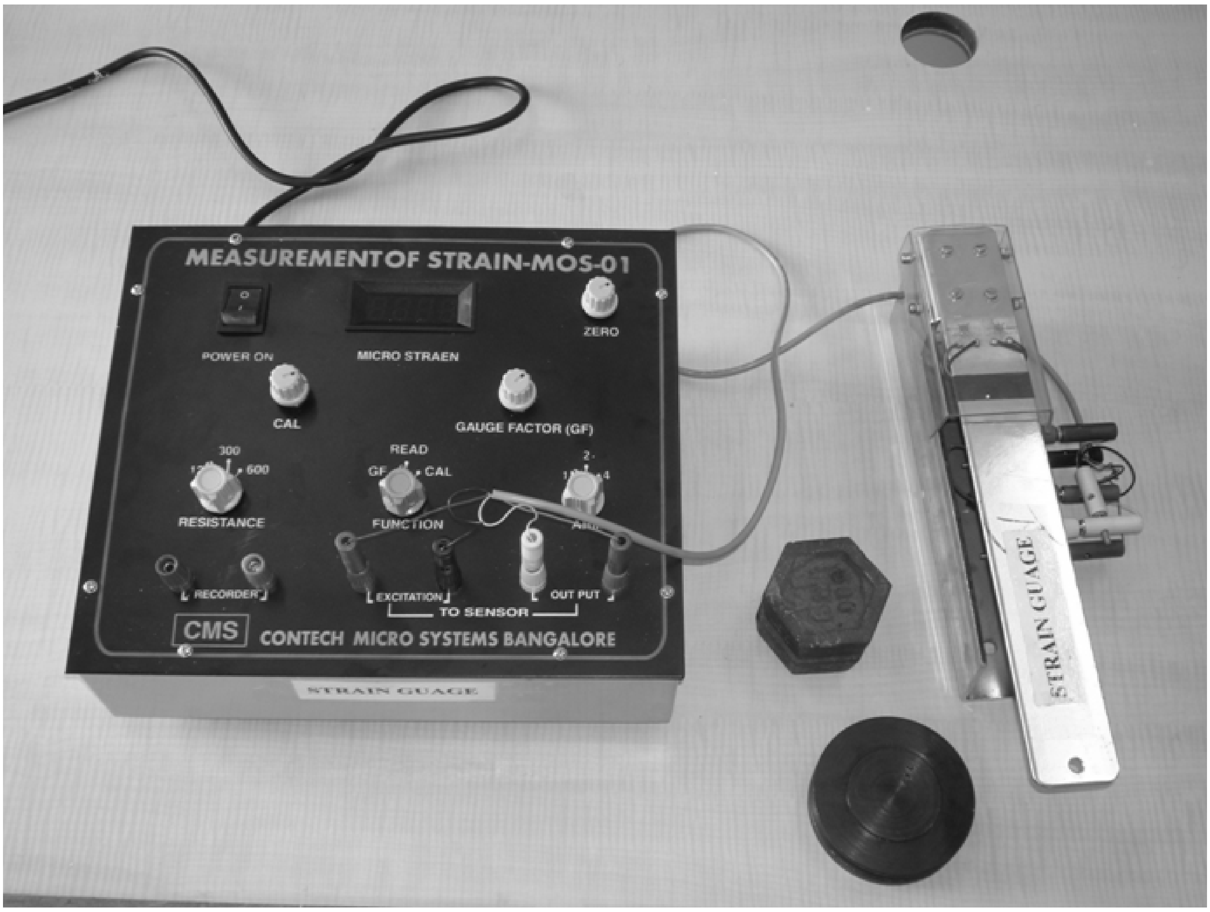


(Under Ideal Conditions)

Result:

The given Load cell is calibrated by using actual loads.

EXPERIMENTAL SET UP FOR STRAIN GAUGE



Specification:

Type	: Strain gauge based.
Range	: 10 Kg.
Gauge Resistance	: 350 ohms.
Max Excitation	: 12 Volt DC.
Insulation Resistance	: 1000 mega ohms @ 25 degrees measured at 30 volt DC.
Combined Error	: + or – 0.5 % of the F.5.
Operating Temperature	: 0 degree to 50 degree.
Safe overload	: 10 % of the rated load.

Experiment No.: 05

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 and strain indicator.

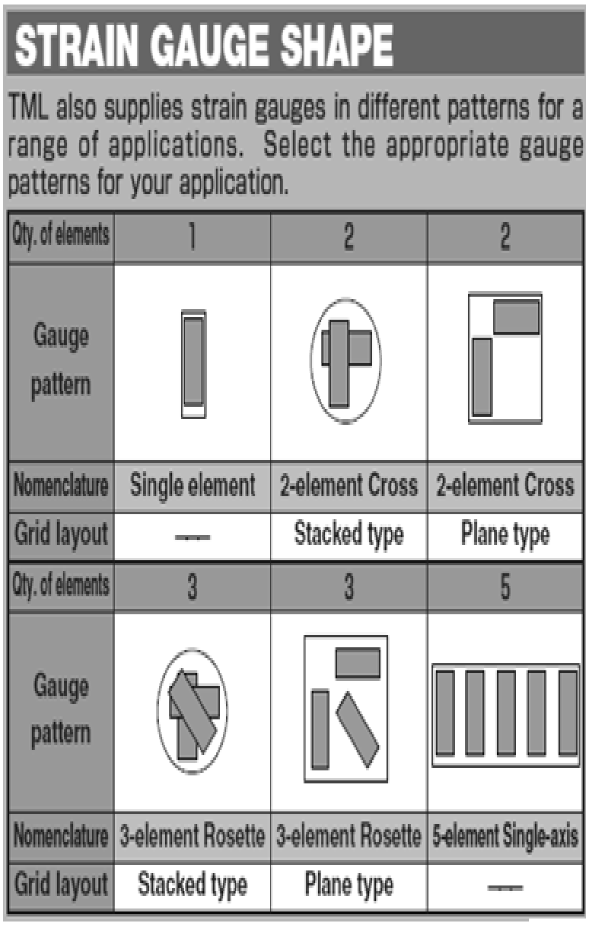
Theory:

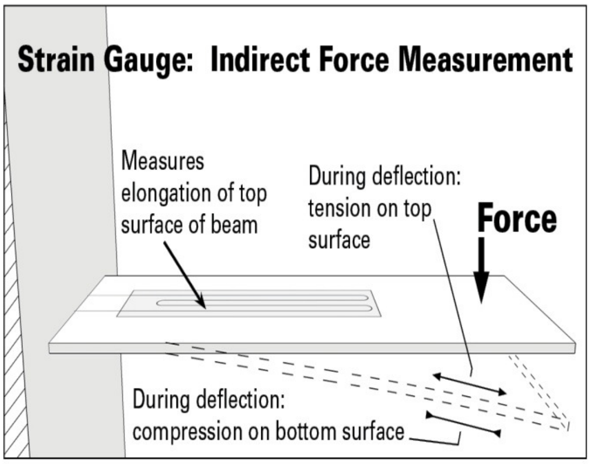
A body subjected to external forces is in a condition both stress and strain. Stress cannot be directly measured but its effects, i.e. change of shape of the body can be measured. If there is a relationship between stress and strain, the stresses occurring in a body can be computed if sufficient strain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

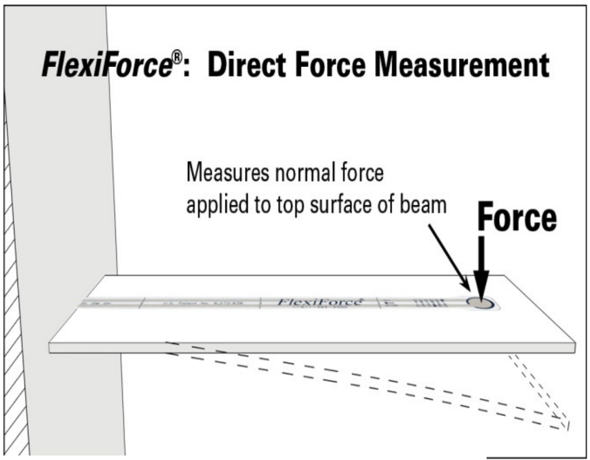
The principle of the electrical resistance strain gauge was discovered by Lord Kelvin, when he observed that a stress applied to a metal wire, besides changing its length and diameter, also changes its electrical resistance. Metallic electrical strain gauges are made in to two basic forms, bonded wire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

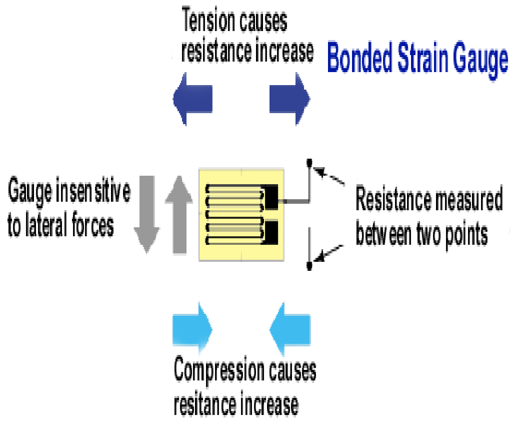
The strain gauge is connected to the material in which it is required to measure the strain, with a thin coat of adhesive. Most common adhesive used is Eastman, duco cement, etc. As the test specimen extends are contracts under stress in the direction of windings, the length and cross sectional area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

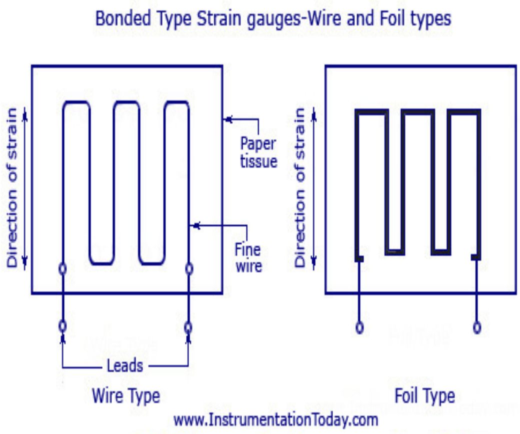
A strain gauge is a device used to measure strain on an object. Invented by Edward E. Simmons and Arthur C. Ruge in 1938, the most common type of strain gauge consists of an insulating flexible backing which supports a metallic foil pattern. The gauge is attached to the object by a suitable adhesive, such as cyanoacrylate. 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 ***gauge factor*.**

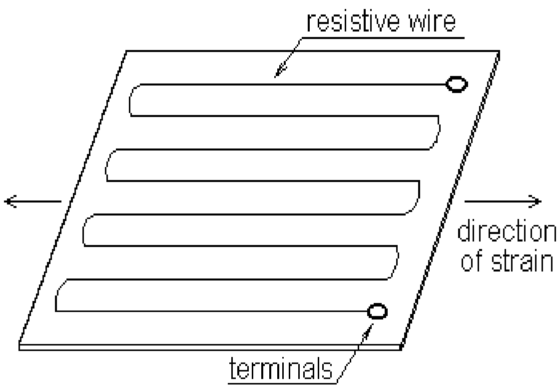

STRAIN GAUGE SHAPE
TML also supplies strain gauges in different patterns for a range of applications. Select the appropriate gauge patterns for your application.
Qty. of elements | 1 | 2 | 2
Gauge pattern
Nomenclature | Single element | 2-element Cross | 2-element Cross
Grid layout | — | Stacked type | Plane type
Qty. of elements | 3 | 3 | 5
Gauge pattern
Nomenclature | 3-element Rosette | 3-element Rosette | 5-element Single-axis
Grid layout | Stacked type | Plane type | —

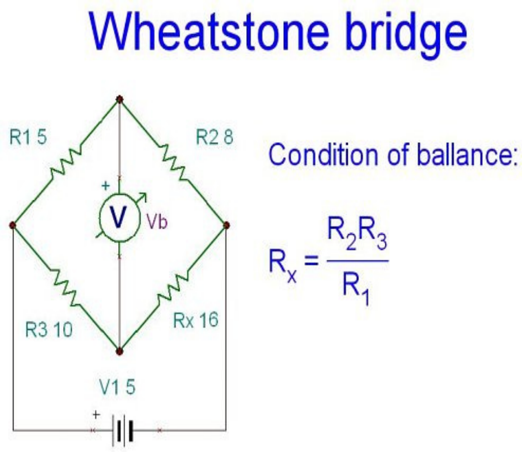

Strain Gauge: Indirect Force Measurement
Measures elongation of top surface of beam
During deflection: tension on top surface
Force
During deflection: compression on bottom surface


FlexiForce®: Direct Force Measurement
Measures normal force applied to top surface of beam
Force


Tension causes resistance increase
Bonded Strain Gauge
Gauge insensitive to lateral forces
Resistance measured between two points
Compression causes resitance increase


Bonded Type Strain gauges-Wire and Foil types
Direction of strain
Paper tissue
Fine wire
Leads
Wire Type
Foil Type
www.InstrumentationToday.com


resistive wire
direction of strain
terminals


Wheatstone bridge
R1 5
R2 8
V
Vb
R3 10
Rx 16
V1 5
Condition of ballance:
$R_x = \frac{R_2 R_3}{R_1}$

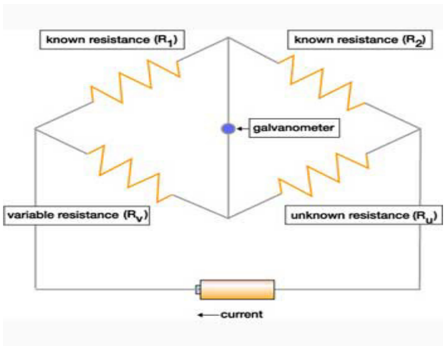
A strain gauge takes advantage of the physical property of electrical conductance and its dependence on the conductor's geometry. When an electrical conductor is stretched within the limits of its elasticity such that it does not break or permanently deform, it will become narrower and longer, changes 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 stress may 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.

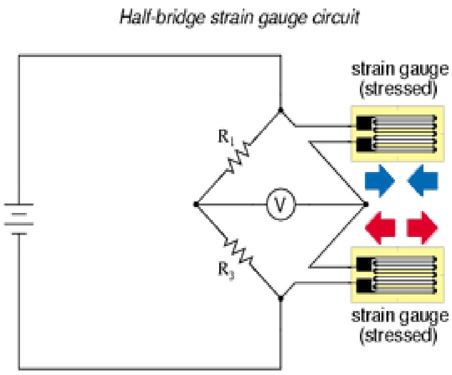
A **Wheatstone bridge** is an electrical circuit used to measure an unknown electrical resistance by balancing two legs of abridge circuit, one leg of which includes the unknown component. Its operation is similar to the original potentiometer. It was invented by Samuel Hunter Christie in 1833 and improved 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

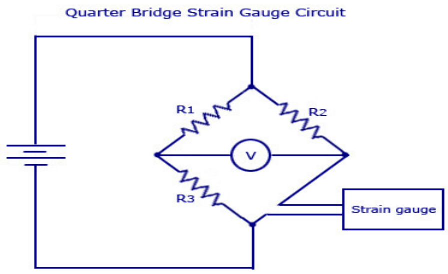
$$\frac{R_2}{R_1} = \frac{R_x}{R_3}$$
$$\Rightarrow R_x = \frac{R_2}{R_1} \cdot R_3$$

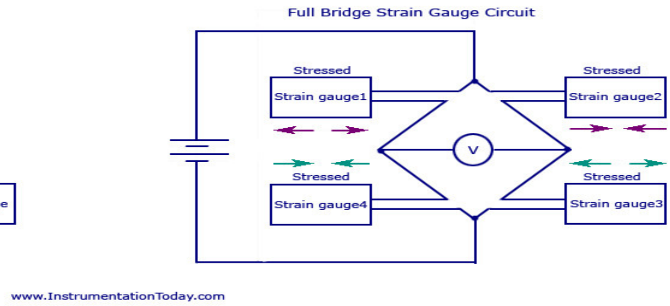
Alternatively, if R_1, R_2, and R_3 are known, but R_2 is not adjustable, the voltage difference across or current flow through the meter can be used to calculate the value of R_x, using Kirchhoff's (also known as Kirchhoff's rules). This setup is frequently used in strain gauge and resistance thermometer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









Observations:

Distance between gauge centres to the point application of load

Length in mm L = 250 mm.

Width of beam, b in mm = 42 mm.

Thickness of beam, h in mm = 3 mm.

Tabular Column (Full Bridge):

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

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 Blumle in around 1926.

3. Strain Measurement in Four Arm Modes (Full Bridge)

Procedure:

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

Gauge Factor or Strain Sensitivity

For a given amount of unit strain ($\Delta L/L$), the gauge will undergo a corresponding change in resistance ($\Delta R/R$). The ratio of the unit change in the resistance to the unit change in the length is known as gauge factor. Conventional foil gauges have standardised nominal resistance values of 120 & 350 ohms & typically exhibit gauge factors between 1.5 & 3.5. in typical transducer applications, they are subjected to full scale design strain levels ranging from 500 to 2000 micro strain.

$G_F = \frac{dR/R}{dL/L}$ Where *R* is the nominal resistance of the gauge

Result:

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

Calculation:

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

Bending Stress, $\sigma = 6WL / bh^2$ **=** (6 x 1.962 x 250) / (42×3^2) = 7.78 N / mm^2

For Four Arm Modes, (Full Bridge)

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

Young's modulus, $E = \sigma/\varepsilon m$ = 2×10^5 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 $\sigma = \frac{6Wl}{bh^2}$	Modulus of Elasticity $\sigma = \frac{E}{\sigma}$ (N/mm^2)
	gms	N				
1	200					
2	400					
3	600					
4	800					
5	1000					

Tabular Column (for Quarter Bridge):

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

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

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 centre pin in the sensor part and green pin in the indicator panel.
4. Keep the arm selector switch on 2.
5. Keep the function to gauge factor and adjust the gauge factor pot to read 500 in display.
6. Select the function switch to cal and adjust the cal pot to read 1000.
7. Keep the function switch to read and adjust the display to read zero.
8. Apply load of 100 gms gradually and note down the reading.
9. Calculate the Young's Modulus and compare the value with theoretical value.

III. Strain Measurement in one Arm Modes (Quarter Bridge)

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

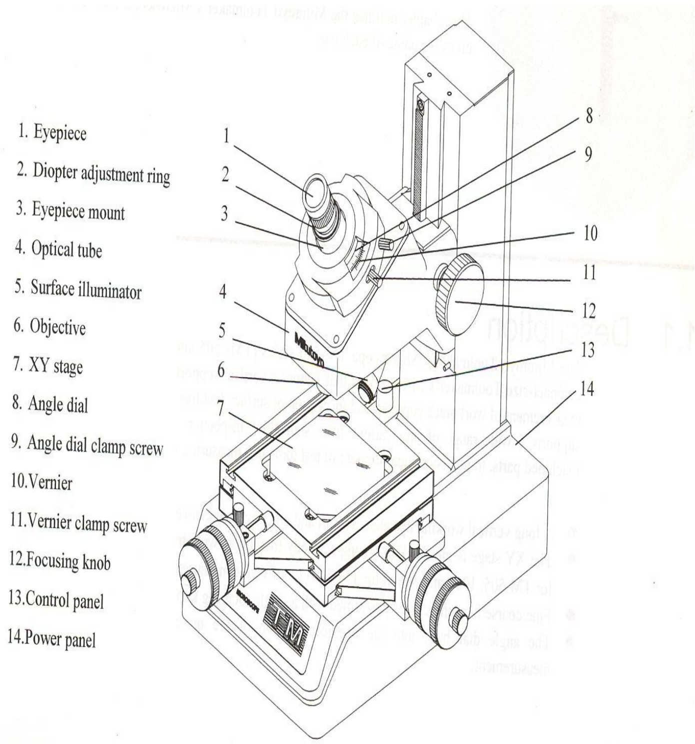
Applications:

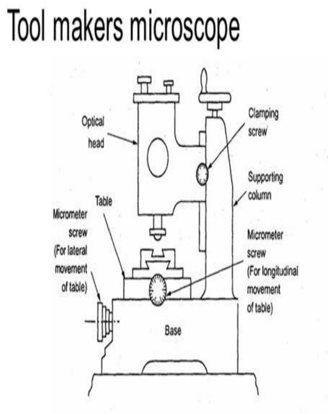
1. Wherever load cells are using there is a strain gauge embedded in it.
2. Estimation of structural strength in steel & concrete structures, bridges & hydraulic structures.
3. In large machineries, pipelines & pressure vessels.
4. Estimation of remaining life of old & huge structures like civil engineering 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.

Result:

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





Experiment No.: 06

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.

Observations:

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

= 0.005 mm or 5 microns.

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

= 0.005 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	Pitch (mm)			
4	Helix angle (Degree)			

Angle Measurement*:*

Angles are measured with the angle dial using the following procedure

1. Align an edge of the work piece with the cross – hair reticle.
2. Align the end edge with the centre 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 instrument, and
5. Understand the principle of working of tool room microscope.

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.

Procedure:

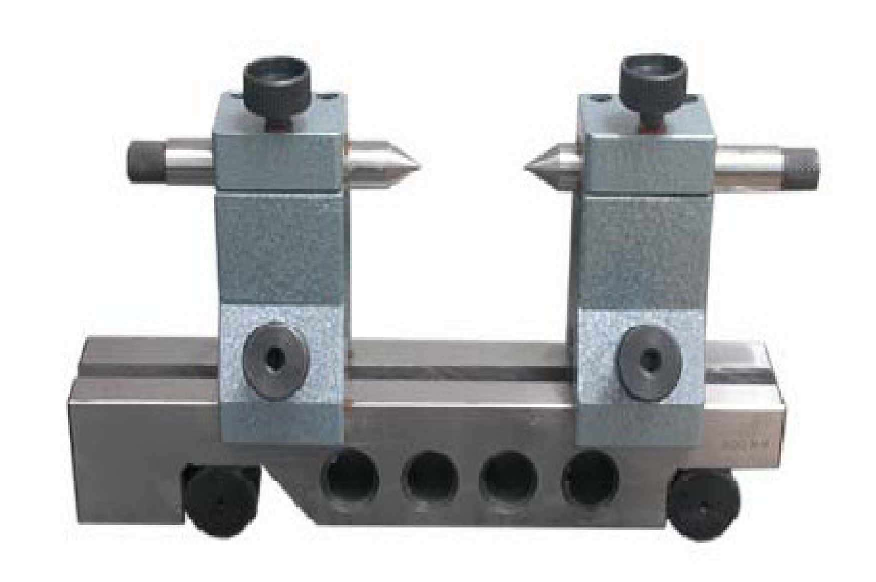
1. Note the least count of the micrometers.
2. Dimensions of the screw thread whose elements have to be measured are noted.
3. Place or fix the screw thread on XY stage (stage glass) of the tool maker's microscope.
4. Align a measuring point on the work piece with one of the cross hairs.
5. Take the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

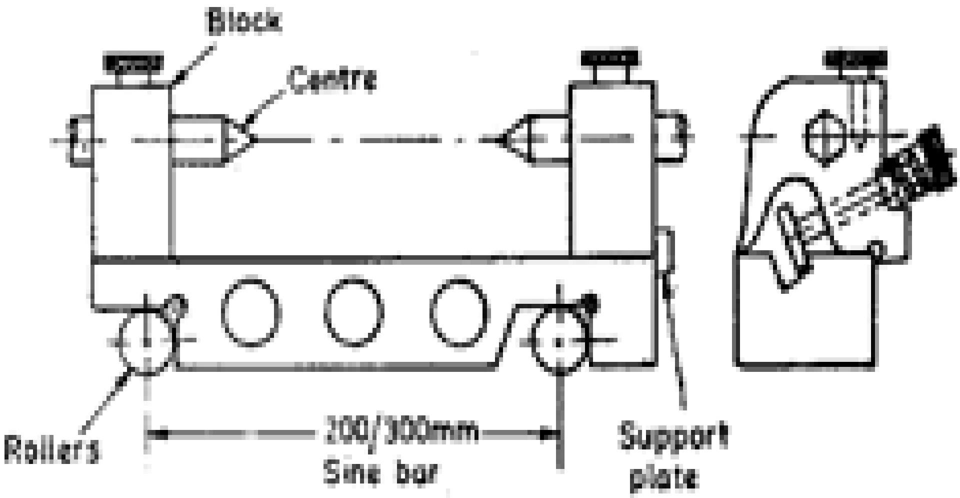
Results:

The following parameters are found that;

1. Outside dia. = ____________mm
2. Inside dia. = ____________mm
3. Pitch = ___________mm
4. Helix angle = ___________Degrees

EXPERIMENTAL SET UP FOR SINE CENTER





Observations:

1. Least count of vernier calliper = __________ 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

Experiment No.: 07 (A)

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 centre. The distance between the axes of the two cylinders is exactly 5^0 or 10^0 in British system and 100, 200, 300, mm in Metric system. Some holes are drilled in the body of the bar to reduce the weight and to facilitate handling. Sine centre itself is not a complete measuring instrument. Another datum such as surface plate is used as well as auxiliary equipment notably slips gauges.

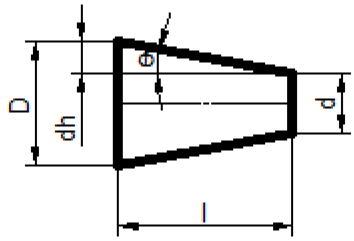
Sine centre is basically a sine bar with block holding centres which can be adjusted and rigidly clamped in any position. These are used for inspection of conical objects between centres. These are used up to inclination of 60°. Rollers are clamped firmly to the body without any play. This is a very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

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.

Tabular Column:

SL No	Taper length of the specimen 'l' mm	Diameter of one side of the work piece (Larger) 'D' mm	Diameter of another side of the work piece (Smaller) 'd' mm	Difference-e of Diameter-s $dh = (\frac{D-d}{2})$	App. Ht. of slip gauge Read. H_{app}	Actual Ht. of slip gauge Read. H_{act}	Theoretical taper angle, θth	Actual taper angle θact	Error
1									
2									



Calculations:

1. Diameter of one side of the work piece 'D' = -------------- mm
2. Diameter of another side of the work piece 'd' = -------------- mm
3. Difference in Diameter, dh = (D- d)/2 = -------------- mm.
4. Approximate height of slip gauge used = H_{app}.

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

5. Theoretical taper angle, $\theta_{th} = tan^{-1}(\frac{D-d}{2l})$ = ------------- Degrees

   2l

6. Actual taper angle, θ_{act} = [sin-1 (H_{act})] /L = ----------- Degrees
7. Error θ_{act} - θ_{the} =--------------- Degrees

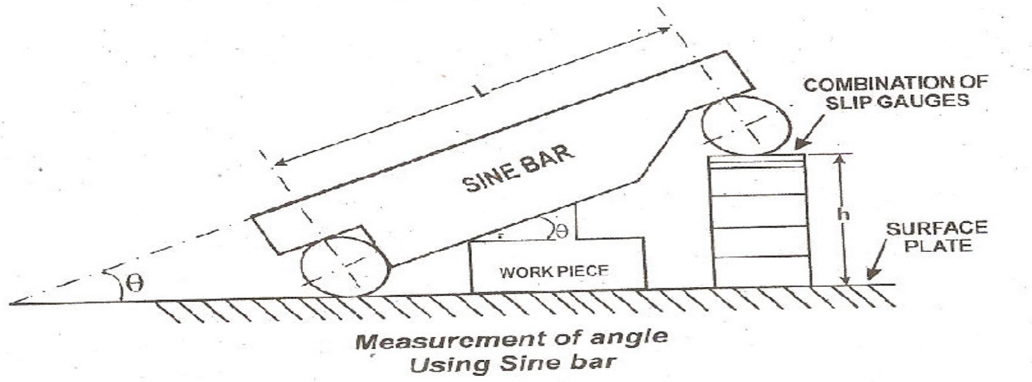
Procedure:

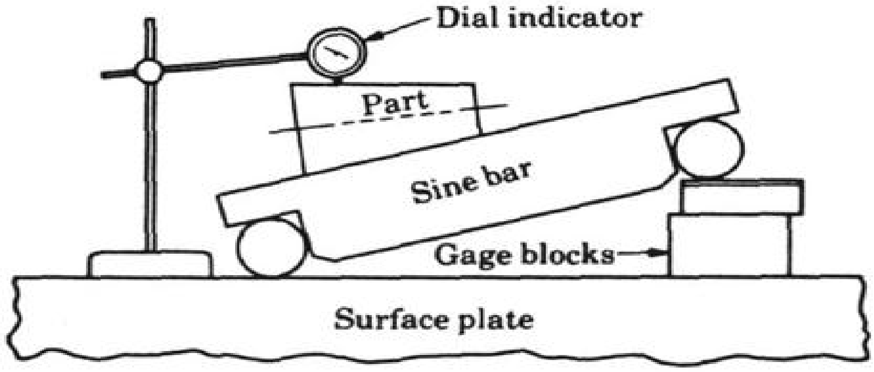
1. Note down the least count of the vernier calliper and dial gauge.
2. Measure the minimum, maximum diameter and axial length of taper plug gauge using Vernier calliper.
3. Calculate approximate height of slip gauge using formula.
4. Build up the height using M-87 set of cleaning the surface of slip 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.

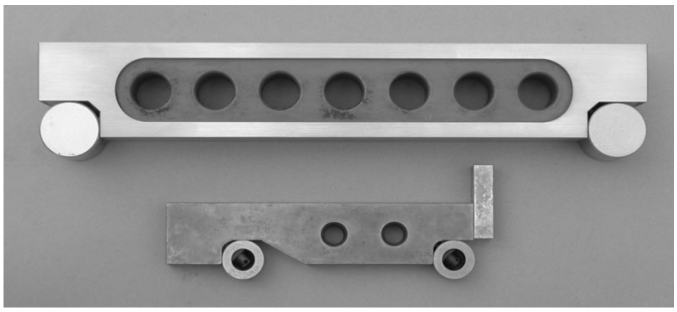
Result:

For a given component/ plug gauge, we found the theoretical taper angle is _______degrees & also actual taper angle is __________ degrees.

EXPERIMENTAL SET UP FOR THE SINE BAR







Concepts and objectives of the Sine bars as follows

Experiment No.: 07 (B)

MEASUREMENT OF TAPER ANGLE USING SINE BAR

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

Apparatus: Surface plate, sine bar, slip gauge sets, Vernier 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 is the centre to centre distance of plugs is which is generally 100, 200 and 300 mm and so on.

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 devices 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 measuring and setting any angle of the object having flat surface. Sine bars are also used to measure or set angle of the object not larger than the 45^0, if higher accuracy is demanded.

Observations:

1. Least count of Vernier calliper = ___________ mm

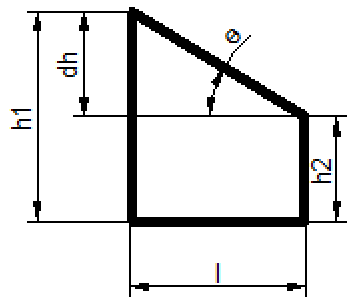
2. Least count of dial gauge = ___________ mm

3. Distance between the centre of rollers & side bar L = 200 mm

4. Length of specimen (taper length), l = ___________ mm

Tabular Column:

SL No	Taper length of the specimen 'l' mm	Height for one side of the work piece 'h'_1' mm	Height for another side of the work piece 'h_2' Mm	Diff. of height dh = $(h_2 - h_1)$	App. Ht. of slip gauge Read. $H_{app.}$	Actual Ht. of slip gauge Read. H_{act}	Theoretical taper angle, θ_{th}	Actual taper angle, θ_{act}	Error
1									
2									



Calculations:

1. Height for one side of the work piece 'h_1' = -------------- mm
2. Height for another side of the work piece 'h_2' = -------------- mm
3. Difference in height dh = $(h_2 - h_1)$ = -------------- mm.
4. Approximate height of slip gauge used = $H_{app.}$

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

5. Theoretical taper angle, θ_{th} = tan-1(dh/l) = ------------- Degrees
6. Actual taper angle, θ_{act} = [sin-1 (H_{act})] /L = ----------- Degrees
7. Error $\theta_{act} - \theta_{the}$ =--------------- Degrees

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.

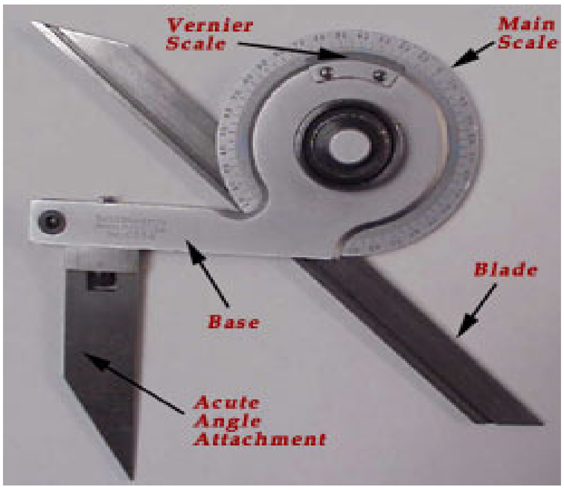
Procedure:

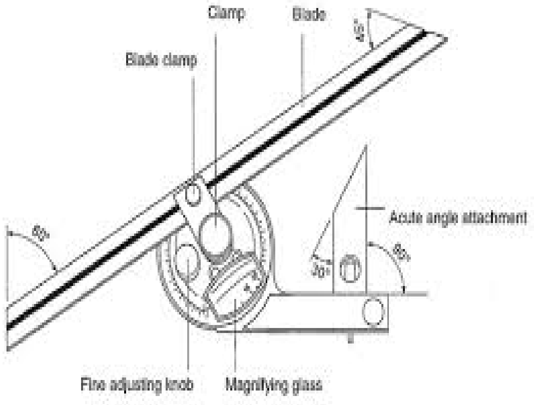
1. Set the sine bar on the surface plate.
2. Measure the distance between rollers of centre of sine bar.
3. Mark the position of the rollers on the surface plate which is advantage if the position of sine bar is changed.
4. The axial length of taper under test is noted by use of vernier calliper.
5. 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 slide way.
7. Note down the least count of the dial gauge used.
8. Adjust the slip gauge height on the taper to be measure in such a way that it easily takes slip on the smaller end and note down dial gauge reading at the entry end.
9. By sliding the dial gauge across the work piece length take reading of the dial gauge on other end.
10. Calculate approximate height of slip gauge required at smaller dimension end in order to become an upper surface of the work piece parallel to the reference plane.
11. Without altering the position of the roller place the slip gauge pile under the roller of small size end of the sine bar set up 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.

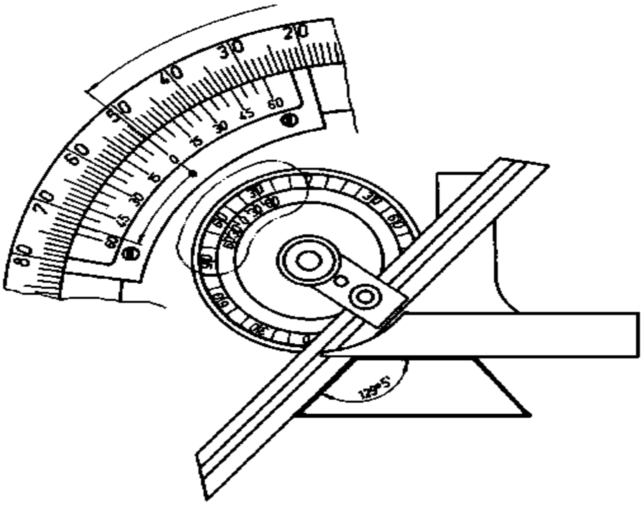
Results:

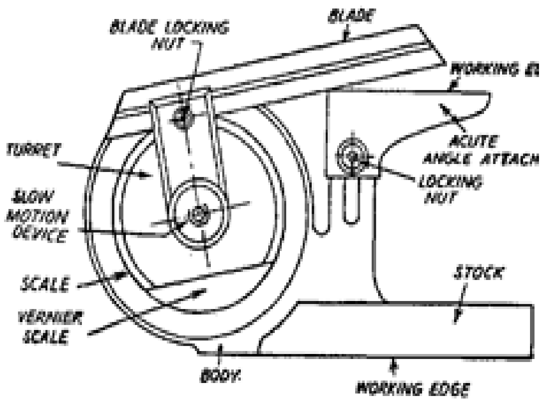
For a given component/ plug gauge, we found the theoretical taper angle is ____________ degrees & also actual taper angle is ____________ degrees.

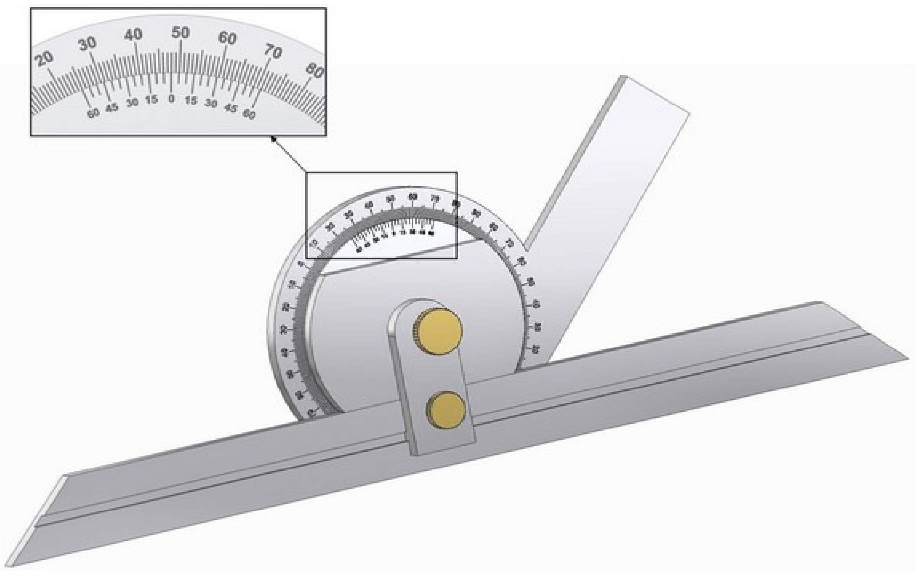
EXPERIMENTAL SET UP FOR BEVEL PROTRACTOR











Experiment No.: 07 (C)

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

Observations:

Least count of the Bevel Protractor = ________________ minutes

Tabular Column:

SL No.	Faces/Sides	Angles
1		
2		
3		
4		

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 bevelled 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.

$$Least\ count\ of\ vernier\ bevel\ Protractor = \frac{Smallest\ division\ on\ main\ scale}{Total\ no\ of\ divosion\ on\ Vernier\ scale}$$

$$= 1^0 (equal\ to\ 60^0)\ i.e\ \frac{60}{12}$$

$$= 5\ minutes\ (writtenas\ 5^0)$$

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.

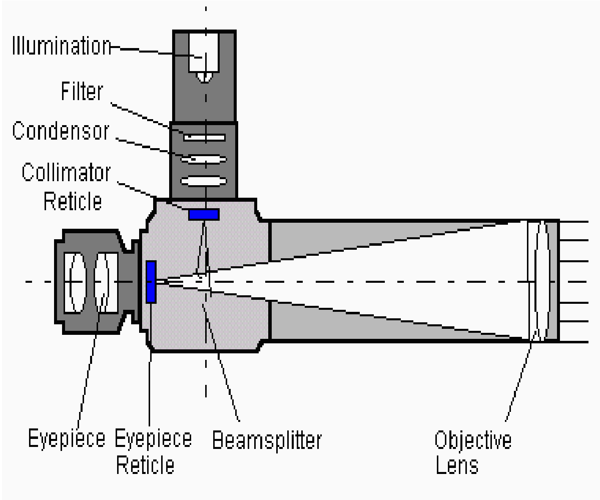
Procedure:

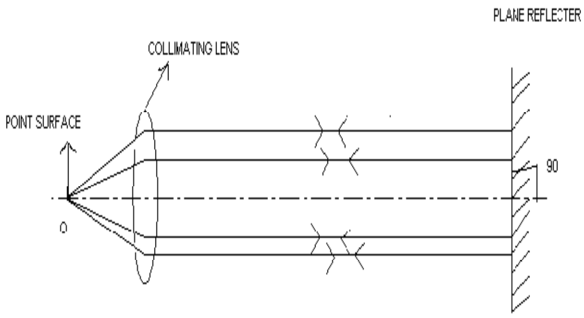
1. Note down the least count of the Bevel Protractor.
2. Keep the work piece on the surface plate.
3. Fix the slide of Bevel Protractor to the Turret.
4. Keep one of the surfaces of the specimen on the working edge and rotate the turret.
5. Remove the slide on to the other surface.
6. Fix the centre,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

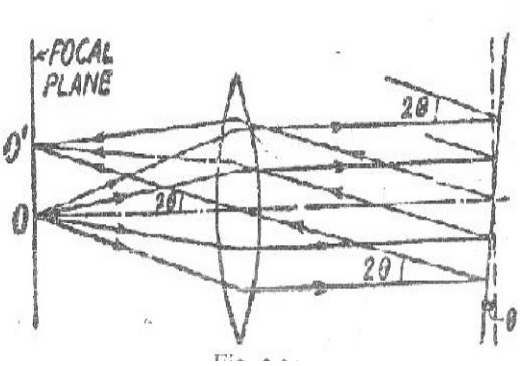
Result:

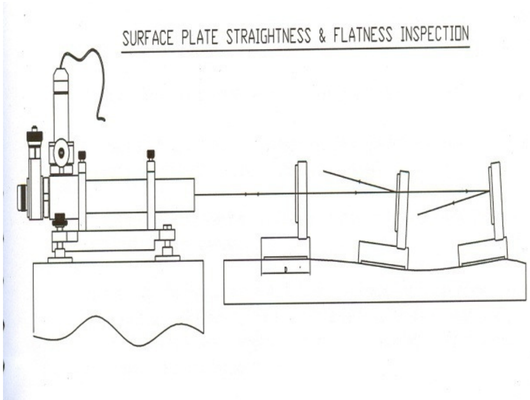
By using the bevel protractor, the taper angle of the given specimen is calculated.

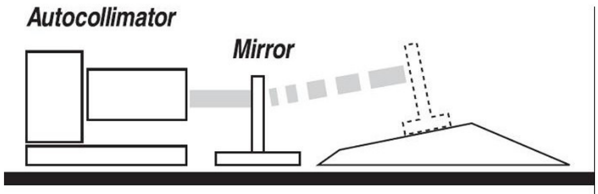
EXPERIMENTAL SET UP FOR AUTOCOLLIMATOR











Measuring straightness.

Experiment No.: 08

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" gratitude 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 gratitude 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 as a**"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 reticules and exactor coincident with its intersection. Aproportion 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 $2\theta * f$.

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.

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 (ϴ in degrees)	Deviation for each 100mm (X in microns)
1					
2					
3					
4					

Calculation:

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

X = (100 x **Tan**$^{\theta}$) 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).

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 autocollimator 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 $OO' = x = 2\theta . f$, where f is the focal length of the lens.

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.

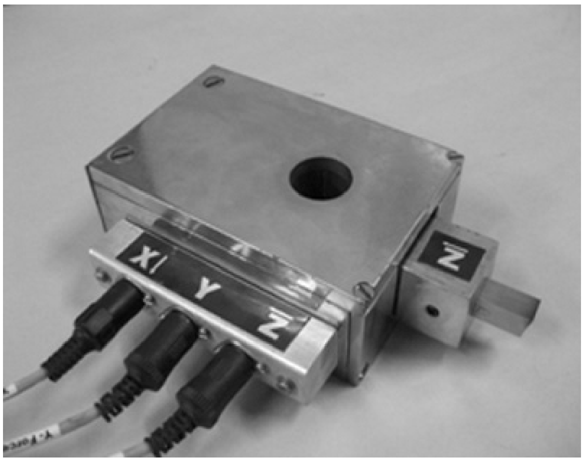
Procedure:

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

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.

EXPERIMENTAL SET UP FOR LATHE TOOL DYNAMOMETER



SPECIFICATIONS:

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

Demonstration Experiments No. 09 (A)

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.	RPM of the motor N	Speed V = πDN mm/min	Forces in Kg-f			Resultant force	
			F_X	F_Y	F_Z	Kg	N
1							
2							
3							
4							

Calculation:

Diameter of the specimen(D) = MSR + (CVD x LC) mm

1. For ________ RPM

   F_r = ________ Kg

2. For ________ RPM

   F_r = ________ Kg

3. For ________ RPM

   F_r = ________ Kg

4. For ________ RPM

   F_r = ________ Kg

Result:

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

EXPERIMENTAL SET UP FOR DRILL TOOL DYNAMOMETER

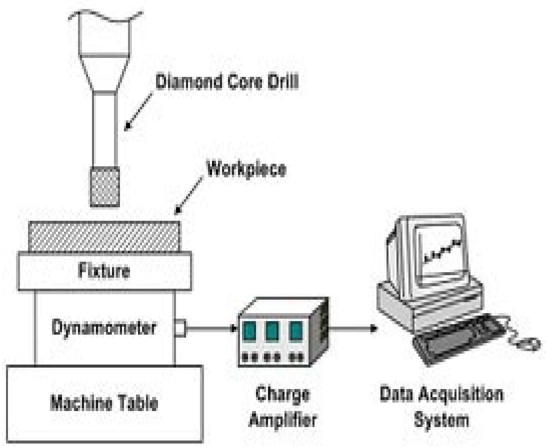


FIGURE 1. Structure of experimental setup

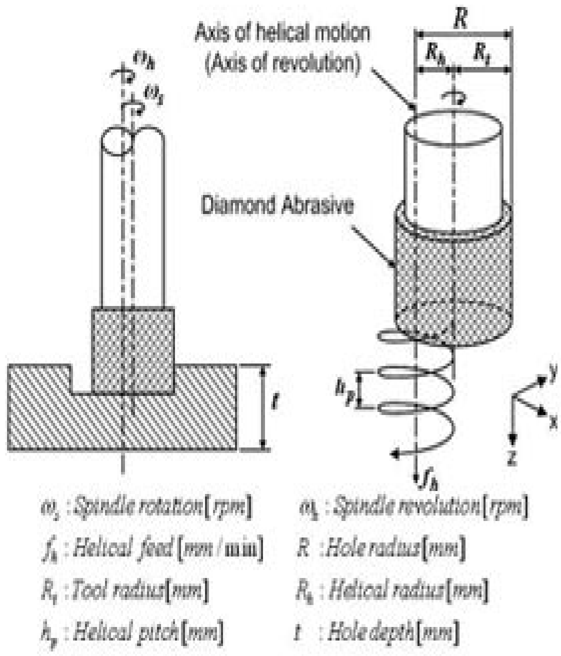


FIGURE 2. Illustration of helical-feed drilling

Demonstration Experiment No. 09 (B)

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	: 350 ohms
Bridge voltage	: 12 Volts maximum

Applications:

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

Tabular Column:

Material used: ___________________

Sl. No.	Torque in Kg-m	Thrust Force in Kg-f	Drill Bit Size in mm
1			
2			
3			
4			

Calculations:

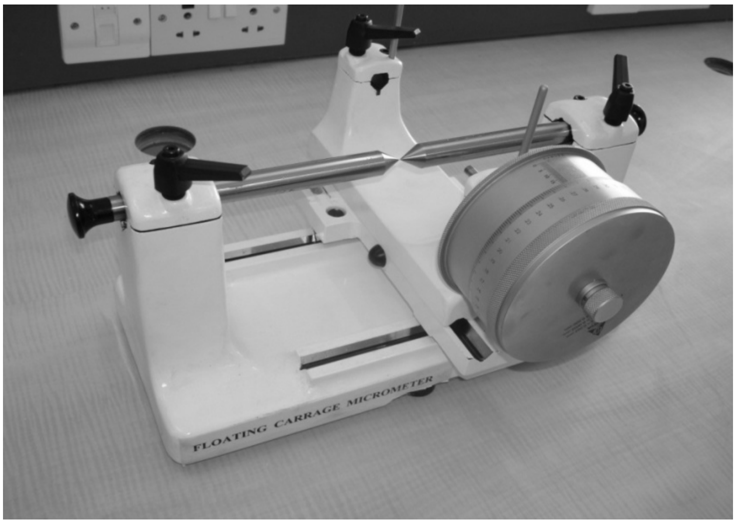
Procedure:

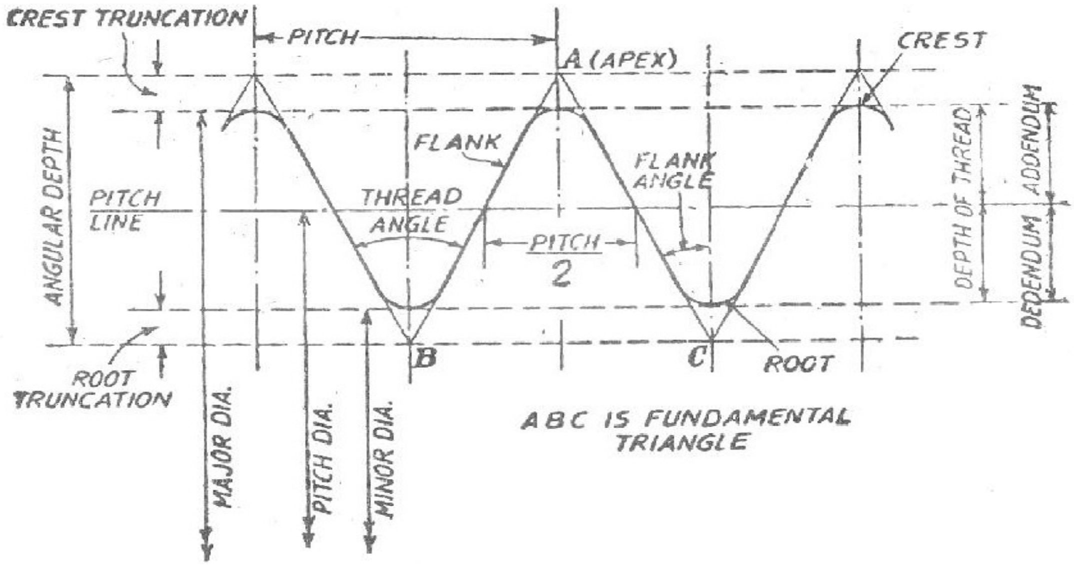
1. Fix the drill Tool dynamometer on the work platform post using slot provided on the dynamometer. Ensure that the object being drilled is mounted on the top centre of the drill tool dynamometer.
2. Plug the power cable to the 230V, 50Hz mains supply.
3. Connect the input cable to the respectively thrust 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.

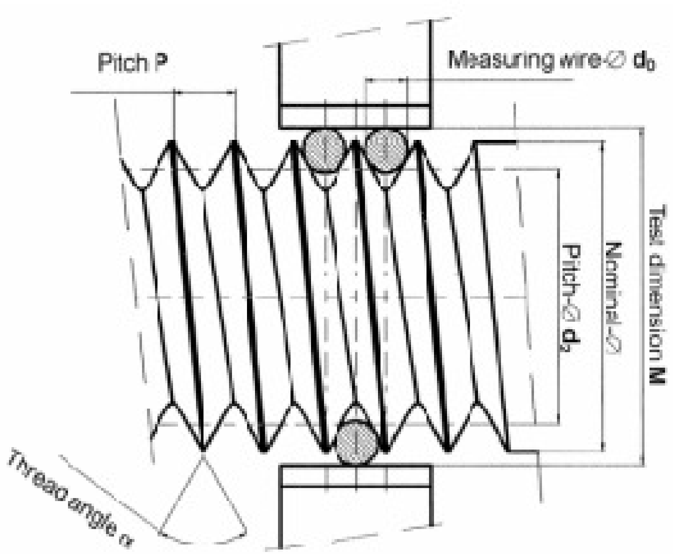
Results:

Measured the “Torque and Thrust” forces by using Drill Tool Dynamometer.

EXPERIMENTAL SET UP FOR TWO WIRE METHOD







Demonstration Experiment No. 10

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

Aim: To determine the major, minor and effective diameter of a given screw thread specimen using floating carriage micrometer.

Apparatus: Floating carriage diameter measuring machine, test specimen, master specimen, wires and thread measuring prisms.

Theory: The floating carriage diameter measuring machine is a precision measuring equipment used to measure major, minor and effective (pitch) diameter of threads gauges and precision thread components. This instrument ensures that the axis of the micrometer is maintained at 90^o to the axis of the screw thread specimen under test. It consists of two slides (lower and upper). The lower slide moves parallel to the thread axis. The upper slide also called as measuring slide carries a micrometer head and a fiducially indicator. The measuring slide or carriage floats on three balls in the V-grooves of the lower slide. The thimble of micrometer is graduated for readings of 0.002mm and vernier has a least count of 0.0002mm. The fiducially indicator is a highly sensitive indicator which reduces the errors due to feel of micrometer. The indicator operates at a constant pressure at null position of the pointer. It has a magnification of more than 150 times the movement of the micrometer anvil. This helps in high degree of control and repeatability required for accurate measurements. The micrometer readings are taken with indicator pointer at null position.

Procedure:

1) Measurement of major diameter:

a) Fix a standard cylinder of approximately same size as the nominal size of the threads between the centres of the floating carriage diameter measuring machine.
b) Note down the reading of micrometer as R_1 when the fiducially indicator is at null position.
c) Replace the standard cylinder by the given screw thread specimen and note down the reading of micrometer as R_2.
d) Calculate the major diameter of the screw thread.

Fig. Standard Mandrel

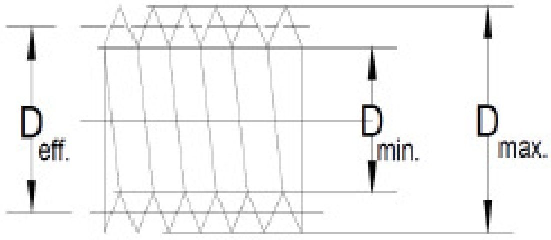


Fig. Threaded Specimen

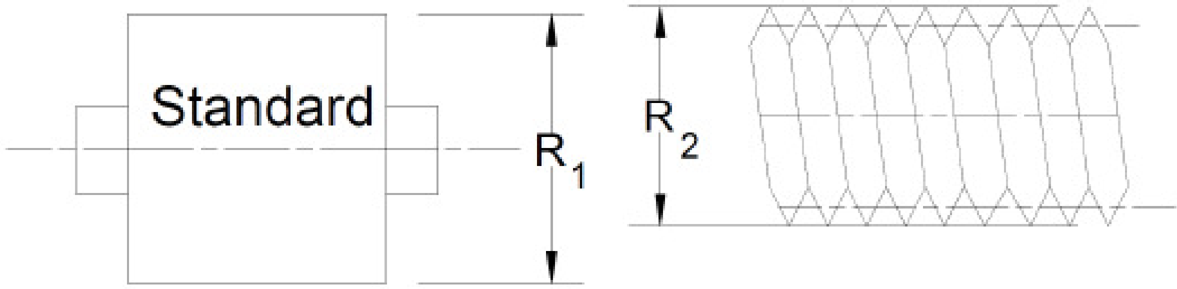


Fig. Readings for Major Diameter

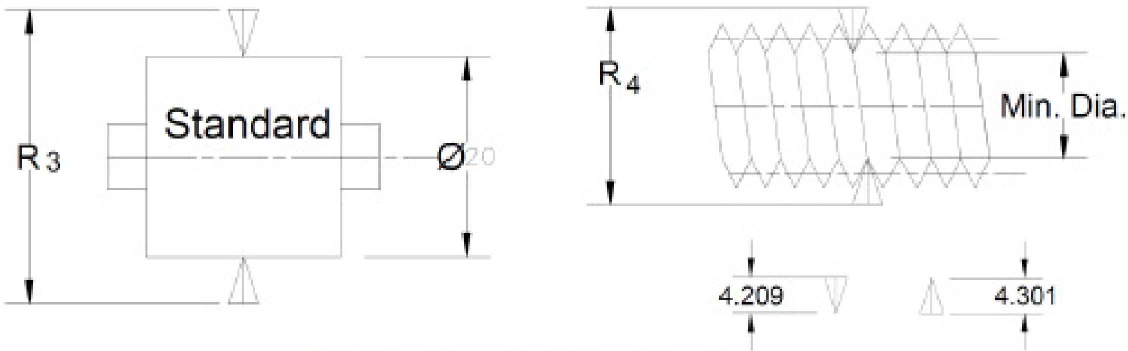


Fig. Readings for Minor Diameter

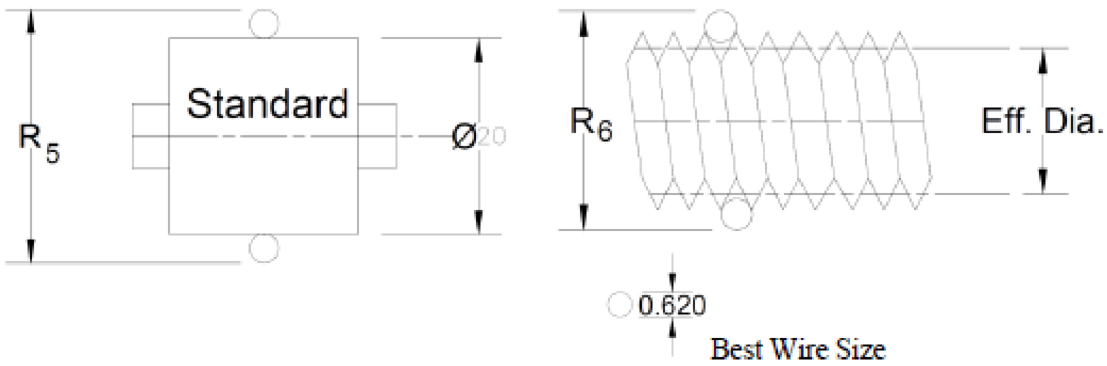


Fig. Readings for Effective Diameter

2) Measurement of minor diameter:

a) Fix a standard cylinder of approximately same size as the nominal size of the threads between the centres of the floating carriage diameter measuring machine.

b) Select a best sized prism based on the type of thread and pitch from the given chart. Insert the prisms between the measuring anvils and the standard cylinder and note down the reading of micrometer as R_1 when the fiducially indicator is at null position.

c) Replace the standard cylinder by the given screw thread specimen and note down the reading of micrometer as R_2.

d) Calculate the minor diameter of the screw thread.

3) Measurement of effective diameter:

a) Fix a standard cylinder of approximately same size as the nominal size of the threads between the centres of the floating carriage diameter measuring machine.

b) Select a correct sized wires based on the type of thread and pitch. Insert the wires between the measuring anvils and the standard cylinder and note down the reading of micrometer as R_1 when the fiducially indicator is at null position.

c) Replace the standard cylinder by the given screw thread specimen and note down the reading of micrometer as R_2.

d) Calculate the Pitch value P. It is the difference between the effective pitch and diameter under the thread measuring wire. It can read from the given chart and calculated by the formula $P = 0.86602\ p - d$ [for metric thread] where 'p' is the pitch and'd' is the diameter of the thread measuring wire.

e) Calculate the 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

Observations and Calculations:

Major diameter:

Diameter of the standard cylinder, D = mm

Reading on standard cylinder, R_1 = mm

Reading on threaded specimen, R_2 = mm

Major diameter of threaded specimen $D_1 = D + (R_1 \sim R_2)$ = mm

Minor diameter:

Diameter of the standard cylinder, D = mm

Reading on standard cylinder, R_3 = mm

Reading on threaded specimen, R_4 = mm

Major diameter of threaded specimen $D_2 = D + (R_3 \sim R_4)$ = mm

Effective diameter:

Diameter of measuring wire, d = mm

Pitch of the thread, p = mm

Diameter of the standard cylinder, D = mm

Reading on standard cylinder, R_5 = mm

Reading on threaded specimen, R_6 = mm

Pitch value, $P = 0.86602\ p - d$ = mm

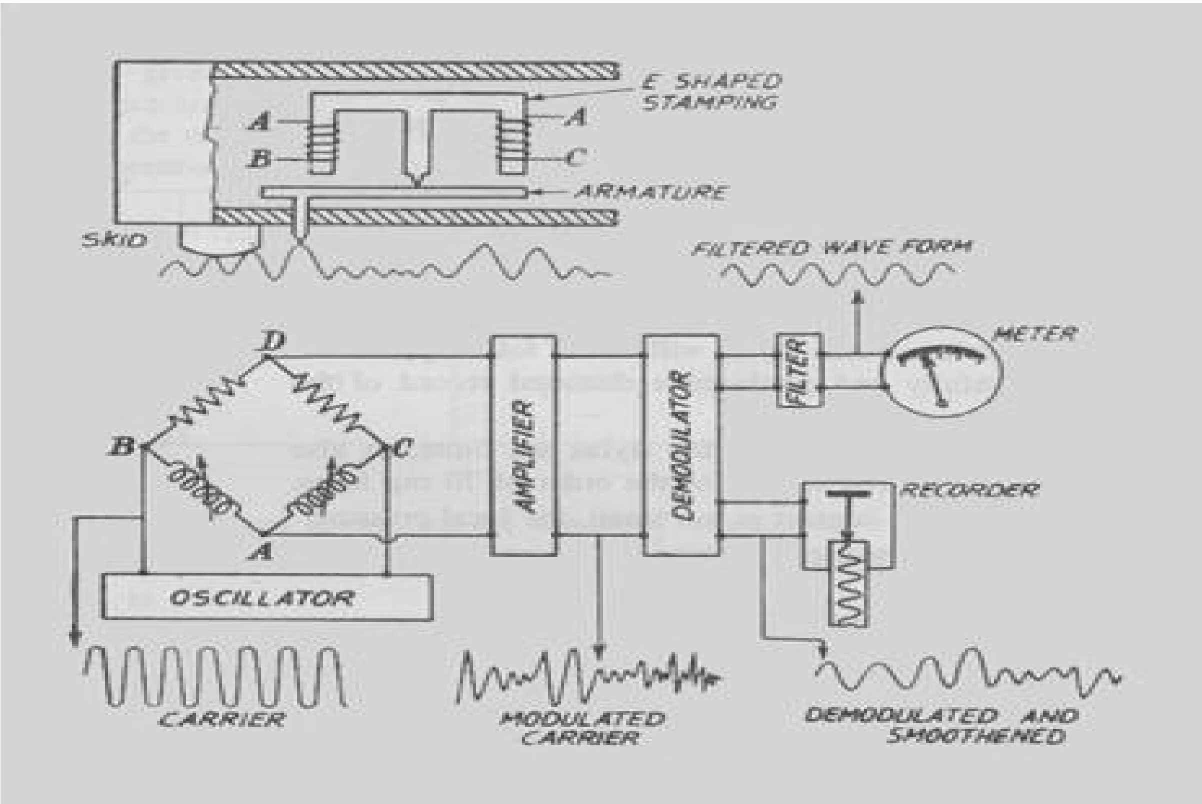
Major diameter of threaded specimen $D_3 = D + [(R_5 - P) \sim R_6)]$ = mm

Results:

The following parameters are found as follows.

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

EXPERIMENTAL SET UP FOR TALY SURF



Demonstration Experiment No.: 11 (A)

MEASUREMENT OF SURFACE ROUGHNESS (TALLYSURF)

Aim: To measure surface roughness parameter as per ISO Standards

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

Procedure:

2. Connect Ac adopter to the measuring instrument & Switch on the power supply
3. 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.
4. Adjust or modify the measurement condition such as sample length, number samples, Standard required for the measurement
5. Calibrate the instrument using standard calibration piece
6. Carefully place the detector on the work piece. Care should be taken to see that work piece & detector are aligned properly
7. Press the start button to measure the work piece & result are displaced on the console
8. Press print button to take the print out.

Applications:

1. Tally 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.

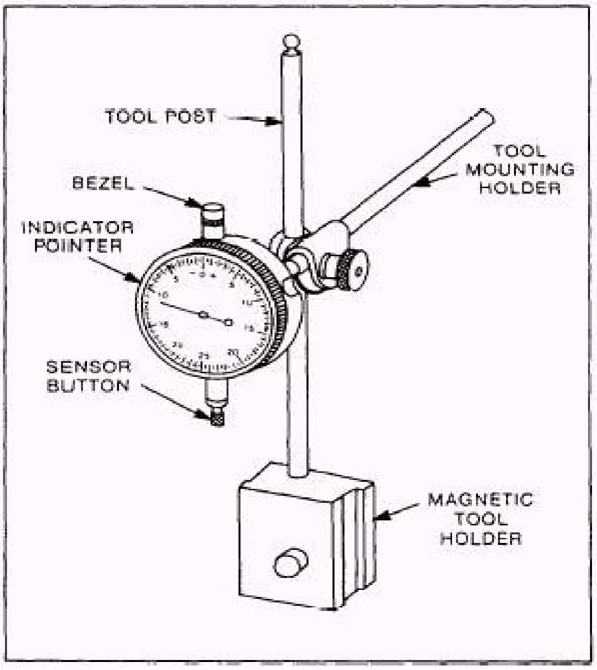
Tabular column:

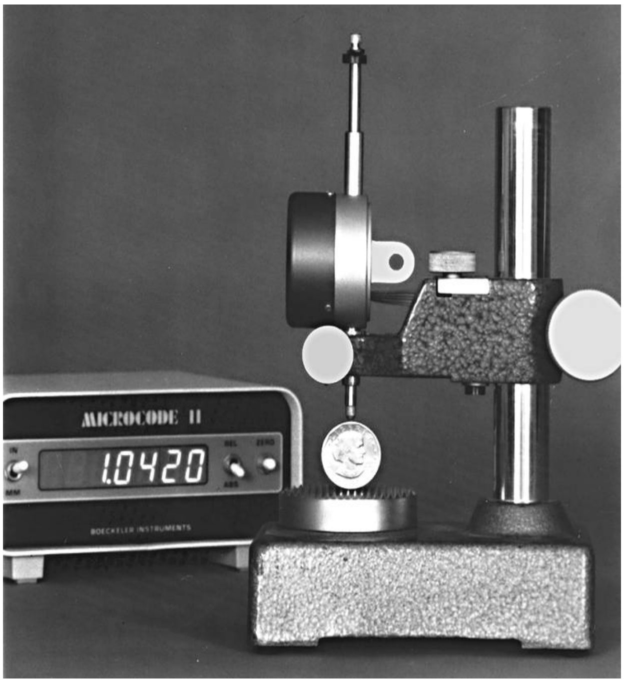
Sl. no	Specimen	Ra value	Rz value	Rq value
1				
2				
3				
4				

Results:

Surface roughness checked for different specimens by Tally surf.

EXPERIMENTAL SET UP FOR MECHANICAL COMPARATOR





Demonstration Experiment No.: 11 (B)

MEASUREMENT / INSPECTION OF COMPONENTS USING MECHANICAL COMPARATOR

Aim: To measure the deviation in values of a given specimens by using mechanical comparator.

Apparatus: Mechanical comparator (Dial indicator), Comparator stand, Slip gauges and specimens.

Theory: Comparators are used to compare the unknown dimension with one of the reference standard. The purpose of a comparator is to detect and display the small difference between the unknown and standard. The deviations in size are detected as the displacement of sensing device. The comparator should also magnify the small input displacements. The scale used on the comparator should be linear. The various types of comparators are mechanical, optical, mechanical – optical, electrical, electronic and pneumatic, etc. dial gauge is used as a mechanical comparator. It is simple and robust in design. It can be set to be comparing any dimension easily and quickly. The major disadvantage of a mechanical comparator is that the range is small and mechanical parts have large inertia

Procedure:

1) Clean the comparator stand and fix the dial gauge to the stand.
2) Place the combination of slip gauges of specified basic size on the comparator stand.
3) Adjust the needle of the dial gauge such that it touches the slip gauges with some pressure.
4) Set the dial reading to zero.
5) Mark the tolerance values on either side of the zero dial reading.
6) Place the given components one after the other under the dial gauge and note down the dial reading.
7) Find the mean and standard deviation and draw the control chart.

Observations and Calculations:

Least count of dial gauge = ______________mm

Specified basic size of the component, b = _____________mm

Tolerance on the component = ____________mm

Total number of components, N = _____________

Tabular Column:

Sl. No	Dial gauge reading (Deviation), d	Accepted / Rejected	Size of the component, X = (b + d)	Standard deviation, σ
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

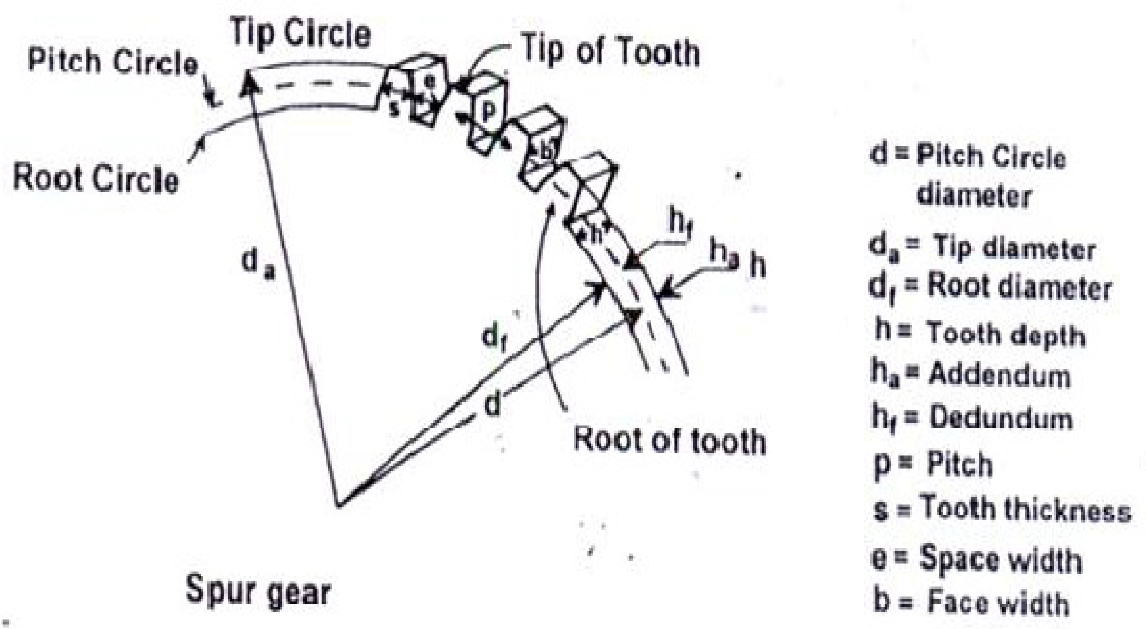
1. Mean, $X = (\Sigma X) / N$
2. Standard deviation, $\sigma = \sqrt{(X^2/N-1)}$
3. Upper control limit = $X + 3\sigma$ =
4. Lower control limit = $X - 3\sigma$ =

Results:

The given components are checked for deviations and are tabulated in the tabular column.

EXPERIMENTAL SET UP FOR GEAR TOOTH MICROMETER

DIMENSIONS OF A SPUR GEAR



Demonstration Experiment No.: 12

MEASUREMENT OF GEAR TOOTH PROFILE BY USING GEAR TOOTH MICROMETER

Aim: To determine the actual and theoretical tooth thickness of a gear by using Gear tooth micrometer.

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 millimetre 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.

Dedenum: 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.

Observation:

Least count of the gear tooth micrometer ________________ mm

Tabular Column:

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

Calculations:

1. Diameter of gear blank, D = MSR + (VSR x LC) ± Initial Error in mm
2. Number of teeth on gear T =
3. Module m = D/T
4. Theoretical thickness of tooth, W_t =Tx m x sin (90/T) in 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 & dedendum etc.
4. To find out the involute profiles of hypoidal gears, helical, bevel, warm & planetary gears.

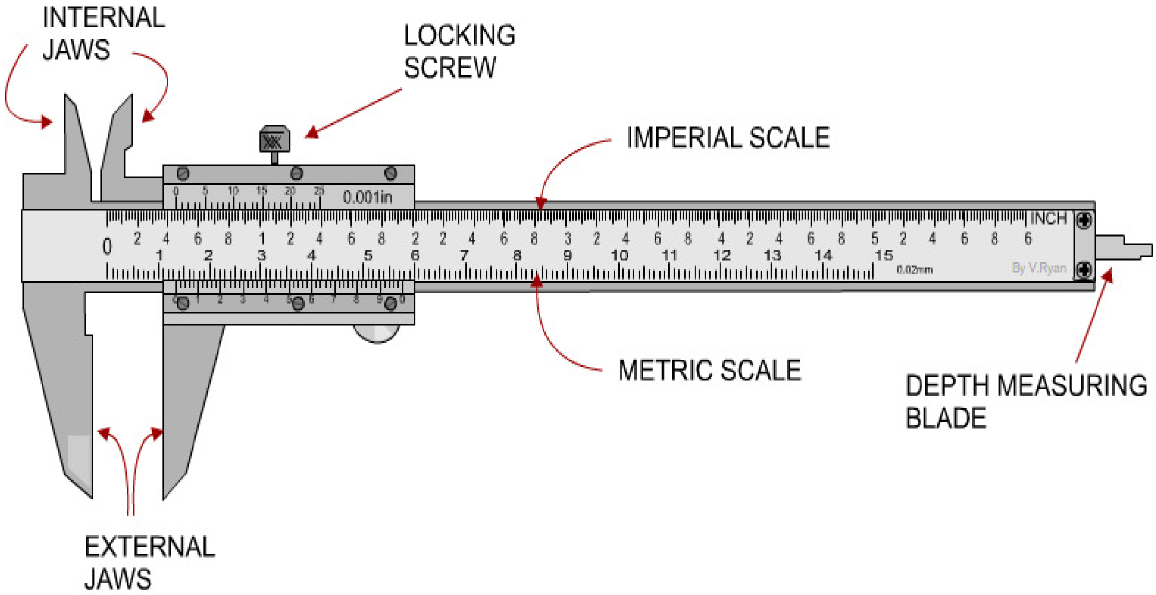
Procedure:

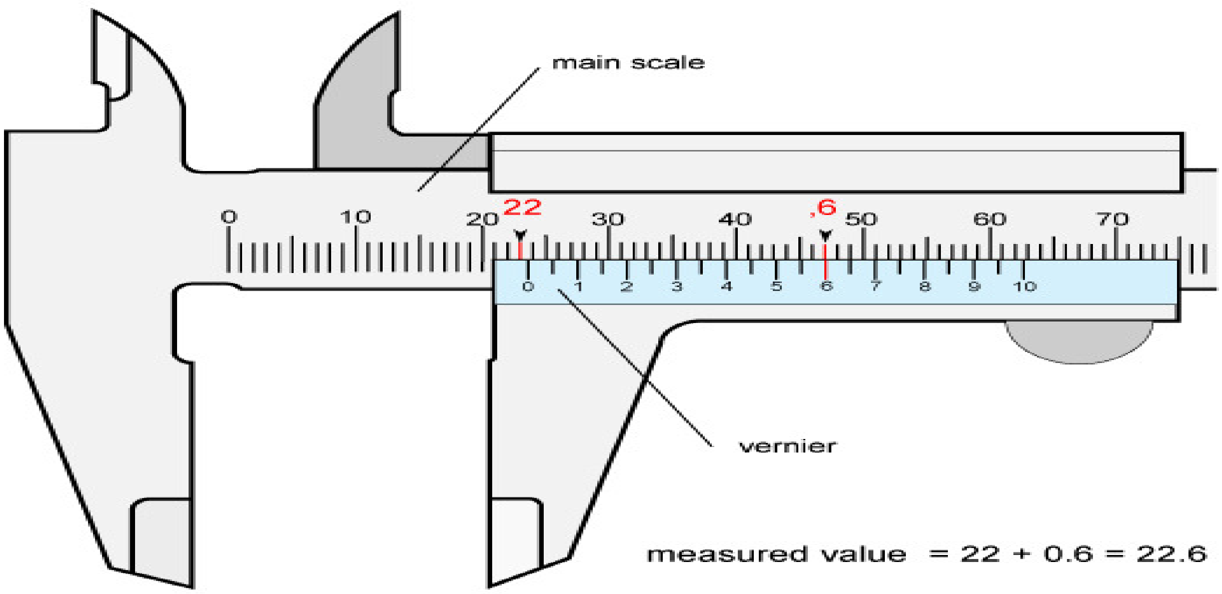
1. Note down the least count of the gear tooth micrometer
2. Measure the diameter of gear blank using vernier calliper also count the number of teeth on the gear blank.
3. Calculate the addendum of the gear tooth and fix the same dimension in gear tooth micrometer
4. Measure the same parameters for different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

Results:

The actual and theoretical tooth thickness of a gear is calculated by using Gear tooth micrometer.

EXPERIMENTAL SET UP FOR CALIBRATION OF VERNIER CALIPER





Additional Experiment No. 01

CALIBRATION OF VERNIER CALIPER USING SLIP GAUGES

Aim : To calibrate and measure the given component by using vernier calliper.

Apparatus required: Slip gauges and Vernier Calliper.

Theory: The Vernier Calliper is a precision instrument that can be used to measure internal and external distances extremely accurately. Measurements are interpreted from the scale by the user. This is more difficult than using a digital vernier Calliper which has an LCD digital display on which the reading appears. Manually operated vernier Calliper can still be bought and remain popular because they are much cheaper than the digital version. Also, the digital version requires a small battery whereas the manual version does not need any power source.

The **main use of the vernier Calliper** is to measure the internal and the external diameters of an object. To measure using a vernier scale, the user first reads the finely marked "fixed" scale (in the diagram). This measure is typically between two of the scale's smallest graduations. The user then reads the finer vernier scale which measures between the smallest graduations on the fixed scale providing much greater accuracy.

Example: On decimal measuring instruments, as in the diagram below, the indicating scale has 10 graduations that cover the same length as 9 on the data scale. Note that the vernier 10^{th} graduation is omitted.

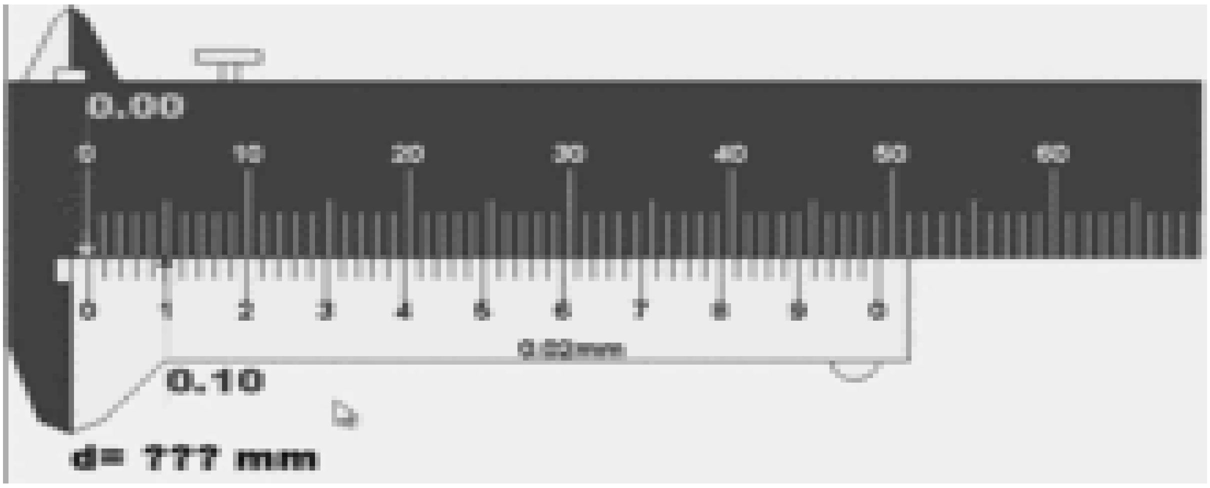
The method to use a vernier scale or Calliper with zero error is to use the formula: actual reading = main scale + vernier scale – (zero error). Zero error may arise due to knocks that cause the calibration at the 0.00 mm when the jaws are perfectly closed or just touching each other.

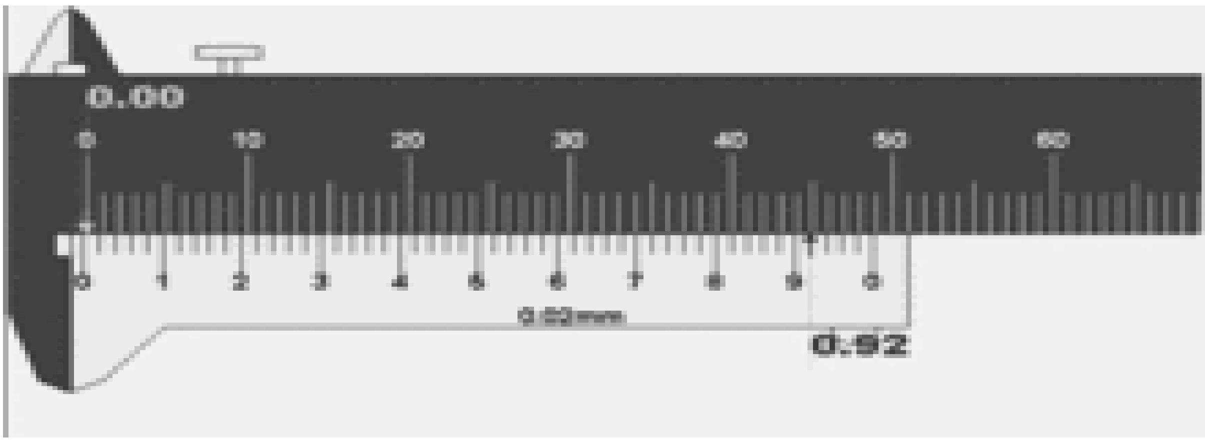
When the jaws are closed and if the reading is 0.10mm, the zero error is referred to as +0.10mm The method to use a vernier scale or Calliper with zero error is to use the formula 'actual reading = main scale + vernier scale – (zero error)' thus the actual reading is 19.00 + 0.54 – (0.10) = 19.44 mm

Positive zero error refers to the fact that when the jaws of the vernier Calliper are just closed, the reading is a positive reading away from the actual reading of 0.00mm. If the reading is 0.10mm, the zero error is referred to as + 0.10 mm.

CALIBRATION OF VERNIER CALIPER:

S.NO	Slip gauge in mm	MSD	VSD	Output value in mm	Actual value in mm	Error in mm
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						





When the jaws are closed and if the reading is −0.08mm, the zero error is referred to as −0.08 mm. The method to use a vernier scale or Calliper with zero error is to use the formula actual reading = main scale + vernier scale – (zero error)' thus the actual reading is 19.00 + 0.36 – (−0.08) = 19.44 mm

Negative zero error refers to the fact that when the jaws of the vernier Calliper are just closed, the reading is a negative reading away from the actual reading of 0.00mm. If the reading is 0.08mm, the zero error is referred to as −0.08mm.

Principle:

Vernier Calipers the most commonly used instrument for measuring outer and inner diameters. It works on the principle of Vernier Scale which is some fixed units of length (Ex: 49mm) divided into 1 less or 1 more parts of the unit (Ex: 49mm are divided into 50 parts). The exact measurement with up to 0.02mm accuracy can be determined by the coinciding line between Main Scale and Vernier Scale .Total Reading = M.S.R + L.C X V.C

M.S.R – Main Scale Reading
L.C – Least Count
V.C – Vernier Coincidence

Procedure:

Calibration:

1. With the help of slip gauges as standard, calibrate the gauges.

2. Plot a graph of (i) STD Input vs Output and (ii) Standard Input vs Error.

Measurement:

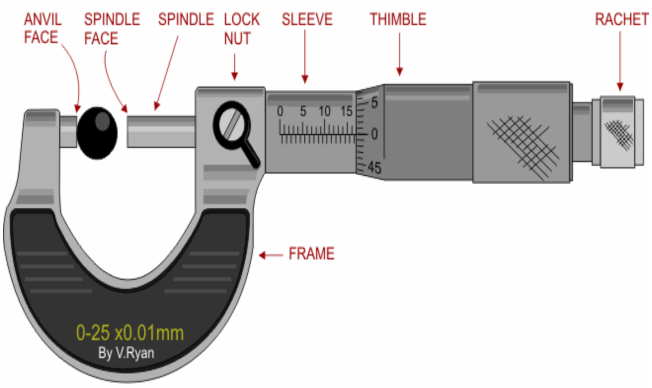
1. Place the work piece and the gauge appropriately and carry out the measurement of the job.

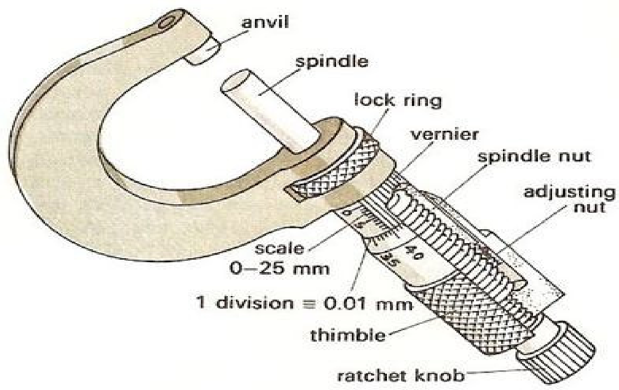
2. Prepare a report of the measurement and indicate the characteristics of the work pieces.

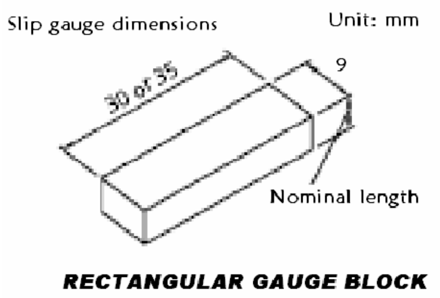
Result:

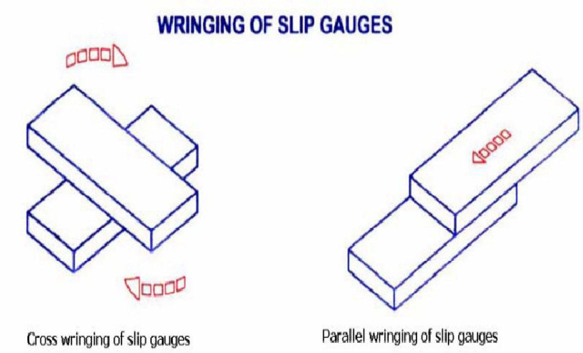
Calibrated the vernier calliper and measured the values of the given component.

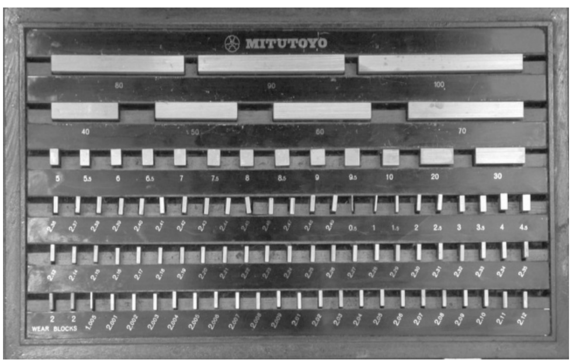
EXPERIMENTAL SET UP FOR MICROMETER CALIBRATION

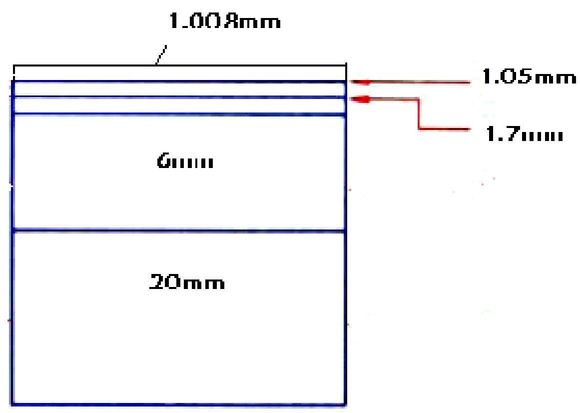












Additional Experiment No.: 02

CALIBRATION OF MICROMETER USING SLIP GAUGES

Aim: To calibrate the given micrometer using set of slip gauges.

Apparatus: Micrometer and set of slip gauges.

Formulae: (i) Least Count = Pitch / no. of divisions on the head scale

(ii) Total Reading = PSR + (HSR x LC)

(iii) Error = $R_a - R_m$

(iv) % Error = $\left(\frac{R_{a-R_m}}{R_a}\right) \times 100$

Theory: Micrometer is one of the common precision linear measuring instruments. The operation of micrometer depends upon the principle that the distance moved by the nut along the screw is proportional to the number of revolutions made by the nut, therefore by controlling the number of revolutions and fractions of a revolution made by a nut, the distance it moves along the screw can be accurately predicted.

Many types of errors are indicated while manufacturing micrometers. Pitch errors are most common among all errors. Pitch errors are errors in effective diameter of helix measured parallel to the axis of screw thread and are of mainly two types –progressive and periodic errors.

Progressive errors: If the pitch of the thread is uniform but is longer the shorter than its nominal value, such a type of errors is called as progressive errors. Progressive errors progressive in nature and increases as the length of axis increases. These errors occur when,

a) Tool work velocity ratio is incorrect.
b) Due to fault in saddle guide ways.
c) Due to casing of an incorrect gear train between work and tool

Periodic errors: Periodic errors are those which vary in magnitude along the length of the thread and repeats at regular intervals. The deviation from the true helix occurs adjacent threads at the same fraction of revolution but the pitch remains constant and such errors will not be detected by measurement along e line parallel to the axis. Errors of this type are most frequently caused by lack of squareness in the thrust bearing of the lead screw used to produce the thread.

Some possible sources of errors which may result the incorrect functioning of the instrument are

a) Lack of flatness of the anvils.
b) Lack of parallelism of the anvils.
c) Inaccurate setting of the zero reading.
d) Inaccurate reading followed by the zero position.
e) Inaccurate reading shown by the fractional divisions on the thimble.
f) Errors in micrometer screw threads.

Tabular Column:

(a) **Progressive Error**

Sl. No.	Readings (mm)		Error	% Error
	Actual Reading (R_a)	**Measured Reading** (R_m)		
1	2.5			
2	5.0			
3	7.5			
4	10.0			
5	12.5			
6	15.0			
7	17.5			
8	20.0			

(b) **Periodic Error**

Sl. No.	Readings (mm)		Error	% Error
	Actual Reading (R_a)	**Measured Reading** (R_m)		
1	2.1			
2	2.2			
3	2.3			
4	2.4			
5	20.1			
6	20.2			
7	20.3			
8	20.4			

Procedure:

1) Clean the anvils and check the micrometer for zero reading.
2) Note down the least count of the micrometer.
3) For progressive error, take readings of micrometer by placing the slip gauges from 2.5mm to 20mm in steps of 2.5mm.
4) For periodic error, take readings of micrometer by placing the slip gauges rom 2.1mm to 2.4mm in steps of 0.1mm and from 20mm to 20.4mm in steps of 0.1mm.
5) Record the readings of slip gauges [measured reading] to the corresponding micrometer readings [actual reading].
6) Calculate the error and % error.
7) Plot the graph of error v/s actual reading for both the type of errors.

Graphs:

i. Progressive Error v/s Actual reading
ii. Periodic Error v/s Actual reading

Result:

The given micrometer is calibrated and the corresponding readings are recorded and tabulated in the tabular column.

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 capabilities.
   - 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) Height Gauge d) Micrometer etc.

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 error sand 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.

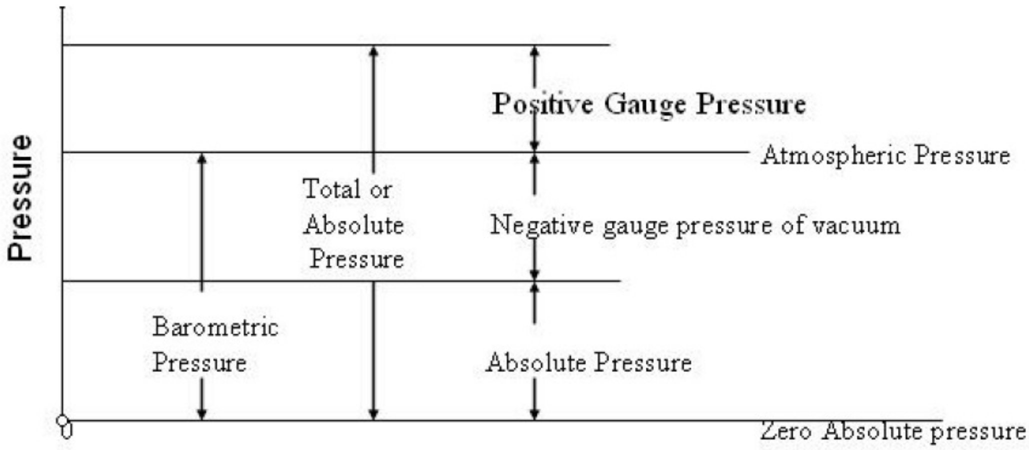
23. True value (v_t) or Actual value (v_a)
    It is the actual magnitude of the input signal to a measuring system which may be approximated but never truly be determined.

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 62º 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 canter?
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 canters can be Clamped. These are useful for testing of conical work cantered at each end, up to 60°.

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