I

Name ______________________

Roll No. ______________ Year 20______20______

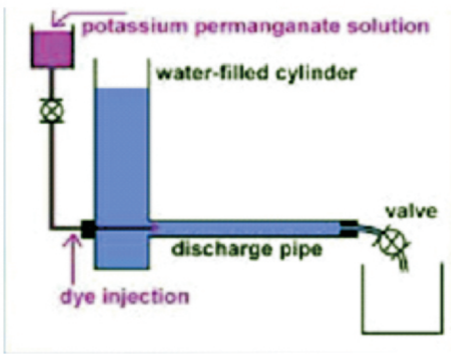
Exam Seat No. ______________________

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

A LABORATORY MANUAL

FOR

FLUID FLOW OPERATION (22409)



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

Fluid Flow Operation

(22409)

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 **Fluid Flow Operation (22409)** 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 programs with outcome-based 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 practicals to ***focus*** on the ***outcomes***, rather than the traditional age old practice of conducting practicals 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.

Chemical Engineers during their course of work have to deal with various aspects of chemical processes. They are responsible for the storage and transfer of the materials/utilities to the reactor, which involves selection of appropriate/relevant pumps and piping, flow meters etcAn understanding of the fluids is essential, not only for accurately treating problems in the movement of fluids through pipes, pumps, and all kinds of process equipment but also for the study of heat flow and the many separation operations that depend on diffusion and mass transfer. To control industrial processes, it is essential to know the amount of material entering and leaving the process. Because materials are transported in the form of fluids wherever possible, it is important to accurately measure the rate at which the fluid is flowing through a pipe or other channel.

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 practical of the chemical engineering.

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

PO2. Discipline knowledge: Apply **Chemical Engineering** knowledge to solve industry based Chemical Engineering problems.

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

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

PO6. Environment and sustainability: Apply Chemical engineering solutions also for sustainable development practices in societal and environmental context.

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.

PO9. Communication: Communicate effectively in oral and written form.

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

****

List of Industry Relevant Skills

The following industry relevant skills of the competency '***Maintain flow of different fluids in the chemical plant according to the process requirement.'*** are expected to be developed in you by undertaking the practicals of this practical manual.

1. Maintain fluid parameters accurately.
2. Use flow meters for accurate measurement of flow rate
3. Operate relevant liquid pumping device and gas pumping device.
4. Maintain the required pressure drop in the piping system

Practical- Course Outcome matrix

Course Outcomes (COs)

a. Maintain the fluid parameters in chemical process.
b. Interpret the pressure drop in piping systems
c. Maintain the flow rate of incompressible fluid.
d. Select the relevant piping system for fluid transportation.
e. Use liquid pumping devices.
f. Use gas pumping devices.

S. No.	Practical Outcome	CO a.	CO b.	CO c.	CO d.	CO e.	CO f.
1.	Use viscometer to measure the viscosity of starch solution of different concentration	√	-	-	-	-	-
2.	Determine the effect of temperature on the viscosity of given liquid	√	-	-	-	-	-
3.	Use U tube manometer for measuring differential and gauge pressure	√	√	-	-	-	-
4.	Use Reynolds apparatus to identify the type of flow	√	-	√	-	-	-
5.	Use friction factor set up to determine friction factor and plot friction factor vs Reynolds number for a given pipe.	-	√	√	√	-	-
6.	Use the experimental set up to calculate viscosity of flowing fluid using Hagen Poiseuille equation	√	√	√	√	-	-
7.	Use Bernoulli's set up to identify "energy associated with flowing fluid is conserved".	√	-	√	-	-	-
8.	Use orificemeter set up to calculate coefficient of discharge and prepare calibration curve	-	√	√	-	-	-
9.	Use venturimeter set up to calculate coefficient of discharge and prepare calibration curve	-	√	√	-	-	-
10.	Use rotameter to measure the flow rate and prepare a curve showing relationship area and flow rate	√	-	√	-	-	-
11.	Calculate equivalent length for globe valve, gate valve and bend/ elbow	-	-	√	√	-	-
12.	Determine head loss due to sudden expansion and contraction	-	-	√	√	-	-
13.	Use the centrifugal test rig to plot the characteristics curve	√	-	-	-	√	-
14.	Use the reciprocating pump set up to prepare a plot of flow rate vs head developed.	√	-	-	-	√	-
15.	Use fiuidized bed to determine the fluidization velocity for bed of different materials.	-	-	-	-	-	√
16.	Use fixed bed of given material to prepare curve of pressure drop vs flow rate	-	-	-	-	-	√

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 practical 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 banks 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 ask any difficulties they face during the conduct of practical.

Content Page

List of Practicals and Progressive Assessment Sheet

S. No	Practical Outcome	Page No.	Date of performa-nce	Date of submi ssion	Assess ment marks(25)	Dated sign. of teacher	Remark s (if any)
14.	Use the reciprocating pump set up to prepare a plot of flow rate vs head developed..	104					
15.	Use fiuidized bed to determine the fluidization velocity for bed of different materials.	113					
16.	Use fixed bed of given material to prepare curve of pressure drop vs flow rate .	119					
Total							

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

Practical No. 1: Measure the viscosity of starch solution of different concentration.

I. Practical Significance :

Fluid viscosity is a basic physical property that directly influences unit operations such as pumping, filtration, distillation, extraction, and evaporation as well as heat and mass transfer. So measurement of viscosity and its effect on fluid flow is important.

II. Relevant Program Outcomes (POs)

PO 1.Basic knowledge: *Apply knowledge of basic mathematics, sciences and basic engineering to solve the Chemical engineering problems.*

PO2. Discipline knowledge*: Apply* ***Chemical Engineering*** *knowledge to solve industry based 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****.*

III. Competency and Practical Skills

'Maintain flow of different fluids in the chemical plant according to the process requirement.'

1. Use Redwood viscometer to measure viscosity.
2. Use specific gravity bottle to measure density.

IV. Relevant Course Outcomes

Maintain the fluid parameters in chemical process.

V. Practical Outcome

Use viscometer to measure the viscosity of starch solution of different concentration.

VI. Relevant Affective Domain Related Outcomes.

1. Follow safe practices
2. Maintain tools and equipment.

VII. Minimum Theoretical Background

Newton's law of viscosity states that for given rate of deformation of fluid, the shear stress is directly proportional to the viscosity. Viscosity is a measure of a fluid's resistance to flow. It describes the internal friction of a moving fluid. A fluid with large viscosity resists motion because its molecular makeup gives it a lot of internal friction. A fluid with low viscosity flows easily because its molecular makeup results in very little friction when it is in motion. Kinematic viscosity is defined as the ratio of absolute viscosity to mass density and has the unit of m^2/s

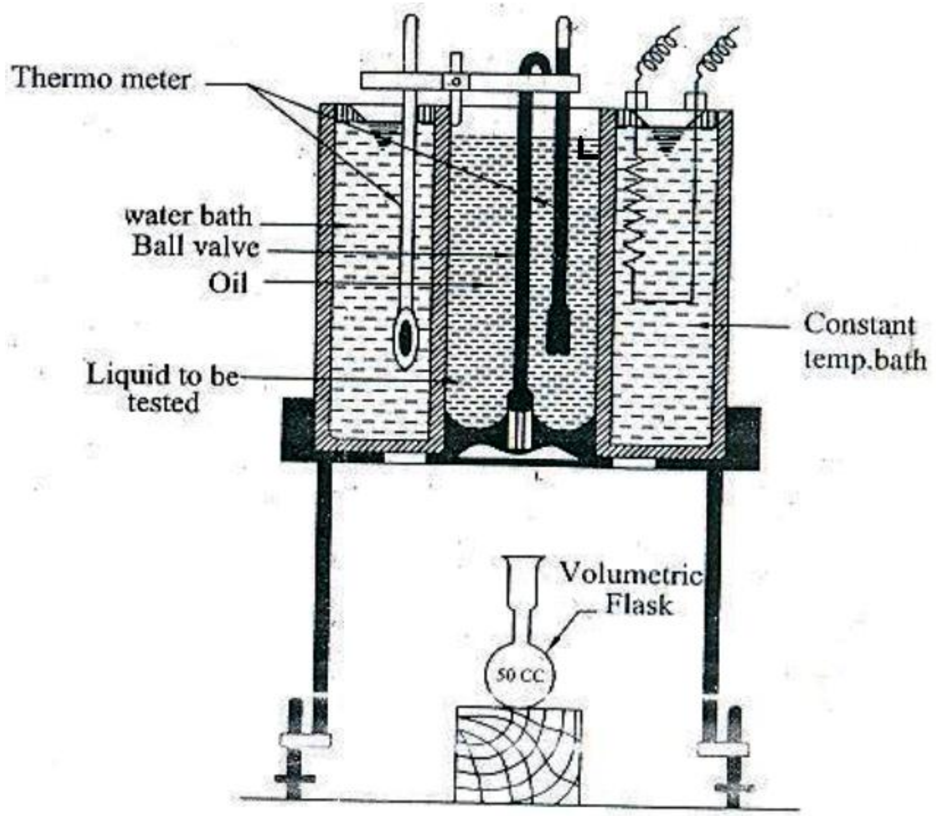


Figure 1 Redwood Viscometer

VIII. Experimental set up:

Figure 2

IX. Resources required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Red wood viscometer	As per standard specification	1
2.	Weighing balance	1-300mg capacity with 0.1mg accuracy	1
3.	Specific gravity bottle	25 / 50 ml capacity	1
4.	Kohlrausch flask	50ml	1
5.	Stop watch	0.1 s accuracy	1

X. Precautions to be followed.

1. Care should be taken not to fill the liquid above the pointer level in the oil cup.
2. Wash and dry the Kohlrausch flask after each reading.

XI Procedure

1. Clean the viscometer cup with the help of suitable solvent and dry to remove any traces of solvent.
2. Level the instrument with the help of leveling screws on the tripod.
3. Prepare at least three starch solution of different concentration.
4. Measure density of prepared starch solution sample.
5. Keep the ball (valve) in position and pour clean filtered starch solution sample to be tested into the viscometer cup up to the pointer and cover it with the lid.
6. Take a clean dry 50mlKohlrausch flask and place it under the orifice jet of the cup and center it.
7. Lift the ball (valve) and simultaneously start a stop watch and allow the starch solution to fall into the receiving flask.
8. Wait till the liquid level touches the 50 ml mark, stop the watch and record the time in sec.
9. Repeat the experiment at room temperature for different concentration of starch solution.

XII. Resources used

Sr. No.	Name of Resource	Suggested Broad Specification		Quantity	Remarks (If any)
		Make	Details		
1					
2					
3					
4					
5					

XIII Actual procedure followed

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XIV Precautions followed

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XV Observations and Calculations:

1. Weight of empty specific gravity bottle w_1 = gm
2. Volume of specific gravity bottle = ml

Sr. No.	Starch solution	Weight of specific gravity bottle + solution (w_2)gm	Density of starch solution (gm/cc)	Viscosity in Redwood seconds	Kinematic viscosity (Stoke)	Dynamic/ Absolute Viscosity (Poise)
1	Sample solution 1					
2	Sample solution 2					
3	Sample solution 3					

Sample calculation for set no.

1. t = Redwood Second =

2. $\nu = 0.002\, t - \frac{1.8}{t}$ =

3. Density of starch solution sample= $\rho = \frac{w_2 - w_1}{V}$

Where $w_1 = weight\ of\ empty\ specific\ gravity\ bottle$=

$w_2 = weight\ of\ specific\ bottle\ with\ starch\ solution\ sample$ =

V= volume of specific gravity bottle =

4. $\mu = \nu X \rho$

XVI Results

1. The dynamic viscosity of starch solution sample 1 is -------
2. The dynamic viscosity of starch solution sample 2 is -------
3. The dynamic viscosity of starch solution sample 3 is --------

XVII Interpretation of results

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XVIII Conclusions

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XIX Practical related Questions

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

a) Specify type of Redwood viscometer used for practical

b) State SI unit of kinematic and dynamic viscosity.

c) Write equation relating Redwood Second to dynamic viscosity.

d) List out viscometer used to measure viscosity

[Space for Answers]

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XX References / Suggestions for further Reading

1. https://www.mechanicalduniya.com/2012/07/redwoodviscometer.html
2. http://nptel.ac.in/courses/101103004/module7/lec1/1.html
3. https://www.youtube.com/watch?v=VzJ60uMdFe8

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Preparation of the experimental set up	20%
2	Setting and operation	20%
3	Safety measures, observation and recording	20%
Product related (10 Marks)		**40%**
4	Calculation and Interpretation of result	20%
5	Practical related question and submission of report	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

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

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

Practical No. 2: Use Redwood viscometer to determine the effect of temperature on viscosity of the given liquid

I. Practical Significance

Fluid viscosity is a basic physical property that directly influences unit operations such as pumping, filtration, distillation, extraction, and evaporation as well as heat and mass transfer. As Temperature effects are highly significant so it is important to determine effect of temperature on viscosity.

II. Relevant Program Outcomes (POs)

PO 1.Basic knowledge: *Apply knowledge of basic mathematics, sciences and basic engineering to solve the Chemical engineering problems.*
PO 3.Experiments and practice: *Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.*

III. Competency and Practical Skills

Maintain flow of different fluids in the chemical plants according to the process requirement.'

1. Use Redwood viscometer to measure viscosity.

2. Measure viscosity of liquid with variation in temperature.

IV. Relevant Course Outcomes

Maintain the fluid parameters in chemical process.

V. Practical Outcome

Determine the effect of temperature on viscosity of the given liquid.

VI. Relevant Affective domain related Outcome(s)

1. Follow safe practices.
2. Maintain tools and equipment.
3. Practice good housekeeping

VII. Minimum Theoretical Background

Whenever the fluid is used for any application, operating temperature should be given due considerations. The fluid that can sustain those operating temperatures should only be selected for those applications; otherwise the very purpose of using the fluid will be lost. When the liquid is heated the cohesive forces between the molecules reduce thus the forces of attraction between them reduce, which eventually reduce the viscosity of the liquids.

VIII. Experimental set up :

Fig 1

IX. Resources required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Red wood viscometer	As per ASTM specification	1
2	Weighing balance	1-300mg capacity with 0.1mg accuracy	1
3	Specific gravity bottle	25/50 ml capacity	1
4	Kohlrausch flask	50ml	2
5	Thermometer	0-100ºC	2
6	Stop watch	0.1 s accuracy	1

X. Precautions to be followed

1. Care should be taken not to fill the liquid above the pointer level in the oil cup.
2. Adjust the Kohlrausch flask (50ml) in such a way that the liquid string coming out of the jet strikes the neck of the flask to avoid foaming (formation of air bubbles) on the liquid surface.

XI. Procedure

1. Clean the viscometer cup with the help of suitable solvent and dry to remove any trace of solvent.
2. Level the instrument with the help of leveling screws on the tripod.
3. Fill the bath with water for determining viscosity at 80ºC and below.
4. Keep the ball (valve) in position and pour clean filtered given liquid to be tested into the viscometer cup up to the pointer and cover it with the lid.
5. Take a clean dry 50ml kohlrausch flask and place it under the orifice jet of the cup and center it.

6. Insert a thermometer and a stirrer and cover with lid. Keep stirring the water in the bath and liquid in the cup and adjust the bath temperature until the liquid attains desired constant temperature.
7. When the temperature of liquid has become quite steady in the cup and shows constant reading lift the ball (valve) and simultaneously start a stop watch and allow the liquid to fall into the receiving flask.
8. Wait till the liquid level touches the 50 ml mark, stop the watch and record the time in sec.
9. Replace the ball in position to seal the cup to prevent overflow of the oil.
10. Refill the cup and repeat the experiment with same liquid sample at different

XII. Resources used

Sr. No.	Name of Resource	Suggested Broad Specification		Quantity	Remarks (If any)
		Make	Details		
1					
2					
3					
4					
5					
6					

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations:

Sr. No.	Temperature	Viscosity in Redwood seconds	Kinematic viscosity (Stoke)
1			
2			
3			
4			

Sample calculation for set no.

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1. t = Redwood Second =

2 $\nu = 0.002\, t - \frac{1.8}{t} =$

XVI. Results

1. The kinematic viscosity of given liquid sample at -----ºC temperature is ………
2. The kinematic viscosity of given liquid sample at -----ºC temperature is ………
3. The kinematic viscosity of given liquid sample at -----ºC temperature is ………

XVII. Interpretation of results

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XVIII. Conclusions

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XIX. Practical related Questions

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

a) Calculate specific gravity of given liquid sample at room temperature.

b) Calculate dynamic viscosity of given liquid sample at room temperature.

c) List out device used to measure density of liquid.

[Space for Answers]

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XX. References / Suggestions for further Reading

- https://www.azom.com/article.aspx?ArticleID=10036
- https://www.mechanicalduniya.com/2012/07/redwoodviscometer.html
- http://nptel.ac.in/courses/101103004/module7/lec1/1.html
- https://www.youtube.com/watch?v=VzJ60uMdFe8

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Preparation of the experimental set up	20%
2	Setting and operation	20%
3	Safety measures, observation and recording	20%
Product related (10 Marks)		**40%**
4	Calculation and Interpretation of result	20%
5	Practical related question and submission of report	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1…………………………

2…………………………

3…………………………

4…………………………

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

Practical No. 3: Measure differential and gauge pressure using U tube manometer.

I. Practical Significance

The manometer, one of the earliest pressure measuring instruments, when used properly is very accurate. The U tube manometer is used as a primary standard due to its inherent accuracy and simplicity of operation. The manometer has no moving parts subject to wear, age, or fatigue. Manometers operate on the Hydrostatic balance principle: a liquid column of known height will exert a known pressure when the weight per unit volume of the liquid is known.

II. Relevant Program Outcomes (POs)

PO 1.Basic knowledge :*Apply knowledge of basic mathematics, sciences and basic engineering to solve the Chemical engineering problems.*

PO 3.Experiments and practice: *Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.*

PO 4. Engineering tools: *Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.*

III. Competency and Practical Skills

Maintain flow of different fluids in the chemical plants according to the process requirement.'

1. Use U tube manometer to measure differential pressure.
2. Operate valve to vary the pressure.

IV. Relevant Course Outcomes

1. Maintain the fluid parameters in chemical process.
2. Interpret pressure drop in piping system.

V. Practical Outcome

Use U tube manometer for measuring differential and gauge pressure.

VI. Relevant Affective domain related Outcome(s)

1. Follow safe practices
2. Maintain tools and equipment.

VII. Minimum Theoretical Background

U tube Manometer consists of a tube of glass bent into a U shape. It is then filled with a fluid. The density of the fluid dictates the range of pressures that can be measured. Both ends of the tube have pressure ports. If one port is left open to the atmosphere and the other port is connected to the pressure to be measured, the device acts as a gauge pressure meter.

If both ports are connected to two different unknown pressures, the instrument acts as a differential pressure gauge. When positive pressure is applied to one leg, the liquid is forced down in that leg and up in the other.

VIII. Experimental set up:

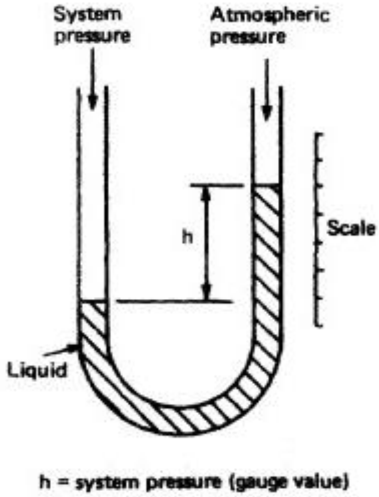

Figure 1

IX. Resources required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Pipe line	Length- 1.5 to 2m	1
2	Manometer	Mercury as manometric fluid	1
3	Sump Tank	150cmx40cm	1

X. Precautions to be followed

1. Remove air from the manometer and experimental set up.
2. Air vent valve of the manometer should be closed while performing the differential pressure experiment.
3. Operate manometer valve gently to prevent overflow of mercury while measuring gauge pressure.

XI. Procedure

Part I. Measurement of differential pressure:

1. Level the manometric fluid in both the limbs using air vent.
2. Close both the limbs simultaneously.
3. Start the flow of fluid through the pipe and wait for steady flow of fluid.
4. Note down the height of manometric fluid (h_1 and h_2) from the U tube manometer.
5. Increase the flowrate of fluid by adjusting the valve and take required number of reading.

Part II. Measurement of gauge pressure:

1. To measure gauge pressure connect one limb of a U tube to pipeline and leave the other open to atmosphere. Operate manometer valve gently (low flow rate) to prevent overflow of mercury.
2. Note down the height of manometric fluid (h_1 and h_2) from the U tube manometer.
3. Increase the flow rate of fluid by adjusting the valve and take the reading.
4. Repeat the procedure for at least two readings

XII. Resources used

Sr. No.	Name of Resource	Suggested Broad Specification		Quantity
		Make	Details	
1				
2				
3				

XIII. Actual procedure followed

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XIII. Precautions followed

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XV. Observations and Calculations:

Density of manometric fluid:(ρm) =

Density of flowing fluid(ρ) =

Differential pressure measurement:

Sr No.	h_1 (mm)	h_2 (mm)	Δhm (mm of Hg)	ΔH_f (mm of water)	Differentia l pressure
1					
2					
3					
4					

Gauge pressure measurement:

Sr No.	h_1	h_2	Δhm	ΔH_f	Gauge

	(mm)	(mm)	(mm of Hg)	(mm of water)	pressure
1					
2					
3					

Sample calculation

For differential pressure set no.

1. h_1 =

2. h_2=

3. $\Delta hm = h_1 - h_2$

$4\Delta H_f = \Delta h_m \frac{(\rho m - \rho)}{\rho}$

For gauge pressure set no.

1. h_1 =

2. h_2=

3. $\Delta hm = h_1 - h_2$

$4\Delta H_f = \Delta h_m \frac{(\rho m - \rho)}{\rho}$

XVI. Results

1. The differential pressure measured for reading no... is -------
2. The gauge pressure measured for reading no…. is -------

XVII. Interpretation of results

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XVIII. Conclusions

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XIX. Practical related Questions

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

a)State Principle of hydrostatic equilibrium.

b) Identify steady/ unsteady flow of liquid by observing the level of manometric fluid.

c) List out different types of manometer.

d) Convert 20 m of water head to into Pascal.

e) Convert 500mm Hg pressure to absolute pressure.

[Space for Answers]

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XX. References / Suggestions for further Reading

https://www.youtube.com/watch?v=9SQ2FPHCZJk
https://www.youtube.com/watch?v=JHCS7Idf4aU
http://eleceng.dit.ie/gavin/Instrument/Pressure/Manometer
https://www.meriam.com/assets/eng/050-MHB-1.pdf

XXI. Assessment Scheme

Performance indicators		Weightage
Process related (15 Marks)		**60%**
1	Preparation of the experimental set up	20%
2	Setting and operation	20%
3	Safety measures, observation and recording	20%
Product related (10 Marks)		**40%**
4	Calculation and Interpretation of result	20%
5	Practical related question and submission of report	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1…………………………

2…………………………

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

Practical No. 4 : Identify type of flow by using Reynolds apparatus.

I. Practical Significance

The main objective of this study is to determine the characteristic flow of the liquid, whether it is laminar or turbulent. The Reynold's apparatus is used to determine the Reynold's number for each state of flow. Using Reynolds number we can i) predict flow pattern, ii) calculate friction factor, iii) find the heat transfer coefficient and iv) determine power consumption in mixing.

II. Relevant Program Outcomes (POs)

PO 1.Basic knowledge: Apply knowledge of basic mathematics, sciences and basic engineering to solve the Chemical engineering problems.

PO 3.Experiments and practice: Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.

PO 4. Engineering tools: Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.

PO 7.Ethics: Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Chemical engineering.

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

III. Competency and Practical Skills

Maintain flow of different fluids in the chemical plants according to the process requirement.'

1. Use Reynolds apparatus to identify nature of flow.
2. Measure the flow rate using measuring cylinder.

IV. Relevant Course Outcomes

1. Maintain the fluid parameters in chemical process.
2. Maintain the flowrate of the incompressible fluid.

V. Practical Outcome

Use Reynolds apparatus to identify type of flow.

VI. Relevant Affective domain related Outcome(s)

1. Follow safe practices
2. Practice good housekeeping.
3. Maintain tools and equipment.

VII. Minimum Theoretical Background

Osborne Reynolds during his famous Reynolds experiment discovered that occurrence of laminar and turbulent flow is governed by the relative magnitude of the inertia and viscous force acting on the flowing fluid. For laminar flow ,$N_{Re}<2100$ and fluid particles flow in a straight line. For transition flow, $2100<N_{Re}<4000$ and fluid flow is little wavy and disturbed flow. For turbulent flow, $N_{Re}>4000$ and intermixing of layers takes place. Due to intermixing of layers and zigzag movement of particles, eddies are formed.

VIII. Experimental set up :

Figure 1

IX. Resources required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Transparent tube	2cmdia, Length:1m	1
2	Dye tank		1
3	Measuring cylinder	1000ml capacity	1
4	Stop watch	0.1 s accuracy	1
5	Supply Tank	150cmx40cm	1

X. Precautions to be followed.

1. Fill the measuring cylinder carefully upto the mark.
2. During filling of the tank ensure that addition of water inside the tank should not create turbulence. The turbulence can affect nature of filament

XI. Procedure

1. Close regulating valve at the end of test section.
2. Fill the fluid tank with water until it overflow.
3. Fill dye in dye tank.
4. Open valve slightly(low flowrate) and allow steady flow of water through tube.
5. Use syringe to introduce the dye in the center of pipe.
6. Observe nature of filament.
7. Wait till the steady state is reached.
8. Note the time required to collect known volume of liquid. during steady flow of liquid
9. Repeat steps iv to viii by changing the flowrate with the help of regulating valve

for laminar, transition and turbulent flow.

XII. Resources used

Sr No.	Name of Resource	Suggested Broad Specification		Quantity	Remarks (If any)
		Make	Details		
1					
2					
3					
4					
5					

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations:

1. Diameter of pipe (D) = -------------cm
2. Density of water: (ρ)=
3. Viscosity of water (μ) =

Sr No.	Volume collected (cm^3)	Time (s)	Volumetric flowrate(Q) (cm^3/s)	Velocity (cm/s)	Nature of filament	Reynolds No.	Type of flow
1							
2							
3							
4							
5							
6							
7							
8							
9							

10							

Sample calculation for set no.

1. Cross sectional area of pipe (A)= $\frac{\pi D^2}{4}$ =------------------cm^2

2. Volumetric flowrate = $\frac{volume\ of\ fluid\ collected}{Time}$

$Q = \frac{V}{t} =$ cm^3/s

3. Velocity (u) = $\frac{volumetric\ flowrate}{Area} = \frac{Q}{A} =$ cm/s

4. Reynolds number =$N_{Re} = \frac{Du\rho}{\mu} =$

XVI. Results

Reynolds number for ….. reading is ……… and type of flow is ………

XVII. Interpretation of results

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XVIII. Conclusions

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XIX. Practical related Questions

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

a) State significance of Reynolds number.

b) Differentiate between laminar and turbulent flow.

c) Name chemical used to prepare dye and state use of dye in the experiment.

d) State formula to calculate velocity if volumetric flowrate is given.

e) Based on Reynolds number give classification of nature of flow

[Space for Answers]

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XX. References / Suggestions for further Reading

- https://en.wikipedia.org/wiki/Osborne_Reynolds
- http:// uotechnology.edu.iq/depuilding/LECTURE/dams%20and%20water/first_class/Lect.No .8-pdf.pdf
- https://www.youtube.com/watch?v=UheRHQTUgJQ

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Preparation of the experimental set up	20%
2	Setting and operation	20%
3	Safety measures, observation and recording	20%
Product related (10 Marks)		**40%**
4	Calculation and Interpretation of result	20%
5	Practical related question and submission of report	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1…………………………

2…………………………

3…………………………

4…………………………

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

Practical No. 5: Determine fanning friction factor at different flow rate and plot friction factor vs Reynolds number for a given pipe.

I. Practical Significance

Darcy Weisbach equation is an important equation used for estimation of pressure drop or head loss during flow of fluid through the pipe. This head loss predicts additional power required for overcoming the friction. One of the most common problems in fluid flow operation is the estimation of this pressure drop/ head loss. Calculating head losses is necessary for determining the appropriate size pump. Knowledge of the magnitude of frictional losses is of great importance because it determines the power requirements of the pump forcing the fluid through the pipe. For example, in refining and petrochemical industries, these losses have to be calculated accurately to determine where booster pumps have to be placed when pumping crude oil or other fluids in pipes to distances thousands of kilometers away.

II. Relevant Program Outcomes (POs)

PO 1.Basic knowledge: Apply knowledge of basic mathematics, sciences and basic engineering to solve the Chemical engineering problems.

PO 3.Experiments and practice: Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.

PO 4. Engineering tools: Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.

III. Competency and Practical Skills

'Maintain flow of different fluids in the chemical plants according to the process requirement.'

1. Operate valve to regulate flow through relevant pipeline.
2. Use manometer to measure the pressure drop.
3. Plot friction factor chart.

IV. Relevant Course Outcomes

1. Identify pressure drop in piping systems.
2. Maintain the flow rate of incompressible fluid.
3. Select the relevant piping system for fluid transportation.

V. Practical Outcome

Use friction factor set up to determine friction factor and plot friction factor vs Reynolds number for a given pipe.

VI. Relevant Affective domain related Outcome(s)

1. Follow safe practices
2. Maintain tools and equipment.

VII. Minimum Theoretical Background

Fluid flows in pipelines are important in many process industries. But when fluid flows in pipes, mechanical energy is lost due to friction between the fluid flowing and the pipe. Friction losses depend on the properties of the pipe in which the fluid flow, the properties of the fluid and the behavior of the fluid flow itself. For fluid flow through a straight pipe with uniform diameter, factor such as velocity, density, viscosity of the fluid and diameter, length and roughness of pipe play a significant role in building up friction losses.

A pipe is a closed conduit through which fluid flows under the pressure. When fluid flows in the pipe, some of potential energy is lost to overcome hydraulic resistance which is classified as:-

1. Major loss: The viscous friction effect associated with fluid flow.
2. Minor loss: The local resistance which result from flow disturbances caused by pipe fittings and valves.

The viscous friction loss or major loss in head due to friction is given by,

$$h_f=\frac{4flu^2}{2gd}$$ -------- Darcy equation

Where, h_f =Major head loss, l= Length of pipe, f = Friction factor
u = Inlet velocity ,g = Acceleration due to gravity and d = Diameter of pipe

The friction factor, f, varies with Reynolds number and a roughness factor. Friction factor chart is graphical representation of friction factor versus Reynolds number. The nature of curve depends upon the type of flow and relative roughness. It is log log plot for accommodating wide range of friction factors and Reynolds number.

VIII. Experimental set up:

Figure 1

IX. Resources required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Pipe line of different diameter	Length- 1.5 to 2m of different diameter	3
2	Manometer	Mercury as manometric fluid	1
3	Stop watch	0.1 s accuracy	1
4	Sump Tank	150cmx40cm	1
5	Measuring tank	60cmx30cm	1

X. Precautions to be followed.

1. Remove air from the manometer and experimental set up.
2. Air vent valve of the manometer should be closed while performing the experiment.
3. Make sure that the pressure tappings are connected to the relevant pipeline.
4. Note the time of discharge carefully.

XI. Procedure

1. Arrange the experimental setup as shown above.
2. Fill the sump tank up to around 80% of its capacity.
3. Open the drain valve of collection tank and close the drain valve of sump tank.
4. To allow the flow through branch 1, open the valve in that branch and close the valve in the other branches.
5. Start the pump and ensure continuous full bore flow through branch 1.
6. Open the tap of appropriate lead pipe connected to manometer.
7. Wait till the fluctuations in the flow are reduced. This will ensure steady flow of fluids.
8. Now close the drain valve of collection tank.

9. Start the stop watch and collect known volume of liquid by observing the level of liquid in sight glass. Note down the time required.
10. After the reading is noted, drain the water collected in collection tank by opening drain valve provided
11. Note down height difference in the manometer
12. Now change the flow rate by regulating the valve
13. Repeat the steps 6 to 12 for obtaining additional readings.
14. Now open valve in branch 2 and close valves in the other branches.
15. Repeat the steps 6 to 12 depending upon number of observations to be reported.
16. Now open valve in branch 3 and close valves in the other branches.
17. Repeat the procedure as mentioned in steps 6 to 12 as above depending upon number of observations to be reported
18. Calculate volumetric flow rate, velocity, Reynolds number and friction factor by experiment and formula
19. Plot graph of f vs N_{Re}

XII. Resources used (with major specifications)

Sr No.	Name of Resource	Suggested Broad Specification		Quantity	Remarks (If any)
		Make	Details		
1					
2					
3					
4					

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations:

1. Tank area=A=B*L= -------------------m^2

2. Height of fluid collected (H) = -------------------m

3. Density of flowing fluid= -------------------Kg/m^3

4. Density of fluid in manometer = -------------------Kg/m^3

Sr No.	Pipe Diameter	h_1 (cm)	h_2 (cm)	Δh_m (cm)	ΔH_f (m)	Time for collection t (s)	Q m^3/s	$u=\frac{Q}{A}$ m/s	N_{Re} $=\frac{Du\rho}{\mu}$	Type of flow	$f=\frac{2gD\Delta Hf}{4lu^2}$ (by expt)	f by formula
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												

Sample Calculation for set no

1. h_1 =

2. h_2=

3. $\Delta hm = h_1 - h_2 =$

4. $\Delta H_f = \Delta h_m \frac{(\rho m-\rho)}{\rho} =$

5. Volume of water collected= Tank area x Height of fluid collected = -------------------m^3

6. Volumetric flow rate = Q = Volume of fluid (water) collected / time = (AxH)/t =

7. Velocity of fluid = $u = \frac{Q}{A}$ = ----------- =

Where A is cross sectional area of pipe through which fluid is flowing = $\frac{\Pi D^2}{4}$ = ---------- =

8. $N_{Re} = \frac{Du\rho}{\mu}$ = --------------------------- =

Since N_{Re} is …………., flow is …………………

9. For laminar flow, $f = \frac{16}{N_{Re}}$ = ------------- =

For turbulent flow, $f = \frac{0.078}{N_{Re}^{0.25}}$ = --------------- =

10. $\Delta H_f = \frac{\Delta P}{\rho g} = \frac{4flu^2}{2gD}$

11. Experimental $f = \frac{2gD\Delta H_f}{4lu^2}$ = ------------- =

XVI. Results

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XVII. Interpretation of results

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XVIII. Conclusions

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XIX. Practical related Questions

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

a. Relate head loss due to friction to pressure drop.
b. Write formula to calculate friction factor for laminar and turbulent flow.
c. Name and write the equation used to calculate pressure drop for turbulent flow through pipeline.
d. Define the term major and minor losses in the piping system.

[Space for Answers]

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XX. References / Suggestions for further Reading

- http://uorepc-nitk.vlabs.ac.in/exp1/index.html
- https://www.scribd.com/document/274166296/Friction-Factor-Laboratory-Report

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Preparation of the experimental set up	20%
2	Setting and operation	20%
3	Safety measures, observation and recording	20%
Product related (10 Marks)		**40%**
4	Calculation and Interpretation of result	20%
5	Practical related question and submission of report	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1…………………………

2…………………………

3…………………………

4…………………………

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

Scale

X-axis -

Y-axis -

Practical No. 6: Calculate viscosity of flowing fluid using Hagen Poisuillie equation

I. Practical significance:

Hagen–Poiseuille equation is used in the experimental measurement of viscosity, by measuring the pressure drop and volumetric flowrate through a tube of known length and diameter.

II. Relevant Program Outcomes (POs)

PO 1.Basic knowledge: Apply knowledge of basic mathematics, sciences and basic engineering to solve the Chemical engineering problems.
PO 3.Experiments and practice: Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.
PO 4. Engineering tools: Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.

III. Competency and Skills

'Maintain flow of different fluids in the chemical plants according to the process requirement.'

1. Operate vacuum regulating system.
2. Observe and record readings.

IV. Relevant Course Outcome(s)

1.Maintain the fluid parameters in chemical process.
2.Interpret pressure drop in piping systems.
3.Maintain the flow rate of the incompressible fluid.
4.Select the relevant piping system for fluid transportation.

V. Practical Outcome

Use the experimental set up to calculate viscosity of flowing fluid using Hagen Poisuillie equation.

VI. Relevant Affective Domain Related Outcomes.

a. Follow safe practices
b. Maintain tools and equipment.

VII. Minimum Theoretical Background

Hagen–Poiseuille law, is a physical law that gives the pressure drop in an incompressible and Newtonian fluid in laminar flow flowing through a long cylindrical pipe of constant cross section. Hagen–Poiseuille equation is given by,

$$\Delta P = \frac{32\mu u L}{D^2}$$

Where ΔP = Pressure drop across length of pipe
μ = Viscosity of fluid, u = Velocity of Fluid

L = Length of pipe and D = Diameter of pipe

VIII. Experimental setup

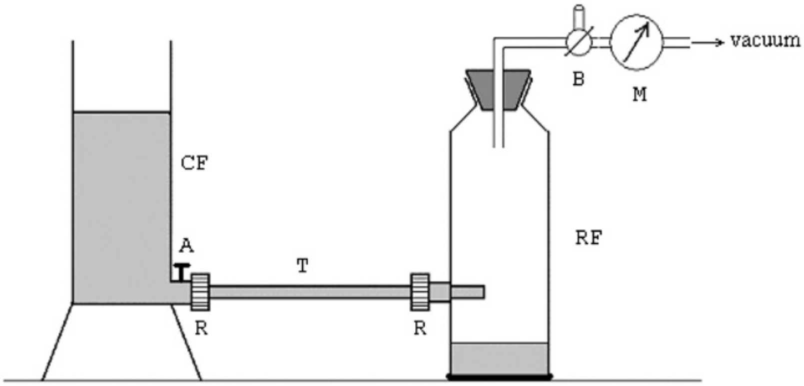

Figure 1 Hagen Poisuillie experimental set up

The set-up (figure 1) consists of a container flask CF with the liquid (water), and a cylindrical receptor flask RF for collecting the liquid that passes through the tube T in a period of time t. In this latter flask it is possible to modify the pressure, measured with a manometer M, by means of a vacuum regulating system. The tubes are easily replaced by means of the wing nuts R on both flasks. Flask RF must be easily separable from the rest of the assembly. Key B in turn is used to connect RF to the vacuum system or atmosphere .The experiment requires the use of fluids with viscosity values that are independent of the flow velocity (Newtonian fluids). These fluids can be obtained, e.g., with different concentrations of glycerol and water.

IX. Resources Required.

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Container flask	0-2 litre	1
2	Receptor flask	0-2 litre	1
3	Tube	1 meter	1
4	Pressure measuring device	0-760 mm Hg	1

X. Precautions to be followed.

1. Carefully measure height of water in the receptor flask.

XI. Procedure

1. Take liquid (water) in container flask CF with key A closed.
2. The vacuum system is turned on to obtain a pressure difference ΔP between the ends of the tube T (we assume the fluid height in CF to be in the order of 10 cm, as a result of which the hydrostatic pressure can be considered negligible), measured with the manometer M.
3. Key A is then opened, and the liquid circulating through T accumulates in Receptor flask RF.
4. After a period of time t, key A is closed.
5. Measure height of water collected in cylindrical receptor flask RF.
6. Repeat the procedure for different flowrate and pressure drop.

XII. Resources used.

Sr No.	Name of Resource	Suggested Broad Specification		Quantity	Remarks (If any)
		Make	Details		
1					
2					
3					
4					

XIV. Actual Procedure Followed.

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XIV. Precaution followed.

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XV. Observation and Calculation

1. Diameter of tube T (D) = -------------cm
2. Length of tube T (L) = -------------------cm
3. Diameter of the cylindrical receptor flask RF (D_1) = ---------cm

Sr No.	Pressure drop	Time for collection of water (t)s	Height of water collected (h)cm	Velocity of water	Viscosity of water	Average viscosity
1						
2						
3						
4						

Sample calculation for set no.

1. Height of water collected in the cylindrical receptor flask RF (h) = cm

2. Volume of water collected in the cylindrical receptor flask RF= $\frac{\Pi D_1^2}{4}$h =

=-------cm^3

3. Volumetric flow rate of water = $\frac{\text{Volume of water collected}}{Time\,(t)}$

4. Velocity of water through tube T (u) = $\frac{\text{Volumetric flowrate of water}}{\text{Cross-sectional area of tube T}}$

Where $\text{Cross-sectional area of tube T} = \frac{\pi D^2}{4} =$

5. Viscosity of water, $\mu = \frac{\Delta P D^2}{32uL} =$

XVI Results

The viscosity of flowing liquid (water) =

XVII. Interpretation of Results

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XVIII. Conclusions

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XIX. Practical Related Questions

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

a) Name and write equation to calculate loss of pressure head for the viscous flow through a circular pipe.

b) Relate head loss due to friction to pressure drop.

[Space for Answers]

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X. References/ Suggestions for Further Reading

- https://en.wikipedia.org/wiki/Hagen%E2%80%93Poiseuille_equation
- https://nptel.ac.in/courses/103104043/17#
- https://www.youtube.com/watch?v=_hvgvZuIZOc
- https://www.rosehulman.edu/~moloney/Ph425/ejp_projects_0708/poiseuille_lab_experiment_ejp6_5_007.pdf

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Preparation of the experimental set up	20%
2	Setting and operation	20%
3	Safety measures, observation and recording	20%
Product related (10 Marks)		**40%**
4	Calculation and Interpretation of result	20%
5	Practical related question and submission of report	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1.............................

2.............................

3.............................

4.............................

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

Practical No. 7: Calculate pressure head, kinetic head and potential head to prove Bernoulli's theorem using Bernoulli's set up.

I. Practical Significance

Bernoulli's theorem states that, for a steady, irrotational ideal flow of an incompressible fluid, the total energy at any point is constant. The total energy consists of pressure energy, kinetic energy and potential energy. The Bernoulli's equation forms the basis for solving a wide variety of fluid flow problems such as jets issuing from an orifice; flow under a gate and over a weir, flow metering by obstruction meters, flow around submerged objects, flows associated with pumps and turbines etc.

II. Relevant Program Outcomes (POs)

PO 1.Basic knowledge: Apply knowledge of basic mathematics, sciences and basic engineering to solve the Chemical engineering problems.

PO 2.Discipline knowledge: Apply Chemical engineering knowledge to solve industry based Chemical Engineering problems.

PO 7.Ethics: Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Chemical engineering.

PO 8.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.

III. Competency and Practical Skills

'Maintain flow of different fluids in the chemical plants according to the process requirement.'

1. Measure flow rate using measuring tank.
2. Operate appropriate valve to maintain steady flow.
3. Observe and record the pressure head in piezometric tube.

IV. Relevant Course Outcomes

1. Maintain the fluid parameters in chemical process.
2. Maintain the flow rate of incompressible fluid.

V. Practical Outcome

Use Bernoulli's set up to identify "energy associated with flowing fluid is conserved".

VI. Relevant Affective domain related Outcome(s)

1. Follow safe practices
2. Practice energy conservation.
3. Maintain tools and equipment.
4. Follow ethical practices.

VII. Minimum Theoretical Background

Bernoulli's equation states that the "sum of the kinetic energy (velocity head), the pressure energy (static head) and Potential energy (elevation head) per unit weight of the

fluid at any point remains constant " provided the flow is steady, irrotational and frictionless and fluid used is incompressible. The key approximation in the derivation of Bernoulli's equation is that viscous effects are negligibly small compared to inertial, gravitational, and pressure effects.
Bernoulli's principle can be derived from the principle of conservation of energy. We can write the theorem as,

$$P_1/\rho g + u_1^2/2g + Z_1 = P_2/\rho g + u_2^2/2g + Z_2 = \text{constant}$$

Where $P/\rho g$ is the pressure head $u^2/2g$ is the velocity head Z is the potential head.

VIII. Experimental set up :

Figure 1

IX. Resources required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Test section	Acrylic	1
2	Piezometer tubes		7/11
3	Stop watch	0.1 s accuracy	1
4	Inlet tank		1
5	Sump Tank	150cmx40cm	1
6	Measuring tank	60cmx30cm	1

X. Precautions to be followed

1. Note the head readings after the level has been stabilized.
2. After measuring discharge drain the measuring tank.

XI. Procedure

1. Close all drain valves provided.
2. Fill sump tank with clean water.
3. Open bypass valve given on water supply line.
4. Start the pump.
5. Partially close bypass valve to allow water to fill in overhead tank.
6. Wait until overflow occurs from overhead tank.
7. Regulate flow of water through test section (tapering tube) with the help of valve provided at the end of test section.
8. Adjust regulating and bypass valve such that continuous over flow occurs during experiment. This will eliminate the error due to change in head.
9. Measure fluid height in every piezometer tube.

10 Measure flow rate of water using measuring tank and stop watch.

11 Repeat steps 7 to 10 for different flow rate of water.

12 After the readings are taken stop the pump and drain the water present in setup and sump.

13 For every reading calculate velocity, kinetic head, pressure head, potential head, also kinetic energy per unit mass, pressure energy per unit mass, potential energy per unit mass.

14 Plot graph of kinetic energy per unit mass, pressure energy per unit mass, potential energy per unit mass and total energy per unit mass versus test points. Adjust the scales so that all can be plotted on the same graph.

XI. Resources used

Sl No.	Name of Resource	Suggested Broad Specification		Quantity	Remarks (If any)
		Make	Details		
1					
2					
3					
4					

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations:

1. Tank area=A=B*L= -------------------m^2

2. Height of fluid collected (H) = -------------------m

Sr No. of test points	Diameter(mm)	Cross-sectional area of tube(mm^2)a_i
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		

Observation table:

Run No.	H_1(m)	H_2(m)	t(s)		h(m) at Piezometric tube No.									
				h_1	h_2	h_3	h_4	h_5	h_6	h_7	h_8	h_9	h_{10}	h_{11}
1														
2														
3														
4														

Sample calculation for set no.

1. $Q = \frac{AxH}{t}$ = ------------=
2. $u_i = \frac{Q}{a_i}$ = ------------=
3. Pressure head $= \frac{P}{\rho g} = h_i =$
4. Kinetic head $= \frac{u_i^2}{2g}$ = ---------=
5. Potential head = Z= Elevation from ground =
6. Pressure energy per unit mass = $h_i g$
7. Kinetic energy per unit mass = $\frac{u_i^2}{2}$ = ----------
8. Potential energy per unit mass = g x Z
9. Total head = Pressure head + Kinetic head + Potential head

   =

10. $\frac{Total\ Energy}{mass}\left(\frac{J}{kg}\right) = \frac{Pressure\ Energy}{mass} + \frac{Kinetic\ Energy}{mass} + \frac{Potential\ Energy}{mass}$

   =

XVI. Results

Result for run no.

Tube No.	1	2	3	4	5	6	7	8	9	10	11
$u_{i(m/s)}$											
Pressure energy/mass (J/kg)											
Kineic energy/mass (J/kg)											
Potential energy/mass (J/kg)											
Total energy/mass											

(J/kg)											

XVII. Interpretation of results

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XVIII. Conclusions

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XIX. Practical related Questions

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

a. Give Bernoulli's equation for steady flow of an ideal fluid.
b. Write modified form of Bernoulli's equation to use it for real situation.
c. Compare pressure energy at two successive points with justification.
d. Define steady state flow.

[Space for Answers]

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XX. References / Suggestions for further Reading

- https://www.youtube.com/watch?v=wR0AlZddJtY
- https://www.scribd.com/document/155647993/Bernoulli-s-theorem-Experiment
- https://www.green-mechanic.com/2016/10/bernoulli-experiment-lab-report.html

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Preparation of the experimental set up	20%
2	Setting and operation	20%
3	Safety measures, observation and recording	20%
Product related (10 Marks)		**40%**
4	Calculation and Interpretation of result	20%
5	Practical related question and submission of report	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1…………………………

2…………………………

3…………………………

4…………………………

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

Scale

X-axis -

Y-axis -

Scale

X-axis -

Y-axis -

Practical No. 8: Calculate coefficient of discharge of orifice meter and prepare calibration curve

I. Practical Significance

Measuring flow rates of fluids is of utmost importance in Chemical Process Industry. The calibration curve prepared for the given orifice meter can be used to determine the flow rate for a given value of differential pressure.

II. Relevant Program Outcomes (POs)

PO 1.Basic knowledge: Apply knowledge of basic mathematics, sciences and basic engineering to solve the Chemical engineering problems

PO 2.Discipline knowledge: Apply Chemical engineering knowledge to solve industry based Chemical Engineering problems.

PO 3.Experiments and practice: Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.

PSO 2.**Material management and quality control:** Manage chemicals and equipment to produce quality chemical products.

III. Competency and Practical Skills

'Maintain flow of different fluids in the chemical plants according to the process requirement.'

1. Use orifice meter for accurate measurement of flow rate.
2. Measure the differential pressure using manometer.

IV. Relevant Course Outcomes

1. Interpret pressure drop in piping systems.
2. Maintain the flow rate of the incompressible fluid.

V. Practical Outcome

Use orifice meter set up to calculate the coefficient of discharge and prepare calibration curve.

VI. Relevant Affective domain related Outcome(s)

1. Follow safe practices
2. Maintain tools and equipment.
3. Practice good housekeeping.
4. Follow ethical practices.

VII. Minimum Theoretical Background

Orifice meter is a variable head meter used for measuring flow rate of fluid flowing through pipe. A metal orifice plate which is held between flanges of a pipe carrying the fluid whose flow rate is being measured. In orifice meter the fluid is accelerated by causing it to flow through restriction (orifice). .As the kinetic energy of fluid increases the pressure energy decreases and the measurement of pressure difference enable the determination of discharge through pipe.

VIII. Experimental set up :

Figure 1

IX. Resources Required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Pipe line	Length- 1.5 to 2m, Dia: 2.6cm	1
2	orifice meter	Diameter: 1.6cm	1
3	Manometer	Mercury as manometric fluid	1
4	Stop watch	0.1 s accuracy	1
5	Sump Tank	150cmx40cm	1
6	Measuring tank	60cmx30cm	1

X. Precautions

1. Remove air from the manometer and experimental set up.
2. Air vent valve of the manometer should be closed while performing the experiment.
3. Make sure that the relevant pressure tapings to the throat and pipe are connected

XI. Procedure

1. Connect the orifice meter in the experimental setup.
2. Use flexible tubes to connect the pressure taps of the orifice meter to the manometer.

3. Start the pump.
4. Remove air from the manometer and experimental set up by opening the air vent valve.
5. Adjust the valve in pipeline for minimum discharge.
6. Wait for stabilization of flow.
7. Note down h_1 and h_2 from the U – tube manometer.
8. Collect known volume of liquid in a measuring tank and note down the time required for collection.
9. Adjust the valve to change flow rate. After changing the flow allow the flow to be established fully.
10. Repeat above two steps by increasing the discharge for more readings.
11. Calculate the theoretical discharge (Qth), actual discharge (Qa) and coefficient of discharge Co.
12. Plot calibration curve (Plot of Qa versus Δh_m)

XII. Resources used

Sr. No.	Name of Resource	Suggested Broad Specification		Quantity	Remarks (If any)
		Make	Details		
1					
2					
3					
4					

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations:

1. Diameter of pipe (D) = -------------mm

2. Diameter of orifice (d) = -------------------mm

3. Density of manometric fluid (ρ_m) =

4. Density of flowing fluid ie water (ρ) =

5. Tank area=A=B*L= -------------------m^2

6. Height of fluid/water collected (H) = -------------------m

7. Volume of water collected(V)= A x H =

8. Area of an orifice (A_o) = $\pi d^2 / 4$

Sr No.	h_1 (cm)	h_2 (cm)	Δh_m (cm of Hg)	ΔH_f (cm of water)	Time (s)	(Q_a) = V/t (cm^3/s)	(Q_{th}) (cm^3/s)	$C_o = Q_a / Q_{th}$	Avg C_o
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									

Sample calculation for set no.

1. h_1 =

2. h_2=

3. $\Delta hm = h_1 - h_2 =$

4. $\Delta H_f = \Delta h_m \frac{(\rho m - \rho)}{\rho}$ = -------------

5. Time(t) =

6. Actual discharge (Qa) = Volume of water collected / time = V/t= ---------

7. Theoretical discharge (Qth) = $= \frac{Ao\sqrt{2g\Delta H_f}}{\sqrt{1-\beta^4}}$ = --------------

8. Co = Qa / Qth =

XV. Results

The average coefficient of discharge of orifice meter (Avg Co) is …………………

XVII. Interpretation of results

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XVIII. Conclusions

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XIX Practical related Questions

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

a. Using calculated value of discharge coefficient of orificemeter(C_o) find the volumetric flowrate for given value of Δh_m
b. Write standard value of coefficient of discharge for orificemeter and venturimeter.
c. Whether orificemeter is variable head or area meter? Justify your answer

[Space for Answers]

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XX References / Suggestions for further Reading

- http://uorepc-nitk.vlabs.ac.in/exp3/index.html
- https://www.scribd.com/document/99401532/Calibration-of-Orifice-Meter
- https://www.coursera.org/lecture/fe-exam/flow-measurement-orifice-meter-8RaF7

XXI. Assessment Scheme

Performance indicators		Weightage
Process related (15 Marks)		**60%**
1	Preparation of the experimental set up	20%
2	Setting and operation	20%
3	Safety measures, observation and recording	20%
Product related (10 Marks)		**40%**
4	Calculation and Interpretation of result	20%
5	Practical related question and submission of report	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1.…………………………

2.…………………………

3.…………………………

4.…………………………

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

Scale

X-axis -

Y-axis -

Practical No: 9: Calculate coefficient of discharge of Venturimeter.

I. Practical Significance:

Measuring flow rates of fluids is of utmost importance in Chemical Process Industry.The calibration curve prepared for the given venturimeter can be used to determine the flow rate by measuring the differential pressure.

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II. Relevant Program Outcomes (POs)

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

PO2. Discipline knowledge: *Apply Chemical Engineering knowledge to solve industry based 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.*

PO 8.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.*

PSO 2.Material management and quality control: *Manage chemicals and equipment to produce quality chemical products.*

III. Competency and Practical Skills

'Maintain flow of different fluids in the chemical plant according to the process requirement.'

1. Use venturimeter for accurate measurement of flow rate.
2. Measure the differential pressure using manometer

IV. Relevant Course Outcomes

1. Interpret the pressure drop in piping system.
2. Maintain the flow rate of the incompressible fluid.

V. Practical Outcome

Use the venturimeter set up to calculate the coefficient of discharge and prepare calibration curve.

VI. Relevant Affective domain related Outcome(s)

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

VII. Minimum Theoretical Background

A venturi meter is a device which is used for measuring the rate of flow of fluid through the pipe. The basic principle on which a venturimeter works is that by reducing the cross sectional area of the flow passage, a pressure difference created and the measurement of the pressure difference enables the determination of the discharge through the pipe. Venturi meter consist of an inlet section which is in the form of convergent cone, throat and an outlet section which is in the form of divergent cone. The inlet section of the venturi meter is of the same diameter as that of the pipe diameter. The convergent cone is a short pipe which tapers from the original size of the pipe to the size of the throat. The throat is a short pipe having its cross sectional area smaller than that of the pipe .The divergent cone of the venturimeter is a gradually diverging pipe with its cross section area increasing from that of throat to the size of the pipe. The divergent cone has more length than the convergent cone to avoid the possibility of flow separation (eddies) and energy loss. Pressure tapping is provided at the location before the convergence commences and another pressure tapping is provided at the throat section of a Venturimeter. The Difference in pressure head between the two tapping is measured by means of a U-tube manometer.

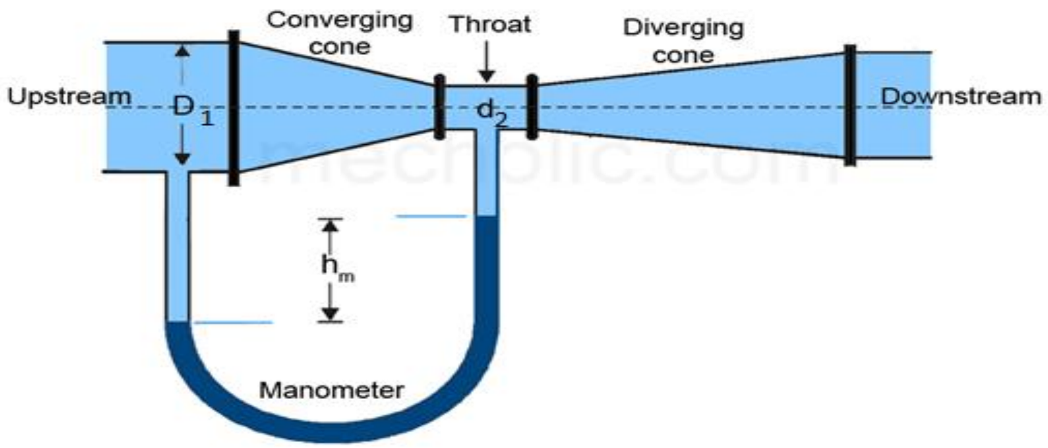

Fig 1 Venturimeter

VIII. Experimental set up :

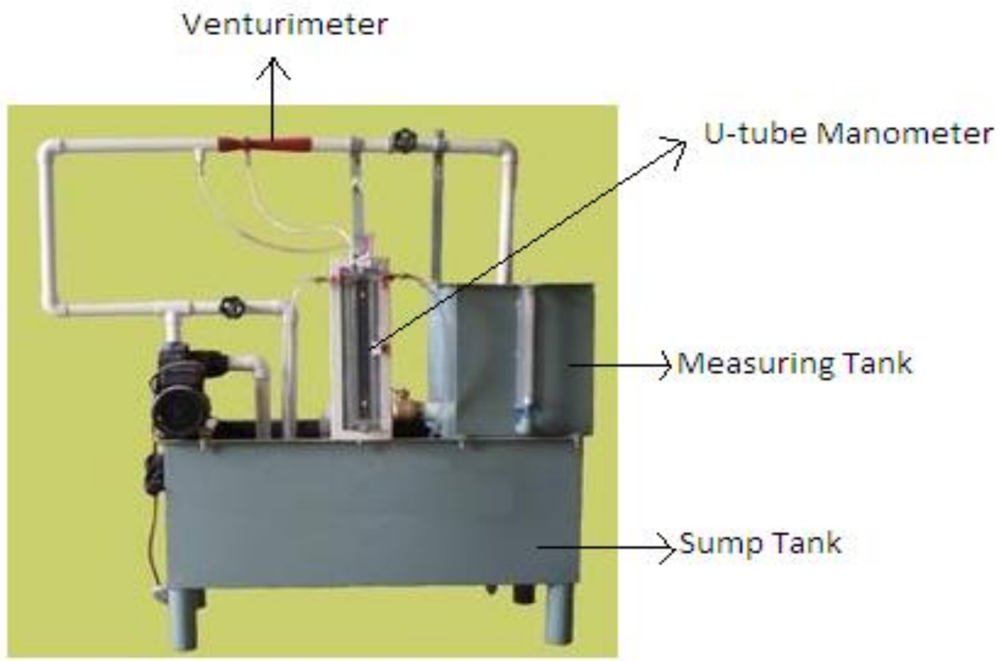

Figure 2

IX. Resources required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Pipe line	Length- 1.5 to 2m	
2	Venturimeter	Throat dia- 1.25-1.8cm	1
3	Manometer	Mercury as manometric fluid	1
4	Stop watch	0.1 s accuracy	1
5	Sump Tank	150cmx40cm	1
6	Measuring tank	60cmx30cm	1

X. Precaution

1. Remove air from the manometer and experimental set up.
2. Air vent valve of the manometer should be closed while performing the experiment.
3. Make sure that the relevant pressure tapping to the throat and pipe is connected.

XI. Procedure

1. Connect the venturimeter in the experimental setup.
2. Connect the pressure tapping of the venturimeter to the manometer.
3. Start the pump.
4. Remove air from the manometer and experimental set up by opening the air vent valve.
5. Adjust the regulating valve in the pipeline for minimum discharge.
6. Wait for stabilization of flow.
7. Note down h_1 and h_2 from the U – tube manometer.
8. Note the time required for collecting a known volume of water in a measuring cylinder / measuring tank.
9. Repeat steps 7 and 8 by increasing the discharge for more readings.
10. Calculate the theoretical discharge (Qth), actual discharge (Qa) and coefficient of discharge Cv.
11. Plot calibration curve (Plot of Qaversus Δhm)

XII. Resources used (with major specifications)

Sr. No.	Name of Resource	Suggested Broad Specification		Quantity	Remarks (If any)
		Make	Details		
1					
2					
3					
4					
5					
6					

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations:

1. Diameter of pipe(d_1) = ------------mm
2. Diameter of throat (d_2) = -------------------mm
3. Density of manometric fluid (ρm) =
4. Density of flowing fluid ie water (ρ) =
5. Area of measuring tank =

Sr No.	h_1 (cm)	h_2 (cm)	Δh_m (cm of Hg)	ΔH_f (cm of water)	Time (s)	(Q_a) = V /t (cm^3/s)	(Q_{th}) (cm^3/s)	C_v = Q_a / Q_{th}	Avg C_v
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									

Calculations
Sample calculation for set no.

1. h_1 =

2. h_2=

3. $\Delta h_m = h_1 \sim h_2$

4. $\Delta H_f = \Delta h_m \left(\frac{\rho_m - \rho}{\rho}\right)$ =

5. Time =

6. Volume of water collected =

7. Actual discharge (Qa) = Volume of water collected / time =

8. Area of throat (A_T) = $\pi d_2^2 / 4$ =

9. Theoretical discharge (Qth) = $A_T \sqrt{\frac{2g\Delta H_f}{1-\beta^4}}$

10. Cv = Qa / Qth =

XVI. Results

The average coefficient of discharge of venturimeter (Avg.Cv) is

XVII. Interpretation of results

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XVIII. Conclusions

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XIX. Practical related Questions

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

1. From the calibration curve, find the flow rate when Δh value is given

Δh (cm)	Qa (cm^3/ s

.

2. Using the Cv found out from the experiment, find the flow rate using the formula

when Δ h = ...

[Space for Answers]

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XX. References / Suggestions for further Reading

nptel.ac.in/courses/122103011/22
https://www.mecholic.com › Fluid Mechanics › Hydraulic Machines › Metrology
https://www.youtube.com/watch?v=UNBWI6MV_lY
https://www.youtube.com/watch?v=H3TcLoapJBo

XXI Assessment Scheme

Performance indicators		Weightage
Process related (15 Marks)		**60%**
1	Preparation of experimental set up	20%
2	Setting and operation	20%
3	Safety measures, observation and recording	20%
Product related (10 Marks)		**40%**
1	Calculation and Interpretation of result	20%
2	Practical related question and submission of report	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1…………………………

2…………………………

3…………………………

4…………………………

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

Scale

X-axis -

Y-axis -

Practical No: 10. Measure the flow rate using rotameter

I. Practical Significance:

Measuring flow rates of fluids is of utmost importance in Chemical Process Industry. Rotameter can be used to determine the flow rate by noting down the position of float.

II. Relevant Program Outcomes (POs)

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

PO2. Discipline knowledge: Apply **Chemical Engineering** knowledge to solve industry based 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**.

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

PSO 2.Material management and quality control: Manage chemicals and equipment to produce quality chemical products.

III. Competency and Practical Skills

'Maintain flow of different fluids in the chemical plant according to the process requirement.'

Use the rotameter for accurate flow rate measurement

IV. Relevant Course Outcomes

1 Maintain the fluid parameters in chemical process.

2 Maintain the flow rate of the incompressible fluid.

V. Practical Outcome

Use the rotameter to measure the flow rate and prepare a curve showing relationship between area and flow rate.

VI . Relevant Affective domain related Outcome(s)

1. Follow safe practices
2. Maintain tools and equipment.

VII. Minimum Theoretical Background

Rotameter is a variable area meter used for measuring volumetric flow rate. It consists of a gradually tapered glass tube mounted vertically in a frame with the large end up. The fluid flows upward through the tapered tube and suspends freely a float. The float is the indicating element and greater the flow rate, higher the float rides in the tube. The entire fluid stream must flow through the annular space between the float and the tube wall. The tube is marked in divisions and the meter is read from the scale reading at the edge of the float. Rotameters are used for both liquid and gas flow measurements.

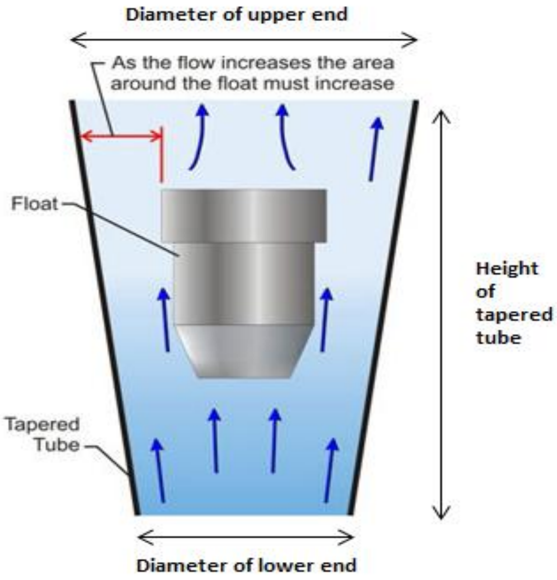

Figure 1

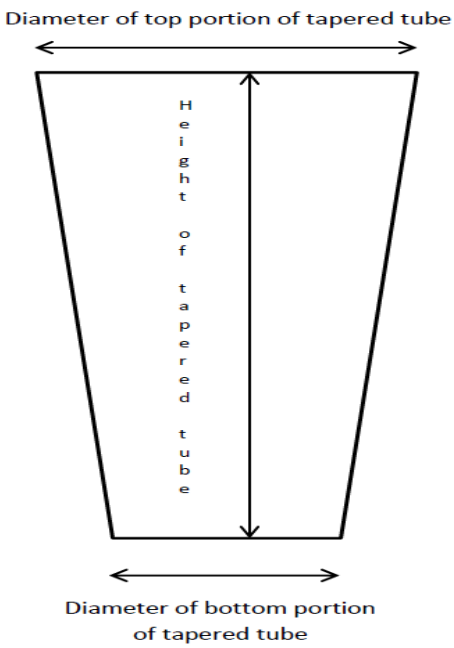

Fig2

VIII. Experimental set up:

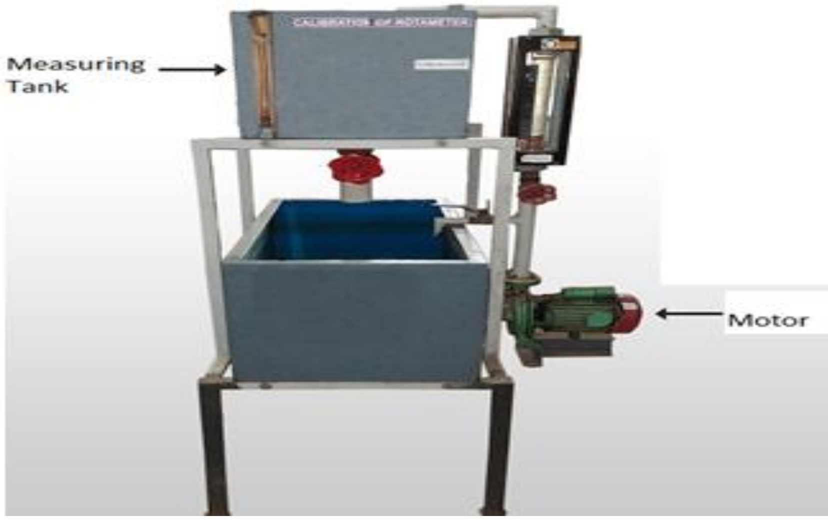

Figure 3

IX. Resources required

Sl No.	Name of Resource	Suggested Broad Specification	Quantity
1	Rotameter	Range 1- 11 LPM	1
2	Stop watch	0.1accuracy	1
3	Sump Tank	150cmx40cm	1
4	Measuring tank	60cmx30cm	1

X. Precautions

1. While taking reading, consider the reading corresponding to reading edge of the float.
2. Wait for the float to be stable before taking the reading.

XI. Procedure

1. Note down the height and diameter of upper and lower end of the rotameter tube.
2. Scale of the rotameter should be this height in cm.
3. Plot the graph between height of rotameter tube and the diameter of the rotameter tube (as shown in fig2)
4. Start the pump.
5. Allow water to flow through the experimental set up.
6. Adjust the float to a particular height using the flow regulating valve.
7. Note down the tapering tube diameter (d_2) corresponding to this height from the graph.
8. Note the time required for collecting a known volume of water in a measuring cylinder / measuring tank.
9 Repeat steps 5 to 8 over the entire range of the meter by changing the height of the float with the help of flow regulating valve.

10. Plot the calibration curve (Plot of volumetric flow rate versus annular area)

XII. Resources used (with major specifications)

Sl No.	Name of Resource	Suggested Broad Specification		Quantity	Remarks (If any)
		Make	Details		
1					
2					
3					
4					

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations:

1. Diameter of the top portion of rotameter tube =
2. Diameter of the bottom portion of the rotameter tube =
3. Height of the rotameter tube =
4. Diameter of reading edge of the float d_1=
5. Area of measuring tank =

Sr No	Height of float (cm)	Time (s)	Tapering tube Diameter d_2 (cm)	Annular area (cm^2)	Volumetric flow rate (cm^3 / s)
1					
2					
3					
4					
5					
6					
7					

8					

Sample calculation for set no

1. Volume of water collected = Area of measuring tank X height of water collected

2. Volumetric flow rate = Volume of water collected / time =

3. Annular area = π / $4(d_2^2 - d_1^2)$ =

XVI. Results

1. Calibration curve is plotted.

2. For reading no 2,when height of tapered tube is ….the volumetric flow rate is……

XVII. Interpretation of results

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XVIII. Conclusions

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XIX. Practical related Questions

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

a. Give the range of rotameter used
b. Rotameter is known as a variable area meter. Give reason.
c. From the graph, find out the volumetric flow rate when annular area is …..

[Space for Answers]

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XX. References / Suggestions for further Reading

- https://www.youtube.com/watch?v=ELJoieQDe6w
- https://www.youtube.com/watch?v=YYM92QFhTDo(hindi)
- https://www.youtube.com/watch?v=TSXS4FqzxAQ

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Preparation of experimental set up	20%
2	Setting and operation	20%
3	Safety measures, observation and recording	20%
Product related (10 Marks)		**40%**
1	Calculation and Interpretation of result	20%
2	Practical related question and submission of report	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1…………………………

2.…………………………

3…………………………

4…………………………

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

Scale

X-axis -

Y-axis -

Scale

X-axis -

Y-axis -

Practical No. 11: Calculate equivalent length for the pipe fittings and valve

1. Practical Significance

Pipe fittings and valves form an integral part of Process Piping System. Fittings and valves disturb the normal flow lines and cause friction. Equivalent length is a method of expressing the pressure drop across the fittings and valves. The overall pressure drop decides the pumping requirement and thereby the cost of pumping operations.

II. Relevant Program Outcomes (POs)

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

PO2. Discipline knowledge: Apply Chemical Engineering knowledge to solve industry based 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.

PO6 Environment and sustainability: Apply Chemical engineering solutions also for sustainable development practices in societal and environmental contexts.

PO 8.Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

III. Competency and Practical Skills

'Maintain flow of different fluids in the chemical plant according to the process requirement.'

1 Calculate the equivalent length of given pipe fitting / valve.
2 Calculate the power required by the pump in a given piping system.

IV. Relevant Course Outcomes

1 Maintain the flow rate of the incompressible fluid.
2 Select the relevant piping system for fluid transportation

V. Practical Outcome

Calculate equivalent length for the globe valve, gate valve and bend/elbow.

VI. Relevant Affective domain related Outcome(s)

1. Follow safe practices
2. Maintain tools and equipment.
3. Practice energy conservation.

VII. Minimum Theoretical Background

Fittings are used to change the direction of flow, for branching the pipe lines, for connecting pipes of same/ different diameter and for terminating the pipe line. Valves are used for on/off service and for flow regulation / throttling the flow.

Fittings and valves disturb the normal flow lines and cause friction. The friction loss from fittings and valves may be greater than that from the straight pipe. Equivalent length is the length of straight pipe of same nominal size as that of the fitting or valve which will give the same pressure drop as that of fitting and valve. It is generally expressed as length of straight pipe in multiple of diameter. It is calculated by the formula $\frac{Le}{D} = \frac{\Delta H_f\ g}{2 f v^2}$

VIII. Experimental set up:

Fig1

IX. Resources required

Sl No.	Name of Resource	Suggested Broad Specification	Quantity
1	Gate valve	Same nominal size as that of the pipe.	1
2	Globe valve	Same nominal size as that of the pipe.	1
3	Bend/ Elbow	Same nominal size as that of the pipe.	1
4	Manometer	Mercury as manometric fluid	1
5	Stop watch	0.1s accuracy	1
6	Sump tank	150cmx40cm	1
7	Measuring tank	60cmx30cm	1

X. Precautions to be followed

1. Connect the pressure tapping of the manometer to the relevant fitting/ valve.
2. Remove air from the manometer and experimental set up.
3. Air vent valve of the manometer should be closed while performing the experiment

XI. Procedure

1. Select the fitting (bend)
2. Open the pressure tapping to the bend and close all other pressure tapping.
3. Remove the air from the setup by opening the air vent valve.
4. Start the pump.
5. Adjust the regulating valve for minimum flow rate.
6. Wait for stabilization of flow.
7. Note down h_1 and h_2 from the U – tube manometer.
8. Note the time required for collecting a known volume of water in a measuring cylinder / measuring tank
9. Repeat steps 7 and 8 by changing the flow rate for taking additional readings.
10. Repeat the above procedure for globe valve and gate valve.
11. Calculate equivalent length for bend/ elbow, gate valve and globe valve

XII. Resources used

Sr. No.	Name of Resource	Suggested Broad Specification		Quantity	Remarks(If any)
		Make	Details		
1					
2					
3					
4					
5					
6					
7					

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations:

1. Diameter of pipe D =
2. Density of manometric fluid (ρm) =
3. Density of flowing fluid ie water (ρ) = 1000kg/m^3
4. Viscosity of water = 0.0008 Pa.s
5. Area of measuring tank =

Sr no	Pipe fittings	h_1 (cm)	h_2 (cm)	Δh_m (cm of Hg)	ΔH_f (m of water)	Time (s)	$Q=\frac{V}{t}$ (m^3/s)	v (m/s)	N_{Re}	f	$\frac{L_e}{D}$	Avg $\frac{L_e}{D}$
1												
2	Bend/ Elbow											
3												
4												
1												
2	Gate Valve											
3												
4												
1												
2	Globe valve											
3												
4												

Calculations
Sample calculation for set no:

1. h_1 =

2. h_2=

3. $\Delta h_m = h_1 \sim h_2$

4. $\Delta H_f = \Delta h_m \left(\frac{\rho_m - \rho}{\rho}\right)$ =

5. Time =

6. Volume of water collected =

7. Volumetric flow rate Q = Volume of water collected / time =

8. Area of pipe = $\pi D^2 / 4$ =

9. Velocity (v) = $\frac{Q}{Area}$ =

10. $N_{Re} = \frac{Dv\rho}{\mu}$

11. Friction factor

$f = \frac{16}{NRe}$ for laminar flow

$f = \frac{0.079}{NRe^{0.25}}$ for turbulent flow

12. $\frac{Le}{D} = \frac{\Delta H_f \; g}{2 f v^2}$ =

XVI. Results

1. Equivalent length of bend=
2. Equivalent length of elbow=
3. Equivalent length of gate valve=
4. Equivalent length of globe valve=.

XVII. Interpretation of results

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XVIII. Conclusions

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XIX. Practical related Questions

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

1. Define equivalent length.
2. Frictional loss in fittings is ………. than in straight pipe.
3. Equivalent length of a wide open gate valve is……….. the equivalent length of a half open gate valve of same nominal size.
4. Globe valve is most suited for applications in which …………………………..
   a. The valve is required to be either fully open or fully closed.

b. The fluid contains dispersed particles.
c. Flow control is required.
d. One way flow is required.

5. Globe valve offers …………………………pressure drop than gate valve.

[Space for Answers]

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XX. References / Suggestions for further Reading

www.nptel.ac.in/courses/112104118/lecture-37/37-3_losses_pipe_fittings.htm
nptel.ac.in/courses/101103004/module5/lec6/2.html
uorepc-nitk.vlabs.ac.in/exp2/index.html

XXI. Assessment Scheme

Performance Inicator		Weightage
Process related (15 Marks)		**60%**
1	Preparation of experimental set up	20%
2	Setting and operation	20%
3	Safety measures, observation and recording	20%
Product related (10 Marks)		**40%**
1	Calculation and Interpretation of result	20%
2	Practical related question and submission of report	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1…………………………

2…………………………

3…………………………

4…………………………

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

Practical No. 12: Measurement of head loss due to sudden expansion and contraction

I. Practical Significance

Whenever the velocity of fluid is changed, in either direction or magnitude, friction is generated. It is necessary to calculate the pressure drop due to this effect since it decides the pumping requirement of the piping system.

II. Relevant Program Outcomes (POs)

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

PO2. Discipline knowledge: Apply Chemical Engineering knowledge to solve industry based 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

PO 8.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.

III. Competency and Practical Skills

'Maintain flow of different fluids in the chemical plant according to the process requirement.'

1. Calculate the head loss due to sudden change in flow area
2. Calculate the power required by the pump in a given piping system.

IV. Relevant Course Outcomes

1 Maintain the flow rate of incompressible fluid.

2 Select the relevant piping system for fluid transportation.

V. Practical Outcome

Determine the head loss due to sudden expansion and contraction.

VI. Relevant Affective domain related Outcome(s)

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

VII Minimum Theoretical Background

When the cross section of the pipe is suddenly reduced, the fluid stream cannot flow around the sharp corner and the stream breaks contact with the wall of the pipe. A jet is formed, which flows into the stagnant fluid in the smaller section. The jet first contracts and then expands to fill the small cross section and downstream from the point of contraction the normal velocity distribution eventually is established. The cross section of minimum area at which the jet changes from a contraction to an expansion is called vena contracta. Head loss due to sudden contraction $h_{fc} = Kc\,\frac{u_1^2}{2g}$

Where Kc is the contraction loss coefficient given by $K_c = 0.4\left(1 - \frac{A_2}{A_1}\right)$ and

$\frac{u_2^2}{2g}$ is the velocity head in the small diameter pipe.

If the cross section of the pipe is suddenly enlarged, the fluid stream separates from the wall and issues a jet in to the enlarged section. The jet then expands to fill the entire cross section of the larger conduit. The space between the expanding jet and the conduit wall is filled with fluid in vortex motion characteristics of boundary layer separation and considerable friction is generated within this space. Head loss due to sudden expansion hfe= $Ke\,\frac{u_1^2}{2g}$

Where Ke is the expansion loss coefficient given by $K_e = \left(1 - \frac{A_1}{A_2}\right)^2$ and

$\frac{u_1^2}{2g}$ is the velocity head in the small diameter pipe.

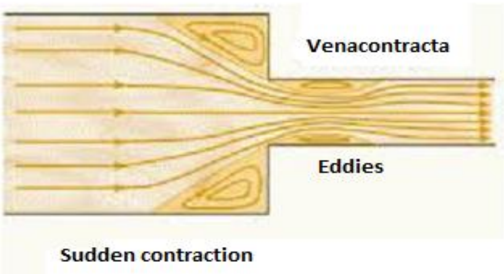

Fig 1

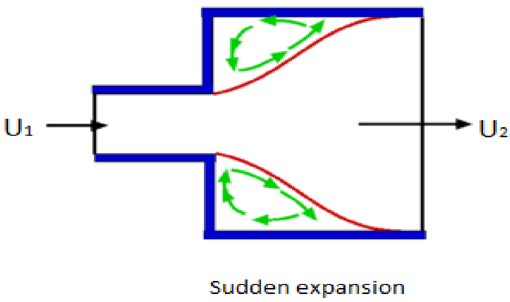

Fig 2

VIII. Experimental set up:

Fig 3

IX. Resources required

Sl No.	Name of Resource	Suggested Broad Specification	Quantity
1	Experimental set up with sudden expansion and sudden contraction arrangement	Diameter of large pipe = 2.3cm Diameter of small pipe = 1.6cm	1
2	Manometer	Mercury as manometric fluid	1
3	Stop watch	0.1 s accuracy	1
4	Sump Tank	150cmx40cm	1
5	Measuring tank	60cmx30cm	1

X. Precautions

1. Connect the pressure tapping of the manometer to the relevant section.
2. Remove air from the manometer and experimental set up.
3. Air vent valve of the manometer should be closed while performing the experiment.

XI. Procedure

1. Arrange the experimental set up
2. Initially allow fluid to pass through sudden expansion section only by opening the relevant valve.
3. Open the pressure tapping to the sudden expansion section and close all other pressure tapping.

4. Remove the air from the setup by opening the air vent valve.
5. Start the pump.
6. Adjust the regulating valve for minimum flow rate.
7. Wait for stabilization of flow.
8. Note down h_1 and h_2 from the U – tube manometer.
9. Note the time required for collecting a known volume of water in a measuring cylinder / measuring tank
10. Repeat steps 8 and 9 by changing the flow rate for taking additional readings.
11. Now allow the fluid to pass through sudden contraction section by opening the valve and close the valve for sudden expansion.
12. Repeat steps 3-10 for sudden contraction.

XII. Resources used

Sl No.	Name of Resource	Suggested Broad Specification		Quantity	Remarks (If any)
		Make	Details		
1					
2					
3					
4					
5					

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations:

1. Area of measuring tank =
2. Sudden enlargement pipe diameter at entry D_1= ……..m At exit D_2 =…………m
3. Sudden contraction pipe diameter at entry D_1= ………..m At exit D_2 =…………m
4. Volume of water collected V =

Sudden Expansion

Sr No	h_1 (cm)	h_2 (cm)	Δh_m (cm of Hg)	ΔHf (cm of water)	Time (s)	$Q=\frac{V}{t}$ (m^3/s)	u_1 (m /s)	$h_{fe}=\frac{k_e u_1^2}{2g}$
1								
2								
3								

Sudden Contraction

Sr No	h_1 (cm)	h_2 (cm)	Δh_m (cm of Hg)	ΔHf (cm of water)	Time (s)	$Q=\frac{V}{t}$ (m^3/s)	u_2 (m /s)	$h_{fc}=\frac{k_c u_2^2}{2g}$
1								
2								
3								

Sample calculation for set no

Volume of water collected V =

Sudden expansion

1. Time =
2. Volumetric flow rate Q = Volume of water collected / time =
3. A_1 =Area of small diameter pipe = $\pi D_1^2 / 4$ =
4. A_2 =Area of large diameter pipe = $\pi D_2^2 / 4$ =
5. Velocity in small diameter pipe $u_1 = Q / A_1$ =
6. Expansion loss coefficient $K_e = \left(1 - \frac{A_1}{A_2}\right)^2 =$
7. Head loss due to sudden expansion $h_{fe} = \frac{k_e u_1^2}{2g}$

Sudden contraction

1. Time =

2. Volumetric flow rate Q = Volume of water collected / time =

3. A_1 =Area of large diameter pipe = $\pi D_1^2 / 4$ =

4. A_2 =Area of small diameter pipe = $\pi D_2^2 / 4$ =

5. Velocity in small diameter pipe $u_2 = Q / A_2$ =

6. Contraction loss coefficient $K_c = 0.4\left(1 - \frac{A_2}{A_1}\right)$ =

7. Head loss due to sudden contraction $h_{fc} = \frac{k_c\ u_2^2}{2g}$

XVI Results

Head loss due to sudden expansion when velocity at the entrance section is ……m/s is …………

Head loss due to sudden contraction when velocity at the exit section is ……m/s is ……………………..

XVII. Interpretation of results

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XVIII. Conclusions

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XIX. Practical related Questions

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

a. Velocity head in small diameter pipe is always used in the calculation of head loss for sudden expansion and contraction. Give reason?
b. Give examples of practical situation representing sudden expansion and sudden contraction
c. Give the equation for calculating head loss due to sudden expansion and contraction.

[Space for Answers]

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XX. References / Suggestions for further Reading

- https://www.youtube.com/watch?v=6DFe8eUrbcI
- www.nptel.ac.in/courses/112104118/lecture-14/14-6_losses_sudden_enlarg.htm
- https://www.youtube.com/watch?v=kM2oCVv58Kw

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Preparation of experimental set up	20%
2	Setting and operation	20%
3	Safety measures, observation and recording	20%
Product related (10 Marks)		**40%**
4	Calculation and Interpretation of result	20%
5	Practical related question and submission of report	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1…………………………

2.…………………………

3.…………………………

4.…………………………

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

Practical No. 13: Operate the centrifugal pump and plot the characteristics curves.

I. Practical Significance

Liquids are moved through pipes and channels with the help of pumps. Considering the versatile utility of centrifugal pumps in pumping liquids, its efficient operation and maintenance is of utmost importance in process industry.

II. Relevant Program Outcomes (POs)

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

PO2. Discipline knowledge: Apply Chemical Engineering knowledge to solve industry based 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

PO 8.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.

PSO 2.Material management and quality control: Manage chemicals and equipment to produce quality chemical products

III. Competency and Practical Skills

'Maintain flow of different fluids in the chemical plant according to the process requirement.'

1 Operate a centrifugal pump.
2 Note down the various parameters at different operating conditions.
3 Use energy meter to measure power consumption.

IV. Relevant Course Outcomes

1 Maintain fluid parameters in chemical process
2 Use liquid pumping devices.

V. Practical Outcome

Use the centrifugal pump test rig to plot the characteristics curve.

VI. Relevant Affective domain unrelated Outcome(s)

1. Follow safe practices
2. Maintain tools and equipment.

VII. Minimum Theoretical Background

Centrifugal pumps are machines which employ centrifugal force to lift the liquid from a lower level to a higher level by developing pressure. A simplest type of pump comprises of an impeller fitted into a shaft, rotating in a casing. Liquid led into the centre of the impeller known as the 'eye' of the impeller, is picked up by the vanes of the impeller and accelerated to a high velocity by the rotation of the impeller, and discharged by centrifugal force into the spiral casing and then out through the discharge pipe. In the casing, the velocity head of the liquid from the impeller is converted to pressure head. When liquid is forced away from the centre, a vacuum is created and more liquid flows in. Continuous lifting of liquid, thus takes place from sump to the pump.

The performance of a pump is illustrated by plots of actual head, power consumption and efficiency curves versus volumetric flow rate as shown in fig 2. The theoretical head flow rate (usually called head capacity) relation is a straight line but the actual developed head at given flow rates is considerably less and drops to zero as the flow rate increases to a certain value. This is known as zero head flow rate. Optimum flow rate is less than this. The difference between the theoretical and actual head is due to fluid friction and shock losses. The output power (fluid power) rises with flow rate to a maximum value at or near rated capacity and then falls slightly. The input or actual power rises through most of the range of flow rates. The difference between them represents the power lost in the pump. Pump efficiency is the ratio of output power (fluid power) to input power(power consumed).

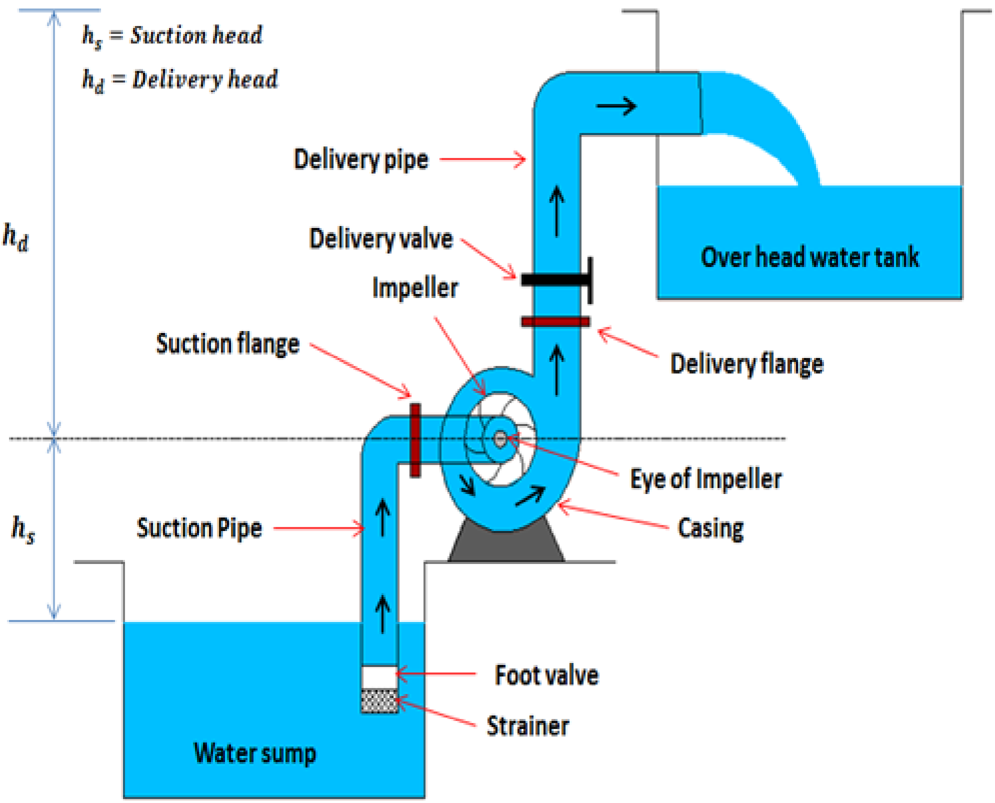

Fig 1 Working of centrifugal pump

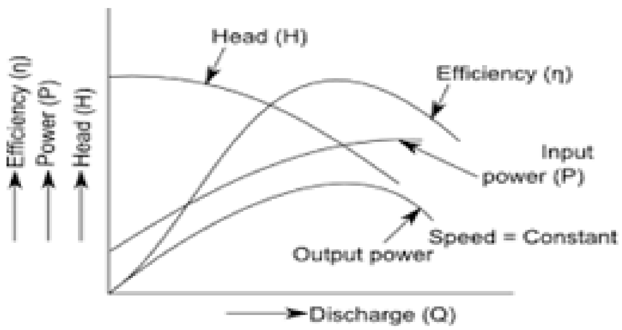

Fig 2 Characteristics curve of centrifugal pump.

VIII. Experimental set up:

Fig3

IX. Resources required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Centrifugal pump	Motor power 5HP	1
2	Stop watch	0.1 accuracy	1
3	Energy meter		1
4	Vacuum Gauge	0 to 760 mm of Hg	1
5	Pressure Gauge	0 to 2.1 kg / cm^2	1
6	Measuring tank	35cm X30cm X 30cm provided with gauge tube and funnel for diverting the flow into either measuring tank or sump tank.	1
7	Sump tank	90cm X 50 cm X 30	1

X. Precautions .

1. Priming is necessary if pump doesn't give discharge
2. Leakage should be avoided at joints.
3. Foot valve should be checked periodically.
4. Lubricate the joints & moving parts periodically
5. Avoid overheating, however, if overheating occurs, stop the pump immediately and allow it to cool to the air temperature.
6. Check for Suction line blockage
7. Before starting operations, always ensure all the guards and shields of the pump are in place

XI. Procedure

1. Fill the sump tank with water.
2. Prime the motor, close the delivery valve.
3. Switch on the motor and check the direction of rotation of pump in proper direction.
4. Adjust the speed of the pump with the help of the dimmer.
5. Keep the discharge valve fully open and allow the water to fall in the discharge tank.
6. Note the suction pressure and discharge pressure.
7. Note the time taken for …… revolution of energy meter.
8. Divert the flow to the measuring tank.
9. Close the drain valve and note down the time taken for collecting …..cm of water in the measuring tank.
10. Adjust the regulating valve for varying the discharge.
11. Repeat steps 5-9 depending up on the number of readings to be taken.
12. Plot the graph of head Vs discharge, efficiency Vs discharge, input power Vs discharge, and output power Vs discharge

XII. Resources used

Sl No.	Name of Resource	Suggested Broad Specification		Quantity	Remarks (If any)
		Make	Details		
1					
2					
3					
4					
5					
6					
7					

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations:

1. Area of measuring tank =
2. Number of revolutions of energy meter disc N_E=
3. Energy Meter Constant EMC =
4. Distance between Discharge gauge and suction gauge = Z_2-Z_1 =……m

Sr No	Speed of the pump	Delivery pressure P_d (Pressure gauge reading)		Suction pressureP_s(Vacuum gauge reading)		Time for 10 cm rise in collecting tank t_q (s)	Time required for ….. revolution of energy meter disc t_P(s)
		(kgf/cm^2)	N / m^2	mm of Hg	N / m^2		
1							
2							
3							
4							
5							

6							
7							
8							

Sample calculation for set no

1. Volume of water collected V= Area of measuring tank X height of water collected =

2. Suction head H_s(m) = $\frac{P_s}{\rho g}$ =

3. Delivery head H_d(m) = $\frac{P_d}{\rho g}$ =

4. Total head H_a (m) = $H_s + H_d$ =

5. Discharge Q (m^3 /s) = $\frac{Volume\ of\ water\ collected}{Time}$

6. Input power P_i(w) = $\frac{N_E X\ 3600}{t_p X EMC}$

7. Output power P_o(w) = ρ x Q x H_a x g

8. Overall efficiency of the pump η = $\frac{P_o}{P_i}$ =

Sr No	Suction head H_s (m)	Discharge head H_d (m)	Total head H_a (m)	Discharge (Q) m ^{3}/sec	Input Power P_i (w)	Output Power P_o (w)	η%
1							
2							
3							
4							
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 few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. From the graph of head developed Vs discharge, find out the head developed for the given values of discharge

Discharge Q (m^3/sec)	**Head developed H_a(m)**

2. From the graph, find out the shut off head.
3. Define air binding and priming.
4. Explain cavitation. Give is drawbacks.

[Space for Answers]

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XX. References / Suggestions for further Reading(Times New Roman, 12, Bold)

- https://www.youtube.com/watch?v=70mCj_QK8D0
- https://www.youtube.com/watch?v=p54HAatQOcA
- https://www.youtube.com/watch?v=XcY5IxgkCS0
- http://nptel.ac.in/courses/105103021/41
- https://www.youtube.com/watch?v=BaEHVpKc-1Q
- https://www.youtube.com/watch?v=dLq3B21iWZU

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Preparation of experimental set up	20%
2	Setting and operation	20%
3	Safety measures, observation and recording	20%
Product related (10 Marks)		**40%**
4	Calculation and Interpretation of result	20%
5	Practical related question and submission of report	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1…………………………

2…………………………

3…………………………

4…………………………

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

Scale

X-axis -

Y-axis -

Scale

X-axis -

Y-axis -

Practical No. 14: Operate a reciprocating pump

I. Practical Significance

Pumps are used for many different applications. Understanding which pump type you need for your application is very important. Pumps are used to transfer energy to an incoming fluid. The pressure or velocity of the fluid increases, which helps the fluid overcome physical barriers such as pipe friction and height changes. Reciprocating pumps are often used in the food industry. In sugar factories, piston pumps are used to pump carbonation slurry. They are also used in the construction industry to help pour concrete foundations.

II. Relevant Program Outcomes (POs)

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

PO2. Discipline knowledge: Apply Chemical Engineering knowledge to solve industry based 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

PO6. Environment and sustainability: Apply Chemical engineering solutions also for sustainable development practices in societal and environmental contexts.

PSO 2.Material management and quality control: Manage chemicals and equipment to produce quality chemical products

III Competency and Practical Skills

'Maintain flow of different fluids in the chemical plant according to the process requirement.'

Operate a reciprocating pump.

IV. Relevant Course Outcomes

1. Maintain fluid parameters in chemical process
2. Use liquid pumping devices.

V. Practical Outcome

Use reciprocating pump set up to prepare a plot of flow rate Vs head developed

VI. Relevant Affective domain unrelated Outcome(s)

1. Follow safe practices
2. Maintain tools and equipment.
3. Practice energy conservation

VII. Minimum Theoretical Background

Reciprocating pump consists of a piston or plunger which reciprocates in stationary cylinder. Suppose the piston is initially at extreme left position and when crank rotates through 180 ^{0} , piston moves to extreme right position. Due to outward movement of piston, a partial vacuum is created in cylinder, which forces the liquid up from the sump tank through the suction pipe & fill the cylinder by forcibly opening the suction valve(it is called as a suction stroke).When the crank rotates through further 180 ^{0} ,piston moves inwardly from its extreme right position. The inward movement of piston causes the pressure of liquid in the cylinder to rise above atmospheric pressure, because of which the suction valve closes & delivery valve opens. The liquid is then forced up the delivery valve & raised to the required height.(Delivery stroke) . In case of double acting pump, the liquid is in contact with both the sides of a piston. This pump has two suction valves & two delivery valves. During each stroke, the suction takes place on one side of piston & other side delivers the liquid .The liquid is drawn into the pump & discharged from the pump during backward as well as forward stroke.

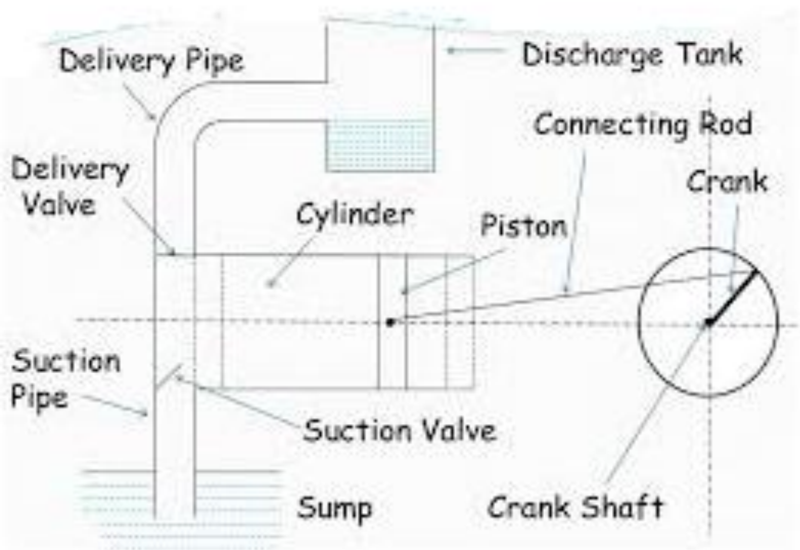

Figure 1 Constructional features of reciprocating pump

VIII. Experimental set up :

Sump tank

Fig 2

IX. Resources required

Sr No.	Name of Resource	Suggested Broad Specification	Quantity
1	Reciprocating pump	Motor power 5HP	1
2	Stop watch	0.1 accuracy	1
3	Energy meter		1
4	Vacuum Gauge	0 to 760 mm of Hg	1
5	Pressure Gauge	0 to 2.1 kg / cm^2	1
6	Tachometer		1
7	Measuring tank	35cm X30cm X 30cm provided with gauge tube	1
8	Sump tank	90cm X 50 cm X 30	1

X. Precautions

1. Before starting the pump ensure that discharge valve is opened fully.
2. Operate all the controls gently.
3. The pump and motor assembly must be securely fastened to the base, and the base must be securely attached to the ground.
4. Always use clean water for the experiment.

XI. Procedure

1. Keep the delivery valve open and switch on the pump.
2. Note the delivery and suction gauge reading.
3. Note the time for .... cm rise in water level in the measuring tank.
4. Note the speed of the pump (N) rpm using tachometer.
5. Repeat step 2 and 3 by reducing discharge (Note.: Don’t close discharge valve completely)

6. Repeat steps 2 to 5 by changing the speed using compound pulley.
7. Plot the graph of flow rate Vs head developed

XIII. Resources used

Sl No.	Name of Resource	Suggested Broad Specification		Quantity	Remarks(If any)
		Make	Details		
1					
2					
3					
4					
5					
6					
7					
8					

XIII Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations:

Sr No	Speed of the pump	Delivery pressure P_d (Pressure gauge reading)		Suction pressure P_s(Vacuum gauge reading)		Time for 10 cm rise in collecting tank t_q (s)
		(kgf/cm^2)	N / m^2	mm of Hg	N / m^2	
1						
2						
3						
4						
5						
6						

7						
8						

Sample calculation for set no.

1. Suction head $H_s = \frac{P_S}{\rho g}$ (m)=

2. Delivery head $H_d = \frac{P_d}{\rho g}$ (m)=
3. Total head $H_a = H_s + H_d$ (m)=
4. Volume of water collected V= Area of measuring tank X height of water collected =

5. Discharge $Q = \frac{Volume\ of\ water\ collected}{Time}$ (m^3 /s)

Sr No.	Suction head H_s (m)	Discharge head H_d (m)	Total head H_a (m)	Discharge (Q) m^3/sec
1				
2				
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8				

XVI. Results

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XVII. Interpretation of results

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XVIII. Conclusions

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XIX. Practical related Questions

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

a. Discharge capacity of the reciprocating pump is ___________ that of the centrifugal pump.

b. Which pump is more suitable for an application where very high pressure is required to be developed at moderate discharge?
   i. Reciprocating pump
   ii. Centrifugal pump
   iii. Turbine
   iv. None of the above

c. Compare single acting and double acting reciprocating pump.

d. While operating, don't close the discharge valve of the reciprocating pump fully. Give reason

[Space for Answers]

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XX. References / Suggestions for further Reading(Times New Roman, 12, Bold)

- o https://www.youtube.com/watch?v=tGYIKkJtxUE
- o https://www.youtube.com/watch?v=s6RIx0SL3C8
- o https://www.youtube.com/watch?v=oQqMrtc6kJQ
- https://www.youtube.com/watch?v=c7Yxm8uJkKQ

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Preparation of experimental set up	20%
2	Setting and operation	20%
3	Safety measures, observation and recording	20%
Product related (10 Marks)		**40%**
4	Calculation and Interpretation of result	20%
5	Practical related question and submission of report	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1…………………………

2…………………………

3…………………………

4…………………………

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

Scale

X-axis -

Y-axis -

Practical No. 15: Operate the fluidized bed and determine the fluidization velocity.

I. Practical Significance

A fluidized bed is a state of a two-phase mixture of particulate solid material and fluid, which is widely used in many modern technologies for efficient implementation of various physical and chemical processes. Fluidized beds have been used in technological processes such as: cracking and reforming of hydrocarbons (oil), carbonization and gasification of coal, ore roasting, Fischer-Tropsch synthesis, polyethylene manufacturing, combustion of waste, nuclear fuel preparation, combustion of solid, liquid and gaseous fuels etc. The most common reason for fluidizing a bed is to obtain vigorous agitation of the solids in contact with the fluid, leading to excellent contact of the solid and the fluid and the solid and the wall. This means that nearly uniform temperatures can be maintained even in highly exothermic reaction.

II. Relevant Program Outcomes (POs)

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

PO2. Discipline knowledge: Apply Chemical Engineering knowledge to solve industry based 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

PO 8.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.

III. Competency and Practical Skills

'Maintain flow of different fluids in the chemical plant according to the process requirement.'

1. Operate a fluidized bed.
2. Observe behavior of solid with respect to gas flow rate .

IV. Relevant Course Outcomes

Use gas pumping devices

V. Practical Outcome

Use fluidized bed to determine the fluidization velocity for bed of different materials

VI. Relevant Affective domain related Outcome(s)

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

VII. Minimum Theoretical Background

A fluidized bed is a packed bed through which fluid flows at such a velocity that the bed is loosened and the particle-fluid mixture behaves as though it is a fluid. Thus, when a bed of particles is fluidized, the entire bed can be transported like a fluid, if desired. Both gas and liquid flows can be used to fluidize a bed of particles. The minimum velocity at which a bed of particles fluidizes is a crucial parameter needed for the design of any fluidization operation. The details of the minimum velocity depend upon a number of factors, including the shape, size, density etc of the particles. The density, for example, directly alters the net gravitational force acting on the particle, and hence the minimum drag force, or velocity, needed to lift a particle. The shape alters not only the relationship between the drag force and velocity, but also the packing properties of the fixed bed and the associated void spaces and velocity of fluid through them

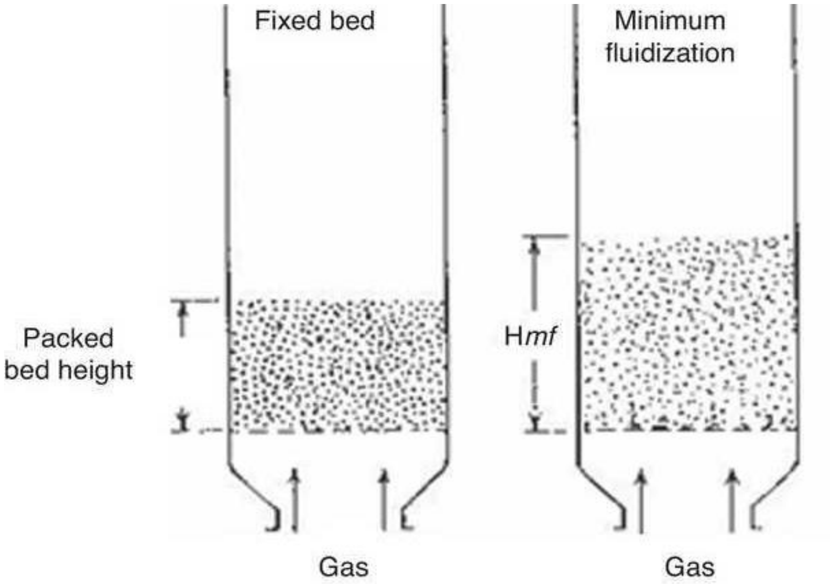

Fig 1 Fluidised bed

VIII. Experimental set up : ->

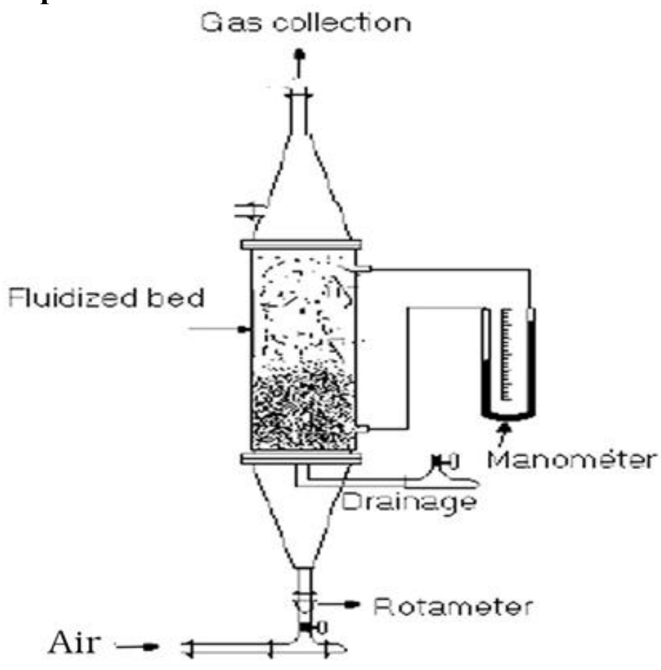

Figure 2

IX. Resources required

Sr No.	Name of Resource	Suggested Broad Specification	Quantity
1	Rotameter	Range 1-11 LPM	1
2	Manometer	Water as manometricfliuid	1
3	Compressor	1Hp	1
4	Cylindrical vessel	1m height	1

X. Precautions

1. Admit the gas evenly into the tube from bottom

XI. Procedure

1. Fill the tube partially with a fine granular material.
2. Admit air from the bottom at a low flow rate. The air should pass upward through the bed without causing any particle motion.
3. Increase the flow rate of air gradually using the valve .As the flow rate is gradually increased, the pressure drop increases, but the particles do not move.
4. At a certain higher flow rate of air, the particles will get separated from each other and start to move in the bed.
5. Again increase the flow rate so that the bed is fluidized vigorously.
6. Now turn off the air supply and allow the bed to settle.
7. Again increase the air flow rate until the bed just starts to expand.
8. Note down this air flow rate from rotameter. The velocity corresponding to this flow rate will give the minimum fluidization velocity.
9. Repeat all the steps by using a different material.

XII. Resources used

Sr.No.	Name of Resource	Suggested Broad Specification		Quantity	Remarks(If any)
		Make	Details		
1					
2					
3					
4					

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations:

1. Diameter of column =

Sr No:	Type of material	Volumetric flow rate of air		Velocity of air
		LPM	m^3 / s	
1				
2				
3				
4				

Sample calculation

1. Volumetric flow rate =
2. Area of column = $\frac{\pi d^2}{4}$
3. Velocity of air = $\frac{Volumetric\ flow\ rate\ of\ air}{Area\ of\ column}$ m / s

XVI. Results

1. Minimum fluidization velocity for material 1 =
2. Minimum fluidization velocity for material 2 =
3. Minimum fluidization velocity for material 3 =

XVII. Interpretation of results

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XVIII. Conclusions

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XIX. Practical related Questions

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

a. Define minimum fluidization velocity
b. List the factors on which the fluidization velocity depends.
c. Give the industrial application of fluidization.

[Space for Answers]

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XX. References / Suggestions for further Reading

- https://www.youtube.com/watch?v=n2fxJAlNiQM
- https://www.youtube.com/watch?v=jp1nsRPz8oU
- https://www.youtube.com/watch?v=rb47Hyg2ci8
- https://www.youtube.com/watch?v=JsO45IPDyXg

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Preparation of experimental set up	20%
2	Setting and operation	20%
3	Safety measures, observation and recording	20%
Product related (10 Marks)		**40%**
4	Calculation and Interpretation of result	20%
5	Practical related question and submission of report	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1…………………………

2…………………………

3…………………………

4…………………………

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

Practical No. 16: Operate the fixed bed and plot a graph of pressure drop Vs flow rate.

I. Practical Significance

Chemical engineering operations commonly involve the use of fixed and fluidized beds. These are devices in which a large surface area for contact between a liquid and a gas (absorption, distillation) or a solid and a gas or liquid (adsorption, catalysis) is obtained for achieving rapid mass and heat transfer. Fixed bed columns are largely employed for absorption, desorption, rectification and direct heat transfer processes in chemical and food industry, environmental protection and also processes in thermal power stations like water purification, flue gas heat utilization and SO_2 removal.

II. Relevant Program Outcomes (POs)

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

PO2. Discipline knowledge: Apply Chemical Engineering knowledge to solve industry based 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.

PO9. Communication: Communicate effectively in oral and written form.

III. Competency and Practical Skills

'Maintain flow of different fluids in the chemical plant according to the process requirement.'

Operate a fixed bed column.

IV. Relevant Course Outcomes

Use gas pumping devices.

V. Practical Outcome

Use fixed bed of given material to prepare curve of pressure drop Vs flow rate

VI. Relevant Affective domain related Outcome(s)-

1. Follow safe practices
2. Maintain tools and equipment.

VII. Minimum Theoretical Background

A typical packed bed is a cylindrical column that is filled with a suitable packing material. The liquid is distributed as uniformly as possible at the top of the column and flows downward, wetting the packing material. A gas is admitted at the bottom, and flows upward, contacting the liquid in a counter current fashion. An example of a packed bed is an absorber. Here, the gas contains some carrier species that is insoluble in the liquid (such as air) and a soluble species such as carbon dioxide or ammonia. The soluble species is absorbed in the liquid, and the lean gas leaves the column at the top. The liquid rich in the soluble species is taken out at the bottom. From a fluid mechanics perspective, the most important issue is that of the pressure drop required for the liquid or the gas to flow through the column at a specified flow rate.

VIII. Experimental set up :

Fig1

IX. Resources required

Sr No.	Name of Resource	Suggested Broad Specification	Quantity
1	Rotameter	Range 1-11 LPM	1
2	Manometer	Water as manometric fliuid	1
3	Compressor	1Hp	1
4	Cylindrical vessel	1m height	1

X. Precautions

Admit the gas evenly into the packed bed from bottom

XI. Procedure

1. Fill the tube with the given granular material.
2. Start the flow of air.
3. Measure the flow rate of air using rotameter
4. Note down the manometer reading.
5. Increase the flow rate of air using the relevant valve and note down the manometer reading.
6. Repeat the procedure for various flow rates of air.
7. Plot the graph of pressure drop Vs flow rate.

XII. Resources used

Sr No.	Name of Resource	Suggested Broad Specification		Quantity	Remarks (If any)
		Make	Details		
1					
2					
3					
4					

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations:

1. Diameter of column =
2. Density of manometric fluid (water), (ρm) = 1000kg/m^3

3. Density of flowing fluid ie air (ρ) =

Sr No	Volumetric flow rate of air		Manometer reading			Pressure drop across the column (ΔH_f) m of air	Pressure drop across the column (ΔP) N /m^2
	LPM	m^3/hr	h_1 cm	h_2 cm	Δhm m of water		
1							
2							
3							
4							
5							
6							
7							
8							

Sample calculation for set no:

1. Area of column =
2. h_1 =
3. h_2 =
4. $\Delta h_m = h_1 \sim h_2$
5. $\Delta H_f = \Delta h_m \left(\frac{\rho m - \rho}{\rho}\right) =$
6. $\Delta P = \rho g \Delta H_f =$

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 few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

a. Give the industrial application of fixed bed.
b. Compare packed bed and fixed bed.

[Space for Answers]

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XX. References / Suggestions for further Reading

- https://www.youtube.com/watch?v=nTm1H_X5h4E
- https://www.youtube.com/watch?v=S0RIz9ONuiI
- https://www.youtube.com/watch?v=vj53WeOfGUA

XXI. Assessment Scheme

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Total (25 Marks)		**100 %**

Names of Student Team Members

1…………………………

2…………………………

3…………………………

4…………………………

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

Scale

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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