INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal - 500 043, Hyderabad, Telangana

COURSE CONTENT

FLUID MECHANICS AND HYDRAULIC MACHINES LABORATORY								
IV Semester: ME								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AMEC16	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		-	-	3	1.5	30	70	100
Contact Classes: Nil	**Tutorial Classes: Nil**	**Practical Classes: 45**				**Total Classes: 45**		
Prerequisite:								

I. COURSE OVERVIEW:

The purpose of this laboratory is to strengthen and enhance the understanding of the basics of fluid mechanics and Hydraulic machines. The experiments here are designed to demonstrate the applications of the basic mechanics principles and to provide a lot of intuitive and physical understanding of the theory. The most objective is to introduce a spread of classical experimental and diagnostic techniques, and also the principles behind these techniques. This laboratory exercise additionally provides practice in making engineering judgments, estimates and assessing the reliability of your measurements, skills that are important in all engineering disciplines.

II. COURSE OBJECTIVES:

The students will try to learn:

I. Understand hands on experience in flow measurements using different devices.
II. Fluid flow patterns and describes continuity equation.
III. Know, how to calculate and draw characteristics curves for various experiments related to fluid mechanics.

III. COURSE OUTCOMES:

At the end of the course students should be able to:

CO 1 Infer the concept of calibrating orifice and venturi meter to minimize uncertainty in the discharge coefficient.
CO 2 Utilize the pipe friction test apparatus to measure the friction factorunder a range of flow rates and flow regimes for calculating major loses in closed pipes.
CO 3 Demonstrate the validation of Bernoulli's theorem for incompressible, steady, continuous flow in order to regulate pipe flow across a cross-section and datum.
CO 4 Illustrate the minor losses to measure the head loss
CO 5 Make use of the jet impact apparatus to investigate the reaction forces generated due to changes in momentum.
CO 6 Distinguish the performance characteristics of turbo machinery to Various operating conditions for calculating efficiency of turbines and pumps under specific applications.

IV. COURSE CONTENT

EXERCISES ON HEAT TRANSFER LABORATORY

Safety

Safety is a vital issue in all workplaces. Before using any equipment and machines or attempt practical work in a laboratory everyone must understand basic safety rules. These rules will help keep all safe in the laboratory.

Safety Rules

1. Always listen carefully to the teacher and follow instructions.
2. When learning how to use a machine, listen very carefully to all the instructions given by the faculty / instructor. Ask questions, especially if you do not fully understand.
3. Always wear an apron as it will protect your clothes and holds lose clothing such as ties in place.
4. Wear good strong shoes.
5. Know where the emergency stop buttons are positioned in the laboratory. If you see an accident at the other side of the workshop you can use the emergency stop button to turn off all electrical power to machines.
6. Always be patient, never rush in the laboratory.
7. Keep hands away from moving/rotating machinery.
8. Use hand tools carefully, keeping both hands behind the cutting edge.
9. Report any UNSAFE condition or acts to instructor.
10. Report any damage to machines/equipment as this could cause an accident.

Getting Started Exercises

Introduction

The Fluid Mechanics laboratory is designed to examine the properties of fluids. . It is an introductory course where flow behavior, fluid forces and analysis tools are introduced. The experiments here are designed to demonstrate the applications of the basic fluid mechanics principles and to provide a more intuitive and physical understanding of the theory. The study of fluid mechanics and hydraulic machines is an important area for mechanical engineers while designing steam engine or working on a pump or turbine that power our everyday world.

1. Coefficient of discharge of Venturimeter

Venturimeter is a flow measurement device, which is based on the principle of Bernoulli's equation. Inside the pipe pressure difference is created by reducing the cross-sectional area of the flow passage.

1.1 Calculate the coefficient of discharge compared with theoretical using the experimental setup by taking 5cm raise of water.

Hints:

- Start the pump, operate the valves
- Measure the variations in manometer readings (h1 &h2).
- Note down the time (t).

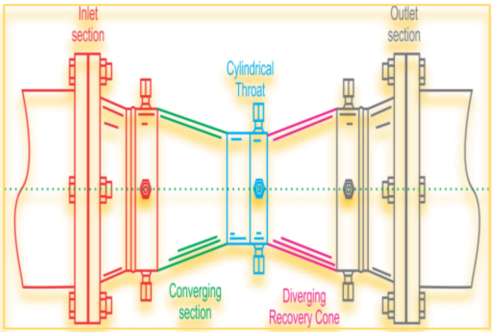

Figure1. Venturimeter

1.2 Calculate the coefficient of discharge compared with theoretical using the experimental setup by taking 10cm raise of water.

Venturimeter is a flow measurement device, which is based on the principle of Bernoulli's equation. Inside the pipe pressure difference is created by reducing the cross-sectional area of the flow passage.

Hints:

- Start the pump, operate the valves as shown in figure1.
- Measure the variations in manometer readings (h1 &h2).
- Note down the time (t).

Try

1. Open the valves half only and repeat the experiment and compare the results with full open condition
2. Open the valves to 2/3 and repeat the experiment and compare the results with full open condition

2. Coefficient of discharge of Orifice Meter

The orifice meter is a type of inferential flow meter that utilizes an orifice plate with an aperture that is concentrically inserted into a pipeline in order to create the required constriction in the flow path

2.1 Calculate the coefficient of discharge compared with theoretical using the experimental setup by taking 5cm raise of water.

Hints:

- Start the pump, operate the valves as shown in Figure 2.
- Measure the variations in manometer readings (h1 &h2).
- Note down the time (t).

2.2 Calculate the coefficient of discharge compared with theoretical using the experimental setup by taking 10cm raise of water.

Hints:

- Start the pump, operate the valves
- Measure the variations in manometer readings (h1 &h2).
- Note down the time (t).

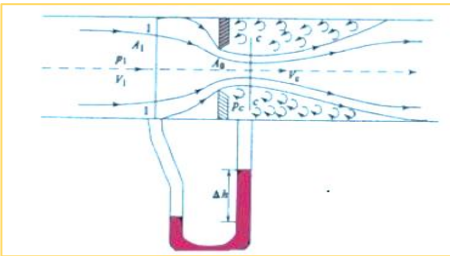

Figure 2. Orifice meter

Try

1. Change the height of wedge for orifice and find the discharge coefficient
2. Open the valves half only and repeat the experiment and compare the results with full open Condition.

3. Friction factor for a square Pipe

The major losses of energy are due to friction. Which are considerable hence it is called as major losses. It is determined by Darcy- Weisbach formula. Head loss due to friction is denoted by hf.

3.1 Calculate the Friction factor for a square Pipe using the experimental setup by taking 5cm raise of water.

Hints:

- Start the pump, operate the valves as shown in figure3.
- Measure the variations in manometer readings (h1 &h2).
- Note down the time (t).

3.2 Calculate the Friction factor for a square Pipe using the experimental setup by taking 10cm raise of water.

Hints:

- Start the pump, operate the valves
- Measure the variations in manometer readings (h1 &h2).

- Note down the time (t).

Try

1. Change the roughness of a pipe and find the friction loses for a square pipe with full valves open.
2. Open the valves half only and repeat the experiment for a square pipe and compare the results with full open condition.

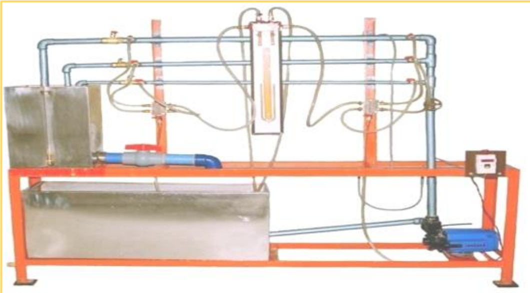

Figure 3. Flow through pipe experiment setup

4.1 Friction factor for a Circular Pipe

The major losses of energy are due to friction. Which are considerable hence it is called as major losses. It is determined by Darcy- Weisbach formula and Chezy's formula. Head loss due to friction is denoted by hf.

4.1 Calculate the Friction factor for a Circular Pipe using the experimental setup by taking 5cm raise of water.

Hints:

- Start the pump; operate the valves as shown in figure4.
- Measure the variations in manometer readings (h1 &h2).
- Note down the time (t).

4.2 Calculate the Friction factor for a Circular Pipe using the experimental setup by taking 10cm raise of water.

Hints:

- Start the pump, operate the valves as shown in figure4.
- Measure the variations in manometer readings (h1 &h2).
- Note down the time (t).

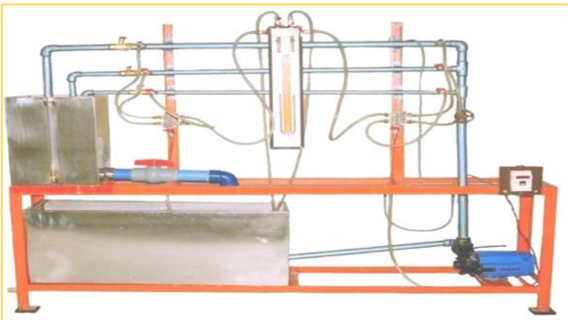

Figure 4. Flow through pipe experiment setup

Try

1. Change the roughness of a pipe and find the friction loses for a circular pipe with full valves open.
2. Change the dimensions of a pipe, open the valves half only and repeat the experiment for a circular pipe and compare the results with full open condition.

5. Verification of Bernoulli's Theorem.

Bernoulli's theorem, also known as Bernoulli's principle, states that the whole mechanical energy of the moving fluid, which includes gravitational potential energy of elevation, fluid pressure energy, and kinetic energy of fluid motion, remains constant.

5.1 verify the Bernoulli's Theorem by altering the heights of water level in manometers limbs.

Hints:

- Start the pump
- Adjust the flow
- Note down the piezometer readings and time (t)
- Calculate the pressure head, velocity head, and datum head, and verify the Bernoulli's Theorem shown in figure 5.

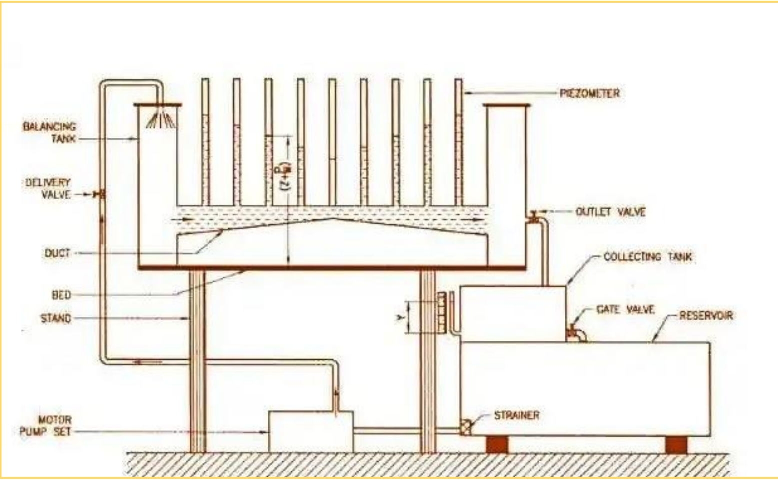

Figure 5: Bernoulli experiment setup

Try

1. Vary the mass flow rate and verify Bernoulli's theorem
2. Change the fluid type and verify Bernoulli's theorem

6. Performance Test on Pelton Wheel Turbine

The Pelton Wheel Turbine is a hydroelectric device that converts water's kinetic energy into mechanical power. It employs high-speed jets of water striking spoon-shaped blades on a wheel, generating rotational energy.

6.1 Calculate the mechanical and electrical efficiencies of Pelton Wheel Turbine by nozzle opening about half.

Hints:

- Start the pump
- Adjust the nozzle opening about half
- Note down the pressure gauge, vacuum gauge readings
- Note the Speed of the turbine, manometer readings (h1 & h2) shown in figure 6.

6.2 Calculate the mechanical and electrical efficiencies of Pelton Wheel Turbine by nozzle opening about full.

Hints:

- Start the pump
- Adjust the nozzle opening about half
- Note down the pressure gauge, vacuum gauge readings
- Note the Speed of the turbine, manometer readings (h1 & h2) shown in figure 6.

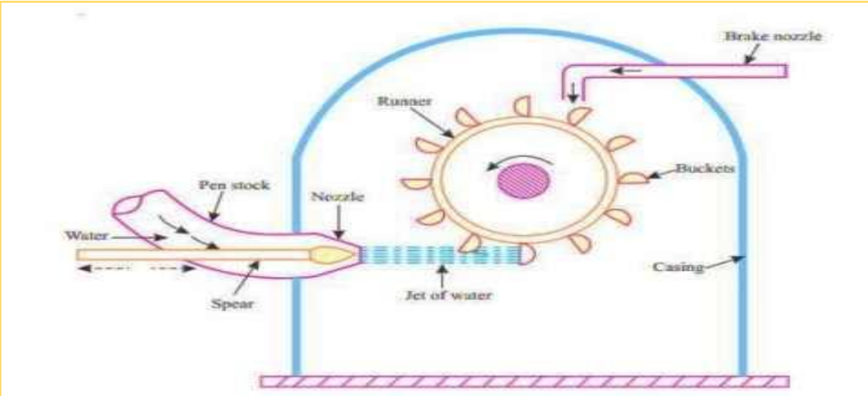

Figure 6: Schematic diagram of a Pelton turbine

Try

1. Adjust the nozzle opening for 3/4, and calculate the efficiency of the Pelton wheel turbine
2. Performance characteristics of Pelton wheel turbine for change in the bucket design.

7. Performance Test on Francis Turbine

The Francis Turbine represents a remarkable combination of impulse and reaction turbine principles. Operating as a reaction turbine, it harnesses the power of water under high pressure, utilizing both the reaction and impulse forces generated as the water flows past its blades.

7.1 Calculate the mechanical and electrical efficiencies of Francis Turbine by nozzle opening about half.

Hints:

- Start the pump
- Adjust the nozzle opening about half
- Note down the pressure gauge, vacuum gauge readings
- Note the Speed of the turbine, manometer readings (h1 & h2) shown in figure 7.

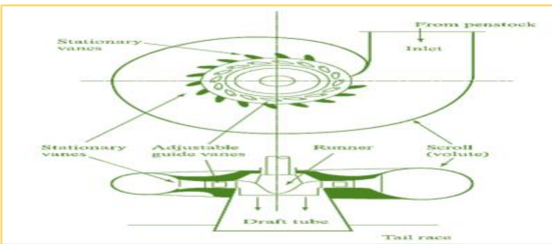

Figure 7: Schematic diagram of a Francis turbine

7.2 Calculate the mechanical and electrical efficiencies of Pelton Wheel Turbine by nozzle opening about full.

Hints:

- Start the pump
- Adjust the nozzle opening about half
- Note down the pressure gauge, vacuum gauge readings
- Note the Speed of the turbine, manometer readings (h1 & h2) shown in figure 7.

Try

1. Performance characteristics of Francis turbine for change in the vane angle
2. Performance characteristics of Francis turbine for change in datum head

8. Performance Test on Kaplan turbine.

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.

8.1 Calculate the mechanical and electrical efficiencies of Kaplan turbine by nozzle opening about half.

Hints:

- Keep the runner vane at require opening.
- Keep the guide vanes at required opening.
- Prime the pump if necessary. Close the main sluice valve and then start the pump.
- Measure the turbine rpm with tachometer shown in figure 8.

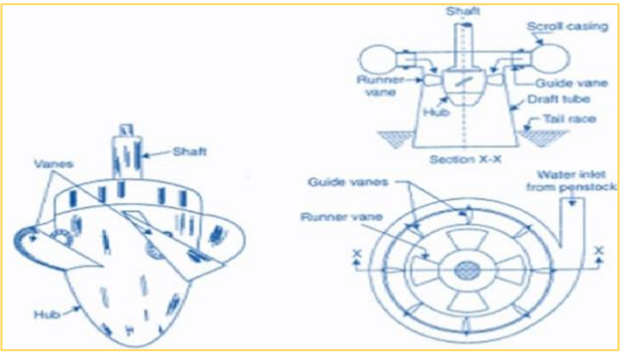

Figure 8: Schematic diagram of a Kaplan turbine

8.2 Calculate the mechanical and electrical efficiencies of Kaplan turbine by nozzle opening about full.

Hints:

- Keep the runner vane at require opening.
- Keep the guide vanes at required opening.
- Prime the pump if necessary. Close the main sluice valve and then start the pump.
- Measure the turbine rpm with tachometer shown in figure 8.

Try

1. Performance characteristics of Francis turbine for change in the vane angle
2. Performance characteristics of Francis turbine for change in datum head

9. Performance Test on Reciprocating Pump

Reciprocating pump is a positive displacement pump where certain volume of liquid is collected in enclosed volume and is discharged using pressure to the required application.

9.1 Calculate the Hydraulic efficiency of Reciprocating Pump for 3 revolutions of energy meter.
Hints:

- Start the pump
- Operate the valves
- Note down the readings for delivery valve, pressure head reading, time (t)
- Calculate the actual discharge, input power, output power, using the experimental setup, shown in figure 9.

9.2 Calculate the Hydraulic efficiency of Reciprocating Pump for 5 revolutions of energy meter.
Hints:

- The pump was primed and motor was started by keeping the delivery valve closed.
- Calculate discharge.
- Now calculate the output power. Calculate Efficiency (ŋ) using the experimental setup, shown in figure 9.

Try

1. Note down the time for 15 cm rise of water and calculate the efficiency of the Reciprocating Pump.
2. Note down the time for 25 cm rise of water and calculate the efficiency of the Reciprocating Pump.

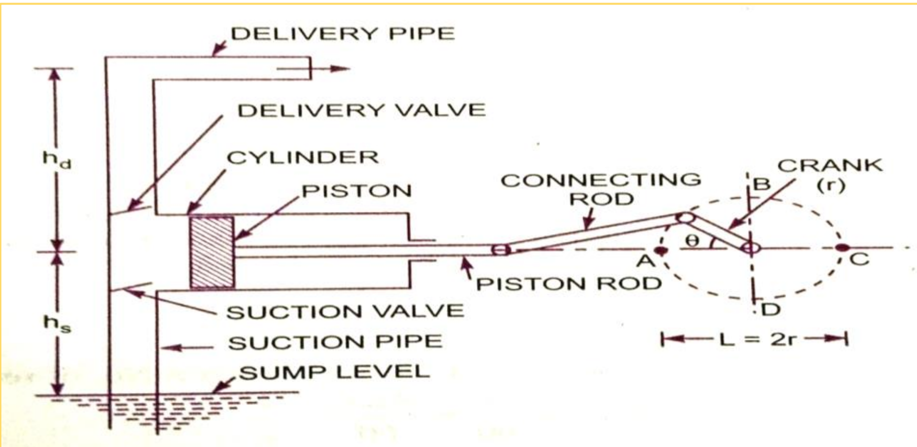

Figure 9: Reciprocating pump setup

A hydraulic device that uses the centrifugal force generated by the fluid to convert mechanical energy into hydraulic energy is called a centrifugal pump.

10. Performance Test on Centrifugal Pump

A hydraulic device that uses the centrifugal force generated by the fluid to convert mechanical energy into hydraulic energy is called a centrifugal pump.

10.1 Calculate the Hydraulic efficiency of Centrifugal Pump for 3 revolutions of energy meter.
Hints:

- Start the motor
- Operate the valves, note down the readings for pressure head, time (t),

- Calculate the actual discharge, input power, output power, and calculate the efficiency of the centrifugal pump, using the experimental setup, shown in figure 10.

10.2 Calculate the Hydraulic efficiency of Centrifugal Pump for 5 revolutions of energy meter.

Hints:

- Start the motor
- Operate the valves, note down the readings for pressure head, time (t),
- Calculate the actual discharge, input power, output power, and calculate the efficiency of the centrifugal pump, using the experimental setup, shown in figure 10.

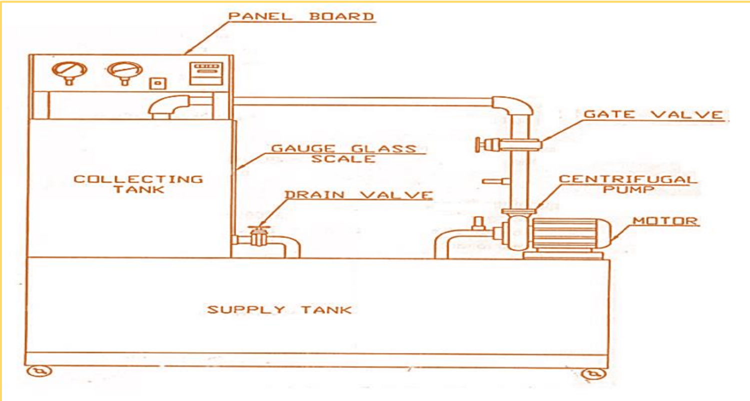

Figure 10: Centrifugal pump experiment setup

Try

1. Note down the time for 15 cm rise of water and calculate the efficiency of the centrifugal pump.
2. Note down the time for 25cm rise of water and calculate the efficiency of the centrifugal pump.

11. Coefficient of Impact of Jets on Vanes

The liquid comes out in the form of a jet from the outlet of a nozzle, which is fitted to a pipe through which the liquid if flowing under pressure.

11.1 Calculate the Coefficient of Impact of flat vane.

Hints:
Fix the given vane and add dead weight
Note down the forces, note down the time
Calculate the flow speed, discharge, and coefficient of impact vanes, shown in Figure 11.

11.2 Calculate the Coefficient of Impact of curved vane.

Hints:
Fix the given vane and add dead weight
Note down the forces, note down the time
Calculate the flow speed, discharge, and coefficient of impact vanes, shown in Figure 11.

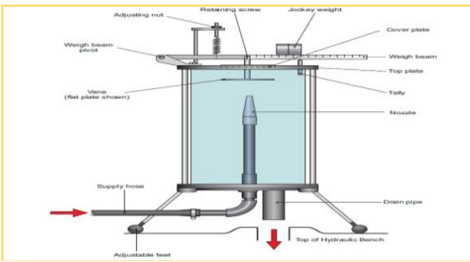

Figure 11. Lay out of the jets on vanes experimental set up

Try

1. Change the orifice geometry and find the coefficient of impact vanes.

12. Performance Test on Multi stage Centrifugal Pump

A multistage pump is a type of pump which contains 2 or more impellers which may be of the same or different types i.e low NPSH suction impeller, double suction impeller or combination with Centrifugal first stage and side channel stage impellers.

12.1 Calculate the Hydraulic efficiency of multi stage Centrifugal Pump for 3 revolutions of energy meter.

Hints:

- The pump was primed and motor was started by keeping the delivery valve closed.
- Note down the pressure gauge and vacuum gauge reading by adjusting the delivery valve.
- Note down the time required for the rise of 10cm (i.e. 0.1m) water in the collecting tank by using stop watch.
- Calculate discharge.
- Now calculate the output power. Calculate Efficiency (ŋ).

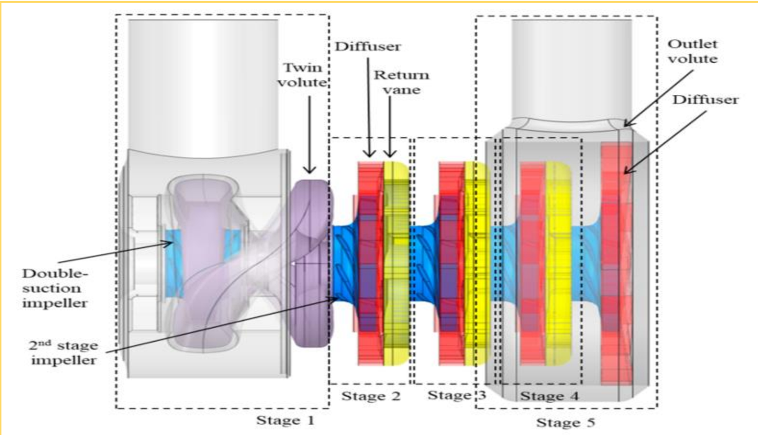

Figure 12: Schematic diagram of a Francis turbine

12.2 Calculate the Hydraulic efficiency of multi stage Centrifugal Pump for 5 revolutions of energy meter.

Hints:

- The pump was primed and motor was started by keeping the delivery valve closed.
- Calculate discharge.
- Now calculate the output power. Calculate Efficiency (ŋ).

Try

1. Note down the time for 15 cm rise of water and calculate the efficiency of the Multi stage centrifugal pump.
2. Note down the time for 30 cm rise of water and calculate the efficiency of the Multi stage centrifugal pump.

13. Loss of head due to sudden contraction

A sudden contraction in a pipeline refers to a section where the diameter of the pipe abruptly decreases, resulting in a smaller cross-sectional area for the fluid to flow through.

13.1 Calculate the head lost due to sudden contraction using the experimental setup by taking 5cm raise of water.

Hints:

- Switch on the pump and open the delivery valve.
- Open the corresponding ball valve of pipe under consideration.
- Close the butterfly valve and note down the time taken for known water level rise.
- Change the flow rate and take the corresponding reading.

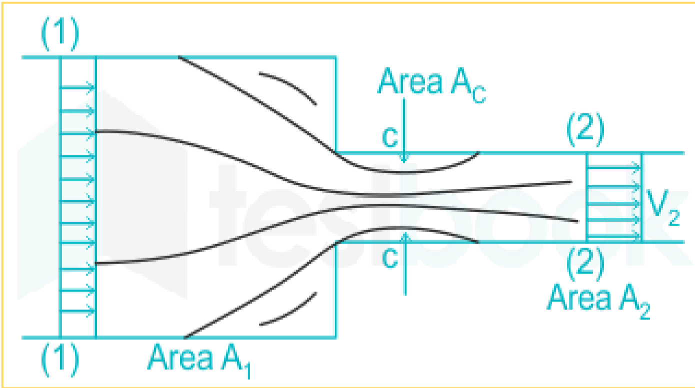

Figure 13: Schematic diagram of loss of head due to sudden contraction.

13.1 Calculate the head lost due to sudden contraction using the experimental setup by taking 10cm raise of water.

Hints:

- Switch on the pump and open the delivery valve.
- Open the corresponding ball valve of pipe under consideration.
- Close the butterfly valve and note down the time taken for known water level rise.

Change the flow rate and take the corresponding reading.

Try

1. Change the rate of flow and find the loss of head in sudden contraction
2. Change the height of the rise in water level in collecting tank find the loss of head in sudden contraction.

14. Coefficient of discharge for a Notch

The rectangular notch is a common device used to regulate and measure discharge in irrigation projects.

14.1Calculate the coefficient of discharge for a Notch using the experimental setup by taking 5cm raise of water.

Hints:

- Fix the plate with rectangular notch (figure 14) in the hydraulic bench
- Start the pump, note down h1, h2 readings in the notch
- Calculate actual, theoretical discharge, and find the coefficient of discharge, using the experimental setup.

14.2Calculate the coefficient of discharge for a Notch using the experimental setup by taking 10cm raise of water.

Hints:

- Fix the plate with rectangular notch (figure 14) in the hydraulic bench
- Start the pump, note down h1, h2 readings in the notch
- Calculate actual, theoretical discharge, and find the coefficient of discharge, using the experimental setup.

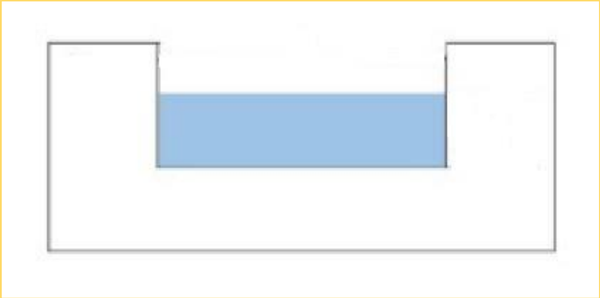

Figure 14: Schematic diagram of a flow through rectangular notch

Try

1. Use triangular notch and find the coefficient of discharge
2. Use Broad crested notch and find the coefficient of discharge

V. TEXT BOOKS:

1. Frank M. White, "Fluid Mechanics ", McGraw Hill Education Private Ltd, 9th edition, 2022.
2. R. K Bansal, “Fluid Mechanics and Hydraulic Machines”, Laxmi Publications Ltd, Revised 9th edition, 2019.

VI. REFERENCE BOOKS:

1. Rathakrishnan. E, “Fluid Mechanics, an introduction”, PHI Learning Pvt. Ltd, 2022.

VII. ELECTRONICS RESOURCES:

1. https://archive.nptel.ac.in/courses/112/105/112105171/
2. https://akanksha.iare.ac.in/index?route=course/details&course_id=522

VIII. MATERIALS ONLINE

1. Course template
2. Lab manual