SCHEME : K

Name : ______________________________

Roll No. : ________________ Year : 20___ 20___

Exam Seat No. : ______________________

LABORATORY MANUAL FOR
FLUID MECHANICS AND MACHINERY
(313309)

MECHANICAL ENGINEERING GROUP

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 challenging technological & 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 following:

- Skill development in line with industry requirements.
- Industry readiness and improved employability of Diploma holders.
- Synergistic relationship with industry.
- Collective and Cooperative development of all stake holders.
- Technological interventions in societal development.
- Access to uniform quality technical education.

A Practical Manual for

FLUID MECHANICS AND MACHINERY (313309)

Semester-III

"K- SCHEME"

Diploma in Mechanical Engineering

Maharashtra State
Board of Technical Education, Mumbai

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

Maharashtra State
Board of Technical Education, Mumbai
(Autonomous) (ISO-9001-2015) (ISO/IEC 27001:2013)
4th Floor, Government Polytechnic Building, 49, Kherwadi,
Bandra (East), Mumbai -400051.
(Printed On July,2024)

Maharashtra State

Board of Technical Education, Mumbai

Certificate

This is to certify that Mr./Ms. ……………………………………………………………

Roll No.…………………..... of the third Semester of Diploma in ………………………………………………………………………… of the Institute ………………………………………………………………………………………………

(Inst. Code……………….) has completed the term work satisfactorily in the course Fluid Mechanics and Machinery **(313309)** for the academic year 20…... – 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 objective of all engineering laboratories or field experience in the technical education system is to help students acquire the critical competencies and skills that businesses demand. In light of this, MSBTE developed the cutting-edge "K" Scheme curricula for engineering diploma programs, emphasizing outcome-based learning and the National Education Policy 2020 (NEP2020). As a result, a sizable portion of the program is dedicated to practical work. This demonstrates how crucial laboratory work is in helping teachers, instructors, and students understand that every minute of lab time must be used efficiently to create these outcomes rather than being spent on pointless tasks. Consequently, each practical has been created to operate as a "vehicle" to advance this industry in order to ensure the successful implementation of this outcome-based curriculum. It is challenging to teach practical skills using only the "chalk and duster" activity. Because of this, the "K" scheme laboratory manual creation team focused on the outcomes when designing the practical rather than following the long-standing custom of doing the practical to "verify the theory" (which may turn out to be a by-product along the way).

This lab manual is intended to support all parties involved, particularly the students, instructors, and teachers, in helping the students achieve the pre-established objectives. It is required of every student to read through the relevant practical process in its entirety and comprehend the bare minimum of theoretical background related to the practical at least one day in advance of the practical. As a crucial starting point for carrying out the practical, each exercise in this manual starts with establishing the competency, industry-relevant skills, course outcomes, and practical outcomes. The skills, the students will acquire from the process outlined there, together with the necessary safety measures to be followed, will subsequently be made clear to them. These will enable them to apply the knowledge and abilities to solve real-world problems in their professional lives.

In all engineering specialties, familiarity with thermal power plants, industrial material handling systems, and various mechanical devices is necessary. In all fields of engineering, understanding fluid mechanics, characteristics & fluid machinery is crucial. Hydraulic machines play a significant part in power generation, irrigation, water supply, and most technical disciplines. The objective of this course is to improve the students' ability to estimate pipe loss, evaluate the efficiency of hydraulic machines such as pumps and turbines, choose the right pump for a given application, diagnose and fix problems with pumps and turbines, replace pressure gauges and other accessories on hydraulic machines, and use their hydraulics knowledge to choose the right pressure gauges, valves, flow devices, pipes, and other devices for various field applications.

The team responsible for developing the Practical manual would like to express its gratitude to MSBTE for taking the lead in developing and implementing the curriculum. Additionally, the team recognizes the valuable contributions made by individual course experts who have been directly or indirectly involved in the development of the “K” scheme curriculum and the laboratory manual.

It is impossible to claim perfection in this laboratory manual, even though every effort has been made to verify it for errors, especially because this is the first edition. Any such mistakes and recommendations for enhancements are quite appreciated and can be brought to our attention.

Lab Manual Development Team

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

Following POs are expected to be achieved through the practical's of the (Fluid Mechanics &Machinery) course.

PO 1. Basic and Discipline specific knowledge: Apply knowledge of basic mathematics, science and engineering fundamentals and engineering specialization to solve the mechanical engineering problems.

PO 2. Problem analysis: Identify and analyse well-defined mechanical engineering problems using codified standard methods.

PO 3. Design/ development of solutions: Design solutions for well-defined technical problems and assist with the design of systems components or processes to meet specified needs in mechanical engineering.

PO 4. Engineering Tools, Experimentation and Testing: Apply modern mechanical engineering tools and appropriate technique to conduct standard tests and measurements.

PO 5. Engineering practices for society, sustainability and environment: Apply appropriate technology in context of society, sustainability, environment and ethical practices.

PO 6. Project Management: Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities in diverse and multidisciplinary fields.

PO 7. Life-long learning: Ability to analyse individual needs and engage in updating in the context of technological changes in mechanical engineering.

List of Industry Relevant Skills-

The following industry relevant skills of the competency 'Maintain hydraulic machinery using knowledge of fluid mechanics 'are expected to be developed in you by undertaking the practical of this laboratory manual.

1. Use pressure measuring devices for measuring pressure of various fluid devices.
2. Operate Fluid Machinery.
3. Maintain Fluid Machinery.
4. Select pressure measuring &flow measuring devices for given application.
5. Evaluate the performance of fluid machinery.

Practical- Course Outcome matrix

Course Outcomes (COs)

- CO1. Determine different properties of fluid and pressure measurements.
- CO2. Apply Bernoulli's theorem to various flow measuring devices.
- CO3. Calculate the various losses in flow through pipes.
- CO4. Select suitable hydraulic turbine and pump for the given application.
- CO5. Evaluate the performance of hydraulic turbines and pumps.

Sr. No.	Laboratory Practical Titles	CO 1.	CO 2.	CO 3.	CO 4.	CO 5.
1.	*Measurement of water pressure by using Bourdon tube pressure gauge and U-tube Manometer.	√	-	-	-	-
2.	Measurement of discharge of water by using a measuring tank and stopwatch.	-	√	-	-	-
3.	Measurement of total energy available at different sections of a pipe layout to verify Bernoulli's theorem.	-	√	-	-	-
4.	*Measurement of discharge through pipe using Venturimeter.	-	√	-	-	-
5.	Measurement of discharge through a pipe provided with sharp edged circular orifice.	-	√	-	-	-
6.	Measurement of the discharge through pipe using Orificemeter.	-	√	-	-	-
7.	Interpretation of the type of flow using Reynolds apparatus.	-	√	-	-	-
8.	*Calculation of Darcy's friction factor 'f' in pipes of different diameters for different discharges.	-	-	√	-	-
9.	*Determination of minor frictional losses in sudden expansion and sudden contraction in a pipe.	-	-	√	-	-
10.	Determination of minor frictional losses in elbow and bend in a pipe.	-	-	√	-	-
11.	Determination of the force exerted and work done by a jet on flat plate.	-	-	-	-	√
12.	*Determination of overall efficiency of Pelton turbine using Pelton wheel test rig.	-	-	-	-	√
13.	*Dismantling and Assembly of a Centrifugal pump.	-	-	-	√	-
14.	*Determination of overall efficiency of Centrifugal pump using Centrifugal pump test rig.	-	-	-	-	√
15.	Dismantling and Assembly of a Reciprocating pump.	-	-	-	√	-
16.	*Determination of overall efficiency and percentage slip of Reciprocating pump using Reciprocating pump test rig.	-	-	-	-	√

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 practical.
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 teacher 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, Technical Manuals, etc.
4. Student should not hesitate to ask any difficulties they face during the conduct of practical.

Content Page

List of Practical and Progressive Assessment Sheet

Sr. No.	Laboratory Practical Titles	Page No.	Date of performance	Date of submission	FA PR marks (25)	Dated sign. of teacher	Remarks (if any)
16.	*Determination of overall efficiency and percentage slip of Reciprocating pump using Reciprocating pump test rig.	109					

Note: To be transferred to Proforma of CIAAN-2023.

A suggestive list of LLOs is given in the above table. More such LLOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practical marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.

Practical No.1 Measurement of water pressure by using Bourdon tube pressure gauge and U- tube Manometer.

I. Practical Significance

The investigation of a fluid's applied force on a surface is known as pressure measurement. The standard unit of measurement for pressure is force per unit of surface area. Numerous methods have been devised to measure pressure.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop skills for the industry identified competency as "Select appropriate process/tool such as Bourdon's pressure gauge & Manometer for Pressure measurement".

III. Course Level Learning Outcome (CO)

CO1-Determine different properties of fluid and pressure measurements.

IV. Laboratory Learning Outcome(s)

LLO1.1: Use Bourdon tube pressure gauge for pressure measurement.
LLO1.2: Use U-tube Manometer for pressure measurement.

V. Relative Affective Domain related Outcome(s)

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.

VI. Minimum Theoretical Background with diagram

- **Bourdon pressure gauge**

The device was invented by Eugene Bourdon in the year 1849. The basic idea behind the device is that, cross-sectional tubing when deformed in any way will tend to regain its circular form under the action of pressure. The bourdon pressure gauges used today have a slight elliptical cross-section and the tube is generally bent into a C-shape or arc length Bourdon pressure gauge is used to measure pressure.

As shown in the figure 1.1, the pressure input is given to a socket which is soldered to the tube at the base. The other end or free end of the device is sealed by a tip. This tip is connected to a segmental lever through an adjustable length link. The lever length may also be adjustable. The segmental lever is suitably pivoted, and the spindle holds the pointer as shown in the figure. A hair spring is sometimes used to fasten the spindle of the frame of the instrument to provide necessary tension for proper meshing of the gear teeth and thereby freeing the system from the backlash.

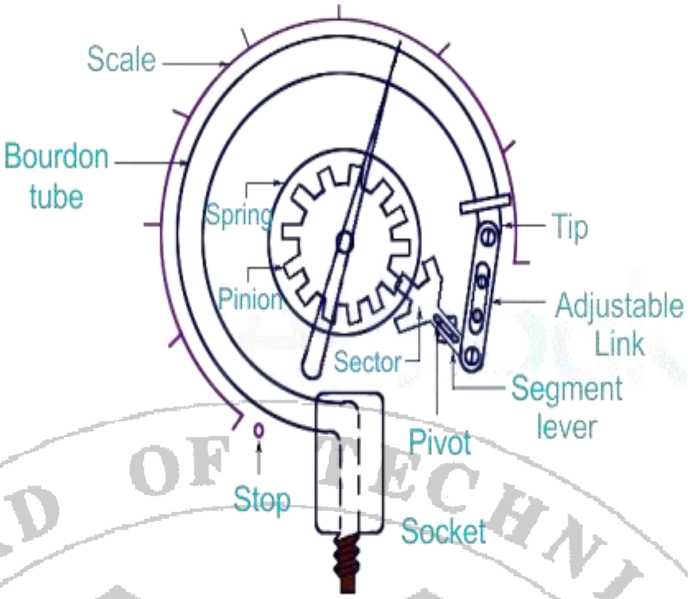


Figure1.1- Construction of Bourdons pressure gauge

U Tube Manometer:

- It is the type of manometer that has a vertical u-tube column that is filled with mercury as a reference fluid. When its columns are revealed to the atmosphere the level of fluid in the columns becomes equal and this denotes the atmospheric pressure of the earth. But if one of its columns is connected to any other fluid then a change in the atmospheric pressure can be seen. The image below shows the diagram of a u-tube manometer.

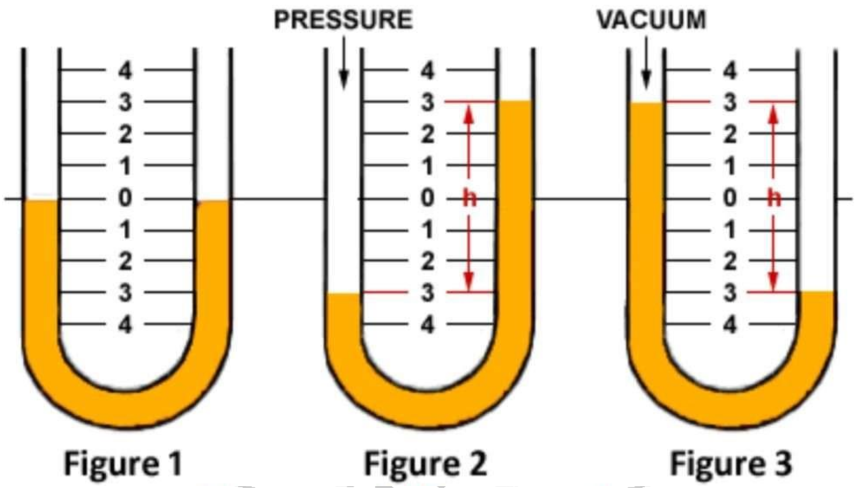


Figure 1.2- U Tube Manometer

VII. Experimental setup

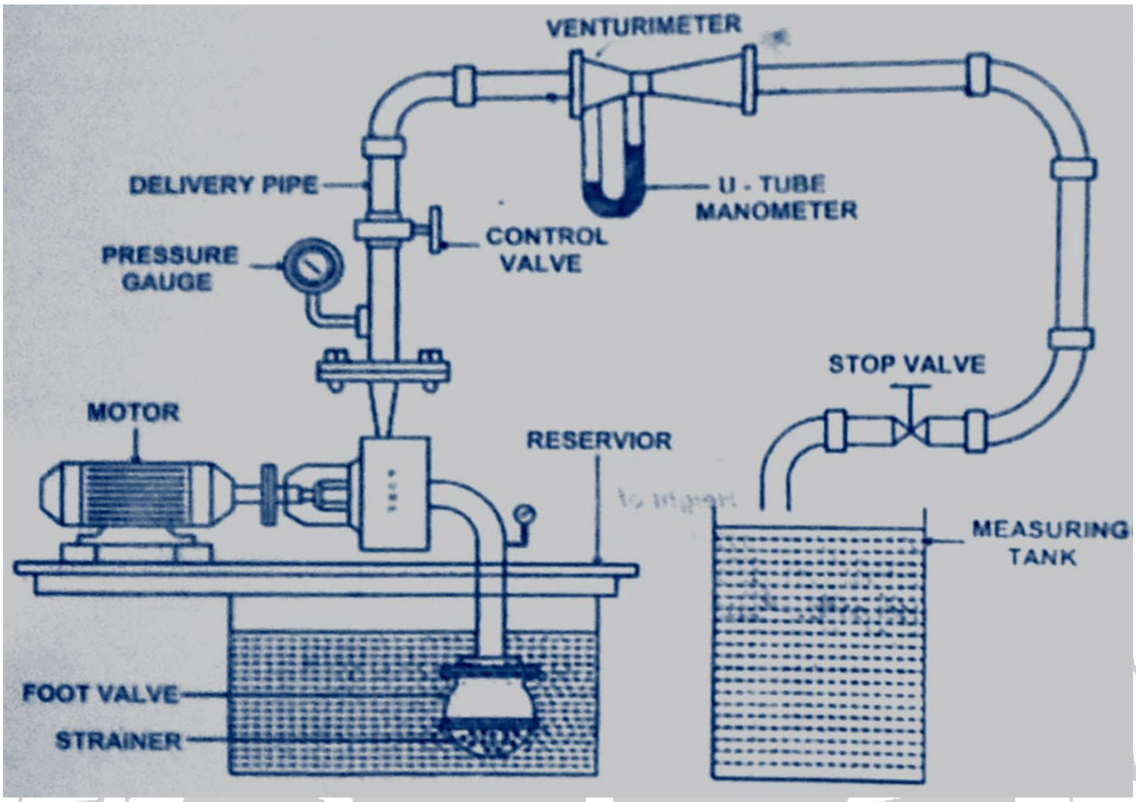


Figure1.3-Experimental Set up of pressure measurement using Bourdon tube pressure gauge and U-tube Manometer

VIII. Required Resources /Apparatus/Equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Centrifugal pump test rig along with necessary pipe fittings and accessories	Centrifugal pump with motor: Variable speed, 2800 RPM Supply tank: 80 Ltrs. made of Mild steel with FRP lining	1
2.	Bourdon tube pressure gauge	Range-0-12 bar	1
3.	Venturimeter	13 mm (Mild steel)	1
4.	U-tube manometer:	Wall/ Stand mounted thick walled Borosilicate glass tube	1

IX. Precautions to be Followed

1. Avoid improper handling of electrical connections of Centrifugal pump.
2. Please ensure Priming is required for centrifugal pump or not.
3. Handle the U-tube manometer with due care.
4. Handle the venturimeter pipes with due care.
5. Handle Stop watch carefully.

X. Procedure

For Bourdon Tube Pressure gauge

1. Start the pump and water will flow in the pipe line.
2. Record the indicated units on the gauge.
3. Record the pressure.
4. Adjust & change the flow control valve to other position and record the reading of pressure gauge.

For U Tube Manometer

1. Connect the manometer to pipe through which fluid/water the is flowing
2. Remove air from the limbs of U tube mercury manometer.
3. Note the heights of mercury columns from the right and left limbs
4. Calculate the difference of above two mercury columns
5. Calculate the head in meters of water, meters of liquid and in N/m^2.
6. Repeat step 6 to 9 by adjusting flow control valve/flow rates.

For Discharge Measurement with Measuring Tank

1. Measure the dimensions for calculating cross sectional area of measuring tank.
2. Start the pump.
3. Collect the flow of water in the measuring tank.
4. Start the stop watch when you start to collect flow of water in the measuring tank.
5. Note the height of water in the tank after pre-decided time.
6. Stop collecting water in the tank.
7. Stop the pump.
8. Calculate volume of water collected in the tank.

XI. Observations and calculations

1. Pressure Gauge reading

Sr. No.	Pressure Reading in Kg/ cm^2	Pressure Reading in N/ m^2
1.		
2.		
3.		

2. U Tube Manometer reading

- S_1= Specific gravity of liquid flowing through pipe (water)= _________
- S_2= Specific gravity of manometer fluid (mercury)=_________

Sr. No	Height of Hg in left limb (in cm)	Height of Hg in Right limb (in cm)	Difference in Meters	Differential head in the meters of water	Differential head in N/m^2
	h_1	h_2	$x=(h_2-h_1)/100$	$H=X(S_2-S_1)/S_1$	P
1.					
2.					
3.					

Calculation of Manometer reading: -

For x= ------------- cm= ------------= m

Differential head in meters of water, H = $\frac{X(S2-S1)}{S1}$ = ---------------

H= ------------------ meter

Pressure Intensity = P = WxH

Where, W= specific weight of water = 9810N/m^3

P=___________x__________ **P=**____________________ N/m^2

XII. Results

Intensity of Pressure for first flow rate-

i. For Bourdon tube pressure Gauge - ________________N/m^2
(Converted from kg/cm^2 to N/m^2)

ii. For Manometer Reading - ______________________N/m^2

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. 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. Explain the concept of Pressure head & obtain the expression of it.
2. Convert the following into N/mm^2 & N/m^2 if a different pressure gauge shows sets of reading:
   i. 75psi
   ii. 10 bar
   iii. $250 kg/cm^2$
3. Explain with neat sketch construction & working of Bourdons tube pressure gauge.

[Space for Answer]

References / Suggestions for Further Reading

1. https://www. slideshare.net/Gauravsingh963/pressure-measuring-devices
2. https://www.youtube.com/watch?v=HYcuHgSQvyg
3. https://www.youtube.com/watch?v=cq7g3FTsUbY

XVI. Rubrics for Assessment Scheme

	Performance Indicators	Weightage
	Process Related (15 Marks)	**(60%)**
1.	Handling of the measuring Instruments	30%
2.	Calculation of final readings	30%
	Product Related (10 Marks)	**(40%)**
3.	Interpretation of result	20%
4.	Conclusions	10%
5.	Practical related questions	10%
	Total (25 Marks)	**100 %**

<table>
<tr><th colspan="3">Marks Obtained</th><th>Dated signature of Teacher</th></tr>
<tr><th>Process Related(15)</th><th>Product Related(10)</th><th>Total (25)</th><td rowspan="2"></td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

Practical No. 02 Measurement of discharge of water by using a measuring tank and stopwatch.

I. Practical Significance

Discharge or flow measurement can be employed to measure the liquid passing through an application or stored in an application. Flow or discharge measurement is a vital function used to monitor and control the rate of liquid flow in applications.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the skills for the industry identified competency as "Select appropriate tool and process to measure the discharge of water/fluid."

III. Course Level Learning Outcome (CO)

CO2- Apply Bernoulli's theorem to various flow measuring devices.

IV. Laboratory Learning Outcome(s)

LLO2.1: Calculate discharge of water using a measuring tank and stopwatch.

V. Relative Affective Domain related Outcome(s)-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.

VI. Minimum Theoretical Background with diagram

Measurement of Discharge:

Discharge is the volumetric flow rate of water. It is commonly expressed in cubic meter per second. Simplest method to measure the discharge of water is with the help of measuring tank.

VII. Experimental setup (Model)

Figure 2.1- Experimental set up of discharge measurement

VIII. Required Resources /Apparatus/Equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Centrifugal pump test rig along with necessary pipe fittings and accessories	Centrifugal pump with motor: Variable speed, 2800 RPM Supply tank: 80 Ltrs. made of Mild steel with FRP lining	1
2.	Measuring tank	40 Ltrs. made of Mild steel with FRP lining and fitted with piezometer tube	1
3.	Stop watch	Electronic with least count of 0.01 sec	1
4.	Measuring scale	Range up to 60 cm	1

IX. Precautions to be Followed

1. Avoid improper handling of flow control valve.
2. Handle stop watch carefully.

X. Procedure

1. Measure the dimensions for calculating cross sectional area of measuring tank.
2. Start the pump.
3. Collect the flow of water in the measuring tank.
4. Start the stop watch when you start to collect flow of water in the measuring tank.
5. Note the height of water in the tank after pre-decided time.
6. Stop collecting water in the tank.
7. Stop the pump.
8. Calculate volume of water collected in the tank.
9. Calculate the discharge of water = $\frac{\text{Volume of Water}}{\text{Time}}$ in $\frac{m^3}{sec}$

XI. Observations and calculations

Sr.No.	Rise in height of water in measuring tank (H) in m	Time required to collect the water in measuring tank (t)	Discharge (Q)
1.			
2.			
3.			
4.			
5.			

Volume of water collected in the tank, - V=WxBxH

W=__________ cm = ____________m B=____________cm = ____________ m

H_1 = _____________ cm = ______________ m

Volume of water collected in the tank, - V=WxBxH_1=______________________________

V=______________ m^3

Time (t_1) = __________seconds

Discharge = Q= $\frac{\text{Volume of Water collected}}{\text{Time}}$

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

XII. Results

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. 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. Identify which relevant discharge measuring device is used in following application:
   i. To measure the speed of the air around the plane.

ii. To measure the fuel and air distribution in carburetor
iii. Volumetric or mass flow rate determination in chemical & petrochemical plants.

2. Enlist the factors considered while selecting the flow meters.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. www.youtube.com/watch?v-ELJoieQDe6w

XVII. Rubrics for Assessment Scheme

	Performance Indicators	**Weightage**
	Process Related (15 Marks)	**(60%)**
1.	Handling of the models/set up	40%
2.	Observations of the models/set up	20%
	Product Related (10 Marks)	**(40%)**
3.	Interpretation of result	20%
4.	Conclusions	10%
5.	Practical related questions	10%
	Total (25 Marks)	**100 %**

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

Practical No. 03 Measurement of total energy available at different sections of a pipe layout to verify Bernoulli's theorem.

I. Practical Significance

Bernoulli's theorem states "for a perfect and incompressible fluid flowing in a continuous stream, the total energy of a particle remains same while moving from one point to other".

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the skills for the industry identified competency as "Select appropriate hydraulic machines and process to Measure the flow through hydraulic machinery &calculate total energy of flowing fluid by using knowledge of fluid mechanics."

III. Course Level Learning Outcome (CO)

CO2- Apply Bernoulli's theorem to various flow measuring devices.

IV. Laboratory Learning Outcome(s)

LLO3.1: Calculate total energy available at different sections of a pipe layout.
LLO 3.2: Verify Bernoulli's theorem.

V. Relative Affective Domain related Outcome(s)-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.

VI. Minimum Theoretical Background with diagram

1. **Energy:** is defined as the capacity to do work. It exists in various forms and can change from one form to another.
2. **Potential Energy (Potential Head):** It is the energy possessed by virtue of its position; it is due to configuration or position above some suitable height or datum line. It is denoted by Z.
3. **Kinetic Energy (Velocity Head):** It is energy possessed by a liquid particle by virtue of its motion. It is due to the velocity flowing liquid and is measured as V^2/g Where V is velocity of flow and 'g' is acceleration due to gravity (g- 9.81m/s²)
4. **Pressure Energy (Pressure Head) :-I**t is energy possessed by a liquid particle by virtue of its existing pressure. It is due to the pressure of liquid and measured as P /w Where 'P' is intensity and 'W' is the specific weight of liquid.
5. **Total Energy (Total Head): -** it is the sum of potential energy, kinetic energy and pressure energy. It is denoted by 'E' and mathematically it is expressed as,
   E=Potential Energy+ Kinetic Energy+ Pressure Energy
   $$E = Z + \frac{V^2}{2g} + \frac{P}{w}$$

VII. Experimental setup (Model)-

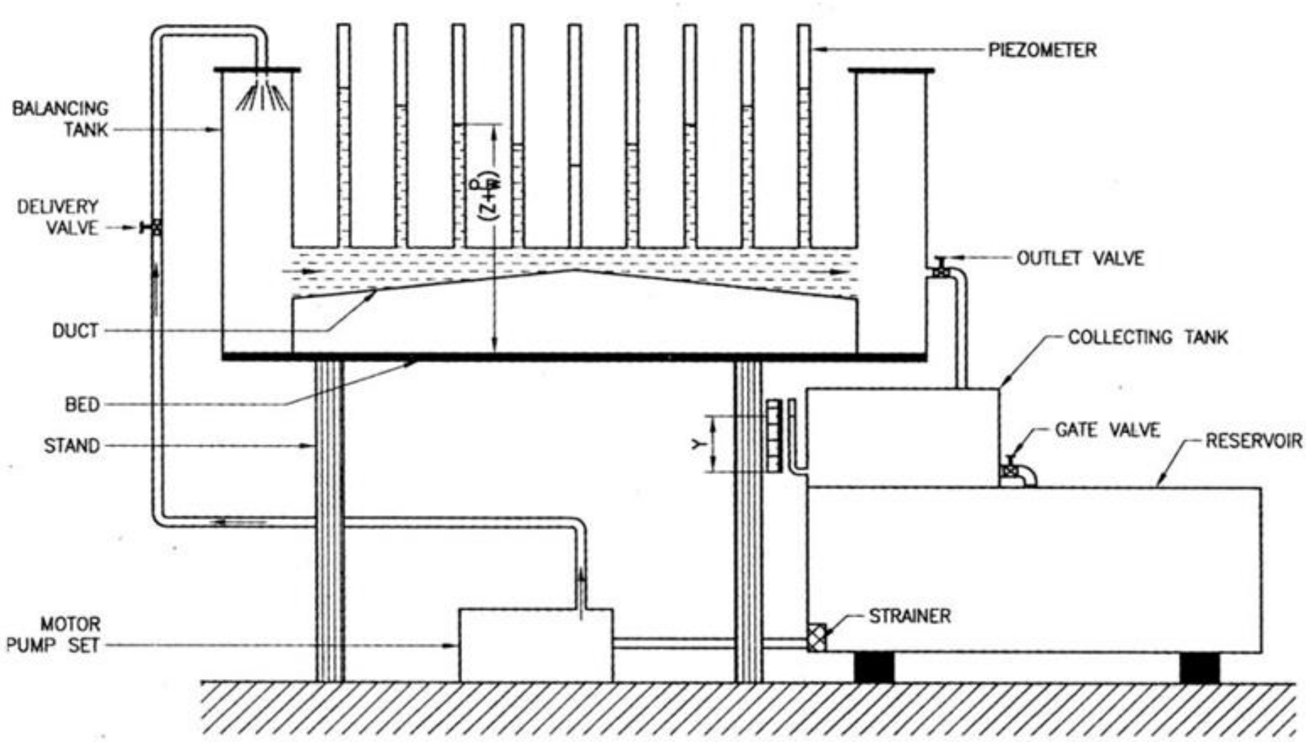


Figure3.1- Experimental set up for Bernoulli's theorem

VIII. Required Resources /Apparatus/Equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Experimental set up of Bernoulli's theorem	Pump with Motor: Mono-block pump- Single phase, 0.5 HP Differential Venturi of 300 mm length made out of Acrylic square bar Supply tank: 80 Ltrs. made of Mild steel with FRP lining	1
2.	Piezometer tubes	Range 0 to 12 bar	1
3.	Measuring tank	40 Ltrs. made of Mild steel with FRP lining and fitted with piezometer tube and scale	1
4.	Stop watch	Electronic with least count of 0.01 sec	1
5.	Measuring scale	Range up to 60 cm	1

IX. Precautions to be Followed

1. When fluid is flowing, there is a fluctuation in the height of piezometer tubes. Note the mean position carefully.
2. Carefully keep some level of fluid in inlet and outlet supply tank.
3. Avoid improper handling of electrical connections of Centrifugal pump.
4. Please ensure Priming is required for centrifugal pump or not.
5. Handle the Piezometer tubes with due care.
6. Handle Stop watch carefully.

X. Procedure

1. Start the pump and water will flow in the pipe line.
2. Open the valve so that the water can enter in the pipe of varying cross section.
3. Open the outlet valve after rising water in piezometer.
4. Maintain level of water.
5. Record head shown in the piezometer.
6. Measure discharge in the measuring tank.
7. Note the time taken for collecting of water by stop-watch.
8. Vary the discharge.
9. Repeat the procedure as above.
10. Plot the following graphs:
    i) No. of piezometer tube vs. pressure head.
    ii) No. of piezometer tube vs. velocity head.
    iii) No. of piezometer tube vs. total head.

XI. Observations and calculations -

Discharge Measurement reading

Measuring tank Dimension, - Width **W**=________m, Breadth **B**= _________m

Height of water observed in auxiliary tube H_1=__________m

Time required for collecting water =_____________Seconds.

Calculation of Discharge Measurement reading, -

Volume of water collected in the tank, -V=WxBxH$_1$=________________________________

V=______________ m^3

Time (t) = __________seconds

Discharge = Q= $\frac{\text{Volume of Water collected}}{\text{Time}}$

Q= $\frac{V}{t}$ =

Q= m^3/s

Velocity V= $\frac{Q}{A}$ = = __________ m/s

Where A= Area at corresponding tube section

Velocity head at respective point = $\frac{V^2}{2g}$= =__________m

Pressure Head= $\frac{P}{w}$ = =_________m

Potential head= constant (same datum for all tubes)

For 1st Reading, -

For Discharge -Q_1= ______________ m^3/s

Tube No.	Cross Sectional Ares of the Pipe	Velocity 'v'	Velocity Head	Pressure Head	Total Head =Velocity Head+ Pressure Head
	m^2	m/sec	$V^2/2g$ in m	P/w in m	$(V^2/2g)$ + P/w
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					

For 2ndReading, -

For Discharge- Q_2= ______________ m^3/s

Tube No.	Cross Sectional Ares of the Pipe	Velocity 'v'	Velocity Head	Pressure Head	Total Head =Velocity Head+ Pressure Head
	m^2	m/sec	$V^2/2g$ in m	P/w in m	$(V^2/2g)$ + P/w
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					

For 3rd Reading, -

For Discharge-Q_3= _______________ m^3/s

Tube No.	Cross Sectional Ares of the Pipe	Velocity 'v'	Velocity Head	Pressure Head	Total Head =Velocity Head+ Pressure Head
	m^2	m/sec	$V^2/2g$ in m	P/w in m	$(V^2/2g) + P/w$
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					

Scale

X-axis -

Y-axis -

XII. Results

i)Velocity Head at respective point = $V^2/2g$ = ____________ m

ii)Pressure Head=P/w = ___________ m

iii)Total Head=(V^2/2g) + P/w = ________________ m

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. 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. Explain the Bernoulli's theorem and give the assumptions made while delivering it.
2. Calculate the difference of pressure between two section if pipe is uniformly tapering and velocity of water at the smaller section is 2 m/s. A 5 m long pipe is inclined at an angle of 10^0. The pipe is tapering from larger diameter of 200 mm to smaller diameter 50 mm. The smaller section of pipe is at lower level.
3. Calculate the discharge pressure if the water enters the pipe at pressure of 9.81 bar. The discharge through a horizontal trapping is 0.06 m^3/s. The diameter at inlet and outlet are 250 mm and 200 mm respectively.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://study.com/academy/lesson/bernoullis-equation-formula-and-examples
2. https://ovc.vale.edu/physics/phys-200/lecture-20
3. https://www.youtube.com/watch?v=QnTt9huzdNU
4. https://www.youtube.com/watch?v=DCIKIRZKWWk
5. https://www.slideshare.net/eliseb/bernoullis-principle-465993

XVII. Rubrics for Assessment Scheme

	Performance Indicators	**Weightage**
	Process Related (15 Marks)	**(60%)**
1.	Handling of the measuring Instruments	30%
2.	Calculation of final readings	30%
	Product Related (10 Marks)	**(40%)**
3.	Interpretation of result	20%
4.	Conclusions	10%
5.	Practical related questions	10%
	Total (25 Marks)	**100 %**

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

Practical No. 04 Measurement of discharge through pipe using Venturimeter.

I. Practical Significance

Venturimeter is a device which is used for measuring rate of flow flowing through pipe. It consists of three parts, a short converging part, throat & diverging part. It is based on the principle of Bernoulli's Theorem.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the skills for the industry identified competency as to "Select appropriate hydraulic machinery and process to measure the discharge of water/fluid by using venturimeter and compare it with theoretical one."

III. Course Level Learning Outcome (CO)

CO2- Apply Bernoulli's theorem to various flow measuring devices.

IV. Laboratory Learning Outcome(s)

LLO 4.1: Apply Bernoulli's theorem to Venturimeter.

LLO 4.2: Measure discharge through pipe using Venturimeter.

V. Relative Affective Domain related Outcome(s)-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/team member.
- Maintain tools and equipment.
- Follow ethical Practices.

VI. Minimum Theoretical Background

1. **Discharge:** The volume of liquid flowing per unit time through a section of pipe or channel is known as discharge or flow rate.
2. **A venturi meter** is also called a venturi flow meter. It is used to calculate the discharge of fluids flowing through a pipeline.

VII. Experimental setup (Model)-

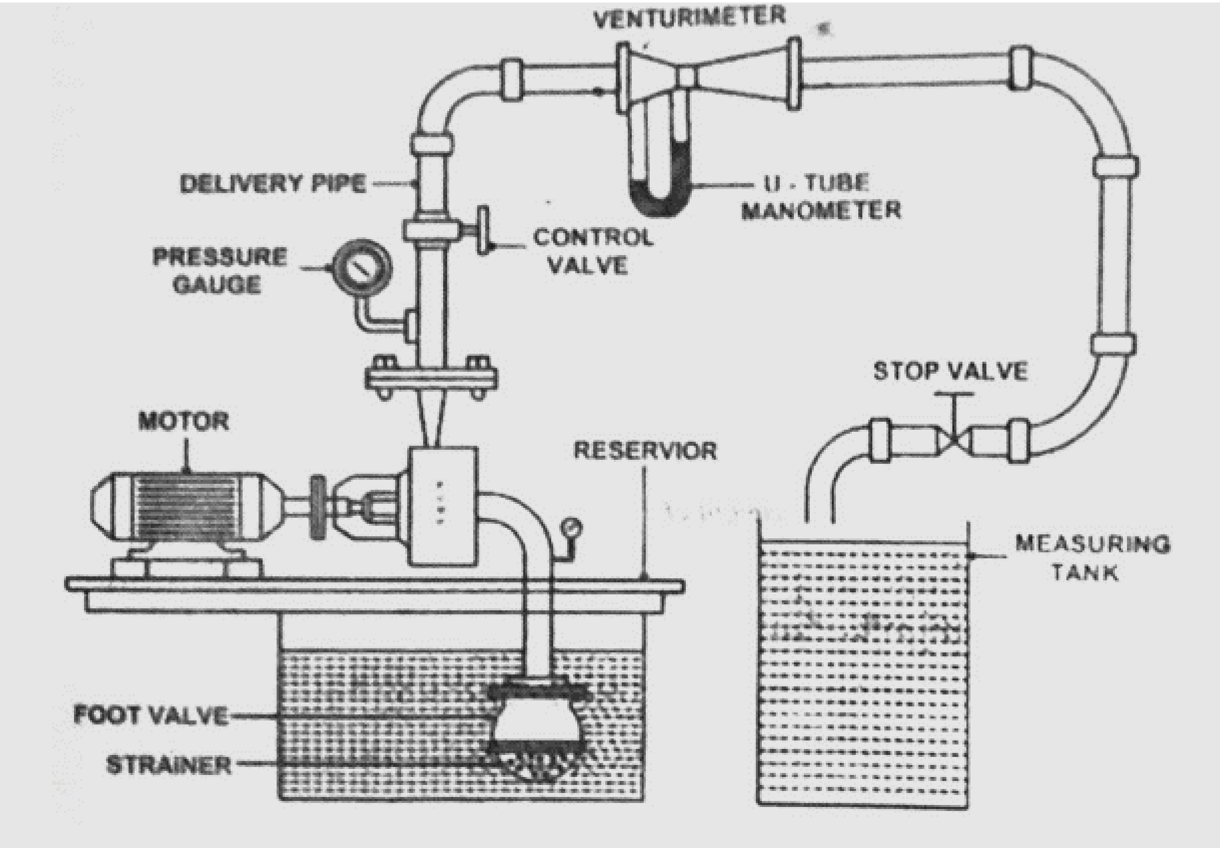


Figure 4.1 Experimental Set up

VIII. Required Resources /Apparatus/Equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Venturimeter Test Rig	Centrifugal pump with motor: Variable speed, 2800 RPM Supply tank: 80 Ltrs. made of Mild steel with FRP lining Venturimeter: 13 mm (Mild steel) (or Orifice meter of suitable specifications)	1
2.	U-tube manometer	Connected to pipe and throat of Venturimeter	1
3.	Measuring tank	40 Ltrs. made of Mild steel with FRP lining and fitted with piezometer tube and scale	1
4.	Stop watch	Electronic with least count of 0.01 sec	1
5.	Measuring scale	Range up to 60 cm	1

IX. Precautions to be Followed

1. Carefully keep some level of fluid in inlet and outlet supply tank.
2. Avoid improper handling of electrical connections of Centrifugal pump.
3. Please ensure Priming is required for centrifugal pump or not.
4. Handle the U tube Manometer tubes with due care.
5. Handle Stop watch carefully.

X. Procedure

1. Open the delivery valve of centrifugal pump, to avoid development of sudden pressure.
2. Carry out priming of pump if necessary.
3. Start the pump which allows water to flow through system.
4. Adjust the discharge by control valve.

XI. Observations and calculations –

Sr. No.	Rise of water level of Measuring Tank 'H'		Deflection of mercury column of the manometer			Converted water columns height h= H_{hg} (13.6-1)	Time to collect the water in measuring tank (t)
			H_{throat}	H_{pipe}	$H_{hg}=\frac{(H_t-Hp)}{100}$		
	cm	m	cm	cm	m	m	Sec
1.							
2.							
3.							
4.							
5.							
6.							

Discharge measurement reading, -

Measuring tank Dimension = Width **W**=_________m, Breadth **B**=___________m

Height of water observed in auxiliary tube **H_1**= _________m

Time for collecting water in tank t=__________sec

Calculation of Actual Discharge

Volume of Water collected in the tank, **-V=WxBxH =**______________________________

V=____________m^3

Time (t)= __________sec

Diameter of Venturimeter at inlet, d_1= mm= m

Cross section area a_1= = m^2

Diameter of Venturimeter at throat, d_2= mm= m

Cross section area a_2= = m^2

Actual Discharge= $Q_{act} = \frac{\text{Volume of Water collected}}{\text{Time}}$

$= \frac{V}{t} =$ = ____________________ m^3/sec

Theoretical Discharge = $Q_{th} = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}} =$

Q_{th}= ______________________ m^3/sec

XII. Results

1. Actual Discharge = Q_{act} = __________________ m^3/sec
2. Theoretical Discharge = Q_{th} = ________________ m^3/sec
3. Coefficient of Discharge = $C_d = \frac{Q_{act}}{Q_{th}}$ = ___________

XIII. Interpretation of Result

XIV. Conclusions and Recommendation

XV. 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. Discuss the pressure and velocity variation in convergent cone, throat and divergent cone of Venturimeter.
2. List the industrial applications of Venturimeter.
3. Explain whether Venturimeter can be used in vertical position.
4. Explain the use of Venturi in carburetor of automobiles.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=UNBWI6MV_IY
2. https://www.youtube.com/watch?v=tGQqEZDFVUA
3.https://www.youtube.com/watch?v=YHEPx9m9VXc
4.https://www.youtube.com/watch?v=WvFNqEPNPOC

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1.	Handling of the measuring Instruments	40%
2.	Observations/Calculation of final readings	20%
Product Related (10 Marks)		**(40%)**
3.	Interpretation of result	20%
4.	Conclusions	10%
5.	Practical related questions	10%
	Total (25 Marks)	**100 %**

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

Practical No. 05 Measurement of discharge through a pipe provided with sharp edged circular orifice.

I. Practical Significance

One tool for measuring discharge is an orifice plate. The computation related to the orifice plate can determine the mass or volumetric flow rate.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the skill for the industry identified competency as "Select the appropriate hydraulic equipment/process for measurement of discharge."

III. Course Level Learning Outcome (CO)

CO2 - Apply Bernoulli's theorem to various flow measuring devices.

IV. Laboratory Learning Outcome(s)

LLO 5.1: Measure discharge using sharp edged circular orifice.

V. Relative Affective Domain Related Outcome(s)-

- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.

VI. Minimum Theoretical Background with diagram

An orifice plate is a device used for measuring flow rate, for reducing pressure or for restricting flow.

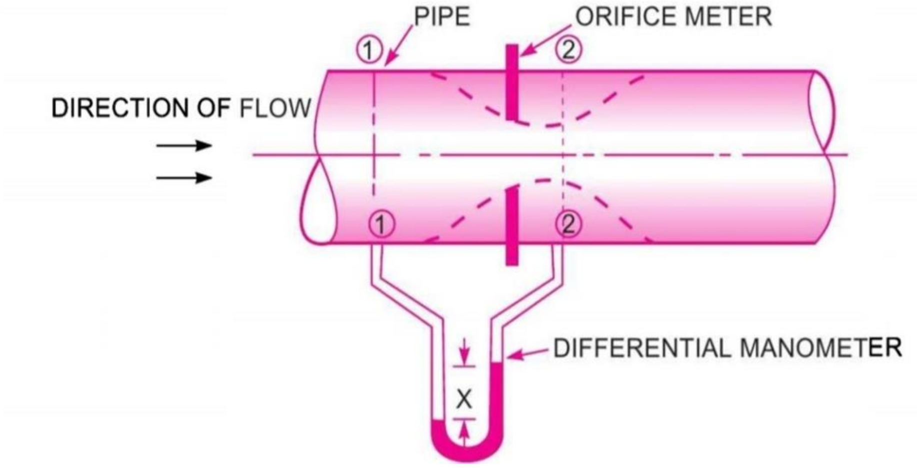


Figure 5.1 Orifice Meter

1. **Vena-contracta: -**

Consider an orifice is fitted with a tank. The liquid particles, in order to flow out through the orifice, move towards the orifice from all directions. A few of the particles first move downward, then take a turn to enter into the orifice and then finally flow through it.

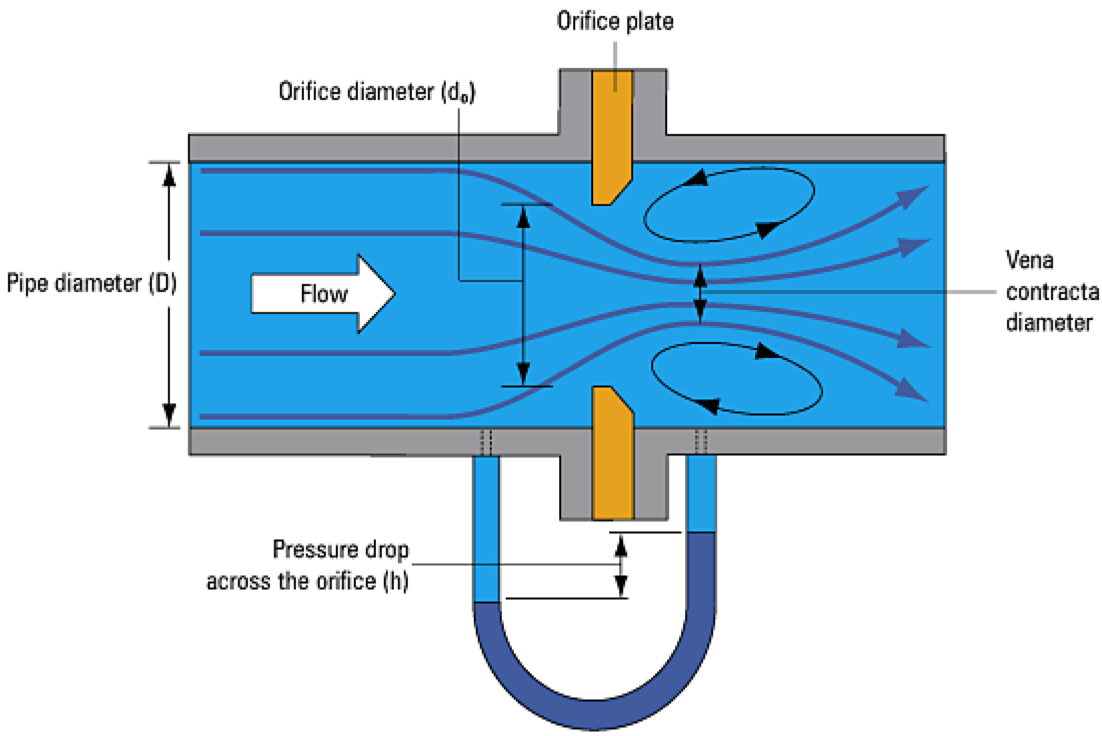


Figure 5.2 Vena Contracta

2. **Coefficient of Discharge: -**

For an orifice meter, the discharge coefficient (also known as coefficient of discharge) is the ratio of the actual discharge to the theoretical discharge.

3. **Coefficient of Velocity: -**

The ratio of actual velocity of the stream at vena-contract to the theoretical velocity is known as the coefficient of velocity.

$$C_v = \frac{v_{act}}{v_{th}}$$

$$= \frac{v_{act}}{\sqrt{2gh}}$$

4. **Coefficient of contraction: -**

It is the ratio between the area of the jet at the vena contracta to the area of the orifice.

$$C_c = \frac{\text{Area at vena contracta}}{\text{Areaoforifice}}$$

VII. Experimental setup

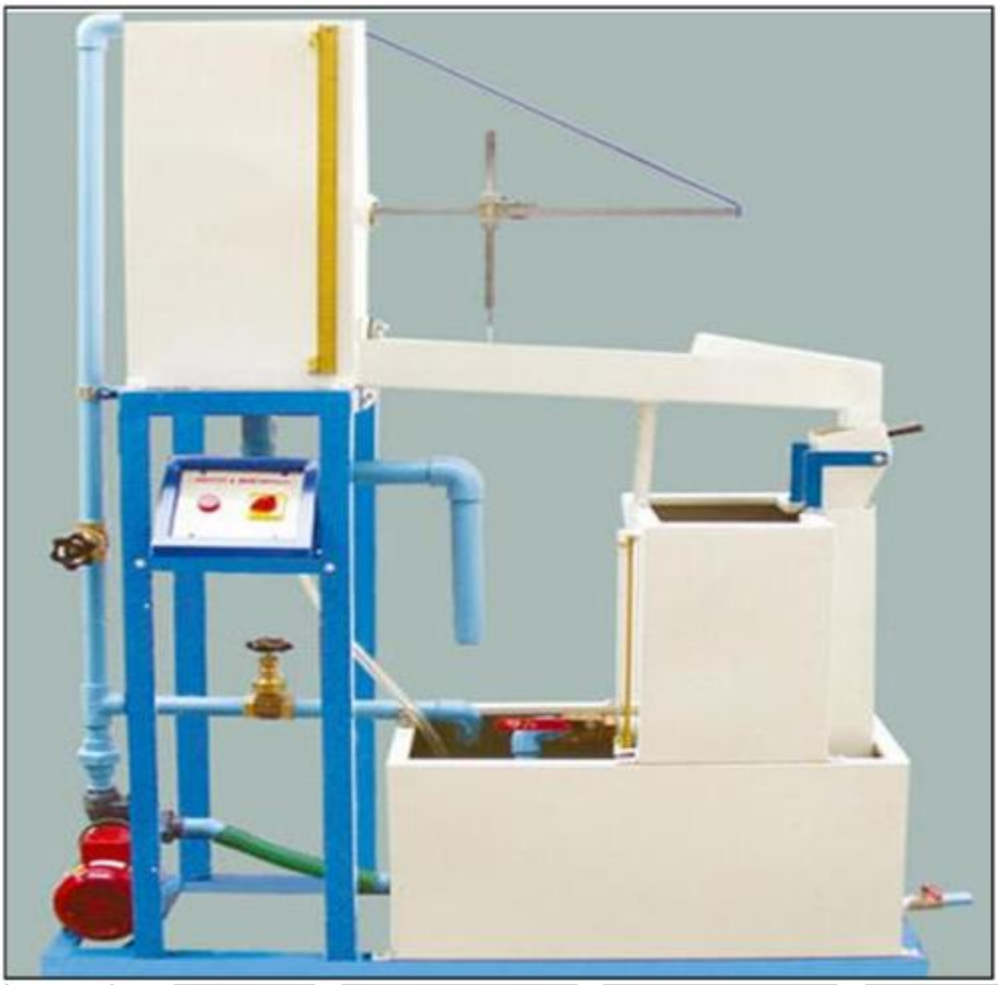


Figure 5.3 Experimental set up of measurement of discharge through a pipe provided with sharp edge circular orifice

VIII. Required Resources /Apparatus/Equipment with specification

Sr.No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Sharp edged circular orifice test rig along with necessary pipe fittings and accessories	Centrifugal pump with motor of suitable specifications Supply tank: 80 Ltrs. made of Mild steel with FRP lining Sharp edged circular orifice of suitable specifications	1
2.	U-tube manometer	Connected to pipe and Orifice meter	1
3.	Measuring tank	40 Ltrs. made of Mild steel with FRP lining and fitted with piezometer tube and scale	1
4.	Stop watch	Electronic with least count of 0.01 sec	1
5.	Measuring scale	Range up to 60 cm	1

IX. Precautions to be Followed

1. Carefully keep some level of fluid in inlet and outlet supply tank.
2. Avoid improper handling of electrical connections of Centrifugal pump.
3. Handle the U tube Manometer tubes with due care.
4. Handle Stop watch carefully.

X. Procedure

1.Switch on the power supply to the pump.
2.Adjust the delivery flow control valve.
3.Note down manometer heads (h1, h2).
4 Note down time taken for collecting 5 cm rise of water in collecting tank (t).
5. Repeat it for different flow rates.
6. Switch off the pump after completely opening the delivery valve.

XI. Observations and calculations –

Sr. No.	Manometer Reading (cm)			Manometer Head (m)	Time taken for 5 cm rise of water level sec	Actual Discharge m^3/sec	Theoretical Discharge m^3/sec
	h_1	h_2	$h_m = h_2 - h_1$	h_m	T	Q_a	Q_t
1.							
2.							
3.							

Size of pipe: Inlet Dia. d_1 =____________ mm

Area of pipe = a_1= ____________mm^2

Orifice Dia. d_2 =____________ mm

Area of Orifice = a_2= ____________mm^2

The actual Discharge Qa = $\frac{W*B*h}{t}$ = =________________m^3/sec

Where : A - A of the measuring tank m^2

h=Height of water (5cm) in collecting tank (m),

t = Time taken for 5cm rise of water (sec)

The Theoretical discharge through orifice meter,

$Q_t = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{{a_1}^2 - {a_2}^2}}$ m3/sec

Where, H = Differential head of manometer in m of water

$= 12.6 \times h_m$ m

g= Acceleration due to gravity (9.81m/sec²)

Inlet Area of orifice meter in m², $= a_1 = \frac{\pi d_1^2}{4}$

Area of the throat or orifice in m² $= a_2 = \frac{\pi d_2^2}{4}$

Draw graph Qa Vs Qt

Scale

X-axis -

Y-axis -

XII. Results

1. Actual Discharge = Q_{act} = ____________________ m3/sec
2. Theoretical Discharge = $Q_{th} = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{{a_1}^2 - {a_2}^2}}$ = ________________ m3/sec
3. Coefficient of Discharge = $C_d = \frac{Q_{act}}{Q_{th}}$ = _______________

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. 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. State the application of orifice plate.
2. Enlist the different types/designs used in Orifice plate for flow measurement.
3. List the advantages of orifice plate for flow measurement.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://youtu.be/PhXhGf8-KWY
2. https://youtu.be/JXQxdQt3Zac?t=4
3. https://www.youtube.com/watch?v=YrBUN-8tmsY
4. https://www.youtube.com/watch?v=0lm5n70fxHg
5. https://www.youtube.com/watch?v=if421Ty1qcE
6. https://www.youtube.com/watch?v=4Ce5TOwmSV1
7. https://www.youtube.com/watch?v=ojTHroPw4TM

XVII. Rubrics for Assessment Scheme

	Performance Indicators	Weightage
	Process Related (15 Marks)	**(60%)**
1.	Handling of the measuring Instruments	40 %
2.	Observations/Calculation of final readings	20 %
	Product Related (10 Marks)	**(40%)**
3.	Interpretation of result	20 %
4.	Conclusions	10 %
5.	Practical related questions	10 %
	Total (25 Marks)	**100 %**

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

Practical No. 06 Measurement of discharge through pipe using Orifice meter.

I. Practical Significance

Orifice meter is a device used for measuring the flow rate. It consists of a flat circular plate which has a sharp edged hole called orifice, which is concentric with the pipe.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the skills for the industry identified competency as "Select appropriate hydraulic equipment/process based on its application for measurement of flow rate.".

III. Course Level Learning Outcome (CO)

CO2- Apply Bernoulli's theorem to various flow measuring devices.

IV. Laboratory Learning Outcome(s)

LLO 6.1: Apply Bernoulli's theorem to Orifice meter.
LLO 6.2: Measure discharge through pipe using Orifice meter.

V. Relative Affective Domain related Outcome(s)-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation
- Demonstrate working as a leader/ team member.
- Maintain tools and equipment.
- Follow ethical Practices.
- Follow ethical Practices.

VI. Minimum Theoretical Background with diagram

1.Discharge: The volume of liquid flowing per unit time through a section of pipe or channel is known as discharge or flow rate.

2.Orifice meter. It is used to calculate the velocity of fluids flowing through a pipeline

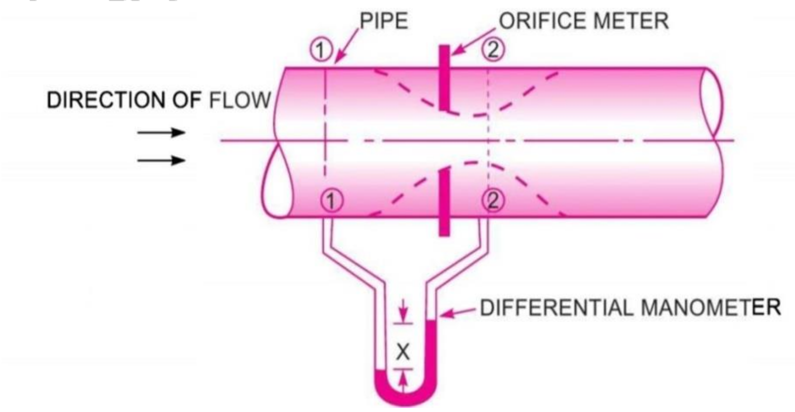


Figure 6.1 Orifice Meter

VII. Experimental setup (Model)-

Figure 6.2 Experimental Set up for Orificemeter.

VIII. Required Resources /Apparatus/Equipment with specification

Sr.No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Orificemeter Test Rig	Centrifugal pump with motor: Variable speed, 2800 RPM Supply tank: 80 Ltrs. made of Mild steel with FRP lining. Orifice meter of suitable specifications	1
2.	U-tube manometer	Connected to pipe and vena contracta of Orificemeter	1
3.	Measuring tank	40 Ltrs. made of Mild steel with FRP lining and fitted with piezometer tube and scale	1
4.	Stop watch	Electronic with least count of 0.01 sec	1
5.	Measuring scale	Range up to 60 cm	1

IX. Precautions to be Followed

1. Carefully keep some level of fluid in inlet and outlet supply tank.
2. Avoid improper handling of electrical connections of Centrifugal pump.
3. Please ensure Priming is required for centrifugal pump or not.
4. Handle the U- tube Manometer tubes with due care.
5. Handle Stop watch carefully.

X. Procedure

1. Open the delivery valve of centrifugal pump, to avoid development of sudden pressure.
2. Carry out priming of pump if necessary.
3. Start the pump which allows water to flow through system.
4. Adjust the discharge by control valve.

XI. Observations and calculations –

Sr. No.	Rise of water level of Measuring Tank 'H'		Deflection of mercury column of the manometer			Converted water columns height	Time to collect the water in measuring tank (t)
			H_{throat}	H_{pipe}	$H_{hg}=\frac{(H_t-H_p)}{100}$	h= H_{hg} (13.6-1)	
	cm	m	cm	m	m	m	sec
1.							
2.							
3.							
4.							
5.							
6.							

Discharge Measurement reading, -

Measuring tank Dimension = Width **W**=_________m, Breadth **B**=___________m

Height of water observed in auxiliary tube **H_1**= _________m

Time for collecting water in tank t=__________sec

Calculation of Actual Discharge

Volume of Water collected in the tank, **-V=WxBxH_1 =**________________________________

V=____________m^3

Time (t)= __________sec

Diameter of Orificemeter at inlet, d_1= mm= m

Cross section area $a_1=\frac{\pi {d_1}^2}{4}$= = m^2

Diameter of Orificemeter, d_2= mm= m

Cross section area $a_2=\frac{\pi {d_2}^2}{4}$= = m^2

Actual Discharge= $Q_{act}=\frac{Volume\ of\ Water\ collected}{Time}=\frac{V}{t}$ = ______________m^3/sec

Theoretical Discharge $=Q_{th} = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}} =$

Q_{th}=____________________________ m^3/sec

XII. Results

1. Actual Discharge = Q_{act} = ___________________
2. Theoretical Discharge $=Q_{th} = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}} =$________________
3. Coefficient of Discharge = $C_d = \frac{Q_{act}}{Q_{th}} =$

XIII. Interpretation of Result

XIV. Conclusions and Recommendation

XV. 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. Compare between Venturimeter and Orificemeter.
2. Explain the process for conversion of pressure head of Hg column into liquid.
3. Explain the industrial applications of Orificemeter.
4. Calculate rate of flow of oil in lit/sec if an orifice of 50 mm diameter is inserted in a pipe of 120 mm diameter and has a coefficient of discharge 0.65. The oil of specific gravity 0.8 is flowing through pipe. A differential U-tube mercury manometer used to measure pressure difference on both sides of orifice gives reading of 70 mm of mercury.

[Space for Answer]

XVI . References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=hGLj4FEPmH0

XVII. Rubrics for Assessment Scheme

	Performance Indicators	Weightage
	Process Related (15 Marks)	**(60%)**
1.	Handling of the measuring Instruments	40%
2.	Calculation of final readings	20%
	Product Related (10 Marks)	**(40%)**
3.	Interpretation of result	20%
4.	Conclusions	10%
5.	Practical related questions	10%
	Total (25 Marks)	**100 %**

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

Practical No. 07 Interpretation of the type of flow using Reynolds apparatus

I. Practical Significance

Conduit design requires deciding on the kind of flow. There are various kinds of flows, including turbulent, laminar, uniform, non-uniform, and stable. Through observation and computation, we will be able to distinguish between laminar and turbulent flow in this experiment.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop skills for the industry identified competency as “Select appropriate hydraulic machine and process to interpret the type of flow.”

III. Course Level Learning Outcome (CO)

CO2- Apply Bernoulli’s theorem to various flow measuring devices.

IV. Laboratory Learning Outcome(s)

LLO 7.1: Calculate Reynolds number at given flow rate of water.

LLO 7.2: Interpret the type of flow based on calculated Reynolds number.

V. Relative Affective Domain related Outcome(s)-

b. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/ team member.
d. Maintain tools and equipment.
e. Follow ethical Practices.

VI. Minimum Theoretical Background with diagram

1. In fluid dynamics, laminar flow is a flow in which fluid particles do not cross each other’s path. It occurs when a fluid flows in parallel layers, with no disruption between the layers. At low velocities, the fluid tends to flow without lateral mixing and adjacent layers’ slide past one another like playing cards.
2. Turbulent flow is the type of fluid flow in which the fluid particles move in a zigzag manner. In turbulent flow the speed of the fluid at a point is continuously undergoing changes in both magnitude and direction.
3. Reynold’s number is a dimensionless number (no units) used in fluid mechanics to indicate whether fluid flow is laminar or turbulent.
4. Reynold’s number values is different for open channel and pipe flow.
5. $Re = \rho v D/\mu$ where ρ = mass density, v = velocity of flow, D= diameter the pipe, μ = coefficient of friction.

VII. Experimental setup (Model)-

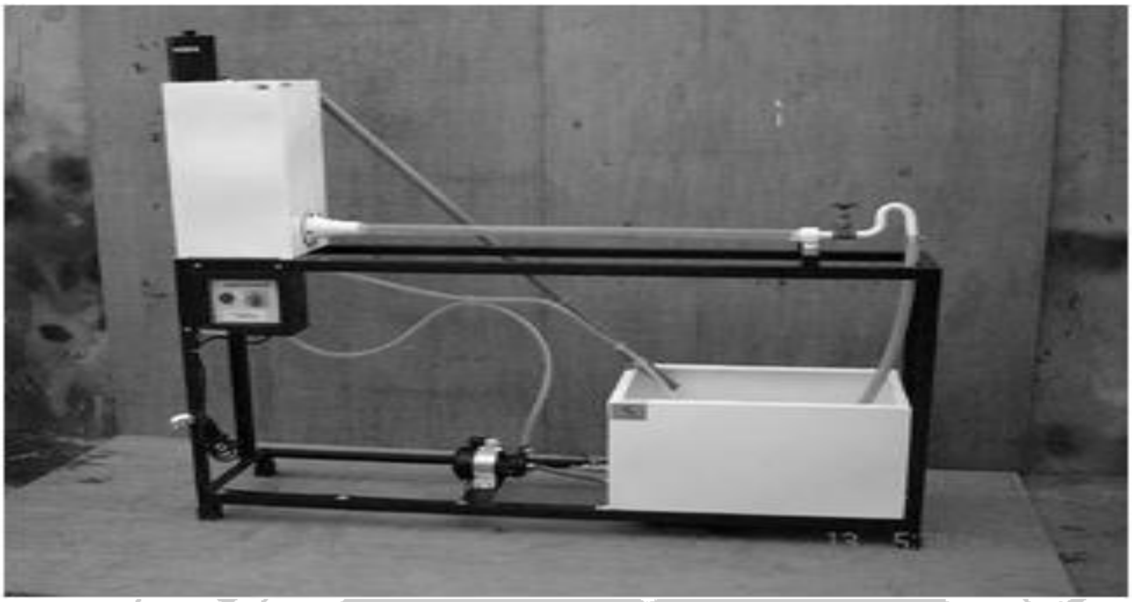


Fig.7.1 Experimental set up for Reynolds apparatus

VIII. Required Resources /Apparatus/Equipment with specification.

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Reynolds apparatus Test rig with necessary pipe fittings and accessories	Tube Clear acrylic 800 mm Length, 32mm Outer Dia. and 25mm Inner Dia. Dye Vessel: Material Stainless Steel, 1 liter capacity Constant Head Tank: 300mm x 300mm x 450mm Measuring Tank: 300mm x 300mm x 300mm Supply Tank: 600mm x 300mm x 300mm Valves (Gunn Metal): 2 Nos. for Drain, 1 No. for Water Control, 1 No. for Bye pass	1
2.	Stop watch	Electronic with least count of 0.01 sec	1
3.	Pump	Single phase, 0.5 HP	1

IX.Precautions to be Followed

1. Use the apparatus carefully.
2. Observe the readings with precision.

X.Procedure

1. Note the diameter of the pipe.
2. Fill the tank with water by keeping outlet of glass tube partly opened so that no air is entrapped in the glass tube.
3. When the tank is full, close the outlet valve of glass tube and inlet valve of the tank. Allow the water in the tank to come to the state of rest.
4. Maintain constant level of water by opening both inlet valve.
5. Allow the dye from the dye ejector in to the flow.
6. Allow a certain volume of water to be collected in the measuring tank, note time of collection of water and compute the discharge.
7. Gradually increase the velocity of flow and measure the discharge.
8. Repeat the readings till dye get dispersed in the flow of water.
9. Repeat the experiment with the varying the rate of flow Explain working principle of electric generator.

XI.Observations and calculations –

1. Inner diameter of the glass tube, D=_________________m
2. C/S area of the glass tube = A = $\frac{\pi D^2}{4}$
3. Mass density of water ρ_w=1000kg/m^{3} =
4. Dynamic viscosity of water= μ= _________________Ns/m^2
5. Area of tank= L*B = _______________m^2
6. Name of the dye used = ______________

Sr.No.	Volume, m^3	Time (T) sec	Discharge Q=$\frac{\text{Volume}}{\text{Time}}$	Velocity V= $\frac{Q}{A}$	R_e= $\rho vD/\mu$	Type of flow in pipe
1.						
2.						
3.						

1.Discharge, Q= Volume / Time

2.Velocity, V= Q/A

3.Re= ρvD/μ

XII.Results

Reynolds number, Re and type of flow,

1.
2.
3.

XIII.Interpretation of Results

XIV. Conclusions and Recommendation

XV. 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. State two practical examples for laminar and turbulent flow.
2. Name two dyes used in Reynold's experiment.
3. State the values of Reynold's number for laminar, turbulent and transition flow through pipes and channels.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=upHHx42r4E0

XVII. Rubrics for Assessment Scheme

	Performance Indicators	**Weightage**
	Process Related (15 Marks)	**(60%)**
1.	Handling of the measuring Instruments	40%
2.	Calculation of final readings	20%
	Product Related (10 Marks)	**(40%)**
3.	Interpretation of result	20%
4.	Conclusions	10%
5.	Practical related questions	10%
	Total (25 Marks)	**100 %**

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

Practical No. 08 Calculation of Darcy's friction factor 'f' in pipes of different diameters for different discharges.

I. Practical Significance

Fluid encounters resistance when traveling through a pipe, which causes part of the fluid's energy to be lost. The amount of power needed by the pump to force the fluid down the pipe is determined by the magnitude of frictional losses. Frictional head loss is dependent on the type of surface in contact, pipe length, flow velocity, and pipe diameter.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the skills for the industry identified competency as "Select the appropriate tool/process to measure the frictional losses and friction factor for different discharges of pipes of different materials having different diameters."

III. Course Level Learning Outcome (CO)

CO3 - Calculate the various losses in flow through pipes.

IV. Laboratory Learning Outcome(s)

- LLO 8.1: Calculate Darcy's friction factor 'f' in pipe of different diameters.
- LLO 8.2: Interpret effect of material and diameter of pipe, flow rate of water on Darcy's friction factor 'f'.

V. Relative Affective Domain related Outcome(s)-

- Follow safety practices.
- Practice good housekeeping
- Practice energy conservation.
- Demonstrate working as a leader / team member.

VI. Minimum Theoretical Background with diagram

1. **Frictional Resistance**: The fluid flowing in a pipe is subjected the resistance due to

(a)Shear forces between fluid particles & boundary walls of the pipe.

(b)Shear forces among the fluid particles resulting from viscosity of fluid. The frictional resistance causes loss of head (loss of energy).

2. **Head loss due to friction**: It is the difference of pressure head between two distinct points.

3. **Magnitude of head loss**: - Magnitude of frictional losses is used to determine the power requirement of pumps forcing the fluid through the pipe. The Darcy Weisbach has formulated following equation for the magnitude of head loss:

$$h_f = \frac{4flv^2}{2gd}$$

Where, h_f =Head loss due to friction in meters /of liquid column

f= Friction factor (Coefficient of friction)

1= Length of pipe in meters.

v= Velocity of liquid flowing through pipe in m/sec.

d= Diameters of pipe in meters.

g=Acceleration due to gravity in m/s^2.

VII. Experimental setup

Fig.8.1 Experimental setup for calculation of Darcy's friction factor 'f'

VIII. Required Resources /Apparatus/Equipment with specification

Sr.No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Flow through pipe Test rig with necessary pipe fittings and accessories	• Pipes: 03 nos. Made of GI ½'', 1'', 1.5'' diameter or equivalent diameters and length 1m, 1.5m, 2m or equivalent length • Pump: 1HP Centrifugal pump • Supply tank: 80 Ltrs. made of Mild steel with FRP lining • U-tube manometer: Connected to pipe at required locations using plastic tubing	1

		Gate valves to regulate the flow of water	
2.	Measuring tank	40 Ltrs. made of Mild steel with FRP lining and fitted with piezometer tube and scale	1
3.	Stop watch	Electronic with least count of 0.01 sec	1
4.	Measuring scale	Range up to 60 cm	1

IX. Precautions to be Followed

1. Carefully keep some level of fluid in inlet and outlet supply tank.
2. Avoid improper handling of electrical connections of Centrifugal pump.
3. Please ensure Priming is required for centrifugal pump or not.
4. Handle the pipe fitting with due care.
5. Handle Stop watch carefully.
6. Handle U tube manometer carefully.
7. Operate various valve slowly.

X. Procedure

1. Open the valve of centrifugal pump.
2. Open the inlet & outlet valves of first Pipe and close valves of the others.
3. Start the pump and observe flow of water through Pipe.
4. Open tapping of manometer connected to this pipe.
5. Measure the rise in level of water in measuring tank for 10 sec.
6. Measure pressure difference by Manometer.
7. Repeat the procedure for 3-4 discharge condition by operating valve of outlet pipe near centrifugal pump.
8. Repeat the step 1 to 7 for remaining pipes.

XI. Observation Tables-

i. Material of pipe: -______________________
ii. Measuring tank Dimension
iii. Width W = _____________m, Breadth B =___________ m
iv. Area of Measuring tank- WxB= ______________m^2
v. Distance between tapping =______________m
vi. Specific gravity of fluid in pipe = s1 = 1 (for water).
vii. Specific gravity of fluid in manometer = s2= 13.6 (for mercury).

Sr. No	Diameter of pipe	Manometer Reading			h_f=X x$\frac{(s_2-s_1)}{s_1}$	Rise in height of water in measuring tank H	Time to collect the water in measuring tank (t)	Discharge(Q) = $\frac{WxBxH}{t}$	Velocity (v)=Q/A	Darcy's friction factor $f=\frac{h_f\times 2gd}{4lv^2}$
		X_1	X_2	X=X_2 -X_1						
	m	m	m	m	m of water	m	sec	m^3/sec	m/sec	
1.										
2.										
3.										
1.										
2.										
3.										
1.										
2.										
3.										

Calculation:

1.Actual loss of head due to friction (h_f) in meters of water column

h_f=X x$\frac{(s_2-s_1)}{s_1}$ = --------------- m of water

Where x= manometer reading in meter

s_1 = Specific gravity of water

s_2 = Specific gravity of mercury

1.Actual Discharge = Q =$\frac{Volume\ of\ Water\ collected}{Time}$

Q=$\frac{W \times B \times H}{t}$ = ________ = ________m³/sec

2.Velocity of flow = v=$\frac{4Q}{\pi d^2}$ = ________ = ____________m/sec

Now, $h_f = \frac{4flv^2}{2gd}$

Friction factor = $f=\frac{h_f\times 2gd}{4lv^2}=\frac{h_f\times 2gd}{4lv^2}$

= ________

= m

XII. Results

For given value pipe diameter d_1, d_2, d_3. The average value of Darcy's friction factor are found to be

f_1= ____________________, f_2= _____________________, f_3= ___________________

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. 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. Explain the effects of friction loss if Viscosity of fluid flowing through the pipe is more.
2. State the effect of temperature of liquid on friction losses.
3. Explain the effects of friction losses of horizontal and vertical position of pipes.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=YrBUN-8tmsY
2. https://www.youtube.com/watch?v=0lm5n7OfxHg
3. https://www.youtube.com/watch?v=if421Ty1qcE
4. https://www.youtube.com/watch?v=oiTHroPw4TM

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1.	Handling of the measuring Instruments	40%
2.	Calculation of final readings	20%
Product Related (10 Marks)		**(40%)**
3.	Interpretation of result	20%
4.	Conclusions	10%
5.	Practical related questions	10%
	Total (25 marks)	**100 %**

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

Practical No.9 Determination of minor frictional Losses in Sudden Expansion and Sudden Contraction in a Pipe

I. Practical Significance

Minor losses are head losses brought on by numerous pipe fittings, including bends, elbows, joints, valves, and abrupt changes in pipe diameter. Because of their design, these fittings in a pipeline result in localized energy losses (pressure head), which are categorized as minor losses.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the following skills for the industry identified competency as "Select appropriate hydraulic machinery/ process to determine minor frictional losses in the fluid flow system".

III. Course Level Learning Outcome (CO)

CO3–Calculate the various losses in flow through pipes.

IV. Laboratory Learning Outcome(s)

LLO 9.1: Calculate minor frictional losses due to sudden expansion in a pipe.
LLO 9.2: Calculate minor frictional losses due to sudden contraction in a pipe.

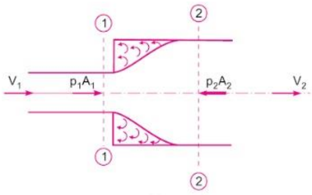
V. Relative Affective Domain related Outcome(s)-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.

VI. Minimum Theoretical Background with diagram

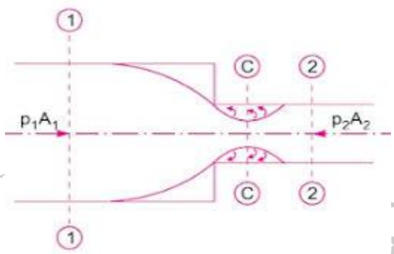
1. Minor losses: These are the losses of head due to large number of pipe fitting such as bends, elbows, joints, valves, sudden expansion and contraction in pipe diameter. In pipe fitting these losses are also occurred at entry & exit of pipe. These causes localized energy losses due to their shape and are classified as minor losses. Minor losses are usually neglected, as they are insignificant if they are less than 5% of the frictional losses.
2. Loss of head due to sudden expansion: This is energy loss due to sudden enlargement. Sudden enlargement in diameter of pipe results in formation of eddies by the flowing fluid at the corners of enlarged pipe. Because of eddies formation, loss of head takes place. Mathematically it is written as this results in loss of head which is equal to:

$$H_e = \frac{(V_1 - V_2)^2}{2g}$$



3. Loss of head due to sudden contraction: This is energy loss due to sudden contraction. It does not take place due to sudden contraction but due to sudden enlargement which takes place just after vena contracta. Mathematically it is written as:

$$H_c = \frac{0.5\, V_4^2}{2g}$$



VII. Experimental setup

Figure 9.1- Experimental Set Up

VIII. Required Resources /Apparatus/Equipment with specification

Sr.No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Experimental Set up for minor frictional losses	A Centrifugal pump of 25mm x 25mm with 1/2 HP Motor M.S. Sump Tank 80 Ltr. to collect the water. M.S. Measuring Tank 30 Ltr fitted with piezometer tube to measure the discharge. G.I. pipe of internal dia 25mm and	1

		Gunmetal ISI mark Control Valve and regulating valves are used to circulate water. Bye-pass line is also used to regulate the discharge. Large bend made up of G.I. Sudden enlargement from 25mm dia to 32mm dia. Sudden contraction from 32mm dia to 25mm. Gunmetal gate valve of 25mm dia. A U tube manometer is connected to pet cock through plastic tubing to measure head difference. The tanks are well	
2.	Stopwatch	Timing capacity:23hrs, 59mins and 59.99secs, Accuracy: ±3 seconds/day	1
3.	Measuring Scale/steel rule	Range upto 60 cms	1

IX. Precautions to be Followed

1. Handle the pipe fitting like elbow, bend etc. with due care.
2. Observe that bubbles are not present in the plastic tube connected to manometer.
3. Open the delivery valve of centrifugal pump, to avoid development of sudden pressure.
4. Avoid improper handling of electrical connections of Centrifugal pump.
5. Please ensure priming is required for centrifugal pump or not.
6. Handle Stop watch carefully.

X. Procedure

a. Open the delivery valve of centrifugal pump.
b. Carry out priming of pump if necessary.
c. Adjust inlet & outlet valve such that 'sudden enlargement arrangement' of pipe is only connected.
d. Connect point 1 and 2 on the given pipe circuit to the manometers limbs.
e. Start the pump which allows water to flow through Storage tank.
f. Adjust the discharge by control valve stop valve and ensure steady flow in system.
g. Note the difference of levels of the mercury columns.
h. Collect water in a measuring tank to measure the actual discharge for 5 cm water rise (or suitable for set up).
i. Use stop watch to measure time 'T'.
j. Drain the water collected in the measuring tank after each observation.
k. Adjust inlet & outlet valve such that 'sudden contraction arrangement' of pipe is only connected.
l. Repeat the step **d** to **j** for when 'sudden contraction arrangement' is connected in system.

XI. Observations and calculations

1. Measuring tank Dimension Width w = ……..m, Breadth, B= ……….m
2. Time interval for 5 cm water rise in measuring tank , t=………………sec
3. For Sudden enlargement:
   Diameter of pipe at entry, d_1 =………..m
   Diameter of pipe at enlargement d_2 = ……....m
4. For Sudden Contraction:
   Diameter of pipe at entry, d_3 =…………m
   Diameter of pipe at contraction, d_4 =…………...m

Sr.No.	**Nature of pipe fitting**	**Inlet & Exit diameter of pipe**		**Manometer Reading**		**Pressure Difference**	**Actual head lost in meters of water column height**	**Time interval for 5 cm water rise in measuring tank**
				H_1	**H_2**	**$H_{hg}=\frac{(H2-H1)}{100}$ m of hg**	**$H=H_{hg}(13.6-1)$**	
		m	m	cm	cm	m	m	sec
1.	Sudden Enlargement	Inlet	Exit					
2.	Sudden Contraction							

Calculations:

Actual Discharge,

$$Q_{act} = \frac{Area\ of\ measuring\ tank\ x\ Rise\ in\ water\ level}{Time\ required\ for\ rise}\ m^3/sec$$

= …………………………….....

= …………………………….

1. Loss of head due to sudden enlargement

   Velocity of water at Entry $V_1 = \frac{Q}{A_1} = \frac{Q}{\pi/4 \text{ x } d1^2}$

   = …………..

   =………….... m/sec

   Velocity of water at Outlet $V_2 = \frac{Q}{A_2} = \frac{Q}{\pi/4 \text{ x } d2^2}$

   = …………..

   =………….... m/sec

   Theoretical loss of head due to sudden enlargement H_e

   $H_e = \frac{(V_1 - V_2)^2}{2g}$ = …………….m of water

2. Loss of head due to sudden contraction

Velocity of water at Entry $V_3 = \frac{Q}{A_3} = \frac{Q}{\pi/4 \text{ x } d3^2}$

= …………..

=………….. m/sec

Velocity of water at Outlet $V_4 = \frac{Q}{A_4} = \frac{Q}{\pi/4 \text{ x } d4^2}$

= …………..

=………….. m/sec

Theoretical loss of head due to sudden contraction H_c

$H_c = \frac{0.5\, {V_4}^2}{2g}$

=…………….m of water

XII. Results

Case I For sudden enlargement

Actual Loss of head=………… m of water

Theoretical Loss of head=……….. m of water

Case II- For sudden Contraction

Actual Loss of head=…………..m of water

Theoretical Loss of head = …………..m of water

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. 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. Compare pipes in series & pipes in parallel (any two).
2. Explain the different methods to minimize water hammer.
3. Find loss of head due to expansion if diameter of pipe is 25 cm is suddenly enlarged to a diameter of 50 cm and pipe carries 350 lit/sec.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=6DFe8eUrbcl
2. https://www.youtube.com/watch?v=WMtiH5LyOY
3. https://www.youtube.com/watch?v=6jClbqlGetY
4. https://www.youtube.com/watch?v=IcJOkRZPNMI

XVII. Rubrics for Assessment Scheme

	Performance Indicators	Weightage
	Process Related (15 Marks)	**(60%)**
1.	Handling of the Instruments	40%
2.	Calculation of final readings	20%
	Product Related (10 Marks)	**(40%)**
3.	Interpretation of result	20%
4.	Conclusions	10%
5.	Practical related questions	10%
	Total (25 Marks)	**100 %**

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

Practical No. 10 Determination of minor frictional Losses in elbow and bend in a pipe

I. Practical Significance

Minor losses are the losses of head due to large number of pipe fittings such as bends, elbows, joints, valves, sudden expansion and contraction in pipe diameter. In a pipeline these fittings cause localized energy losses (pressure head) due to their shape and these losses are classified as minor losses.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the following skills for the industry identified competency as "Select appropriate hydraulic machinery/ process to determine minor frictional losses in the fluid flow system".

III. Course Level Learning Outcome (CO)

CO3–Calculate the various losses in flow through pipes.

IV. Laboratory Learning Outcome(s)

LLO 10.1: Calculate minor frictional losses due to bend provided in a pipe.
LLO 10.2: Calculate minor frictional losses due to elbow provided in a pipe.

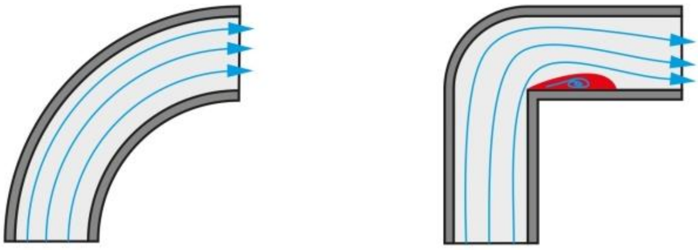
V. Relative Affective Domain related Outcome(s)-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.

VI. Minimum Theoretical Background with diagram

Minor losses: These are the losses of head due to large number of pipe fitting such as bends, elbows, joints, valves, sudden expansion and contraction in pipe diameter. In pipe fitting these losses are also occurred at entry & exit of pipe. These causes localized energy losses due to their shape and are classified as minor losses. Minor losses are usually neglected, as they are insignificant if they are less than 5% of the frictional losses.

Loss of head due to bend or elbow in pipe: This is energy loss due to bend or elbow. When bend or elbow is provided in the pipe, there is change in the direction of velocity of liquid. Due to this liquid separates from wall of bend and formation of eddies takes place.



Mathematically it is written as

$$H = \frac{kV^2}{2g}$$

Where, k Coefficient of bend or elbow.

VII. Experimental setup

Figure 10.1- Experimental Set Up

VIII. Required Resources /Apparatus/Equipment with specification

Sr.No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Experimental Set up for minor frictional losses	A Centrifugal pump of 25mm x 25mm with 1/2 HP Motor M.S. Sump Tank 80 Ltr. to collect the water. M.S. Measuring Tank 30 Ltr fitted with piezometer tube to measure the discharge. G.I. pipe of internal dia 25mm and Gunmetal ISI mark Control Valve and regulating valves are used to circulate water. Bye-pass line is also used to regulate the discharge. Large bend made up of G.I. Sudden enlargement from 25mm dia to 32mm dia. Sudden contraction from 32mm dia to	1

		25mm. Gunmetal gate valve of 25mm dia. A U tube manometer is connected to pet cock through plastic tubing to measure head difference. The tanks are well	
2.	Stopwatch	Timing capacity:23hrs, 59mins and 59.99secs, Accuracy: ±3 seconds/day	1
3.	Measuring Scale/steel rule	Range upto 60 cms	1

IX. Precautions to be Followed

1. Handle the pipe fitting like elbow, bend etc. with due care.
2.Observe that bubbles are not present in the plastic tube connected to manometer.
3.Open the delivery valve of centrifugal pump, to avoid development of sudden pressure.
4. Avoid improper handling of electrical connections of Centrifugal pump.
5. Please ensure priming is required for centrifugal pump or not.
6. Handle Stop watch carefully.

X. Procedure

a. Open the delivery valve of centrifugal pump.
b. Carry out priming of pump if necessary.
c. Adjust inlet & outlet valve such that 'elbow fitting' of pipe is only connected.
d. Connect point 1 and 2 on the given pipe circuit to the manometers limbs.
e. Start the pump which allows water to flow through Storage tank.
f. Adjust the discharge by control valve stop valve and ensure steady flow in system.
g. Note the difference of levels of the mercury columns.
h. Collect water in a measuring tank to measure the actual discharge for 5 cm water rise (or suitable for set up).
i. Use stop watch to measure time 'T'.

j. Drain the water collected in the measuring tank after each observation.
k. Adjust inlet & outlet valve such that 'bend fitting' of pipe is only connected.
1. Repeat the step **d** to **j** for when 'elbow fitting' is connected in system.

XI. Observations and calculations

1. Measuring tank Dimension Width w = ……...m, Breadth, B= ……….m
2. Time interval for 5 cm water rise in measuring tank , t=………………sec
3. Angle of bend 90^0, diameter of pipe, d_5 =…………..m
4. Diameter of pipe at elbow, d_6 =……………m

Sr. No.	Nature of pipe fitting	Inlet & Exit diameter of pipe		Manometer Reading		Pressure Difference	Actual head lost in meters of water column height	Time interval for 5 cm water rise in measuring tank
				H_1	H_2	$H_{hg}=\frac{(H2-H1)}{100}$ m of hg	$H=H_{hg}(13.6-1)$	
		m	m	cm	cm	m	m	sec
		Inlet	Exit					
1.	Elbow							
2.	Bend							

Calculations:

Actual Discharge,

$Q_{act} = \frac{Area\ of\ measuring\ tank\ x\ Rise\ in\ water\ level}{Time\ required\ for\ rise}$ m^3/sec

= ………………………………....

= …………………………….

1.Elbow

Actual loss of head due to Elbow Hel_{act}=………m of water (From observation table)

Theoretical loss of head due to Elbow= $Hel_{act} = \frac{k_{el}V_6^2}{2g}$

Velocity of water flowing through Elbow = $V_6=\frac{Q}{A_6} = \frac{Q}{\pi/4 \text{ x } d6^2}$

= …………..

=………….... m/sec

Equating Actual loss of head = Theoretical loss of head

$Hel_{act} = \frac{k_{el}V_6^2}{2g}$

Constant for Elbow $k_{el} = \frac{\text{Hbact x 2g}}{V_6^2}$

2. Bend

Actual loss of head due to Bend Hb_{act}=…………m of water (From observation table)

Theoretical loss of head due to Bend = $H_b = \frac{kV_5^2}{2g}$

Velocity of water flowing through bend = $V_5=\frac{Q}{A_5} = \frac{Q}{\pi/4 \text{ x } d5^2}$

= …………..

=………….. m/sec

Equating Actual loss of head = Theoretical loss of head

$$Hb_{act} = \frac{kV_5^2}{2g}$$

Constant for bend $k = \frac{\text{Hbact x 2g}}{V_5^2}$

XII. Results

Case I :-Constant for Elbow k_{el}= …………

Case II :-Constant for Bend k =………..

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. 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. Draw the flow pattern of Hydraulic gradient line (HGL) & Total energy line(TEL) for two cases of flow in a sudden contraction in the pipe line & flow in a sudden expansion of pipe line.
2. Explain the concept of compound pipe. State its use.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=6DFe8eUrbcl
2. https://www.youtube.com/watch?v=WMtiH5LyOY
3. https://www.youtube.com/watch?v=6jClbqlGetY
4. https://www.youtube.com/watch?v=IcJOkRZPNMI

XVII. Rubrics for Assessment Scheme

	Performance Indicators	Weightage
	Process Related (15 Marks)	**(20%)**
1.	Handling of the Instruments	10%
2.	Calculation of final readings	10%
	Product Related (10 Marks)	**(80%)**
3.	Interpretation of result	40%
4.	Conclusions	20%
5.	Practical related questions	20%
	Total (25 Marks)	**100 %**

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

Practical No. 11 Determination of the Force Exerted and Work done by a Jet on Flat Plate

I. Practical Significance

Analysis & design of hydraulic machines (turbine and pumps) is essentially based on forces exerted by moving fluids. When a jet of water flowing with a steady velocity strikes a solid surface, the water is deflected to flow along the surface. In this practical, we measure the force generated by a jet of water striking a flat plate, and compare the results with the computed momentum flow rate in the jet. This practical investigates the reaction force produced by the impact of a jet of water on to various target vanes so that work done by impact of jet can be calculated.

.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the skills for the industry identified competency as "Select the appropriate hydraulic machine/process to determine the force exerted and work done by a jet on flat plate & verify the momentum equation experimentally."

a. Measure the discharge of jet of water.
b. Measure the Velocity of jet of water.
c. Calculate area of nozzle.
d. Calculate force of jet of water.
e. Determine work done by jet of water.

III. Course Level Learning Outcome (CO)

CO4 - Select suitable hydraulic turbine and pump for the given application.
CO5 - Evaluate the performance of hydraulic turbines and pumps.

IV. Laboratory Learning Outcome(s)

LLO 11.1: Calculate the force exerted by a jet on flat plate.
LLO 11.2: Calculate the work done exerted by a jet on flat plate.

V. Relative Affective Domain related Outcome(s)-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member
- Maintain tools and equipment.
- Follow ethical Practices.

VI. Minimum Theoretical Background with diagram

Jet of water: - A jet is a stream of fluid that is projected into a surrounding medium, usually from some kind of a nozzle, aperture or orifice etc. Jets can travel long distances without dissipating. Jet fluid has higher momentum compared to the surrounding fluid medium.

Impact of Jet: - The force generated by a jet of water deflected by an impact surface is measured and compared to the momentum change of the jet. The jet of water from the nozzle impinges on the impact surface.

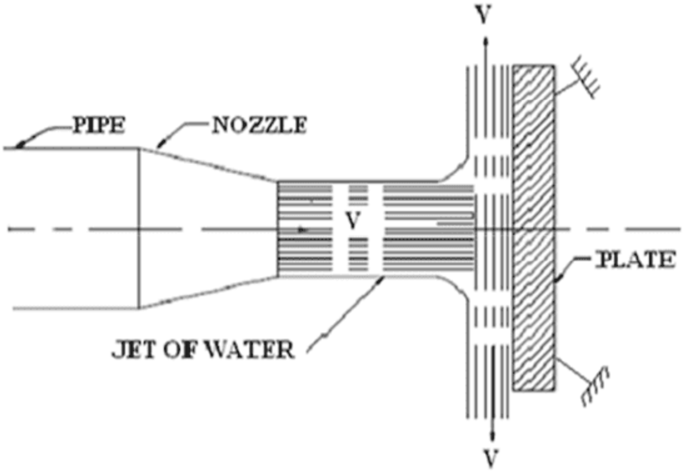


Figure 11.1- Impact of jet on a flat plate

The force exerted by jet on the flat plate in the direction of jet

F_x = Rate of change of momentum in the direction of force

$= \frac{\text{Initial Momentum} - \text{Final Momentum}}{\text{Time}}$

$= \frac{\text{Mass (Initial velocity} - \text{Final velocity)}}{\text{Time}}$

$= \frac{\text{Mass}}{\text{Time}} (Initialvelocity - Finalvelocity)$

$= \rho \; x \; a \; x \; V \; (V - 0)$

$F_x = \rho \; x \; a \; x \; V^2$

VII. Experimental setup

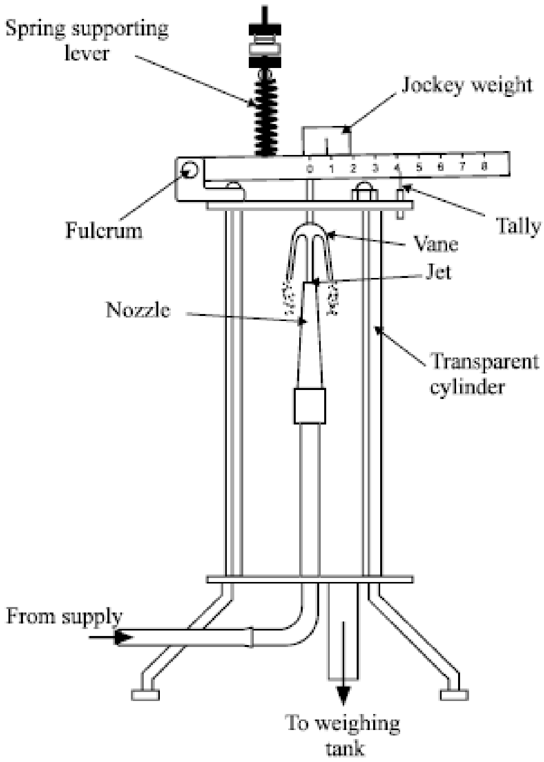


Figure 11.2- Experimental Set up

VIII. Required Resources /Apparatus/Equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Impact of Jet experimental set up	Plexi glass diameter cylindrical tank, 5 mm diameter Nozzle, 8 mm diameter Nozzle, Impact object of flat shape having 30 mm diameter, Nozzle distance impact object: -20mm, Set of stain steel weight	1
2.	Measuring Tank	40 Liters. Made of MS with FRP Lining and fitted with piezometer tube & scale	1
3.	Stop watch	Electronic with least count of 0.01 sec	1
4.	Measuring Scale/steel rule	Range up to 60 cms	1

IX. Precautions to be Followed

1. Avoid improper handling of electrical connections of Centrifugal pump.
2. Please ensure Priming is required for centrifugal pump or not.
3. Handle Stop watch carefully.

X. Procedure

1. Note down the relevant dimensions as area of collecting tank and diameter of nozzle.
2. When jet is not running, note down the position of upper disc or plate.
3. Admit water supply to the nozzle.

4. As the jet strikes the disc, the disc moves upward, now place the weights to bring back the upper disc to its original position.
5. At this position find out the discharge and note down the weights placed above the disc.
6. The procedure is repeated for different values of flow rate by reducing the water supply in steps.

For Discharge Measurement with Measuring Tank

1. Measure the dimension of measuring tank (i.e. Width, W_1& Breadth, B) in centimeters.
2. Collect the flow of water in the measuring tank.
3. Start the stop watch when you start to collect flow of water in the measuring tank
4. Collect the water in the tank up to pre-decided time (i.e. for 2 or 3 or 5 minutes).
5. Stop to collect the water after completion of pre-decided time.
6. Record height of water, "H" collected on the auxiliary glass tube fixed on the measuring tank.
7. Calculate volume of water collected (i.e W*B*H).
8. Calculate the discharge of water Q- Volume of Water/Time = cm^3/sec.

XI. Observations and calculations -

Measuring tank Dimension Width W = ……...m, Breadth, B= ……….m
Time considered for water rise in measuring tank , T=………………sec
Height of water observed in auxiliary tube H_1=………………..m
Diameter of Nozzle =……………..m
Volume of water collected in tank = W x B x H_1
V =…………..m^3

$$\text{Discharge (Q)} = \frac{\text{(Volume of water collected)}}{\text{(Time of water collection)}}$$

$$= \frac{V}{T} = \text{---------------}$$

= …………………………= m^3/sec

Sr. No.	Dis-charge Q	Balancing		Height of target above nozzle (h)	Jet Velocity V_o= Q/A	Final Velocity $V_1 = \sqrt{(V_o^2 - 2gh)}$	Theore-tical Force F_{th}= mV_1	Work done W= $F_{act} V_1$	Error
		Mass (m)	Experi-mental Force F_{act}=mg						
	m^3/sec	kg	N	mm	m/sec	m/sec	N	Nm/sec	%
1.									
2.									
3.									
4.									
5.									
6.									

XII. Results

Discharge = ------------m^3/sec.

Theoretical Force = ---------N & Error in balancing -----% (for 20mm Nozzle diameter)

Theoretical Force =--------- N & Error in balancing----- % (for 25mm Nozzle diameter)

Theoretical Force = ----------N & Error in balancing ------% (for 30mm Nozzle diameter)

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. 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. State the principle of Impulse momentum.
2. State the effect of change in diameter of nozzle jet (from 5mm to 8mm) on work done by impact of jet.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=tXLI-IeAynl
2. https://www.youtube.com/watch?v=dcyRHnrFMhU

XVII Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1.	Handling of the measuring Instruments	30%
2.	Calculation of final readings	30%
Product Related (10 Marks)		**(40%)**
3.	Interpretation of result	20%
4.	Conclusions	10%
5.	Practical related questions	10%
	Total (25 Marks)	**100 %**

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

Practical No. 12 Determination of overall efficiency of Pelton turbine using Pelton wheel test rig

I. Practical Significance

The Pelton wheel or Pelton Turbine is an impulse-type water turbine. The Pelton wheel extracts energy from the impulse of moving water, as opposed to water's dead weight like the traditional overshot water wheel. Many earlier variations of impulse turbines existed, but they were less efficient than Pelton's design. Water leaving those wheels typically still had high speed, carrying away much of the dynamic energy brought to the wheels.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the skills for the industry identified competency as "Select the appropriate process to evaluate performance of hydraulic machinery using knowledge of fluid mechanics."

1. Ability to operate the Pelton Wheel.
2. Ability to measure Pressure at inlet of pipe.
3. Measure speed of turbine with the help of tachometer.
4. Ability to measure input and output power.

III. Course Level Learning Outcome (CO)

CO4 - Select suitable hydraulic turbine and pump for the given application.
CO5 - Evaluate the performance of hydraulic turbines and pumps.

IV. Laboratory Learning Outcome(s)

LLO 12.1: Measure the power output of Pelton wheel at different flow rates.
LLO 12.2: Calculate overall efficiency of Pelton wheel.
LLO 12.3: Plot performance characteristics of Pelton wheel based on results.

V. Relative Affective Domain Related Outcome(s)-

1. Maintain pressure gauges and tachometer.
2. Follow safe practices.
3. Practice energy conservation.

VI. Minimum Theoretical Background with diagram

The Pelton wheel is an impulse turbine in which vanes, sometimes called buckets, of elliptical shape are attached to the periphery of a rotating wheel, as shown in Fig l2.1. One or two nozzles project a jet of water tangentially to the vane pitch circle. In the impulse turbines the available head is converted into the kinetic energy. The jets issuing from the nozzles strike vanes attached to the periphery of a rotating wheel. Because of the rate of change of angular momentum and the motion of the vanes, work is done on the runner (impeller) by the fluid and, thus, energy is transferred. Hydraulic efficiency is the ratio of power developed by the runner (Pelton wheel) to the net power supplied by the water at the entrance of the turbine.

VII. Experimental setup

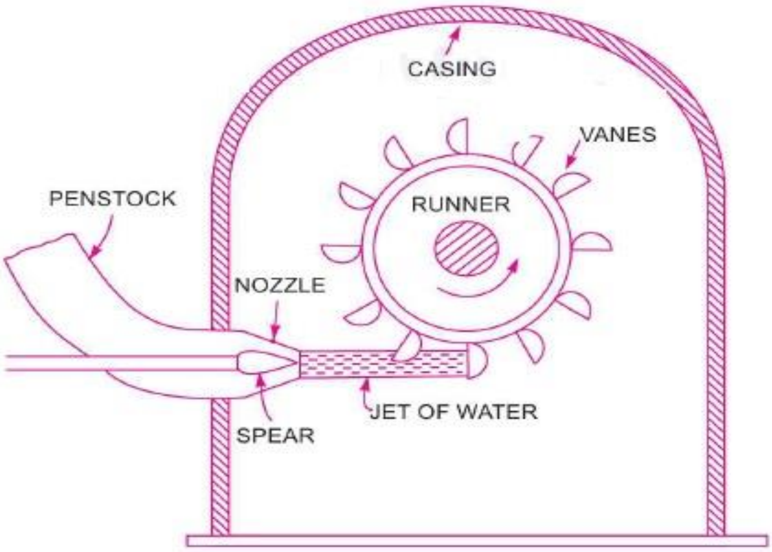


Figure 12.1- Pelton wheel turbine line diagram

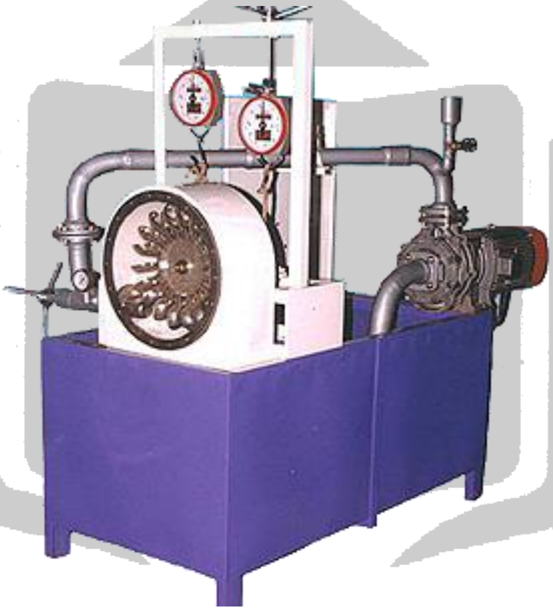


Figure 12.2- Pelton wheel turbine test rig

VIII. Required Resources /Apparatus/Equipment with specification

Sr.No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Pelton wheel test rig consists of, 1. Pelton Wheel 2. Centrifugal Pump. 3. Venturimeter.	Design Speed-750- 900 RPM. Output Power - 3.7 kW. (5.0 HP) design Head and discharge 45-50m and 700-900 lpm	1

	4. U-tube differential manometer. 5. Suitable arrangement of water supply and storage.		
2.	Tachometer	Range 0 to 3000rpm	1
3.	Pressure gauge		1

IX. Precautions to be Followed

1. Avoid parallax while taking the manometer readings.
2. Tachometer should be placed perfectly perpendicularly while taking the reading.

X. Procedure

1. Complete the priming of Centrifugal pump, if required and start the pump.
2. Open the regulating valve.
3. Observe flow of water through the nozzle.
4. Note the reading of pressure gauge.
5. Note the readings of manometer.
6. Adjust the spear for 1/4th gate opening.
7. Apply dead loads on the hanger of dynamometer
8. Note readings of spring balance.
9. Measure speed of turbine by Tachometer.
10. Change the position of regulating valve so as to increase the flow rate towards the buckets.
11. Repeat steps 3 to 8 for half, three quarter & full gate opening.
12. Stop the pump. Fully open the regulating valve.

XI. Observations and calculations –

Sr. No.	Gate Opening	Pressure gauge P	Pressure head H= p x 10	Manometer Reading			Load applied on turbine		Speed of turbine N
				Left limb h1	Right limb h2	Pressure head h = h1 –h2	Dead Weight W1	Spring Weight S2	
	Unit	Kg/cm^2	m of water	m	m	m	Kg	Kg	RPM
1.	1/4								
2.	1/4								
3.	1/4								
4.	1/4								
5.	1/2								

6.	1/2								
7.	1/2								
8.	1/2								
9.	3/4								
10.	3/4								
11.	3/4								
12.	3/4								
13.	Full								
14.	Full								
15.	Full								
16.	Full								

Calculations:

I. Discharge

1. Manometer left limb reading h1 = ………………..m
2. Manometer right limb reading h2= ……………….m
3. Difference of level, h = h1 – h2 =………………….m
4. Equivalent head of water, H1= 12.6 x h = …………….m
5. Area $a_1^2 = \pi/4 \times d_1^2$ = ………………….m^2
6. Area $a_2 = \pi/4 \times d_2^2$ = ………………….m^2
7. Discharge measured by Venturimeter Q

$$Q = \frac{C_d \times a_1 \times a_2 \times \sqrt{2gH}}{\sqrt{(a_1^2 - a_2^2)}} \quad m^3/sec$$

=…………………………

= …………………………

II. Head:

1. Pressure gauge reading, $P = \rho \times 9.81 \times 10^4$ N/m^2

= ………………

2. Specific weight of water w = 9810 N/m^3

Net pressure head on Pelton wheel, H=P/w = ……………….. m of water

III. Input to Pelton wheel P_i = W x Q x H /1000

= ………………..

= ………………..KW

IV. Output of Turbine:

1. Equivalent brake drum diameter D =………………m
2. Hanger dead weight, W_1= ………Kg = …….Kg x 9.81 = ………..N
3. Spring load, S_2 = ………Kg = …….Kg x 9.81 = ………..N
4. Resultant load on Pelton wheel, W = (W_1 - S_2) =…………….N

5. Torque (T) on Pelton wheel

= Resultant load x Effective brake drum radius

= W x d/2 = ………………….Nm

6. Specific speed of turbine, $N_s = N \times \sqrt{P/H^{5/4}}$

= …………………. Rpm

7. Output power from turbine, $P_o = \frac{2\pi NT}{60}$ Watts

= …………Watts

8. Efficiency of turbine = $\frac{Output\ power}{Input\ power} \times 100$

$= \frac{P_o}{P_i} \times 100$

XII. Results

The Results after calculations

Sr. No.	Discharge Q	Head H	Input Power P_i	Specific speed of turbine N_s	Resultant Load T	Output Power P_o	Efficiency
	m^3/sec	m	Kw	rpm	N	Kw	%
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. 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. Draw the layout of Hydroelectric Power Plant and mention nomenclature.
2. Enlist the 5 biggest hydroelectric power station in India with the power generation capacity.
3. Determine the following:
    1. Discharge of the turbine
    2. Diameter of the wheel
    3. Diameter of the nozzle

    If, a Pelton wheel working under a head of 500 m, produces 13000 kw at 430 rpm. and the efficiency of the wheel is 85 %.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://youtube/isK9uMs6qf0
2. https://youtu.be/byMXJqKC150

XVII. Rubrics for Assessment Scheme

	Performance Indicators	Weightage
	Process Related (15 Marks)	**(60%)**
1.	Handling of the measuring Instruments	30%
2.	Calculation of final readings	30%
	Product Related (10 Marks)	**(40%)**
3.	Interpretation of result	20%
4.	Conclusions	10%
5.	Practical related questions	10%
	Total (25 Marks)	**100 %**

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

Practical No. 13 Dismantling and Assembly of a Centrifugal Pump.

I. Practical Significance

Centrifugal pump uses rotational kinetic energy to deliver the fluid. The rotational energy typically comes from an engine or electric motor. The fluid enters the pump impeller along or near to the rotating axis, accelerates in the propeller and flung out to the periphery by centrifugal force.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the skills for the industry identified competency as "Select appropriate hydraulic machines/process for dismantling and assembly of a Centrifugal Pump."

.

III. Course Level Learning Outcome (CO)

CO4 - Select suitable hydraulic turbine and pump for the given application.

CO5 - Evaluate the performance of hydraulic turbines and pumps.

IV. Laboratory Learning Outcome(s)

LLO 13.1: Identify various components of Centrifugal Pump.

LLO 13.2: Assess the condition of various components of Centrifugal Pump.

LLO 13.3: Suggest remedial action to be taken.

V. Relative Affective Domain related Outcome(s)-

- Follow ethical Practices.
- Practice energy conservation.
- Demonstrate working as a leader/ team member.
- Follow ethical practices.

VI. Minimum Theoretical Background with diagram

The centrifugal pump's function is as simple as its design. It is filled with liquid and the impeller is rotated. Rotation imparts energy to the liquid causing it to exit the impeller's vanes at a greater velocity than it possessed when it entered. This outward flow reduces the pressure at the impeller eye, allowing more liquid to enter. The liquid that exits the impeller is collected in the casing (volute) where its velocity is converted to pressure before it leaves the pump's discharge.

VII. Experimental setup

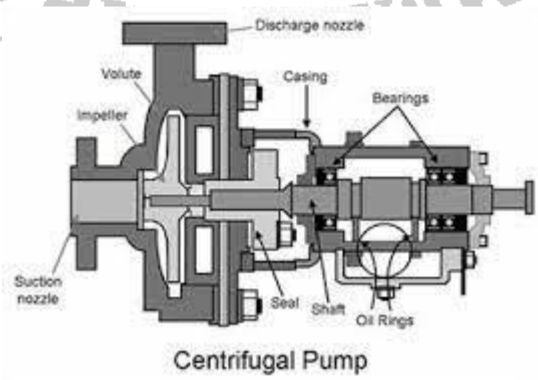


Figure 13.1- Schematic diagram of Centrifugal pump

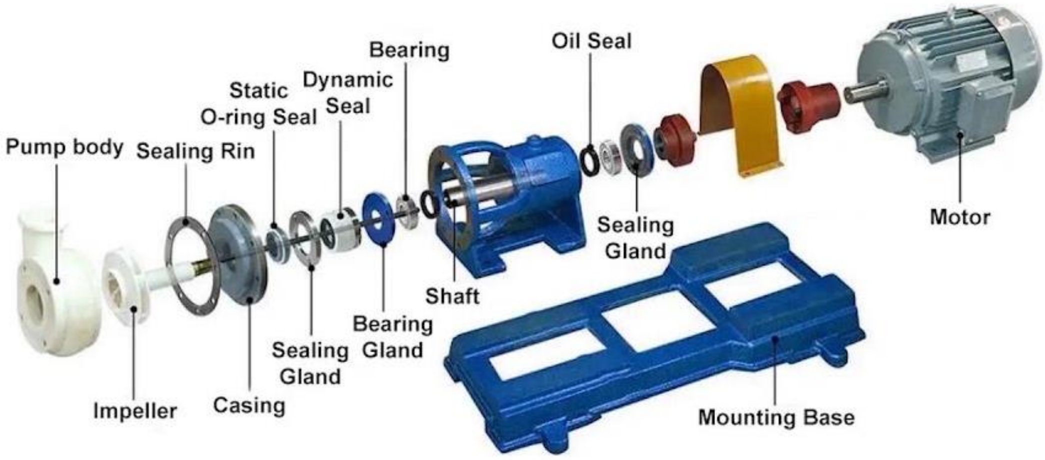


Figure 13.2- Parts of Centrifugal pump

VIII. Required Resources /Apparatus/Equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Centrifugal Pump	Working model of Centrifugal Pump having technical specification: Power: 1 HP (0.75KW) Max. head : Up to 34 meters Max Discharge: Up to 2700 LPH Or Any other Centrifugal Pump which can be dismantled and assembled using spanner set and tool kit.	1
2.	Spanner Set		1

IX. Precautions to be Followed

1. Avoid improper handling of instrument.
2. Don't apply excessive pressure on fastening parts of a pump.

X. Procedure

A. Dismantling the Centrifugal Pump

1. Drain the Pump Completely.
2. Remove coupling and make pump free from motor.
3. Remove casing with the help of spanners.
4. Remove gland packing.
5. Remove impeller from Pump shaft.
6. Observe the condition of parts.

B. Assembly of Centrifugal Pump

1. Assemble the shaft with bearing bush.
2. Clean the shaft and remove all dirt particles.
3. Assemble impeller with given marking.
4. Assemble the housing/casing.
5. Check pump shaft to rotate freely.

6. Tighten the bolts of housing.
7. Tight bolts of coupling.

XI. Observations and Calculations

Sr. No.	Name of Part	Condition of part	Causes of Damage	Suggestive Remedies
1.	Coupling			
2.	Pump Housing/Casing			
3.	Impeller			
4.	Pump Shaft			
5.	Gland Packing			
6.	Wear Rings			
7.	Suction Pipe			
8.	Delivery Pipe			

XII. Results

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. 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. Draw a neat sketch of any two types of Casings used for Centrifugal pump.
2. List any five Manufacturers of Centrifugal pump.
3. State any four troubles and their causes and remedies commonly experienced during operation of centrifugal pump.
4. Enlist applications of Centrifugal pump.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=sLZeR7RMGFA

XVII. Rubrics for Assessment Scheme

	Performance Indicators	**Weightage**
	Process Related (15 Marks)	**(60%)**
1.	Handling of the measuring Instruments	30%
2.	Calculation of final readings	30%
	Product Related (10 Marks)	**(40%)**
3.	Interpretation of result	20%
4.	Conclusions	10%
5.	Practical related questions	10%
	Total (25 Marks)	**100 %**

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

Practical No. 14 Determination overall efficiency of Centrifugal Pump using Centrifugal Pump test rig.

I. Practical Significance

A Pump is generally used to induce flow or raise the pressure of a liquid. Centrifugal pumps are a category of Dynamic pumps. The efficiency of a centrifugal pump plays a crucial role in the production processes of practically all industries like food, pharmaceutical, chemical. The performance of centrifugal pump can have a significant impact on the overall efficiency of production. The efficiency of a centrifugal pump depends to a large extent on the industrial application for which the pumps are intended and the time elapsed after their installation, since the natural wear and tear of operation leads to a reduction in efficiency.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the skills for the industry identified competency as "Select appropriate machinery/process to evaluate performance of hydraulic machinery using knowledge of fluid mechanics."

1.Ability to prime the Centrifugal pump.

2.Ability to measure Pressure gauge reading at Suction pipe and delivery pipe of the Centrifugal pump.

3.Ability to measure Flow, I/P power and calculate overall efficiency of Centrifugal Pump.

III. Course Level Learning Outcome (CO)

CO4 - Select suitable hydraulic turbine and pump for the given application.

CO5 - Evaluate the performance of hydraulic turbines and pumps.

IV. Laboratory Learning Outcome(s)

LLO 14.1: Measure the manometric head (Hm) at different flow rates.

LLO 14.2: Calculate overall efficiency of Centrifugal Pump.

LLO 14.3: Plot performance characteristics based on the results.

V. Relative Affective Domain Related Outcome(s)-

1. Maintain pressure gauges, electronic energy meter, stop watch in good condition.
2. Follow safe practices.
3. Practice energy conservation.
4. Demonstrate working as a leader/ a team member.
5. Follow ethical practices.

VI. Minimum Theoretical Background with diagram

Centrifugal pump efficiency is the ratio of Hydraulic power delivered by the pump to the brake horsepower supplied to the pump.

VII. Experimental setup

Figure 14.1- Centrifugal Pump Test Rig

VIII. Required Resources /Apparatus/Equipment with specification

Sr.No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Centrifugal Pump test rig. test rig consists of, 1. Centrifugal pump with motor. 2. Measuring tank. 3. Electronic energy meter. 4. Suction and delivery valves. 5. U tube Manometer 6. Suitable arrangement of water supply and storage.	Vacuum Gauge Bourdon type. Range: 0-760 mm of Hg Stop Watch Electronic Measuring Tank Material Stainless 40 ltrs. Made of Mild steel with FRP lining & fitted with piezometer tube & scale. Electricity supply Single Phase, 220 VAC, 50 Hz, 5-15 Amp Clear Water Flow Medium Pump Type Centrifugal, 2800 RPM Driven Speed Variable Pressure Gauge Range0-4 kg/cm2 Compound Gauge Bourdon Type, Bourdon type, Range: -760 mm of Hg to 2 kg/cm2	1
2.	Stopwatch	Electronic with least count of 0.01 sec	1

IX. Precautions to be Followed

1. The delivery valve should be kept completely open while priming operation of Centrifugal pump.
2. Count the no of blinks occurring per minute in the electronic energy meter perfectly.

X. Procedure

1. Check the experimental set up carefully.
2. Ensure that the delivery valve is completely open for the priming of pump by filling liquid/water so as to remove entrapped air by operating the key present on casing.
3. Switch 'ON' the pump.
4. Collect the discharge of liquid in a measuring tank and measure rise of water level after T seconds
5. Note the delivery and suction pressure.
6. Note no of blinks per minute of electronic energy meter.
7. Note down the reading of manometer connected to Venturimeter.
8. Note 3-4 sets of reading.
9. Plot the graphs on single graph paper.

Discharge Vs Head.
Discharge Vs Power
Discharge Vs Overall efficiency.
(Note: Take discharge Q on X-axis)

XI. Observations and calculations –

1. Cross sectional area of rectangular measuring tank

A = L X B =....................m^2

2. Efficiency of electric motor used =

(Assume it 90% * if not indicated on motor)
Electronic energy meter constant (EMC) * K = imp/Kwh
(1Kwh .=3600KJ)

3. Take mass density of water = 1000 Kg/m^3

Sr.No.	Suction Pressure (P_1)	Pressure Head at Inlet $H_1 = \frac{P1}{w}$ (-ve for vacuum)	Delivery Pressure (P_2)	Pressure Head at Outlet $H_2 = \frac{P2}{w}$	Rise in water level in measuring tank H	Time of water collection in measuring tank T	No. of Blinks per Minute n
	Kg/cm^2	$=P_1$ x 10m	Kg/cm^2	$=P_2$ x 10m	m	seconds	
1.							
2.							
3.							
4.							
5.							
6.							

Calculations:

I. The input power to the pump.

input power =Energy supplied in KJ per sec X efficiency of electric motor

$=\frac{nx\ 3600}{60\ x\ 3200}$ x efficiency of electric motor KW

II. Volume of water collected in measuring tank. V

V = cross section, area of tank x Rise in level of water in tank

V = A x H = …………………………..

=…………………………………….m^3

Discharge (Q) $=\frac{\text{(Volume of water collected)}}{\text{(Time of water collection)}}$

$= \frac{V}{T}$

= …………………………= m^3/sec

III. Manometric Head (Hm)

Hm = Pressure head at outlet of pump - Pressure head at Inlet of pump

$= H_2 - (- H_1)$

$= H_2 + H_1$

Hm = ………………………………. m

IV. The Output power from the pump

O / P $=\frac{W\ x\ Q\ x\ Hm}{1000}$

= ………………………………….

= ……….…... KW

V. Overall efficiency of Centrifugal Pump = $\frac{\textbf{Output power}}{\textbf{Input power}}$

= ………………..

XII. Results

The Results after calculations

Sr.No.	I/P Power	Discharge Q	Manometric Head Hm	O/P Power	Overall efficiency
	KW	m^3/sec	m	KW	%
1.					
2.					
3.					
4.					
5.					
6.					

Scale

X-axis -

Y-axis -

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. 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. Explain the factors affecting on overall efficiency of Centrifugal Pump.
2. Explain the following terms in case of Centrifugal Pump:
   i. Manometric Efficiency
   ii. Mechanical Efficiency
   iii. Overall Efficiency
3. Explain the significance of Net Positive Suction Head in case of centrifugal pump.
4. Calculate the power required to drive the pump if a Centrifugal pump delivers 30 lit/sec to a height of 18 meters through a pipe of 90 m long and of 100 mm diameter. The overall efficiency of the pump is 75 %.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://youtu.be/oLUjy8lyfbk
2. https://youtu.be/BaEHVpKc-1Q4

XVII. Rubrics for Assessment Scheme

	Performance Indicators	Weightage
	Process Related (15 Marks)	**(60%)**
1.	Handling of the measuring Instruments	30%
2.	Calculation of final readings	30%
	Product Related (10 Marks)	**(40%)**
3.	Interpretation of result	20%
4.	Conclusions	10%
5.	Practical related questions	10%
	Total (25 Marks)	**100 %**

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

Practical No. 15 Dismantling and Assembly of a Reciprocating Pump.

I. Practical Significance

Reciprocating pump is a positive plunger pump. They are used widely in lifting water from ground to the storage tanks in residential areas. They develop high pressures but has limited use. Reciprocating pump consists of "suction stroke" and a "delivery stroke" Suction stroke is the place where the water is sucked in from the ground and delivery stroke is the place where the sucked water is delivered to the required place.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the skills for the industry identified competency as “Select appropriate hydraulic machine/process for Dismantling and Assembly of a Reciprocating Pump.”

III. Course Level Learning Outcome (CO)

CO4 - Select suitable hydraulic turbine and pump for the given application.
CO5 - Evaluate the performance of hydraulic turbines and pumps.

IV. Laboratory Learning Outcome(s)

LLO 15.1: Identify various components of available Reciprocating Pump.
LLO 15.2: Assess the condition of various components of Reciprocating Pump.
LLO 15.3: Suggest remedial action to be taken.

V. Relative Affective Domain related Outcome(s)-

- Follow safety practices.
- Practice energy conservation.
- Demonstrate working as a leader/ team member.
- Follow ethical practices.

.

VI. Minimum Theoretical Background with diagram

Reciprocating pump operates on the principle of pushing of liquid by a piston that executes a reciprocating motion in a closed fitting cylinder.

Components of reciprocating pumps: -

a. Piston or plunger a piston or plunger that reciprocates in a closely fitted cylinder.
b. Crank and Connecting rod: crank and connecting rod mechanism operated by a power source. Power source gives rotary motion to crank. With the help of connecting rod we translate reciprocating motion to piston in the cylinder.
c. Suction pipe: one end of suction pipe remains dip in the liquid and other end attached to the inlet of the cylinder.
d. Delivery pipe at discharge point. one end of delivery pipe attached with delivery part and other end at discharge point.
e. Suction and Delivery value: suction and delivery values are provided at the suction end and delivery end respectively. These values are non-return values.

VII. Experimental setup

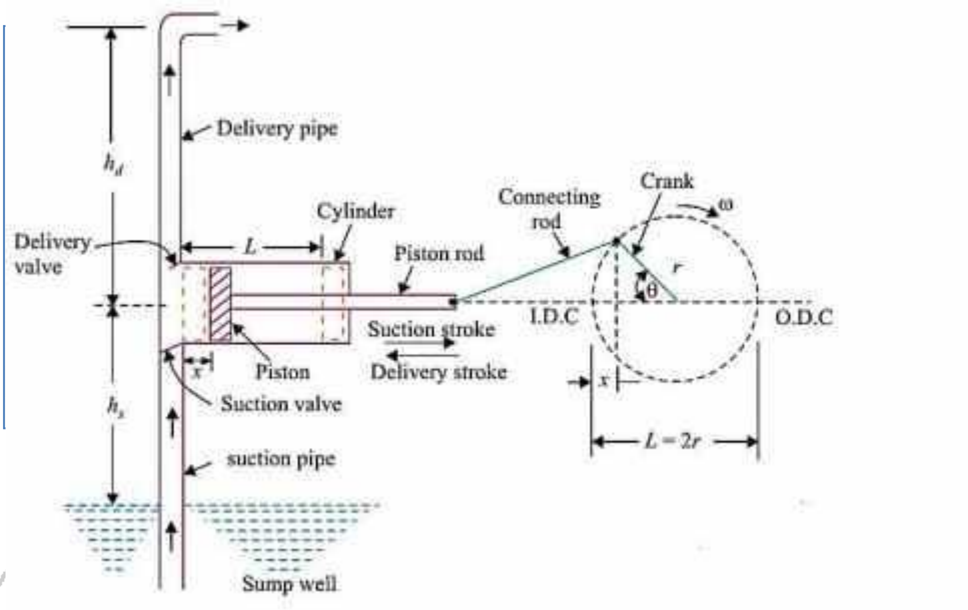


Figure 15.1- Layout of Reciprocating pump

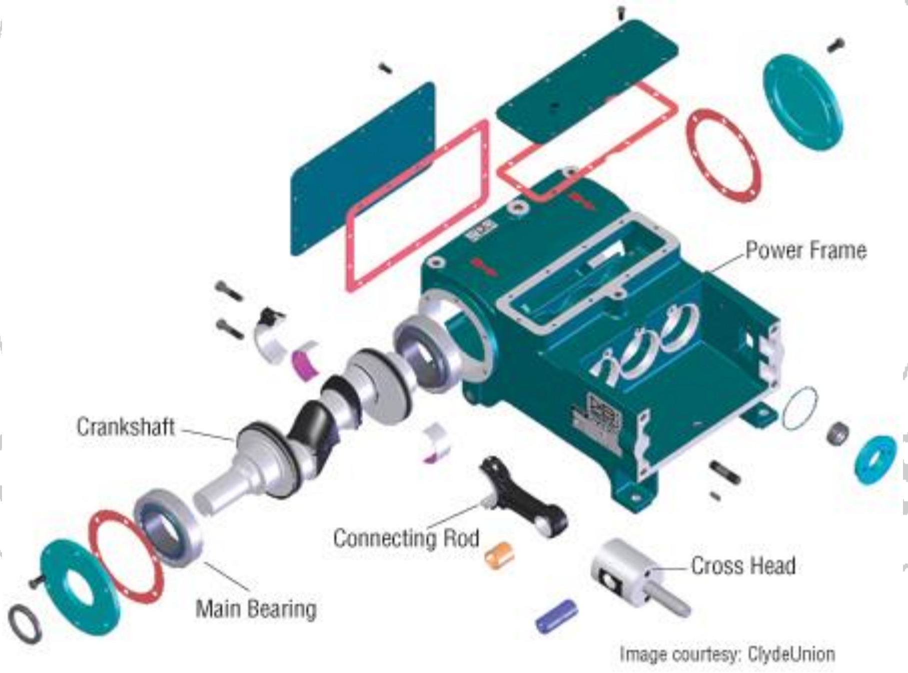


Figure 15.2- Parts of Reciprocating pump.

VIII. Required Resources /Apparatus/Equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Single Acting Reciprocating Pump	Reciprocating Pump: 1.02 HP/0.8 KW, 2900RPM, Single Phase	1
2.	Spanner Set		1

IX. Precautions to be Followed

1. Avoid improper handling of instrument.
2. Don't apply excessive pressure on fastening parts of a pump.

X. Procedure

A. Dismantling the Reciprocating Pump.

1. Loose packing nuts of suction pipe.
2. Remove suction Pipe.
3. Loose packing nuts of delivery pipe.
4. Remove Delivery Pipe.
5. Remove the casing of a pump.
6. Remove packaging seal from the pump.
7. Loose the valve pin.
8. Remove valves from pump.
9. Remove upper piston guide.
10. Unthread piston bar.
11. Remove bearing between piston and connecting rod.
12. Remove Bearing between Connecting rod and crank.
13. Observe the conditions of each part.
14. Note down the condition of each dismantled part.

B. Assembly of Reciprocating Pump

1. Assemble the connecting rod.
2. Check the condition of bearing.
3. Assemble piston and connecting rod.

XI. Observations and calculations –

Sr. No.	Name of Part	Condition of part	Causes of Damage	Suggestive Remedies
1.	Casing			
2.	Piston/Plunger			
3.	Connecting Rod			
4.	Bearing			
5.	Bushings			
6.	Crank			
7.	Suction Pipe			
8.	Delivery Pipe			
9.	Suction Valve			
10.	Delivery Valve			

Sr. No.	Name of Part	Condition of part	Causes of Damage	Suggestive Remedies
11.	Packaging Seals			

XII. Results

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. 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. State any four applications of Reciprocating pump.
2. Explain the methods of getting continuous discharge from Reciprocating pump.
3. Explain the use of Air vessels provided in Reciprocating pump.
4. State the faults which are common to the Reciprocating pump

[Space for Answer]

XVI. References / Suggestions for Further Reading

1.https://www.youtube.com/watch?v=sLZeR7RMGFA

XVII. Rubrics for Assessment Scheme

	Performance Indicators	**Weightage**
	Process Related (15 Marks)	**(60%)**
1.	Handling of the measuring Instruments	30%
2.	Calculation of final readings	30%
	Product Related (10 Marks)	**(40%)**
3.	Interpretation of result	20%
4.	Conclusions	10%
5.	Practical related questions	10%
	Total (25 Marks)	**100 %**

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

Practical No.16 Determination of Overall Efficiency and Percent Slip of Reciprocating Pump using Reciprocating pump test rig

I. Practical Significance

A positive plunger pump is a reciprocating pump. They are frequently employed in residential areas to raise water from the ground to storage tanks. Although they have limited function, they develop considerable pressure. A "delivery stroke" and a "suction stroke" make up a reciprocating pump. The water is drawn up from the ground during the suction stroke, and it is delivered to the desired location during the delivery stroke.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the skills for the industry identified competency as "Select the appropriate hydraulic machinery/process to evaluate performance of hydraulic machinery using knowledge of fluid mechanics."

1. Operate the Single/Double acting reciprocating pump.
2. Measure Pressure at Suction and delivery of the reciprocating pump.
3. Measure rpm of the shaft with the help of tachometer.
4. Measure actual and theoretical discharge of reciprocating pump.

III. Course Level Learning Outcome (CO)

CO4 - Select suitable hydraulic turbine and pump for the given application.
CO5 - Evaluate the performance of hydraulic turbines and pumps.

IV. Laboratory Learning Outcome(s)

LLO 16.1: Calculate overall efficiency of Reciprocating Pump.
LLO 16.2: Calculate percentage slip of Reciprocating Pump.

V. Relative Affective Domain related Outcome(s)-

1. Follow safe practices.
2. Practice energy conservation.

VI. Minimum Theoretical Background with diagram (if required)

(i) Reciprocating pumps draw liquid into a cylinder by the action of a piston, a plunger or a diaphragm; the liquid is then discharged in the required direction by theuse of check valves.

(ii) Coefficient of Discharge: The ratio between the actual discharge and theoretical discharge is known as coefficient of discharge.

Cd=Qact/Qthe.

(iii) Slip in reciprocating pump is the measure of difference between theoretical discharge and actual discharge.

Slip = Q_{th}-Q_{act}

When actual discharge delivered by reciprocating pump is less then theoretical discharge then that difference is called as Positive Slip. Actual discharge becomes less than theoretical discharge due to leakages while operation. And when actual discharge delivered by reciprocating pump is more than theoretical discharge then that difference is called as Negative Slip.

VII. Experimental setup

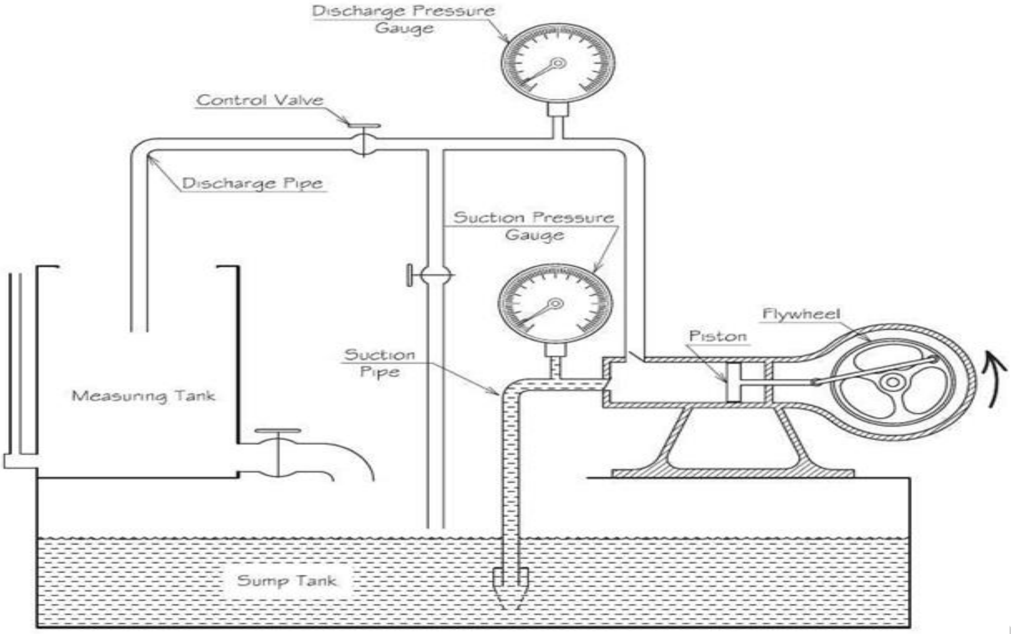


Figure 16.1- Line diagram of Experimental Set Up

Figure 16.2- Experimental Set Up

VIII. Required Resources /Apparatus/Equipment with specification

Sr.No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Reciprocating pump test rig	Reciprocating Pump - 1HP,700 RPM	1
2.	Motor	D.C. Motor-1HP ,1500 RPM	1
3.	Supply tank	80 ltrs made up of Mild Steel with FRP lining.	1

4.	Measuring Tank	40 ltrs made up of Mild Steel with FRP lining and fitted with Piezometer tube and scale.	1
5.	Tachometer	RPM Ranges 10-10,000 rpm, Accuracy ±0.5% Full Scale	1
6.	Pressure gauge	Pressure & Vacuum gauge for measurement of head.	1
7.	Stopwatch	Timing capacity:23hrs, 59mins and 59.99secs, Accuracy: ±3 seconds/day	1

IX. Precautions to be Followed

1. Avoid parallax while taking the pressure gauge points Z1 and Z2.
2. Tachometer should be placed perfectly perpendicularly while taking the reading.

X. Procedure

1. Measure the distance between the gauges i.e. difference between potential heads (ΔZ).
2. Note the diameters of suction and delivery pipes D1 and D2.
3. Note the step of the core pulley on which the belt is mounted.
4. Start the pump.
5. Note the time required for 20 revolutions of electric Energy meter disc.
6. Close the discharge valve of the collecting tank.
7. Note time required to rise in height of water level (say 10 cms).
8. Note the suction and delivery pressures.
9. Switch off the motor.
10. Shift the belt in other step of cone pulley.
11. Repeat steps 6 to 9 again.
12. Follow similar procedure for remaining two steps.

XI. Observations and calculations

Suction pipe diameter, D_1 = ……………m

C/S Area of suction pipe, As=$\frac{\pi}{4} D_1^2$ =…………m^2

Delivery pipe diameter, D_2 =...................m

C/S Area of Delivery pipe, Ad = $\frac{\pi}{4} D_2^2$ = …………… m^2

Difference between heights of pressure gauge points i.e. Z_1 and Z_2 from datum.

$Z_2 - Z_1 = Z$ = ……………….m

Diameter of cylinder bore, D = ... m

Length of stroke, L=.......... m

Area of measuring container, A = ……………….m^2

Take transmission efficiency: ht =60%=0.6(if not mentioned in the instructional /operational manual of Reciprocating pump test rig)

Electric motor efficiency: h_e = 70% = 0.7

Constant of electric energy meter = ...

Sr.No.	Suction Pressure (P_1)	Pressure Head at Inlet $H_1 = \frac{P1}{w}$ (-ve for vacuum)	Delivery Pressure (P_2)	Pressure Head at Outlet $H_2 = \frac{P2}{w}$	Time for 20 revolution of disc of energy meter	Time for 10 cm rise in height of water level in measuring tank T	RPM of the crank shaft
	Kg/cm^2	$=P_1$ x 10m	Kg/cm^2	$=P_2$ x 10m	sec	sec	
1.							
2.							
3.							
4.							
5.							
6.							

Calculations:

Input Power $= \frac{\textit{No of disc revolution x 3600 sec x ht x he x 1000}}{\textit{Constant of electric energy meter x Time required for no of revolution of disc}}$

= ....

= ....Watts

$Q_{th} = \frac{2 \, x \, \frac{\pi}{4} x D2 x \, L \, x \, N}{60}$ m^3/sec (For double acting pump)

= ....

= ....

$Q_{act} = \frac{\textit{Area of measuring tank x Rise in water level}}{\textit{Time required for rise}}$ m^3/sec

= ....

= ....

Output Power = w x Q x ($h_s + h_d$ + Z) Watts

= ....

= ....

Theoretical discharge: $Q_{th} = \frac{A x \, L \, x \, N}{60}$ (for single acting)

Theoretical discharge: $Q_{th} = \frac{2 \, x \, A \, x \, L \, x \, N}{60}$ (for double acting)

Where, A = cross section of piston = $\frac{\pi}{4} D^2$

D = Diameter of cylinder

L = Length of stroke = 2 x r

r = Radius of crank

N = RPM of crank

Coefficient of discharge $C_d = \frac{\textit{Actual discharge}}{\textit{Theoretical discharge}}$

$= \frac{Qact}{Qth}$

= ....

Slip = Q_{th} - Q_{act}= ………………

% Slip = $\frac{Qth - Qact}{Qth}$ x 100

= …………..

Efficiency = $\frac{Output\ Power}{Input\ Power}$

XII. Results

Sr. No.	I/P Power	O/P Power	Efficiency	Average efficiency
	W	W	%	%
1.				
2.				
3..				
4.				
5.				
6.				

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. 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. State the applications of Reciprocating Pump.
2. Explain the reason behind occurrence of negative slip in case of Reciprocating Pump.
3. Explain the phenomenon of Cavitation in Reciprocating Pump. State the effects of Cavitation.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=h4LSj59gC2k
2. https://www.youtube.com/watch?v=uIsXXewKzlc
3. https://www.youtube.com/watch?v=nM-Vmgo_ZxM
4. www.youtube.com/watch?v=FmQjDQ4q2ww

XVII. Rubrics for Assessment Scheme

Performance Indicators		**Weightage**
Process Related (15 Marks)		**(60%)**
1.	Handling of the measuring Instruments	30%
2.	Calculation of final readings	30%
Product Related (10 Marks)		**(40%)**
3.	Interpretation of result	20%
4.	Conclusions	10%
5.	Practical related questions	10%
	Total (25 Marks)	**100 %**

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