`

II YEAR
II SEM

HYDRAULICS AND HYDRAULIC MACHINERY LAB MANUAL

DEPARTMENT OF CIVIL ENGINEERING

MLRS
EMPOWERING THROUGH INNOVATIONS

MARRI LAXMAN REDDY
INSTITUTE OF TECHNOLOGY AND MANAGEMENT
(AN AUTONOMOUS INSTITUTION)
(Approved by AICTE, New Delhi & Affiliated to JNTUH, Hyderabad)
Accredited by NBA and NAAC with 'A' Grade & Recognized Under Section2(f) & 12(B)of the UGC act,1956

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CERTIFICATE

This is to certify that this manual is a bonafide record of practical work in the **Hydraulics and Hydraulic Machinery Laboratory in Second Semester of Second year B.Tech (Civil) programme** during the academic year **2020-21**. The book is prepared by **Dr.R.Gopi, Associate Professor, Department of Civil Engineering.**

Signature of HOD Signature of Director Signature of Principal

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PREFACE

This book entitled "Hydraulics and Hydraulic Machinery Lab Manual" is intended for the use of second semester (i.e, II-II) B.Tech (Civil) students of Marri Laxman Reddy Institute of Technology and Management, Dundigal, Hyderabad. The aim to prepare this manual is to understand fundamental principles, concepts and significance of various experiments as per existing laboratory experimental practice and evaluation procedure in the subject Hydraulics and Hydraulic Machinery. The manual explains the procedure for various experiments including principle, apparatus, experimental set up, handling of apparatus, range and accuracy of observations, model calculation, engineering significance, practical applications for each experiment in hydraulics. This manual also gives comprehensive view about how to perform various experiments, how to presentation of experiment results in the form of laboratory report and how to evaluate performance of a student in the laboratory and how to implement experiment results in field. Also it provides to the students the essential information required to understand fundamental concepts, to carry out the experiment and to implement the experiment results in the field. It improves skills in experimentation, presentation and implement of experimental results in the field.

By,
Dr.R.Gopi, Associate Professor
Department of Civil Engineering

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ACKNOWLEDGEMENT

First I would like to thank to Mr.K.Murali, Head of the Department of Civil Engineering, Marri Laxman Reddy Institute of technology & Management, for his concern towards me and gave me opportunity to prepare Hydraulics and Hydraulic Machinery laboratory manual.

I express my hearty thanks to Dr.K.Venkateswara Reddy, Principal, Marri Laxman Reddy Institute of Technology & Management, for giving me this wonderful opportunity for preparing the Hydraulics and Hydraulic Machinery laboratory manual.

At last, but not the least I would like to thanks the entire Civil Department faculties those who had inspired and helped me to achieve our goal.

By,
Dr.R.Gopi, Associate Professor
Department of Civil Engineering

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GENERAL INSTRUCTIONS

1. Students are instructed to come to Hydraulics and Hydraulic Machinery laboratory on time. Late comers are not entertained in the lab.

2. Students should be punctual to the lab. If not, conducted experiments will not be repeated.

3. Students are expected to come prepared at home with the experiments which are going to performed.

4. Students are instructed to display their identity cards and apron before entering into the lab.

5. Students are instructed not to bring mobile phones to the lab.

6. Any damage to the equipment during the lab session is student's responsibility and penalty or fine will be collected from the student.

7. Carefully handle the experiments in which mercury is used.

8. Students should update the records and lab observation books session wise. Before leaving the lab the student should get his lab observation book signed by the faculty.

9. Students should submit the lab records 2/3 days in advance to the concerned faculty members in the staffroom for their correction and return.

10. Students should not move around the lab during the lab session.

11. If any emergency arises, the student should take the permission from faculty member concerned in written format.

12. The faculty members may suspend any student from the lab session on disciplinary grounds.

13. Never cook up the result by recording false observations or by making manipulated calculations.

14. All the data should be prettified with the relevant units.

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SAFETY PRECAUTIONS

Clothing: When handling dangerous substances, wear gloves, laboratory coats, and safety shield or glasses. Shorts and sandals should not be worn in the lab at any time. Shoes are required when working in the machine shops.

1. Wear safety glasses or face shields when working with hazardous materials and/or equipment.

2. Keep the work area clear of all materials except those needed for your work.

3. Students are responsible for the proper disposal of used material if any in appropriate containers.

4. Obtain permission before operating any high voltage equipment.

5. When using compressed air, use only approved nozzles and never directs the air towards any person.

6. Guards on machinery must be in place during operation.

7. Exercise care when working with or near hydraulically- or pneumatically-driven equipment.
8. Sudden or unexpected motion can inflict serious injury.

9. Clean your lab bench and equipment, and lock the door before you leave the laboratory.

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INSTITUTION VISION AND MISSION

VISION

To establish as an ideal academic institutions in the service of the nation, the world and the humanity by graduating talented engineers to be ethically strong, globally competent by conducting high quality research, developing breakthrough technologies, and disseminating and preserving technical knowledge.

OUR MISSION

To fulfil the promised vision through the following strategic characteristics and aspirations:

- Contemporary and rigorous educational experiences that develop the engineers and managers.
- An atmosphere that facilitates personal commitment to the educational success of students in an environment that values diversity and community.
- Prudent and accountable resource management.
- Undergraduate programs that integrate global awareness, communication skills and team building.
- Leadership and service to meet society's needs
- Education and research partnerships with colleges, universities, and industries to graduate education and training that prepares students for interdisciplinary engineering research and advanced problem solving abilities.
- Highly successful alumni who contribute to the profession in the global society.

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DEPARTMENT VISION, MISSION , PROGRAMME EDUCATIONAL OBJECTIVES AND SPECIFIC OUTCOMES

VISION

The Civil Engineering department strives to impart quality education by extracting the innovative skills of students and to face the challenges in latest technological advancements and to serve the society.

MISSION

M-I Provide quality education and to motivate students towards professionalism

M-II Address the advanced technologies in research and industrial issues

PROGRAMME EDUCATIONAL OBJECTIVES

The Programme Educational Objectives (PEOs) that are formulated for the civil engineering programme are listed below:

PEO-I Solving civil engineering problems in different circumstances
PEO-II Pursue higher education and research for professional development.
PEO-III Inculcate qualities of leadership for technology innovation and entrepreneurship.

PROGRAM SPECIFIC OUTCOMES

PSO1 – UNDERSTANDING: Graduates will have ability to describe, analyse and solve problems using mathematical, scientific, and engineering knowledge.

PSO2 – ANALYTICAL SKILLS: Graduates will have an ability to plan, execute, maintain, manage, and rehabilitate civil engineering systems and processes.

PSO3 – EXECUTIVE SKILLS: Graduates will have an ability to interact and work effectively in multi disciplinary teams.

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PROGRAMME OUT COMES

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

COURSE STRUCTURE, OBJECTIVES & OUTCOMES

COURSE STRUCTURE

Hydraulics and Hydraulic Machinery lab will have a continuous evaluation during 4th semester for 30 sessional marks and 70 end semester examination marks.

Out of the 30 marks for internal evaluation, day-to-day work in the laboratory shall be evaluated for 20 marks and internal practical examination shall be evaluated for 10 marks conducted by the laboratory teacher concerned.

The end semester examination shall be conducted with an external examiner and internal examiner. The external examiner shall be appointed by the principal / Chief Controller of examinations

COURSE OUTCOME

At the end of the course, the student will be able to:

CE 229.1	Understand calibration of flow measuring devices.
CE 229.2	Apply the practical aspects of Bernoulli's principle
CE 229.3	Understand calibration of flow measuring devices.
CE 229.4	analyse the Manning's and Chezy's constants for Open channel flow
CE 229.5	Analyse the characteristics of turbine
CE 229.6	Analyse the characteristics of pumps

CO-PO mapping:

Program	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**PSO 1**	**PSO 2**	**PSO 3**
CE214.1	3	3	2	3	3	3							3	3	3
CE214.2	3	3	2	3	3	3							3	3	3
CE214.3	3	3	2	3	3	3							3	3	3
CE214.4	3	3	2	3	3	3						3	3	3	3
CE214.5	3	3	2	3	3	3						3	3	3	3
CE214.6	3	3	2	3	3	3						3	3	3	3
Total	18	18	12	18	18	18						9	18	18	18
Average	3	3	2	3	3	3						3	3	3	3

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EXPERIMENTS LEARNING OUTCOMES

1. Verification of Bernoulli's equation
OBJECTIVES:

- Datum head, pressure head and velocity head can be determined.
- Total head can be determined
- We prove that the total head at any point along the flow is same i.e, datum head + pressure head + velocity head is constant along the flow

2. Determination of coefficient of discharge for small orifice by constant head method
OBJECTIVES:

- The co-efficient of velocity [Cv] co-efficient of contraction [Cc] and co-efficient of discharge [Cd] for circular orifice under variable heads can be determined.

OUTCOMES:

- Found out the actual and theoretical velocity.
- Found out the coefficient of contraction after getting the coefficients of discharge and velocity.

3. Calibration of Venturimeter and Orifice meter
OBJECTIVES:

- The coefficient of discharge of Venturimeter and orifice meter can be determined.
- We can differentiate between actual discharge and theoretical discharge.

OUTCOMES:

- Found the actual and theoretical discharge from which the coefficient of discharge is found out.

4. Calibration of contracted Rectangular notch / Triangular notch / Trapezoidal Notch
OBJECTIVES:

- Can differentiate rectangular and triangular notch.

OUTCOMES:

- Discharge coefficient can be found

5. Determination of minor losses in pipe flow
OBJECTIVES:

- Loss of head can be determined
- Discharge can be determined.

OUTCOMES:

- Loss of head due to sudden contraction and coefficient of contraction are found

6. Determination of friction factor of a pipe line.
OBJECTIVES:

- The frictional losses in pipes of different sizes can be determined.
- Coefficient of friction for the pipe can be determined.

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OUTCOMES:

- We can find the friction factor and coefficient of loss of head h_f.

7. Determination of energy loss in Hydraulic jump

OBJECTIVES:

- Loss of energy in the jump can be determined

OUTCOMES:

- The energy loss due to hydraulic jump

8. Determination of Chezy's & Manning's constant for open channel flow

OBJECTIVES:

- Chezy's & Manning's constant determination

OUTCOMES:

- Value of Chezy's & Manning's constant calculated for discharge measurement in open channel flow

9. Impact of jet on vanes

OBJECTIVES:

- Discharge and velocity can be determined using coefficient contraction.
- Can differentiate between flat and hemi spherical vanes

OUTCOMES:

- Can compute graph between actual force and velocity.
- Value of the coefficient of impact is calculated.

10. Performance characteristics of Pelton wheel turbine

OBJECTIVES:

- The main objective of pelton turbine is to convert the hydraulic energy to mechanical energy and mechanical energy to electrical energy.

OUTCOMES:

- The performance characteristics of Pelton wheel turbine under constant head and constant speed is found.
- The output power, input power and efficiency are found.

11. Performance characteristics of Francis turbine

OBJECTIVES:

- The working fluid changes pressure as it moves through the turbine, giving up its energy.
- Head on the turbine is determined.

OUTCOMES:

- The performance characteristics of Francis turbine under constant head and constant speed are found.
- The output power, input power and efficiency are found.

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12. Performance characteristics of Kaplan turbine

OBJECTIVES:

- The main objective of kaplan turbine is to convert the hydraulic energy to mechanical energy and mechanical energy to electrical energy.

OUTCOMES:

- The performance characteristics of kaplan turbine is found.
- The output power, input power and efficiency are found.

13. Performance of characteristics of a single / multistage centrifugal pump.

OBJECTIVES:

- The main objective of pumps is that it changes electrical energy to mechanical energy and mechanical energy to hydraulic energy.

OUTCOMES:

- Various tests on centrifugal pumps are done at various heads.
- The output power, input power and efficiency are found.

14. Determination of coefficient of discharge for mouthpiece by constant head method

OBJECTIVES:

- The co-efficient of velocity [Cv] co-efficient of contraction [Cc] and co-efficient of discharge [Cd] for mouth piece under variable heads can be determined.

OUTCOMES:

- Found out the actual and theoretical velocity.
- Found out the coefficient of contraction after getting the coefficients of discharge and velocity.

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EXPERIMENT NO: 1

VERIFICATION OF BERNOULLI'S EQUATION

OBJECTIVE:

To understand the Bernoulli's theorem through an experiment.

OUTCOME:

The student will be able to verify the total head of an incompressible liquid is always constant.

SCOPE:

The knowledge of Bernoulli's theorem is used for flow measuring device like Venturimeter, Orificemeter & Pitot tube.

APPARATUS:

Bernoulli's apparatus, Controlling valve at inlet and outlet, Discharge Measuring Tank, Scale, Stopwatch etc.

EXPERIMENTAL SET UP:

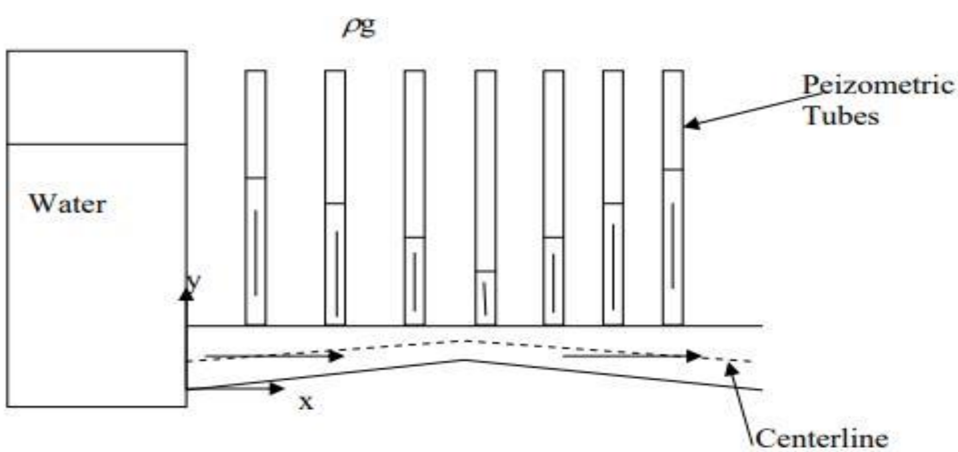

Fig.1 Experimental set up.

PROCEDURE:

1. The apparatus should be accurately leveled by means of screws provided at the base.
2. Connect the water supply to the radial diffuser in the upstream tank.
3. Adjust the level of the discharge pipe by means of the stand and clamp provided to a convenient position.
4. Allow water to flow through the apparatus until all air has been expelled and steady flow conditions are achieved. This can be accomplished by varying the rate of inflow into the apparatus and adjusting the level of the discharge tube.

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5. Readings may then be taken from the piezometer tubes and the flow through the apparatus measured.
6. A series of readings can be taken for various through flows.

THEORY:

Bernoulli's principle formulated by **Daniel Bernoulli (1700-1780)** states that as the speed of a moving fluid increases (liquid or gas), the pressure within the fluid decreases. Although Bernoulli deduced the law, it was Leonhard Euler who derived Bernoulli's equation in its usual form in the year 1752. "Bernoulli's theorem states that, the sum of pressure energy, kinetic energy and potential energy per unit volume of an incompressible, non-viscous fluid in stream line flow remains constant". This statement is called Bernoulli's theorem with reference to section 1 – 1 and 2 – 2 along the length of steady flow in the stream tube. The total energy at section 1 – 1 is equal to the total energy at section 2 – 2 as stated in Bernoulli's theorem.

FORMULA:

Total energy at Section 1 – 1 = $P_1 / \gamma g + V_1^2 / 2g + Z_1$
Total energy at section 2 – 2 = $P_2 / \gamma g + V_2^2 / 2g + Z_2$
Where,
$P / \rho g$ = Pressure head
$V^2 / 2g$ = Kinetic head
Z = Potential head

OBSERVATION:

Area of pipe (a) (m^2)	Time for 10cm rise of water (sec)	Actual discharge Qact =AH/t (m^3/sec)	Velocity = Qact/a (m/sec)	Velocity head $V^2/2g$ (m)	Pressure head $P/\gamma g$ (m)	Datum head (Z) (m)	Total head $P/\gamma g + V^2/2g + z$ (m)

1. **Actual discharge:**

   Qact =AH/t

2. **Velocity:**

   Qact/a =

3. **Velocity head:**

   $V^2/2g$ =

4. **Total head:**

   $P/\rho g + V^2/2g + z$ = constant

`

GRAPH:

The graphs of pressure head, velocity head and total head are drawn at various cross-sections, taking the cross section area on X-axis.

RESULT:

The total energy of a streamline, while the particle moves from one point to another. Bernoulli's theorem for an incompressible fluid flow is verified.

Viva Questions:

1. Bernoulli's Equation is a mathematical expression of _______?
2. A stagnation point is a point in fluid flow where total energy is ?
3. When is Bernoulli's equation applicable between any two points in a flow field?
4. Bernoulli's equation relates various forms of ?
5. Bernoulli's equation mathematically is written as ?
6. Velocity head is given by ?
7. The piezometric head is the summation of ?
8. Eulers equation (in differential form) is written as ?
9. In hydraulic gradient line indicates the variation of ?
10. What are the different types of heads in fluid ?
11. What are the practical applications of Bernoulli's equation ?
12. The total energy line is always __________ the hydraulic gradient line
13. The vertical distance between TEL and HGL represents ?
14. The units of total energy is ?
15. The Bernoulli's equation written in the conventional form represents?
16. What is the basic principle of Bernoulli's equation ?
17. What are the assumptions used in Bernoulli Equation?
18. What is the similarity between Bernoulli's equation and energy equation
19. What is the di-similarity between Bernoulli's equation and energy equation
20. Which forces are neglected to obtain Euler's equation of motion from Newton's second law of motion?
21. Chimney works best on principle of ?
22. When a fluid's pressure decreases, what happens to the speed of the fluid?
23. State the Bernoullis theorem ?
24. What are the precautions taken in this experiment?
25. What are the basic equations of fluid mechanics?
26. What is the purpose of Bernoulli's principle?
27. Which apparatus is used to verify the Bernoulli's theorem?
28. What are the names of tubes in Bernoulli's apparatus?
29. Name the parts of Bernoulli's apparatus.
30. What is energy gradient line?

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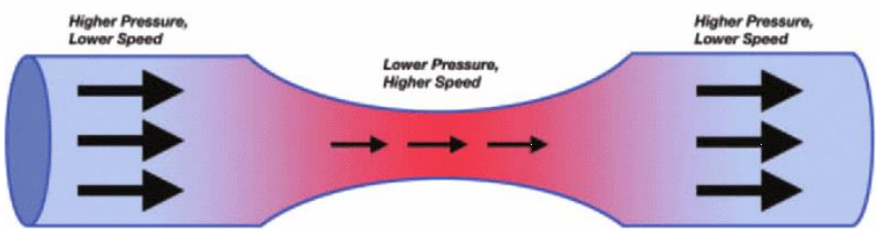
PRACTICAL APPLICATIONS

Bernoulli's Energy Equation can be applied in practice for the construction of flow measuring devices such as Venturimeter, flow nozzle, orifice meter and Pitot tube, Furthermore, it can be applied to the problems of flow under a sluice gate, free liquid jet, radial flow and free vortex motion. It can also be applied to real incompressible fluids with good results in situations where frictional effect is very small.



MID EXAMINATION QUESTIONS

1. Verify the Bernoulli's theorem.
2. Show that for an incompressible liquid the total head is always constant.
3. Find the total head of an incompressible liquid using Bernoulli's apparatus.

UNIVERSITY EXAMINATION QUESTION

1. Determine the pressure head, velocity head and datum head & total head for an incompressible fluid flow in a pipe.
2. State Bernoulli's theorem. Conduct the experiment and show that the total head is constant.

EXPERIMENT VIDEO LINKS

1. https://www.youtube.com/watch?v=3IKYQ7BYU2g
2. https://www.youtube.com/watch?v=ev-3wrE8WWQ

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EXPERIMENT NO: 2

DETERMINATION OF COEFFICIENT OF DISCHARGE FOR A SMALL ORIFICE BY CONSTANT HEAD METHOD

OBJECTIVE:

To determine the co-efficient of velocity [C_v] co-efficient of contraction [C_c] and co-efficient of discharge [C_d] for circular orifice by constant head method.

OUTCOME:

The student will be able to find the actual and theoretical discharges and hydraulic coefficients.

SCOPE:

The knowledge of hydraulic coefficients for a small orifice mainly used to find the discharge.

APPARATUS:

An Orifice fitted across a pipeline leading to a collecting tank, Stop Watch

EXPERIMENTAL SETUP:

The orifice meter consists of a throat tiling device (an orifice plate) inserted in the flow. This orifice plate creates a measurable pressure difference between its upstream and downstream sides. This pressure is then related to the flow rate. Like the Venturimeter, the pressure difference varies directly with the flow rate. The co-efficient of discharge is 0.62-0.67 for orifice meter.

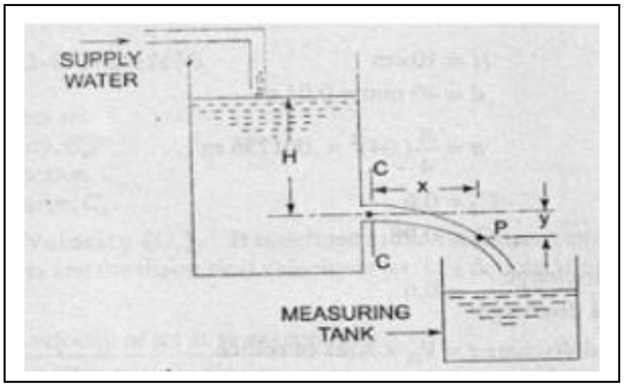

Fig.2 Experimental setup

PROCEDURE:

1. Measure the diameter of the orifice.
2. Supply water to the tank.
3. When the head at the tank (measured by a piezometer attached to the tank) is steady record the reading of the manometer.
4. Measure the x and y co-ordinate of the jet from the vena contracta.
5. Measure the flow rate.
6. Repeat the procedure for different combinations of discharge.

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THEORY:

Orifice is a small opening of any cross section such as circular, triangular, rectangular, on a side or on the bottom of the tank, through which a fluid flows. Orifices are used for measuring the rate of flowing fluid. The water is allowed to flow through an orifice fitted to tank and a constant head 'h'. The water is collected in measuring tank for known time ' t '. The height of water in the measuring tank is noted. Then the actual discharge through the orifice was calculated.

FORMULA:

Q_{act} = AH/t

Coefficient of discharge = C_d= Q_{act}/Q_{the}

Coefficient of velocity = C_v = Actual velocity/theoretical velocity

OBSERVATION:

Diameter of the orifice (d) = Area of orifice (a) =

S.No	Constant Head (h) (m)	Time required for 10cm Rise of water (t)(sec)	Actual discharge Qact (m^3/sec)	Theoretical discharge Qthe (m^3/sec)	Coefficient of discharge Cd = Qact/Qthe	Pointer reading (m)		Coeff. of velocity (Cv)	Coeff. of contraction (Cc)
						x	y		
1.									
2.									
3.									

1. **Actual discharge:**
   Qact = AH/t =

2. **Theoretical discharge:**
   Qthe **=** ax$\sqrt{(2gh)}$ =

3. **Coefficient of discharge:**
   Cd = Qact/Qthe =

4. **Coeff.of velocity:**
   Cv = $\sqrt{(x^2/4yH)}$ =

5. **Coeff.of contraction:**
   Cc=Cd/Cv =

GRAPH:

Draw a graph between Qact vs $\sqrt{h}$. Take Qact in Y axis.

`

RESULT:

The mean values of hydraulic coefficients are as follows:

a) Coefficient of discharge, Cd = _____

b) Coefficient of velocity, Cv = _______

c) Coefficient of contraction, Cc = _______

Viva Questions:

1. Define an orifice.
2. For what purpose orifices are used?
3. What are the applications of orifices?
4. What is Vena Contracta?
5. Which diameter is less? Orifice or Pipe
6. What is the diameter of the orifice in the experiment?
7. What are the hydraulic coefficients?
8. What is meant by coefficient of discharge?
9. Define the coefficient of velocity.
10. Define the coefficient of contraction.
11. What is the use of measuring tank?
12. What is discharge? What is its unit?
13. What is mass flow rate Mention its unit?
14. What is volume flow rate? write its unit.
15. State the equation for theoretical discharge for orifice meter.
16. How will you find out actual discharge?
17. Describe the principle of manometers and its uses?
18. What is the theoretical velocity of jet of water coming out from orifice?
17. Mention the types of orifice meters.
18. Distinguish between small orifice and large orifice
19. What is meant by constant head?
20. Write the formula for loss of head in orifice meter.
21. The top edge of the orifice is always __________ (above/below) the free surface
22. In orifice it is convenient to work in terms of _______ pressures(gauge/absolute)
23. An orifice is said to be __________ (submerged/discharging free) when it discharges into another liquid
24. What is the range of coefficient of discharge for small orifice?
25. Write the formula for discharge through an orifice.
26. Write the formula for a time taken by an orifice for emptying tank.
27. Give any two practical applications of Bernoulli's equation.
28. The coefficient of discharge through an orifice meter is ___________ (small/equal/greater) than the venture meter
29. List out any two precautions in the experiment.
30. What is the difference between orifice and mouth piece?

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PRACTICAL APPLICATIONS

The usual purpose of an orifice is the measurement or control of flow from a reservoir. The orifice is frequently encountered in engineering practice operating under a static head where it is usually not used for metering but rather as a special feature in a hydraulic design. Another problem of orifice flow, which frequently arises in engineering practice, is that of discharge from an orifice under falling head, a problem of unsteady flow.

MID EXAMINATION QUESTIONS

1. Determine the orifice diameter (d) required by constant head method. Take Coefficient of discharge C_d = 0.6.
2. Determine the coefficient of discharge for the give orifice diameter 15 mm by constant head method.
3. Determine the actual discharge in the pipe for the given orifice. Take C_d = 0.6.

UNIVERSITY EXAMINATION QUESTION

1. Find the hydraulic coefficients (C_d, C_c, C_v) for the given orifice.
2. What are the methods available for finding the coefficient of discharge for a small orifice? Conduct the experiment and find the C_d value.

EXPERIMENT VIDEO LINKS

1. **https://www.youtube.com/watch?v=xq_IgKAPt_c**
2. **https://www.youtube.com/watch?v=F6NubRmW7tE**

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EXPERIMENT NO: 3

CALIBRATION OF VENTURIMETER / ORIFICE METER

OBJECTIVE:

To determine the co-efficient of discharge [C_d] for Venturimeter and Orificemeter.

OUTCOME:

The student will be able to find the actual and theoretical discharges and co-efficient of discharges.

SCOPE:

The knowledge in practical application of Bernoulli's theorems through Venturimeter and Orifice meter.

APPARATUS:

Venturimeter/Orifice meter fitted across a pipeline leading to a collecting tank, Stop Watch, U-Tube manometer connected across entry and throat sections etc.

EXPERIMENTAL SETUP:

Venturimeter and Orifice meter are working on the principle on Bernoulli's equation. Venturimeter and Orifice meter is a device used for measuring the rate of fluid flowing through a pipe. Venturimeter consists of three parts 1. Converging cone part, 2. Throat. 3. Diverging cone part. Orifice meter consist of orifice plate with concentric hole at center.

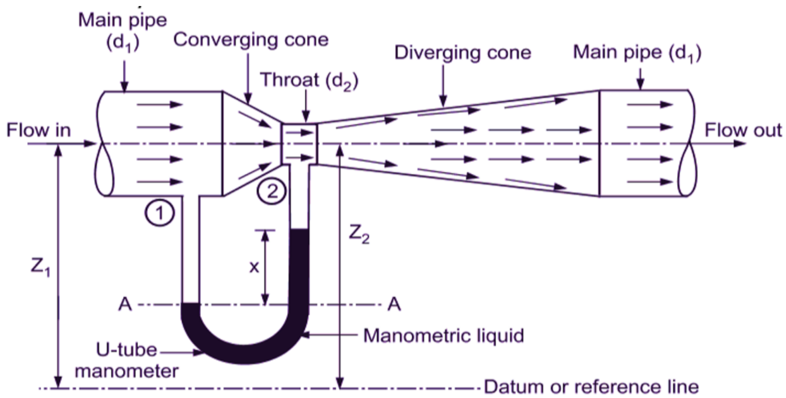

Fig.3.1 Venturimeter

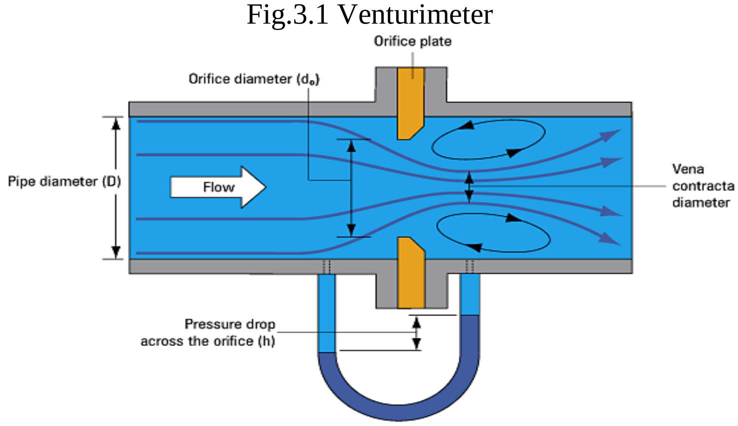

Fig.3.2 Orifice meter

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PROCEDURE:

1. Set the manometer pressure to the atmospheric pressure by opening the upper valve.
2. Now start the supply at water controlled by the stop valve.
3. One of the valves of any one of the pipe open and close all other of three.
4. Take the discharge reading for the particular flow.
5. Take the reading for the pressure head on from the u-tube manometer for corresponding reading of discharge.
6. Now take three readings for this pipe and calculate the Cd for that instrument using formula.
7. Now close the valve and open valve of other diameter pipe and take the three reading for this.
8. Similarly take the reading for all other diameter pipe and calculate Cd for each.

THEORY:

Clemens Herschel (1842 – 1930) was an American hydraulic engineer. His career extended from about 1860 to 1930, and he is best known for inventing the Venturimeter, which was the first large-scale, accurate device for measuring water flow. Venturimeter is a device consisting of a short length of gradual convergence and a long length of gradual divergence. Pressure tapping is provided at the location before the convergence commences and another pressure tapping is provided at the throat section of a Venturimeter. The Difference in pressure head between the two tapping is measured by means of a U-tube manometer.

An Orificemeter is used to measure the discharge in a pipe. An Orificemeter in its simplest form consists of a plate having a sharp edged circular hole known as an orifice. The plate is fixed inside the pipe.

Orifice meters need calibration a priori where a known quantity of fluid is passed through the flow meter and the differential pressure across the flow meter related to the actual mass flow rate through a discharge coefficient given as the ratio of actual to theoretical mass flow rate. Two methods of knowing the actual mass flow rate are- measurement of time for collection of a finite volume of fluid and measurement of mass collected in a certain amount of time.

A mercury U-tube manometer is inserted to know the difference of pressure head between the two tapping. Orifice meter works on the same principle as that of Venturimeter i.e. by reducing the area of flow passage a pressure difference is developed between the two sections and the measurement of pressure difference is used to find the discharge.

FORMULA:

Coefficient of discharge = $C_d = Q_{act}/Q_{the}$

$Q_{act} = A.H/t$

$Q_{the} = a1\ a2\ /\sqrt{a1^2 - a2^2} * \sqrt{2gh}$ ……. For Venturimeter

$Q_{the} = a1\ ao/\ /\sqrt{a1^2 - ao^2} * \sqrt{2gh}$ ……. For orifice meter

`

OBSERVATION:

a) Venturimeter

S.No	Manometer reading pressure difference Hm (m)	Head loss h(m)	Time required for 10cm Rise of water (t) (sec)	Actual discharge Qact (m^3/sec)	Theoretical discharge Qthe (m^3/sec)	Coefficient of discharge Cd = Q_{act}/Q_{the}
1.						
2.						
3.						

a) Orifice meter

S.No	Manometer reading pressure difference Hm (m)	Head loss h(m)	Time required for 10cm Rise of water (t) (sec)	Actual discharge Q_{act} (m^3/sec)	Theoretical discharge Q_{the} (m^3/sec)	Coefficient of discharge Cd = Q_{act}/Q_{the}
1.						
2.						
3.						

Diameter of inlet pipe (d1) = Area of inlet pipe (a_1) =

Diameter of throat (d2) = Area of throat (a_2) =

Diameter of orifice (do) = Area of orifice (a_0) =

1. Head loss (h)= $(S_m/S_w - 1)Hm$

2. Actual discharge:

$Q_{act} = AH/t$

3. Theoretical discharge (Venturimeter):

$Q_{the} = a1\ a2 / \sqrt{a1^2 - a2^2} * \sqrt{2gh}$

Theoretical discharge (Orifice meter):

$Q_{the} = a1\ ao / \sqrt{a1^2 - ao^2} * \sqrt{2gh}$

4. Coefficient of discharge:

$C_d = Q_{act}/Q_{the}$

GRAPH:

Draw a graph between Qact vs √h and Qact vs Qthe. Take Qact in Y axis.

RESULT:

a) Coefficient of discharge (Cd) for Venturimeter =

b) Coefficient of discharge (Cd) for Orifice meter =

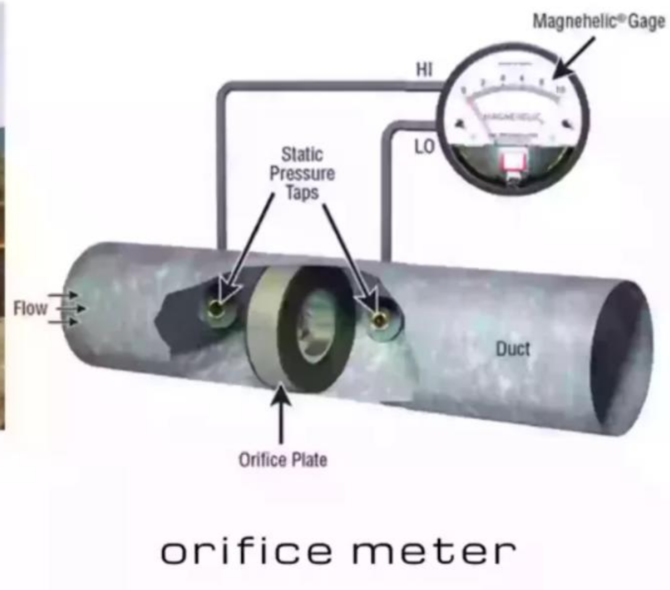
`

Viva Questions:

1. Draw the Venturimeter and mention the parts.
2. Why the divergent cone is longer than convergent cone in Venturimeter?
3. Compare the merits and demerits of Venturimeter with orifice meter.
4. Why Cd value is high in Venturimeter than orifice meter?
5. Mention few discharge measuring devices
6. What is the use of Venturimeter?
7. What is Venturimeter constant?
8. What is the principle of Venturimeter?
9. Why is the pressure difference between entrance and throat section increased due to friction?
10. It is recommended that the diffuser angle of a venturimeter should be kept less than _____
11. Define venturimeter
12. List out the types of venturimeters
13. Define horizontal Venturimeter
14. Define vertical Venturimeter
15. Define inclined Venturimeter
16. What is the use of horizontal Venturimeter?
17. What is the use of vertical Venturimeter?
18. What is use of inclined Venturimeter?
19. What is the range of throat ratio?
20. What is the range of Cd for Venturimeter?
21. Venturimeter are suitable for measuring low velocities or high velocities ?
22. Who found Venturimeter?
23. In which year Venturimeter is found
24. Write the discharge formula of Venturimeter.
25. What is meant by calibration?
26. What is meant by convergent section in Venturimeter?
27. What are the materials used in construction of Venturimeter?
28. What are the precautions to be taken in this experiment?
29. Define venture effect.
30. For what purpose Venturimeter is used?

PRACTICAL APPLICATIONS

Venturimeter & Orificemeter is a measuring or also considered as a meter device that is usually used in industries to measure the flow of a fluid in the pipe. A Venturimeter may also be used to increase the velocity of any type fluid in a pipe at any particular point. Both Venturimeter & Orifice meter basically works on the principle of Bernoulli's Theorem.



MID EXAMINATION QUESTIONS

1. Determine the actual discharge in the pipe for the given Venturimeter. Take Cd = 0.95.
2. Determine the actual discharge in the pipe for the given Orificemeter. Take Cd = 0.65.
3. Find the velocity of water in the pipe. Take the coefficient of discharge of Venturimeter as 0.95.
4. Find the velocity of water in the pipe. Take the coefficient of discharge of Orificemeter as 0.65.

UNIVERSITY EXAMINATION QUESTIONS

1. Find the coefficient of discharge (C_d) for the given Venturimeter.
2. Calculate the coefficient of discharge (C_d) for the given Orifice meter.

EXPERIMENT VIDEO LINKS

1. **https://www.youtube.com/watch?v=3wfUev6TQv0**
2. **https://www.youtube.com/watch?v=NsW-8FjgjpY**

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EXPERIMENT NO: 4

CALIBRATION OF TRIANGULAR / RECTANGULAR NOTCH / TRAPEZOIDAL NOTCH

OBJECTIVE:

To determine the co-efficient of discharge [C_d] for Triangular/Rectangular notch/Trapezoidal notch.

OUTCOME:

The student will be able to find the actual and theoretical discharges and co-efficient of discharges.

SCOPE:

The knowledge in practical applications notches through Triangular/Rectangular/Trapezoidal notch experiments.

APPARATUS:

Channel with triangular/rectangular notch, Point gauge, Collecting tank, Stop watch, Scale

EXPERIMENTAL SETUP:

The notch is a thin steel plate which placed across a channel to measure the rate of flow of water. Based on the shape of the crest notches are classified into rectangular notch, triangular notch and trapezoidal notch.

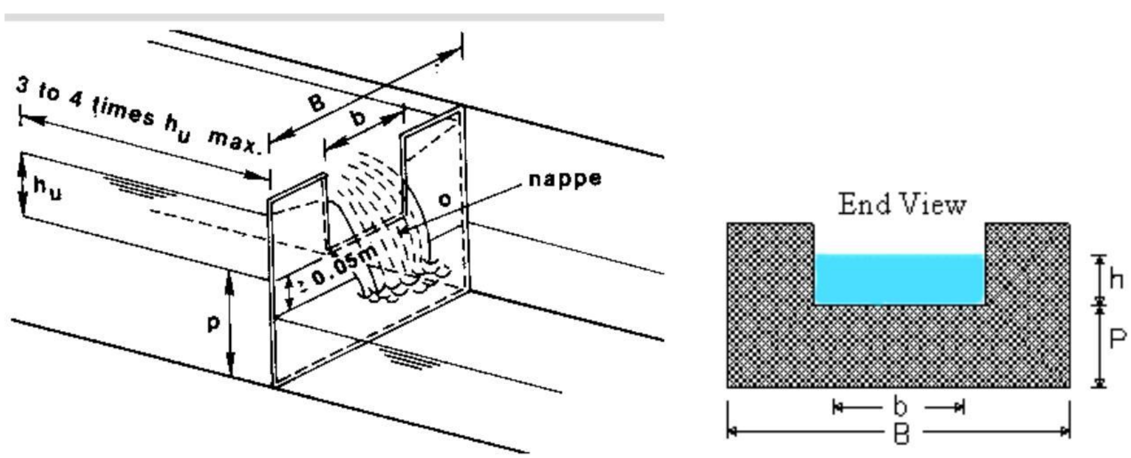

Fig 4.1 Rectangular Notch

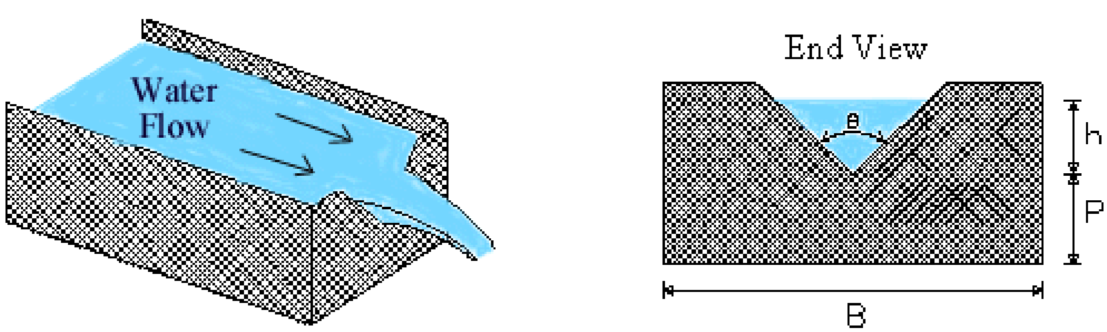

Fig 4.2 Triangular Notch

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PROCEDURE:

1. Position the notch plate at the end of approach channel, in a vertical plane, with the sharp edge on the upstream side.
2. Admit water to channel until the water discharges over the notch plate.
3. Close the flow control valve and allow water to stop flowing over weir.
4. Set the point gauge to a datum reading (H1).
5. Position the gauge about half way between the notch plate and stilling baffle.
6. Admit water to the channel and adjust flow control valve to obtain heads (H2).
7. For each flow rate, stabilize conditions, measure and record H.
8. Take readings of volume and time using the volumetric tank to determine the flow rate.

THEORY & FORMULA:

A notch is a device used for measuring the rate of flow of a liquid through a small channel or a tank. It may be defined as an opening in the side of a tank or a small channel in such a way treat the liquid surface edge of the opening.

a) Rectangular notch

Consider a rectangular notch provided in channel or tank carrying water. Let, H = Head of water of still or crest. b = width of notch.

For finding the discharge of water flowing over notch, consider an elementary horizontal strip of water of thickness 'dh' and length surface of water.

The area of strip = b x dh

∴ Theoretical discharge Q_{the} :

$$Q = \int_0^H C_d b.\sqrt{2.g}.\sqrt{h.dh}$$

$$Q = C_d.b.\sqrt{2.g}.\int_0^H \sqrt{h.dh}$$

$$Q = C_d.b.\sqrt{2.g}\,\frac{(H)^{3/2}}{3/2}$$

$$Q_{th} = \frac{2}{3}b\sqrt{2.g}(H)^{3/2}$$

b) Triangular notch

Theoretical discharge for the entire triangular notch may be integration above expression within limit O to H. Then,

$$Q = \int_0^H C_d.\times 2(Hh + H)\tan(\theta/2)dh.\sqrt{2.gh}.$$

`

Assuming coefficient C_d to be constant for entire notch

$$Q = C_d \times 2(H+h)\tan(\theta/2)\int_0^H \sqrt{h}(dh)$$

$$Q = C_d \times 2(H+h)\tan(\theta/2)\left[\frac{2}{3}H.h^{3/2} - \frac{2}{5}h^{5/2}\right]_0^H$$

$$Q = \frac{8}{15}C_d\left[\tan\left(\frac{\theta}{2}\right)\right]\sqrt{2.g}(H)^{5/2}$$

OBSERVATION:

a) Rectangular notch:

Width of crest in rectangular notch (B) =

S.No	Difference in water depth (H) (m)	Time required for 10cm Rise of water (t) (sec)	Actual discharge Q_{act} (m^3/sec)	Rectangular notch Theoretical discharge Q_{the} (m^3/sec)	Rectangular notch Coefficient of discharge Cd = Qact/Qthe
1.					
2.					
3.					

b) Triangular notch:

Triangular notch included angle (θ) =

S.No	Difference in water depth (H) (m)	Time required for 10cm Rise of water (sec)	Actual discharge Q_{act} (m^3/sec)	Triangular notch Theoretical discharge Q_{the} (m^3/sec)	Triangular notch Coefficient of discharge Cd = Qact/Qthe
1.					
2.					
3.					

1. **Actual discharge:**

Q = AH/t (H = 0.1m)

2. Theoretical discharge (Rectangular notch):

$$Q_t = \frac{2}{3}\sqrt{2g}\ \mathrm{BH}^{3/2}$$

3. Theoretical discharge (Triangular notch):

$$Q_t = \frac{8}{15}\sqrt{2g}\ \tan\frac{\theta}{2}H^{5/2}$$

4. Coefficient of discharge:

C_d (Rectangular) = Qact/Qthe

C_d (Triangular) = Qact/Qthe

`

GRAPH:

1. Plot a graph between Qact vs $H^{3/2}$ and Qact vs Qthe. Take Qact in Y axis for Rectangular notch.
2. Plot a graph between Qact vs $H^{5/2}$ and Qact vs Qthe. Take Qact in Y axis for Triangular notch.

RESULT:

a) Coefficient of discharge of Rectangular notch =

b) Coefficient of discharge of Triangular notch =

Viva Questions

1. Define a notch.
2. Define a weir.
3. Distinguish between a notch and weir.
4. What are the types of notches?
5. What is velocity approach?
6. Write the expression for the discharge over a rectangular notch.
7. Write the expression for the discharge over a triangular notch.
8. What are the advantages of triangular notch over rectangular notch?
9. What do you understand by end contraction of weir?
10. A notch is generally made off _______________
11. The head due to velocity of approach is given by_____________
12. What is the application of Notches?
13. Is the Coefficient of discharge a constant for all notches? Why?
14. What is Crest height?
15. Define nappe.
16. What are the applications of notch/weirs?
17. An error of 1% in measuring head over the apex of the notch (*H*) will produce an error of
18. ___________ in discharge over a triangular notch.
19. An error of 1% in measuring head over the apex of the notch (*H*) will produce an error of
20. ___________ in discharge over a rectangular notch. .
21. What are the precautions to be made in this experiment
22. The error in the discharge due to the error in the measurement of head over a rectangular notch or weir is given by________________
23. The error in the discharge due to the error in the measurement of head over a Triangular notch or weir is given by________________
24. For measuring the flow of water in river which measuring device is used_________
25. Which material is used to construct weir ______________
26. Notch is usually made of ______________
27. What is the angle used in triangular notch?
28. What is the coefficient of discharge for triangular notch?
29. What is the coefficient of discharge for rectangular notch?
30. The discharge over a rectangular notch is proportional to ________

`

PRACTICAL APPLICATIONS

Notches are generally used to measure flow rate in an open channel flow.In real life applications it is used for seepage measurement of dam in foundation, inspection and top galleries and toe-drains in reservoirs. When small quantity of flow need to be measured the V-notch is preferable because the triangular cross-section of the flow 'nappe' leads to a relatively greater variation in head. V-notch has the advantage that it can function for a very small flows and also measure reasonably larger flows as well.

Rectangular Notch

Triangular Notch

MID EXAMINATION QUESTIONS

1. Determine the actual discharge in the open channel flow using rectangular notch. Take coefficient of discharge of the notch as 0.62.
2. Determine the width of crest of the rectangular notch. Take coefficient of discharge of the notch as 0.62.
3. Determine the included angle of the triangular notch. Take coefficient of discharge of the notch as 0.8.
4. Determine the actual discharge in the open channel flow using triangular notch. Take coefficient of discharge of the notch as 0.8.

UNIVERSITY EXAMINATION QUESTIONS

1. Find the Coefficient of discharge for the given Rectangular notch having 10cm crest width.
2. Calculate the Coefficient of discharge for the given Triangular notch having 60° included angle.

EXPERIMENT VIDEO LINKS

1. **https://www.youtube.com/watch?v=HGQM913rI10**
2. **https://www.youtube.com/watch?v=K2NyRPGPS-8**
3. **https://www.youtube.com/watch?v=YaQkU5FfigM**

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EXPERIMENT NO: 5

DETERMINATION OF MINOR LOSSES IN PIPE FLOW

(Sudden Expansion & Sudden Contraction)

OBJECTIVE:

To determine the loss of head due to sudden expansion & sudden contraction in the pipe flow.

OUTCOME:

The student will be able to find the minor losses and its effects on the pipe flow.

SCOPE:

The knowledge in various minor losses in the pipe flow is necessary for the design of pipes, calculating velocity and discharge in the pipe flow.

APPARATUS:

Pipe of smaller diameter connected to larger diameter, Pipe of larger diameter connected to smaller diameter inlet, outlet valves, collecting tank, stop watch etc.

EXPERIMENTAL SETUP:

Two pipe of cross-sectional area A1 and A2 flanged together with a constant velocity fluid flowing from smaller diameter pipe. This flow breaks away from edges of narrow edges section, eddies from and resulting turbulence cause dissipation of energy. The initiations and onset of disturbances in turbulence is due to fluid momentum and its area.

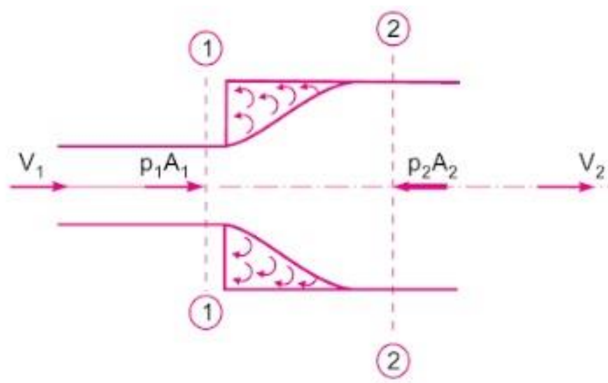

Fig.5.1 Sudden Expansion

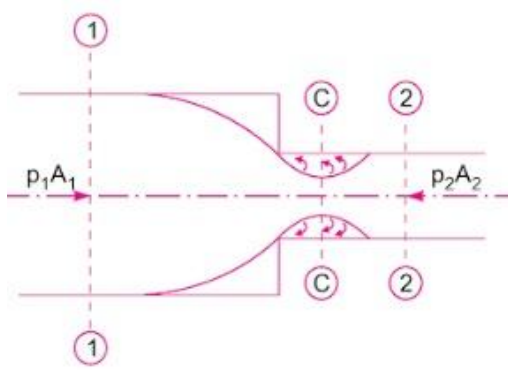

Fig.5.2 Sudden Contraction

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PROCEDURE:

1. Measure the diameter of the pipes.
2. Prime the mercury manometer
3. Connect the test section pipe to the main water supply pipe
4. Open flow control valve, priming test section and pipe work.
5. Open clips on water manometer, allowing water to circulate through the system until all the air is expelled.
6. Close pipe clips.
7. Bleed mercury manometers via bleed sewers in conjunction with control valves
8. Close flow control valve.
9. Observe datum level on manometers.
10. To achieve maximum flow fully open flow control valve. Note levels in manometer and measure flow rate. Repeat for different control valve position.

THEORY:

a) Sudden expansion:

Loss of energy duet to change of velocity of the flowing fluid in magnitude or direction is called as minor loss of energy. Consider a fluid flowing through a pipe line which has sudden enlargement. Consider two section 1 – 1 and 2 – 2 before and after enlargement.

Let,

P1 = Pressure intensity at section 1 – 1.

V1 = Velocity of flow at section 1 – 1.

A1 = Area of pipe at section 1 – 1.

P2, V2 and A2 = Corresponding values of pressure, velocity & area at section 2 - 2.

Due to sudden change of diameter, the liquid flowing from smaller pipe is not able to fallow abrupt change of boundary and turbulent eddies are formed, since the flow separates from the boundary.

Let,

P1 = Pressure intensity of the liquid eddies on Area A2 – A1,

he = Loss of head due to expansion.

Applying Bernoulli's equation at section 1 – 1 and 2 – 2.

—

$$\frac{p_1}{w} + \frac{v_1^2}{2g} + Z_1 = \frac{p_2}{w} + \frac{v_2^2}{2g} + Z_2$$

But Z1 = Z2

$$h_e = \left(\frac{p_1}{w} - \frac{p_2}{w}\right) + \left(\frac{v_1^2}{2g} - \frac{v_2^2}{2g}\right) \text{ ------- } 1$$

Consider the control volume of liquid between 2 sections.

$Fx = P_1 A_1 + P_1 (A_2 - A_1) P_2 A_2 = (P_1 - P_2) A_2$ --------------------------2.

Momentum of liquid / sec at section 1 –1 = Mass x Velocity

$= \varrho A_1 V_1 \cdot V_1$

$= \varrho A_1 V_1^2$

Similarly Momentum of liquid / sec at section 2 – 2 = $\varrho A_2 V_2^2$

∴Change of momentum / Sec $= \varrho A_2 V_2^2 – \varrho A_2 V_2 \times V_1$

$= \varrho A_2 (V_2^2 – V_1 V_2)$ ------- 3.

Net force acting on the control vol. in the direction of flow must be equal to the rate of change of momentum per second. Hence equating equation 2 and 3.

$$(P_1 - P_2) A_2 = \varrho A_2 (V_2^2 – V_1 V_2)$$

On solving we get $He = (V_1 – V_2)^2 / 2g$

Where : He = Loss of head due to sudden expansion.

V_1 = Velocity of flow at smaller section.

V_2 = Velocity of flow at larger Section.

b) Sudden contraction:

Water is flowing from large diameter pipe to smaller diameter pipe as shown in figure. The loss of head due to sudden contraction is actually due to sudden enlargement from vena-contracta to sec.2.

$$Hc = 0.5V_2^2 /2g$$

OBSERVATION:

a) Sudden expansion:

S.No	Difference in manometric reading (m)	Pressure head difference (m)	Time required for 10cm rise of water (t) sec	Actual discharge (Qact) (m^3/sec)	Inlet velocity V_1 (m/sec)	Outlet velocity V_2 (m/sec)	Head loss due to expansion (m) $He = (V_1-V_2)^2/2g$
1.							
2.							
3.							

Diameter of smaller pipe (d1) =

Diameter of larger pipe (d2) =

1. **Pressure head loss (H)** = $(S_m/S_w -1)Hm$

2. **Actual discharge:**

$$Qact = AH/t$$

`

3. **Inlet velocity (V_1)** $= 4Q/Лd_1^2$

4. **Outlet velocity (V_2)** $= 4Q/Лd_2^2$

5. **Loss of head (He)** $= (V_1-V_2)^2/2g$

b) Sudden contraction:

S.No	Difference in manometric reading (m)	Pressure Head loss (m)	Time required for 10cm rise of water (sec)	Actual discharge (Qact) (m^3/sec)	Outlet velocity V_2 (m/sec)	Head loss due to contraction $Hc = (0.5V_2)^2/2g$
1.						
2.						
3.						

Diameter of larger pipe (d1) =

Diameter of smaller pipe (d2) =

1. **Pressure head loss (H) =** $(S_m/S_w -1)Hm$

2. **Actual discharge:**

   Qact = AH/t

3. **Inlet velocity (V_1)** $= 4Q/\pi d_1^2 =$

4. **Outlet velocity (V_2)** $= 4Q/\pi d_2^2 =$

5. **Loss of head (Hc)** $= 0.5V_2^2/2g =$

GRAPH:

1. Draw the graph between Qact vs Head loss due to expansion. Take Qact in Y axis
2. Draw the graph between Qact vs Head loss due to contraction. Take Qact in Y axis

RESULT:

a) Head loss due to sudden expansion (H_e) =

b) Head loss due to sudden contraction (H_c) =

`

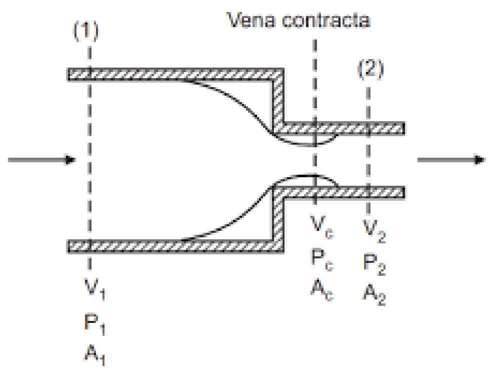
Viva Questions:

1. Minor losses occur due to ___________________
2. Minor losses do not make any serious effect in ___________
3. What is the correct formula for loss at the exit of a pipe?
4. Loss of head due to sudden enlargement is given by ?
5. Loss of head due to sudden contraction is given by ?
6. Write the formula for loss of head at the entrance to pipe ?
7. Write the formula for loss of head at the exit of pipe ?
8. Write the formula for loss of head at the bend in pipe ?
9. Define Minor losses.
10. Define Cc in loss of head due to contraction.
11. What is the value of Cc?
12. What is the difference between friction factor and coefficient of friction?
13. What is loss coefficient?
14. What is pipe?
15. What are the types of flow of fluid in a pipe?
16. What is frictional resistance?
17. What is the effect of change in Reynold's number on friction factor in turbulent flow?
18. The friction factor in fluid flowing through pipe depends upon______
19. What are the units of loss of head due to friction?
20. What is the equation to determine head loss for minor losses?
21. How many types of energy losses are there?
22. Major losses are due to?
23. What are the precautions taken in this experiment?
24. What are the formulas used to measure major energy losses?
25. What is the chezy's formula for measuring the loss of head due to friction?
26. Why does the pressure a long a horizontal pipe go on decreasing?
27. What is hydraulic gradient line?
28. In a pipe where the velocity of flow is high
29. Are the loss coefficients constant?
30. Distinguish between major loss, minor loss and head loss.

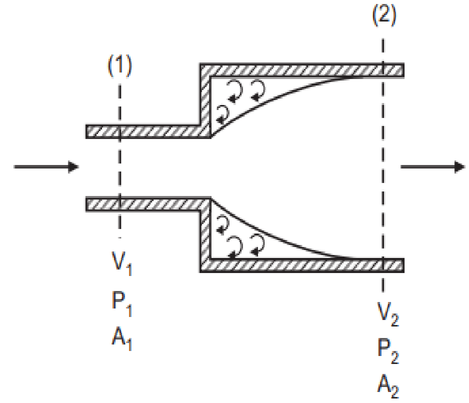
`

PRACTICAL APPLICATIONS

In practical setting, fluid flows through different pipe fittings such as sudden contraction, sudden enlargement valve, elbow or bend, tee section etc. Sudden changes in the flow path result in secondary flow patterns, denoted as separation region and vena contracta. In the pipe network there may sudden change in pipe diameter, In any change in pipe diameter there is considerable head loss and we need to calculate the loss. From this experiment, we can determine the coefficient to calculate the losses.



Sudden Contraction



Sudden expansion

MID EXAMINATION QUESTIONS

1. Determine the loss of head due to sudden expansion and sudden contraction.
2. Determine the minor losses in the pipe flow.
3. Determine the power lost due to sudden expansion and sudden contraction.
4. Determine the actual discharge in the pipe flow due to sudden expansion & contraction

UNIVERSITY EXAMINATION QUESTIONS

1. Find the minor losses due to sudden expansion and sudden contraction in the pipe flow.
2. How minor losses occur in the pipe flow? Conduct an experiment find the head loss due to sudden expansion and sudden contraction.

EXPERIMENT VIDEO LINKS

1. **https://www.youtube.com/watch?v=7tI_1qVOAE4**
2. **https://www.youtube.com/watch?v=6z4NZY-iwZQ**

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EXPERIMENT NO: 6

DETERMINATION OF FRICTION FACTOR OF A PIPE LINE

OBJECTIVE:

To investigate the friction factor (f) for a pipe carrying water.

OUTCOME:

The student will be able to find the major loss due to friction and its effects in a pipe flow.

SCOPE:

The knowledge in major loss in the pipe flow is necessary for the design of pipes, calculating velocity and discharge in a pipe flow.

APPARATUS:

U – tube manometer connected across a pipe line, Stop Watch, Collecting tank.

EXPERIMENTAL SETUP:

The equipment used in the experiment was the fluid flow setup and the materials used were steel tape, stopwatch and thermometer. Water was used as the working fluid. The pump was primed and started in order for the fluid to initiate the flowing along the pipelines. Collecting tank collects the water for calculating volumetric flow rate.

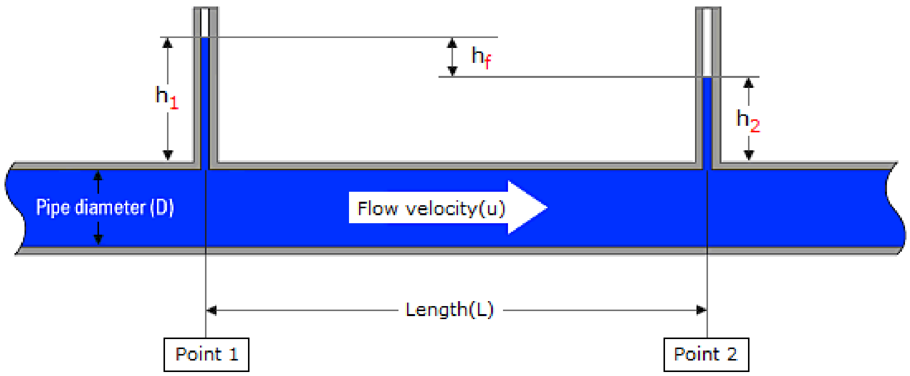

Fig.6 Experimental setup

PROCEDURE:

1. Measure the diameter of the pipe and distance between the two tapings.
2. Prime the mercury manometer.
3. Connect the test section pipe to the main water supply pipe.
4. Open flow control valve, priming test section and pipe work.
5. Open clips on water manometer, allowing water to circulate through the system until all the air is expelled.
6. Close pipe clips.
7. Bleed mercury manometer via bleed screws in conjunction with the control valves.
8. Close flow control valve.

`

9. Observe datum level on manometer.

10. To achieve maximum flow fully open flow control valve. Note levels in manometer and measure flow rate. Repeat for different control valve position.

THEORY:

In fluid dynamics, the **Darcy–Weisbach** equation is an empirical equation that relates the head loss, or pressure loss, due to friction along a given length of pipe to the average velocity of the fluid flow for an incompressible fluid. The equation is named after Henry Darcy and Julius Weisbach (1806-1871). A pipe is a closed conduit which is used for carrying fluids under pressure. Pipes are commonly circular section. As the pipes carry fluids under pressure, the pipes always run full.

The fluid flowing in a pipe is always subjected to resistance due to shear forces between fluid particles and the boundary walls of the pipe and between the fluid particles themselves resulting from the viscosity of the fluid. The resistance to the flow of fluid is, in general known as frictional resistance. Since certain amount of energy possessed by the flowing fluid will be consumed in overcoming this resistance to the flow, there will always be some loss of energy in the direction of flow, which however depends on the type of flow, W.froude conducted a series of experiments to investigate frictional resistance offered to the flowing water by different surfaces.

As per Darcy Weisbach equation

$$hf = 4flv^2/2gd.$$

Above equation is used to find loss of head due to friction in pipes. Here is f friction factor. In order to determine the loss of head due to friction correctly, it is essential to estimate the value of the factor f correctly when a fluid flows through a pipe, certain resistance is offered to the flowing fluid, which results in causing a loss of energy. The various energy losses in pipes may be classified as

i) major losses

ii) minor losses

The major loss of energy, as a fluid of flows through a pipe, is caused by friction. It may be computed by Darcy-Weisbach equation. The loss of energy due to friction is classified as a major loss because in the case of long pipelines it is usually much more than the loss of energy incurred by other causes.

FORMULA:

Loss of head due to friction (hf) = $4flv^2/2gd$

Where,

f = friction factor

l = length of the pipe

v = velocity in the pipe

d = diameter of the pipe

`

is Darcy Weisbach equation which is commonly used for computing the

OBSERVATION:

Diameter of the pipe (d) = Area of the pipe =

Length of the pipe (l) =

S.No	Difference in manometric reading (m) (Hm)	Frictional head loss(h_f) (m)	Time required for 10cm rise of water (t) (sec)	Actual discharge (Qact) (m^3/sec)	Velocity in the pipe (m/sec)	Friction factor (f)
1.						
2.						
3.						

1. **Frictional head loss (hf)** $= (S_m/S_w - 1)Hm$
2. **Actual discharge: Q_{act}** $= AH/t$
3. **Velocity (V)** $= 4Q/\pi d^2$
4. **Friction factor (f)** $= \frac{2\ h_f\ g\ d}{4lV^2} =$

GRAPH:

Draw the graph between hf vs $V^2/2g$ with hf on X-axis.

RESULT:

The friction factor "f" for the pipe is found to be ________.

`

Viva Questions:

1. The major loss for the flow through the pipes is due to the ________
2. Which property of the fluid accounts for the major losses in pipes?
3. In case of laminar flow the loss of head is approximately proportional to its ?
4. In case of turbulent flow the loss of head is approximately proportional to its ?
5. _____________formula is generally used for head loss in flow through both pipes
6. The head loss at the entrance of the pipe is that at it's exit
7. Write the formula for head loss in pipes due to friction
8. Write the formula for friction factor(f) using Blasius equation
9. How do we calculate losses for a larger range of Reynolds number?
10. Darcy- Weisbach equation gives relation between__________
11. What happens to the head loss when the flow rate is doubled?
12. The energy loss in a pipe line is due to?
13. In case of turbulent flow through pipes the viscous friction associated with fluid are proportional to ?
14. In formula loss of head due to friction in pipe the factor "f" is known as ?
15. What is pipe?
16. What are the types of flow of fluid in a pipe?
17. What is frictional resistance?
18. What is the effect of change in Reynold's number on friction factor in turbulent flow?
19. The friction factor in fluid flowing through pipe depends upon
20. What are the units of loss of head due to friction?
21. The coefficient of friction interms of shear stress is given by f= ?
22. How many types of energy losses are there
23. Major losses are due to?
24. What are the precaution taken in this experiment?
25. Name the scientist who conducted a series of experiments to investigate frictional resistance offered to the flowing water by different surfaces
26. What are the formulas used to measure major energy losses?
27. What is the chezys formula for measuring the loss of head due to friction?
28. Why does the pressure a long a horizontal pipe go on decreasing?
29. What is hydraulic gradient line?
30. In a pipe where the velocity of flow is high?

`

PRACTICAL APPLICATIONS

Flow through a single pipe line, pipes in series and parallel and also in pipe network system, cause head loss due to friction. The head loss from source to the point of interest due to the friction along the pipe also provides the basis of pipe size (diameter) design. This experiment gives an estimate of head loss due to friction in the pipe per unit length of the pipe.

MID EXAMINATION QUESTIONS

1. Determine the loss of head due to friction for the given pipe.
2. Determine the difference in actual discharge for the given Stainless Steel pipe and GI pipe of 20 mm diameter.
3. Find the velocity of flow in the given Stainless Steel pipe and GI pipe of 20 mm diameter.

UNIVERSITY EXAMINATION QUESTIONS

1. Find the friction factor for the given Stainless Steel pipe and GI pipe of 20 mm diameter.
2. What is the effect of major loss in the pipe flow? Conduct an experiment find the head loss due to friction.

EXPERIMENT VIDEO LINKS

1. **https://www.youtube.com/watch?v=f83D4h2LN4I**
2. **https://www.youtube.com/watch?v=tSVwiAc8DWo**

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EXPERIMENT NO: 7

DETERMINATION OF ENERGY LOSS IN HYDRAULIC JUMP

OBJECTIVE:

To understand the Energy loss in Hydraulic jump through an experiment.

OUTCOME:

The student will be able to verify the total Energy loss in Hydraulic jump.

SCOPE:

The knowledge of Energy loss in Hydraulic jump is used for flow measuring device like at Dams, rivers and other slope areas.

APPARATUS:

Open Channel Flow Setup, Depth Gauges, Stopwatch

EXPERIMENTAL SETUP:

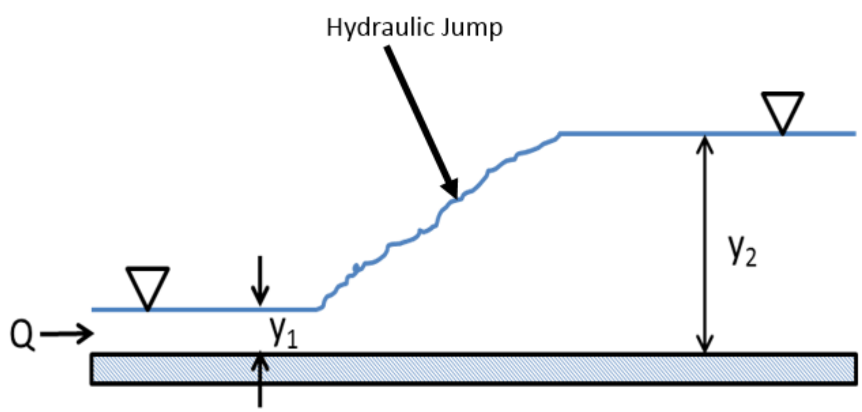


Fig.7 Hydraulic Jump experimental setup

PROCEDURE:

1. Set the channel for a given slope.
2. Close both the inlet and outlet gates.
3. Allow water in the channel.
4. Open the gate II completely.
5. Open the gate I slightly, so that water flows under the gate in supercritical (shooting) condition.
6. Close the gate II gently, so that it causes obstruction to the shooting flow, and a Hydraulic Jump is formed.
7. Regulate the gate II finely that the Hydraulic Jump stays at the middle of the channel.
8. With the help of traveling hook gauge measure the conjugate depths of the flow before and after the Hydraulic Jump, y1 and y2.
9. Note the time taken for 'R' level rise for calculating the actual discharge.

`

THEORY:

Hydraulic jump forms in an open channel when the unstable super critical flow changes to the stable sub critical flow. This change in the flow condition will cause the flow to cross the critical depth. As the water surface slope becomes infinity at the critical depth, the water surface tends to become vertical which is manifested in the formation of a hydraulic jump. Since the hydraulic jump occurs in an abrupt manner over a relatively short distance. It is classified as rapidly varied flow. The flow in a hydraulic jump is accompanied by the formation of turbulent rollers resulting in a considerable dissipation of energy.

The formation of hydraulic jump also known as standing wave occurs frequently in a canal below a regulating sluice, at the foot of a spillway or at the place where the bottom slope of the channel changes from steep to mild.

FORMULA:

1. Velocity before the jump, $V_1 = Q/(W \times y1)$ m/sec
2. Velocity after the jump, $V_2 = Q/(W \times y2)$ m/sec
3. Loss of Energy, $E_L = (y2-y1)^3 / 4y1y2$ m.kg/kg

OBSERVATION:

Depth before jump, y1=

Depth after jump, y2=

Sl. No.	Depth before jump (y1) m	Depth after jump (y2) m	Time taken for 10 cm rise of water in the collecting tank (t) sec
1.			
2.			
3.			

Sl. No	Discharge Q (m^3/sec)	Velocity V1 (m/sec)	Velocity V2 (m/sec)	Loss of Energy (E_L)	Average Loss of Energy
1.					
2.					
3.					

1. Actual discharge:

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

2. Velocity before the jump, $V_1 = Q/(W \times y_1) =$

3. Velocity after the jump, $V_2 = Q/(W \times y_2)) =$

4. Loss of Energy, $E_L = (y_2 - y_1)^3 / 4y_1y_2 =$

GRAPH:

Draw the graph between Qact vs Loss of energy.

RESULT:

Average Loss of Energy due to Hydraulic Jump, E_L =

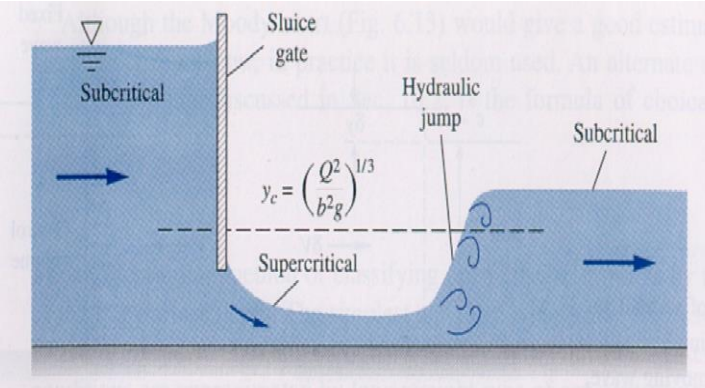
`

Viva-Questions

1. Define open channel flow.
2. What is meant by hydraulic jump?
3. Explain zone of zero velocity.
4. Define liquid surface.
5. Define kinetic Energy.
6. Explain energy transition in flow.
7. Explain the phenomenon
8. What is Froude Number?
9. Where Hydraulic Jump does occur?
10. What is the range of Froude Number for Sub Critical and Super Critical Flows?
11. Explain Sub Critical, Super Critical flows.
12. Derive the expression for energy lost due to Hydraulic Jump?
13. Why hydraulic jump occurs?
14. Is it possible for subcritical flow to undergo a hydraulic jump?
15. What are waves?
16. Define celerity of wave.
17. What are surges?
18. What is meant by positive type surge?
19. What is meant by negative type surge?
20. Describe discharge measurement of canal by current meters
21. How hydraulic jump used as an energy dissipater?
22. Describe different kinds of waves.
23. Differentiate between positive and negative surge?
24. What is Reynold's number
25. Explain critical flow.
26. What is critical velocity of flow in open channel?
27. What is the fundamental difference between flow domain and control volume?
28. Define critical speed.
29. Explain transition zone.
30. What is the effect of hydraulic jump on erodible surfaces?

PRACTICAL APPLICATIONS

Usually Hydraulic jump reverses the flow of water. Hydraulic jump usually maintains the in high water level on downstream side. the water level can be used for irrigation purposes. hydraulic jump can be used to remove the air from water supply and sewage lines to prevent the air locking.



MID EXAMINATION QUESTIONS

1. Determine the Average Loss of Energy due to Hydraulic Jump.
2. A rectangular horizontal channel 1m wide, which carries a flow. The depth water on the downstream side of the hydraulic jump.
3. Find the average loss of energy loss in Hydraulic Jump.
4. Determine the Fluid flow after the hydraulic jump.

UNIVERSITY EXAMINATION QUESTION

1. Determine the energy loss due to hydraulic jump in an open channel flow.

EXPERIMENT VIDEO LINKS

1. **https://www.youtube.com/watch?v=5etwhZ0d2GU**

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EXPERIMENT NO: 8

DETERMINATION OF MANNING'S AND CHEZY'S CONSTANTS FOR OPEN CHANNEL FLOW

OBJECTIVE:

To determine the Chezy's and Manning's constant for an open channel.

OUTCOME:

The student will be able to verify the total head of Chezy's and Manning's constant for an open channel.

SCOPE:

The knowledge of the Chezy's and Manning's constant is used for flow measuring device like Dams, rivers and different water levels.

APPARATUS:

Open Channel Flow Setup, Stop Watch

EXPERIMENTAL SETUP:

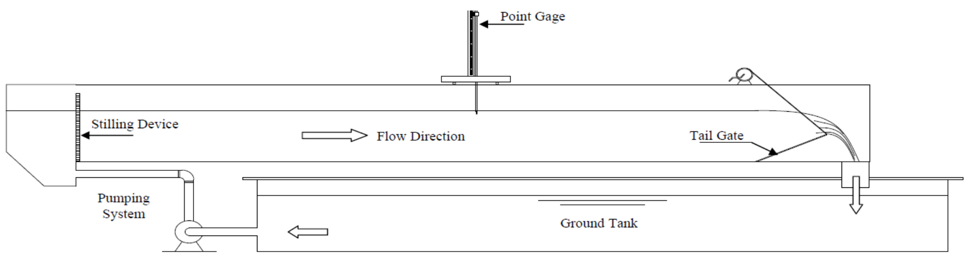


Fig.8 Open channel experimental setup

PROCEDURE:

1. Set the channel for the required slope and allow the water to flow through the channel.
2. Adjust the inlet valve to get the required depth of water in the channel and measure the depth as d cm, using pointer gauge.
3. Adjust the inlet valve opening to get the required depth of water in the channel
4. Note the time 't' to collect water for a rise of 'H' m in the measuring tank.
5. Repeat the experiment for different depths of water for the same bed slope.

THEORY:

Chezy's equation was presented in 1775. It states that velocity in an open channel flow is a function of hydraulic radius and slope of the channel bed. It describes the mean flow velocity of steady, turbulent open channel flow. The formula is named after **Antoine de Chezy** (1718-1798), the French hydraulics engineer who devised it in 1775. One the most commonly used equations governing Open Channel Flow is known as the Mannings's Equation. It was introduced by the Irish Engineer **Robert Manning** in 1889 as an alternative to the Chezy Equation. The Manning's equation is an empirical equation that applies to uniform flow in open channels and is a function of the channel velocity, flow area and channel slope.

`

FORMULA:

Chezy's formula,

$$V = C * \sqrt{(mi)}$$

Where,

V = Average Velocity (m/s)

C = Chezy's Constant

m = hydraulic mean depth (m)

i = bottom slope (m/m)

The Manning's formula is an empirical formula estimating the average velocity of a liquid flowing in an open channel.

Gauckler-Manning formula,

$$V = (1/N)\, R^{2/3}\, S^{1/2}$$

$$= (1/N)\, m^{2/3}\, i^{1/2}$$

Where,

V = Average Velocity (m/s)

R = the hydraulic radius = depth (m)

N = Manning's constant

S = Slope of the hydraulic gradient line (m/m)

Manning derived the following relation between Manning's Constant and Chezy's Constant,

$$C = \frac{1}{N} \times m^{1/6}$$

OBSERVATION:

1. Length of channel, L = m
2. Width of the channel, W = m
3. Area of the collecting tank, A = m^2

S. No.	Bed Slope (i)	Depth of water in the channel (d) (m)	Time taken for 10 cm rise of water (t)	Discharge (Qact) (m^3/sec)
1.				
2.				
3.				

`

S. No.	Bed Slope (i)	Hydraulic Mean depth (m)	Discharge (Qact) m^3/s	Velocity (V) m/s	Chezy's Constant	Manning's Constant
1.						
2.						
3.						

1. Slope of the channel, i = vertical shift of channel from pointer (y /L)
2. Hydraulic mean radius, m = Area/Wetted perimeter = wd /(w+2d)
3. Actual Discharge, (Q) = AH/t
4. Velocity, V = Q / (wxd)
5. Chezy's constant, C = V /√(mi)
6. Manning's constant, N = 1/C x m $^{1/6}$

RESULT:

1. Average Chezy's constant for the given channel, C =
2. Average Manning's constant for the given channel, N =

Viva Questions:

1. What do Chezy’s and Manning’s constants represent?
2. What is the statement of Chezy’s equation?
3. What are the assumptions in Chezy’s and Manning’s equations?
4. What the use of knowing Chezy’s and Manning’s constants for an open channel?
5. What is the importance of studying roughness of the open channel?
6. Derive the expression for finding roughness of the open channel?
7. What is meant by open channel?
8. Define laminar flow.
9. Define transitional flow.
10. What is meant by hydraulic mean depth?
11. What are limitations of manning’s equation?
12. What is the expression for chezys formula?
13. What is the Value of manning’s coefficient for cement concrete?
14. What is the expression for manning’s formula?
15. What is the maximum value of manning’s coefficient for soil?
16. What is the relation between chezys and manning’s formula?
17. Define free surface.
18. Define open channel flow.
19. Define steady flow.
20. Define unsteady flow.
21. Define turbulent flow.
22. Define uniform flow.
23. Define varied flow.
24. Define rapidly varied flow.
25. Define steadily varied flow.
26. Define continuous flow.
27. Define discontinuous flow.
28. Define rate of flow.
29. How does viscosity impact the flow in an open channel?
30. What are the internal forces in an open channel flow?

PRACTICAL APPLICATIONS

The Chezy's and Manning formula are empirical formulas estimating the average velocity of a liquid flowing in a conduit that does not completely enclose the liquid, i.e., open channel flow. However, this equation is also used for calculation of flow variables in case of flow in partially full conduits, as they also possess a free surface like that of open channel flow. All flow in so-called open channels is driven by gravity. The most common application is used in cannel and culvert, dams and also common forestry/rangeland/agriculture to estimate flood travel time in land-use management.

Rectangular channel

Trapezoidal channel

MID EXAMINATION QUESTIONS

1. Determine the Chezy's and Manning's constant for an open channel.
2. What are the external forces involved in the Chezy's and Manning's constant?
3. What is the relation between the Chezy's and Manning's constant?
4. Using the open channel setup determine the Chezy's and Manning's constant.

UNIVERSITY EXAMINATION QUESTION

1. Determine the Chezy's and Manning's constant for an open channel.

EXPERIMENT VIDEO LINKS

1. **https://www.youtube.com/watch?v=MIULW-w3pPo**

EXPERIMENT NO: 9

IMPACT OF JET ON VANES

OBJECTIVE:

To determine the coefficient of impact when jet strikes a) Flat Vane b) Curved Vane with 135^0 angle of deflection.

OUTCOME:

The student will be able to verify average coefficient of impact on flat vane and curved vane from the experiment.

SCOPE:

The knowledge of impact of jet on vanes is used for flow measuring device like Flat Vane, Turbine vanes and other plates.

APPARATUS:

Jet and Vane Setup, Flat and Curved Vanes, Digital Weighing Balance, Stop watch

EXPERIMENTAL SETUP:

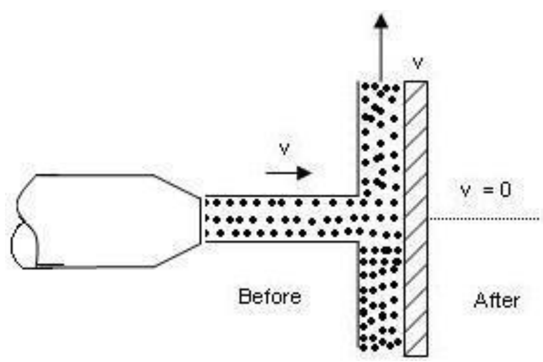


Fig 9.1 Jet striking flat stationary plate

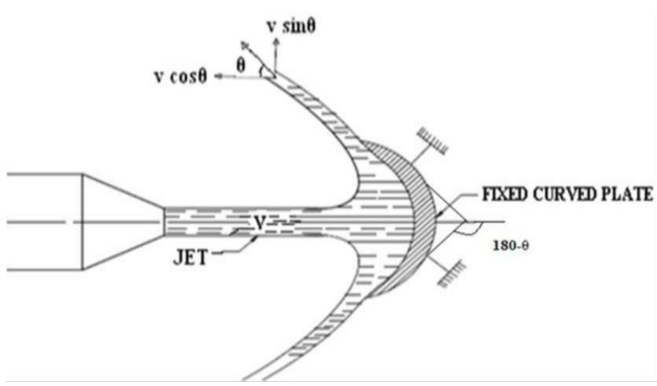


Fig 9.2 Jet striking curved stationary vane

PROCEDURE:

1. Fix up the required vane to the setup and balance the lever.
2. Start the water supply and adjust the water flow to allow the jet create an impact on the fixed vane such that lever will be lifted up.
3. Note the lifting or impact weight on the vane using digital weighing balance as a positive value.
4. Measure the time required (T) for 10cm rise of water level in the collecting tank by closing its valve.
5. The experiment is repeated for a minimum of 3 times for different input discharges.
6. Tabulate the observations as shown in Tabular Column and calculate the average Ci value by substituting the values of Fa and Ft obtained.

THEORY:

A fluid jet is a stream of fluid issuing from a nozzle with a high velocity and hence a high kinetic energy. When a jet strikes a plate or vane, it exerts a force on it due to change in momentum as shown in figures 9.1 and 9.2. This force can be evaluated by using impulse momentum principle.

The following cases of impact of jet will be considered:

1. When jet strikes stationary flat plate
2. When jet strikes moving flat plate
3. When jet strikes stationary inclined plate
4. When jet strikes moving inclined plate
5. When jet strikes stationary curved vane
6. When jet strikes moving curved vane

OBSERVATIONS:

1. Diameter of the nozzle (d) =
2. Area of orifice (a) = $\pi/4 * d^2$ =

Sl. No.	Actual Force (Fa) kg	Time taken for 10 cm rise (H) of water in the collecting tank (t) sec
1.		
2.		
3.		

Sl. No.	Discharge Q (m^3/sec)	Velocity V (m/sec)	Theoretical Force Ft (kg)	Actual Force Fa (kg)	Coefficient of Impact Ci	Average Coefficient of Impact
1.						
2.						
3.						

1. Actual discharge, Q= $\frac{AH}{t}$

2. Velocity of Water, V = Q/a

3. Actual force, F_a =

4. Theoretical Force, $F_t = \rho aV$

5. Coefficient of Impact, $C_i = F_a/F_t$

GRAPH:

Plot the graph between F_a (on X-axis) and V^2 (on Y-axis)

RESULT:

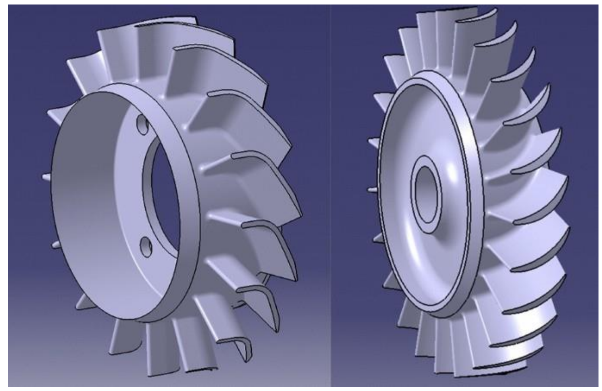
1. Average Coefficient of Impact on flat Vane from the experiment, C_i =
2. Coefficient of Impact on Flat Vane from the graph, C_i =

Viva Questions:

1. What is Impulse Momentum principle?
2. What is the density of water?
3. Define viscosity.
4. What is Vane and explain its significance.
5. What is mass flow rate?
6. Classify the Vanes based on shape.
7. Classify different types of flows in pipes.
8. What will happen to the overall velocity of water when the cross sectional area is reduced?
9. What are the losses observed in this experiment?
10. Define discharge.
11. What do you mean by impact of jet?
12. Write the formula for force exerted by a jet of water on a stationary & moving plate.
13. What is mass momentum principle?
14. What is the effect of density of fluid on force of impact?
15. What is the force exerted by jet on unsymmetrical rough surface fixed curved vane?
16. What is jet propulsion?
17. What is the difference between flow through a pipe and jet?
18. What kind of losses did you note in this experiment?
19. How will you estimate the force exerted by a jet?
20. How will you calculate the force exerted by water on a stationary plate?
21. How will you calculate the force exerted by water on an inclined plate?
22. How will you calculate the pressure exerted by water on an submerged plate?
23. Define force.
24. Define momentum.
25. Define energy.
26. If the velocity of jet increases will it increase the force?
27. Which one will be more efficient in receiving the force from a jet a plane plate, concave plate or convex plate?
28. What is the purpose of nozzle in this experiment?
29. How will you calculate the force on the plate from discharge?
30. Define impact.

PRACTICAL APPLICATIONS

Engineers and designers use the momentum equation to accurately calculate the force that moving fluid may exert on a solid body. For example, in hydropower plants, turbines are utilized to generate electricity. Turbines rotate due to force exerted by one or more water jets that are directed tangentially onto the turbine's vanes or buckets. The impact of the water on the vanes generates a torque on the wheel, causing it to rotate and to generate electricity.



MID EXAMINATION QUESTIONS

1. Determine the Impact of Jet on a Plate or Vane.
2. Explain a jet of water impinging normally on a flat plate at rest.
3. Determine the coefficient of impact when jet strikes with 1350 angle of deflection.
4. What the Coefficient of Impact on Flat Vane?

UNIVERSITY EXAMINATION QUESTION

1. To determine the coefficient of impact when jet strikes a) Flat Vane b) Curved Vane with 135^{o} angle of deflection.

EXPERIMENT VIDEO LINKS

1. **https://www.youtube.com/watch?v=52aGAp7qZdU**

EXPERIMENT NO: 10

PERFORMANCE CHARACTERISTICS OF PELTON WHEEL TURBINE

OBJECTIVE:

To conduct performance test on Pelton Wheel turbine and to draw characteristic curves.

OUTCOME:

The student will be able to verify the efficiency of Pelton Wheel Turbine from the experiment.

SCOPE:

The knowledge on working principle & efficiency of Pelton Wheel Turbine used in hydro electric power plants.

APPARATUS:

Pelton Wheel turbine test rig, weights, tachometer

EXPERIMENTAL SETUP:

The turbine capable of working under the high potential head of water is the Pelton Wheel Turbine which works on the head greater than 300 m. The runner consists of a circular disc with a suitable number of double semi-ellipsoidal cups known as buckets which are evenly spaced around its Periphery. One or more nozzles are mounted so that, each directs a jet along the tangent to the circle through the centres of the buckets called the Pitch Circle. A casing is provided only to prevent the splashing of water and for discharging the water to the tailrace.

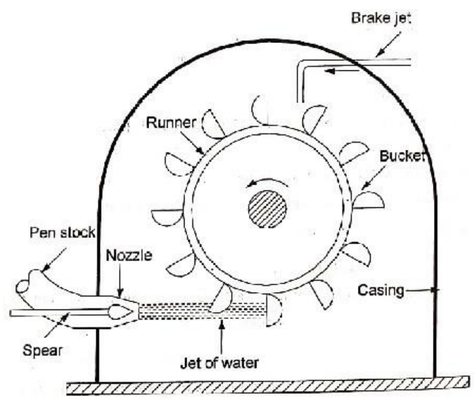


Fig.10 Pelton wheel turbine experimental setup

PROCEDURE:

1. Close the inlet valve and prime the pump.
2. Keep the nozzle at full opening.
3. Start the pump, gradually open the gate valve while monitoring the inlet pressure to the turbine, and set it to the desired value.
4. Add minimum load to the weight hanger of the break drum say 1 kg.
5. Measure the turbine speed in rpm with tachometer.
6. Note the pressure gauge reading at the turbine inlet.
7. Note down the Venturimeter pressure gauge readings P1 and P2.
8. Repeat the experiment by increasing weights on the hanger.

THEORY:

The Pelton wheel or Pelton Turbine is an impulse-type water turbine invented by American inventor **Lester Allan Pelton** (1829-1908) in the 1870s. The Pelton wheel extracts energy from the impulse of moving water, as opposed to water's dead weight like the traditional overshot water wheel. Pelton wheel is an impulse turbine, which is used to utilize high heads for conversion of hydraulic energy into mechanical energy which in turn can be transformed into electrical energy by coupling shafts of turbine and generator. All the available head is converted into velocity energy by means of spear and nozzle arrangement. The water leaves the nozzle in jet formation. The jet of water then strikes the buckets of the Pelton wheel runner. The buckets are in the shape of double semi-ellipsoidal cups, joined at the middle portion by a vertical splitter. The jet strikes the sharp edged splitter of the buckets with least resistance and shock. Then the jet slides along the path of the cup, and the jet is deflected through more than 160° to 170°. The dynamic force of the jet on the buckets causes the wheel to rotate and hence the shaft also is rotated.

A brake pulley or brake drum is fitted to the shaft. A rope is wound round the pulley with one end of the rope connected to spring balance at top and the other lower end of the rope to a weight hanger for placing loads. Tachometer is used to record shaft speeds. The Pelton Wheel is supplied with water under high pressure by centrifugal pump. The water is conveyed through Venturimeter to the Pelton wheel. The Venturimeter with manometer connection is used to determine the discharge of the water in the pipe. The nozzle opening can be decreased by operating the spear wheel at the entrance side of the turbine. Pelton wheel turbines are best suited at high heads and specific speed range varies from 10 to 100.

FORMULA:

Input Power, IP = $\rho x Q x H$ kW

Turbine Output, OP = $\frac{2\Pi NT}{60000}$ kW

Efficiency, η = Output/Input x100 %

OBSERVATION:

Effective Break Drum diameter =

Constant 'K' Value = 3.183×10^{-3}

Weight of rope and hanger =

Specific Weight of Water, ρ = 9.81 kN/m^3

S. No.	Inlet Pressure P (kg/cm^2)	Venturimeter Pressure Gauge Readings		Speed of the turbine N (rpm)	Weight on hanger W1 (kg)	Spring Balance Reading W2 (kg)
		P1 (kg/cm^2)	P2 (kg/cm^2)			
1.						
2.						
3.						
4.						
5.						

S. No.	Venturimeter head h (m)	Net Load N (kg)	Discharge Q (m^3/s)	Input Power I/P	Output Power O/P	Efficiency η (%)
1.						
2.						
3.						
4.						
5.						

1. Input Total Head, H = Pressure Gauge Reading (P) in kg/cm^2 x10 m
2. Venturimeter Head, h = (P1 – P2)x10 m
3. Theoretical discharge Q = $K\sqrt{h}$
4. Input Power IP = ρxQxH kW
5. Torque (T) = ((W1 + Weight of rope and hanger) – W2)x D/2 x 9.81 N
6. Turbine Output, OP = $\frac{2\Pi NT}{60000}$ kW
7. Efficiency, η = OP/IP x100

GRAPH:

1. Plot a graph between Qact vs Input power and Output power
2. Plot a graph between Qact vs Efficiency

RESULT:

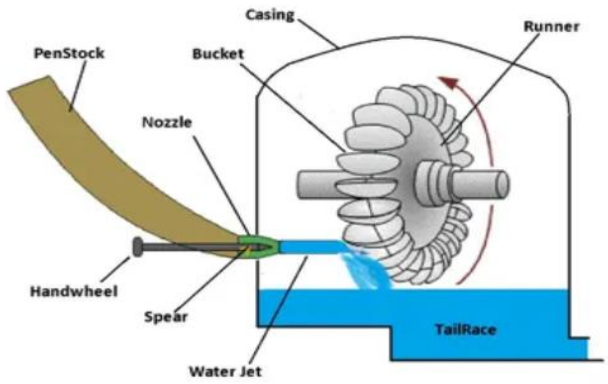
The efficiency of Pelton Wheel Turbine, Η =

Viva Questions:

1. Draw velocity diagrams (at inlet and outlet) for Pelton blade
2. Why is Pelton turbine suitable for high heads?
3. What is the function of spear mechanism?
4. What is the normal range of specific speed of a Pelton Turbine?
5. What are the characteristics of Pelton wheel? What are their uses?
6. After the nozzle water has atmospheric pressure throughout, then why is a casing provided to the wheel?
7. Why not Pelton wheel turbines are suitable for low heads?
8. What are the methods available to govern the turbine?
9. On what principle the pelton wheel turbine works?
10. What is the shape of buckets in pelton wheel turbine?
11. What is the clearance angle of buckets?
12. Define specific speed?
13. What is shaft power?
14. Define overall efficiency.
15. Define volumetric efficiency.
16. Define mechanical efficiency.
17. Define effective head.
18. Define gross head.
19. What is meant by impulse turbine?
20. What is meant by reaction turbine?
21. Explain swirling action.
22. Define pitch.
23. What are the advantages of a Pelton Wheel?
24. What is the outlet flow direction in Pelton Wheel?
25. What is the difference between Kaplan Turbine and Pelton Wheel?
26. What is the maximum allowed runner diameter in Pelton Wheel?
27. What is the use of nose cone?
28. How do you determine the Torque capacity?
29. Can we apply Euler's turbine equation for Pelton Wheel?
30. Explain the energy conversion mechanism in a turbine.

PRACTICAL APPLICATIONS

Pelton turbine is used in the hydroelectric power plant where the water available at high head i.e. 150 m to 2000 m or even more. In hydroelectric power plant, it is used to drive the generator attached to it and the generator generates the mechanical energy of the turbine into electrical energy. Pelton wheels are the preferred turbine for hydro-power, when the available water source has relatively high hydraulic head at low flow rates. For maximum power and efficiency, the wheel and turbine system is designed such that the water jet velocity is twice the velocity of the rotating buckets.



MID EXAMINATION QUESTIONS

1. Explain the conduct performance test on Pelton wheel Turbine.
2. Explain the working principle of Pelton wheel Turbine.
3. Determine the actual efficiency of Pelton Wheel Turbine.
4. Find the performance test on Pelton wheel Turbine.

UNIVERSITY EXAMINATION QUESTION

1. Determine the actual efficiency of Pelton Wheel Turbine.

EXPERIMENT VIDEO LINKS

https://www.youtube.com/watch?v=R171zuPqa3w

EXPERIMENT NO: 11

PERFORMANCE CHARACTERISTICS OF FRANCIS TURBINE

OBJECTIVE:

To conduct performance test on Francis turbine and to draw characteristic curves.

OUTCOME:

The student will be able to verify the efficiency of Francis Turbine from the experiment.

SCOPE:

The knowledge on working principle & efficiency of Francis Turbine used in hydro electric power plants.

APPARATUS:

Francis turbine test rig, weights, tachometer

EXPERIMENTAL SETUP:

Francis turbine blades are designed in such a way that one portion of the blade design creates the pressure difference between the opposite faces of the blade when water flows through it, and the remaining portion's blade design use the impulse force of water hitting it and this combined action of pressure difference and impulse force generates enough power to get turbine moving at a required speed. Thus there would be a decrease in both kinetic energy and potential energy of water at exit, then what it has when it enters the turbine.

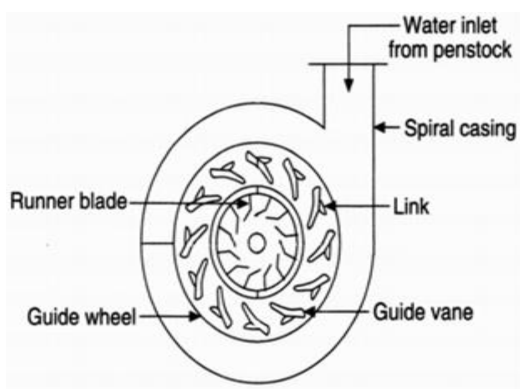


Fig.11 Francis Turbine

PROCEDURE:

1. Close the inlet valve and prime the pump.
2. Start the pump, gradually open the gate valve while monitoring the inlet pressure to the turbine, and set it to the desired value.
3. Add minimum load to the weight hanger of the break drum say 1kg.
4. Measure the turbine speed in rpm with tachometer.
5. Note the pressure gauge reading at the turbine inlet.
6. Note down the Venturimeter pressure gauge readings P1 and P2.
7. Repeat the experiment by increasing weights on the hanger.

THEORY:

James Bicheno Francis (1815 – 1892) was a British-American civil engineer, who invented the Francis turbine. Francis turbine is a reaction type hydraulic turbine, used in dams and reservoir of medium height to convert hydraulic energy into mechanical and electrical energy. Francis turbine is radial inward flow reaction turbine. This has the advantage of centrifugal forces acting against the flow, thus reducing the tendency of the turbine to over speed. Francis turbines are best suited for medium heads. The specific speed ranges from 25 to 300.

Water under the pressure from the pump enters the guide vanes into the runner while passing through the spiral casing and guide vanes; a portion of pressure energy is converted into velocity energy. Water thus enters the runner at high velocity and as it passes through the runner vanes, the remaining pressure energy converted into kinetic energy. Due to the curvature of the vanes, the kinetic energy is transformed into mechanical energy. The water head is converted into mechanical energy and hence the runner rotates. A tachometer is used to measure the speed of rotor.

FORMULA:

1. Input Power, IP = ρxQxH kW
2. Turbine Output, OP= $\frac{2\Pi NT}{60000}$ kW
3. Efficiency, η = OP/IP x100

OBSERVATION:

Effective Break Drum diameter =

Weight of rope and hanger =

Constant 'K' Value = 1.4863 x 10^{-2}

Specific Weight of Water, ρ = 9.81 kN/m^3

Sl. No.	Inlet Pressure P (kg/cm^2)	Venturimeter Pressure Gauge Readings		Speed of the turbine N (rpm)	Weight on hanger W1(kg)	Spring Balance Reading W2(kg)
		P1 (kg/cm^2)	P2 (kg/cm^2)			
1.						
2.						
3.						
4.						
5.						

Sl. No.	Venturimeter head h(m)	Net Load N (kg)	Discharge Q (m^3/s)	Input Power I/P	Output Power O/P	Efficiency η (%)
1.						
2.						
3.						
4.						
5.						

1. Input Total Head, H = Pressure Gauge Reading (P) in kg/cm^2x10 m
2. Venturimeter Head, h = (P1 – P2)x10 m
3. Theoretical discharge Q = $K\sqrt{h}$
4. Input Power IP = ρxQxH kW
5. Torque (T) = ((W1 + Weight of rope and hanger) – W2)x D/2 x 9.81 N
6. Turbine Output, OP = $\frac{2\Pi NT}{60000}$ kW
7. Efficiency, η = OP/IP x100

GRAPH:

1. Plot a graph between Qact vs Input power and Output power
2. Plot a graph between Qact vs Efficiency

RESULT:

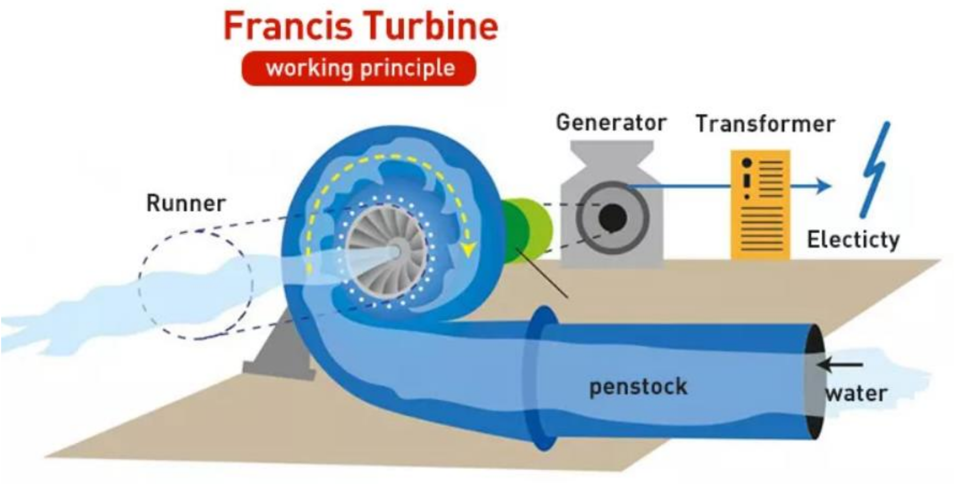
The efficiency of Francis Turbine, Ƞ =

Viva Questions:

1. What is general principle of Francis Turbine?
2. Which type of runner is used is used in Francis Turbine?
3. Francis Turbine is used for which range of input heads?
4. What is the range of Specific Speed for Francis Turbine?
5. What is the function of Draft Tube?
6. What is effect of guide vane angle on efficiency?
7. Define flow ratio.
8. Define speed ratio.
9. What is the formula for discharge of Francis turbine?
10. Why draft tube is used in Francis turbine?
11. What is reaction turbine?
12. What are the disadvantages of Francis turbine?
13. What type of flow occurs in Francis turbine?
14. What type of turbine is Francis turbine?
15. What is meant by draft tube?
16. What is the shape of draft tube in Francis turbine?
17. What is the function of draft tube in Francis turbine?
18. What is the purpose of guide vanes?
19. What are the advantages of Francis turbine?
20. Difference between impulse turbine and reaction turbine?
21. What is the difference between Kaplan and Francis Turbines?
22. What is the range of Specific Speed for Francis Turbine?
23. What is the function of Draft Tube?
24. What type of turbine is a Francis turbine?
25. What is effect of guide vane angle on efficiency?
26. On what principle the Francis turbine works?
27. What is the shape and function of draft tube?
28. Are the propeller blades adjustable in Francis turbine?
29. Explain the functioning of Francis turbine.
30. How cavitation occurs in Francis Turbine?

PRACTICAL APPLICATIONS

Francis turbine is the most widely used turbine in hydro-power plants to generate electricity. Mixed flow turbine is also used in irrigation water pumping sets to pump water from ground for irrigation. It is efficient over a wide range of water head and flow rate. Francis turbine covers a wide range of heads, from 20 to 700 m, and its output varies from a few kilowatts to 200 megawatts. This possibility, in addition to its high efficiency, has made the Francis turbine the most widely used turbine in the world.



MID EXAMINATION QUESTIONS

1. Explain the conduct performance test on Francis turbine.
2. Explain the working of Francis turbine.
3. Determine the actual efficiency of Francis turbine.
4. Find the performance test on Francis turbine.

UNIVERSITY EXAMINATION QUESTION

1. Determine the actual efficiency of Francis turbine.

EXPERIMENT VIDEO LINKS

1. https://www.youtube.com/watch?v=r4EBCorqKNI
2. https://www.youtube.com/watch?v=R171zuPqa3w

EXPERIMENT NO: 12

PERFORMANCE CHARACTERISTICS OF KAPLAN TURBINE

OBJECTIVE:

To conduct performance test on Kaplan turbine and to draw characteristic curves.

OUTCOME:

The student will be able to verify the efficiency of Kaplan turbine from the experiment.

SCOPE:

The knowledge on working principle & efficiency of Kaplan turbine used in hydro electric power plants.

APPARATUS:

Kaplan turbine test rig, tachometer.

EXPERIMENTAL SETUP:

Kaplan Turbine works on the principle of axial flow reaction. In axial flow turbines, the water flows through the runner along the direction parallel to the axis of rotation of the runner. The water at the inlet of the turbine possesses both kinetic energy as well as pressure energy for effective rotation the blades in a hydro-power station.

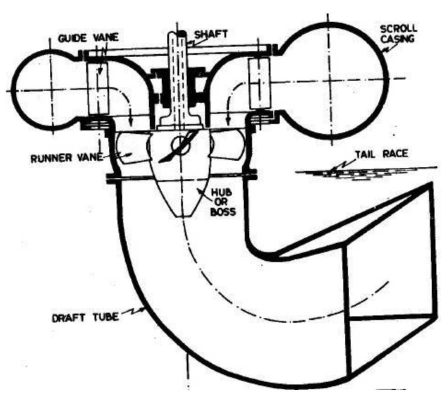


Fig 12.1. Longitudinal Section View of Kaplan Turbine

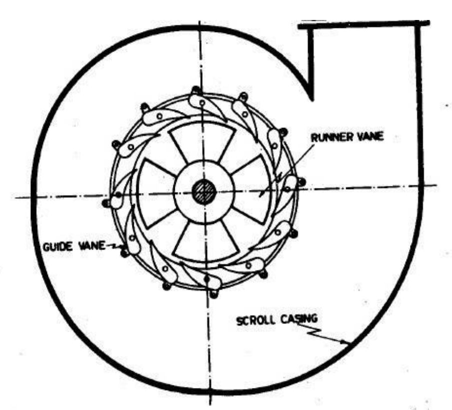


Fig 12.2. Top Sectional View of Runner Casing

PROCEDURE:

1. Close the inlet valve and prime the pump.
2. Start the pump, gradually open the gate valve while monitoring the inlet pressure to the turbine, and set it to the desired value.
3. Increase the primary load on the break drum say 1 kg, thus secondary load gets increased.
4. Measure the turbine rpm using tachometer.
5. Note the pressure gauge reading at the turbine inlet.
6. Note down the Orifice meter pressure gauge readings P1 and P2.
7. Repeat the experiment by increasing weights on the hanger.

THEORY:

This Kaplan turbine is one of the first three machines to be put into service in the United States. Named for its Austrian inventor, **Viktor Kaplan** (1876-1934), the turbine was an outstanding innovation, operating with a high, nearly constant efficiency over a wide load range. The Kaplan turbine is an inward flow reaction turbine, which means that the working fluid changes pressure as it moves through the turbine and gives up its energy. The design combines radial and axial features.

The inlet is a scroll-shaped tube that wraps around the turbine's wicket gate. Water is directed tangentially, through the wicket gate, and spirals on to a propeller shaped runner, causing it to spin. Between the scroll casing and the runner, the water turns through right angle into the axial direction and passes through the runner and thus rotating the runner shaft. The runner has four blades which can be turned about their own axis so that the angle of inclination may be adjusted while the turbine is in motion. When runner blade angles are varied, high efficiency can be maintained over wide range of operating conditions. In other words even at part loads, when a low discharge is flowing through the runner, a high efficiency can be attained in case of Kaplan turbine, whereas this provision does not exist in Francis & Propeller turbines where, the runner blade angles are fixed and integral with hub.

The outlet is a specially shaped draft tube that helps decelerate the water and recover kinetic energy. The turbine does not need to be at the lowest point of water flow, as long as the draft tube remains full of water. A higher turbine location, however, increases the suction that is imparted on the turbine blades by the draft tube. The resulting pressure drop may lead to cavitations.

FORMULA:

Input Power IP = ρxQxH kW

$$\text{Turbine Output, OP} = \frac{2\Pi NT}{60000} \text{ kW}$$

Efficiency, η = OP/IP x100

OBSERVATION:

Sl. No.	Inlet Pressure P (kg/cm²)	Orifice meter Pressure Gauge Readings		Speed of the turbine N (rpm)	Primary Load W1 (kg)	Secondary Load W2 (kg)
		P1 (kg/cm²)	P2 (kg/cm²)			
1.						
2.						
3.						
4.						
5.						

Sl. No.	Orificemeter head h (m)	Net Load W (N)	Discharge Q (m^3/s)	Input Power I/P	Output Power O/P	Efficiency η (%)
1.						
2.						
3.						
4.						
5.						

2. Input Total Head, H = Pressure Gauge Reading (P) in kg/cm^2x10 m
3. Orifice meter head, h = (P1 – P2)x10m
4. Theoretical discharge Q = $a_1 a_o \sqrt{(2gh)}/\sqrt{(a_1^2 - a_o^2)}$ m^3/sec
5. Input Power IP = ρxQxH kW
6. Torque = (W1+Weight of rope and hanger – W2)x D/2 x 9.81 N
7. Turbine Output, OP = $\frac{2\Pi NT}{60000}$ kW
8. Efficiency, η = OP/IP x100

GRAPH:

1. Plot a graph between Qact vs Input power and Output power
2. Plot a graph between Qact vs Efficiency

RESULT:

The efficiency of Kaplan Turbine, η =

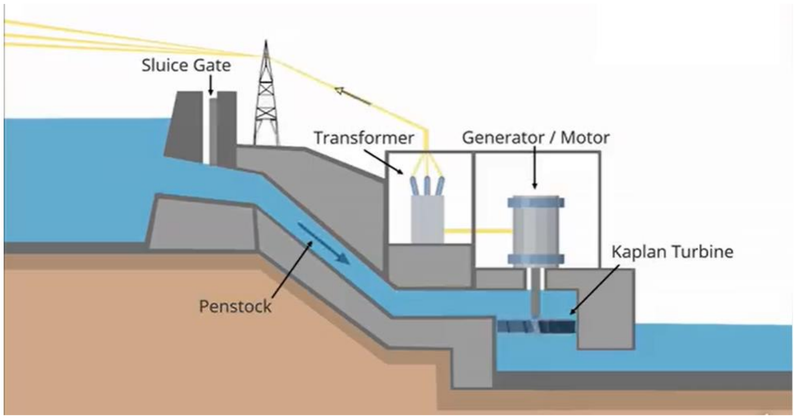
Viva Questions:

1. What is general principle of Kaplan Turbine?
2. What is the Difference between Kaplan Turbine and Francis Turbine?
3. Define specific speed.
4. What is the general specific speed of Kaplan Turbine?
5. Which turbine has highest discharge at lowest speed?
6. What is the speed ratio of Kaplan turbine?
7. Which is the highest efficiency turbine?
8. Which type of runner is used is used in Kaplan Turbine?
9. What is the difference between Kaplan and Francis Turbines?

10. What is the range of Specific Speed for Kaplan Turbine?
11. What is the function of Draft Tube?
12. What type of turbine is a Kaplan turbine?
13. What is effect of guide vane angle on efficiency?
14. On what principle the Kaplan turbine works?
15. What is the shape and function of draft tube?
16. Why V notch is not used in Kaplan turbine?
17. Are the propeller blades adjustable in Kaplan turbine?
18. Define unit quantities and specific speed.
19. Why can't Kaplan turbine used for higher heads?
20. Explain Inward Flow Reaction Tube.
21. What is the difference between pump and turbine?
22. What is the average head range for Kaplan Turbine?
23. Explain the functioning of Kaplan turbine.
24. How cavitation occurs in Kaplan Turbine?
25. Explain why Kaplan Turbine efficiency is so high?
26. For what kind of conditions Kaplan turbines are most suited for?
27. Can Kaplan Turbines be used under higher discharge conditions?
28. What is the nature of flow in Kaplan turbine?
29. What is the difference between Kaplan turbine and propeller turbine?
30. What is meant by degree of reaction?

PRACTICAL APPLICATIONS

Kaplan turbines are widely used throughout the world for electric power production. They cover the lowest head hydro sites and are especially suited for high flow conditions. Inexpensive micro turbines are manufactured for individual power production with as little as two feet of head. Large Kaplan turbines are individually designed for each site to operate at the highest possible efficiency, typically over 90%. They are very expensive to design, manufacture and install but operate for decades.



MID EXAMINATION QUESTIONS

1. Explain the conduct performance test on Kaplan turbine.
2. Explain the working of Kaplan turbine.
3. Determine the actual efficiency of Kaplan turbine.
4. Find the performance test on Kaplan turbine.

UNIVERSITY EXAMINATION QUESTION

1. Determine the actual efficiency of Kaplan turbine.

EXPERIMENT VIDEO LINKS

1. https://www.youtube.com/watch?v=KUnEGPRxCb4
2. https://www.youtube.com/watch?v=P6PZw68eBjY
3. https://www.youtube.com/watch?v=r4EBCorqKNI

EXPERIMENT NO: 13

PERFORMANCE CHARACTERISTICS OF A SINGLE / MULTI STAGE CENTRIFUGAL PUMP

OBJECTIVE:

To find the efficiency and draw the performance characteristics of Single / Multi Stage Centrifugal pump.

OUTCOME:

The student will be able to verify the efficiency of the single /Multi stage centrifugal pump.

SCOPE:

The knowledge of Single /Multi stage centrifugal pump is used for flow measuring device like agriculture, irrigation and other residential areas.

APPARATUS:

Single and Multistage Centrifugal Pump Test Rig, Stop watch

EXPERIMENTAL SETUP:

The primary difference between single-stage and multistage centrifugal pumps lies in the number of stages (also referred to as impellers) they have. As the name implies, single-stage pumps have only one impeller, whereas multistage pumps have at least two.

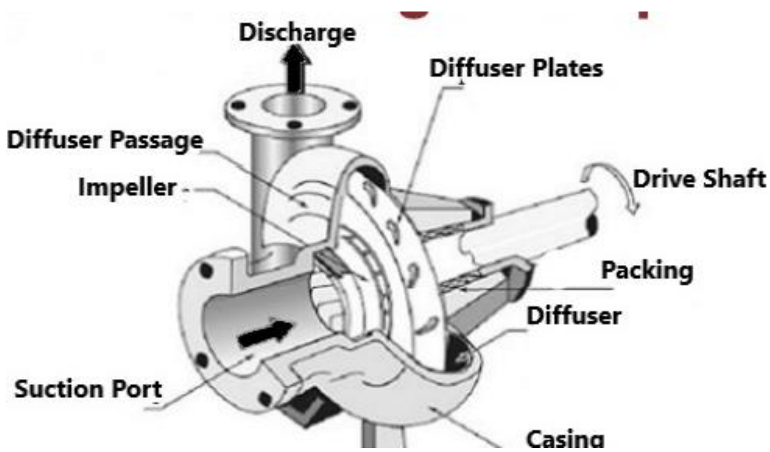


Fig.13 Centrifugal Pump

PROCEDURE:

1. Prime the pump, close the delivery valve and switch on the unit.
2. Set the speed of the pump to a certain desired rated RPM, open the delivery valve and maintain the required delivery head.

   Note:
   a) The pressure gauge reading G
   b) The Vacuum gauge reading V
   c) Time taken for 5 pulses in the energy meter by means of stopwatch.

3. Close the drain valve and note down the time taken for 10 cm rise of the water level in the collecting tank.
4. Take atleast 4 to 5 sets of readings varying the head from maximum at shutoff to minimum where valve is fully open.

THEORY:

The invention of centrifugal pumps was done by **Denis Papin** a Physicist in 1689. The centrifugal pump is one of the most used pump in the world currently due to the following reasons.

- Cheap to construct
- Strong
- Delivers fluids faster than other pumps
- Simple

The pump which raises water from lower level to higher level by the action centrifugal force is known as centrifugal pump. . A centrifugal pump consists of essentially an impeller rotating inside the casing. The impeller has a number of curved vanes. Due to the centrifugal head imposed by the rotation of impeller, the fluid enters axially through the middle portion of the pump call the eye, after which it encounters the rotating blades. It acquires tangential and radial velocity by the momentum transfer with impeller blades and acquires additional radial velocity by centrifugal force. Thus water is lifted to higher locations with the acquired energy.

OBSERVATION:

a) Single stage centrifugal pump:

S. No.	**Pressure gauge reading (G) kg/cm^2**	**Vacuum gauge reading (V) mm of Hg**	**Time required for 5 pulses of energy meter (t) sec**	**Time required for 10 cm rise of water level (t) sec**
1.				
2.				
3.				
4.				
5.				

S. No.	Actual Discharge (Qact) m^3/sec	Total head (H) meters of water	Output power of pump (O.P) kW	Input power of pump (I.P) kW	Efficiency of the pump (η) %
1.					
2.					
3.					
4.					
5.					

1) Actual Discharge (Q_{act}) = AH/t

Where, A= Area of tank

h= Rise of water level considered

t= Time required for rise

2) Pressure Head, G = Pressure Gauge reading x 10

Vacuum Head, V= (mm of Hg x13.6)/1000

Datum Head, X = 0m

Total Head (H) = G+V+X

3) Output power of pump (B.P) =W*Q_{act}*H

Where, W= Equivalent weight of water (9.81 kN/m^3)

Qact = Actual Discharge

H = Total head

4) Input power = X x 3600 x 0.6 / C x T kW

Where, X = No.of revolutions of energy meter disc (say 5 Rev)

T = Time for energy meter revolutions disc in sec

C = Energy meter constant

5) Efficiency = OP/IP x 100

a) Multi stage centrifugal pump:

S. No.	Pressure gauge reading (G) kg/cm^2	Vacuum gauge reading (V) mm of Hg	Time required for 5 pulses of energy meter (t) sec	Time required for 10 cm rise of water level (t) sec
1.				
2.				
3.				
4.				
5.				

S. No.	Actual Discharge (Qact)m^3/sec	Total head (H) meters of water	Output power of pump (O.P) kW	Input power of pump (I.P) kW	Efficiency of the pump (η) %
1.					
2.					
3.					
4.					
5.					

1) Actual Discharge (Q_{act}) = AH/t

   Where, A= Area of tank

   h= Rise of water level considered

   t= Time required for rise

2) Pressure Head, G = Pressure Gauge reading x 10

   Vacuum Head, V= (mm of Hg x13.6)/1000

   Datum Head, X = 0m

   Total Head (H) = G+V+X

3) Output power of pump (B.P) =W*Q_{act}*H

   Where, W= Equivalent weight of water (9.81 kN/m^3)

   Q_{act} = Actual Discharge

   H = Total head

4) Input power = X x 3600 x 0.6 / C x T kW

   Where, X = No.of revolutions of energy meter disc (say 5 Rev)

   T = Time for energy meter revolutions disc in sec

   C = Energy meter constant

2) Efficiency = OP/IP x 100

GRAPH:

1. Plot a graph between Qact vs Input power and Output power
2. Plot a graph between Qact vs Efficiency

RESULT:

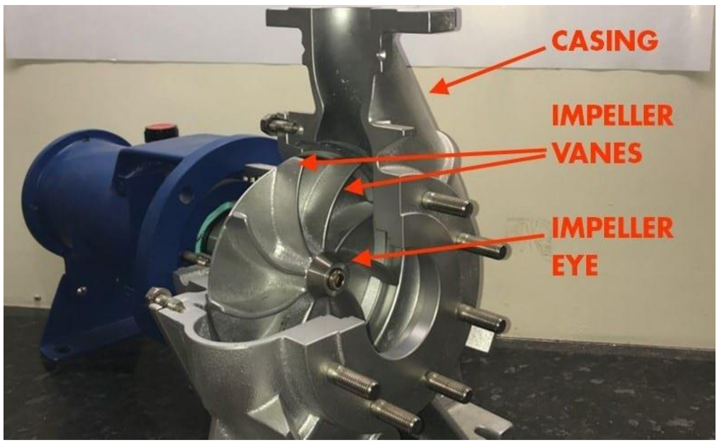
1. The efficiency of the single- stage centrifugal pump is =
2. The efficiency of the multi- stage centrifugal pump is =

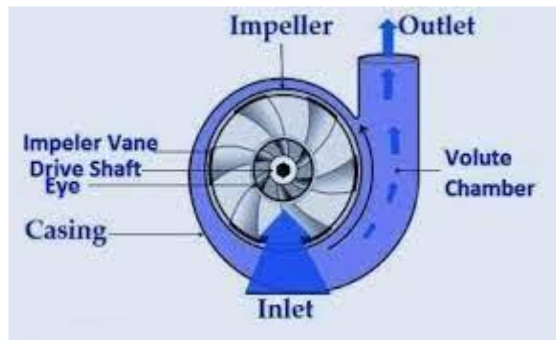
Viva Questions:

1. What is priming? What is use of foot valve?
2. What is manometric head?
3. What is the function of the casing used in centrifugal pump?
4. What is NPSH?
5. What is the minimum starting speed of a centrifugal pump?
6. What precautions are to be taken while starting and closing the centrifugal pump?
7. Under what conditions would a reaction turbine work as pump?
8. What is meant by a roto-dynamic machine?
9. What is meant by priming of a pump?
10. What are the pumping characteristics of a centrifugal pump?
11. What is meant by efficiency of a pump?
12. What is meant by suction head?
13. What is meant by delivery head?
14. What is manometric head?
15. Define manometric efficiency.
16. What is meant by static head?
17. What are the losses in pump?
18. Define mechanical efficiency of pump.
19. What is the Euler momentum equation for centrifugal pump?
20. What is meant by efficiency of pump?
21. What is a multi-stage reciprocating pump?
22. What is the difference between axial piston pump and radial piston pump?
23. What are the disadvantages of cavitation?
24. What is meant by negative slip?
25. What is the function of air vessel?
26. What types of fluids are pumped by reciprocating pump?
27. Is a reciprocating pump good for higher heads?
28. What are the normal precautions to be taken when operating a pump?
29. What is the normal efficiency of centrifugal pump?
30. What is the use of indicator diagram?

PRACTICAL APPLICATIONS

A centrifugal pump containing two or more impellers is called a multistage centrifugal pump. For higher pressures at the outlet, impellers can be connected in series. For higher flow output, impellers can be connected in parallel. A common application of the multistage centrifugal pump is the boiler feed water pump. Centrifugal pumps are the most popular choice for fluid movement makes them a strong contender for many applications and as mentioned previously; they are used across numerous industries. Supplying water, boosting pressure, pumping water for domestic requirements, assisting fire protection systems, hot water circulation, sewage drainage and regulating boiler water are among the most common applications. Outlined below are some of the major sectors that make use of these pumps.





MID EXAMINATION QUESTIONS

1. Find the efficiency & performance characteristics of Single Stage Centrifugal pump.
2. Determine the Average performance of Single Stage Centrifugal Pump.
3. Find the efficiency &performance characteristics of Multi Stage Centrifugal Pump.
4. Determine the Average performance of Multi Stage Centrifugal Pump.

UNIVERSITY EXAMINATION QUESTION

1. Find the efficiency & performance characteristics of Single Stage Centrifugal pump.
2. Find the efficiency & performance characteristics of Multi Stage Centrifugal pump.

EXPERIMENT VIDEO LINKS

1. https://www.youtube.com/watch?v=6iENU-Pp3Q0
2. https://www.youtube.com/watch?v=8rhSzpSh2LE

Beyond the Syllabus – Additional Experiments

EXPERIMENT NO: 14

DETERMINATION OF COEFFICIENT OF DISCHARGE OF A MOUTH PIECE BY CONSTANT HEAD METHOD

OBJECTIVE:

To determine the co-efficient of velocity [C_v] co-efficient of contraction [C_c] and co-efficient of discharge [C_d] for a mouth piece by constant head method.

OUTCOME:

The student will be able to find the actual and theoretical discharges and hydraulic coefficients.

SCOPE:

The knowledge of hydraulic coefficients for a mouth piece mainly used to find the discharge.

APPARATUS:

A mouth piece fitted across a pipeline leading to a collecting tank, Stop Watch

EXPERIMENTAL SETUP:

The apparatus consists of a mouthpiece fitted to one side of a vertical tank, main water tank and a collecting tank. Water in the main tank can be driven by means of a motor so that it flows in the mouthpiece fitted tank and there by into the collecting tank through the mouth piece. A valve is provided at the site of motor so that flow in the mouth piece fitted tank can be adjusted. The vertical tank is provided with some scale to measure the head of water above the mouth piece. The collecting tank is provided with some scale to read the water level in it and there by volume of water collected can be computed.

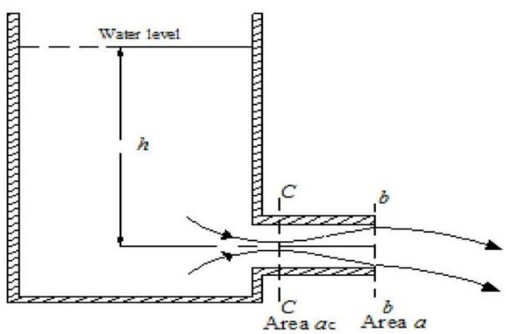


Fig. 14 Experimental setup

PROCEDURE:

1. Measure the diameter of the mouth piece.
2. Supply water to the tank.
3. When the head at the tank (measured by a piezometer attached to the tank) is steady record the reading of the manometer.
4. Measure the x and y co-ordinate of the jet from the vena contracta.
5. Measure the flow rate.
6. Repeat the procedure for different combinations of discharge.

THEORY:

Mouth piece is a short length pipe which is two or three times its diameter in length, fitted in a tank or vessel containing fluid. It is used to measure the rate of flow of fluid. Mouth piece fitted external to the tank is called external mouthpiece (this is the present use with our experiment). The jet of liquid entering the mouth piece constructs to form a vena – contracta. Beyond this section jets again expands and fill the mouth piece completely.

FORMULA:

$Q_{act} = AH/t$

Coefficient of discharge = $C_d = Q_{act}/Q_{the}$

Coefficient of velocity = C_v = Actual velocity/theoretical velocity

OBSERVATION:

Diameter of the mouth piece (d) =   Area of mouth piece (a) =

S.No	Constant Head (h) (m)	Time required for 10cm Rise of water (t)(sec)	Actual discharge Qact (m^3/sec)	Theoretical discharge Qthe (m^3/sec)	Coefficient of discharge Cd = Qact/Qthe	Pointer reading (m)		Coeff. of velocity (Cv)	Coeff. of contraction (Cc)
						x	y		
1.									
2.									
3.									

1. **Actual discharge:**
   Qact = AH/t =

2. **Theoretical discharge:**
   Qthe = ax$\sqrt{(2gh)}$ =

3. **Coefficient of discharge:**
   Cd = Qact/Qthe =

4. **Coeff.of velocity:**
   Cv = $\sqrt{(x^2/4yH)}$ =

5. **Coeff.of contraction:**
   Cc=Cd/Cv =

GRAPH:

Draw a graph between Qact vs √h. Take Qact in Y axis.

RESULT:

The mean values of hydraulic coefficients are as follows:

d) Coefficient of discharge, Cd = _____

e) Coefficient of velocity, Cv = _______

f) Coefficient of contraction, Cc = _______

Viva Questions:

1. Define mouth piece.
2. For what purpose mouth pieces are used?
3. What are the applications of mouth piece?
4. What is Vena Contracta?
5. Which diameter is less? Orifice or Pipe
6. What is the diameter of the orifice in the experiment?
7. What are the hydraulic coefficients?
8. What is meant by coefficient of discharge?
9. Define the coefficient of velocity.
10. Define the coefficient of contraction.
11. What is the use of measuring tank?
12. What is discharge? What is its unit?
13. What is mass flow rate Mention its unit?
14. What is volume flow rate? write its unit.
15. State the equation for theoretical discharge for orifice meter.
16. How will you find out actual discharge?
17. Describe the principle of manometers and its uses?
18. What is the theoretical velocity of jet of water coming out from orifice?
21. Mention the types of mouth piece
22. Distinguish between small mouth piece and large mouth piece
23. What is meant by variable head?
24. Write the formula for Qthe.
31. The top edge of the mouth piece is always __________ (above/below) the free surface
32. In mouth piece it is convenient to work in terms of _______ pressures (gauge/absolute)
33. An mouth piece is said to be __________ (submerged/discharging free) when it discharges into another liquid
34. What is the range of coefficient of discharge for mouth piece?
35. Write the formula for discharge through a mouth piece.
36. Write the formula for a time taken by a mouth piece for emptying tank.
37. Give any two practical applications of mouth piece.
38. The coefficient of discharge through a mouth piece is ___________ (small/equal/greater) than the orifice
39. List out any two precautions in the experiment.
40. What is the difference between orifice and mouth piece?

PRACTICAL APPLICATIONS

A mouthpiece is a short length of pipe or tube attached to the tank or vessel, used to determine the rate of flow of fluid. It is an extended form of an orifice with a length equal to 2 to 3 times the diameter of the orifice. Flow through an orifice can not represent the flow through a pipe properly. Also in orifice, coefficient of discharge is only 0.62. So to increase discharge from a reservoir and represent the flow through pipe mouthpiece is used.

MID EXAMINATION QUESTIONS

1. Determine the mouth piece diameter (d) required by constant head method. Take Coefficient of discharge $C_d = 0.6$.
2. Determine the coefficient of discharge for the given mouth piece diameter 15 mm by constant head method.
3. Determine the actual discharge in the pipe for the given mouth piece. Take $C_d = 0.6$.

UNIVERSITY EXAMINATION QUESTION

1. Find the hydraulic coefficients (C_d, C_c, C_v) for the given mouth piece.
2. What are the methods available for finding the coefficient of discharge for a mouth piece? Conduct the experiment and find the C_d value.

EXPERIMENT VIDEO LINKS

1. **https://www.youtube.com/watch?v=l19PirXrzcE**
2. **https://www.youtube.com/watch?v=jZieCS2ufTg**