LABORATORY MANUAL

# INSTRUMENTATION LAB

**IV B.TECH -I Semester**

## DEPARTMENT OF MECHANICAL ENGINEERING


## CMR ENGINEERING COLEGE

**(Approved by AICTE, New Delhi & Affiliated JNTU, Hyderabad)**

Kandlakoya (V), Medchal Road, RR.Dist – 501401


**ACADEMIC YEAR-2017-2018**

## VISION OF THE INSTITUTE

- To be recognized as a premier institution in offering value based and futuristic quality technical education to meet the technological needs of the society

## MISSION OF THE INSTITUTE

1. To impart value based quality technical education through innovative teaching and learning methods
2. To continuously produce employable technical graduates with advanced technical skills to meet the current and future technological needs of the society
3. To prepare the graduates for higher learning with emphasis on academic and industrial research.

## VISION OF THE DEPARTMENT

To be a center of excellence in offering value based and futuristic quality technical education in the field of mechanical engineering.

## MISSION OF THE DEPARTMENT

**M1.** To impart quality technical education imbibed with values by providing state of the art laboratories and effective teaching and learning process.

**M2.** To produce industry ready mechanical engineering graduates with advanced technical and lifelong learning skills.

**M3.** To prepare graduates for higher learning and research in mechanical engineering and its allied areas.

## PROGRAM EDUCATIONAL OBJECTIVES (PEOS):

**PEO 1:** The Graduates will exhibit strong knowledge in mathematics, sciences and engineering for successful employment or higher education in mechanical engineering.

**PEO 2**: The Graduates will design and implement complex modeling systems, conduct research and work with multi disciplinary teams.

**PEO 3:** The Graduates will be capable of communicating effectively with lifelong learning attitude and function as responsible members of global society.

## PROGRAM OUTCOMES (POS):

**1. Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

**2. Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

**3. Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

**4. Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

**5. Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

**6. The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

**7. Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

**8. Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

**9. Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

**10. Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

**11. Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

**12. Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

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## PROGRAM SPECIFIC OUTCOMES (PSOS):

**PSO.1** Design a Thermal system for efficiency improvement as per industrial needs.

**PSO.2** Design and manufacture mechanical components using advanced manufacturing technology as per the industrial needs.

**Course Name: ICS & PDP LAB (C418)**

| Course Code | CO No. | Course Outcome (CO's) |
|---|---|---|
| C418 | CO1 | Recall and label the conventional representation of machine parts used in production drawing practice. |
| C418 | CO2 | Construct the various types of fits, determine their limits and indicate their tolerances on a drawing sheet. |
| C418 | CO3 | Develop detailed and part drawings from assembled drawings of machine components and indicate symbols, dimensions and specifications. |
| C418 | CO4 | Improve the accuracy in measurements through calibration of gauges, transducers used in the measurement of pressure, discharge, temperature level and angular measurements. |
| C418 | CO5 | Make use of seismic pick up to study mechanical vibrations. |
| C418 | CO6 | Calibrate the photo and magnetic speed pickups used for measurement of speed. |

**<u>Course Outcome (CO) – Program Outcome (PO) Matrix:</u>**

| CO's/PO's | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 3 | - | - | - | - | - | 3 | - | - |
| CO2 | 3 | 2 | 2 | 3 | - | - | - | - | - | 3 | - | - |
| CO3 | 3 | 2 | 2 | 3 | - | - | - | - | - | 3 | - | - |
| CO4 | 3 | 2 | 2 | 3 | - | - | - | - | - | 3 | - | - |
| CO5 | 3 | 2 | 2 | 3 | - | - | - | - | - | 3 | - | - |
| CO6 | 3 | 2 | 2 | 3 | - | - | - | - | - | 3 | - | - |

**Course Outcomes (CO) – Program Specific Outcomes (PSO) Matrix:**

| CO's/PSO's | PSO1 | PSO2 |
|---|---|---|
| CO1 | - | - |
| CO2 | - | - |
| CO3 | - | - |
| CO4 | - | - |
| CO5 | - | - |
| CO6 | - | - |

## GENERAL INSTRUCTIONS FOR LABORATORY CLASSES

1. All the students must follow the prescribed dress code (apron, formals, shoes) wear their ID cards

2. All the students should sign in login register.

3. All students must carry their observation books and records without fail.

4. Students must take the permission of the laboratory staff before handling the machines in order to avoid any injury.

5. The students must have basic understanding about the theory and procedure of the experiment to be conducted.

6. Power supply to the test table/test rig should be given in the presence of only through the lab technician.

7. Do not LEAN on and do not come CLOSE to the equipment.

8. Instruments like TOOLS, APPARATUS and GUAGE sets should be returned before leaving the lab.

9. Every student is required to handle the equipment with care and follow proper precautions

10. Students should ensure that their work areas are clean.

11. At the end of each experiment, the student must take initials from the staff on the data / observations taken after completing the necessary calculations.

12. The record should be properly written with following section in each experiment:
    a) Aim of the experiment
    b) Apparatus / Tools / Instruments required
    c) Procedure / Theory
    d) Model Calculations
    e) Schematic Diagram
    f) Specifications / Designs Details
    g) Tabulations.
    h) Graph
    i) Result and discussions.

13. Students should attend regularly to all lab classes.

14. Day- to- day evaluation of student performance is carried out and recorded for finalizing internal marks.

## SCHEME OF EVALUATION FOR EXTERNAL LABS

| Correctness of Write up and Precautions | Conduct Experiment & observations | Model Calculations | Results and Graphs | Viva |
|---|---|---|---|---|
| **Marks: 5** | **Marks: 15** | **Marks: 10** | **Marks: 10** | **Marks: 10** |
| **Total Marks: 50 Marks** | | | | |

## SCHEME OF EVALUATION FOR INTERNAL LABS

| **Day to Day Evaluation ------15 Marks** | | | | | **Internal Exam------10 Marks** | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Uniform | Observation &Record | Performance of experiment | Results | Viva Voce | Correctness of Write up and Precautions | Conduct Experiment & observations | Model Calculations | Results and Graphs | Viva Voce |
| **Marks:2** | **Marks:3** | **Marks:3** | **Marks:4** | **Marks:3** | **Marks:2** | **Marks:2** | **Marks:2** | **Marks:2** | **Marks:2** |
| **Total Marks: 15+10=25 Marks** | | | | | | | | | |

# LIST OF EQUIPMENT

| S.NO | EQUIPMENT NAME |
|---|---|
| 01 | Pressure Gauges |
| 02 | Transducers |
| 03 | Thermocouple |
| 04 | Photo and Magnetic Speed pickups |
| 05 | Rota meter |
| 06 | Vibration Generator |

# LIST OF EXPERIMENTS

# CALIBRATION OF PRESSURE GAUGE

# CALIBRATION OF PRESSURE GAUGE

## OBJECT:

To calibrate the given pressure gauge.

## APPARATUS:

Pressure cell, Dial type pressure indicator, Hydraulic dead weight, Pressure gauge Tester to develop the pressure, Digital pressure indicator.

## THEORY:

Pressure is defined as force per unit area and is measured in Newton per square meter (Pascal) or in terms of an equivalent head of some standard liquid (mm of mercury or mater of water). A typical pressure gauge will measure the difference in pressure between two pressures. Thus a pressure gauge is connected to the hydraulic line and the gauge itself stands in atmospheric pressure. The gauge reading will be the difference between the air pressure and the atmospheric pressure and is called gauge pressure. The absolute pressure (the actual pressure within the air line) is the sum of the gauge pressure and atmospheric pressure.

Pressure transducer is basically an electro mechanical devices, especially manufactured and designed or wide range application in pressure measurement. The pressure transducer comprises of diaphragm and an inputs to facilitate pressure measurement. The strain gauges are bonded directly to the sensing member to provide excellent linearity, low hysteresis and repeatability. Fluid medium whose parameter has to be measured is allowed to deflect the diaphragm (sensing member), which is a single block material and forms an integral part of the pressure transducer. It is made up non-magnetic stainless steel and thus has the advantage of avoids the yielding effects and leakage problems. The slight deflection of the diaphragms due to the pressure provided an electrical output.

The material most commonly used for manufacture of diaphragms are steel, phosphor bronze, nickel silver and beryllium copper. The deflection generally follows a linear variation with the diaphragm thickness.

## SET UP:

Setup comprises of one Hydraulic Dead weight Pressure gauge tester fitted with analog pressure gauge and pressure cell to be calibrated. Along with calibrated dead weights.

## DIGITAL PRESSURE INDICATOR:

Pressure indicator comprises of induct power supply, which provides power for strain gauge excitation. Signal conditioning and amplifying circuits access input from the strain gauges linearise and amplifies the signal level. The output of the amplifier is controlled to required level and calibrated to read the pressure in N/Sq Mt. any stray forces on the sensor can be balanced by balancing the strain gauge bridge through potentiometer in the front panel till the display reads zero. The system operates by 230V AC supply.

## PANEL DETIALS:

**POWER:** Rocker switch which switches on the supply of the instrument, indicates with red light.

**ZERO:** Ten turn potentiometer. The display can be adjusted to read Zero when no force is applied.

**CAL:** Single turn potentiometer. The output of the amplifier is adjusted by this potentiometer such that the display gives full scale for given range of sensor.

**TO SENSOR:** Sensor is connected to the indicator through a four core cable with 5 pin socket at sensor end and respective colour connectors.

**MAINS INPUT:** Power cable. Power cable to be connected to the mains supply of 230V 50Hz.

**FUSE:** 500 mA cartridge fuse with holder located on the rear side of the instrument to protect the instrument from internal electrical shorting.

**CAUTION:** Do not remove the fuse cap with power cable plugged to the mains supply.

## PROCEDURE:

1. Connect the pressure cell to the pressure indicator given cable.
2. Connect the instrument to mains i.e. 230V. Power supply and switch on the instrument.
3. Adjust the zero pot of the indicator to indicate zero.
4. Close the release valve of pressure gauge tester and apply the 5/10kg dead weight on flange.
5. Slowly rotate the screw road in clockwise direction with the help of handle until flange lift up (so that pressure is developed up to applied load). Now observed the digital reading. If it is not showing zero then make it zero by rotating ZERO knob. Now instrument is calibrated.

6. Apply the load (up to 10Kgs) on the flange and give pressure by rotating the screw rod.
7. Note down the readings of dial gauge and pressure indicator, simultaneously in every step.
8. Calculate the error if any and % error.

**TABLUR COLUMN:**

| SI. No | Pressure in Dial gauge, $P_c$ kg / $cm^2$ | Pressure in Digital indicator, $P_g$ kg / $cm^2$ | Error $P_g - P_c$ | % Error $(P_g - P_c)/ P_g \times 100$ |
|---|---|---|---|---|
| 01 | 9.2 | 9.2 | 0 | 0 |
| 02 | 6.6 | 6.7 | 0.1 | 1.5 |
| 03 | 4.7 | 5.0 | 0.3 | 6.3 |
| 04 | 2.6 | 2.8 | 0.2 | 7.6 |

**CALCULATIONS:**

**Error:** Pressure in Digital indicator ($P_g$) - Pressure in Dial gauge ($P_c$)

1. 9.2 -9.2 = 0

2. 6.7- 6.6 = 0.1

3. 5.0 - 4.7 = 0.3

4. 2.8 – 2.6 = 0.2

**% Error**: $\frac{\text{Pressure in Digital indicator } (P_g) - \text{Pressure in Dial gauge } (P_c)}{\text{Pressure in Digital indicator } (P_g)} * 100$

1. $\frac{9.2 - 9.2}{9.2} * 100 = 0$

2. $\frac{6.7 - 6.6}{6.7} * 100 = 1.5$

3. $\frac{5.0-4.7}{5.0}*100$ = 6.3

4. $\frac{2.8-2.6}{2.8}*100$ = 7.6

**RESULT:**

Hence I calibrated the given pressure gauge by using different dead weights.

Average % of error: 3.85

# CALIBRATION OF TRANSDUCER

# CALIBRATION OF TRANSDUCER FOR TEMPERATURE MEASUREMENT

## AIM:

To calibrate the given Thermister by using Thermometer.

## APPARATUS:

Temperature sensor (Thermister), Heating coil to heat water in water bath, Digital temperature Indicator & Thermometer.

## THEORY:

A Thermister is a type of resistor whose resistance varies significantly with temperature, more so than in standard resistors. The word is a portmanteau of thermal and resistor. Thermister are widely used as inrush current limiters, temperature sensor, self-resetting over current protectors and self-regulating heating elements.

Thermister differ from resistance temperature detectors (RTD) in that the material used in a Thermister is generally a ceramic or polymer, while RTD's use pure metals. The temperature response is also different, RDT's are useful over larger temperature ranges, while Thermister typically achieve a higher precision within a limited temperature range (usually – 90 $^{o}$C to 130 $^{o}$C).

Assuming, as a first order approximation, that the relationship between and temperature is linear, then

$\Delta R = k \, \Delta T$

Where,

$\Delta R$ = change in resistance

$\Delta T$ = change in temperature

k = first order temperature co-efficient of resistance

Thermister can be classified into two types, depending on the sign of k. if k is positive, the resistance increases with increasing temperature, and the device is called a positive temperature co-efficient (PTC) Thermister or posistor. If k is negative, the resistance decreases with increasing temperature, and the device is called a negative temperature co-efficient (NTC)

Thermistor. Resistors that are not thermistor are designed to have a k as close to zero as possible, so that their resistance remains nearly constant over a wide temperature range.

## RESISTANCE TEMPERATURE DETECTOR (RTD):

Resistance thermometers, also called **resistance temperature detectors or resistive thermal devices (RTD)**, are temperature sensors that exploit the predictable change in electrical resistance of some materials with changing temperature. As they are almost invariably made of platinum, they are often called **platinum resistance thermometers (PTR)**. They are slowly replacing the use of thermocouples in many industrial applications below 600$^{o}$C, due to higher accuracy and repeatability.

There are many categories like carbon resistors, film and wire wound types are the most widely used.

- **Carbon resistors** are widely available and are very inexpensive. They have very reproducible results at low temperatures. They are the most reliable from at extremely low temperatures. They generally do not suffer from significant hysteresis or strain gauge effects.
- **Film thermometer** have a layer of platinum on a substrate, the layer may be extremely thin, perhaps one micrometer. Advantage of this type is relatively low cost and fast response. Such devices have improved performance although the different expansion rates of the substrate and platinum give “strain gauge” effects and stability problems.
- **Wire – wound thermometers** can have greater accuracy, especially for wide temperature ranges.
- **Coil elements** have largely replaced wire wound elements in industry. This design has a wire coil which can expand freely over temperature, held in place by some mechanical support which lets the coil keep its shape.

## ADVANTAGES:

- High accuracy
- Low drift
- Wide operating range
- Suitable for precision applications.

## PANEL DETALIS:

**POWER ON:** Rocker switch which switches on the supply of the instrument, with red light indication.

**MIN:** Single turn potentiometer. The display can be adjusted to read minimum temperature, when no voltage output from the sensor is measured.

**MAX:** Single turn potentiometer. The output of the amplifier is adjusted by this pot such that the display reads same as in the given reference temperature. i.e. Thermometer temperature reading.

**SELECTOR:** Two-position selector switches to select thermistor or RTD sensor.

**TERMINALS:** Screw type terminals are provided to connect the given Thermister & RTD sensor.

**MAINS SUPPLY**: Power cable. Power cable to be connected to the mains supply of 230V, 50Hz.

**FUSE:** 500 mA cartridge fuse with holder located on the rear side of the instrument to protect the instrument from internal electrical shorting.

**CAUTION:** Do not remove the fuse cap with power cable plugged to the mains supply.

## PROCEDURE:

1. Turn the selector switch to the desire position according to the given sensor probe (Thermister / RTD).
2. Connect the given sensor to the temperature display unit.
3. Place the sensor probe and the thermometer into a beaker containing water at room temperature.
4. Connect the power supply to the temperature indicator.
5. Record the room temperature from the thermometer.
6. Adjust the MIN setting knob of the temperature indicator until the display shows the room temperature.
7. Connect the power supply to hearting coil and heat the water in the bath.
8. Set the temperature of thermocouple to the thermometer reading when the water is boiling, using MAX knob.

9. Now the given thermocouple is calibrated with reference to thermometer. Record the thermometer reading and the temperature indicator reading simultaneously at regular intervals.

## OBSERVATION AND TABULAR COLUMN:

**Thermister and Thermometer**

| SI. NO | Temp. of Water by Thermometer $T_a$ °C | Temp. of Water by Thermister $T_m$ °C | Correction $T_a - T_m$ | Error $T_m - T_a$ | % Error $(T_m - T_a) / T_m$ |
|---|---|---|---|---|---|
| 01 | 35 | 35.5 | -0.5 | 0.5 | 1.44 |
| 02 | 40 | 45.1 | -5.1 | 5.1 | 11.3 |
| 03 | 45 | 51 | -6 | 6 | 11.764 |
| 04 | 50 | 56.1 | -6.1 | 6.1 | 10.87 |

## GRAPHS:

Draw the following graphs:

- $T_m$ v/s $T_a$
- Correction v/s $T_m$
- % Error v/s $T_m$

## CALCULATIONS:

**Correction:** $T_a - T_m$

1. 35 - 35.5 = -0.5

2. 40 - 45.1 = -5.1

3.45 - 51 = -6

4. 50 – 56.1 = -6.1

**Error:** $T_m - T_a$

1. 35.5 – 35 = 0.5

2. 45.1 – 40 = 5.1

3. 51 -45 = 6

4. 56.1- 50 = 6.1

**% Error:** $\frac{T_m - T_a}{T_m} * 100$

1. $\frac{35.5 - 35}{35.5} * 100 = 1.44$

2. $\frac{45.1 - 40}{45.1} * 100 = 11.3$

3. $\frac{51 - 45}{51} * 100 = 11.764$

4. $\frac{56.1 - 50}{56.1} * 100 = 10.87$

## RESULT:

Hence I calibrated the Thermister with thermometer.

Average % of Error: 8.8435

# CALIBRATION OF LVDT

# STUDY AND CALIBRATION OF LVDT

## AIM:

To calibrate Liner Variable Differential Transformer (LVDT) for the performance using Micrometer.

## APPARATUS:

LVDT, Digital Indicator, Micrometer.

## THEORY:

LVDT is an inductive transducer used to translate the linear motion into electrical signal LVDT consists of a single primary winding 'P' and two secondary windings (S1 & S2) wounds on a cylindrical armature. An AC source is connected to the primary winding. A movable soft iron core attached with an arm placed inside the armature.

The primary winding produces and alternating magnetic field which includes alternating voltage in the secondary windings. Single voltage is obtained by connecting the two secondary windings in series. Thus the output voltage of the transducer is the difference of the two voltages.

When the core is at null position, the flux linking with both the secondary windings is equal. Since both the secondary winding has equal number of turns, M the induced emf is same in them. The output voltage is the difference of the two emf says E1 & E2. When they are equal, the voltage is zero at null position.

When the core is moved to the left side from null position more flux links with S1. The output voltage is V=E2-E1, is greater, the V value is –ve. Means the voltage is read in terms of mm length on the display board indicates the negative value. When the core is moved to the right side of the null position, more flux links with S2 induces voltages which is +ve. The display board indicates the +ve value in mm of length.

The voltage output is linear and is depending on the position of the core. Hence LVDT can be conveniently used to measure the thickness ranging from fraction of a mm to a few cm's. Normally LVDT can give better result up to 5mm.

## PANEL DETAILS:

**POWER ON:** Rocker switch which switches on the supply of the instrument, with red light indication.

**ZERO:** Ten turn potentiometer. The display can be adjusted to read Zero when no force is applied.

**CAL:** Single turn potentiometer. The output of the amplifier is adjusted by this potentiometer such that the display gives full scale for given range of sensor.

**TO SENSOR:** Sensor is connected to the indicator through a five core cable with 5 pin respective color connectors.

**MAINS INPUT:** Power cable. Power cable to be connected to the mains supply of 230V 50Hz.

**FUSE:** 500 mA cartridge fuse with holder located on the rear side of the instrument to protect the instrument from internal electrical shorting.

**CAUTION:** Do not remove the fuse cap with power cable plugged to the mains supply.

## PROCEDURE:

The experiment can be carried out for both +ve and –ve sides.

1. Connect the power cable to 230V 50Hz to mains and switch on the instrument.
2. Make the display to read zero (000) by using zero knob.
3. Connect the LVDT cable pins to the instrument with proper colour code.
4. Make the display to read zero by rotating the micrometer. This is called null balancing and note down the micrometer reading.
5. Give the displacement of 5mm by rotating the micrometer from the null position either clockwise or anticlockwise.
6. Then display will read 5.00mm. if not adjust the display by using Cal knob. Now the instrument is calibrated.
7. Again rotate the micrometer to null position and from there take down the reading in steps of 1mm. that is both the sides.

8. Plot the graph micrometer reading v/s display reading (Actual reading v/s Measure reading).

   X axis micrometer reading (in mm)

   Y axis display reading (in mm)

## OBSERVATIONS:

Range of Micrometer: 0-25 mm

Least count of Micrometer: 0.01 mm

Linearity Range of LVDT.

Least count of LVDT.

Initial reading of Indicator (null position): 0

Micrometer reading at null position: 10 mm

## TABLUR COLUMN:

**Display for +ve side: (clockwise rotation)**

| SI. NO | Actual Reading, '$R_a$' mm | Measured Reading, '$R_m$' mm | Error $R_a - R_m$ mm | % Error $\frac{R_a - R_m}{R_a}*100$ |
|---|---|---|---|---|
| 01 | 1 | 0.85 | 0.15 | 15 |
| 02 | 2 | 1.75 | 0.25 | 12.5 |
| 03 | 3 | 2.9 | 0.1 | 3.33 |
| 04 | 4 | 3.85 | 0.15 | 3.75 |

**Display for -ve side: (anti clockwise rotation)**

| SI. NO | Actual Reading, '$R_a$' mm | Measured Reading, '$R_m$' mm | Error $R_a - R_m$ | % Error $\frac{R_a - R_m}{R_a} *100$ |
|---|---|---|---|---|
| 01 | -1 | -0.75 | -0.25 | 25 |
| 02 | -2 | -1.5 | -0.5 | 25 |
| 03 | -3 | -2.8 | -0.2 | 6.667 |
| 04 | -4 | -3.9 | -0.1 | 2.5 |

## SPECIMEN CALCULATIONS:

1. $R_a$ = Actual Reading (Pressure gauge reading)
2. $R_m$ = Measured Reading (Indicator reading)
3. 'E' Error = $R_m$ - $R_a$
4. % Error = Error / Actual reading

### Graphs:

On X – axis & Y – axis.

Actual reading v/s Measured reading (for both +ve & -ve displacements)

### Calculations:

**Clockwise Rotation**

**Error:** $R_a - R_m$

1. 1- 0.85 = 0.15
2. 2- 1.75 = 0.25
3. 3- 2.9 = 0.1
4. 4- 3.85 = 0.15

**% Error:** $\frac{R_a - R_m}{R_a} * 100$

1. $\frac{0.15}{1} * 100$ = 15

2. $\frac{0.25}{2} * 100$ = 12.5

3. $\frac{0.1}{3} * 100$ = 3.33

4. $\frac{0.15}{4} * 100$ = 3.75

**Anti-Clockwise Rotation**

**Error:** $R_a - R_m$

1. -1+ 0.75 = -0.25
2. -2+ 1.5 = -0.5
3. -3+ 2.8 = -0.2
4. -4+ 3.9 = -0.1

**% Error:** $\frac{R_a - R_m}{R_a} * 100$

1. $\frac{-0.25}{-1} * 100$ = 25

2. $\frac{-0.5}{-0.2} * 100$ = 25

3. $\frac{-0.2}{-3} * 100$ = 6.667

4. $\frac{-0.1}{-4} * 100$ = 2.5

## RESULT:

Hence I Calibrated the LVDT for linear displacement.

Average % of error in clock wise direction: 8.645

Average % of error in anti clock wise direction: 14.79175

# CALIBRATION OF STARIN GAUGE

# CALIBRATION OF STRAIN GAUGE

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

**APPARATUS:** A cantilever beam with concentrated end load arrangement, strain gauges and strain indicator.

**THEORY:** A body subjected to external forces is in a condition of both stress and strain. Stress can be directly measured but its effect. i.e. change of shape of the body can be measured. If there is a relationship between stress and strain, 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. $E=\sigma / \epsilon$

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 resistance strain gauges are made into two basic forms, bonded wire and bonded foil. Wire gauges are sandwiched between two sheets thin paper and foil gauges are sandwiched between two thin sheets of epoxy.

The resistance factor 'R' of a metal depends on its electrical resistively, $\rho$, 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 resistively, a large number of grid loops and a very small cross sectional area. The most common material for strain gauge 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, Deco Cement, etc. as the test specimens extends or 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.

## GAUGE FACTOR:

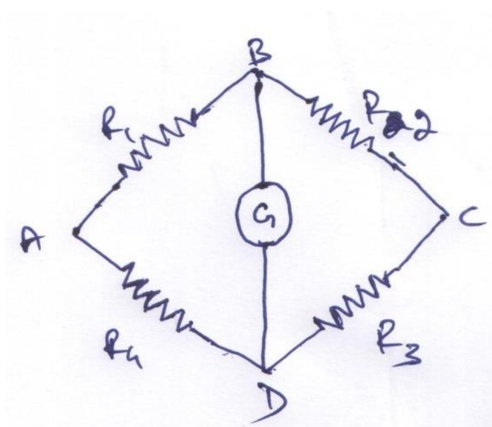
The dimension less relationship between the change in gauge resistance and change in length is called Gauge factor of the strain, which is expressed mathematically,

Gauge Factor, $\delta g = (\Delta R/R) / (\Delta l/l)$

In this relationship R and I represent, respectively the initial resistance and initial length of the strain gauge filament, while $\Delta R$ & $\Delta l$ represents the small change in resistance and length, which occurs as the gauge is strained along with the surface to which it is bonded. This gauge factor of a gauge is a measure of the amount of resistance change for a given strain. The higher the gauge factor greater the electrical output for indication or recording purpose. The gauge factor is supplied by the manufacturer and may range from 1.7 to 4.

The usual method of measuring the change of resistance in a gauge element is by means of Wheatstone bridge as shown in figure. It consists of Galvanometer, 4 resistor & a battery. Resistance $R_1$ is the strain gauge is used for strain measurement, which is mounted on the specimen. The three resisters $R_{2,}$ $R_3$ and $R_4$ are internal to the device.

Let us assume that the resistance has been adjusted so that the bridge is balanced.




i.e. Voltage $\mathbf{E_{bd} = 0.}$

Thus for initial balance, $\mathbf{R_1 * R_3 = R_2 * R_4}$

Or

$\mathbf{R_1 = (R_2 * R_4) / R_3}$

If the structural member, to whom the strain gauge is bonded, is to be loaded and strained, there would be a resultant change in the resistance $\mathbf{R_1}$.

According to the relationship,

$$\Delta R = R_1 \delta g * (\Delta l/l)$$

The strain indicator is calibrated for gauges of a given factor, thus it provides accurate reading only when gauges having the same gauge factor are used.

The most common bridge arrangements are single arm, two arm and four arm mode.

## Single Arm Mode (Quarter Bridge):

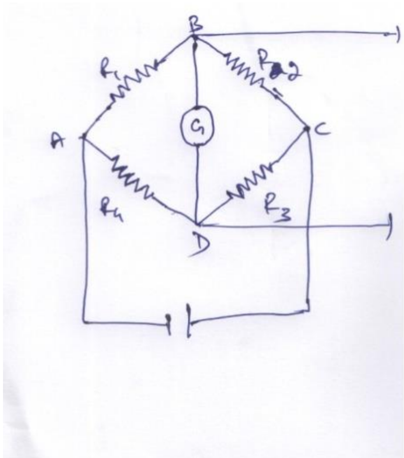
This bridge arrangement consists of a single active gauge in position; say $R_1$ and three resistors are internal to the device. Temperature compensation is possible only if a self temperature compensating strain gauge is used.

## Two Arm Modes (Half Bridge):

In this mode, two resistors are internal to the device and the remaining two are strain gauges. One arm of this bridge is commonly labeled as active arm and the other as compensating arm. The bridge is temperature compensated.

## Four Arm Modes (Full Bridge):

In this bridge arrangement, four active gauges are placed in the bridge with one gauge in each of the four arms. If the gauges are placed on a beam in bending as shown in fig of the elastic constant by bending test experiment, the single from each of the four gauges will add. This bridge arrangement is temperature compensated.




Consider a cantilever beam as shown in fig. Let,

W = load applied on the beam in N.

l = distance between the center of the gauge to the point of application of load.

b = width of the beam in mm.

h = thickness of the beam in mm.

$M_b$ = bending moment = WL in N-mm.

I = moment of inertia = $bh^3 / 12\ mm^4$.

c = h/2 mm.

The bending equation is,

$$M_b / I = \sigma / c$$

Bending stress, $\sigma = M_b\, c / I$.

$$Wl * h/2 * 12 / bh^3 = 6Wl / bh^2.$$

Let,

$\epsilon$ = strain indicator reading in micro strain.

i = number of active gauges.

Measured strain, $(\epsilon_m) = \epsilon * 10^{-5} / i$

Modulus of elasticity, $E = \sigma / \epsilon_m$

$$= 6WI / bh^3 \epsilon_m$$

The strain gauge $R_1$, $R_3$ measure the tensile strain while the gauges $R_2$, $R_4$ measure the compressive strains. The strains ϵ1, ϵ2, ϵ3 and ϵ4 as measured by the gauges are of equal magnitude. The bridge in this said to be working as full bridge and sensitivity (out put) is four times that achievable with a single active gauge.

## SET UP:

The set up comprises of cantilever beam made up of mild steel material. Square pipe with opening at one end the other end land for fixing the beam. Bottom of the square pipe has got a provision for fixing the sensor rigidly to the table. A loading pan is provided to load the sensor. Weights up to 1Kg in steps of 10gms will be provided with the setup. Specimen with strain gauges of 120 ohms are bonded on the material and connected in the form of wheat stones bridge and the terminals are brought out through a connector.

## DIGITAL STRAIN INDICATOR:

Strain indicator comprises of induct power supply, which provides power for strain gauge excitation. Signal conditioning and amplifying circuit's access input from the strain gauges linearises and amplifies the signal level. The output of the amplifier is controlled to required level and calibrated to read the strain in micro strain. Any stray forces on the sensor can be balanced by balancing the strain gauge bridge through pot in the front panel till the display reads zero. The system operates by 230V AC supply.

## SPECIFICATION OF CANTELIVER BEAM SET UP:

Capacity : 1kg

Type : Strain gauge based.

Strain gauge : Foil type, 120 ohms.

Gauge factor : 2

Weights : 100gms – 10 Nos.

Beam material : Mild steel.

Beam width : 41mm.

Beam thickness : 2.85mm.

## STRAIN INDICATOR

Display : 3 ½ digital, LED displays.

Accuracy : 1.

Resolution : 1μs.

Connection : Through 4 cores shielded cable.

Power required : 230V, 50 Hz.

## PANEL CETAILS

**POWER ON:** Rocker switch which switches on the supply of the instrument, with red light indication.

**ZERO:** Ten turn potentiometer. The display can be adjusted to read Zero when no force is applied.

**CAL:** Single turn potentiometer. The output of the amplifier is adjusted by this potentiometer such that the display gives full scale for given range of sensor.

**TO SENSOR:** Sensor is connected to the indicator through a four core cable with core male pins at both ends and respective color connections at the other end to connect the instrument.

**FUNCTION:** Three position rotary switch is provided to select GF position READ position and CAL position. In READ position display will read directly Micro strain which load applied on the cantilever beam. In CAL position display will read maximum calibrated point i.e. 1000. In GF position display gauge factor i.e. 500.

**ARM:** Selector switch is to select the ARM are provided on the panel i.e. 4, 2 & 1.

**MAINS INPUT:** Power cable. Power cable to be connected to the mains supply of 230V 50Hz.

**FUSE:** 500 mA cartridge fuse with holder located on the rear side of the instrument to protect the instrument from internal electrical shorting.

**CAUTION:** Do not remove the fuse cap with power cable plugged to the mains supply.

## PROCEDURE:

## STRAIN MEASUREMENT IN FOUR ARM MODES (FULL BRIDGE)

1. Switch on the instrument and leave 5 minutes to warm up.
2. Connect the sensor (Cantilever beam) to instrument by 4 core cable with respective colored pins.
3. Keep the ARM selector switch to 4 positions.
4. Select the FUNCTION switch to GF position and adjust the display to read 500 by GF pot.
5. Select the FUNCTION switch to READ position and adjust the display to read zero by zero pot.
6. Select the FUNCTION switch to CAL position and adjust the display to read 1000 by CAL pot.
7. Apply the load on cantilever beam, in steps of 100 grams and note down the readings.

**TABULAR COLUMN FOR FULL BRIDGE**

| SI. No | Load Applied W (N) | | Strain Indicator Reading Є – micro strain | Measured Strain $Є_m = Є*10^{-6} / 4$ | Bending stress. $\sigma = 6wI / bh^2$ | Modulus of elasticity. $E = \sigma / Є_m$ $(N/mm^2)$ |
|---|---|---|---|---|---|---|
| | W | N | | | | |
| 01 | 0.2 | 1.962 | 113 | $2.8*10^{-5}$ | 7.069 | 252.14 |
| 02 | 0.4 | 3.924 | 225 | $5.6*10^{-5}$ | 14.13 | 253.3 |
| 03 | 0.6 | 5.88 | 339 | $8.4*10^{-5}$ | 21.18 | 252.14 |
| 04 | 0.8 | 7.848 | 454 | $11.3*10^{-5}$ | 28.27 | 250.14 |
| 05 | 1.0 | 9.81 | 570 | $14.2*10^{-5}$ | 36.23 | 255.14 |

## STRAIN MEASUREMENT IN TWO ARM MODES (HALF BRIDGE)

1. Switch on the instrument and leave 5 minutes to warm up.
2. Connect the sensor (Cantilever beam) to instrument by 4 core cable with respective colored pins.
3. Keep the ARM selector switch to 2 positions.
4. Remove the yellow pins from both sides.
5. Select the FUNCTION switch to GF position and adjust the display to read 500 by GF pot.
6. Select the FUNCTION switch to READ position and adjust the display to read zero by zero pot.

7. Select the FUNCTION switch to CAL position and adjust the display to read 1000 by CAL pot.
8. Apply the load on cantilever beam, in steps of 100 grams and note down the readings.

**TABULAR COLUMN FOR HALF BRIDGE**

| SI. No | Load Applied W (N) | | Strain Indicator Reading Є – micro strain | Measured Strain $Є_m = Є*10^{-6} / 2$ | Bending stress. $σ = 6wI / bh^2$ | Modulus of elasticity. $E = σ / Є_m$ ($N/mm^2$) |
|---|---|---|---|---|---|---|
| | W | N | | | | |
| 01 | 0.2 | 1.962 | 62 | $3.1*10^{-5}$ | 7.069 | 228 |
| 02 | 0.4 | 3.924 | 120 | $6.0*10^{-5}$ | 14.13 | 235.5 |
| 03 | 0.6 | 5.88 | 176 | $8.8*10^{-5}$ | 21.18 | 240.6 |
| 04 | 0.8 | 7.848 | 234 | $11.7*10^{-5}$ | 28.27 | 241.6 |
| 05 | 1.0 | 9.81 | 292 | $14.6*10^{-5}$ | 36.23 | 248.15 |

## STRAIN MEASUREMENT IN ONE ARM MODES (QUARTER BRIDGE)

1. Switch on the instrument and leave 5 minutes to warm up.
2. Connect the sensor (Cantilever beam) to instrument by 4 core cable with respective colored pins.
3. Keep the ARM selector switch to 1 position.
4. Remove the yellow and black pins.
5. Select the FUNCTION switch to GF position and adjust the display to read 500 by GF pot.
6. Select the FUNCTION switch to READ position and adjust the display to read zero by zero pot.
7. Select the FUNCTION switch to CAL position and adjust the display to read 1000 by CAL pot.
8. Apply the load on cantilever beam, in steps of 100 grams and note down the readings.

**TABULAR COLUMN FOR QUATER BRIDGE**

| Sl. No | Load Applied W (N) | | Strain Indicator Reading Є – micro strain | Measured Strain $Є_m = є*10^{-6} / 1$ | Bending stress. $σ = 6wl / bh^2$ | Modulus of elasticity. $E = σ / Є_m$ ($N/mm^2$) |
|---|---|---|---|---|---|---|
| | W | N | | | | |
| 01 | 0.2 | 1.962 | 30 | $3*10^{-5}$ | 7.069 | 235.6 |
| 02 | 0.4 | 3.924 | 61 | $6.1*10^{-5}$ | 14.13 | 231.63 |
| 03 | 0.6 | 5.88 | 90 | $9*10^{-5}$ | 21.18 | 235.3 |
| | | | | | | |
| 04 | 0.8 | 7.848 | 120 | $12*10^{-5}$ | 28.27 | 235.5 |
| 05 | 1.0 | 9.81 | 149 | $14.9*10^{-5}$ | 36.23 | 243.15 |

## RESULT:

Hence I determined the modulus of elasticity of given cantilever beam.

Modulus of elasticity in full bridge mode: 252.14 $N/mm^2$

Modulus of elasticity in half bridge mode: 238.4 $N/mm^2$

Modulus of elasticity in quarter bridge mode: 236.236 $N/mm^2$

# CALIBRATION OF THERMOCOUPLE

# CALIBRATION OF THERMOCOUPLE

## OBJECT:

To calibrate the given thermocouple using thermometer.

## APPARATUS:

Thermocouple, a heating coil to heat the water in the water bath, thermometer and a digital indicator to indicate the temperature of thermocouple.

## THEORY:

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

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

The material used in the Thermocouple probe is:

1. Iron – Constantan (Type J)
2. Copper – Constantan (Type T)
3. Chromyl – Alumel (Type K)

## SETUP:

Setup comprises of thermometer as a reference and three types of Thermocouples as mentioned above, to be calibrated. All the sensor can be placed in a hot bath where the water can be heated up to boiling temperature through heating coil. Heater of capacity 500 watts is provided which will be connected to the 230V, 50Hz. power supply through three-pin mains cord.

## DIGITAL TEMPERATURE INDICATOR:

Temperature indicators for thermocouples are provided in a unit with digital display. For thermocouples, the output of the sensor (i.e. in mV) is amplified through electronic circuits. Calibration provision is provided out to calibrate any sensor required. RTD sensor is calibrated and the output in terms temperature in degree centigrade is displayed.

## PANAL DETAILS:

**POWER ON:** Rocker switch which switches on the supply of the instrument, with red light indication.

**MIN:** Single turn potentiometer. The display can be adjusted to read minimum temperature, when no voltage output from the sensor is measured.

**MAX:** Single turn potentiometer. The output of the amplifier is adjusted by this pot such that the display reads same as in the given reference temperature. i.e. Thermometer temperature reading.

**SELECTOR:** Two-position selector switches to select Temperature or mV output of the sensor.

**SELECTOR:** Three- position selector switches to select J-type / K-type / T-type thermocouples.

**TERMINALS:** Screw type terminals are provided to connect the given thermocouples.

**MAINS SUPPLY:** Power cable. Power cable to be connected to the mains supply of 230V, 50Hz.

**FUSE:** 500 mA cartridge fuse with holder located on the rear side of the instrument to protect the instrument from internal electrical shorting.

**CAUTION:** Do not remove the fuse cap with power cable plugged to the mains supply.

## PROCEDURE:

10. Turn the type selector to the desire position according to the given T.C probe.
11. Connect the given thermocouple to the temperature display unit.
12. Place the thermocouple and the thermometer into a beaker containing water at room temperature.
13. Connect the power supply to the temperature indicator.
14. Record the room temperature from the thermometer.
15. Adjust the MIN setting knob of the temperature indicator until the display shows the room temperature.
16. Connect the power supply to hearting coil and heat the water in the bath.
17. Set the temperature of thermocouple to the thermometer reading when the water is boiling, using MAX knob.
18. Now the given thermocouple is calibrated with reference to thermometer. Record the thermometer reading and the temperature indicator reading simultaneously at regular intervals.

### OBSERVATIONS TABULAR COLUMN:

Type of Thermocouple: **J** -Type

Material for thermocouple wires = Iron – Constantan

| SI. NO | Temp. of Water by Thermometer $T_a$ °C | Temp. of Water by Thermocouple, $T_m$ °C | Correction $T_a - T_m$ | Error $T_m - T_a$ | % Error $(T_m - T_a) / T_m$ |
|---|---|---|---|---|---|
| 01 | 30 | 34 | -4 | 4 | 11.764 |
| 02 | 35 | 36 | -1 | 1 | 2.778 |
| 03 | 40 | 42.8 | -2.8 | 2.8 | 6.54 |
| 04 | 45 | 46.5 | -1.5 | 1.5 | 3.225 |

Type of Thermocouple: **K -** Type

Material for thermocouple wires = Chromyl – Alumel

| SI. no | Temp. of Water by Thermometer $T_a$ °C | Temp. of Water by Thermocouple, $T_m$ °C | Correction $T_a - T_m$ | Error $T_m - T_a$ | % Error $(T_m - T_a) / T_m$ |
|---|---|---|---|---|---|
| 01 | 30 | 30.6 | -0.6 | 0.6 | 1.96 |
| 02 | 35 | 42 | -7 | 7 | 16.6 |
| 03 | 40 | 51.4 | 11.4 | 11.4 | 22.1 |
| 04 | 45 | 60.7 | 15.7 | 15.7 | 25.86 |

Type of Thermocouple: **T-** Type

Material for thermocouple wires = Copper – Constantan

| SI. no | Temp. of Water by Thermometer $T_a$ °C | Temp. of Water by Thermocouple, $T_m$ °C | Correction $T_a - T_m$ | Error $T_m - T_a$ | % Error $(T_m - T_a) / T_m$ |
|---|---|---|---|---|---|
| 01 | 25 | 25.8 | -0.8 | 0.8 | 3.1 |
| 02 | 30 | 36.8 | -6.8 | 6.8 | 18.47 |
| 03 | 35 | 44.9 | -9.9 | 9.9 | 22.0 |
| 04 | 40 | 51.7 | -11.7 | 11.7 | 22.6 |

## Calculations:

**Type of Thermocouple: J –Type**

**Correction:** $T_a - T_m$

1. 30- 34 = -4

2. 35- 36 = -1

3. 40-42.8 = - 2.8

4. 45-46.5 = -1.5

**Error:** $T_m - T_a$

1. 34- 30 = 4

2.36- 35 = 1

3. 42.8- 40 = 2.8

4. 46.5- 45 = 1.5

**% Error:** $\frac{T_m - T_a}{T_m} * 100$

1. $\frac{4}{34} * 100$ = 11.764

2. $\frac{1}{36} * 100$ = 2.778

3. $\frac{2.8}{42.8} * 100$ = 6.54

4. $\frac{1.5}{46.5} * 100$ = 3.225

**Type of Thermocouple: K –Type**

**Correction:** $T_a - T_m$

1. 30- 30.6 = -0.6

2. 35- 42 = -7

3. 40- 51.4 = 11.4

4. 45- 60.7 = 15.7

**Error:** $T_m - T_a$

1. 30.6- 30 = 0.6

2. 42- 35 = 7

3. 51.4 – 40 =11.4

4. 60.7 – 45 = 15.7

**% Error:** $\frac{T_m - T_a}{T_m} * 100$

1. $\frac{0.6}{30.6} * 100$ = 1.96

2. $\frac{7}{42} * 100$ = 16.6

3. $\frac{11.4}{51.4} * 100$ = 22.1

4. $\frac{15.7}{60.7} * 100$ = 25.86

**Type of Thermocouple: T –Type**

**Correction:** $T_a - T_m$

1. 25- 25.8 = -0.8

2. 30-36.8 = -6.8

3. 35- 44.9 = -9.9

4. 40- 51.7 = -11.7

**Error:** $T_m - T_a$

1. 25.8- 25 = 0.8

2. 36.8- 30 = 6.8

3. 44.9-35 = 9.9

4.51.7- 40 = 11.7

**% Error:** $\frac{T_m - T_a}{T_m} * 100$

1. $\frac{0.8}{25.8} * 100$ = 3.1

2. $\frac{6.8}{36.8} * 100$ = 18.47

3. $\frac{9.9}{44.9} * 100$ = 22.0

4. $\frac{11.7}{51.7} * 100$ = 22.6

## GRAPHS:

Draw the following graphs:

1. $T_m$ Vs $T_a$
2. Correction Vs $T_m$
3. % Error Vs $T_m$

## RESULT:

Hence I calibrated the thermocouple with thermometer

The average % error of **J**- Type Thermocouple: 26.3

The average % error of **K**- Type Thermocouple: 16.63

The average % error of **T**- Type Thermocouple: 16.54

# MEASUREMENT OF ANGULAR DISPLACEMENT USING CAPACITIVE TRANSDUCER

# CALIBRATION OF CAPACITIVE TRANSDUCER FOR ANGULAR DISPLACEMENT

## AIM:

Measurement of angular displacement using capacitive transducer.

## APPARATUS:

Capacitive transducer & Angular displacement indicator.

## THEORY:

Capacitance is well known to be a function of effective area of the conductors, separation between them, the dielectric strength of the material in the separation. Capacitive transducers convert the physical quantity to be measured into a change of capacitance which is processed by the measuring circuit of the transducer. The capacitance of a parallel plate capacitor may be changed by varying the separation between the plates, varying the effective area of the plates or varying the dielectric.

Capacitive type transducers are used essentially for displacement or positioning measurements. But they are more susceptible to environmental factors such as dust or moisture in the atmosphere than inductive type transducers.

The meshing area between two stator and rotor plates of the capacitor goes on changing as the shaft capacitor is rotated. The arrangement is used to demonstrate the measurement of angular displacement.

The transducer is mounted on to the face of a protractor which indicates the angle of displacement and the readout display the amount of displacement.

## PROCEDURE:

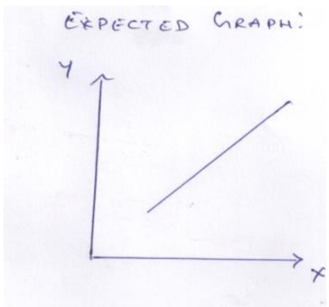
- ❖ Connect the power card to the 230V AC mains & switch on the instrument.
- ❖ Connect the capacitive transducer to the angular displacement indicator with proper color codes of the pins.
- ❖ Rotate the transducer knob to zero position. Now display shows the zero.
- ❖ Rotate the transducer knob to any angle (Ex. 90 deg) and the reading of the display should be same. If not, then adjust by rotating the CAL POT.

## TABULAR COLUMN:

| SI. No | The displacement protractor reading ($P_r$) In degrees | Measured displacement meter reading ($P_m$) In degrees | Deviation $P_r – P_m$ |
|---|---|---|---|
| 01 | 20 | 18.2 | 1.8 |
| 02 | 40 | 39.1 | 0.9 |
| 03 | 60 | 59.6 | 0.4 |
| 04 | 80 | 79.4 | 0.6 |

## GRAPH:

Plot a graph using the true displacement on X axis & measured displacement on Y axis.




## Calculations:

**Deviation:** $= P_r – P_m$

1. 20 -18.2 = 1.8

2. 40 -39.1 = 0.9

3. 60 – 59.6 = 0.4

4. 80 – 79.4 = 0.6

## RESULT:

Hence I determined the Angular displacement of capacitive transducer.

Average deviation of displacement: 0.925mm

# CALIBRATION OF PHOTO AND MAGNETIC SPEED PICK UPS

# STUDY AND CALIBRATION OF PHOTO AND MAGNETIC SPEED PICKUPS

The measurement of rotational velocity is more common. For velocity (speed) measurement the most convenient calibrator scheme uses a combination of toothed wheel, a simple magnetic proximity pickup a photo couple sensor and an electronic indicator to measure the speed. The angular rotation is provided by some adjustable speed drive of adequate stability. The toothed wheel mounted with iron rods while passing under magnetic and photo pickup produces an electric pulse. These pulses are fed to signal conditioner unit and displays reading visually. The stability of the rotational drive is easily checked by observing the variation of display reading.

## CONTROL AND OPERATION:

Speed measurement system is provided with display or signal conditioner unit and sensor unit. Sensor unit consist of magnetic and photo pick up unit with variable speed controller and a AC motor. The pulse generated by pickup sensor is sensed by signal conditioner.

Refer the front panel of the instrument, it is provided with toggle switch to select the mode of display reading by magnetic or photo pickup display reads the speed in RPM.

Also provided with sensor socket for connecting magnetic and photo pickup units. Back panel of the instrument is provided with power on switch, fuse holder and power chord for connecting AC supply.

## OPERATION:

- Connect the indicator to 230V AC main and motor to variac.
- Arrange the sensor (magnetic & photo) suitable so that it is mounted properly to sense the pulses.
- Connect the sensor to instrument.
- Switch ON the instrument and note the reading in display in no velocity mode the display has to be zero.
- Vary the speed of motor by variac and note the reading in digital display.
- By selecting toggle switch we can note the speed reading of either magnetic or photo pickup sensors.

## TABULAR COLUMN:

| SI. No | Magnetic Sensor | Photo Pickup sensor | Speed Measurement by any other model |
|---|---|---|---|
| 01 | 500 | 500 | NO |
| 02 | 1003 | 1005 | NO |
| 03 | 1506 | 1507 | NO |
| 04 | 2004 | 2013 | NO |

## RESULT:

Hence the speed is measured through magnetic and photo pick up sensors.

The average speed measured through magnetic sensor: 1253.25 m/s

The average speed measured through photo pick up sensor: 1256.25 m/s

# CALIBRATION OF RTD

# CALIBRATION OF RTD

## AIM:

To calibrate the given RTD by using Thermometer.

## APPARATUS:

Temperature sensor (RTD), Heating coil to heat water in water bath, Digital temperature Indicator & Thermometer.

## THEORY:

**RESISTANCE TEMPERATURE DETECTOR (RTD)**

Resistance thermometers, also called **resistance temperature detectors or resistive thermal devices (RTD)**, are temperature sensors that exploit the predictable change in electrical resistance of some materials with changing temperature. As they are almost invariably made of platinum, they are often called **platinum resistance thermometers (PTR)**. They are slowly replacing the use of thermocouples in many industrial applications below 600°C, due to higher accuracy and repeatability.

There are many categories like carbon resistors, film and wire wound types are the most widely used.

- **Carbon resistor**s are widely available and are very inexpensive. They have very reproducible results at low temperatures. They are the most reliable from at extremely low temperatures. They generally do not suffer from significant hysteresis or strain gauge effects.

- **Film thermometer** have a layer of platinum on a substrate, the layer may be extremely thin, perhaps one micrometer. Advantages of this type are relatively low cost and fast response. Such devices have improved performance although the different expansion rates of the substrate and platinum give “strain gauge” effects and stability problems.

- **Wire – wound thermometers** can have greater accuracy, especially for wide temperature ranges.

- **Coil elements have** largely replaced wire wound elements in industry. This design has a wire coil which can expand freely over temperature, held in place by some mechanical support which lets the coil keep its shape.

## ADVANTAGES

- High accuracy
- Low drift
- Wide operating range
- Suitable for precision applications.

## PANAL DETALIS:

**POWER ON:** Rocker switch which switches on the supply of the instrument, with red light indication.

**MIN:** Single turn potentiometer. The display can be adjusted to read minimum temperature, when no voltage output from the sensor is measured.

**MAX:** Single turn potentiometer. The output of the amplifier is adjusted by this pot such that the display reads same as in the given reference temperature. i.e. Thermometer temperature reading.

**SELECTOR:** Two-position selector switches to select thermistor or RTD sensor.

**TERMINALS:** Screw type terminals are provided to connect the given Thermister & RTD sensor.

**MAINS SUPPLY:** Power cable. Power cable to be connected to the mains supply of 230V, 50Hz.

**FUSE:** 500 mA cartridge fuse with holder located on the rear side of the instrument to protect the instrument from internal electrical shorting.

**CAUTION:** Do not remove the fuse cap with power cable plugged to the mains supply.

## PROCEDURE:

19. Turn the selector switch to the desire position according to the given sensor probe (Thermister / RTD).
20. Connect the given sensor to the temperature display unit.

21. Place the sensor probe and the thermometer into a beaker containing water at room temperature.
22. Connect the power supply to the temperature indicator.
23. Record the room temperature from the thermometer.
24. Adjust the MIN setting knob of the temperature indicator until the display shows the room temperature.
25. Connect the power supply to hearting coil and heat the water in the bath.
26. Set the temperature of thermocouple to the thermometer reading when the water is boiling, using MAX knob.
27. Now the given thermocouple is calibrated with reference to thermometer. Record the thermometer reading and the temperature indicator reading simultaneously at regular intervals.

## OBSERVATIONS TABULAR COLUMN:

### RTD and Thermometer

| SI. No | Temp. of Water by Thermometer $T_a$ °C | Temp. of Water by RTD $T_m$ °C | Correction $T_a - T_m$ | Error $T_m - T_a$ | % Error $\frac{T_m - T_a}{T_m} * 100$ |
|---|---|---|---|---|---|
| 01 | 30 | 30.5 | -0.5 | 0.5 | 1.639 |
| 02 | 35 | 36.5 | -1.65 | 1.65 | 4.520 |
| 03 | 40 | 43 | -3.0 | 3.0 | 6.976 |
| 04 | 45 | 46.5 | -1.5 | 1.5 | 3.22 |

## GRAPHS:

Draw the following graphs:

- $T_m$ v/s $T_a$
- Correction v/s $T_m$
- % Error v/s $T_m$

## Calculations:

**Correction:** $T_a - T_m$

1. 30- 30.5 = -0.5

2. 35- 36.5 = -1.5

3. 40- 43 = -3.0

4. 45- 46.5 = -1.5

**Error:** $T_m - T_a$

1. 30.5- 30 = 0.5

2. 36.5- 35 = 1.5

3.43- 40 = 3.0

4.46.5- 45 = 1.5

**% Error:** $\frac{T_m - T_a}{T_m} * 100$

1. $\frac{0.5}{30.5} * 100$ = 1.639

2. $\frac{1.5}{36.5} * 100$ = 4.520

3. $\frac{3.0}{43.0} * 100$ = 6.976

4. $\frac{1.5}{46.5}*100$ = 3.22

## RESULT:

Hence I calibrated the RTD with thermometer.

Average % of Error: 4.08875

# CALIBRATION OF ROTAMETER

# STUDY AND CALIBRATION OF ROTAMETER

## INTRODUCTION:

A Rotameter is a device that is used for measuring the rate of flow of fluid through a pipeline. The basic principle on which a Rotameter works is that by variable or straight tube opening inserted with the pre calibrated weight.

In this experiment we are trying to demonstrate how the rotameter can be used as a measuring device using the pre calibrated rotameter.

## 2. DESCRIPTION OF THE APPARATUS:

1. The apparatus consists of a **Rota meter** made of **clear ACRYLIC.**
2. **ACRYLIC Piezometer** is provided to measure the height of the water collected in the **measuring tank**.
3. **Ball valve** is provided in the measuring tank for instant close and release.
4. **Overflow arrangement** is also provided to the tanks.
5. A **supply pump (Kirloskar make)** is provided for supplying the water and a supply tank is provided to store the water.
6. **Vinyl sticker scale** is provided for Piezometer for better readability.
7. The whole arrangement is mounted on an aesthetically designed sturdy frame made of MS angle with all the provisions for holding the tanks and accessories.

## 3. EXPERIMENTATION:

### i. AIM:

The experiment is conducted to know how to calibrate Rota meter at different flow rate.

### ii. PROCEDURE:

1. Fill in the sump tank with clean water.
2. Keep the delivery valve closed.
3. Paste the Log sheet from zero marking on the rotameter to its full height and make marking if necessary.

4. Connect the power cable to 1Ph, 220V, 10 Amps with earth connection.

5. Switch on the pump & open the delivery valve.

6. Adjust the flow through the control valve of the pump.

7. Set the height from the log sheet sticked on the rotameter and note the height in cm the rotameter reading in lpm.

8. Note down the differential head reading in the Manometer. (Expel if any air is the by opening the drain cocks provided with the Manometer.)

9. Operate the Butterfly valve to note down the collecting tank reading against the known time and keep it open when the readings are not taken.

10. Change the flow rate and repeat the experiment.

## OBSERVATIONS:

| SI. No | Time for 'R' cm rise in water 'T' sec | Rotameter Reading 'Q' Lpm | Height measured on Log scale, 'R' cm |
|---|---|---|---|
| 01 | 56 | 10 | 10 |
| 02 | 28 | 20 | 10 |
| 03 | 18 | 30 | 10 |

## iii. CALCULATIONS:

### 1. Theoretical Discharge, $Q_{TR}$

$$Q_{TR} = \frac{Q}{1000 * 60}\ m^3/s$$

Where,

Q = Rotameter reading in LPM

### 2. Actual Discharge, $Q_A$

$$Q_A = \frac{A * R}{t * 100}\ m^3/s$$

Where,

A = Area of collecting tank = 0.125 $m^2$.

R = Rise in water level of the collecting tank, cm.

t = time for 'R' cm rise of water, sec

100 = Conversion from cm to m.

### 3. Co – efficient of discharge, $C_D$

$$C_d = \frac{Q_A}{Q_{TH}}$$

Where,

$Q_A$ = Actual Discharge.

$Q_{TH}$ = Theoretical Discharge from Venturi or Rotameter.

## iv. TABULAR COLUMNS AND GRAPHS:

### A. For Rotameter:

| Height measured on Log scale, cm | Actual Discharge $Q_A$ m³/sec | Theoretical Discharge $Q_{TH}$ m³/sec | Coefficient of Discharge '$C_D$' | Average '$C_D$' |
|---|---|---|---|---|
| 10 | 0.00015 | 0.000166 | 0.975 | 0.958 |
| 10 | 0.0003107 | 0.000333 | 0.933 | |
| 10 | 0.00043 | 0.0005 | 0.966 | |

### B. Graphs:

Draw graph of Actual discharge Vs Height on Log scale

Draw graph of Theoretical Discharge Vs Height on log scale

## 4. PRECAUTIONS:

1) Do not run the pump dry.
2) Clean the tanks regularly, say for every 15days.
3) Do not run the equipment if the voltage is below 180V.
4) Check all the electrical connections before running.
4) Before starting and after finishing the experiment the main control valve should be in close position.
5) Do not attempt to alter the equipment as this may cause damage to the whole system.

## Calculations:

**1. Theoretical Discharge, $Q_{TH}$:**

$$Q_{TH} = \frac{Q}{1000 * 60} \; m^3/s$$

1. $\frac{10}{1000*60}$ = 0.000166 $m^3$/sec

2. $\frac{20}{1000*60}$ = 0.000333 $m^3$/sec

3. $\frac{30}{1000*60}$ = 0.0005 $m^3$/sec

**2. Actual Discharge, $Q_A$:**

$$Q_A = \frac{A * R}{t * 100} \; m^3/s$$

1. $\frac{0.125*10}{56*100}$ = 0.00015

2. $\frac{0.125*10}{28*100}$ = 0.0003107

3. $\frac{0.125*10}{18*100}$ = 0. 00043

**3. Co – efficient of discharge, $C_D$:** $C_D = \frac{Q_A}{Q_{TH}}$

1. $\frac{0.00015}{0.000166}$ = 0.975

2. $\frac{0.0003107}{0.000333}$ = 0.933

3. $\frac{0.00043}{0.0005}$ = 0.966

## RESULTS:

1. Actual Discharge, $Q_A$ = 0.000314 $m^3/s$
2. Theoretical Discharge, $Q_T$ = 0.000333 $m^3/s$
3. Co – efficient of Discharge, $C_d$ = 0.958

# STUDY AND USE OF SEISMIC PICK UP FOR THE MEASUREMENT OF VIBRATION

# STUDY AND USE OF A SEISMIC PICK UP FOR THE MEASUREMENT OF VIBRATION

## AIM:

Measuring vibration by using Piezo electric transducer.

## INTRODUCTION:

Mechanical vibration is something which, people usually like to avoid if they can except in some places where artificial vibration are purposely generated to speed up processes this mechanical vibration, if not within limits may cause damage to the materials, components or structure associated with it under some circumstance such as in transport, on machine floors where the vibration is inevitable, the components associated have withstand these vibrations. If such vibrations can be artificially generated on the components, their stability, reliability ect., at the end of the test can be studied. One such device to generate artificial vibrations is called VIBRATION EXCITER or VIBRATION GENERATOR.

The study and measurement of vibration in any structure or machine is of paramount importance for the following reasons:

1. Undesirable vibration is a waste of energy and causes wear and tear and subsequent breakdown resulting in high maintenance costs.
2. The noise produced due to vibrating bodies or structures cause human fatigue resulting in reduced efficiency.
3. Undamped vibration transmitted to structures (like bridges) might excite vibrations at natural frequency and cause permanent damage.

The instrument along with the above mentioned sensors can be employed for the following application:

1. Studying damping qualities of solids and road surface materials.
2. Monitoring vibrations on structures and machines.
3. Checking vibration severity on machines according to standards.
4. Used for institute balancing of rotors in machines.
5. Used with dampers to isolate vibrations of machines to their foundations and structures.

## OPERATION:

## MOUNTING VIBRATION SENSOR:

Whenever accurate measurement or continuous monitoring is required, the vibration sensor should be mounted such that the axis of the sensor is perpendicular to the direction of vibrating surface.

Whenever fast measurements and vibrations on remote points are required the sensor can be used with extension probe and should be held gently perpendicular to the direction of vibrating surface.

## MEASUREMENT:

Connect the vibration sensor and indicator by means of the connecting cable provided to INPUT socket. The instrument indicates velocity or displacement or frequency of vibration depending on the function switch position. The range switch indicates full scale deflection range of the parameter selected. The multiplier mentioned on the panel meter should multiply the readings.

## RECORDING VIBRATIONS:

The velocity of vibration can be recorded on an oscillograph between AC output terminals. If a visual observation is required on oscilloscope scope can be connected between the same terminals. 200mV RMS signal is available for full scale deflection on velocity range.

If a D.C. recorder is available or continuous monitoring of vibration level is required the same can be connected between D.C. output terminals D.C. voltage is available in velocity and displacement positions A 100mV D.C. signal is available for full scale deflection of meter.

## OPERATING PROCEDURE:

1. Connect the generator cable to power amplifier output connectors (i.e.., red & green).
2. Fix the vibration pickup (i.e. piezo electric sensor) on vibrator generator shaft.
3. Keep the amplitude pot at minimum position.
4. Connect the 3 pin power cable, i.e., both power amplifier & vibration analyzer to 230V / 50Hz AC mains.
5. Connect the vibration pickup cable (red) to vibration analyzer.
6. Switch on the power on switch of both.
7. Slowly rotate the amplitude pot in clockwise direction. So the both analog meter will start show the readings.

8. First select the frequency selector switch to 100 range so that generator will start vibrating depending upon frequency and amplitude.
9. Keep amplitude constant & select the frequency from 50Hz then observe the reading of vibration parameter in vibration analyzer display (analog).
10. Observe different reading for different frequencies.
11. Before switch off the power amplifier, please keep the amplitude pot at minimum position.

## **Tabular column:**

## **Output: (Measurement parameters)**

Acceleration: ± 5% of the reading value

Velocity : ± 5% of the reading value

Displacement: ± 5% of the reading value

| S.No | Frequency in HZ | Indicator Readings | | |
|---|---|---|---|---|
| | | Acceleration in $m/s^2$ | Velocity in cm/s | Displacement in mm |
| 01 | 200 | 85.3 | 4.62 | 0.095 |
| 02 | 400 | 142.4 | 4.22 | 0.046 |
| 03 | 600 | 176.4 | 3.42 | 0.025 |
| 04 | 800 | 203.3 | 2.96 | 0.017 |

# DRAWINGS

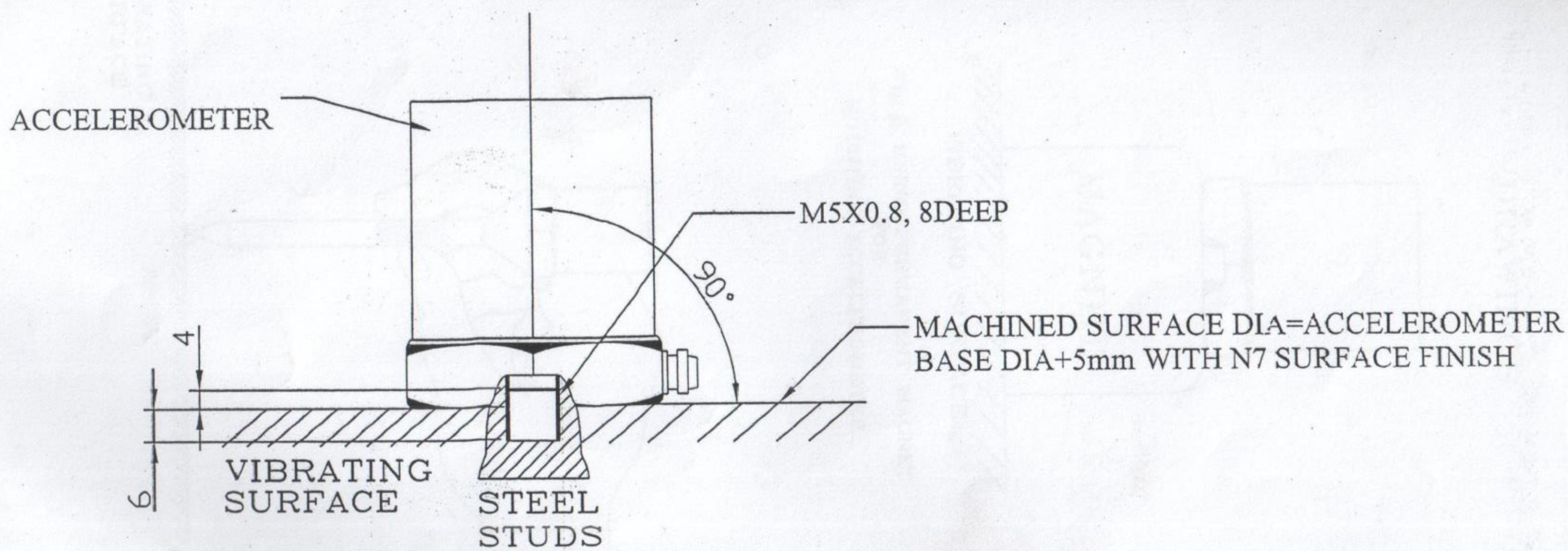



Fig.1 ACCELEROMETER MOUNTED RIGIDLY ON VIBRATING SURFACE

ALL DIMENSIONS ARE IN mm

# DRAWINGS

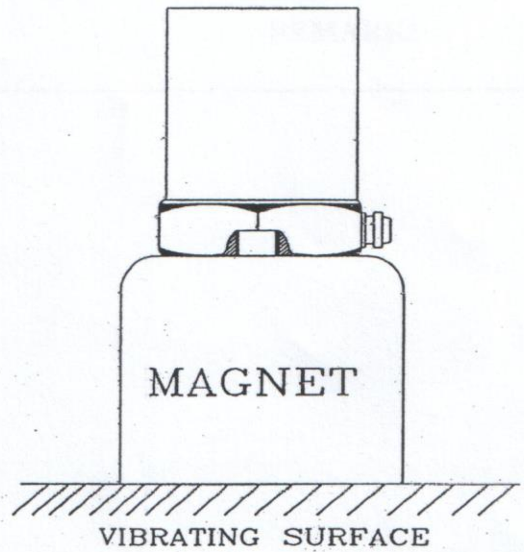



Fig.2 USING PERMANENT MAGNET
FOR
MOUNTING ACCELEROMETER

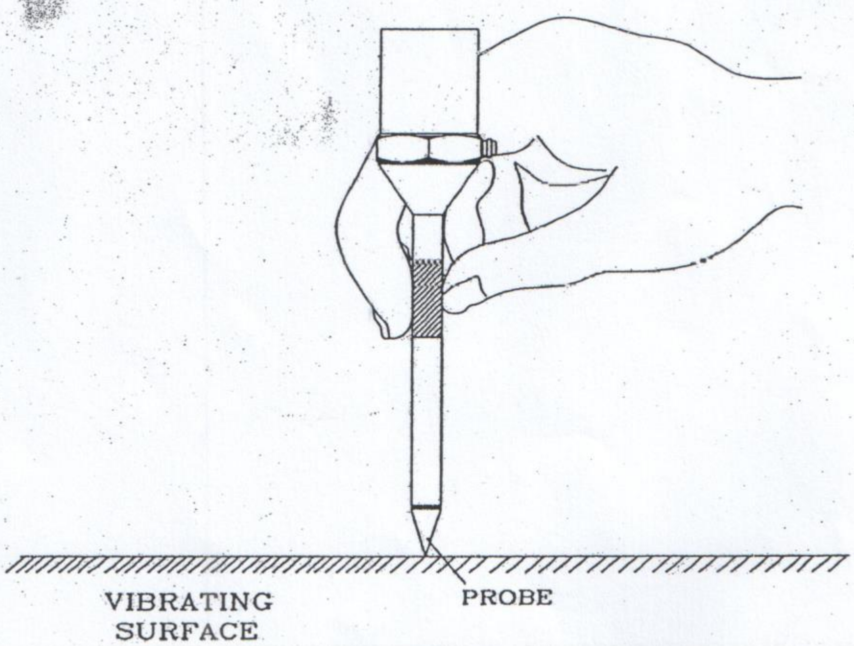



Fig.3 ACCELEROMETER PRESSED
ON VIBRATING OBJECT USING PROBE

## RESULT:

Hence I Measured vibration by using Piezo electric transducer.

The average Frequency : 500 Hz

The average Displacement: 0.04575 mm

The average Velocity : 3.805 cm/s

The average Acceleration: 151.85 $m/s^2$

# CALIBRATION OF McLeod GAUGE

# STUDY AND CALIBRATION OF McLeod GAUGE

## AIM:

To calibrate the given vacuum cell. (Low Pressure Cell)

## APPARATUS:

Vacuum Cell, Dial type Vacuum gauge Vacuum Chamber, Vacuum pump to develop vacuum and digital vacuum indicator.

## THEORY:

In everyday usage, vacuum is a volume of space that is essentially empty of matter, such that its gaseous pressure is much less than atmospheric pressure. The word comes from the Latin for “empty”. A perfect vacuum would be one with no particles in it at all, which is impossible to achieve in practice. Physicists often discuss ideal test results that would occur in a perfect vacuum, which they simply call “vacuum” or “free space”, and use the term partial vacuum to refer to real vacuum. The Latin term in vacuum is also used to describe an object as being in what would otherwise be a vacuum.

Vacuum is useful in a variety of processes and devices. Its first widespread use was in the incandescent light bulb to protect the filament from chemical degradation. The chemical inertness produced by a vacuum is also useful for electron beam welding, cold welding, vacuum packing and vacuum frying. Ultra-high vacuum is used in the study of atomically clean substrates, as only a very good vacuum preserves atomic-scale clean surfaces for a reasonably long time (on the order of minutes to days). High to ultra-high vacuum removes the obstruction of air, allowing particle beams to deposit or remove materials without contamination. This is the principle behind chemical vapor deposition, physical vapor deposition, and dry etching which are essential to the fabrication of semi conductors and optical coatings, and to surface science. The reduction of convection provides the thermal insulation of thermos bottles. Deep vacuum lowers the boiling point of liquids and promotes low temperature out gassing which is used in freeze drying, adhesive preparation, distillation, metallurgy, and process purging. The electrical properties of vacuum make electron microscopes and vacuum tubes possible, including cathode ray tubes. The elimination of air friction is useful for flywheel energy storage and ultracentrifuges.

## DIGITAL VACUUM INDICATOR:

Vacuum indicator comprises of inbuilt power supply which provides power for strain gauge excitation, signal conditioning and amplifying circuits. Access input from the strain gauges leanearizes and amplifies the signal level. The output of the amplifier is controlled to required level and calibrated to read the vacuum in mm/in. Hg. Any stray forces on the sensor can be balanced by balancing the strain gauge bridge through potentiometer, which is provided in the front panel. This system operates by 230v Ac supply.

## PANEL DETAILS:

**POWER ON:** Rocker switch which switches on the supply of the instrument, with red light indication.

**ZERO:** Ten turn potentiometer. The display can be adjusted to read Zero when no force is applied.

**CAL:** Single turn potentiometer. The output of the amplifier is adjusted by this potentiometer such that the display gives full scale for given range of sensor.

**TO SENSOR:** Sensor is connected to the indicator through a four core cable with 5 pin socket at sensor end ends and respective color connections at the other end to connect the instrument.

**MAINS INPUT:** Power cable. Power cable to be connected to the mains supply of 230V 50Hz.

**FUSE:** 500 mA cartridge fuse with holder located on the rear side of the instrument to protect the instrument from internal electrical shorting.

**CAUTION:** Do not remove the fuse cap with power cable plugged to the mains supply.

## PROCEDURE:

- Connect the vacuum cell to the vacuum indicator through given cable.
- Connect the instrument to mains i.e. 230V power supply and switch on the instrument.
- Adjust the zero pot on the indicator, to indicate zero.
- Connect the vacuum pump to 230V AC mains.
- Close the outlet valve of the vacuum chamber and open the inlet valve.
- Switch on the pump.
- Wait until vacuum reaches maximum level.

- Now read the vacuum gauge reading and adjust the CAL pot of the digital indicator to same vacuum. Now the given vacuum cell is calibrated.
- Close the inlet valve and switch of the vacuum pump.
- Now solely open the outlet valve and down the reading of dial gauge and digital indicator.
- Calculate the error if any and plot the graph of dial gauge reading v/s Digital reading.

## TABULAR COLUMN:

| SI. No | Vacuum in Dial gauge in. Hg $P_c$ | Vacuum in Digital Indicator, in Hg $P_g$ | Correction $P_c - P_g$ | Error $P_g - P_c$ | % Error $\frac{P_g - P_c}{Pg} * 100$ |
|---|---|---|---|---|---|
| 01 | 25 | 26.6 | -1.6 | 1.6 | 6.015 |
| 02 | 20 | 20.9 | -0.9 | 0.9 | 4.306 |
| 03 | 15 | 15.1 | -0.1 | 0.1 | 0.662 |

## Calculations:

**Correction:** $P_c - P_g$

1. 25- 26.6 = -1.6
2. 20 – 20.9 = - 0.9
3. 15- 15.1 = - 0.1

**Error:** $P_g - P_c$

1. 26.6 – 25 = 1.6
2. 20.9 – 20 = 0.9
3. 15.1 – 15 = 0.1

**% Error:** $\frac{P_g - P_c}{Pg} * 100$

1. $\frac{1.6}{26.6} * 100$ = 6.015

2. $\frac{0.9}{20.9} * 100$ = 4.306

3. $\frac{0.1}{15.1} * 100$ = 0.662

## RESULT:

Hence I calibrated the given McLeod gauge.

Average % of error: 3.661

# COMPARISION OF TEMPERATURE BETWEEN THERMISTER AND RTD

# COMPARISION OF TEMPERATURE BETWEEN THERRMISTOR AND RTD WITH REFERENCE TO THERMOMETER

## AIM:

To compare the temperature between Thermister & RTD wit reference to Thermometer.

## APPARATUS:

Temperature sensor (Thermister & RTD), Heating coil to heat water in water bath, Digital temperature Indicator & Thermometer.

## THEORY:

A Thermister is a type of resistor whose resistance varies significantly with temperature, more so than in standard resistors. The word is a portmanteau of thermal and resistor. Thermister are widely used as inrush current limiters, temperature sensor, self-resetting over current protectors and self-regulating heating elements.

Thermister differ from resistance temperature detectors (RTD) in that the material used in a Thermister is generally a ceramic or polymer, while RTD's use pure metals. The temperature response is also different, RDT's are useful over larger temperature ranges, while Thermister typically achieve a higher precision within a limited temperature range (usually – 90 $^{o}C$ to 130 $^{o}C$). Assuming, as a first order approximation, that the relationship between and temperature is linear, then

$\Delta R = k\ \Delta T$

Where,

$\Delta R$ = change in resistance

$\Delta T$ = change in temperature

k = first order temperature co-efficient of resistance

Thermister can be classified into two types, depending on the sign of k. if k is positive, the resistance increases with increasing temperature, and the device is called a positive temperature co-efficient (PTC) Thermister or posistor. If k is negative, the resistance decreases with increasing temperature, and the device is called a negative temperature co-efficient (NTC) thermistor.

Resistors that are not thermistor are designed to have a k as close to zero as possible, so that their resistance remains nearly constant over a wide temperature range.

## RESISTANCE TEMPERATURE DETECTOR (RTD):

Resistance thermometers, also called **resistance temperature detectors or resistive thermal devices (RTD)**, are temperature sensors that exploit the predictable change in electrical resistance of some materials with changing temperature. As they are almost invariably made of platinum, they are often called **platinum resistance thermometers (PTR)**. They are slowly replacing the use of thermocouples in many industrial application below 600°C, due to higher accuracy and repeatability.

There are many categories like carbon resistors, film and wire wound types are the most widely used.

- ***Carbon resistor***s are widely available and are very inexpensive. They have very reproducible results at low temperatures. They are the most reliable from at extremely low temperatures. They generally do not suffer from significant hysteresis or strain gauge effects.
- ***Film thermometer*** have a layer of platinum on a substrate, the layer may be extremely thin, perhaps one micrometer. Advantage of this type are relatively low cost and fast response. Such devices have improved performance although the different expansion rates of the substrate and platinum give “strain gauge” effects and stability problems.
- ***Wire – wound thermometers*** can have greater accuracy, especially for wide temperature ranges.
- ***Coil element*** have largely replaced wire wound elements in industry. This design has a wire coil which can expand freely over temperature, held in place by some mechanical support which lets the coil keep its shape.

### ADVANTAGES:

- High accuracy
- Low drift
- Wide operating range
- Suitable for precision applications.

**PANEL DETALIS:**

**POWER ON:** Rocker switch which switches on the supply of the instrument, with red light indication.

**MIN:** Single turn potentiometer. The display can be adjusted to read minimum temperature, when no voltage output from the sensor is measured.

**MAX:** Single turn potentiometer. The output of the amplifier is adjusted by this pot such that the display reads same as in the given reference temperature. i.e. Thermometer temperature reading.

**SELECTOR:** Two-position selector switches to select thermistor or RTD sensor.

**TERMINALS:** Screw type terminals are provided to connect the given Thermister & RTD sensor.

**MAINS SUPPLY**: Power cable. Power cable to be connected to the mains supply of 230V, 50Hz.

**FUSE:** 500 mA cartridge fuse with holder located on the rear side of the instrument to protect the instrument from internal electrical shorting.

**CAUTION:** Do not remove the fuse cap with power cable plugged to the mains supply.

## PROCEDURE:

28. Turn the selector switch to the desire position according to the given sensor probe (Thermister / RTD).
29. Connect the given sensor to the temperature display unit.
30. Place the sensor probe and the thermometer into a beaker containing water at room temperature.
31. Connect the power supply to the temperature indicator.
32. Record the room temperature from the thermometer.
33. Adjust the MIN setting knob of the temperature indicator until the display shows the room temperature.
34. Connect the power supply to hearting coil and heat the water in the bath.
35. Set the temperature of thermocouple to the thermometer reading when the water is boiling, using MAX knob.

36. Now the given thermocouple is calibrated with reference to thermometer. Record the thermometer reading and the temperature indicator reading simultaneously at regular intervals.

**OBSERVATION AND TABULAR COLUMN:**

**Thermister, RTD and Thermometer**

| Sl. no | Temp. of Water by Thermometer, $T_a$ °C | Temp. of Water by Thermister, $T_{M1}$ °C | Temp.of Water by RTD, $T_{M2}$ °C | Error $T_{M1} - T_{M2}$ | % Error $\frac{T_{M1}-T_{M2}}{T_{M2}} * 100$ |
|---|---|---|---|---|---|
| | 35 | 35.5 | 35 | 0.5 | 1.428 |
| | 40 | 45.1 | 41 | 4.1 | 10 |
| | 45 | 51 | 44.5 | 6.5 | 14.606 |

**GRAPHS:**

Draw the following graphs:

- $T_m$ v/s $T_a$
- Correction v/s $T_m$
- % Error v/s $T_m$

**RESULT:**

Hence I compared the temperature of RTD and thermister with reference to thermometer.

Average % of Error: 8.678