MECHANICAL MEASUREMENT & METROLOGY LAB MANUAL

GOVT. ENGG. COLLEGE, VALSAD.

MECHANICAL ENGG. DEPT. (FOR EVEN TERM - 2020)

GOVERNMENT ENGINEERING COLLEGE, VALSAD
MECHANICAL ENGINEERING DEPARTMENT

CERTIFICATE

This is to certify that Mr./Miss____ of Mechanical Branch, Sem-IV, Enrollment No.______________________, has satisfactorily completed his/her term work for the subject **Mechanical Measurement & Metrology (241901)** during even term-2020.

Date :

Sign of Faculty   Head of the Department

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INDEX

subject : Mechanical Measurement & Metrology (241901)

PRACTICAL	TITLE	GRADE	DATE	SIGN OF FACULTY
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2	Calibration of Vernier Calliper and Micrometer using Slip Gauge.			
3	Temperature measurement using Thermocouple.			
4	To calibrate given Resistance Temperature Detector (RTD).			
5	Calibration of L.V.D.T.			
6	Calibration of Bourdon Tube pressure gauge.			
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PRACTICAL-1: Performance on linear and angular measurements and check different characteristics of measurements

OBJECTIVE: Objective of this practical is to acquire basic fundamental understanding of measurement and metrology.

Objective: is to get familiar with linear and angular measuring device.

Linear measuring instruments: Engineer's steel rule, Vernier callipers, micrometer, Angular measurements: -Sine bar, sine centre, protractors, Spirit Levels, clinometers.

Sr. No	Instrument Based on	List of Instrument
1	**Vernier Scale**	**a. Vernier Calliper** **b. Vernier Height Gauge**
2	**Screw and nut**	**a. Micrometer** **b. Depth Gauge Micrometer**

Note: VISUAL INSPECTION

Before using the instrument in this practical session;

1. Inspect bottom of measuring instrument surface, which could affect proper calibration.
2. Inspect anvil for wear, nicks, or burrs.
3. Check for proper instrument function's: Spindle locks, thimble ratchet.
4. Inspect readability of sleeve, and thimble numbers and lines.

PART 1 LINEAR MEASUREMENTS

- **How to use Vernier Calliper?**

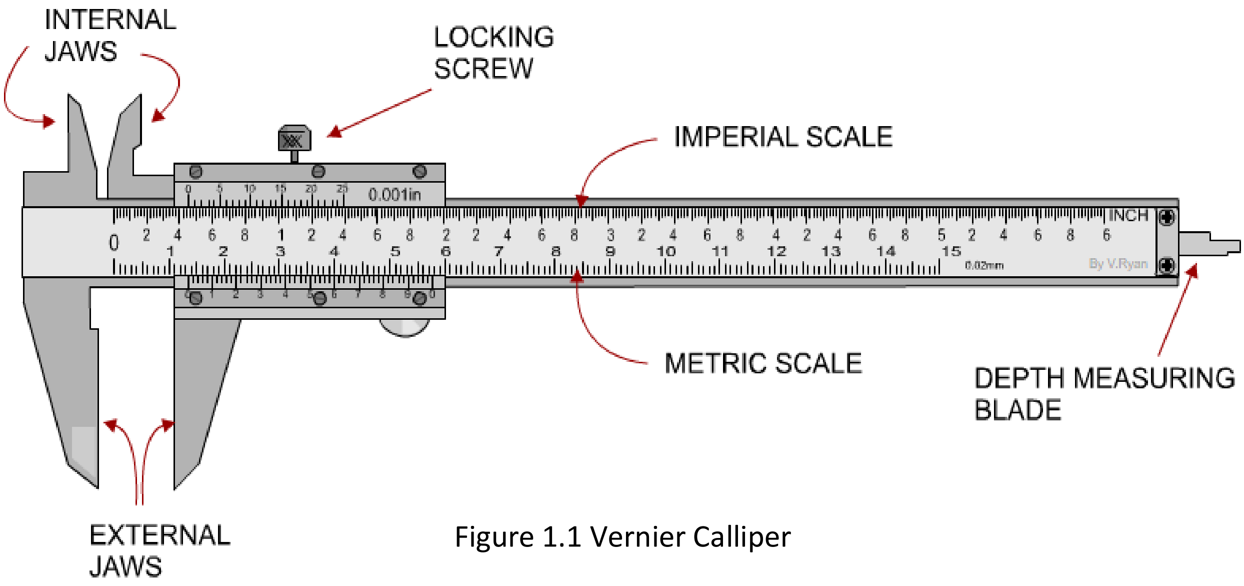


Figure 1.1 Vernier Calliper

Principle of Vernier-

The graduations on the vernier scale are such that the length of ' n' divisions on the vernier scale is equal to (n-1) divisions of the main scale. Generally, a vernier has 10 divisions and the length of these 10 divisions is equal to the length of 10 – 1 = 9 divisions of the main scale.

That is, 10 div of vernier scale = 9 mm.

1 div of vernier scale = 9/10 mm

Least Count of Vernier or Vernier Constant :

It is defined as the difference between the values of one main scale division and one vernier scale division .

L.C.= Value of one main scale division – Value of one vernier scale division

= 1 mm – 9/10 mm

= 1 mm – 0.9 mm

= 0.1 mm or 0.01 cm OR

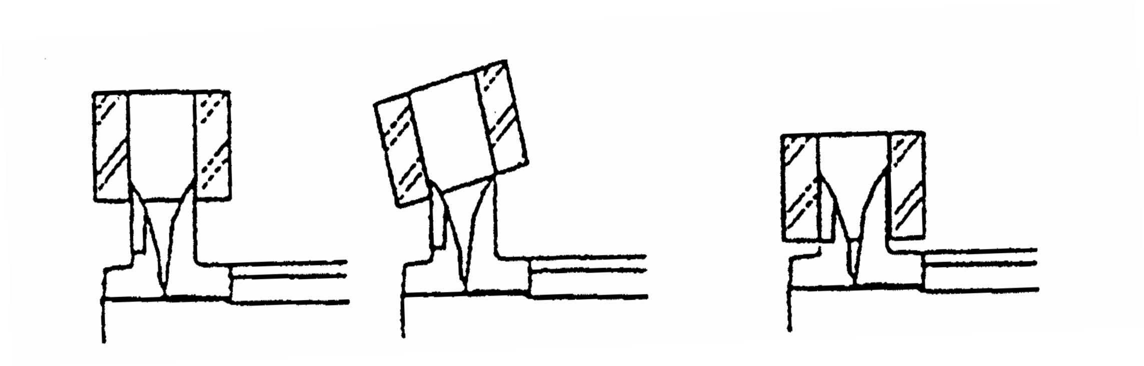
L.C. = Value of one main scale division / Total number of divisions on vernier

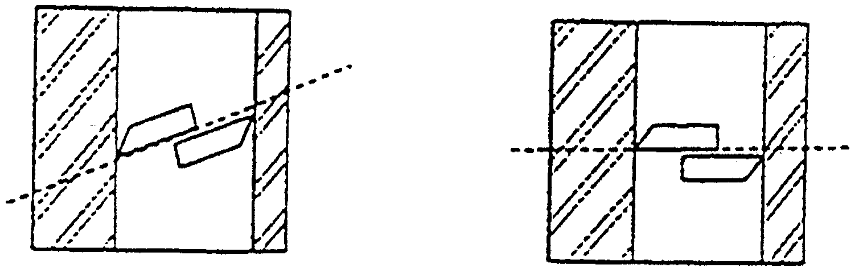
= 1 mm / 10 = 0.1 mm or 0.01 cm

Procedure:

1) Clean the object to be measured. Place sliding jaw against upper step of object, Open the caliper slightly. Place the sliding jaw against the upper step of the object you are measuring. Make sure that the head of the caliper is perpendicular to the edge of the upper step. In above figure Main scale contains Imperial scale(in Inch.) & metric scale(in mm) respectively. While the sliding scale is the vernier scale.
2) Open caliper jaws, Open the jaws of the caliper using the thumb screw until both jaws (external o r internal) firmly captures the object.

3) Turn lock screw, Turn the lock screw to tighten the jaws so that you can remove your object and take your reading.
4) Read measured value





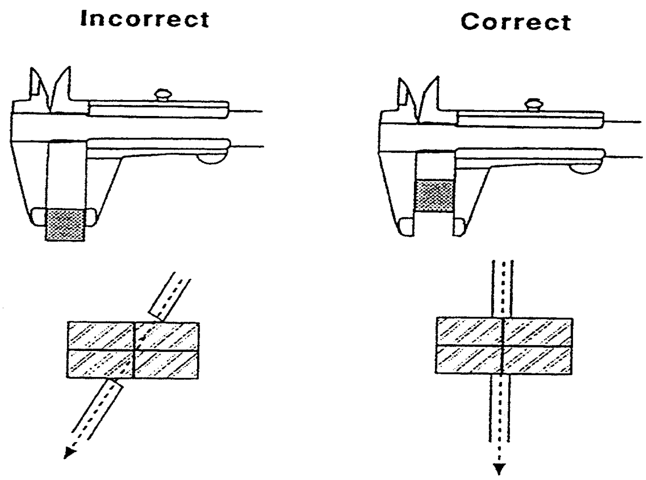


Figure 1.2 correct techniques while using VC

OBSERVATION TABLE 1.1 FOR VERNIER CALIPER

Sr. No.	Object Name	Range of Instrument	MSR	VSR	LC	TSR
1						
2						
3						
4						
5						

- **How to use Vernier Height Gauge?**

This also uses the same principle of vernier caliper and is used especially for the measurement of height. It is equipped with a special base block, sliding jaw assembly and a removable clamp. The upper and lower surfaces of the measuring jaws are parallel to the base, which make possible to measure both over and under surfaces. A scribing attachment in place of measuring jaw can be used for scribing lines at certain distance above the surface. Specification of a vernier height gauge is made by specifying the range of measurement, type of scale required and any particular requirement in regard to the type of vernier desired. For all these measurement, use of surface plate as datum surface is very essential.

Precautions: The height gauges are generally kept in their cases when not in use. Every care should be taken, particularly in case of long height gauges, to avoid its heating by warmth from the hands. The springing of the measuring jaw should be always avoided.

Vernier height gauges

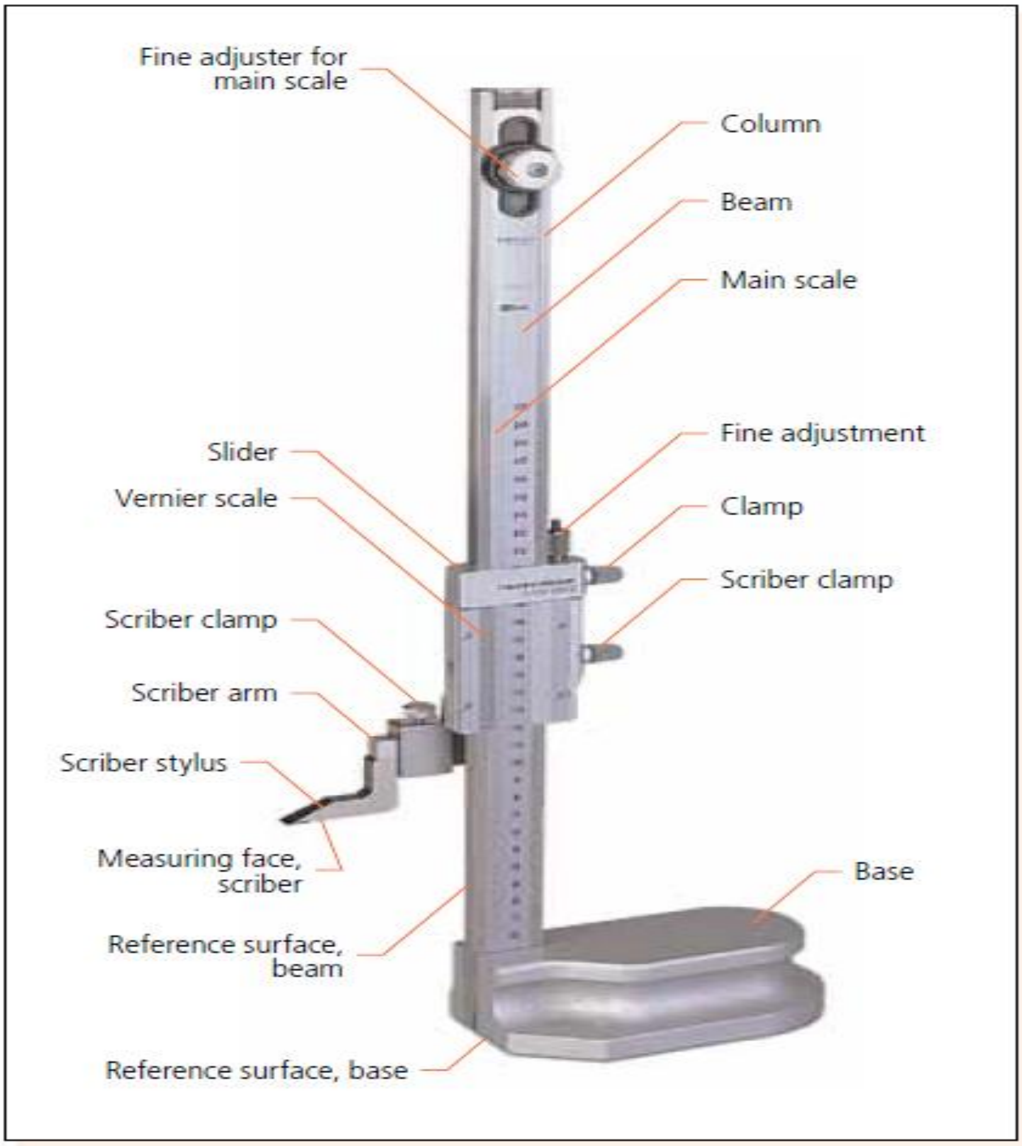


Figure 1.3 Vernier Height Gauge

PROCEDURE-

1. Take the material (sample) for which the value must be measured.
2. Check the vernier and main scale must coincide at 0
3. After checking the 0 mark put the sample piece and slowly leaves the measuring jaw over the piece.
4. Tight the screw and measure the main scale also vernier scale readi.g
5. The line coincide with the main scale that the VSR 6. By adding MSR with VSR*L.

OBSERVATION TABLE 1.2 FOR VERNIER HEIGHT GAUGE

Sr. No.	Object Name	Range of Instrument	MSR	VSR	LC	TSR
1						
2						
3						
4						
5						

- **How to use Micrometer?**
- **<u>Principle of the screw guage or Micrometer:</u>**

The screw gauge works on the principle of screw. When a screw is rotated in a nut, it exhibits both linear and rotational motions. When a screw is moved in a fixed nut, the linear distance travelled by the screw on the main scale when the circular is given one complete rotation is called Pitch of the screw.
Least count of the screw guage
Least count (L.C) = Pitch of the screw / Total number of divisions on the circular scale
Generally , the pitch of the screw guage is 1 mm and it has 100 divisions on its circular scale . Hence ,
L.C. = 1 mm / 100 = 0.01 mm or 0.001 cm

The micrometer is a precision measuring instrument, used by engineers. Each revolution of the rachet moves the spindle face 0.5mm towards the anvil face. The object to be measured is placed between the anvil face and the spindle face. The rachet is turned clockwise until the object is 'trapped' between these two surfaces and the rachet makes a 'clicking' noise. This means that the rachet cannot be tightened any more and the measurement can be read.

Using the first example seen below:

1. Read the scale on the sleeve. The example clearly shows12 mm divisions.
2. Still reading the scale on the sleeve, a further ½ mm (0.5) measurement can be seen on the bottom half of the scale. The measurement now reads 12.5mm.
3. Finally, the thimble scale shows 16 full divisions (these are hundredths of a mm).

The final measurement is 12.5mm + 0.16mm = 12.66

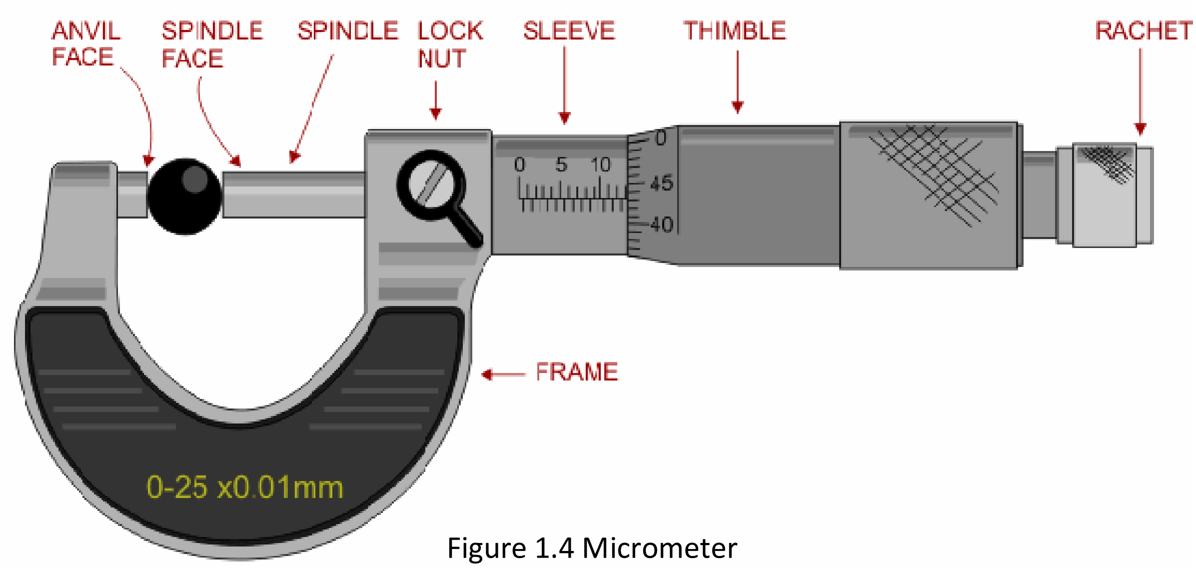


Figure 1.4 Micrometer

OBSERVATION TABLE 1.3 FOR MICROMETER

Sr. No.	Object Name	Range of Instrument	MSR	VSR	LC	TSR
1						
2						
3						
4						
5						

- **How to use Depth gauge Micrometer?**

The depth gauge micrometer is a precision measuring instrument, used by engineers to measure depths. Each revolution of the rachet moves the spindle face 0.5mm towards the bottom of the blind hole. The diagram below shows how the depth gauge is used. The ratchet is turned clockwise until the spindle face touches the bottom of the blind hole. The scales are read in exactly the same way as the scales of a normal micrometer.
A depth micrometer is used to measure the depth of holes, slots, counterbores, recesses, and the distance from a surface to some recessed part. This type of micrometer is read exactly opposite to the method used to read an outside micrometer. The zero is located toward the closed end of the thimble. The measurement is read in reverse and increases in depth amount as the thimble moves toward the base of the instrument.

The micrometer depth gage consists of a flat base attached to the barrel (sleeve) of a micrometer head. It has a range of 0 to 6 inches, depending on the length of the extension rod used. The hollow micrometer screw (the threads on which the thimble rotates) has a range of 1 inch. The flat base is 4 inches and six extension rods are supplied with this gage.

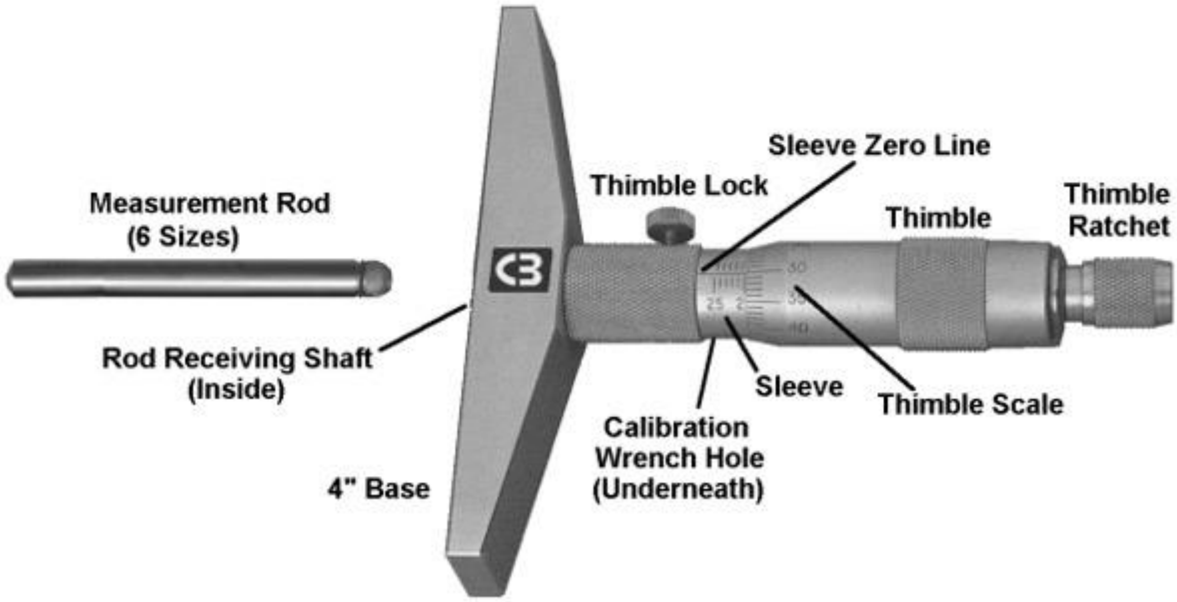


Figure 1.5 Depth gauge Micrometer

OBSERVATION TABLE 1.4 FOR DEPTH GAUGE MICROMETER

Sr. No.	Object Name	Range of Instrument	MSR	VSR	LC	TSR
1						
2						
3						
4						
5						

PART 2 ANGULAR MEASUREMENTS

- **How to use Bevel Protector?**

It is use for measuring & lying out of angles accurately and precisely within 5 minutes. It is a simplest instrument for measuring the angle between two faces of a component. It consists of a base plate attached to a main body and an adjustable blade which is attached to a circular plate containing vernier scale. The protector dial is slotted to hold a blade which can be rotated with dial to the required angle and also independently adjusted to any desired length. The blade can be locked in any position. The adjustable blade along with the circular plate containing the vernier can rotate freely about the center of the main scale engraved on the body of the instrument and can be locked in any position with the help of a clamping knob.

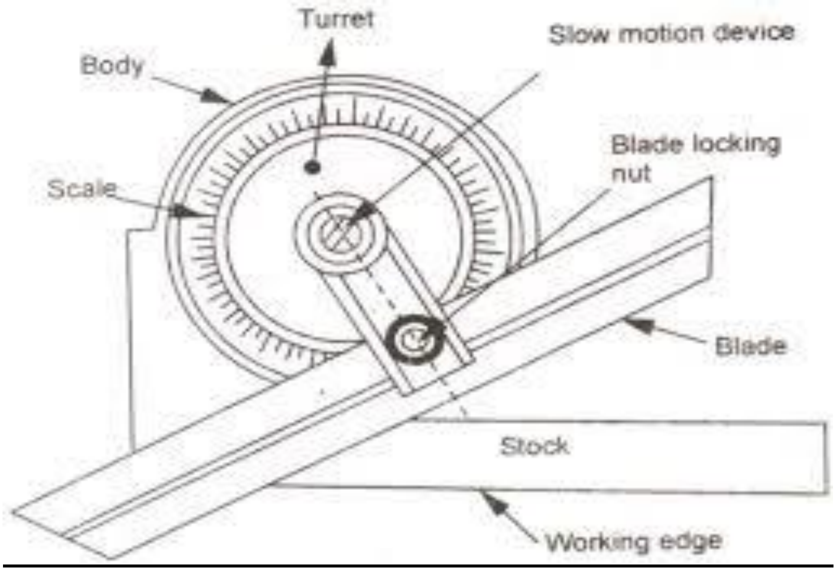


Figure 1.6 Bevel Protector

OBSERVATION TABLE 1.5 FOR BEVEL PROTECTOR

Sr. No.	MSR	VSR	LC	TSR
1				
2				
3				
4				
5				

- **How to use Sine Bar?**

The sine principle uses the ratio of the length of two sides of a right triangle in deriving a given angle. It may be noted that devices operating on sine principal are capable of self generation. The measurement is usually limited to 45 degree from loss of accuracy point of view. The accuracy with which the sine principle can be put to use is dependent in practice, on some from linear measurement. The sine bar itself is not complete measuring instrument. Another datum such as surface plate is needed, as well as other auxiliary instrument, notably slip gauge, and indicating device to make measurements. Accuracy up to 10 millionth of an inch for flatness and parallelism can be obtained in slip gauges.

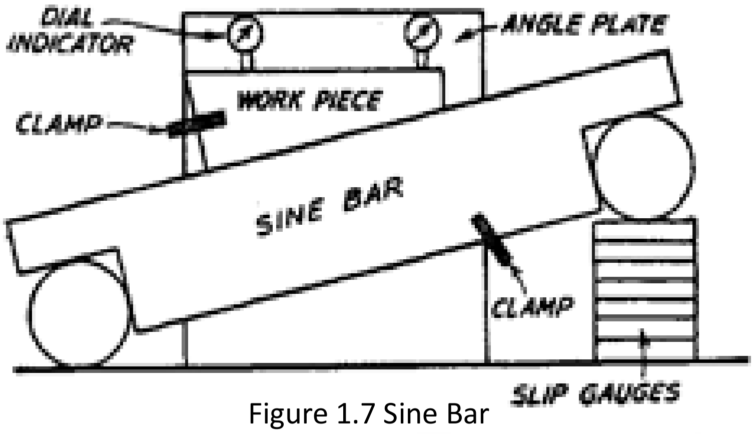


Figure 1.7 Sine Bar

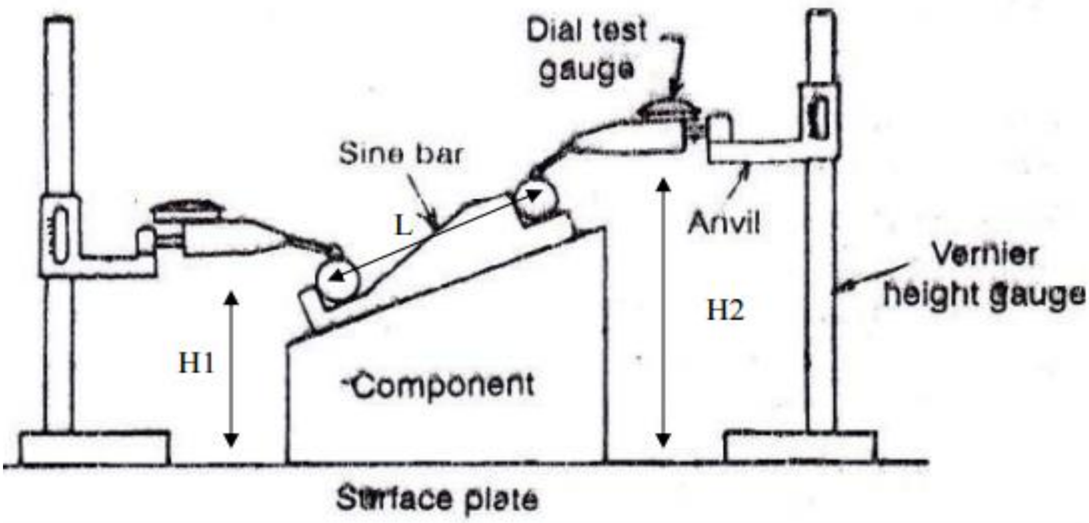


Figure 1.8 Sine Bar Sample for practical Set Up.

Reading & Result:-

A] h= , L=

B] h1= , h2= , L= ,

Calculations:-

A] Sin θ = h/L

θ = Sin-1 (h/L)

θ =

B] Sin θ = h1-h2 / L

θ = Sin-1 (h1-h2 / L) θ =

- **How to use clinometers?**

Clinometer is a special case of the application of spirit level in clinometers; the spirit level is mounted on a rotary member carried in housing. One face of the housing forms the base of the instrument. On the housing, there is a circular scale. The angle of inclination of the rotary member carrying the level relative to its base can be measured by this circular scale. The clinometers are mainly used to determine the included angle of two adjacent faces of work piece. Thus for these purpose, the instrument base is placed on one face and the rotary body adjusted till zero reading of the bubble is obtained. The angle of rotation is then noted on the circular scale against the index. A second reading is then taken in the similar manner on the second face of work piece. The included angle between the faces is then the difference between the two readings.

:Exercise:

1) What is least count? Explain the same for vernier callipers and micrometer.
2) Write down types of vernier callipers and micrometers with their application.
3) Explain use of slip gauge & limit gauge, Slip gauge, dial indicator, Telescopic gauge.
4) Explain the procedure with diagrams for reading the vernier micromerter.
5) Explain vernier callipers construction-working-application and its calibration.
6) How angle is measure using angle dekkor and angle gauge.
7) Application & limitation of angle gauges.
8) Explain construction & working of a) sine bar b) sine centre c) vernier bevel protector d) optical bevel protector.
9) Explain parts of micrometer.
10) Explain least count of micrometer and use of micrometer.

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PRACTICAL-2: Calibration of Vernier Calliper and Micrometer.

OBJECTIVE:- To calibrate given Vernier callipers and micrometres.

INTRODUCTION:-

What is calibration?

Calibration is a comparison between a known measurement (the standard) and the measurement using your instrument.

Typically, the accuracy of the standard should be ten times the accuracy of the measuring device being tested. However, accuracy ratio of 3:1 is acceptable by most standards organizations.

Calibration of your measuring instruments has two objectives.

1. To checks the accuracy of the instrument and
2. To determines the traceability of the measurement.

In practice, calibration also includes repair of the device if it is out of calibration. A report is provided by the calibration expert, which shows the error in measurements with the measuring device before and after the calibration.

Why calibration is important?

The accuracy of all measuring devices degrade over time. This is typically caused by normal wear and tear. However, changes in accuracy can also be caused by electric or mechanical shock or a hazardous manufacturing environment (e.x., oils, metal chips etc.). Depending on the type of the instrument and the environment in which it is being used, it may degrade very quickly or over a long period of time. The bottom line is that, calibration improves the accuracy of the measuring device. Accurate measuring devices improve product quality. To explain how calibration is performed we can use an external micrometer as an example. Here, accuracy of the scale is the main parameter for calibration. In addition, these instruments are also calibrated for zero error in the fully closed position and flatness and parallelism of the measuring surfaces. For the calibration of the scale, a calibrated slip gauge is used. A calibrated optical flat is used to check the flatness and parallelism.

Procedure for Vernier calliper:

Step 1: Measure the ambient temperature and record it. If the temperature is <18 Cº or >24 Cº, and set a temp. ± 21 Cº.

Step 2: Inspect the inside and Outside Jaws and Depth blade for smooth movement.

Step 3: Using gauge blocks, measure and record 3 different lengths in three different position of the digital Vernier caliper of respective jaws.

Step 4: Use a calibrated vernier caliper to measure gauge blocks of appropriate length, lock vernier at that length then measure between jaws distance of the instrument and record the data.

Procedure of performing experiment:

Step 1: Clean the fixed vice and micrometer.

Step 2: Clamp the micrometer in vice putting cushioning material between micrometer and jaws of vice to protect the micrometer from probable damage due to clamping force.

Step 3: Make pile of gauge blocks and insert between two anvils of the micrometer and take reading.

Step 4: Increase the value of gauge blocks pile and take next few readings.

Step 5: Then decrease the value of gauge blocks pile and take same readings in decreasing order.

Step 6: Tabulate the readings.

Step 7: After cleaning the place the gauge blocks should be placed in their respective places.

OBSERVATION TABLE 2.1 FOR CALIBRATION OF INSTRUMENT

Name of the instruments	Sl.No.	Slip Gauge in Combination Reading (Standard Input) mm	Observed Reading(Output)				Error /Bias (mm)
			Reading 1 (mm) Increasing Trend	Reading II (mm) Decreasing Trend	Reading III (mm) Extra	Arithmetic mean (mm).	
Vernier Calliper	1.						
	2.						
	3.						
MIcrometer	1.						
	2.						
	3.						

Conclusion:

:Exercise:

1. Plot calibration graph of (i) Standard Input (slip gauge reading) vs. Output (observed reading) and (ii) Standard Input vs. Error
2. What do you mean by primary and secondary standard of measurement? Explain with example.
3. What is calibration? When & Why it is required?
4. Explain the terms accuracy & precision of an instrument. How they are measured?

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PRACTICAL-3: Temperature measurement using Thermocouple.

OBJECTIVE:- To calibrate given Thermocouple.

INTRODUCTION:-

Thermocouple, a transducer based on see beck effect is the most common and widely used single device for temp. Measurement in industrial application, for the range 0 degree to 4000 degree F. Thermocouple is a self generating transducer and is basically a pair of dissimilar metallic conductors, joined so as to produce an e.m.f. depending upon magnitude of temp. difference and materials of conductors. Combinations used for base metal thermocouple are copper constantan (-30 to 800F) , iron constantan (-300F to 1580F) Chromel – Alumel etc.

Thermocouples are low in cost, reliable in service, are easily used, cover wide range of temp. Measurement have very good time response characteristics (because of low thermal mass), but they are not perfectly linear over entire range and require cold junction compensation if ice-bath is to be avoided.

PRECAUTIONS:-

1. While connecting the thermocouple to the input , observe the correct polarity.
2. A broken or unconnected thermocouple will give out of scale indications.
3. Please ensure that the thermocouple tip does not touch the heater element directly.
4. Proper earthling of the heater may be ensured. Proper stirring of hot water must be carried out

PROCEDURE:-

1) Connect the thermocouple supplied to you at the input terminal. For Chromel – Alumel thermocouple, Chromel must be connected to +ve input terminal and Alumel must be connected to –ve input terminal. If copper constantan thermocouple is used, copper wire must be connected to +ve input terminal (Red) and constantan wire must be connected to -ve terminal (Black). If iron constantan thermocouple is used, then iron wire must be connected to +ve terminal. The thermocouple is provided with RED or BLACK marking. The supplied set up is using 40milivolts excitation for cold junction compensation bridge suitable for Chromel – Alumel thermocouple.
2) Potentiometer marked "MAX" must be turned fully anticlockwise.
3) Ensure that water heater is ready and the container contains sufficient amount of water. Now switch on the heater supply.
4) Prepare a mixture of melting ice and keep the mixture stirring regularly. Immerse the thermocouple in the ice bath and adjust the pot. Marked "MIN" on the panel to

get zero on the DPM. in case ice bath is not available, then you may use ordinary tap water also and minimum temperature can be adjusted equal to that of the tap water as indicated by mercury in glass thermometer.

5) When the water starts boiling, the potentiometer marked "MAX" is adjusted to get an indication of the boiling point temp (which is measured with the help of mercury in glass type thermometer). Repeat steps 4 and 5 until you get satisfactory indication at 0 degree or ambient temperature of tap water and at boiling point.

6) Turn off the heater so that water starts cooling down. Note the indicated reading on the DPM and the thermometer reading. Enter the observations in Table given below and then plot the graph of thermometer reading on X axis and thermocouple reading on Y axis choosing proper scales.

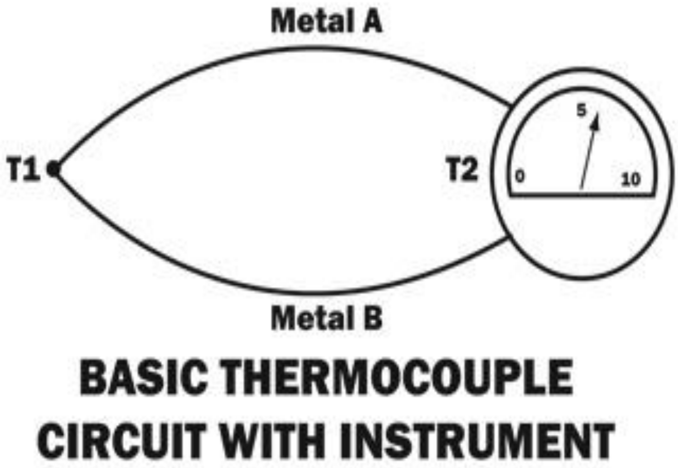

Figure 3.1 Thermocouple Schematic diagram

OBSERVATION TABLE 3.1:-

Sr. No.	Thermometer Reading ºC	DPM Reading ºC	Error
1			
2			
3			
4			
5			
6			
7			
8			

CONCLUSION:-

:Exercise:

1) How thermocouple works? Explain its principle with sketch.
2) What are the types of thermocouple? What do I need to consider when selecting the thermocouple type?
3) What is response time?

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PRACTICAL-4: To calibrate given Resistance Temperature Detector (RTD).

OBJECTIVE:- To calibrate given Resistance Temperature Detector (RTD).

INTRODUCTION:-
The principle of operation of resistance temperature detector (RTD) is based on the fact that the electrical resistance of many metals increases almost directly with temp and is reproducible to high degree of accuracy. The term used to express this characteristic is well known coefficient of resistance and is defined by the appropriate formula.

$R_t = R_o (1+\alpha * t)$ where

α is temp coefficient of resistance for the metal used R_o is resistance of the element at 0 degree Celsius and t is temperature of the element in degree Celsius.
Platinum, Nickel and Copper are generally used as basic materials for RTD.

We may note the following as regards the RTD as transducer for temp. measurement.
The resistance of RTD increases as the temp increases. The resistance and temp are linearly related over a wide temp. range.
In general resistance thermometers are larger and less convenient to apply than the thermocouple. They are massive and hence exhibit poor time response characteristics.
They require bridge balance circuitry and have rather restricted upper temp. range. They exhibit higher accuracy and reliability than thermocouples.

RTD Materials:-

Different materials used in the construction of RTDs offer a different relationship between resistance and temperature. Temperature sensitive materials used in the construction of RTDsinclude platinum, nickel, and copper; platinum being the most commonly used. Important characteristics of an RTD include the temperature coefficient of resistance (TCR), the nominal resistance at 0 degrees Celsius, and the tolerance classes. The TCR determines the relationship between the resistance and the temperature. There are no limits to the TCR that is achievable, but the most common industry standard is the platinum 3850 ppm/K. This means that the resistance of the sensor will increase 0.385 ohms per one degree Celsius increase in temperature. The nominal resistance of the sensor is the resistance that the sensor will have at 0 degrees Celsius. Although almost any value can be achieved for nominal resistance, the most common is the platinum 100 ohm (pt100). Finally, the tolerance class determines the accuracy of the sensor, usually specified at the nominal point of 0 degrees Celsius. There are different industry standards that have been set for accuracy including the ASTM and the European DIN. Using the values of TCR, nominal resistance, and tolerance, the functional characteristics of the sensor are defined.

RTD Configurations:-

In addition to different materials, RTDs are also offered in two major configurations: wire wound and thin film. Wire wound configurations feature either an inner coil RTD or an outer wound RTD. An inner coil construction consists of a resistive coil running through a hole in a ceramic insulator, whereas the outer wound construction involves the winding of the resistive material around a ceramic or glass cylinder, which is then insulated.

The thin film RTD construction features a thin layer of resistive material deposited onto a ceramic substrate through a process called deposition. A resistive meander is then etched onto the sensor, and laser trimming is used to achieve the appropriate nominal values of the sensor. The resistive material is then protected with a thin layer of glass, and lead wires are welded to pads on the sensor and covered with a glass dollop.

Thin film RTDs have advantages over the wire wound configurations. The main advantages include that they are less expensive, are more rugged and vibration resistant, and have smaller dimensions that lead to better response times and packaging capabilities. For a long time wire wound sensors featured much better accuracy. Thanks to recent developments, however, there is now thin film technology capable of achieving the same level of accuracy.

PRECAUTION:-

1) As RTD is having rather large time constant, allow sufficient time for RTD for cooling down.
2) Please handle RTD very carefully as it is very costly.

PROCEDURE:-

1) Connect RTD across the terminals marked "INPUT" Note that polarity is immaterial.
2) Connect terminals marked "OUTPUT" to DPM input terminals.
3) Immerse sensor in ice bath & check that value of RTD resistance at 0˚C & set DPM as zero by rotating 'Minimum' pot.
4) Immerse sensor in boiling water & check that value of RTD resistance at 100˚C & set DPM as 100 by rotating 'Maximum' pot.
5) Enter the readings in observation table for some other unknown temperatures.
6) Plot the graph of RTD resistance vs. Temp.

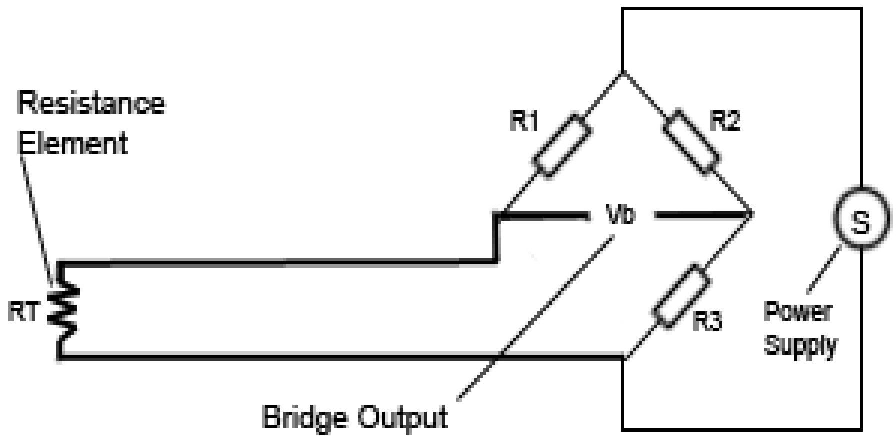

Figure 4.1 Schematic Diagram of
RTD

OBSERVATION TABLE 4.1:-

Sr. No.	Thermometer reading ˚C	RTD indication on DPM ˚C	Resistance of RTD Ω

CONCLUSION:-

:Exercise:

1) Which type of temperature sensor is more accurate—a thermocouple or an RTD?
2) What is the difference between thermocouples and RTD.
3) What are the advantages of RTD over thermocouple?
4) Explain working of RTD.

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PRACTICAL-5: calibration of L.V.D.T.

OBJECTIVE:-To calibrate a L.V.D.T. for displacement measurement.

INTRODUCTION:-

One of the most useful variable inductance transducers is the differential transformer, which provides an A.C. voltage output proportional to the displacement of core passing through the windings. It is a mutual inductance device making use of three coils arranged generally on a single

cylindrical concentric non magnetic form. The center coil is energized from an external power source and the two coils connected in series oppositions to each other, are used as pick up coils. Output amplitude and phase depend on the relative coupling between the two pick up coils and the power coil. Relative coupling in them is dependant on the position of the core. Theoretically there should be core position for which the voltage induced in each of the pick up coil or secondaries will of the same magnitude and the resulting output should be zero.

Within limits on the either side of the position (Null) core displacement results in a proportional output. While the output voltage magnitudes are ideally the same for equal core displacement results on either side of null balance, but phase relation existing between power source and output changes 180 degrees through null. It is therefore possible through phase sensitive detector to distinguish between outputs resulting from displacements on each side of null.

L.V.D.T. is a very widely used transducer for conversion of mechanical displacement into proportional electrical voltage. The displacement into proportional electrical voltage range extends for new microns to few tens of inches. It is free from temp. effects.

Principles of operation: When the primary coil is excited with a sine wave voltage (Vin), this voltage produces a current in the LVDT primary windings, function of the input impedance. In turn, this variable current generates a variable magnetic flux which, channeled by the high-permeability ferromagnetic core, induces the secondary sine wave voltages Va and Vb. While the secondary windings are designed so that the amplitude of the differential output voltage (Va-Vb) is proportional to the core position, the phase of (VaVb) with reference to the excitation, called Phase Shift (close to 0 or 180 degrees) determines the direction away from the zero position. The zero, called Null Position, is defined as the core position where the phase shift of the (Va-Vb) differential output is 90 degrees.

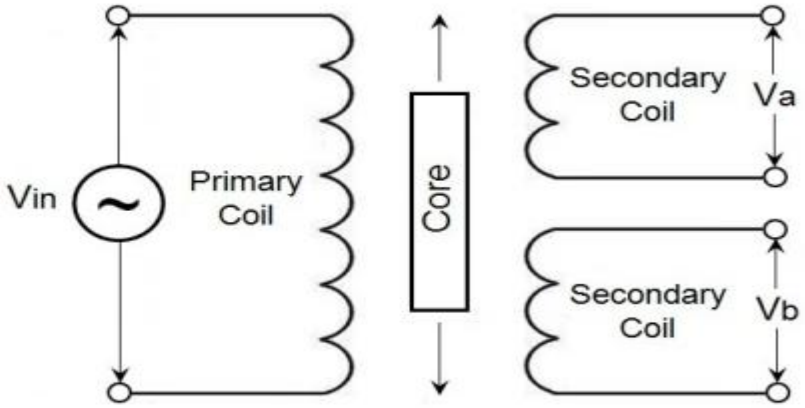

Figure 5.1 Schematic Diagram of L.V.D.T.

The differential output between the two secondary outputs (Va-Vb) when the core is at null position is called the Null Voltage; as the phase shift at null position is 90 degrees, the null voltage is a "quadrature" voltage. This residual voltage is low. It is due to the complex nature of the LVDT electrical model, which includes the parasitic capacitances of the windings. This complexity also explains why the phase shift of (Va-Vb) is not exactly 0 or 180 degrees when the core is away from the null position. The phase shift is very important as most signal conditioning electronics employ synchronous demodulation to provide a DC output that is proportional to the following transfer function: RMS voltage (Va-Vb) multiplied by the cosine of phase shift. This is the best way to provide an accurate and linear (especially around the null) position signal in a measuring system using an LVDT. It is also the method that allows the minimum numbers of electrical connections to the LVDT, as only 4 are needed (2 for the excitation and 2 for the differential output; the secondary windings being connected in series opposing at the LVDT). One drawback of this technique is that the phase shift has to be low enough to avoid affecting the noise level in the demodulator, and to prevent a too large signal drop (due to the cosine in the transfer function). To avoid these adverse effects, MEAS offers instrumentation that includes phase compensation electronic circuitry to bring the phase shift back to zero (or 180 degrees). In some cases it is beneficial to use the secondary sum, (Va+Vb) as the reference for the phase shift of (Va-Vb). However, one must ensure that the LVDT is designed with windings that provide a fairly constant sum along the stroke to be measured. The advantage of this method is that the phase shift between the differential and the sum is very low and therefore there is no need to adjust it. However, only 5 or 6 wire LVDTs must be used

PRECAUTIONS:-

1) While connecting lead wire from panel to transducer, make proper connections. Avoid shorting of the excitation source terminals.
2) Move the core with a gentle fashion.

PROCEDURE:-

1) Connect the terminals marked ‘PRIMARY’, on the front panel of the instrument to the terminals marked ‘PRIMARY’, on the transducer itself, with the help of the flexible wires provided.
2) Identically establish connection from terminals “SECONDARY”.
3) Keep pot marked “MAX” in most anticlockwise position.
4) The magnetic core may be displaced and the pointer may be brought to zero position. If the DPM is not indicating zero use potentiometer marked “MIN”, to get a zero on DPM at zero mechanical position. If the core is displaced in both directions, the meter must show indications with appropriate polarity. Now displace the core to 19mm position in one of the directions. Adjust the ‘MAX’, pot to get an indication of 19.00 on the DPM under these conditions. Now the set up is ready for experimentation. You may again check for zero position also.
5) Now the core can be displaced by a known amount in the range +19 and –19mm and the meter readings can be entered in the table given below. It may be noted that by interchanging the secondary terminals or the primary terminals the polarity of the meter indication can be reserved for a given direction of input displacement.
6) Plot the graph of input displacement and the output indications on the X and Y axis respectively.

OBSERVATION TABLE 5.1:-

Sr. No.	**Input Displacement (mm)**	**Output Indication (mm)**
1		
2		
3		
4		
5		
6		
7		
8		
9		

CONCLUSION:-

:Exercise:

1) Explain with suitable waveforms, working of LVDT.
2) Explain how LVDT can be used with DC supply to measure displacement.
3) Explain the concept of Residual voltage and its effect on measurement.
4) What are the limitations of LVDT
5) What Phase sensitive detector (PSD) is necessary of at the output side of LVDT?

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PRACTICAL-6: Calibration of Bourdon Tube pressure gauge

OBJECTIVE:-

To Calibrate given Bourdon Tube pressure gauge.

INTRODUCTION:-

Bourdon Tubes are known for its very high range of differential **pressure measurement** in the range of almost 100,000 psi (700 MPa). It is an elastic type pressure transducer.The device was invented by Eugene Bourdon in the year 1849. The basic idea behind the device is that, cross-sectional tubing when deformed in any way will tend to regain its circular form under the action of pressure. The bourdon pressure gauges used today have a slight elliptical cross-section and the tube is generally bent into a C-shape or arc length of about 27 degrees. The detailed diagram of the bourdon tube is shown below.

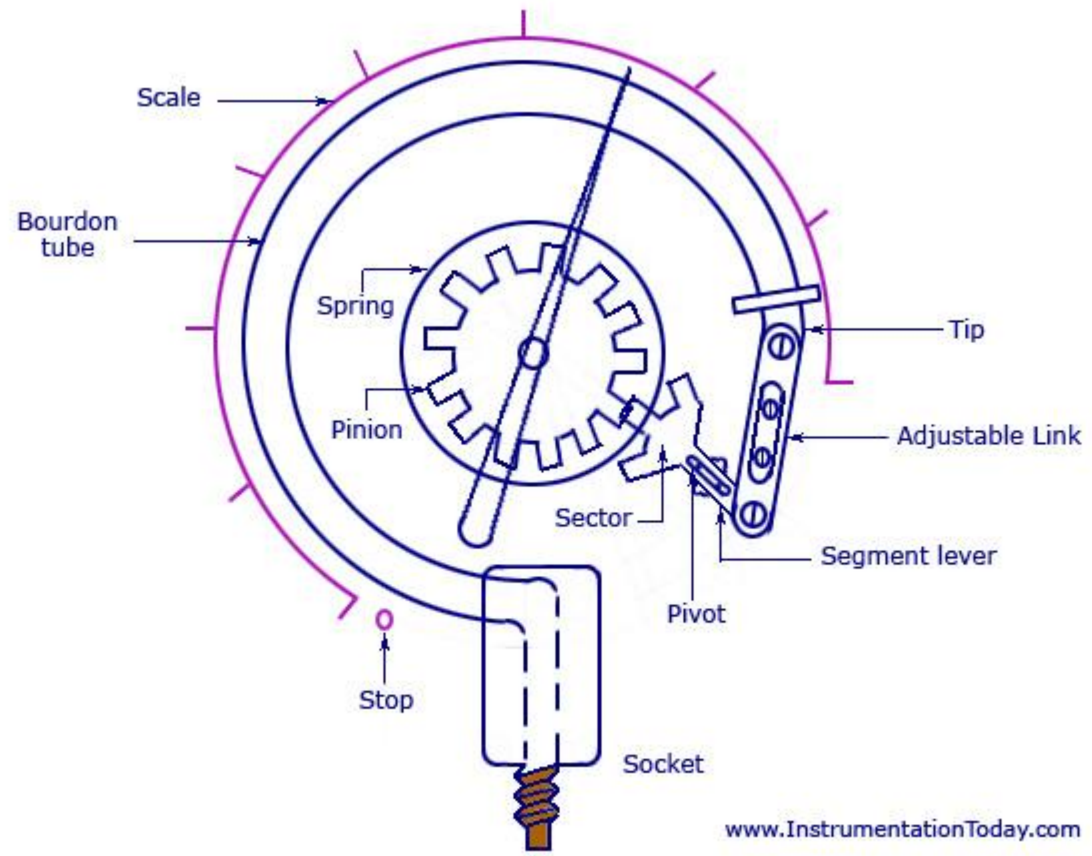

Figure 6.1 Bourdon Tube Pressure Gauge

As seen in the figure, the pressure input is given to a socket which is soldered to the tube at the base. The other end or free end of the device is sealed by a tip. This tip is connected to a segmental lever through an adjustable length link. The lever length may also be adjustable. The segmental lever is suitably pivoted and the spindle holds the pointer as shown in the figure. A hair spring is sometimes used to fasten the spindle of the frame of the instrument to provide necessary tension for proper meshing of the gear teeth and thereby freeing the system from the backlash. Any error due to friction in the spindle bearings is known as lost motion. The mechanical construction has to be highly accurate in the case of a Bourdon Tube Gauge. If we consider a cross-section of the tube, its outer edge will have a larger surface than the inner portion. The tube walls will have a thickness between 0.01 and 0.05 inches.

The dead-weight tester is a device used for balancing a fluid pressure with a known weight. It acts as a source of static pressure. Typically, it is a device, which is used for static calibration of pressure gauges. It can also be employed for measurement of pressure. Here we will use it as a calibration device. It consists of following parts.

Needle Valves:-
There are two needle valves. One at right and at left side. Oil cup is fitted on the top of one of the valves. Pressure gauge to be tested, can be fitted to the other valve by means of adapters. Different types of adapters have been provided to fix the gauges with 3/8" , ½" BSP threading. Both the valves are connected by means of metallic adapters to the main block.

Main Block:-
Besides the above adapters main block houses floating plunger and screw pump assembly.

Screw Pump:-
Screw pump consists of main cylinder, screw and nut support. Rotation of the handle causes the screw to move into the cylinder. By operating the pump and valve, sufficient quantity of oil can be taken in. screw pump also develops sufficient pressure to lift the floating plunger.

Floating Plunger:-
Fluid pressure developed by screw pump acts on the bottom of the plunger and the pushes the plunger up along with the weight-carrier and weights. Effect of friction is eliminated by rotating the plunger along with weights.

Set of Weights:-
Each weight is marked in terms of the pressure equivalent of its weights.

PRECAUTION:-
Floating plunger is most important part of the tester and must be limited to its travel length. If the handle is rotated continuously, the floating plunger may get damaged and locked. Hence care should be taken to limit the displacement of plunger to above value.

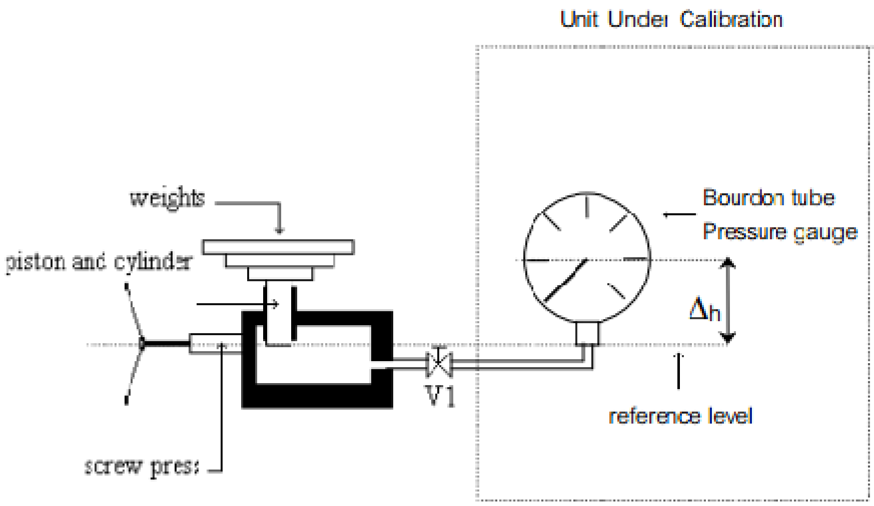

Figure 6.2 Schematic Diagram for practical set up of bourdon tube gauge.

PROCEDURE:-

It is essential that floating plunger is vertical during operation. This could be accomplished by leveling the top face of the weight carrier.

OIL FILLING:-

1) Fix the oil to one of the valves. In fig. No. 1 it is fitted to the right side valve.
2) Open this valve and close the other valve.
3) Fill clean HYDRAULIC MINERAL OIL to nearly top of the oil cup. SAE NO. 20 or 30 are suitable. It is necessary that oil is clean.
4) Turn the screw pump handle clockwise. This will expel some air from the system which will bubble out in the oil cup.
5) Turn the pump handle anticlockwise. Oil will be sucked into the instrument.
6) Repeat this clockwise and anticlockwise turning, until no air bubble appears in the oil cup.
7) Open the other valve and rotate the screw pump handle for oil to come out of this valve.
8) Close this valve and draw more oil in the instrument.

PRESSURE GAUGE TESTER:-

1) Ensure that air has been expelled from the system as per the oil filling procedure given above.
2) Place a spirit level on top of the weight carrier and adjust level by means of the leveling screws in the standard way. The tester is now ready for use.
3) Installation pressure gauge to be tested as shown in the illustration. Use an adapter if necessary.
4) Open valve under the pressure gauge (i.e. left valve) and close valve under the oil cup (i.e. right valve).
5) Place a weight on the weight-carrier and slowly turn the screw pump clockwise. This increases the pressure in the system which will be shown on the pressure gauge.

6) Rotate the weight to reduce the effect of the friction in the free piston. Keep turning the handle until the weight carrier and weights rise by about 3 to 4mm. If the weight-carrier is lifted beyond the above limit, the piston is exposed and may suffer damage.
7) Take reading of the pressure gauge while the weights are rotating. Write it down against the value of pressure which is the sum of pressure markings on the weights and weight-carrier.
8) Progressively add weights and take reading as above.
9) When the maximum reading has been taken reduce the pressure by turning the handle anticlockwise and reducing the weights progressively.
10) Consider the average of the value for increasing and decreasing pressures.
11) In case two pressure gauge are desired to be tested simultaneously, the oil cup may be removed and second gauge installed, on the other valve.
12) The valve under the gauge should also be opened.
13) NOTE:- Care should be taken while operating the instrument that the weight carrier dose not rise too much as otherwise the free piston may be damaged.

CLOSING UP:-

1) After the work is over, turn screw pump handle anticlockwise so that-
2) There is no pressure in the system and
3) Maximum oil is drawn in. Reinstall the oil cup if it had been removed and open the valve under it. This will ensure that (a) there is no residual pressure in the system and (b) prevent pressure build-up by accidental turning of the screw pump handle.
4) Place dust cover on the instrument and stack weights properly.

OBSERVATION TABLE 6.1:-

Sr.No.	**Pressure Applied (kgf/cm^2) p_a**	**Pressure Indicated (kgf/cm^2) p_i**	**Error (kgf/cm^2) $E_p = p_i - p_a$**
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

GRAPH:-

Applied Pressure vs. Indicated Pressure.

CONCLUSION:-

:Exercise:

1) What is Bourdon Pressure gauge?
2) How does Bourdon pressure gauge work? Explain with necessary diagram.
3) What are the advantages and disadvantages of using Bourdon pressure gauge?

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PRACTICAL-7: Calibration of Torque Sensor.

OBJECTIVE:-

To calibrate a Torque Sensor.

INTRODUCTION:-

When a bar supported at end is subjected to torque, by applying load to the end lever. The strain gauges fixed on bar at 45˚ to the axis of shaft or bar, they are subjected to torsional shear strain. A wheat stone bridge balance circuit formed by gauges helps us to determine the shear strain.

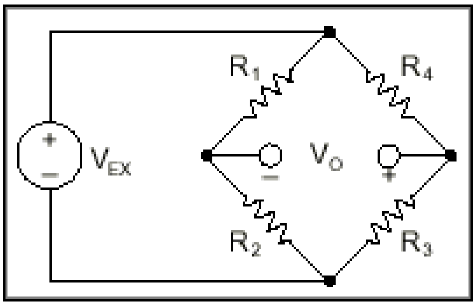

Figure 7.1 Wheat Stone Bridge Schematic Diagram

Fig. (7.1) shows the wheat stone bridge schematic regards to practical set-up. The equipment consists of a test set-up and S.G. bridge balance unit & indicator. The set-up consist of a bar fixed at one end & a lever attached at the other end to apply torsion.
The loading arm carries a weight pan on the other side. Weight are placed on the pan to apply torque to the sensing unit.

The bar carries 4 carry wire resistance strain gauges. The gauges form a bridge.
The S.G. Indicator is connected to the bridge of gauges. The meter on the S.G. Indicator indicates torque in Kg. M.

PRECAUTION:-

1) Do not put load on the pan unless the S.G. Indicator is balanced.
2) Put the load on the pan without any jerk.
3) After the experiment is over remove load and put off the S.G. Indicator.

PROCEDURE:-

Connect the unit to the S.G. Indicator by cable. Attach pan to the arm. Now switch on the S.G. Indicator and wait for 5-10 minutes. Now achieve balance on the S.G. Indicator by the coarse and fine balancing pot. Wait for 2-3 minutes & confirm that balance is not disturbed. Put the load 1 Kg. in the pan. The meter on strain gauge indicator will indicate torque in Kg. M. Add some more load on the pan and note the meter reading. Take 4-5 minutes and complete the observation table.

Plot the graph Ta (Kg.m) vs. Ti (Kg.m).

OBSERVATION TABLE 7.1:-

L = length of lever = -------m

Sr. No.	Applied Wt., w	Torque Kg.m Ta = w x l	Torque on S.G. Indicator Kg.m. Ti

CONCLUSION:-

:Exercise:

1) Define application of torque sensor.
2) Principle of torque Sensor.

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PRACTICAL-8: Measurement of Speed & Calibration.

OBJECTIVE:-

To measure the Speed & Speed Sensor Calibration

(i) Photoelectric Sensors.

(ii) Magnetic Sensors.

(iii) Tachometer using Stroboscope.

(iv) Speed measurement by Contact type and non contact type tachometer.

INTRODUCTION:-

The measurement of RPM can be divided into three methods:

1) Mechanical-The revolutions in a mechanical sensor are analyzed electronically in the instrument (tachometer). Mechanical RPM meters utilize physical contact for purposes of measurement. They work on the concept that the centrifugal force on a rotating object is dependent on the speed of rotation.

2) Optical- In this method rotations are transmitted to the measuring device by an infrared beam originating from the instrument which is reflected by a reflective tape on the rotating shaft. The rotating shaft will have one reflective spot and the rate at which the IR beam is reflected back is used to determine the rotations per minute of the shaft.

3) Stroboscopic- In the stroboscopic effect, objects are viewed as stationary by the observer. if the frequency of the pulses from the instrument are synchronized with the RPM of the shaft. This method has clear advantages over the other two given that the mechanical method is limited to speeds in the range of 0-30,000 rpm. The optical method although superior, it is not always possible to have reflective tapes on a rotating object. With the stroboscopic method however, it is always possible the rotational speed of even very small objects.

Types of Tachometers

A.VARIABLE RELUCTANCE TACHOMETERS:-

The basic variable transducer is an electromagnetic sensor whose reluctance varies as the shaft rotates because of periodic changes in the air gap. Variation in reluctance causes variation in flux, which in turn causes induced e.m.f. in the output coil. The output voltage is fairly sinusoidal and the peak-to-peak value is proportional to shaft speed. (n rev/ min.)

In this set up a toothed wheel is mounted on the motor shaft. The No. of teeth of the gear is 20. The gear wheel is of ferromagnetic material. The pick up consists of a coil wound around a permanent magnet. The magnetic field surrounding the coil is distorted by the passing of a tooth causing a pulse of output voltage in the coil. The RMS value of the output voltage increases with reduction of clearance between rotor and pick up, with an increase in tooth size and with an increase in rotor speed. The frequency of the output pulses is dependent on No. of teeth and the rotor speed.

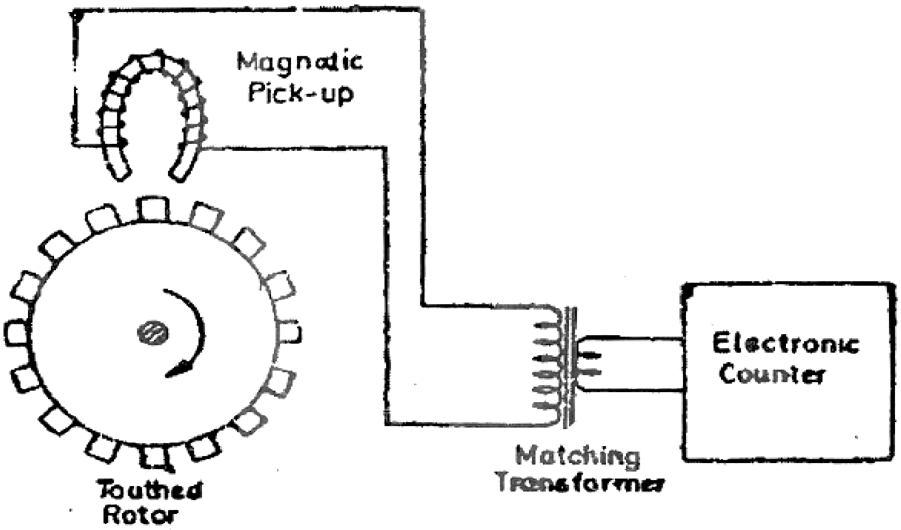

Figure 8.1 Toothed Rotor Tachometer.

B. PHOTOELECTRIC PICK UP:-

This is also one more method of speed measurement based on photoelectric effect. The set up is designed to produce pulses proportional to RPM of shaft using phototransistor as the sensing element. A disc with 20 holes is mounted on the motor shaft and when phototransistor and light source are properly aligned, every passage of hole across them produces a voltage pulse of high magnitude.

C. DIGITAL TACHOMETER:-

Tachometer is a device which indicates the speed of the element when contact between probe of instrument & the element is carried out. So, it is known as contacting type speed measurement device.

In digital tachometer it uses some frequency sensor (e.g. photoelectric or magnetic pick-up) and converts in to rpm for rotational speed & to mpm (meters per minute) for linear speed.

It is having a digital display which directly shows the rpm or mpm of the element in motion.

Applications

- Automobiles, airplanes, trucks, tractors, trains and light rail vehicles
- Laser instruments
- Medical applications
- Analog audio recording, a tachometer is a device that measures the speed of audiotape as it passes across the head
- Numerous types of machinery and prime movers

- To estimate traffic speed and volume.

D. DIGITAL STROBOSCOPE:-

It is a device used for measuring the speed of objects having repeating or reciprocating mechanisms. It can also be used to determine the frequency of vibrating bodies. It is based on the concept of making the object appear motionless the motion by adjusting the timing of a flashing light illuminating the object , relative to the timing of repeating motion. Stroboscope doesn't require any physical contact with the object for measurement. It directly indicates the speed in rpm. Stroboscopes play an important role in the study of stresses on machinery in motion, and in many other forms of research. Bright stroboscopes are able to overpower ambient lighting and make stop-motion effects apparent without the need for dark ambient operating conditions. They are also used as measuring instruments for determining cyclic speed.

PRECAUTIONS:-

1) Always start the motor with zero speed and operate the dimmer knob slowly.
2) Always connect the motor base to the motor earth.
3) As soon as the experiment is over disconnect the photoelectric and magnetic pick-ups.

PROCEDURE:-

1) Connect the calibration source to the input socket (marked 'Magnetic pick-up) by the cable provided and connect the output terminals to the digital panel meter observing polarity. Adjust the pot marked "MAX", to get 1500 on the meter (DPM) Now the set up is calibrated for 1500 RPM Neglect decimal point.
2) Now connect the photoelectric and magnetic pick ups in proper fashion.
3) Connect the motor terminal cable to the output terminals of D.C. supply. Ensure that the dimmer knob is in zero position. Now switch on the power supply for speed controller section and slowly go on changing the speed of the motor.
4) The motor speed in RPM will be indicated by the digital panel meter for each pick up.
5) If an external precision tachometer is available check the speed in RPM as indicated by meter (DPM) and the tachometer it-self.
6) Plot the input tachometer versus output reading. Find out percentage error from the graph.

OBSERVATION TABLE 8.1:-

Sr. No.	Speed indication (rpm)			
	Stroboscope (Actual speed)	Magnetic Pick up	Contact type Digital Tahometer	Non Contatc type Digital Tachometer.

GRAPH :- Actual speed (Na) vs Indicated speed (Ni).

CONCLUSION:-

:Exercise:

1) How does variable reluctance tachometer work?
2) Explain working of photoelectric pick up
3) Explain working of Stroboscope.
4) What is tachometer, list out its application?

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PRACTICAL-9: Calibration of Strain gauge.

OBJECTIVE: - To calibrate a Strain Gauge Sensor.

INTRODUCTION:-

Electrical resistance of a piece of wire is directly proportional to the length and inversely to the area of the cross section. Resistance strain gage is based on that phenomenon (see Sec.11.3 Resistance Strain Gauges, Text p.488-494 or similar reference). If a resistance strain gage is properly attached onto the surface of a structure which strain is to be measured, the strain gage wire/film will also elongate or contract with the structure, and as mentioned above, due to change in length and/or cross section, the resistance of the strain gage changes accordingly. This change of resistance is measured using a strain indicator (with the Wheatstone bridge circuitry), and the strain is displayed by properly converting the change in resistance to strain. Every strain gage, by design, has a sensitivity factor called the gage factor which correlates strain and resistance as follows:

Gage factor (F) = (D R / R)/ e

Where: R = Resistance of un-deformed strain gage
D R = Change in resistance of strain gage due to strain
e = Strain

As specified by the manufacturer of strain indicator, we set the initial gage factor (as 2.005 for example) and take the measurements. In our experiment, we will also assume that we do not know the gage factor of the strain gage in order to calibrate it. We may do so by calculating the theoretical strain using the appropriate formula and adjust the gage factor setting so that we get the theoretical strain value on the display of the indicator. The set gage factor for which the display coincides with the theoretical strain is the calibrated gage factor of our strain gage as applied on a particular structure (a beam in our case).

Procedure:

1. Attach the strain gage to the bar (beam) surface using five basic steps: i.e. degreasing, surface abrading, burnishing, conditioning and neutralizing.
2. Set the specimen bar (beam) to the bar holder so that the bar acts as a cantilever beam. Measure the span (L), breadth (b) and thickness (t, see NOTE 1) of the bar.
3. Balance the instrument by moving the ten turn pot in gentle fashion and then come down to most sensitive range.
4. Additional pots are provided to get the finer balance.
5. Now apply a gentle pressure by a weight on the cantilever beam. The digital indication will show some change in value. If upward force is applied the meter pointer shall show opposite deflection.

PRECAUTION:-

a. Make connections to the binding posts & terminals very carefully.
b. Ensure that the cantilever arrangement is securely fixed to the table.

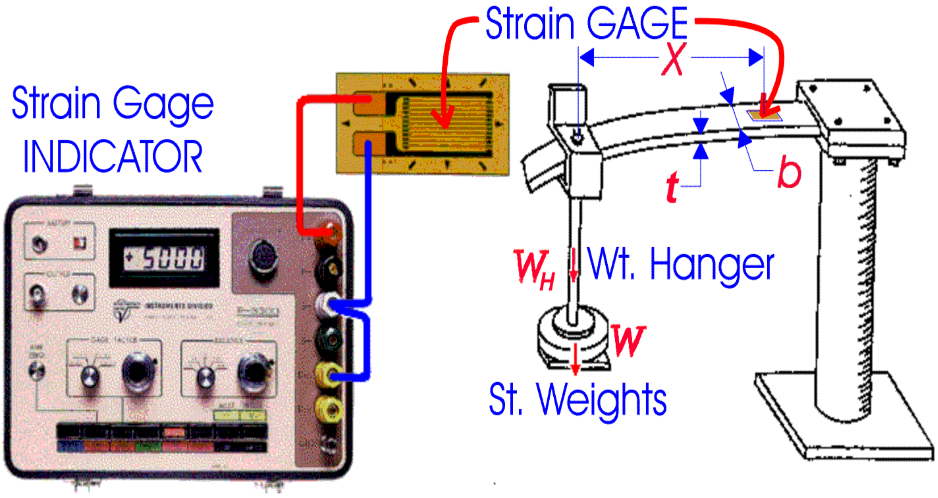

Figure 9.1 Cantilever strain gauge arrangement

After doing the experiment one can check-up the meter output with the help of following formula:-

$$E\ Out = \frac{Exc.\ X\ \Delta R}{R}$$

$$\frac{\Delta R}{R} = \text{Gauge factor x Strain}$$

$$= 1.9 \text{ x Strain}$$

$$Strain = \frac{Stress}{2 \times 10^6}$$ (Modulus of Elasticity = 2 x 106 Kg/cm2) for mild-steel.

$$Stress = f = \frac{M}{Z}$$ Where z = Moment of Cross Section

Z = 1/6 bt2 (b = width of cantilever & t = thickness of beam)

M = Length x Applied Load.

OBSERVATION TABLE:-

- G.F. = Gauge factor = 1.9
- Rg = 350 Ω
- L=Length of cantilever = 17.5 cm
- b= Width of cantilever = 2.42 cm
- t= Thickness of cant. = .4555 cm
- Exc= Excitation source voltage = 5 Volts
- Y= Young modulus of elasticity = 2 x 106 Kgf/cm2

OBSERVATION TABLE 9.1: for strain gauge Measurement

Sr. No.	Output of Bridge $(E_{out})_{gauge}$, Full Bridge	Applied Moment M, Kgf-cm	Stress f = m/z Kgf / cm^2	Strain = $\frac{f}{y}$	$\frac{\Delta R}{R}$ = G.F. X strain	$(E_{out})_{th}$ mV Full Bridge
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						

SAMPLE CALCULATION ;-

$Z = 1/6\ bt^2$ = , cm^3

M = Length (cm) x Applied load (kgf) = Kgf-cm

Stress = f = $\frac{M}{Z}$ = , Kgf/cm^2

Strain = $\frac{Stress}{Y}$ =

$\frac{\Delta R}{R}$ **=** Gauge factor x strain

$(E_{out})_{th}$ **=** Exc X $\frac{\Delta R}{R}$ (for full bridge or 4 arm bridge)

= $\frac{Exc}{2}$ X $\frac{\Delta R}{R}$ (for half bridge or 2 arm bridge)

GRAPH:-

$(E_{out})_{gauge}$ vs $(E_{out})_{th}$ full bridge

CONCLUSION:-

:Exercise:

1) What is the strain gauge?
2) Explain principle of working of strain gauge.
3) What are the materials used for strain gauge.
4) Application of strain gauge.

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PRACTICAL-10: Measurement of Gear Tooth Thickness

OBJECTIVE: To measure spur gear tooth thickness by using Gear tooth vernier.

INSTRUMENTS AND MATERIAL REQUIRED :

a) Gear tooth vernier caliper

b Gear

3 SPECIFICATIONS:

a) Gear Tooth vernier calipers – range _______ mm , LC = ______ mm

b) Spur gear size = Standard size

c) Vernier calipers - range 0-150 mm, LC = 0.02mm

<u>Terminology of Gear Tooth:</u>

1. Pitch circle diameter (P.C.D): It is the diameter of a circle which by pure rolling action would produce the same motion as the toothed gear wheel.
2. Module (m) : It is defined as the length of the pitch circle diameter per tooth. Thus if P.C.D of gear be 'D' and number of teeth 'N', then module (m) = D/N. it is generally expressed in mm.
3. Diametric pitch : It is expressed as the number of teeth per inch of the P.C.D.
4. Circular pitch : It is the arc distance measured around the pitch circle from the flank of one tooth to a similar flank in the next tooth. C.P = ÏD/N = Ïm
5. Addendum : This is the radial distance from the pitch circle to the tip of the tooth. Its value is equal to one module.
6. Clearance : This is the radial distance from the tip of a tooth to the bottom of a mating tooth space when the teeth are symmetrically engaged. Its standard value is 0.157 m.
7. Dedendum : This is the radial distance from the pitch circle to the bottom of the tooth space. Dedendum = Addendum + clearance = m + 0.157 m = 1.157 m.
8. Blank diameter : This is the diameter of the blank from which gear is cut. It is equal to P.C.D plus twice the addendum.

Blank diameter = P.C.D + 2m = mN + 2m = m (N+2).

9. Tooth thickness : This is the arc distance measured along the pitch circle from its intercept with on flank to its-intercept with the other flank of the same tooth. Normally tooth thickness = 1/2 (C.P) = 1/2 (ΠM) But thickness is usually reduced by certain amount to allow for some amount of backlash and also owing to addendum correction.

10. Face of tooth : It is that part of the tooth surface which is above the pitch surface.

11. Flank of tooth: It is that part of the tooth surface which is lying below the pitch surface.

PRINCIPLE : MEASUREMENT OF TOOTH THICKNESS :

The permissible error or the tolerance on thickness of tooth is the variation of actual thickness of tooth from its theoretical value. The tooth thickness is generally measured at pitch circle and is therefore, the pitch line thickness of tooth i.e., length of an arc, which is difficult to measure directly. In most of the cases, it is sufficient to measure the chordal thickness i.e, the chord joining the intersection of the tooth profile with the pitch circle. Also the difference between chordal tooth thickness and circular tooth thickness is very small for gear of small pitch. The thickness measurement is the most important measurement because most of the gears manufactured may not undergo checking of all other parameters, but thickness measurement is a must for all gears. The tooth thickness can be very conveniently measured by a gear tooth vernier. Since the gear tooth thickness varies from the tip to the base circle of the tooth, the instrument must be capable of measuring the tooth thickness at a specified position on the tooth. Further this is possible only when there is some arrangement to fix that position where the measurement is to be taken. The gear tooth vernier has two vernier scales and they are set for the width (w) of the tooth and the depth (d) from the top, at which ‘w’ occurs.

Analytical Method:

1) Total Number of tooth(T): __________

2) Outside Diameter (OD): ____________

3) Least Count of Gear Tooth vernier calliper:

4) PCD= T x OD / (T+2) = ___________

5) Module (m) = D/ T

6) Thickness of the tooth (w):

w= T m Sin90/T , w=____________________

7) Depth of the tooth (d):

d=(Tm/2)[1+(2/T) - Cos90/T]

d=___________

Practical Method:

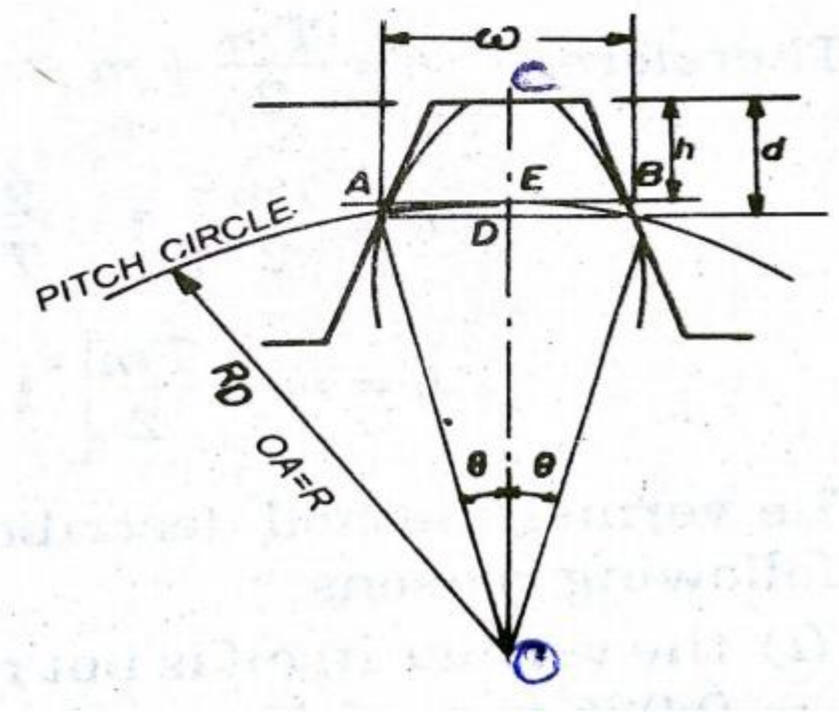

Figure: Chordal thickness method

Procedure:

1. The given gear caliper is held over the gear and the slide is moved down so that it touches the top of the gear tooth.
2. The jaws are made to have contact with the tooth on either side by adjusting the knob.
3. The reading on vertical scale i.e. addendum is noted down.
4. The reading on horizontal scale i.e. tooth thickness is noted down.
5. The above procedure is repeated for three times and readings are noted.

Precautions:

1. Clean the measuring faces of paper or cloth.
2. Set the zero reading of the instrument to before measuring

Calculations:

TABLE 10.1 : For tooth thickness

Sl. No	MSR	VSR	VSR*LC	TR=MSR+(VSR*LC) (mm)

TABLE 10.2 : For tooth width

Sl. No	MSR	VSR	VSR*LC	TR=MSR+(VSR*LC) (mm)

CONCLUSION:

:Exercise:

1. Give comparison between involute and cycloidal gears.
2. Discuss the gear tooth terminology with neat sketch.
3. Explain various forms of Gear teeth and explain Gear tooth vernier caliper with neat sketch.

GOVERNMENT ENGINEERING COLLEGE, VALSAD
MECHANICAL ENGINEERING DEPARTMENT

PRACTICAL-11: Thickness Measurement using Ultrasonic Thickness gauge

OBJECTIVE: To measure thickness by using ultrasonic thickness gauge.

INSTRUMENTS AND MATERIAL REQUIRED :

1) **Ultrasonic thickness gauge 01**

SPECIFIATION:

- Transducer choice : Φ10mm 2.5MHz Transducer,Φ10mm 5.0MHz Transducer
    - Display : 4-digital LCD display
    - Minimum display unit : 0.1mm
    - Working frequency : 5MHz/2.5MHz
    - Measuring range : 1.2 to 220mm (steel)
    - Minimum limit for tube curvature : 20*3mm (steel)
- measurement
    - Accuracy : +/-(1%H+0.1)mm, H denotes the measured thickness
    - Sound velocity range : 1000 to 9999 m/s
- Measuring sound velocity with a : measuring range : 1000 to 9999 m/s. When the given thickness over 20mm, the accuracy is +/-5%;given thickness when the given thickness less than 20mm, the accuracy is +/-1mm/H*100%
    - Operation temperature : 0°C to 40°C
    - Power supply : 3*1.5V AAA alkaline batteries
    - Operation current : Normal operation current≤50mA
    - With Backlight turn on current ≤120mA
    - Stand-by current : ≤20uA
    - Size : 70.0*135*38mm

- CONDITION AND PREPARATION OF SURFACES

The shape and roughness of the test surface are of paramount importance when carrying out ultrasonic thickness testing. Rough, uneven surfaces may limit the penetration of ultrasound through the material, and result in unstable, and therefore unreliable, measurements. The surface being measured should be clean, and free of any small particles, rust, or scale. The presence of such obstructions will prevent the transducer from seating properly against the surface. Often, a wire brush or scraper will be helpful in cleaning surfaces. In more extreme cases, rotary sanders or grinding wheels may be used, though care must be taken to prevent surface gouging, which will inhibit proper transducer coupling. Extremely rough surfaces, such as the pebble-like finish of some cast iron, will prove most difficult to measure. These kinds of surfaces act on the sound beam like frosted glass acts on light, the beam becomes diffused and scattered in all directions. In addition to posing obstacles to measurement, rough surfaces contribute to excessive wear of the transducer, particularly in situations where the transducer is 'scrubbed' along the surface.

PROCEDURE

1. Apply couplant For the gauge to work correctly there must be no air gaps between the transducer and the surface of the material to be measured. This is achieved using a material called a couplant. Before the transducer is placed on the surface, put a small amount of the couplant supplied with the gauge on the surface of the material. Typically a single drop is sufficient.

2. Place transducer onto surface of material to be measured Press the transducer into the couplant. Moderate pressure on the top of the transducer using the thumb or index finger is sufficient; it is only necessary to keep the transducer stationary and the surface seated flat against the surface of the material.

3. Read display If six or seven bars of the stability indicator are showing, the display will be reading the correct thickness of the material directly beneath the transducer. If the stability indicator has fewer than five bars showing, or the numbers on the display seem erratic, check to make sure that there is an adequate film of couplant beneath the transducer, and that the transducer is seated flat against the material. The gauge will perform four measurements every second when the transducer is in contact with the surface of the material. The display is updated as each reading is taken.

4. Remove transducer from surface The display will show the last measurement made.

Object Number	**UTG Reading**	**Vernier Calliper/Micrometer Reading**	**Difference**

TABLE 11.1 Reading of Ultrasonic Thickness Gauge.

:Exercise:

1. Explain working of Ultrasonic thickness gauge.