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Name
Roll No. Year 20 20
Exam Seat No.

CHEMICAL GROUP | SEMESTER - IV | DIPLOMA IN ENGINEERING AND TECHNOLOGY

A LABORATORY MANUAL FOR

CHEMICAL PROCESS INSTRUMENTATION & CONTROL (22407)

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI
(Autonomous) (ISO 9001 : 2015) (ISO / IEC 27001 : 2013)

VISION

To ensure that the Diploma level Technical Education constantly matches the latest requirements of technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

MISSION

To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the changing technological and environmental challenges.

QUALITY POLICY

We, at MSBTE are committed to offer the best in class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation, evaluation and monitoring system along with adequate faculty development programmes.

CORE VALUES

MSBTE believes in the followings:

- Education industry produces live products.
- Market requirements do not wait for curriculum changes.
- Question paper is the reflector of academic standards of educational organization.
- Well designed curriculum needs effective implementation too.
- Competency based curriculum is the backbone of need based program.
- Technical skills do need support of life skills.
- Best teachers are the national assets.
- Effective teaching learning process is impossible without learning resources.

A Laboratory Manual
for

Chemical Process Instrumentation and Control

(22407)

Semester – IV

(CH)

Maharashtra State
Board of Technical Education, Mumbai

(Autonomous) (ISO 9001:2015) (ISO/IEC 27001:2013)

Maharashtra State Board of Technical Education,
(Autonomous) (ISO 9001 : 2015) (ISO/IEC 27001 : 2013)
4th Floor, Government Polytechnic Building, 49, Kherwadi,
Bandra (East), Mumbai - 400051.
(Printed on November 2018)

Maharashtra State
Board of Technical Education

Certificate

This is to certify that Mr. / Ms. …………………………………… Roll No……………………… of Fourth Semester of Diploma in Chemical Engineering of Institute …………………………… …………………… (Code………………..) has completed the term work satisfactorily in course **Chemical Process Instrumentation and Control (22407)** for the academic year 20…….to 20…..... as prescribed in the curriculum.

Place ………………. Enrollment No……………………

Date:…..................... Exam Seat No. ………………….....

Course Teacher **Head of the Department** **Principal**

Seal of the Institute

Preface

The primary focus of any engineering laboratory/ field work in the technical education system is to develop the much needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'I' Scheme curricula for engineering diploma programmes with outcome-base education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher; instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a ***'vehicle'*** to develop this industry identified competency in every student. The practical skills are difficult to develop through 'chalk and duster' activity in the classroom situation. Accordingly, the 'I' scheme laboratory manual development team designed the practical's to ***focus*** on the ***outcomes***, rather than the traditional age old practice of conducting practical's to 'verify the theory' (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the competency, industry relevant skills, course outcomes and practical outcomes which serve as a key focal point for doing the practical. The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

In Chemical Engineering discipline, Chemical Instrumentation and Process Control is an ancillary subject which aims at imparting the necessary interdisciplinary skills among students. The subject deals with the theory and practice of various measurement and control techniques adopted for processes. In chemical industries, parameters like temperature, pressure, level and flow are measured in real-time and controlled automatically so as to run the unit processes effectively. The accurate monitoring and control of these parameters in turn maximize profitability, ensure quality and safety..

Although all care has been taken to check for mistakes in this laboratory manual, yet it is impossible to claim perfection especially as this is the first edition. Any such errors and suggestions for improvement can be brought to our notice and are highly welcome.

Programme Outcomes (POs) to be achieved through Practical of this Course:

Following POs and PSO are expected to be achieved through the practicals of Technology of Organic Chemicals.

PO1. **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the Chemical **Engineering** problems

PO3. **Experiments and practice:** Plan to perform experiments and practices to use the results to solve technical problems related to **Chemical Engineering**.

PO4. **Engineering tools:** Apply relevant technologies and **Chemical Engineering** tools with an understanding of the limitations.

PO7 **Ethics:** Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of chemical engineering.

PO8 **Individual and team work:** Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PO 9 **Communication:** Communicate effectively in oral and written form.

PSO2. **Material management and quality control:** Manage chemicals and equipment to produce quality chemical products.

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List of Industry Relevant Skills

The following industry relevant skills of the competency 'Qualitative & analytical skills' are expected to be developed in you by undertaking the practicals of this practical manual.

1. Understand the importance of industrial measurement & control in chemical processes
2. Familiarize various measurement& control technologies in manufacturing processes.
3. Select and use relevant methods.

Practical - Course Outcome matrix

Course Outcomes (COs):-

a. Select the Instrument for various chemical Processes.
b. Use temperature measuring instruments in chemical industry.
c. Use Pressure measuring instruments in chemical industry.
d. Measure the flow level using various measuring instruments in chemical industry.
e. Select control system for various actions in chemical industry.

S. No.	Practical Outcome	CO a.	CO b.	CO c.	CO d.	CO e.
1.	Calibrate resistance thermometer and draw calibration curve.	-	√	-	-	-
2.	Measure temperature using Resistance temperature Detector.	√	√	-	-	-
3.	Use thermocouple for temperature measurement.	√	√	-	-	-
4.	Use pyrometer for high temperature measurement.	√	√	-	-	-
5.	Calibrate pressure gauge using Dead-weight tester.	-	-	√	-	-
6.	Measure pressure by using linear variable Differential Transducer.(LVDT).	-	-	√	-	-
7.	Use strain gauge for pressure measurement.	-	-	√	-	-
8.	Use McLeod gauge for measurement of low pressure.	-	-	√	-	-
9.	Measure the flow of fluid using electromagnetic flow meter.	-	-	-	√	-
10.	Use turbine flow meter for measurement of fluid.	-	-	-	√	-
11.	Use air purge method for level measurement of liquid in tank.	-	-	-	√	-
12.	Use capacitance probe method for level measurement of liquid in tank.	-	-	-	√	-
13.	Use ON-OFF controller for temperature control system.	-	-	-	-	√
14.	Use PI controller for temperature control system.	-	-	-	-	√
15.	Use PID controller for temperature control system.	-	-	-	-	√
16.	Determine % flow and % valve opening of control valve and draw characteristics of control valve.	-	-	-	-	√

Guidelines to Teachers

1. ***Teacher need to ensure that a dated log book*** for the whole semester, apart from the laboratory manual is maintained by every student which s/he has to ***submit for assessment to the teacher*** in the next practical session.
2. There will be two sheets of blank pages after every practical for the student to report other matters (if any), which is not mentioned in the printed practicals.
3. For difficult practicals if required, teacher could provide the demonstration of the practical emphasizing of the skills which the student should achieve.
4. Teachers should give opportunity to students for hands-on after the demonstration.
5. Assess the skill achievement of the students and COs of each unit.
6. One or two questions ought to be added in each practical for different batches. For this teachers can maintain various practical related question bank for each course.
7. If some repetitive information like data sheet, use of software tools etc. has to be provided for effective attainment of practical outcomes, they can be incorporated in Appendix.
8. For effective implementation and attainment of practical outcomes, teacher ought to ensure that in the beginning itself of each practical, students must read through the complete write-up of that practical sheet.
9. During practical, ensure that each student gets chance and takes active part in taking observations/ readings and performing practical.
10. Teacher ought to assess the performance of students continuously according to the MSBTE guidelines

Instructions for Students

1. For incidental writing on the day of each practical session every student should maintain a ***dated log book*** for the whole semester, apart from this laboratory manual which s/he has to ***submit for assessment to the teacher*** in the next practical session.
2. For effective implementation and attainment of practical outcomes, in the beginning itself of each practical, students need to read through the complete write-up including the practical related questions and assessment scheme of that practical sheet.
3. Student ought to refer the data books, IS codes, Safety norms, Electricity act/rules, technical manuals, etc.
4. Student should not hesitate to discuss any difficulties they face during the conduct of practicals.

Content Page

List of Practicals and Progressive Assessment Sheet

Note: To be transferred to Proforma of CIAAN-2017.

Practical No.1: Calibration of resistance thermometer

I. Practical Significance

Calibration of any instrument is performed to verify its performance and to insure that it maintains specification over time and changing ambient conditions. There are many ways of doing calibration check of any instrument. Aim of this experiment is to perform calibration check on a resistance thermometer, using a standard instrument for comparison.

II. Relevant Program Outcomes (POs)

***PO1* –** Basic Knowledge: Apply knowledge of basic mathematics, Sciences and basic engineering to solve the chemical engineering problems.

PO3 - Experiments and practice: Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.

PO4 - Engineering tools: Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.

PO8 - Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PO 9. Communication: Communicate effectively in oral and written form.

PSO2 - Material management and quality control: Manage chemicals and equipment to produce quality chemical products

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry-identified competency: **'Apply relevant process control parameter in chemical plants':**

1. Calibrate RTD thermometer for a specific range of temperature.
2. Select RTD thermometer for different temperature ranges and applications.
3. Use RTD thermometer for temperature measurement.

IV. Relevant Course Outcomes -

1. Use temperature measuring instruments in chemical industry.

V. Practical Outcome

Calibrate and Measure temperature using mercury thermometer

VI. Relevant Affective domain related Outcome(s)

1. Follow safe practices
2. Practice energy conservation
3. Demonstrate working as a leader/a team member
4. Maintain tools and equipment
5. Follow ethical practices

VII. Minimum Theoretical Background

Resistance thermometers also called Resistance Temperature Detectors (RTDs), are sensors used to measure temperature. Many RTD elements consist of a length of fine wire wrapped around a ceramic or glass core but other constructions are also used. The material of wire has an accurate linear resistance/temperature relationship which is used to provide an indication of temperature.

RTDs are calibrated to generate an R vs. T table or to determine if they are within a predefined tolerance. It is done by comparing it with a known standard, in a stable temperature environment. Calibration baths (water bath) or dry-wells can provide a suitable range of stable temperatures. Figure1 shows the construction of an industrial platinum resistance thermometer. Figure 2 shows the calibration curve for RTD.

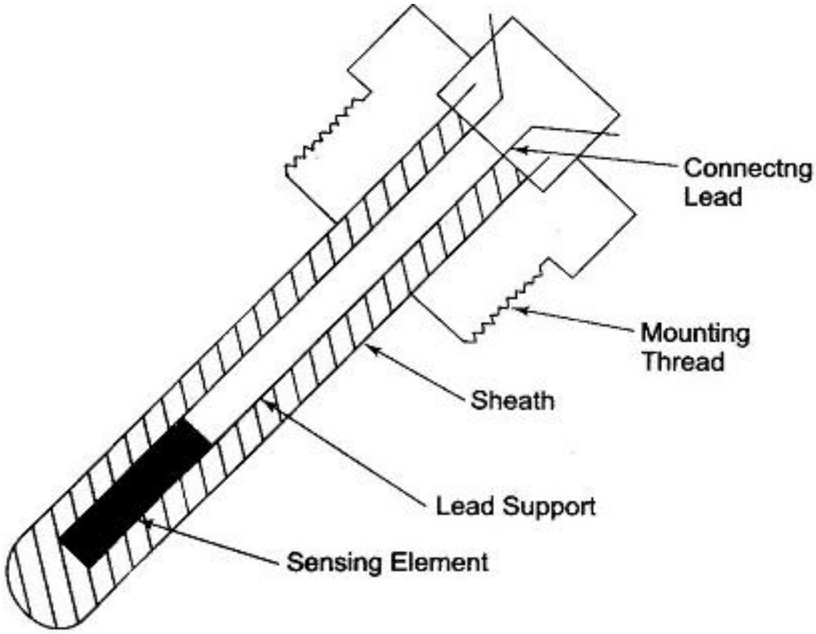

Figure1: Industrial Platinum Resistance Thermometer (PRT)

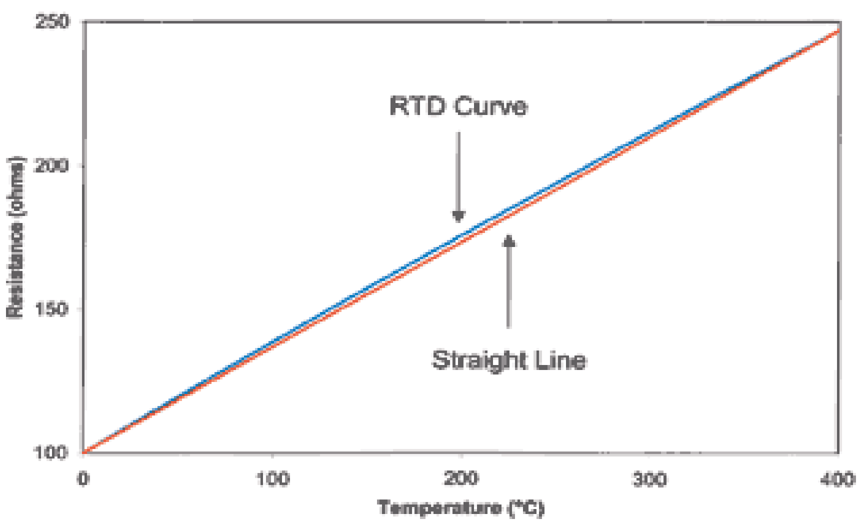

Figure 2: Calibration curve of RTD

(Courtesy: http://www.prelectronics.com/support/pr-knowledge-library/tips-and-tricks/linearization-of-temperature-measurements)

VIII. Practical circuit diagram :-

a) Sample

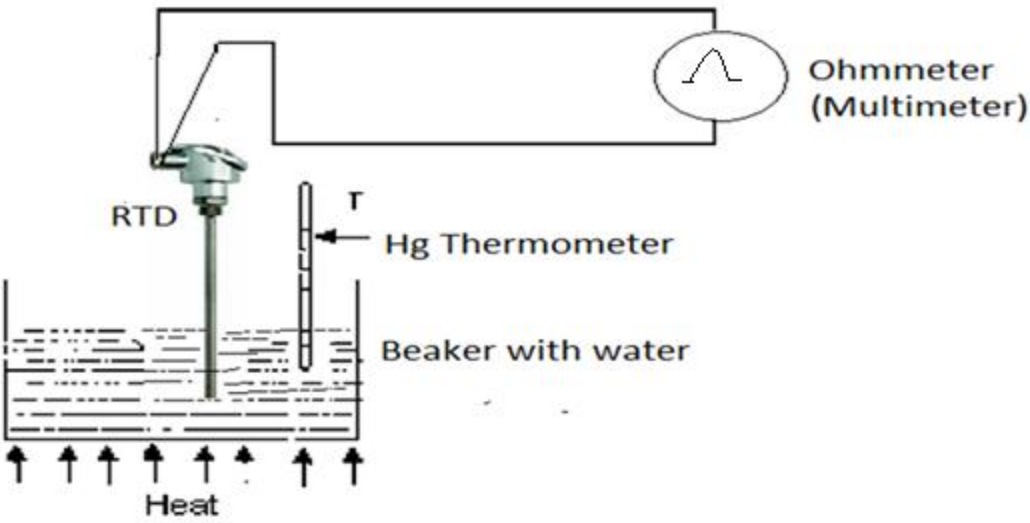

Figure 3

(Courtesy: http://www.prelectronics.com/support/pr-knowledge-library/tips-and-tricks/linearization-of-temperature-measurements)

b) Actual Experimental set up used in laboratory

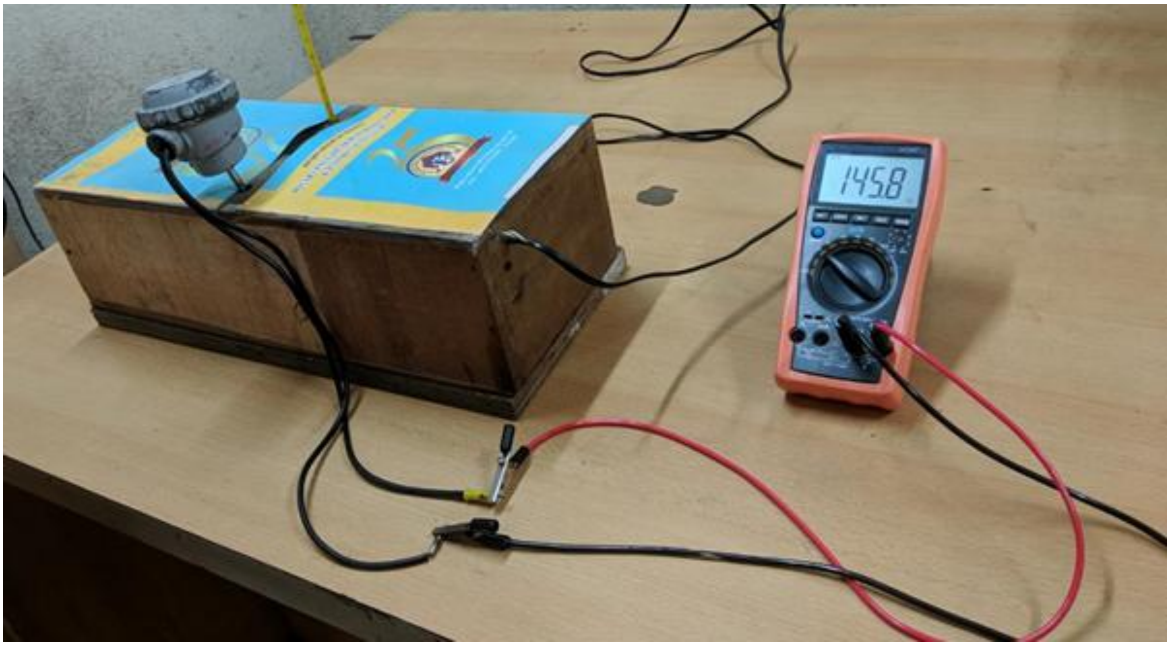

Figure 4

c) Actual Experimental set up used in laboratory

IX. Resources required

S. No.	Instrument /Components	Specification	Quantity
1.	RTD	Pt100	1
2.	Mercury-in-glass thermometer	$0\text{-}150^0C$	1
3.	Temperature-well	Metal box fitted with 230v, 200w incandescent lamp	1
4.	Digital multimeter	Ohm meter, auto range	1
5.	Connecting wires	Flexible multi-stranded	1 pair
6.	AC supply	1∅, 230v, 50Hz	1

X. Precautions

1. In case of water-bath, care must be taken to prevent water from spilling.
2. Wear heat resistant gloves while handling a hot bath.
3. Place the thermometer upright in the bath.
4. Ensure proper setting of range on multimeter.

XI. Procedure

1. Immerse the RTD into a temperature-well capable of covering the required temperature range.
2. Place a temperature standard (Mercury-in-glass thermometer) into the temperature-well for comparison.
3. Connect the RTD to an ohm meter (Digital multimeter).
4. Switch on the temperature-well.
5. Record the readings of the thermometer and RTD, simultaneously at regular intervals of time up to the required temperature range.
6. Compare the measured resistances to the expected resistance from the applicable temperature table and reading of thermometer.
7. Calculate the change in resistance per unit change in temperature and % error.
8. Plot calibration graph temperature Vs $R_{practical}$.

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity	Remarks
1				
2				
3				
4				

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations:

Table 1: Measurement of Temperature and resistance

(Data sheet of RTD should be made available to the students in the laboratory).

Sr.No.	T(^{0}C)	Rpractical(Ω)	Rtheoretical(Ω) (RTD table)	%error	$\frac{dR(practical)}{dT}$ (Ω/^{0}C)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

$$\% \text{ error} = \frac{\text{Rtheoretical} - \text{Rpractical}}{\text{Rtheoretical}} \text{ X } 100\%$$

The change in resistance per unit change in temperature, for two consecutive Readings,

$$\frac{dR(practical)}{dT} = \frac{lower\ value\ resistance - upper\ value\ \ resistance}{lower\ value\ of\ temperature - upper\ value\ of\ temperature}$$

XVI. Results

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XVII. Interpretation of results

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XVIII. Conclusions & Recommendation

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XIX. Practical related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Define calibration.
2. List the different temperature scales.
3. Tabulate the errors indicated in measurement referring to the data sheet (conversion table) of Pt100 RTD.

[Space for Answers]

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XX. References / Suggestions for further Reading

1. http://www.physicsclassroom.com/class/thermalP/Lesson-1/Temperature-and-Thermometers
2. http://hk-phy.org/contextual/heat/tep/tempe/
3. www.burnsengineering.com/local/.../Calibration-Why_When_How_Handout.pdf

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (10 Marks)		**(40%)**
1	Handling of the equipment/measuring instruments	20%
2	Plotting graph / calculations	20%
Product related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. …………………………
2. …………………………
3. …………………………
4. …………………………

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Scale

X-axis -

Y-axis -

Practical No.2: Measurement of temperature using RTD

I. Practical Significance

Temperature is one of the most important measurement parameters that is used for monitoring and control of processes in various industries. It can be measured with the help of a variety of temperature sensing devices which reacts to a change in temperature it is exposed to by varying its parameter. One such device is a resistance temperature detector, commonly called RTD (Resistance Temperature Detector) which converts temperature into an equivalent resistance. Aim of this experiment is to measure temperature using RTD.

II. Relevant Program Outcomes (POs)

PO1 – Basic Knowledge: Apply knowledge of basic mathematics, Sciences and basic engineering to solve the chemical engineering problems.

PO3. - Experiments and practice: Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.

PO4. - Engineering tools: Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.

PO8. - Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

Program Specific Outcomes (PSO)

PSO2. - Material management and quality control: Manage chemicals and equipment to produce quality chemical products.

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry-identified competency: **'Apply relevant process control parameter in chemical plant':**

1. Identification of RTD.
2. Select RTDs for different temperature ranges.
3. Mounting of RTD.
4. Use Digital multimeter to measure the output of RTD.

IV. Relevant Course Outcomes -

1. Select the instrument for various chemical processes.
2. Use temperature measuring instruments in chemical industry.

V. Practical Outcome

Measure temperature using Resistance temperature Detector

VI. Relevant Affective domain related Outcome(s)

1. Follow safe practices
2. Practice energy conservation
3. Demonstrate working as a leader/team member
4. Maintain tools and equipment

VII. Minimum Theoretical Background

RTD is a linear passive transducer used for the measurement of temperature. These are made up of metal wire or fiber material that responds to temperature change by changing resistance. Platinum, nickel, and tungsten are most commonly used that have high resistivity, good temperature coefficient of resistance, good tensile strength and chemical inertness with packaging and insulation materials. The change in resistance can be measured using an ohmmeter or converted into a voltage using a bridge circuit. RTDs are generally more accurate than thermocouples, but are less rugged and cannot be used at high temperatures. The most commonly used RTD is PT100. For small ranges of temperatures the expression for resistance may be,

$$R_2 = R_1 \{1 + a_{t1} (t_2 - t_1)\}$$

t_1, t_2 – initial and final temperatures

R_1, R_2 – initial and final resistances

a_{t1} - Temperature coefficient of resistance at initial temperature.

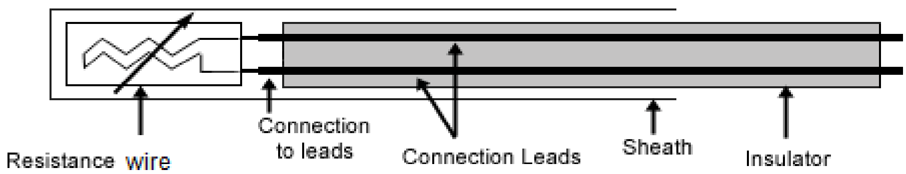

Figure 1: Schematic diagram of RTD

Courtesy: (https://en.wikipedia.org/wiki/Resistance_thermometer#/media/File:Rtdconstruction.gif)

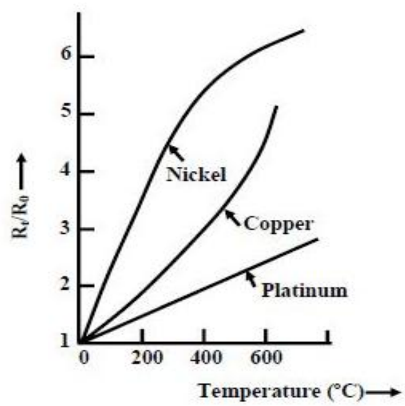

Figure 2: Performance characteristics of different RTD materials

VIII. Practical Circuit Diagram:

a) Sample

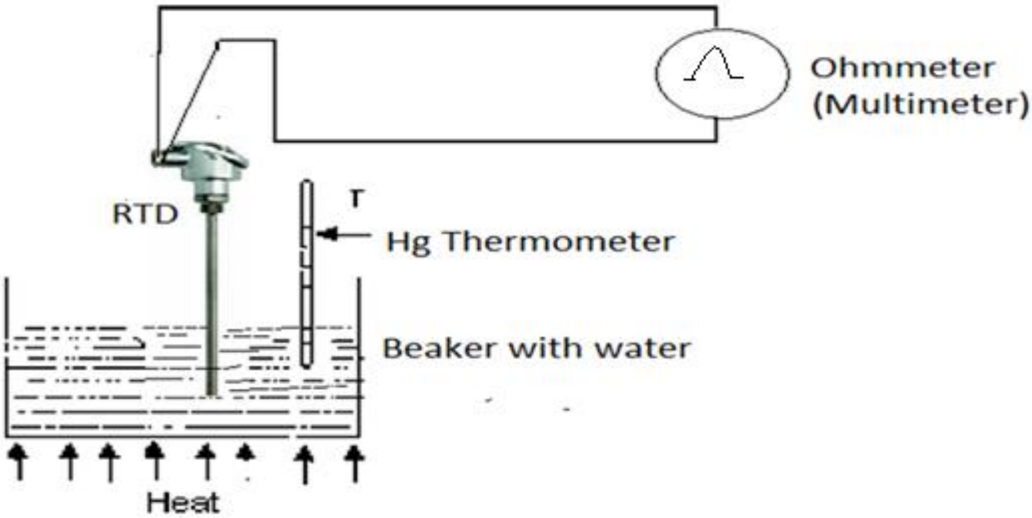

Figure: 3

b) Actual Circuit used in laboratory

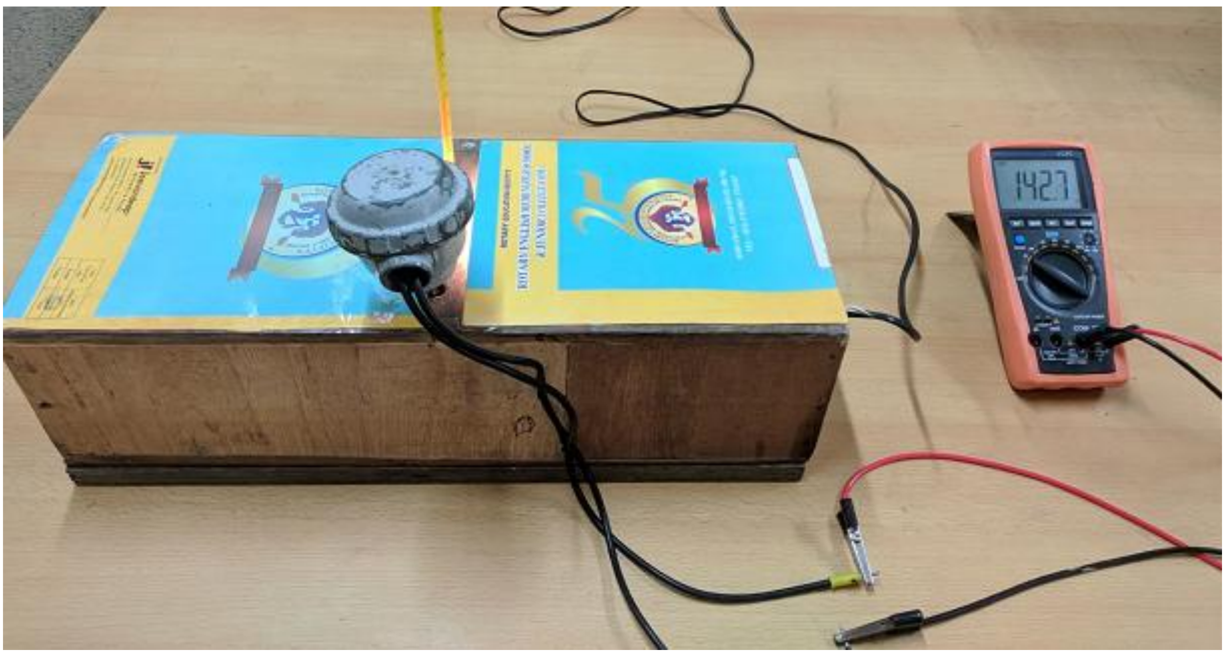

Figure 4

c) Actual Experimental set up used in laboratory

IX. Resources required

S. No.	Instrument /Components	Specification	Quantity
1	RTD	PT 100	1
2	Thermometer	Mercury–in-glass thermometer (0-150^{0}C)	1
3	Temperature-well	Two lamps rated 230V, 200W fitted inside a wooden box	1
4	Digital multimeter	Ohm meter, auto range	1
5	Connecting wires	Flexible, multi-stranded	1 pair

X. Precautions

1. Ensure the heating system is in good working condition to avoid any electrical hazard.
2. Don’t use wet hands while operating electrical connections.
3. Place the thermometer upright in the heating system.
4. Ensure proper setting of range on multimeter.

XI. Procedure

1. Arrange/connect the experimental set up as per the given diagram.
2. Keeping in the resistance mode switch on the multimeter.
3. Place the thermometer upright inside the temperature-well.
4. Note down readings of thermometer and multimeter at room temperature.
5. Switch on the temperature-well.
6. Note down thermometer and multimeter readings simultaneously at regular intervals of time.
7. Now, switch off the temperature-well.
8. Repeat step no. 6 for decrease in temperature.
9. Plot the graph temperature Vs resistance.

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
1			
2			
3			
4			
5			

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations:

Table 1: Measurement of T and R

S.No.	T(^{o}C)	R(Ω)
1		
2		
3		
4		
5		
6		
7		
8		
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10		

XVI. Results

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XVII. Interpretation of results

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XVIII. Conclusions & Recommendation

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XIX. Practical related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. State the classification of RTDs along with materials used and temperature ranges.
2. Enlist any four temperature measuring devices.
3. State any two advantages and disadvantages of RTD.

[Space for Answers]

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XX. References / Suggestions for further Reading

1. https://www.azom.com/article.aspx?ArticleID=5573
2. https://www.omega.com/Temperature/pdf/RTD_GEN_SPECS_REF.pdf
3. https://www.electrical4u.com/resistance-temperature-detector-or-rtd-construction-and-working-principle/

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (10 Marks)		**(40%)**
1	Handling of the equipment/measuring instruments	20%
2	Plotting graph / calculations	20%
Product related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25Marks)		**100 %**

Names of Student Team Members

1..…………………………
2.…………………………
3. ………………………
4.………………………

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Scale

X-axis -

Y-axis -

Practical No.3: Measurement of temperature using thermocouple

I. Practical Significance

Thermocouple is an electrical temperature transducer used to measure temperature. It is the most commonly used temperature sensor with lot of applications in diversified chemical industries. Aim of this experiment is to measure temperature using a thermocouple.

II. Relevant Program Outcomes (POs)

PO1 – Basic Knowledge: Apply knowledge of basic mathematics, Sciences and basic engineering to solve the chemical engineering problems.

PO3. - Experiments and practice:
Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.

PO4. - Engineering tools: Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.

PO8. - Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

Program Specific Outcomes (PSO)

PSO2. - Material management and quality control: Manage chemicals and equipment to produce quality chemical products.

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry-identified competency: **'Apply relevant process control parameter in chemical plants':**

1. Use Thermocouple for specific temperature measurement.
2. Select the specific type of thermocouple for different temperature ranges and applications.

IV. Relevant Course Outcomes -

1. Select the instrument for temperature measurement in chemical processes.
2 Use temperature measuring instruments in chemical industry.

V. Practical Outcome

Use thermocouple for temperature measurement.

VI. Relevant Affective domain related Outcome(s)

1. Follow safe practices
2. Practice energy conservation
3. Demonstrate working as a leader/team member
4. Maintain tools and equipment

VII. Minimum Theoretical Background -

Thermocouples consist of two wires made from dissimilar metals which are welded together at one end, creating a junction. Its working is based on Seebeck effect. It states that when there is a temperature difference between two junctions hot and cold, an electromotive force (emf) is generated across the junction, which is proportional to the temperature difference across the junctions.

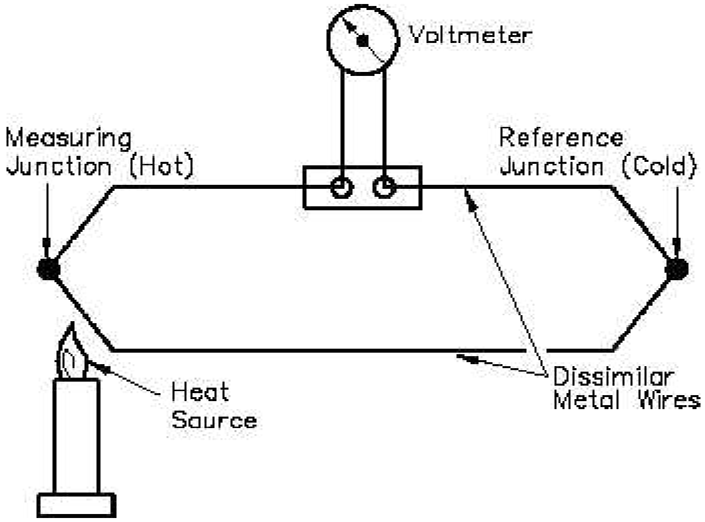

Figure 1: The circuit of thermocouple

Thermocouples are available in different combinations of metals. Base metal thermocouples or type K, J, T, & E are relatively low cost and therefore the most popular. These are commonly used in a broad range of low to medium temperature applications. Noble metal thermocouples or type R, S, and B used in high temperature applications.

Practical Circuit Diagram:

a) Sample diagram:

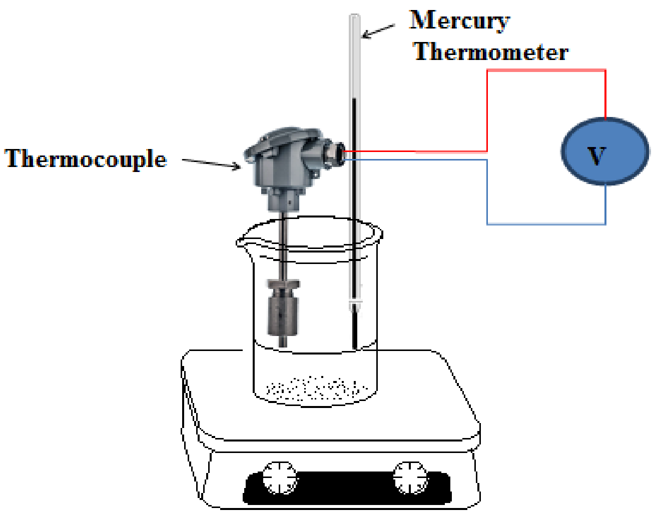

Figure 2

b) Actual Circuit used in laboratory

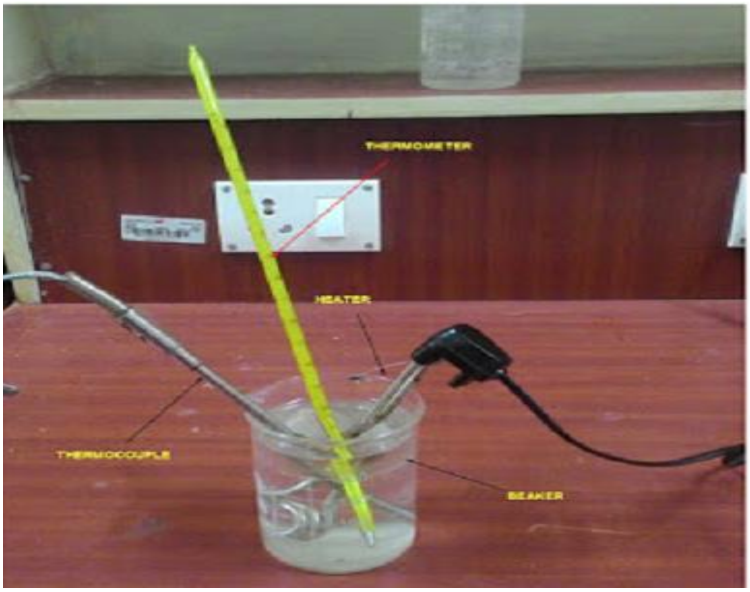

Figure 3

c) Actual Experimental set up used in laboratory

VIII. Resources required

S. No.	Instrument /Components	Specification	Quantity
1	Thermocouple	Iron – constantan (J type)	1
2	Temperature meter	0 - 150^{0}C	1
3	Heating source	230V, 1kW immersion type heater	1
4	Beaker	1litre measure	1
5	Digital multimeter	(milli voltmeter), auto range	1
6	Connecting wires	Flexible, multi-stranded	1 pair

IX. Precautions

1. Ensure the heating system is in good working condition to avoid any electrical hazard.
2. Don't use wet hands while operating instruments.
3. Wear heat resistant gloves when handling a heat source and thermocouple.
4. Place the thermometer upright in the water bath/ heat source.
5. Ensure proper wiring and connections.

X. Procedure

1. Arrange/connect the experimental set up as per the given diagram.
2. Keeping in DC voltmeter mode, switch on the multimeter.
3. Place the Thermocouple and thermometer inside the beaker.
4. Note down readings of Thermocouple and multimeter (milli volt) at room temperature.
5. Switch on the heater.
6. Note down temperature and multimeter readings simultaneously at regular intervals of time, up to the required range.it.
7. Now, switch off the heater.
8. Repeat step no. 6 for a decrease of temperature.
9. Plot the graph temperature Vs voltage.

XI. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
1			
2			
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XII. Actual procedure followed

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XIII. Precautions followed

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XIV. Observations:

Table 1: Measurement of Temperature and thermo emf.

S.No.	T(^oC)	Thermo emf (mV)
1		
2		
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XV. Results

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XVI. Interpretation of results

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XVII. Conclusions & Recommendation

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XVIII. Practical related Questions

1. List the different types of thermocouples with their composition?
2. Calculate the sensitivity of thermocouple ($\Delta V/\Delta T$)?
3. Enlist the limitations of thermocouple.

[Space for Answers]

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XIX. References / Suggestions for further Reading

1. https://www.regal.se/produkter/temperaturgivare-fjaderbelastad-koppling
2. https://circuitglobe.com/thermocouple.html
3. https://www.electrical4u.com/
4. https://www.sterlingsensors.co.uk/thermocouple

XX. Assessment Scheme

Performance Indicators		Weightage
Process related (10 Marks)		**(40%)**
1	Handling of the equipment/measuring instruments	20%
2	Plotting graph / calculations	20%
Product related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25Marks)		**100 %**

Names of Student Team Members

1. …………………………
2. …………………………
3. …………………………
4. …………………………

Marks Obtained			**Dated signature of Teacher**
Process Related(10)	**Product Related(15)**	**Total (25)**	

Scale

X-axis -

Y-axis -

Practical No. 4: Measurement of temperature using Pyrometer

I. Practical Significance:

In an industry environment it is often required to measure high temperatures involving Steam boilers, air balloons, salt bath furnaces and metallurgical furnaces. Pyrometer, a non-contact type device can measure temperatures in the range of 40^0C - 3000^0C. Pyrometers are best suited for the measurement of temperature of moving objects or surfaces that cannot be reached or touched. Aim of this experiment is to measure high temperature using pyrometer.

II. Relevant Program Outcomes (POs)

PO1 – Basic Knowledge: Apply knowledge of basic mathematics, Sciences and basic engineering to solve the chemical engineering problems.

PO3 - Experiments and practice: Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.

PO4 - Engineering tools: Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.

PO8 - Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

Program Specific Outcomes (PSO)

PSO2 - Material management and quality control: Manage chemicals and equipment to produce quality chemical products.

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry-identified competency: '**'Apply relevant process control parameter in chemical plant':**

1. Device identification skills.
2. Familiarize industrial setup of pyrometers.
3. Use pyrometer for high temperature measurement.

IV. Relevant Course Outcomes

1. Select the instrument for various chemical processes.
2. Use temperature measuring instruments in chemical industry

V. Practical Outcome -

Use pyrometer for high temperature measurement

VI. Relevant Affective domain related Outcome(s)

1. Follow safe practices
2. Practice energy conservation
3. Demonstrate working as a leader/team member
4. Maintain tools and equipment

VII. Minimum Theoretical Background -

Pyrometer, or radiation thermometer is a non-contact instrument that detects an object's surface temperature by measuring the temperature of the electromagnetic radiations emitted from the object. For pyrometry, important correlations were discovered by Max Planck, Wilhelm Wien, Josef Stefan and Ludwig Boltzmann. In view of the Stefan-Boltzmann equation, the total emissive power of a real surface is,

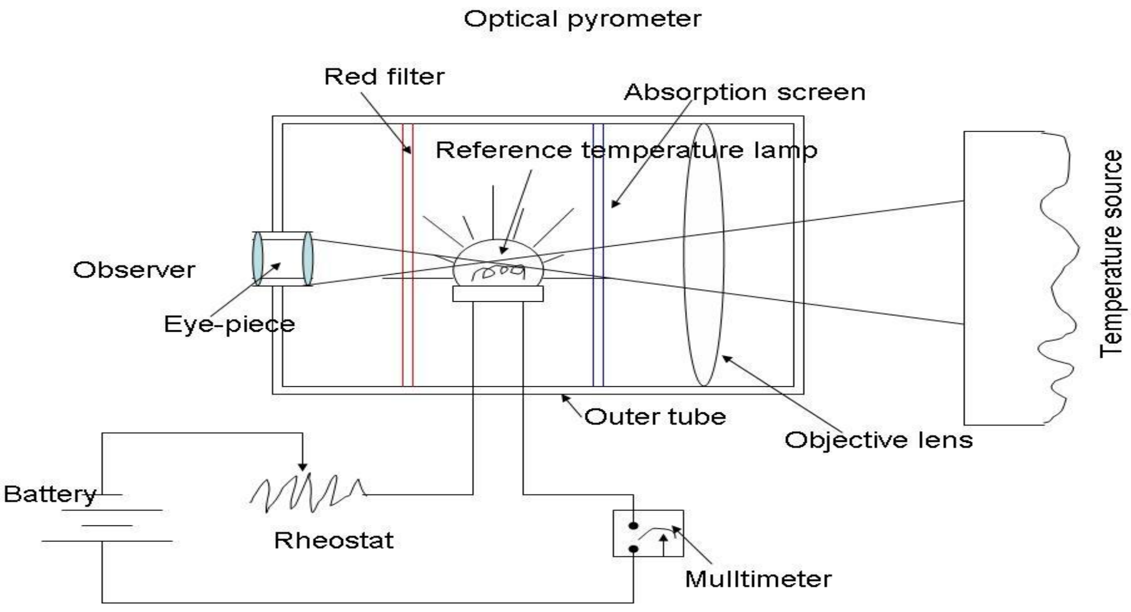
$$e = \epsilon\sigma T^4$$

where,

e = total radiation, ϵ = emissivity, σ = Stefan-Boltzmann constant, T= absolute temperature

According to the working principle these are classified into,

1) **Optical pyrometers**: Optical pyrometers are designed for measuring thermal radiation in the visible spectrum. It uses the principle of temperature measurement by brightness comparison. A colour variation with the change in temperature is taken as an index of temperature. Figure shows an optical pyrometer using the technique of brightness comparison.



Courtesy: (http://instrumentationandcontrollers.blogspot.com/2010/09/optical-pyrometer-disappearing-filament.html)

Figure.1 Schematic diagram of optical pyrometer

2) **Radiation pyrometers**: Radiation thermometers are based on the principle of measurement of thermal radiations emitted by a hot body to measure its temperature. radiation pyrometers are of two types,

a. Total Radiation Pyrometers
b. Selective radiation pyrometers (eg. Infrared Pyrometers)

Total radiation Pyrometers - In this method, it measure the total intensity of radiation emitted from a body ie, it measures the total heat emitted from the hot source at all wavelengths.

Selective Radiation Pyrometer – In this method, the heat radiated from the hot source is measured at a given wavelength. For eg., an infrared pyrometer uses a lens to focus infrared light from an object onto a detector normally a thermopile. Thermopile output an electrical signal which can be measured and monitored.

VIII. Practical Circuit Diagram:

a) Sample

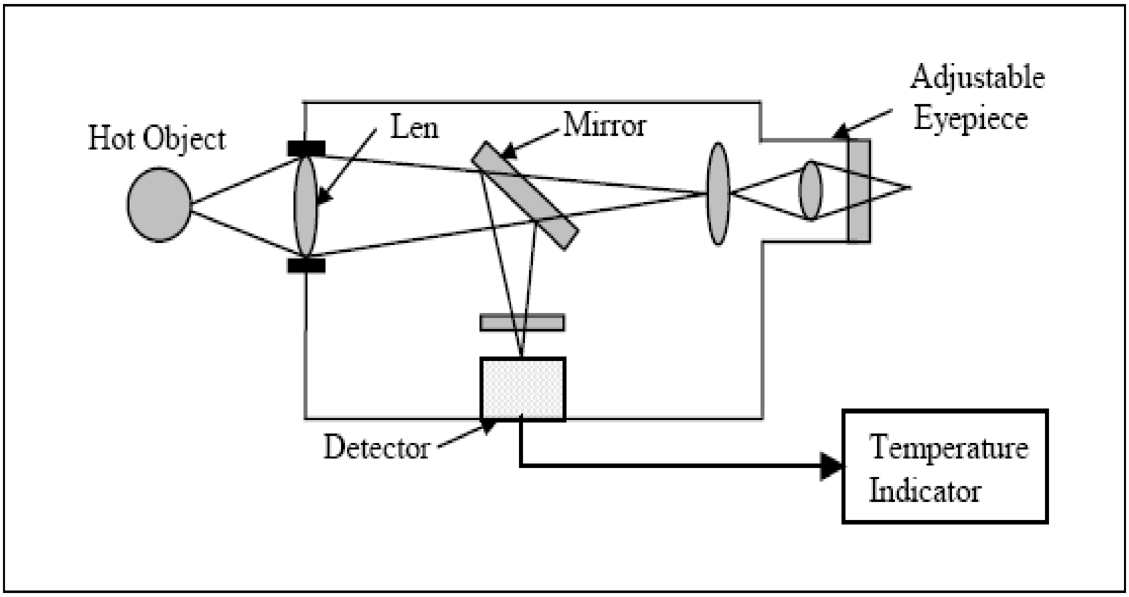


Figure 2: Radiation Pyrometer

Courtesy: *(https://www.globalspec.com/reference/10956/179909/chapter-7-temperature-measurement-radiation-pyrometers)*

b) Actual Circuit used in laboratory

Figure 3

c) Actual Experimental set up used in laboratory

IX. Resources required

S. No.	Instrument /Components	Specification	Quantity
1	Infra Red pyrometer	-20^0C – 450^0C with a spectral response of 6-14μm	1
2	Heating Source	Wooden box fitted with filament lamp rated 230v,200w	1
3	Mercury-in-glass Thermometer	0-150^0C	1

X. Precautions

1. To have accurate readings the device must be kept clean, away from dust and dirt.
2. Handle the heating system with care.
3. For safety reasons, in the given set up the experiment is conducted at low temperature Range.

XI. Procedure

1. Switch on the power supply to heat thermal radiation source (heating box).
2. Wait for a few moments for the temperature to built-up to some convenient value.
3. Place the thermometer inside the box.
3. Switch on the pyrometer.
4. Focus the pyrometer on to the heating box.
5. Note down the readings of pyrometer and thermometer simultaneously up to some safe value.
6. Plot the graph of thermometer (T_t) Vs pyrometer readings (Tp).

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
1			
2			
3			

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations:

Table 1: Measurement of Tt and Tp

S.No.	Tt(°C)	Tp(°C)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

XVI. Results

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XVII. Interpretation of results

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XVIII. Conclusions & Recommendation

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XIX. Practical related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1) State the industry based applications of pyrometers.
2) Write the general specifications of any type of pyrometer by visiting manufacture's site/ Industry.
3) State the advantages of pyrometer over other contact type temperature meters.

[Space for Answers]

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XX. References / Suggestions for further Reading

1) https://sail.co.in/sites/default/files/ipss/2-07-017-13.pdf
2. https://www.globalspec.com/reference/10956/179909/chapter-7-temperature-measurement-radiation-pyrometers.
3) https://nvlpubs.nist.gov/nistpubs/bulletin/01/nbsbulletinv1n2p189_A2b.pdf.

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (10 Marks)		**(40%)**
1	Handling of the equipment/measuring instruments	20%
2	Plotting graph / calculations	20%
Product related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25Marks)		**100 %**

Names of Student Team Members

1. …………………………
2. …………………………
3. …………………………
4. …………………………

Marks Obtained			**Dated signature of Teacher**
Process Related(10)	**Product Related(15)**	**Total (25)**	

Scale

X-axis -

Y-axis -

Practical No.5: Calibration of pressure gauge using dead-weight tester.

I. Practical Significance

Every measuring instrument degrades over time and use due to normal wear and tear or by various reasons such as electric/ mechanical shock or a hazardous manufacturing environment. In those situations, calibration is required to check and correct to enhance its accuracy. The most common instrument used for the measurement of pressure is a C-type Bourdon gauge. Aim of this experiment is to calibrate C-type Bourdon tube using the standard, a dead weight tester.

II. Relevant Program Outcomes (POs)

PO1 – Basic Knowledge: Apply knowledge of basic mathematics, Sciences and basic engineering to solve the chemical engineering problems.

PO3 - Experiments and practice: Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.

PO4 - Engineering tools: Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.

PO8 - Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PSO2 - Material management and quality control: Manage chemicals and equipment to produce quality chemical products

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry-identified competency: **'Apply relevant process control parameter in chemical plants':**

1. Calibrate the given pressure gauges.
2. Use dead weight pressure gauge for unknown pressure measurement.
3. Use of dead weight pressure gauge for the calibrations of different pressure gauges.

IV. Relevant Course Outcomes -

1. Use pressure measuring instruments in chemical industry.

V. Practical Outcome

Calibrate pressure gauge using dead weight tester.

VI. Relevant Affective domain related Outcome(s)

1. Follow safe practices
2. Practice good house keeping
3. Demonstrate working as a leader/team member
4. Maintain tools and equipment
5. Follow ethical practices

VII. Minimum Theoretical Background –

Dead weight pressure gauge is a pressure producing and pressure measuring instrument.

Basically this instrument balances the fluid pressure against the known weight. It uses calibrated weights to apply known pressures to a device under test. The dead weight tester is one of the few instruments that can be used to generate pressure in terms o f the fundamental units of force and area.

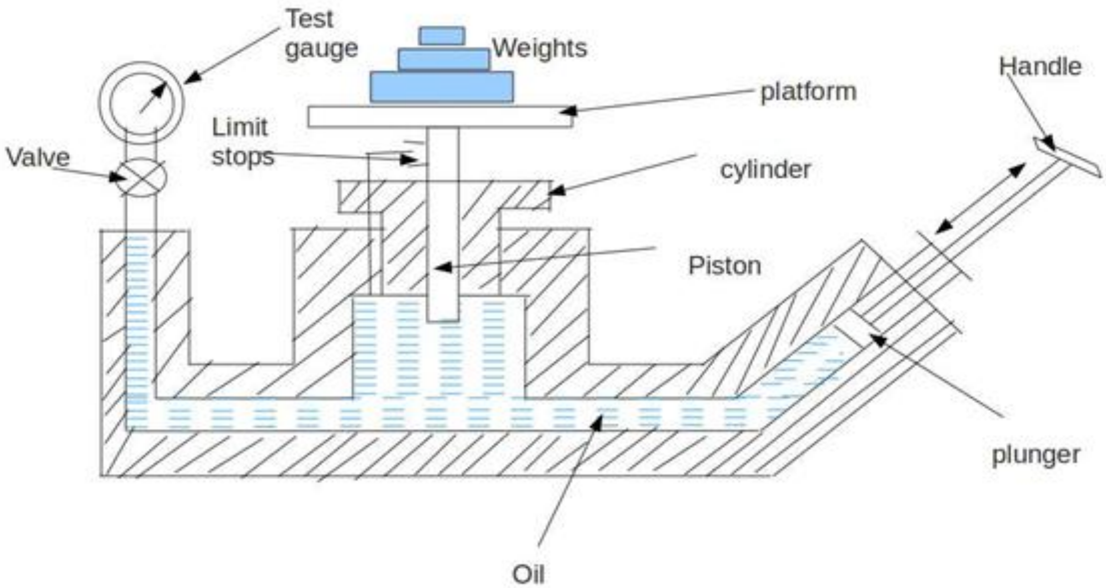

Figure 1: Dead weight tester

*Courtesy: (*http://instrumentationandcontrollers.blogspot.com/2010/10/dead-weight-tester.html*)*

VIII. Practical Circuit Diagram:

a) Sample

Figure 2

b) Actual Circuit used in laboratory:

Figure 3

c) Actual Experimental set up used in laboratory

IX. Resources required

S. No.	Instrument /Components	Specification	Quantity
1	Dead weight tester	0 to 40kg/cm^2 predetermined dead weight	1
2	Weights	100 gmsto 10 kg	10
3	Oil	Non Compressible Oil	500 ml
4	Pressure Gauge	0 to 40 kg/cm^2	1

X. Precautions

1. Ensure the working condition of dead weight tester.
2. Check the proper oil level in the reservoir.
3. Check the check valves properly for upward and backward stroke.
4. Take care of wear and tear of lever by applying proper lubrication.
5. Make sure that there is no leakage in the reservoir.

XI. Procedure

1. Arrange the components of given setup.
2. Check the oil level in the reservoir and open the check valve.
3. Rotate the displacement pump clockwise and anti-clockwise two to three times for removing air bubbles.
4. Close check valve.
5. Place the standard weights 0.5kg/cm^2 on weighing platform.
6. Rotate the displacement pump clockwise so that, the weights floats freely.
7. Note down the output pressure in gauge.
8. Repeat the steps 5 to 7 by increasing the weights.
9. Plot the calibration curve (Standard weight Vs Gauge pressure).

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity

XIII. Actual procedure followed

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XIV. Precautions followed

XV. Observations and Calculations:

Table 1: Standard weights and Gauge pressure

Sr. No.	Standard Weights (kg/cm^2)	Pressure gauge indication (kg/cm^2)	% Error
1			
2			
3			
4			
5			
6			

%Error = (Standard weight- Gauge pressure/ Standard weight)*100

XVI. Results

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XVII. Interpretation of results

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XVIII. Conclusions & Recommendation

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XIX. Practical related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Explain the necessity of pressure gauge calibration.
2. Calibrate the pressure gauge other than calibrated the above one. State its procedure
3. State the purpose of check valve.

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XX. References / Suggestions for further Reading

1. http://instrumentationandcontrollers.blogspot.com/2010/10/dead-weight-tester.html
2.http://ourelabs.blogspot.com/2017/01/calibration-of-pressure-gauge-using.html
3.https://www.instrumentationtoolbox.com/2013/08/how-to-calibrate-pressure-gauge-with.html

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (10 Marks)		**(40%)**
1	Handling of the equipment/measuring instruments	20%
2	Plotting graph / calculations	20%
Product related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25Marks)		**100 %**

Names of Student Team Members

1. …………………………
2.…………………………
3.…………………………
4.…………………………

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Scale

X-axis -

Y-axis -

Practical No.6: Measurement of pressure by using LVDT

I. Practical Significance

Linear variable differential transformer (LVDTs) provide reliable position measurement for applications in subsea, power generation, industrial automation, aerospace, test and measurement, and many more. It has considerable advantages as compared to its other counterparts, which makes it the best option for the measurement of linear displacements as well as pressure measurement. Aim of this experiment is to measure pressure using LVDT.

II. Relevant Program Outcomes (POs)

PO3 - Experiments and practice: Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.

PO4 - Engineering tools: Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.

PO8 - Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

Program Specific Outcomes (PSO)

PSO2 - Material management and quality control: Manage chemicals and equipment to produce quality chemical products

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry-identified competency: '**'Apply relevant process control parameter in chemical plant':**

1. Familiarize LVDT measurement systems for industry applications.
2. Use LVDT as a secondary transducer.
3. Use Digital multimeter to measure voltage.

IV. Relevant Course Outcomes –

1. Use pressure measuring instruments in chemical industry.

V. Practical Outcome –

Measure pressure by using Linear Variable Differential Transducer.

VI. Relevant Affective domain related Outcome(s)

1. Follow safe practices
2. Practice good house keeping
3. Demonstrate working as a leader/team member
4. Maintain tools and equipment

VII. Minimum Theoretical Background

The LVDT converts a position or linear displacement from a mechanical reference called null position, into a proportional electrical signal containing phase to indicate direction and amplitude for distance. **LVDT** act as a primary transducer to convert displacement into electrical signal directly. LVDT can also act as a secondary transducer. E.g. in pressure measurement the Bourbon tube which acts as a primary transducer converts pressure to linear displacement and the LVDT coverts the displacement into an electrical signal which after calibration gives the reading of pressure in engineering units.

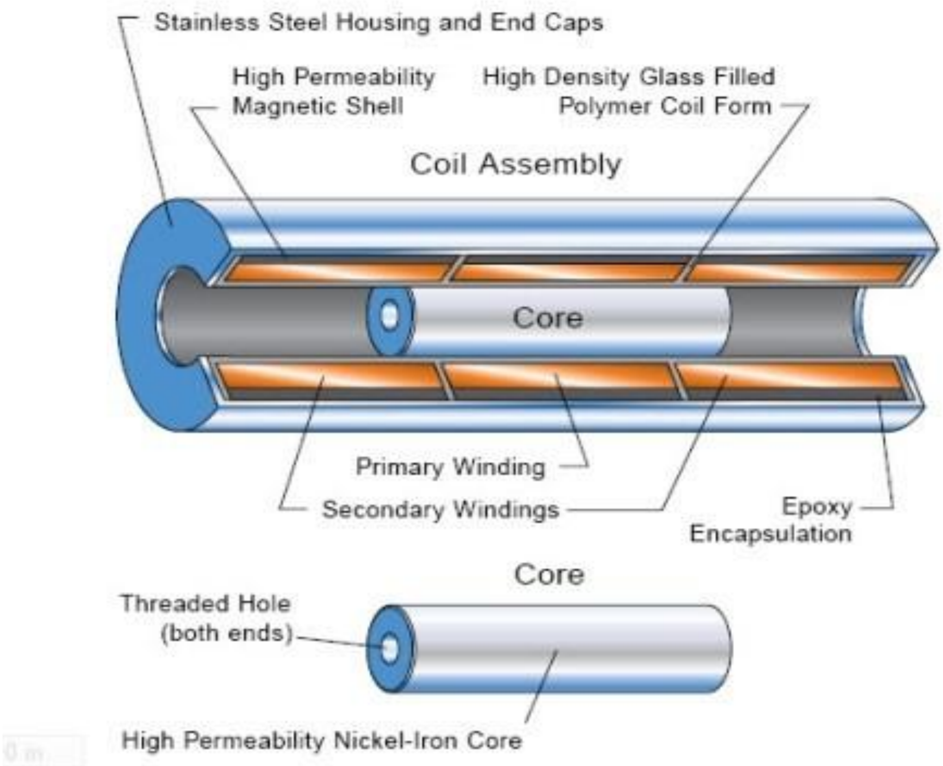

Figure 1: Constructional diagram of LVDT

*Courtesy: (*http://www.te.com/usa-en/industries/sensor-solutions/insights/lvdt-tutorial.html)

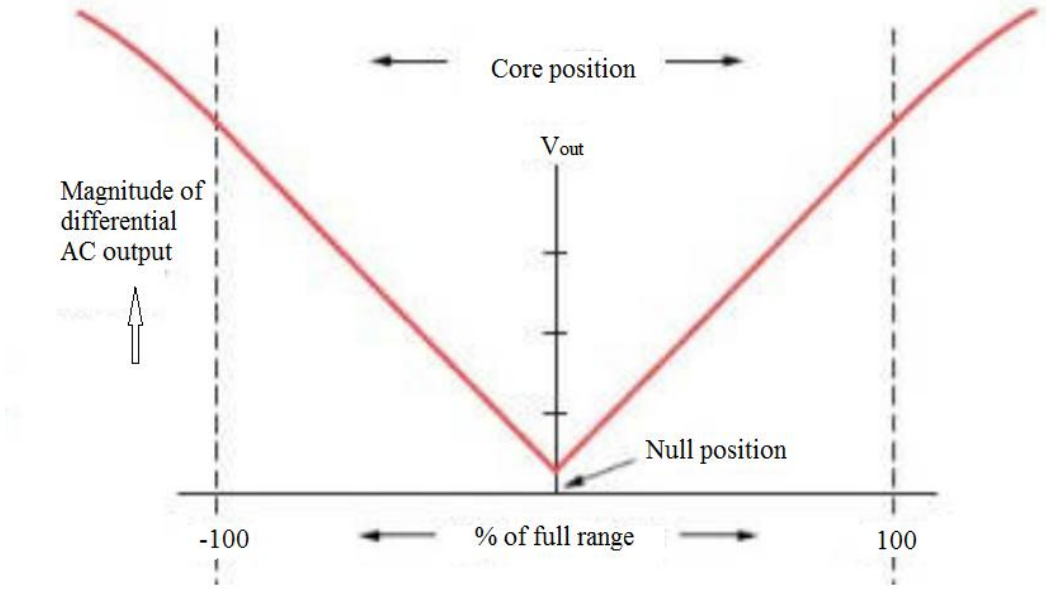

Figure 2: Output characteristics of LVDT

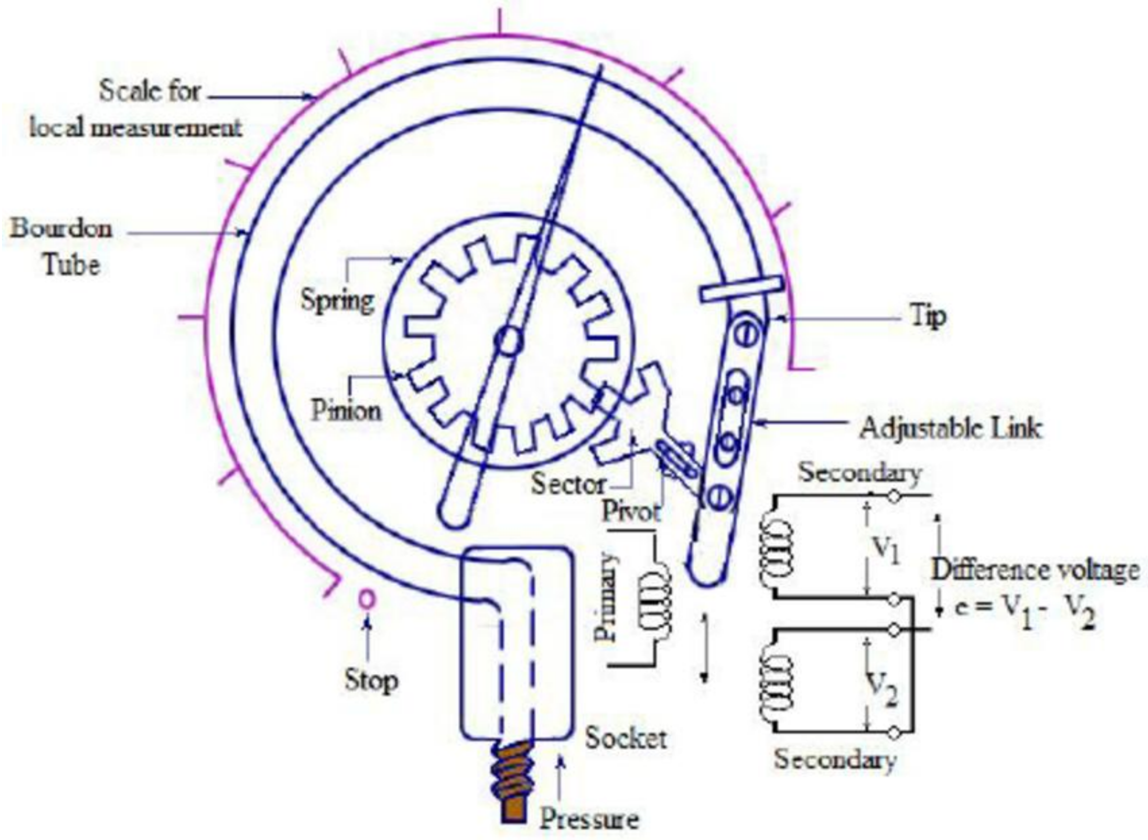

Figure 3: Schematic diagram of Bourdon tube connected with LVDT

VIII. Practical Circuit Diagram:

a) Sample

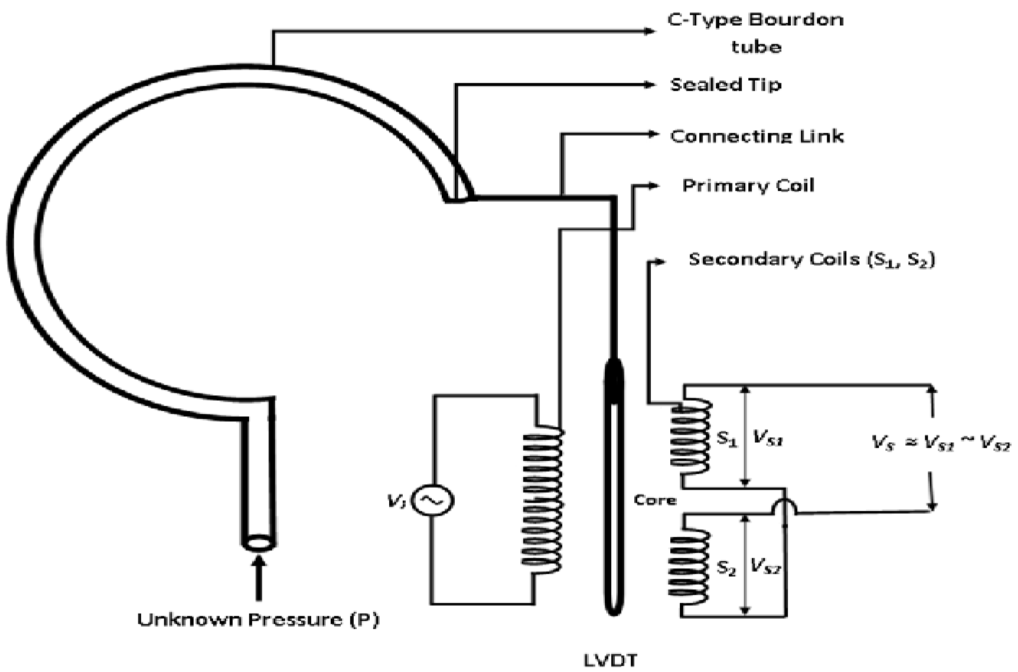

Figure 4

b) Actual Circuit used in laboratory

Figure 5

c) Actual Experimental set up used in laboratory

IX. Resources required

S. No.	Instrument /Components	Specification	Quantity
1	Foot pump	Maximum discharge -80psi Discharge size – 0.25 inch	1
2	Pressure gauge	0-150i	1
3	C- type Bourdon tube	Steel (0-1600bar)	1
4	LVDT with excitation supply	Sensitivity – 2270mv/V Supply voltage - 5Vrms, 3Kz Solenoid plunger with M3 threaded rod	1
5	Electronic kit with digital indication	Necessary signal conditioning circuit with digital display -	1
6	1phase AC supply	230v, 50hz	1

X. Precautions

1. Initially set the LVDT display to read zero, to avoid a zero error.
2. Each time after the application of pressure, wait for some time for the display on the LVDT to stabilize before noting down.

XI. Procedure

1. Arrange the set up as shown in figure.
2. Slowly apply a constant pressure by pressing on the foot rest with your leg.
3. Note down the readings of gauge and LVDT display.
4. Repeat step 2 and 3 by increasing the applied pressure.
5. Plot the graph, gauge pressure Vs LVDT display.

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
1			
2			
3			
4			
5.			

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations

Table 1: Measurement of gauge pressure and LVDT display

S. No.	Gauge pressure	LVDT o/p
1		
2		
3		
4		
5		
6		
7		

XVI. Results

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XVII. Interpretation of results

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XVIII. Conclusions & Recommendation

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XIX. Practical related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. State and explain industrial applications of Bourdon tube and LVDT.
2. State the working principle of LVDT.

3).Identify the primary and secondary sensors of the pressure measurement setup.

[Space for Answers]

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XX. References / Suggestions for further Reading

1) http://www.emerson.com/documents/automation/linear-variable-displacement-transducer-lvdt- specifications-en- 39416.pdf
2) http://www.te.com/usa-en/industries/sensor-solutions/insights/lvdt-tutorial.html
3) http://adtrontechnologies.com/

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (10 Marks)		**(40%)**
1	Handling of the equipment/measuring instruments	20%
2	Plotting graph / calculations	20%
Product related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25Marks)		**100 %**

Names of Student Team Members

1. …………………………
2. …………………………
3. …………………………
4. …………………………

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Scale

X-axis -

Y-axis -

Practical No.7: Measurement of pressure using strain gauge

I. Practical Significance

Next to temperature, pressure is the second most common measurement in manufacturing industries for the quality and consistency of products. A variety of sensors are available for pressure measurement, which converts pressure into some measurable form. Strain gauge is an electrical (resistive) transducer whose resistance changes with the strain due to stress from the applied pressure. Aim of this experiment is to measure pressure using strain gauge.

II. Relevant Program Outcomes (POs)

PO3. - Experiments and practice: Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.

PO4. - Engineering tools: Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.

PO8. - Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PO 9. **Communication:** Communicate effectively in oral and written form.

Program Specific Outcomes (PSO)

PSO2. - Material management and quality control: Manage chemicals and equipment to produce quality chemical products

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry-identified competency: **'Apply relevant process control parameter in chemical plants':**

Use Strain gauge for unknown pressure measurement.

IV. Relevant Course Outcomes

Use pressure measuring instruments in chemical industry.

V. Practical Outcome

Use strain gauge for pressure measurement.

VI. Relevant Affective domain related Outcome(s)

1. Follow safe practices
2. Practice good house keeping
3. Demonstrate working as a leader/team member
4. Maintain tools and equipment
5. Follow ethical practices

VII. Minimum Theoretical Background -

Strain gauge is an electrical sensor whose resistance varies with applied force. It converts force, pressure, tension, and weight into a change in electrical resistance which can then be measured. It uses a Wheatstone bridge circuit to convert the resistance into a voltage. These are available in different forms like bonded, un-bonded, foils and wires.

Its principle is based on fact that the resistance of a wire increases with increasing strain and decreases with decreasing strain. Consider a wire strain gage wire made of a conductor of resistivity ρ with length l and cross-section area A. Its resistance,

$$R = \frac{\rho\, l}{A}$$

As per the above equation, resistance of the wire increases for a tensile stress(increase in longitudinal strain) and decreases with a tangential stress (increase in axial strain). Figure1 shows a quarter bridge circuit used to convert strain gauge resistance into voltage, for display.

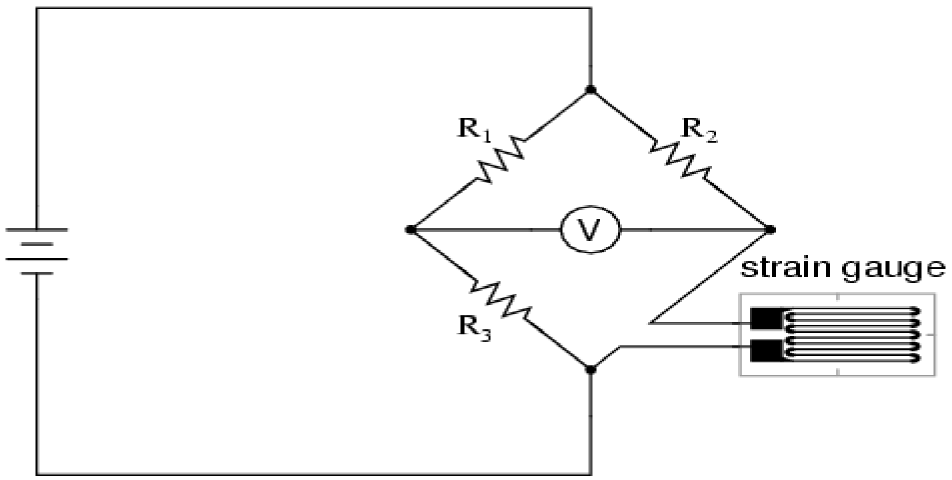

Figure 1: Strain Gauge quarter bridge circuit

*Courtesy: (*http://technlab.blogspot.com/2016/02/experiment-2-study-characteristics-of.html*)*

VIII. Practical Circuit Diagram :

a) Sample

Figure 2

b) Actual Circuit used in laboratory

Figure 3

c) Actual Experimental set up used in laboratory

IX. Resources required

S. No.	Instrument /Components	Specification	Quantity
1	Strain gauge	Cu-Ni foil, 350 Ohms (Nominal)	1
2	Weights	100 gmsto 10 kg	10
3	Wheatstone bridge meter	Signal conditioning circuit for the display	1
4	Digital multimeter	Voltmeter, auto range	1
5	Connecting wires	Multi-stranded, flexible	1 pair

X. Precautions

1. Ensure the working condition of Strain gauge.
2. Check the proper balancing of Wheatstone bridge circuit.
3. Place weight on cantilever beam carefully.
4. Take care of wear and tear of strain element.
5. Allow the readings to stabilize each time during a measurement in order to minimize the hysteresis errors.

XI. Procedure

1. Assemble the setup and switch on the power supply.
2. Place a known weight on the cantilever beam.
3. Note down the reading on display, once the reading stabilizes.
4. Repeat the procedure mentioned in steps 2-3 for with an increase (upscale) in pressure (weight), upto some convenient value.
5. Repeat the same procedure (2-4) for down scale.
6. Draw the calibration curve, weight in kg Vs display.

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations:

Table 1: Readings of applied weight and pressure

S. No.	Applied Weight (Kg)		Reading of strain gauge (Kg)	
	Up Scale	Down Scale	Up scale	Down Scale
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

XVI. Results

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XVII. Interpretation of results

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XVIII. Conclusions & Recommendation

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XIX. Practical related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. List the different types of strain gauges along with the material.
2. State the use of Wheatstone bridge circuit in the experiment setup.
3. State whether a strain gauge is active or passive.

[Space for Answers]

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XX. References / Suggestions for further Reading

1. http://technlab.blogspot.com/2016/02/experiment-2-study-characteristics-of.html
2. http://store.chipkin.com/articles/strain-gauge
3. http://gozips.uakron.edu/~dorfi/Strain%20Measurement%20Lab.pdf
4. https://www.omega.co.uk/prodinfo/StrainGauges.html.

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (10 Marks)		**(40%)**
1	Handling of the equipment/measuring instruments	20%
2	Plotting graph / calculations	20%
Product related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25Marks)		**100 %**

Names of Student Team Members

1……………………………

2……………………………

3……………………………

4……………………………

Marks Obtained			**Dated signature of Teacher**
Process Related(10)	**Product Related(15)**	**Total (25)**	

Scale

X-axis -

Y-axis -

Practical No.8: Measurement of vacuum using McLeod gauge.

I. Practical Significance

In process industries and research-oriented experimentations, at times activities are conducted under pressures below atmospheric pressure. Some of the areas where vacuum technology is used extensively are vacuum melting of reactive metals like titanium, degassing of oils, freeze-drying, desorption of gas from surfaces and particle accelerators. Special devices have been developed for the measurement of pressures in the vacuum range. One such device is a McLeod gauge. Aim of this experiment is to measure vacuum pressure using McLeod gauge.

II. Relevant Program Outcomes (POs)

PO1 – Basic Knowledge: Apply knowledge of basic mathematics, Sciences and basic engineering to solve the chemical engineering problems.

PO3 - Experiments and practice: Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.

PO4 - Engineering tools: Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.

PO8 - Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PSO2 - Material management and quality control: Demonstrate knowledge and understanding for selection, material management and quality control in Chemical engineering.

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry-identified competency: ‘**‘Apply relevant process control parameter in chemical plant’:**

1. Use McLeod gauge for vacuum pressure measurement.
2. Operate equipment in Vacuum range.

IV. Relevant Course Outcomes –

Use pressure measuring instruments in chemical industry.

V. Practical Outcome –

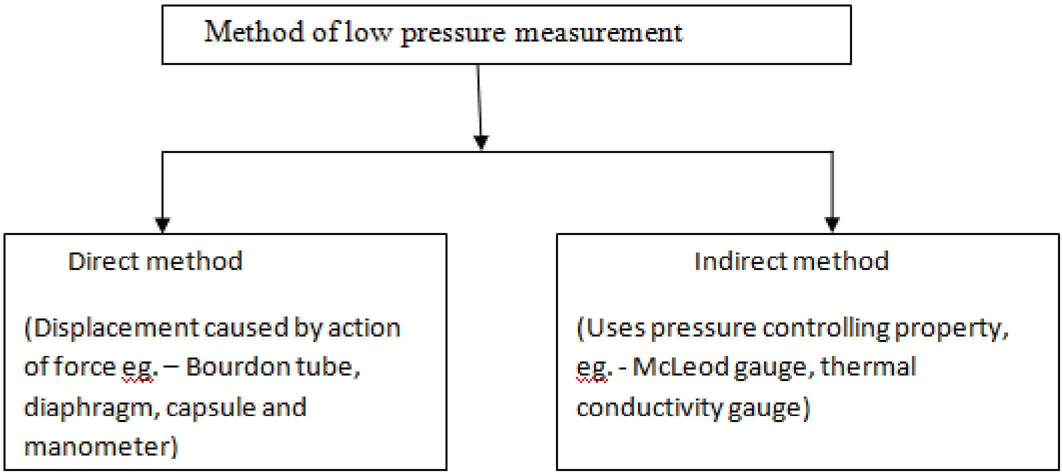
Use McLeod gauge for vacuum pressure measurement.

VI. Relevant Affective domain related Outcome(s)

1. Follow safe practices
2. Practice good house keeping
3. Demonstrate working as a leader/team member
4. Maintain tools and equipment
5. Follow ethical practices

VII. Minimum Theoretical Background

Low pressure measurement is done by two methods, direct and indirect. In direct method, displacement caused by action of force is measured directly. Indirect method uses pressure controlling property like volume and thermal conductivity.



McLeod gauge works on the principle of comparison of low pressure gas to higher pressure and measuring the resulting volume and pressure to calculate the applied pressure. In this a known volume gas (with low pressure) is compressed to a smaller volume (with high pressure), and using the resulting volume and pressure, the initial pressure can be calculated. This is the principle behind the McLeod gauge operation. It is based on Boyles fundamental equation,

$$P_1V_1=P_2V_2$$

where p and v refer to pressure and volume respectively and subscripts 1 and 2 refer to initial and final conditions. Conventional McLeod gauge is made of glass. It consists of the capillary "C", bulb "B" and the mercury sump which is connected to the lower end of the glass tube such that it can be moved up and down.Figure 1 shows the constructional diagram of McLeod gauge.

The pressure to be measured (the unknown pressure) is connected to the upper end of the glass part. When the mercury level in the gauge is below the cut off "F", the unknown pressure fills the gauge including the bulb B and capillary C. When the mercury sump is moved up, the level in the gauge rises and when it reaches the cut off "F" a known volume of gas at pressure to be measured is trapped in bulb B and capillary C.

Mercury is then forced up into the bulb and capillary. Assume the sump is raised to such a level that the gas at the pressure to be measured which filled the volume above the cut off is now compressed to the volume represented by the column h.

Suppose the original volume is V1. This is at a pressure being measured P_1. Then,

$$V1 \times P_1 = ah \times (P_1 + h)$$

$$V1 \times P_1 = P_1\, ah + ah^2$$

$$V_1 \times P1 - P_1 ah = ah^2$$

$$P_1(V1 - ah) = ah^2$$

As "ah" is <<< V1, it is neglected.

$$p_1 = \frac{ah^2}{V_1}$$

Where, Initial Volume of gas entrapped in the bulb plus measuring capillary tube = V1 = V + ahc. V is the volume of the bulb from the cut-off point up to the beginning of the measuring capillary. Figure1 shows the constructional diagram of McLeod gauge.

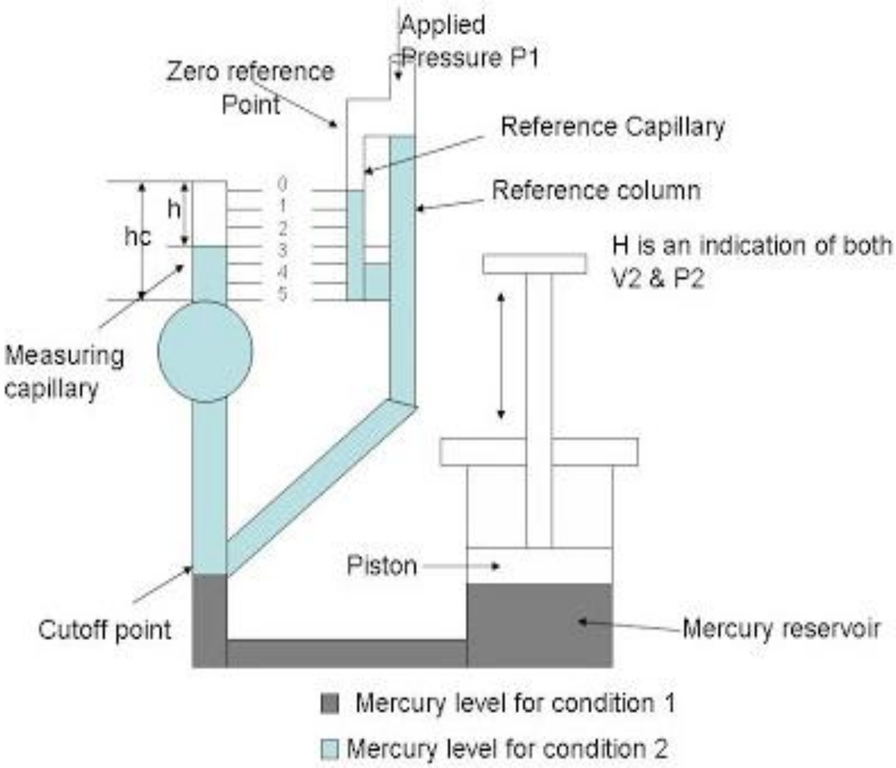


Figure 1: Constructional diagram of McLeod gauge

Courtesy: http://nptel.ac.in/courses/101106040/chapter%205.pdf

VIII. Practical Circuit Diagram:

a) Sample diagram

Figure 2

b) Actual Circuit used in laboratory

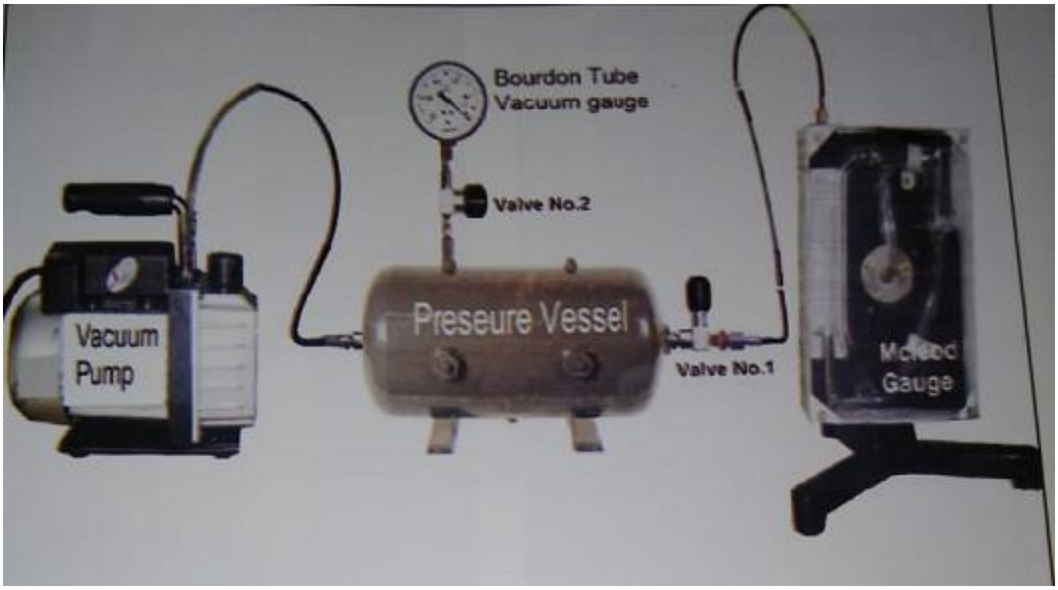


Figure.3

c) Actual Experimental set up used in laboratory

IX. Resources required

S. No.	Instrument /Components	Specification	Quantity
1	McLeod gauge	0 to -760mm of Hg	1
2	Bourdon gauge	0 to -760 mm of Hg	1
3	Vacuum Pump	0 to -760 mm of Hg	1
4	Connecting pipes	½’’ dia	1
5	On/off valves	½”	2

X. Precautions

1. All joints must be leak proof.

XI. Procedure

1. Assemble the experimental setup as shown in figure.
2. Close the valve1 and keep the valve 2 open to read the atmospheric pressure.
3. Open valve 1 and keep valve 2 closed.
4. Start the vacuum pump for a few minutes to create vacuum inside.
5. Read the pressure in the vessel using Bourdon tube pressure gauge.
6. Connect unknown pressure source to McLeod at point 'P1' as shown in figure1.
7. The mercury level gets adjusted to fill the volume represented by darker shading. Now the volume of unknown pressure is volume of pressure and capillary.
8. Force out mercury from the reservoir up into the bulb B and reference column.
9. Continue forcing mercury till it reaches cut off point F (a known volume of gas is trapped inside the bulb and capillary)
10. Raise the level of mercury further until it reaches reference point.
11. Note down the difference in the height of two columns (h).
12. Calculate the pressure using the formula.
13. Repeat the steps 6 – 12, for different values of applied pressure.

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations & calculations:

Table 1: Measurement of Vacuum pressure

S. No.	Bourdon vacuum gauge reading(mm of Hg)	h (mm)	Input pressure (P_1)
1			
2			
3			
4			
5			
6			
7			
8			
10			

Area of cross – section of the measuring capillary tube, a =
Height of measuring capillary tube = h_c =
Volume of the bulb from the cutoff point up to the beginning of the measuring capillary tube = V =
Volume of measuring bulb = a x h_c
Initial Volume of gas entrapped in the bulb plus measuring capillary tube = Volume of the Capillary + volume of measuring bulb, V1 = V + a x h_c = $P_1 = \frac{ah^2}{V1}$

XVI. Results

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XVII. Interpretation of results

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XVIII. Conclusions & Recommendation

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XIX. Practical related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. State the industrial applications of McLeod gauge
2. List the devices used for vacuum measurement other than McLeod gauge.
3. State the limitations of McLeod gauge

[Space for Answers]

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XX. References / Suggestions for further Reading

1. http://instrumentationandcontrollers.blogspot.com/2010/12/mcleod-vacuum-gauge.html
2. https://pubs.acs.org/doi/pdf/10.1021/ac50125a016
3. https://www.scribd.com/document/247651426/Mcleod-gauge-pdf

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (10 Marks)		**(40%)**
1	Handling of the equipment/measuring instruments	20%
2	Plotting graph / calculations	20%
Product related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25Marks)		**100 %**

Names of Student Team Members

1 …………………………

2 …………………………

3 …………………………

4 …………………………

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No.9: Measurement of fluid flow using electromagnetic flow- meter

I. Practical Significance

Flow meter is an important component virtually in every industrial environment. For example in oil and gas operations where tens of millions of gallons of product is transferred from one party to another on a daily basis, their role is mission-critical. Electromagnetic flow-meter is one of the precise flow-meter which is highly effective in handling liquid of various types and concentrations. Aim of this experiment is to measure flow using electromagnetic flow-meter.

II. Relevant Program Outcomes (POs)

PO1 – Basic Knowledge: Apply knowledge of basic mathematics, Sciences and basic engineering to solve the chemical engineering problems.

PO3 - Experiments and practice: Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.

PO4 - Engineering tools: Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.

PO8 - Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PSO2 - Material management and quality control: Manage chemicals and equipment to produce quality chemical products.

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry-identified competency: **'Apply relevant process control parameter in chemical plants':**

1. Use Electromagnetic Flow-meter for flow measurement for different fluids.
2. Select Electromagnetic Flow-meter for different applications.

IV. Relevant Course Outcomes -

Measure the flow level using various measuring instruments in chemical industry.

V. Practical Outcome

Measure the flow of fluid using electromagnetic flow- meter.

VI. Relevant Affective domain related Outcome(s)

5. Follow safe practices
6. Practice good house keeping
7. Demonstrate working as a leader/team member
8. Maintain tools and equipment
9. Follow ethical practices

VII. Minimum Theoretical Background

Electromagnetic Flow-meter is also known as induction flow-meters measure the flow velocity by measuring the alteration of induced voltage of the conductive fluid passing across the controlled magnetic field. It works on the principle of Faraday's Laws of Electro-magnetic Induction. When an electrically conductive fluid flows in the pipe, an electrode voltage E is induced between a pair of electrodes placed at right angles to the direction of magnetic field. The electrode voltage E is directly proportional to the average fluid velocity V. Figure 1 shows the construction of electromagnetic flow meter.

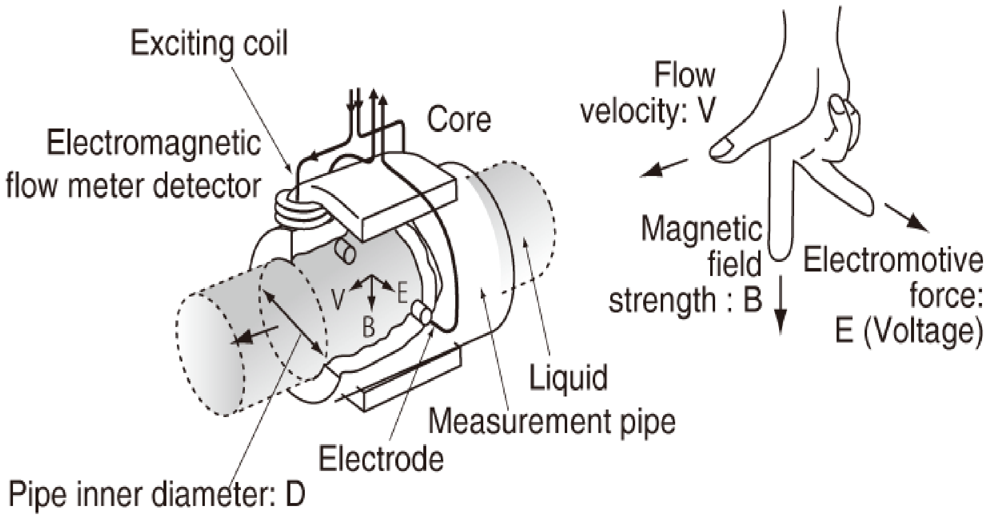

Figure 1: Principle of Electromagnetic Flow-meter
Courtesy: (http://www.efunda.com/designstandards/sensors/flowmeters/flowmeter_mag.cfm)

VIII. Practical Circuit Diagram :

a) Sample

Figure 2

b) Actual Circuit used in laboratory

Figure 3

c) Actual Experimental set up used in laboratory

IX. Resources required

S. No.	Instrument /Components	Specification	Quantity
1	Water circulating tank	Metal tank	1
2	Electric pump	230v, 1hp	1
3	Electromagnetic flow meter	230v, 50hz, minimum conductivity-0.05µS/cm	1
4	Sump tank	20 liters	1
5	Measuring tank	10 liters	1
6	Discharge pipe	2" diameter	1
7	Water pump	230v, 1/4th HP	1
8	Shut-off valves	BS-218 (2" L)	3
9	Water inlet connection	Main line with ON/OFF valve	1

X. Precautions

1. Ensure the Fluid is conductive.
2. Care must be taken for leak proof assembly setup.
3. Care must be taken to prevent water leakages.

XI. Procedure

1. Close the drain valves of sump tank.
2. Fill the sump tank upto desired level.
3. Switch on the pump.
4. Open the discharge valve, allow water to flow through the experimental setup.
5. Wait for some time to allow the flow to become steady.
6. Note down the magnetic flow meter reading.
7. Now, close the drain valve of measuring tank and collect known volume of water.
8. Note down the time required for the collection of water.
9. Open the drain valve of the measuring tank.
10. Repeat the above procedure by varying flow rate.

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity	Remarks
1				
2				
3				
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6.				

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations:

Table 1: Measurement of flow rate by direct method and electromagnetic flow meter

Area of the measuring tank =

Height of water collected =

Sr. No.	Flow rate by direct measurement			Magnetic Flow meter reading		% Error
	Volume of water collected	Time	Volumetric flow rate(m^3/Sec)	Lit/Min	m^3/Sec	
1						
2						
3						
4						
5						
6						
7						
8						

Calculations:-

$$\% \, Error = \frac{flow\ rate\ by\ direct\ measurement - Magnetic\ flow\ meter\ reading}{flow\ rate\ by\ direct\ measurement}\ x\ 100$$

XVI. Results

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XVII. Interpretation of results

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XVIII. Conclusions & Recommendation

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XIX. Practical related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. State the different fluid that can be used for flow measurement using Electromagnetic Flow meter.
2. State the advantages and disadvantages of Electromagnetic Flowmeter.
3. List any four flow measuring devices other than Electromagnetic Flowmeter.

[Space for Answers]

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XX. References / Suggestions for further Reading

1. http://www.onicon.com/Electromagnetic_Flow_Meters.html
2 .https://www.keyence.com/ss/products/process/flowknowledge/types/electromagnetic.jsp
3. http://www.efunda.com/designstandards/sensors/flowmeters/flowmeter_mag.cfm

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (10 Marks)		**(40%)**
1	Handling of the equipment/measuring instruments	20%
2	Plotting graph / calculations	20%
Product related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total(25Marks)		**100 %**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....

Marks Obtained			**Dated signature of Teacher**
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 10: Measurement of flow rate using turbine flow meter.

I. Practical Significance

With most liquid flow measuring instruments, the flow rate is determined inferentially by measuring the liquid's velocity or the change in kinetic energy. Direct measurements of liquid flow can be made with positive displacement meters or rotary element meters. Aim of this experiment is to measure flow using a turbine flow meter, which has comparatively low-pressure drop giving unprecedented accuracy.

II. Relevant Program Outcomes (POs)

PO3 - Experiments and practice: Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.

PO4 - Engineering tools: Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.

PO8 - Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PSO2 - Material management and quality control: Demonstrate knowledge and understanding for selection, material management and quality control in Chemical engineering.

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry-identified competency: ‘**‘Apply relevant process control parameter in chemical plant’:**

1. Use turbine flow meter for measurement of fluid.
2. Select flow meters for different applications.

IV. Relevant Course Outcomes –

Measure flow and level using various measuring instruments in chemical industry.

V. Practical Outcome –

Use turbine flow meter for measurement of fluid.

VI. Relevant Affective domain related Outcome(s)

1. Follow safe practices
2. Practice good house keeping
3. Demonstrate working as a leader/team member
4. Maintain tools and equipment
5. Follow ethical practices

VII. Minimum Theoretical Background

Turbine flowmeter is an accurate and reliable instrument for both liquids and gases. It consists of a multi-bladed rotor mounted at right angles to the flow, suspended in the fluid stream on a free-running bearing. The diameter of the rotor is very close to the inside diameter of the metering chamber, and its speed of rotation is proportional to the volumetric flow rate. Turbine rotation can be detected by solid state devices (reluctance, inductance, capacitive and Hall-effect transistors) or by mechanical sensors (gear or magnetic drives). Other types of rotary element flowmeters include the propeller (impeller), shunt, and paddlewheel designs. Turbine meters are renowned for their reliability and unmatchable accuracy in fiscal metering applications. Figure 1 shows the construction of turbine flow meter.

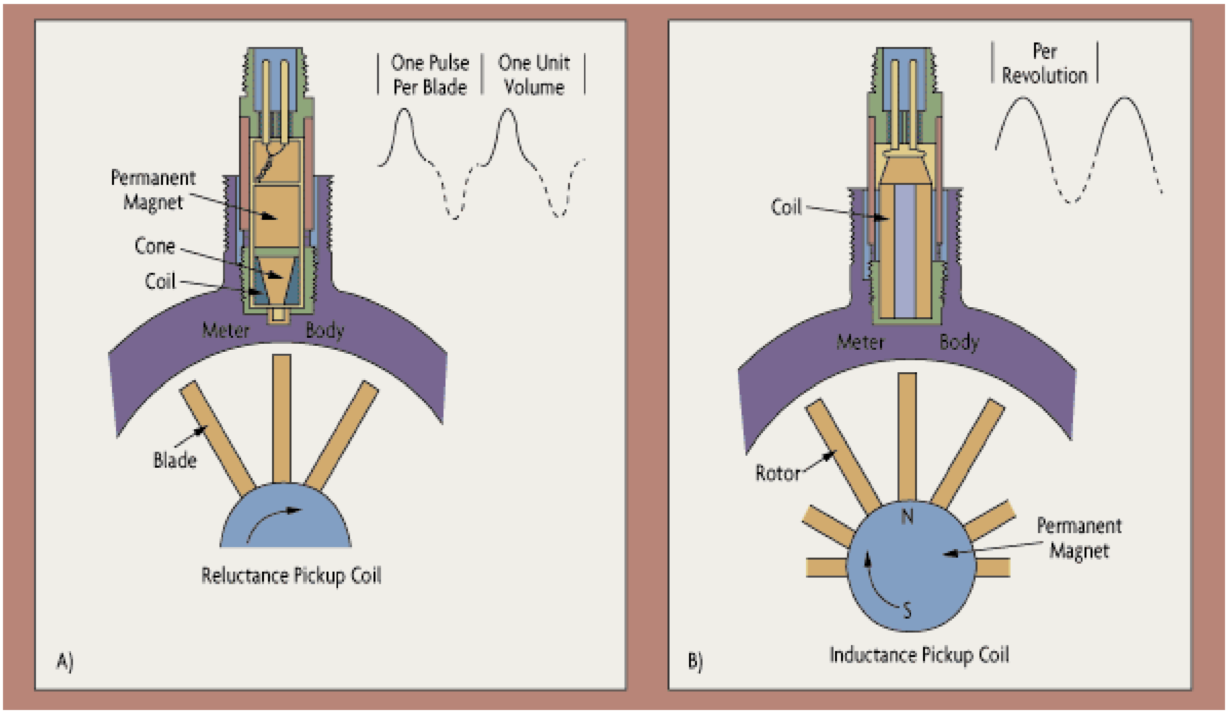

Figure 1: Construction of turbine flow meters

VIII. Practical Circuit Diagram

a) Sample Circuit used in laboratory

Figure 2

b) Actual Circuit used in laboratory

Figure 3

c) Actual Experimental set up used in laboratory

IX. Resources required

S. No.	Instrument /Components	Specification	Quantity
1	Water circulating tank	Metal tank	1
2	Electric pump	230v, 1hp	1
3	Turbine flow meter	(magnetic pic-up type), (2" L), Pmax-150 Psi, With compression fitting	1
4	Flow rate indicator	Pre amplifier with Panel mounted Display with 24v DC supply.	1
4	Discharge pipe	2" diameter	1
5	Shut-off valve	BS-218 (2" L)	1
6	Water inlet connection	Main line with ON/OFF valve	1
7	Rotameter	1200LPH, Pmax -7BAR,With compression fitting	1

X. Precautions

1. Fluid used must be clean.
2. Problems due to cavitations should be checked periodically.
3. Require frequent calibration checks as viscosity affects the accuracy and linearity of turbine meters.

XI. Procedure

1. Switch on the systems power supply and start the electric pump.
2. Adjust the shut-off valve to minimum opening, and wait for the flow to become steady.
3. Note down the readings on the digital display and rotameter.
4. Repeat step no.3 by increasing the flow rate using the valve provided.

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
1			
2			
3			
4			
5			

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations:

Table 1: Measurement of turbine and rotameter readings

S.No.	Reading of turbine meter	Reading of rotameter
1		
2		
3		
4		

S.No.	Reading of turbine meter	Reading of rotameter
5		
6		
7		
8		

XVI. Results

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XVII. Interpretation of results

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XVIII. Conclusions & Recommendation

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XIX. Practical related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Name the different types of flow meter
2. State the working principle of turbine flow meter
3. State the applications of turbine flow meter

[Space for Answers]

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XX. References / Suggestions for further Reading

1. https://www.omega.com/literature/transactions/volume4/T9904-08-MECH.html
2. https://www.smartmeasurement.com/flow-meters/turbine/measuring-principle
3. http://www.eeeguide.com/turbine-flow-meter-principle/

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (10 Marks)		**(40%)**
1	Handling of the equipment/measuring instruments	20%
2	Plotting graph / calculations	20%
Product related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25Marks)		**100 %**

Names of Student Team Members

1. …………………………
2. …………………………
3. …………………………
4. …………………………

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No.11: Measurement of level using Air purge method

I. Practical Significance

It is essential to measure and maintain the level of reactants, fluid and utilities in various chemical process equipment for their effective performance. Air purge method of level measurement is an indirect method of level measurement. This is one of the most popular methods for hydrostatic liquid level measuring system. It is suitable for almost all type of liquids. It is an inexpensive but accurate means of measuring the fluid level in open or vented containers. Aim of this experiment is to measure liquid level inside a tank using air purge method.

II. Relevant Program Outcomes (POs)

PO1 – Basic Knowledge: Apply knowledge of basic mathematics, Sciences and basic engineering to solve the chemical engineering problems.

PO3 - Experiments and practice: Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.

PO4 - Engineering tools: Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.

PO8 - Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PSO2 - Material management and quality control: Manage chemicals and equipment to produce quality chemical products.

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry-identified competency: **'Apply relevant process control parameter in chemical plants':**

1. Use Air purge method for level measurement for different fluids.
2. Use Air Purge method for density measurement.

IV. Relevant Course Outcomes

Measure the flow level using various measuring instruments in chemical industry.

V. Practical Outcome

Measure level using Air purge method

VI. Relevant Affective domain related Outcome(s)

1. Follow safe practices
2. Practice good housekeeping
3. Demonstrate working as a leader/a team member
4. Maintain tools and equipment
5. Follow ethical practices

VII. Minimum Theoretical Background –

Air purge system is also known as bubbler method for indirect level measurement. This is one of the accurate hydrostatic methods of level measurement. This method is suitable for corrosive or abrasive liquid level measurements. In this method, when there is no liquid in the tank or the liquid in the tank is below the bottom end of the bubbler tube, the pressure gauge indicate zero. As the liquid level in the tank increases, the air flow is restricted by the depth of liquid and the air pressure acting against liquid head appears as back pressure to the pressure gauge.

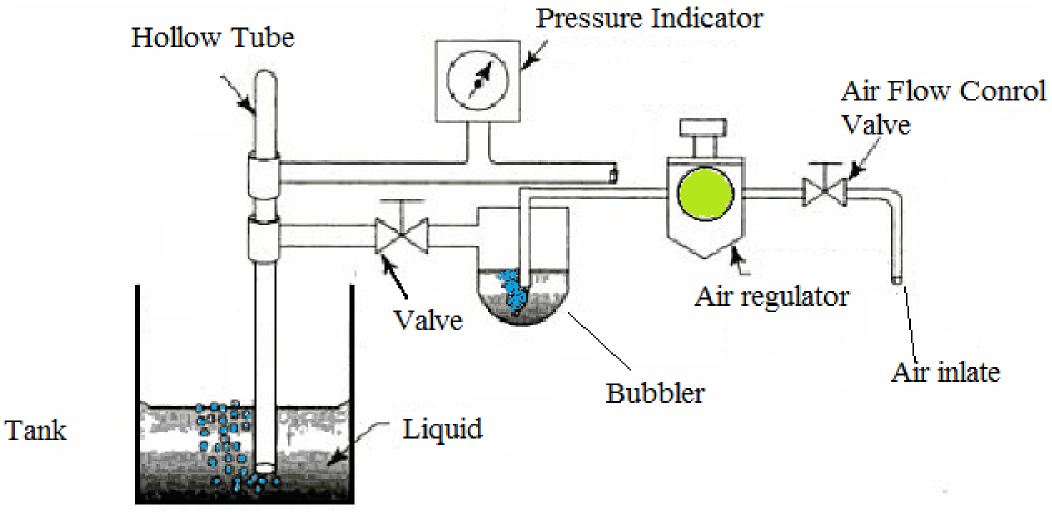

Figure 1: Level measurement by using Air Purge Method
Courtesy: (https://i1.wp.com/www.electricalidea.com/wp-content/uploads/2016/10/dsfds.png)

VIII. Practical circuit diagram:

a) Sample:

Figure 2: Laboratory Air Purge Liquid Level measurement set up
(https://5.imimg.com/data5/JT/KS/.../level-measurement-by-using-air-purge-system.pdf**)**

b) Actual setup used in the laboratory:

Figure 3

c) Actual Experimental set up used in laboratory

IX. Resources required

S. No.	Instrument /Components	Specification	Quantity
1	Level Tank	Transparent	1
2	Level Indicator	U Tube manometer	1
3	Air Regulator	¼" air regulating valve, leak proof.	1
4	Air Input	Compressor (5psi – depends on the height of the tank)	1

X. Precautions

1. Ensure the Fluid is static.
2. Care must be taken to prevent water leakages.
3. Complete air tight and leak proof assembly is required.

XI. Procedure

1. Fill the container up to desired level, above the tip of air purge pipe.
2. Switch on the pumps and compressors.
3. Open the air regulating valve, allow air to purge through the pipe.
4. Note down the level in the tank manually.
5. Now down the manometer reading.
6. Repeat the procedure for varying levels of water in the container.

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity	Remarks

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations:

Table 1: Measurement of level by U-tube manometer and air purge instrument

Sr. No.	Liquid Level measured by scale (cm)	Liquid Level indicated by air purge system(manometer)
1		
2		
3		
4		
5		
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XVI. Results

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XVII. Interpretation of results

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XVIII. Conclusions & Recommendation

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XIX. Practical related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Write two applications of air purge level measurements.
2. What is the air pressure required for air purge system?
3. What is the density of liquid used in air purge system?

[Space for Answers]

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XX. References / Suggestions for further Reading

1.https://5.imimg.com/data5/JT/KS/.../level-measurement-by-using-air-purge-system.pdf
2. https://i1.wp.com/www.electricalidea.com/wp-content/uploads/2016/10/dsfds.png
3. https://www.electricalidea.com/2016/10/26/air-purge-method/

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (10 Marks)		**(40%)**
1	Handling of the equipment/measuring instruments	20%
2	Plotting graph / calculations	20%
Product related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total(25Marks)		**100 %**

Names of Student Team Members

1.…………………………
2.…………………………
3.…………………………
4.…………………………

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 12: Measurement of level using capacitive transducer

I. Practical Significance

Level is an important parameter that requires accurate measurement and control in an industrial environment. There are a variety of direct and indirect level measurement techniques available. Capacitive level measurement method is one of the simplest, effective, fast and precise one. Aim of this experiment is to measure level using a capacitive transducer.

II. Relevant Program Outcomes (POs)

PO3 - Experiments and practice: Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.

PO4 - Engineering tools: Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.

PO8 - Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

Program Specific Outcomes (PSO)

PSO2 - Material management and quality control: Demonstrate knowledge and understanding for selection, material management and quality control in Chemical engineering.

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry-identified competency: ‘**‘Apply relevant process control parameter in chemical plant’:**

1. Use capacitive sensor for level measurement.
2. Analyze and apply the technique to different chemical processes.

IV. Relevant Course Outcomes –

Measure flow and level using various measuring instruments in chemical industry.

V. Practical Outcome

Use capacitance probe method for level measurement of liquid in a tank.

VI. Relevant Affective domain related Outcome(s)

1. Follow safe practices
2. Practice good house keeping
3. Demonstrate working as a leader/team member
4. Maintain tools and equipment
5. Follow ethical practices

VII. Minimum Theoretical Background

The basic principle used in capacitive transducer is the variation of capacitance with variation in area of plates, distance between the plates and dielectric constant, as

$C = f(A, d, \in)$

In conventional capacitive – type level measurement system, two electrodes are used for non-metallic tank and only one electrode for conducting tank as shown below.

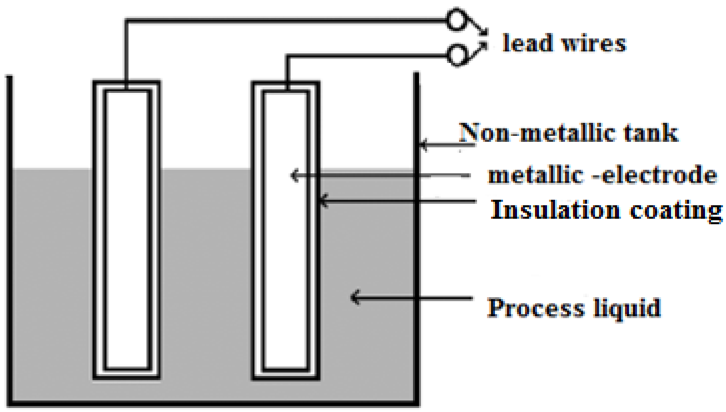

Figure1. Liquid in non-metallic tank

(Courtesy: https://www.brighthubengineering.com/hvac/53147-how-capacitive-transducers work)

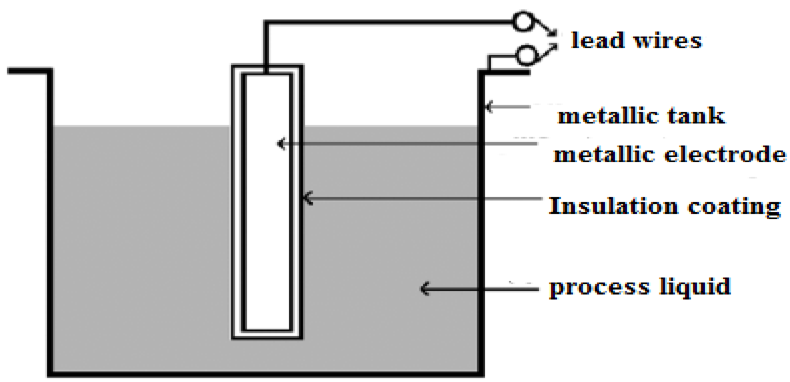

Figure 2. Liquid in metallic tank

(Courtesy: https://www.brighthubengineering.com/hvac/53147-how-capacitive-transducers work)

Capacitance between the electrodes increases with an increase in liquid level ($C \propto \in$). Capacitance output is connected to necessary electronic circuit, which converts capacitance into a DC output voltage. The display unit may be calibrated to express the level in (cm or m) units.

VIII. Practical Circuit Diagram:

a) Sample Circuit used in laboratory

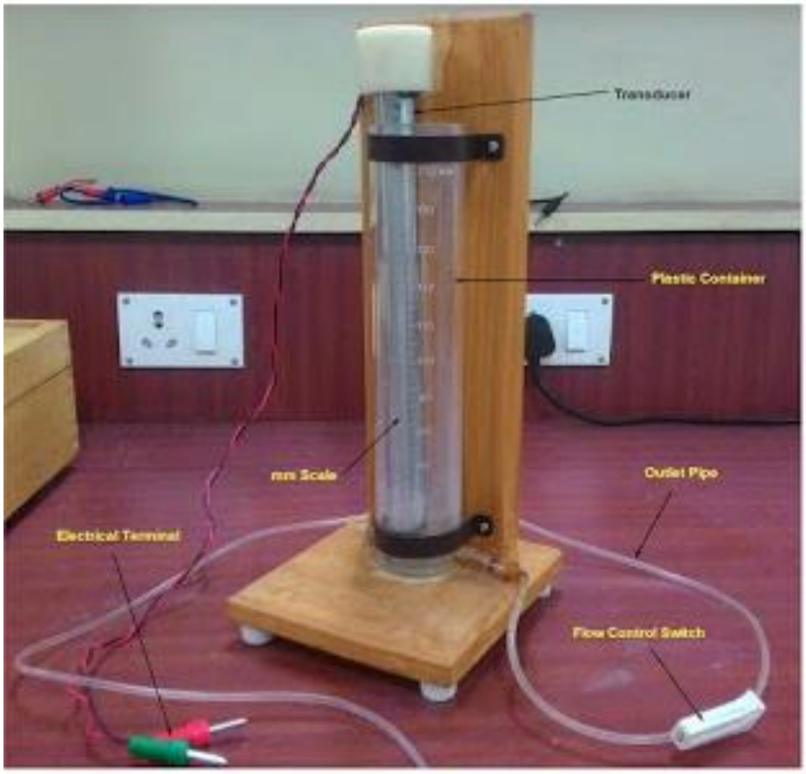

Figure 3

Courtesy: http://technlab.blogspot.com/2016/02/experiment-9b-measurement-of-water.html

b) Actual Circuit used in laboratory

Figure 4

c) Actual Experimental set up used in laboratory

IX. Resources required

S. No.	Instrument /Components	Specification	Qty.	Remarks
1	Capacitive transducer with acrylic tank	Concentric stainless-steel electrodes, Up to 100cm total length	1	Any convenient range
2	Measuring tape	Standard	1	Measuring scale
3	Water supply, pipe connection & drain valve	On/off valve with ½ inch pipe connection	1	Small units may be filled and drained manually
4	Electronic kit	Oscillator, pulse width modulator and digital display, 0-5v output	1	Suitable electronic circuit to convert capacitance into a measurable voltage/current

X. Precautions

1. During measurement, each time wait for some time for the reading to stabilize to avoid error in measurement.
2. Don’t use wet hands while handling electrical connections.

XI. Procedure

1. Insert the capacitive transducer into the acrylic tank.
2. Connect probe of the transducer to the socket provided on the electronic kit (level indicator).
3. Connect the kit to 230v, 50 Hz supply.
4. Adjust the zero adjustment potentiometer so that the display indicate zero reading.
5. Connect the water pipe to the input of acrylic tank.
6. Fill the tank to some convenient level.
7. Note down the display when it stabilizes.
8. Note down the reading of water level using a measuring tape.
9. Repeat steps 6, 7, and 8 by adding more water, each time.

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations:

Table 1: Measurement of level

S.No.	Level in cm (display)	Level in cm (measuring tape)
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3		
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XVI. Results

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XVII. Interpretation of results

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XVIII. Conclusions & Recommendation

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XIX. Practical related Questions

1) State and justify the factors to be considered while selecting capacitive level transducer for level measurement.
2) State the advantages and disadvantages of the method compared to other means of level measurements.
3) Sate and explain the commonly used method of level measurement in industry.

[Space for Answers]

XX. References / Suggestions for further Reading

1. https://www.brighthubengineering.com/hvac/53147-how-capacitive-transducers-work/
2. http://iopscience.iop.org/article/10.1088/1742-6596/776/1/012118/pdf
3. http://www.analog.com/en/analog-dialogue/articles/liquid-level-sensing-using-cdcs.html

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (10 Marks)		**(40%)**
1	Handling of the equipment/measuring instruments	20%
2	Plotting graph / calculations	20%
Product related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25Marks)		**100 %**

Names of Student Team Members

1. …………………………
2. …………………………
3. …………………………
4. …………………………

Marks Obtained			**Dated signature of Teacher**
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No.13: Measurement and control of temperature using ON/OFF controller.

I. Practical Significance

An ON/OFF controller simply drives the manipulated variable from fully closed to fully open depending on the position of the controlled variable relative to the set point. It is frequently used in industrial HVAC and simple furnaces, room heating/cooling systems, refrigerators and level control systems. These are cheap and effective for systems with relatively slow process rates. Aim of this experiment is to control temperature using ON/OFF controller.

II. Relevant Program Outcomes (POs)

PO3 - Experiments and practice: Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.

PO4 - Engineering tools: Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.

PO8 - Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PO10 – Life-long learning: Engage in independent and life-long learning activities in the context of technological changes also in the chemical engineering and allied industries.

PSO2 - Material management and quality control: Manage chemicals and equipment to produce quality chemical products.

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry-identified competency: **'Apply relevant process control parameter in chemical plants':**

1. Set ON/OFF controller.
2. Monitor ON/OFF controller for temperature measurement.

IV. Relevant Course Outcomes -

Select control system for various control action in process industry.

V. Practical Outcome

Use ON-OFF controller for temperature control system.

VI. Relevant Affective domain related Outcome(s)

1. Follow safe practices
2. Practice energy conservation
3. Demonstrate working as a leader/a team member
4. Maintain tools and equipment

VII. Minimum Theoretical Background –

An ON-OFF controller is the simplest form of temperature control device. The output from the device is either ON or OFF. An ON-OFF controller will switch the output only when the temperature crosses the set points. The output of ON-OFF controller is either 0% or minimum to 100% or maximum without any intermediate value. As controlled variable crosses set point either from above or below it, the controller output suddenly changes from its one extreme value to the other. This drives the final control element from one extreme position to other.

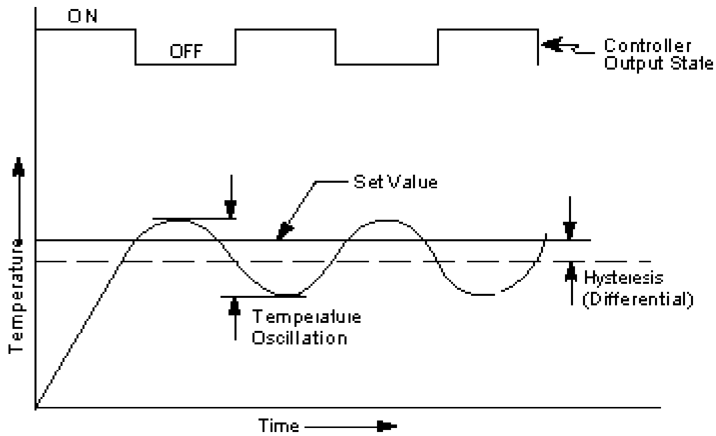

Figure 1: Temperature measurement profile using ON-OFF controller
Courtesy: (http://www.heaters-controls-hydraulics.com/athena/pages/fund.html)

VIII Practical Circuit Diagram

a) Sample

Figure 2: Temperature measurement using ON-OFF controller
Courtesy: (http://www.sincomindia.com/instrumentation-and-control-system.html)

b) Actual Circuit used in laboratory

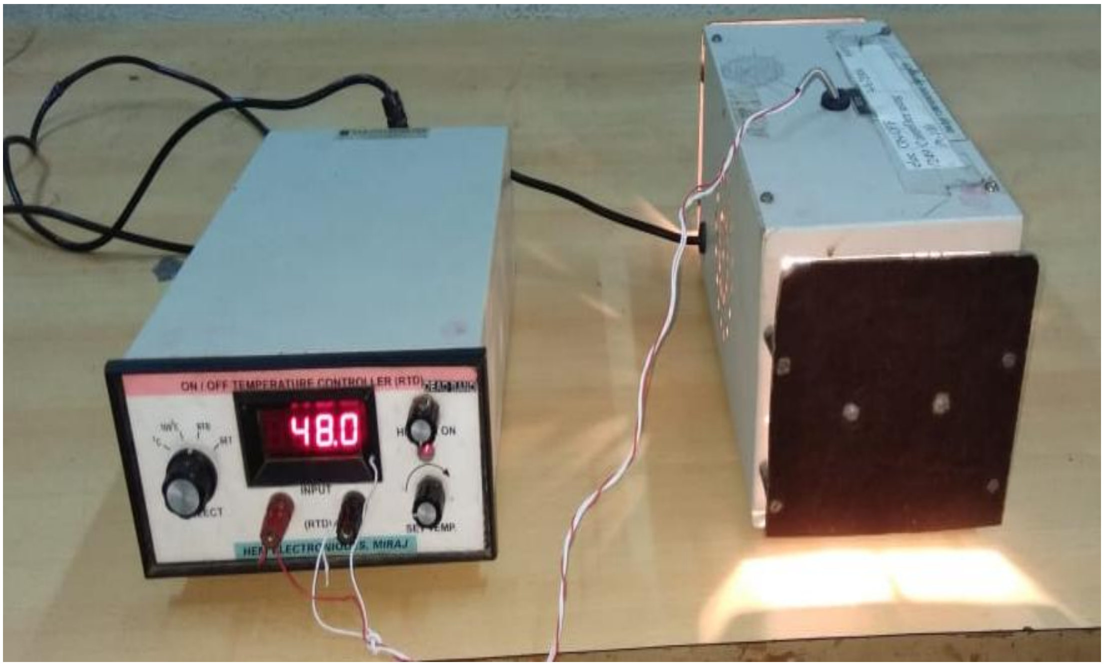

Figure 3

c) Actual Experimental set up used in laboratory

IX. Resources required

S. No.	Instrument /Components	Specification	Quantity
1	ON-OFF controller kit	Supply voltage 1.6V to 5.5V max, operating temperature 0 to 100^{o}C,I/O response - high	1
2	RTD	Pt 100 sensor	1
3	Electric Oven	230v, 50hz supply connected to 200W bulb	1

X. Precautions

1. Ensure the proper insulation and water proof assembly.
2. Ensure the proper connection of all devices.
3. Care must be taken to prevent water leakages.

XI. Procedure

1. Connect the sensor to controller.
2. Insert the sensor into the electric oven.
3. Connect the controller to the power supply, and switch on.
4. Adjust the temperature set point (SP) to some convenient value, say 40^{0}C.
5. Set the neutral zone to some low value.
6. Connect the oven to the controller, and switch on.
7. Note down the readings for some convenient time interval up to a few ON/OFF conditions.
8. In between, create external disturbance (eg., by varying speed of ceiling fan) and observe the response.
9. Repeat steps 4 - 6 for higher hysteresis.
10. Plot the output response, Time Vs Temperature.

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations:
Table 1: Measurement of temperature and time

Set point =

	Less hysteresis (neutral zone)			More hysteresis (neutral zone)		
Sr. No	**Time (Sec)**	**Temperature (0^C)**	**Switch position (ON/OFF)**	**Time (Sec)**	**Temperature (0^C)**	**Switch position (ON/OFF)**
1						
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XVI. Results

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XVII. Interpretation of results

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XVIII. Conclusions & Recommendation

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XIX. Practical related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. List any four temperature controlling devices other than the ON-OFF controller
2. List two applications where ON-OFF controller used.
3. List two devices in the laboratory where ON-OFF controller is installed.
4. List the limitations of ON-OFF control action.

[Space for Answers]

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XX References / Suggestions for further Reading

1. http://www.heaters-controls-hydraulics.com/athena/pages/fund.html
2. https://i1.wp.com/www.electricalidea.com/wp- content/uploads/2016/10/dsfds.png
3. Process Control Instrumentation technology by C.D Johnson

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (10 Marks)		**(40%)**
1	Handling of the equipment/measuring instruments	20%
2	Plotting graph / calculations	20%
Product related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25marks)		**100 %**

Names of Student Team Members

1. …………………………
2. …………………………
3. …………………………
4. …………………………

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Scale

X-axis -

Y-axis -

Practical No. 14: Measurement and control of temperature using PI controller.

I. Practical Significance

The main objective of a process control system is to minimize the effect of changes in the load variables on the system output. In order to achieve optimum control, it is required to match the characteristics and dynamics of the process with that of the control system. P-I controller is mainly used to eliminate the steady state error (offset) resulting from a P controller, in varying load conditions. Aim of this experiment is to control temperature using PI controller.

II. Relevant Program Outcomes (POs)

PO3 - Experiments and practice: Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.

PO4 - Engineering tools: Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.

PO8 - Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PSO2 - Material management and quality control: Manage chemicals and equipment to produce quality chemical products.

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry-identified competency: '**'Apply relevant process control parameter in chemical plant':**

1. Use terminologies related to the world of automation and control.
2. Select controller for different applications.
3. Monitor a PI control loop.

IV. Relevant Course Outcomes

Select control system for various control action in chemical industry.

V. Practical Outcome –

Use PI controller for temperature control system.

VI. Relevant Affective domain related Outcome(s)

1. Follow safe practices.
2. Practice energy conservation.
3. Demonstrate working as a leader/team member.
4. Maintain tools and equipment.
5. Follow ethical practices.

VII. Minimum Theoretical Background

PI controller is a composite controller, which combines the advantage of fast transient response of proportional mode and offset steady state response of integral mode. Analytical equation for the output is,

$$P = k_p e_p + k_p k_i \int_0^{T_i} e_p . dt + P_{t(0)}$$

Where pt (0) = Integral term value at t = 0 (initial value)

When the error is zero, the controller output is fixed at the value that the integral term had, when the error reduced to zero. This output is given by pt(0), because we choose to define the time at which observation starts, as t = 0. If the error is not zero, the proportional term contributes a correction and the integral term begins to increase or decrease the accumulated value [initial pt(0)], depending on the sign of the error and its action, direct or reverse. The integral term cannot become negative, thus it will saturate at zero, if the error and the action try to drive the area to a net negative value (refer fig.1).

In a proportional controller, a permanent offset is created when a load change require a nominal controller output. A proportional controller could not provide this, except by a fixed error from the set point. However, in PI mode, the integral function provides the required new controller output, thereby allowing the error to be zero after a load change. The integral feature effectively provides a 'reset' of the zero error output, after the load, change occurs. At time t_1 a load change occurs, that produces the error. The accommodation of the new load condition requires a new controller output. The controller output is provided through a sum of proportional plus integral action that finally leaves the error at zero (refer fig.1).

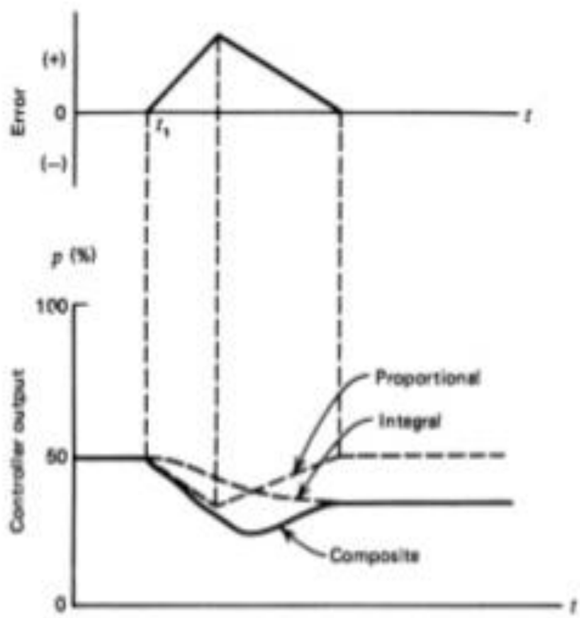

Figure 1: Proportional –Integral action for reverse action

VIII. Practical Circuit Diagram

a) Sample Circuit used in laboratory

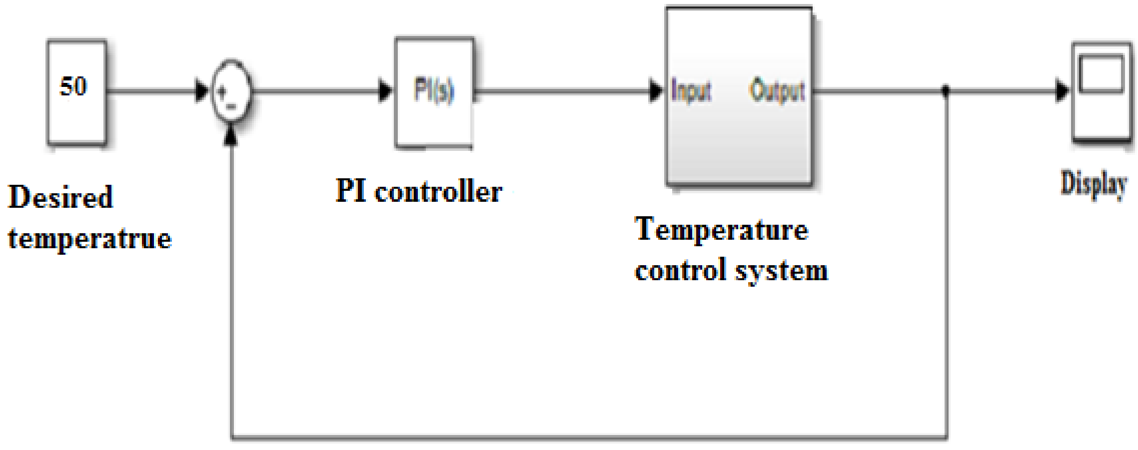

Figure 2: PI based temperature control system

b) Actual Circuit used in laboratory

Figure 3

c) Actual Experimental set up used in laboratory

IX. Resources required

S. No.	Instrument /Components	Specification	Quantity
1	Electric oven	230v, 1KW	1
2	Controller	Microprocessor based PI controller	1
3	Thermocouple	K-type	1
4	1ϕ AC supply	230v, 50 Hz	1
5	Stop watch	Resolution 1Sec, LCD	1

X. Precautions

1. Connect the oven to the process, only after setting the controller.
2. Operate within safe temperature limits.
3. Avoid lose connections at the power supply as well as sensor side.

XI. Procedure

1. Connect the sensor to controller.
2. Insert the sensor into the electric oven.
3. Connect the controller to the power supply, and switch on.
4. Adjust the temperature set point (SP) to some convenient value, say 50^0C.
5. Select the controller mode, auto/manual.
6. In case of manual mode, set the controller parameters (Kp, ti).
7. Connect the oven to the controller, and switch on.
8. Note down the readings for some convenient time interval, till the process temperature (PV) becomes equal / nearly equal to the SP.
9. Create external disturbance (eg., by varying speed of ceiling fan) and observe the controller response.
10. Repeat steps 4 - 6 for a different value of set point.
11. Plot the output response, Time Vs Temperature.

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
1			
2			
3			
4			

XIII. Actual procedure followed

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XIV. Precautions followed:

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XV. Observations and Calculations:

Table 1: Measurement of temperature and time

Set point =			**Set point =**	
Kp = ,ti =			**Kp = ,ti =**	
S.No.	**Time (sec)**	**Temperature(^{0}C)**	**Time (sec)**	**Temperature(^{0}C)**
1				
2				
3				
4				
5				
6				
7				
8				
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10				
11				
12				
13				
14				
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XVI. Results

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XVII. Interpretation of results

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XVIII Conclusions & Recommendation

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XIX. Practical related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. State the function of integral action in PI controller.
2. State the applications of PI controller.
3. Stare the drawbacks of PI controller.

[Space for Answers]

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XX. References / Suggestions for further Reading

1. www.informationvine.com/PID+Control+Theory
2. https://controlguru.com/integral-action-and-pi-control/
3. Process Control Instrumentation technology by C.D Johnson

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (10 Marks)		**(40%)**
1	Handling of the equipment/measuring instruments	20%
2	Plotting graph / calculations	20%
Product related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25Marks)		**100 %**

Names of Student Team Members

1. …………………………
2. …………………………
3. …………………………
4. …………………………

Marks Obtained			**Dated signature of Teacher**
Process Related(10)	**Product Related(15)**	**Total (25)**	

Scale

X-axis -

Y-axis -

Practical No. 15: Measurement and control of temperature using PID controller.

I. Practical Significance

PID controller is the most powerful, but complex controller mode of operations, which combines the advantages of proportional, integral and derivative modes. Most of the industrial controllers are P-I-D in nature. The major reason behind the popularity of P-I-D controller is its applicability to variety of processes, even in the absence of knowledge of the underlying process. Aim of this experiment is to control temperature using PID controller.

II. Relevant Program Outcomes (POs)

PO3 - Experiments and practice: Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.

PO4 - Engineering tools: Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.

PO8 - Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PSO2 - Material management and quality control: Manage chemicals and equipment to produce quality chemical products.

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry-identified competency: **‘‘Apply relevant process control parameter in chemical plant’:**

1. Use terminologies related to the world of automation and control.
2. Select controller for different applications
3. Monitor a PID control loop

IV. Relevant Course Outcomes

Select control system for various actions in chemical industry.

V. Practical Outcome

Use PID controller for temperature control system.

VI. Relevant Affective domain related Outcome(s)

1. Follow safe practices.
2. Practice energy conservation.
3. Demonstrate working as a leader/team member.
4. Maintain tools and equipment.
5. Follow ethical practices.

VII. Minimum Theoretical Background

In a PID controller, the proportional corrects instances of error, the integral corrects accumulation of error, and the derivative corrects present error versus error the last time it was checked. The effect of the derivative is to counteract the overshoot caused by P and I. When the error is large, the P and I will push the controller output. This controller response makes error change quickly, which in turn causes the derivative to more aggressively counteract the P and the I.

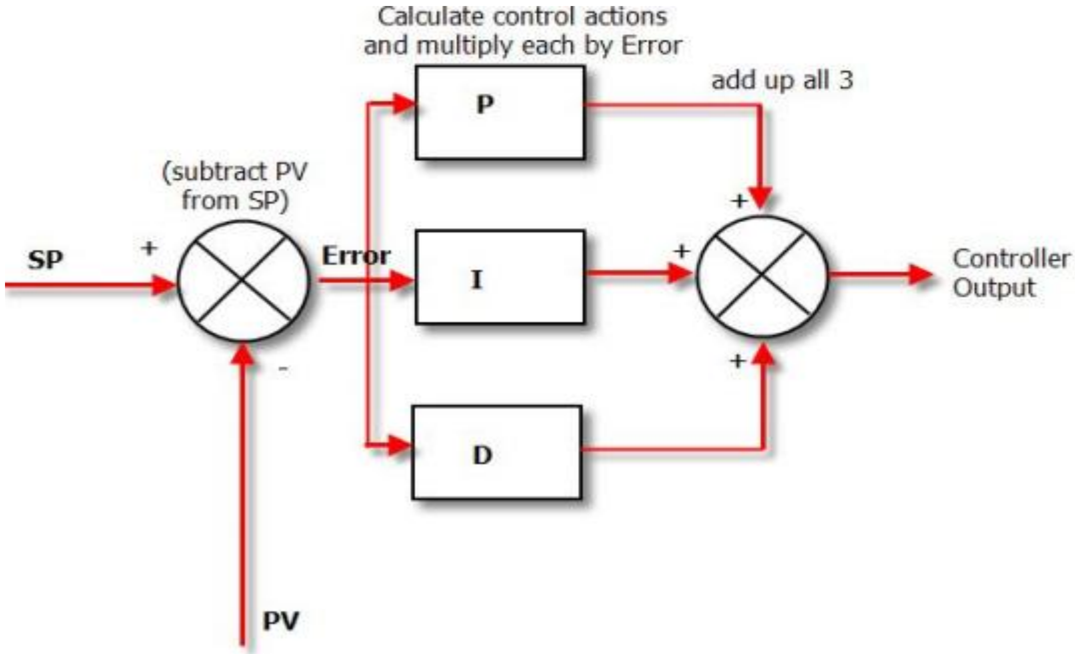

Figure 1: Block diagram of a PID controller
(Courtesy: https://www.csimn.com/CSI_pages/PIDforDummies.html)

VIII. Practical Circuit Diagram :

a) Sample

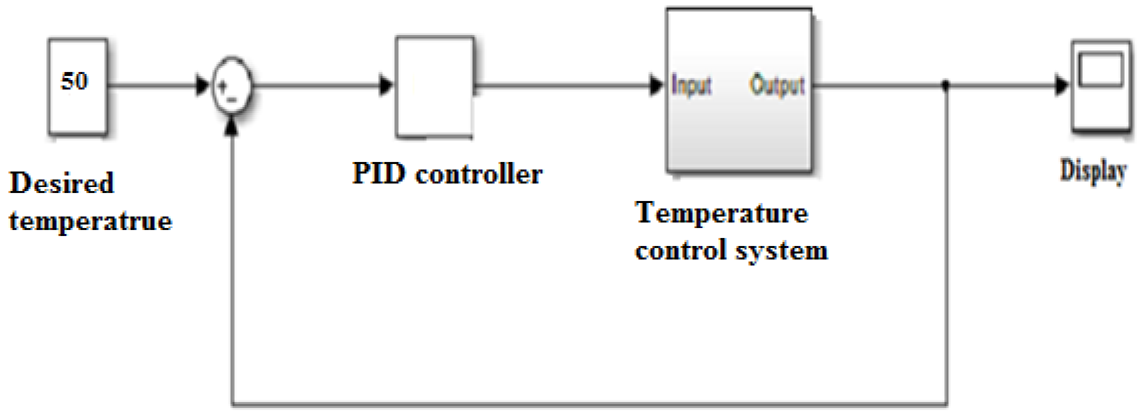

Figure2: PI based water level control system

b) Actual Circuit used in laboratory

Figure 3

c) Actual Experimental set up used in laboratory

IX. Resources required

S. No.	Instrument /Components	Specification	Quantity
1	Electric oven	230v, 1KW	1
2	Controller	Microprocessor based PID controller	1
3	Sensor	K-type thermocouple	1
4	1ϕ AC supply	230v, 50 Hz	1
5	Stop watch	Resolution 1Sec, LCD	1

X. Precautions

1. Connect the oven to the process, only after setting the controller.
2. Operate within safe temperature limits.
3. Avoid lose connections at the power supply as well as sensor side.

XI. Procedure

1. Connect the sensor to controller.
2. Insert the sensor into the electric oven.
3. Connect the controller to the power supply, and switch on.
4. Adjust the temperature set point (SP) to some convenient value, say 50^0C.
5. Select the controller mode, auto/manual.
6. In case of manual mode, set the controller parameters (Kp, ti & td).
7. Connect the oven to the controller, and switch it on.
8. Note down the readings for some convenient time interval, till the process temperature (PV) becomes equal / nearly equal to the SP.
9. Create external disturbance (eg., by varying speed of ceiling fan) and observe the controller response.
10. Repeat steps 4 - 6 for a different value of set point.
11. Plot the output response, Time Vs Temperature.

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations

Table 1: Measurement of temperature and time

Set point =			Set point =	
Kp = ,ti = , td =			Kp = ,ti = ,td =	
S.No.	Time (sec)	Temperature(^{0}C)	Time (sec)	Temperature(^{0}C)
1				
2				
3				
4				
5				
6				

Set point =			Set point =	
Kp = ,ti = , td =			Kp = ,ti = ,td =	
S.No.	**Time (sec)**	**Temperature(^{0}C)**	**Time (sec)**	**Temperature(^{0}C)**
7				
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0				
11				
12				
13				
14				
15				

XVI. Results

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XVII. Interpretation of results

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XVIII. Conclusions & Recommendation

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XIX. Practical related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1) A derivative controller alone cannot be used to control processes. Justify.
2) Write the comparison table of PI, PD and PID controller.
3) State the advantages of PID controller.

[Space for Answers]

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XX. References / Suggestions for further Reading

1. https://melab.wikischolars.columbia.edu/PID+Control+Experiment.
2. https://www.elprocus.com/the-working-of-a-pid-controller/
3. https://www.electricaltechnology.org › Controlling
4. http://www.ni.com/white-paper/3782/en/

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (10 Marks)		**(40%)**
1	Handling of the equipment/measuring instruments	20%
2	Plotting graph / calculations	20%
Product related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25Marks)		**100 %**

Names of Student Team Members

1. …………………………
2. …………………………
3. …………………………
4. …………………………

Marks Obtained			**Dated signature of Teacher**
Process Related(10)	**Product Related(15)**	**Total (25)**	

Scale

X-axis -

Y-axis -

Practical No.16: Determination of valve coefficient of control valves

I. Practical Significance

A control valve is the final control element in a process control system. The effectiveness of any control scheme depends on the performance of control valves. Control valves are available in different size and shapes. The shape of a valve plug is one of the deciding factors in determining its effective flow characteristics. Aim of this experiment is to study the characteristics of different control valves.

II. Relevant Program Outcomes (POs)

PO3 - Experiments and practice: Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.

PO4 - Engineering tools: Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.

PO7 – Ethics: Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of chemical engineering.

PO8 - Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PSO2 - Material management and quality control: Manage chemicals and equipment to produce quality chemical products.

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry-identified competency: **'Apply relevant process control parameter in chemical plants':**

IV. Relevant Course Outcomes

Use control valve characteristics for the selection of control valve in different applications.

V. Practical Outcome

Select control system for various actions in chemical industry.

VI. Relevant Affective domain related Outcome(s)

Draw the control valve characteristics for a given control valve

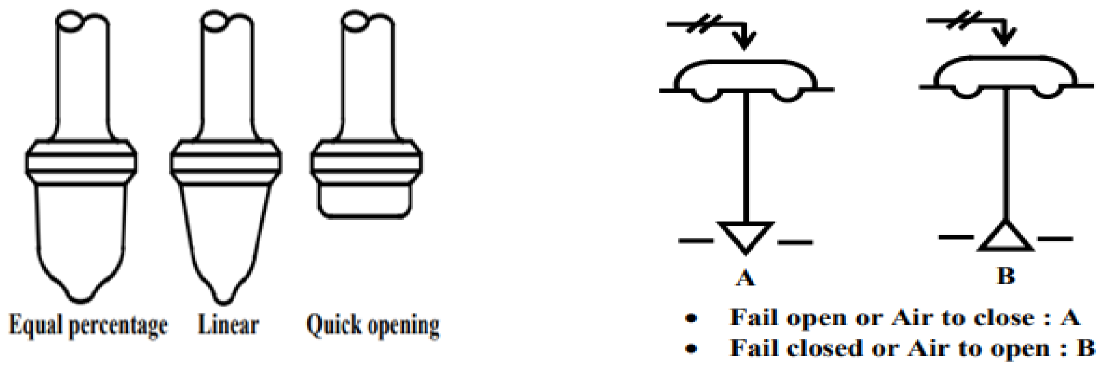
1. Follow safe practices
2. Practice good housekeeping
3. Demonstrate working as a leader/a team member
4. Maintain tools and equipment
5. Follow ethical practices

VII. Minimum Theoretical Background –

Control valve is a valve with a pneumatic, hydraulic, electric or other externally powered actuators. Theses actuators fully or partially open or close the valve to a position dictated by signal transmitted from controlling instruments. Control valve are used primarily to throttle energy in the fluid system and not for shut off purposes. The basic elements of control valve are valve body, stem and seat. There are different control valves available like globe valve, rotary stem valve and butterfly valve. The relation between stem position, plug position and rate of flow is termed as control valve characteristics. The amount of fluid passing through a valve at any point depends on the opening between the plug and seat. The flow coefficient (Cv) of a valve may be expressed as,

$$Cv = 1.16Q\sqrt{\frac{G}{\Delta P}}$$

Cv = Valve Flow coefficient
Q = Discharge of Fluid in m^3/s
G = Specific gravity of fluid
ΔP = Pressure drop in psi



A. 3 common valve plug shapes

B. Air to open & air to close valves

Figure 1: Shape and arrangement of valve plugs

Courtesy: (http://pointing.spiraxsarco.com/resources/steam-engineering-tutorials/control-hardware-el-pn-actuation/control-valve-characteristics.asp)

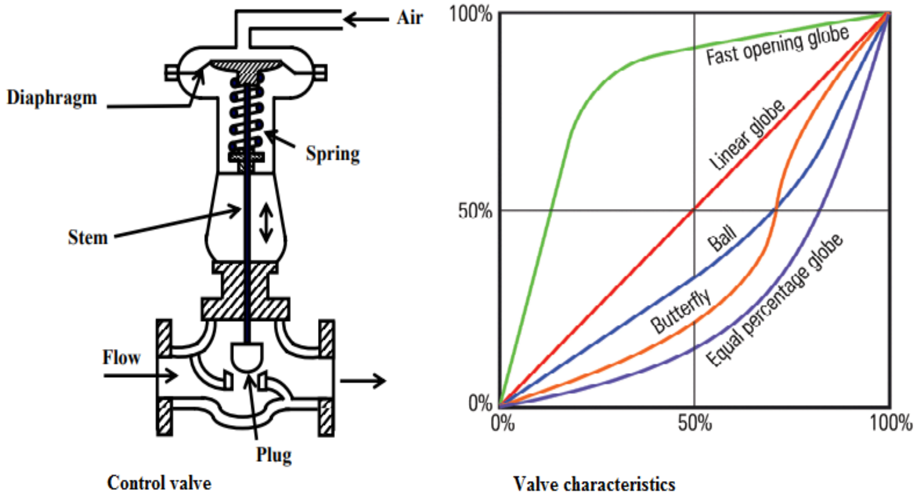


Figure 2: Control valve & characteristics

Courtesy: (http://pointing.spiraxsarco.com/resources/steam-engineering-tutorials/control-hardware-el-pn-actuation/control-valve-characteristics.asp)

VIII. Practical Circuit diagram:

a) Sample diagram

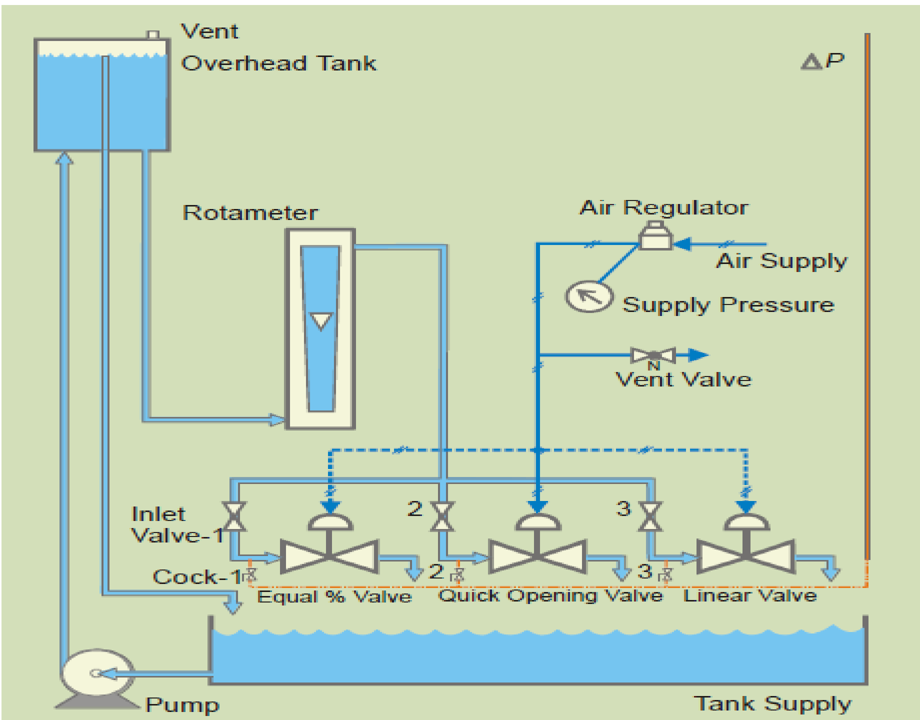


Figure 3: Control valve characteristics experimental trainer

(http://technlab.blogspot.com/2016/08/objective-tostudy-characteristic-of.html)

b) Actual Experimental set up used in laboratory

Figure 4

c) Actual Experimental set up used in laboratory

IX. Resources required

S. No.	Instrument /Components	Specification	Quantity
1	Pneumatic actuated Linear Control Valve	Pneumatic; Size: 1/2", Input: 3–15 psig, Air to open	1
2	Pneumatic actuated Equal % Control Valve	Pneumatic; Size: 1/2", Input: 3–15 psig, Action: Air to open	1
3	Pneumatic actuated Quick opening Control Valve	Pneumatic; Size: 1/2", Input: 3–15 psig, Air to open	1
4	Rotameter	40-400 LPH	1
5	Pressure Indicator	Bourdon gauge	1
5	Overhead Tank	20 liters	1
6	Fluid	Water	
7	Sump tank	20 liters	1

X. Precautions

1. Care must be taken for leak proof assembly setup.

XI. Procedure

1 Start the setup for linear control valve.
2 Open pneumatic line for control valve.
3 Adjust the stem position to 25% of total stem travel, varying the pneumatic supply.
4 Wait for some time to allow the flow to become steady.
5 Record the rotameter reading.
6 Now slowly increase the air pressure (air to open) so that stem valve position becomes 50%.
7 Maintain the pressure drop constant by regulating the throttle valve.
8 Again, note down the reading of rotameter.
9 Repeat the above procedure for entire range of stem travel.
10 Calculate control valve coefficient, using the given formula.
11. Plot the graph of valve coefficient versus stem lift.

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity	Remarks

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations:

Table 1: Inherent Characteristics of Linear valve

Specific gravity of fluid G =

Stem Lift in %	Flow rate (Q)		ΔP (psi)	Cv
	LPH	m^3/s		
25				
50				
75				
100				

Table 2: Inherent Characteristics of equal % valve

Stem Lift in %	Flow rate (Q)		ΔP(psi)	Cv
	LPH	m^3/s		
25				
50				
75				
100				

Table 3: Inherent Characteristics of quick opening valve

Stem Lift in %	Flow rate (Q)		ΔP(psi)	Cv
	LPH	m^3/s		
25				
50				
75				
100				

Calculations:-

$$Cv = 1.16Q\sqrt{\frac{G}{\Delta P}}$$

XVI. Results

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XVII. Interpretation of results

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XVIII. Conclusions & Recommendation

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XIX. Practical related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. List the different control valves available in laboratory. Mention their specification.
2. List the different body parts of control valve set up available in laboratory.
3. Define the Control valve coefficient.

[Space for Answers]

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2. http://www.spiraxsarco.com/Resources/Pages/Steam-Engineering-Tutorials/control-hardware-el-pn-actuation/control-valve-characteristics.aspx
3. https://www.engineeringtoolbox.com/control-valves-flow-characteristics-d_485.html
4. Process Control: Instrument Engineers Handbook by B.G Liptak.

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X-axis -

Y-axis -

List Of Laboratory Manuals Developed by MSBTE

First Semester:

1	Fundamentals of ICT	22001
2	English	22101
3	English Work Book	22101W
4	Basic Science (Chemistry)	22102
5	Basic Science (Physics)	22102

Second Semester:

1	Bussiness Communication Using Computers	22009
2	Computer Peripherals & Hardware Maintenace	22013
3	Web Page Design with HTML	22014
4	Applied Science (Chemistry)	22202
5	Applied Science (Physics)	22202
6	Applied Machines	22203
7	Basic Surveying	22205
8	Applied Science (Chemistry)	22211
9	Applied Science (Physics)	22211
10	Fundamental of Electrical Engineering	22212
11	Elements of Electronics Engineering	22213
12	Elements of Electrical Engineering	22215
13	Basic Electronics	22216
14	C Language programming	22218
15	Basic Electronics	22225
16	Programming in C	22226
17	Fundamental of Chemical Engineering	22231

Third Semester:

1	Applied Multimedia Techniques	22024
2	Advanced Serveying	22301
3	Highway Engineering	22302
4	Mechanics of Structures	22303
5	Building Construction	22304
6	Concrete Technology	22305
7	Strength Of Materials	22306
8	Automobile Engines	22308
9	Automobile Transmission System	22309
10	Mechanical Operations	22313
11	Technology Of Inorganic Chemicals	22314
12	Object Oriented Programming Using C++	22316
13	Data Structure Using 'C'	22317
14	Computer Graphics	22318
15	Database Management System	22319
16	Digital Techniques	22320
17	Principles Of Database	22321
18	Digital Techniques & Microprocessor	22323
19	Electrical Circuits	22324
20	Electrical & Electronic Measurment	22325
21	Fundamental Of Power Electronics	22326
22	Electrical Materials & Wiring Practice	22328
23	Applied Electronics	22329
24	Electrical Circuits & Networks	22330
25	Electronic Measurments & Instrumentation	22333
26	Principles Of Electronics Communication	22334
27	Thermal Engineering	22337
28	Engineering Matrology	22342
29	Mechanical Engineering Materials	22343
30	Theory Of Machines	22344

Fourth Semester:

1	Hydraulics	22401
2	Geo Technical Engineering	22404
3	Chemical Process Instrumentation & Control	22407
4	Fluid Flow Operation	22409
5	Technology Of Organic Chemical	22410
6	Java Programming	22412
7	GUI Application Development Using VB.net	22034
8	Microprocessor	22415
9	Database Managment	22416
10	Electric Motors And Transformers	22418
11	Industrial Measurement	22420
12	Digital Electronic And Microcontroller Application	22421
13	Linear Integrated Circuits	22423
14	Microcontroller & Applications	22426
15	Basic Power Electronics	22427
16	Digital Communication Systems	22428
17	Mechanical Engineering Measurments	22443
18	Fluid Mechanics and Machinery	22445
19	Fundamentals Of Mechatronics	22048
20	Micro Project & Industrial Training Assessment Manual	22049

Fifth Semester:

1	Network Management & Administration	17061
2	Solid Modeling	17063
3	CNC Machines	17064
4	Behavioral Science(Hand Book)	17075
5	Behavioral Science (Assignment Book)	17075
6	Windows Programming using VC++	17076
7	Estimation and Costing	17501
8	Public Health Engineering	17503
9	Concrete Technology	17504
10	Design of Steel Structures	17505
11	Switchgear and Protection	17508
12	Microprocessor & Application	17509
13	A.C. Machines	17511
14	Operating System	17512
15	Java Programming	17515
16	System Programming	17517
17	Communication Technology	17519
18	Hydraulic & Pneumatics	17522
19	Advanced Automobile Engines	17523
20	Basic Electrical & Electronics	17524
21	Measurement and Control	17528
22	Power Engineering	17529
23	Metrology & Quality Control	17530
24	Computer Hardware & Networking	17533
25	Microcontroller	17534
26	Digital Communication	17535
27	Control System & PLC	17536
28	Audio Video Engineering	17537
29	Control System	17538
30	Industrial Electronics and applications	17541
31	Heat Transfer Operations	17560
32	Chemical Process Instrumentation & control	17561

Sixth Semester:

1	Solid Modeling	17063
2	Highway Engineering	17602
3	Contracts & Accounts	17603
4	Design of R.C.C. Structures	17604
5	Industrial Fluid Power	17608
6	Design of Machine Elements	17610
7	Automotive Electrical and Electronic Systems	17617
8	Vehicle Systems Maintenance	17618
9	Software Testing	17624
10	Advanced Java Programming	17625
11	Mobile Computing	17632
12	System Programing	17634
13	Testing & Maintenance of Electrical Equipments	17637
14	Power Electronics	17638
15	Illumination Engineering	17639
16	Power System Operation & Control	17643
17	Environmental Technology	17646
18	Mass Transfer Operation	17648
19	Advanced Communication System	17656
20	Mobile Communication	17657
21	Embedded System	17658
22	Process Control System	17663
23	Industrial Automation	17664
24	Industrial Drives	17667
25	Video Engineering	17668
26	Optical Fiber & Mobile Communication	17669
27	Therapeutic Equipment	17671
28	Intensive Care Equipment	17672
29	Medical Imaging Equipment	17673

Pharmacy Lab Manual

First Year:

1	Pharmaceutics - I	0805
2	Pharmaceutical Chemistry - I	0806
3	Pharmacognosy	0807
4	Biochemistry and Clinical Pathology	0808
5	Human Anatomy and Physiology	0809

Second Year:

1	Pharmaceutics - II	0811
2	Pharmaceutical Chemistry - II	0812
3	Pharmacology & Toxicology	0813
4	Hospital and Clinical Pharmacy	0816

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