COURSE OUT COMES

1	Students will have the ability to determine the flow rate of the fluid using different flow measuring devices, Coefficient of discharge for constant and variable head.
2	Students will have the ability to determine fluid viscosity, application of Bernoulli's theorem.
3	Students will be able to characterize the fluid flow based on the Reynolds number and also determine major/minor losses through the pipes. Also, demonstrate the knowledge of Impulse Momentum equation.

Expt. No.	**Name of The Experiment**
1	Calibration of Venturimeter.
2	Determination of discharge of a given Pipe Flow using Venturimeter/Orifice meter.
3	Determination of Coefficient of discharge for a small orifice by a constant head method.
4	Determination of Coefficient of discharge for a small orifice by a variable head method.
5	Determination of Viscosity of a Fluid.
6	Calibration of contracted Rectangular Notch.
7	Verification of Bernoulli's equation.
8	Pipe friction apparatus with loss of head on pipe fittings.
9	Determination of Coefficient of loss of head in a sudden contraction and friction factor.
10	Estimation of Major loss/Minor losses for a given flow system.
11	Determination of state of flow in a closed conduit using Reynolds Experiment.
12	Impact of Jet over a flat surface.

Fluid Flow Measurements - Introduction:

As the fluid flow relative to the objects either internally or externally, measurements of properties like pressure, velocity, mass flow rate or discharge are of primarily important. This can be achieved by

- Pitot Tubes (Static and Total) for Velocity Measurement.
- Manometers for Pressure Measurement.
- Notches and Weirs for measuring discharge.
- Venturimeter and Orifice Meter for discharge.

The rate of a fluid through a pipe or duct or interflow is measured by instruments like Venturimeter, Orifice meter etc., whereas through an open channel the rate of flow is measured by notches and wires. Pressure in the fluid is measure by manometer, barometer etc.

EXPERIMENT NO:1 - Calibration of Venturimeter.

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

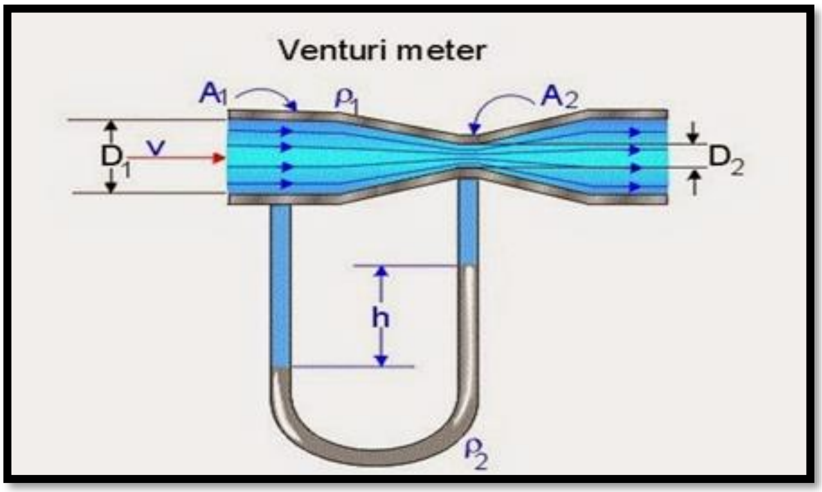


Figure 1: Venturimeter

Venturi meter:

A Venturi meter is a device used for measuring the rate of flow of fluid flowing through a pipe. It consists of three parts as shown in Figure 1:

- A short converging part
- Throat
- Diverging part.

Venturimeter work on the principle by reducing the cross-sectional area of the flow passage. Pressure difference between the two sections is developed and the measurement of the pressure difference enables the determination of the discharge through the pipe. However, a

Venturimeter is a simpler and cost-effective method of discharge measurement through pipes. Venturimeter is used in a very limited space for measurement of discharge through pipes. The small sized Venturimeter suitable for pipes of less than 50mm diameter.

Procedure:

1. Install the equipment near a 230 volts 5 amps electrical source and a water source.
2. Fill the sump tank with clean and soft water to the ¾ its level.
3. Connect upstream and downstream tapings of the Venturimeter with the mercury and open all the four valves of the manometer (two valves for measurement of differential pressure & other two for air vent).
4. Keep the bypass valve fully open and switch on the pump.
5. Gradually close the bypass valve fully & allow the water to flow through the Venturimeter.
6. Remove air bubbles if any from the manometer by momentarily opening & closing the pressure tapping valves & observe all the air is removed from the manometer & only water is flowing through the air vent tubes.
7. Close the air vent valves gradually and simultaneously.
8. Note down the manometer readings (difference in mercury level) & measure the discharge in measuring tank against time (with the help of stopwatch) for a height of 10 cm. Record the observation in the tabular column & calculate the coefficient of discharge.
9. Vary the discharge by opening the bypass valve to any desired position (not fully open) & follow the step 8.
10. Determine the flow rate of (Q_{ac}) and (Q_{th}), Calculate the percentage error to calibrate the given flowmeter.

Observation:

Diameter of pipe, d1 = m

Diameter of throat, d2 = m

Area of collecting tank, A =____x____=________m^2

Area of pipe at entry, A1 = $[(\pi/4)\, d1^2] = [(\pi/4)\, (\quad)^2] = m^2$.

Area of pipe at throat, A2 = $[(\pi/4)\, d2^2] = [(\pi/4)\, (\quad)^2] = m^2$.

Density of mercury, ρ_m =13600 kg / m^3.

Density of water, ρ_w =1000 kg / m^3

Observation Table:

SL. No.	Manometric Reading			Pressure Head Diff.	Tank Reading			Time for 10 cm rise of water. (t)	Actual Discharge	Q th = $\frac{A1A2(2gH)^{1/2}}{[A1^2 - A2^2]^{1/2}}$	% ERROR $\frac{Qth - Qac}{Qac}$ *100
	LHS	RHS	Diff. h1 – h2	H = Hm[(ρm/ρw) -1]	Initial	Final	Diff. H2 - H1		Q ac = (A.ΔH) / t		
	h1	h2 m	Hm m	m	H1 m	H2 m	ΔH m	sec	m^3 / sec	m^3 / sec	
1											
2											
3											

CALCULATION:

1. Theoretical Flow rate

$$Q_{theoretical} = \frac{a_1\, a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}} \quad m^3/sec$$

a_1 = Area of the pipe = $\Pi D_1^2/4$ m^2

a_2 = Area at the throat of the Venturimeter = $\Pi D_2^2/4$ m^2

2. Actual Flow Rate

Q_{actual} = (area of tank x H) / t m^3/sec

3. Co-efficient of discharge Cd

$$C_d = Q_{actual} / Q_{theoretical}$$

RESULT:

EXPERIMENT NO:2 - Determination of discharge of a given Pipe Flow using Venturimeter/Orifice meter.

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

Procedure:

1. Install the equipment near a 230 volts 5 amps electrical source and a water source.
2. Fill the sump tank with clean and soft water to the ¾ its level.
3. Connect upstream and downstream tapings of the Venturimeter with the mercury and open all the four valves of the manometer (two valves for measurement of differential pressure & other two for air vent).
4. Keep the bypass valve fully open and switch on the pump.
5. Gradually close the bypass valve fully & allow the water to flow through the Venturimeter.
6. Remove air bubbles if any from the manometer by momentarily opening & closing the pressure tapping valves & observe all the air is removed from the manometer & only water is flowing through the air vent tubes.
7. Close the air vent valves gradually and simultaneously.
8. Note down the manometer readings (difference in mercury level) & measure the discharge in measuring tank against time (with the help of stopwatch) for a height of 10 cm. Record the observation in the tabular column & calculate the coefficient of discharge.
9. Vary the discharge by opening the bypass valve to any desired position (not fully open) & follow the step 8.
10. Determine the coefficient of discharge (C_d) for each flow rate and find the mean value of coefficient of discharge (C_d) mean.
11. Plot a graph of (Q_{ac}) on y-axis versus (Q_{th}) on x- axis.
12. Calculate the slope of graph of (Q_{ac}) versus (Q_{th}), it gives the mean value of coefficient of discharge (C_d) mean graphically.

Observation:

Diameter of pipe, d_1 = m

Diameter of throat, d_2 = m

Area of collecting tank, A =____x_____=_________m^2

Area of pipe at entry, A_1 = [(л/4) d_1^2] = [(л/4) ($)^2$] = m^2.

Area of pipe at throat, A2 = [(л/4) $d2^2$] = [(л/4) ( )^2] = m^2.

Density of mercury, ρm =13600 kg / m^3.

Density of water, ρw =1000 kg / m^3

Observation Table:

SL. No.	Manometric Reading			Pressure Head Diff.	Tank Reading			Time for 10 cm rise of water. (t)	Actual Discharge	Q th = A1A2(2gH)$^{1/2}$ / [A1^2 – A2^2]$^{1/2}$	$C_d = \frac{Q_{ac}}{Q_{th}}$
	LHS	RHS	Diff. h1 – h2	H = Hm[(ρm/ρw) -1]	Initial	Final	Diff. H2 - H1		Q ac = (A.ΔH) / t		
	h1	h2 m	Hm m	m	H1 m	H2 m	ΔH m	sec	m^3 / sec	m^3 / sec	
1											
2											
3											

CALCULATION:

1. Theoretical Flow rate

$$Q_{theoretical} = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}} \quad m^3/sec$$

a_1 = Area of the pipe = Π D_1^2 /4 m^2

a_2 = Area at the throat of the Venturimeter = Π D_2^2 /4 m^2

2. Actual Flow Rate

Q_{actual} = (area of tank x H) / t m^3/sec

3. Co-efficient of discharge Cd

$C_d = Q_{actual} / Q_{theoretical}$

RESULT:

Orificemeter or Orifice plate:

Apparatus: An Orificemeter fitted across a pipeline leading to a collecting tank, Stop Watch, U-Tube manometer etc.

Theory:

It works on Bernoulli's principle and device use for measuring the rate of fluid flowing through a pipe. It is a cheaper device as compared to venturimeter. It consists of flat circular plate which has a circular sharp edge hole called as orifice called as which is concentric with pipe. The orifice diameter is generally kept ½ times the diameter of pipe. 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 as shown in figure 2. The plate is fixed inside the pipe. A mercury U-tube manometer is inserted to know the difference of pressure head between the two tapping. Orificemeter 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 section and the measurement of pressure difference is used to find the discharge.

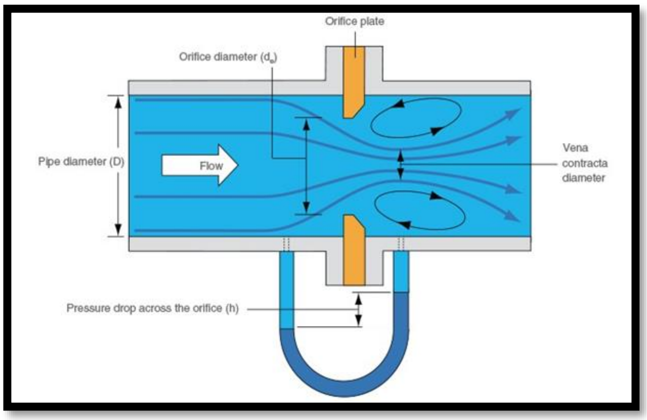


Figure 2: Orificemeter

Procedure:

1. Note the diameter at the inlet of pipe (d_1) and the diameter of an orifice (d_o).
2. Note the density of manometric liquid i.e., mercury (ρ_m) and that of fluid flowing through pipeline i.e., water (ρ_w).
3. Connect the U-tube manometer to the pressure toppings of Orificemeter, one end at the inlet section and the other end at the section where jet of water leaves from orifice forming a vena contracta.
4. Start the flow and adjust the control valve in pipeline to get the required discharge. Measure the pressure difference (H_m) between two sections of Orificemeter by using U - tube mercury manometer.

5. Convert the pressure head difference in meters of fluid flowing through pipeline (i.e., water) by using the equation $h = H_m [(\rho_m / \rho_w) - 1]$
6. Measure flow rate i.e. actual discharge (Q_{ac}) through Orificemeter by means collecting the water in collecting tank for a specified period of time.
   $Q_{ac} = V / t = (A.\Delta H) / t$. Change the flow rate by adjusting the control valve and repeat the process or at least five times.
7. Determine the coefficient of discharge (C_d) for each flow rate and find the mean value of coefficient of discharge (C_d) mean.
8. Plot a graph of (Q_{ac}) on y-axis versus (Q_{th}) on x- axis.
9. Calculate the slope of graph of (Q_{ac}) versus (Q_{th}), it gives the mean value of coefficient of discharge (C_d) mean graphically.

Observation:

Diameter of pipe, d_1 =______m

Diameter of orifice, d_o =_______m

Area of collecting tank, A =____x______=_________m^2

Area of pipe at entry, $a_1 = [(\pi/4)\, d_1^2] = [(\pi/4)\, (\quad)^2]$ =_____m^2 .

Area of orifice, $a_o = [(\pi/4)\, d_o^2] = [(\pi/4)\, (\,)^2]$ =

__________________m^2. Density of mercury, ρ_m =13600 kg / m^3.

Density of water, ρ_w =1000 kg / m^3

Observation Table:

SL. No.	Manometric Reading			Pressure Head Diff.	Tank Reading			Time for 10 cm rise of water. (t)	Actual Discharge	$Q_{th} = \dfrac{A_1A_2(2gH)^{1/2}}{[A_1^2 - A_2^2]^{1/2}}$	$C_d = \dfrac{Q_{ac}}{Q_{th}}$
	Left Limb	Right Limb	Diff. $h_2 - h_1$	$H = H_m[(\rho_m/\rho_w) - 1]$	Initial	Final	Diff. $H_2 - H_1$		$Q_{ac} = (A.\Delta H) / t$		
	h_1 m	h_2 m	H_m m	m	H_1 m	H_2 m	ΔH m	sec	m^3 / sec	m^3 / sec	
1											
2											

3											

CALCULATION:

1. Difference in manometer limbs = $h_{m} =$ (L.H.S – R.H.S)

2. Head in meters of water = $h = h_{m} \times \left(\frac{\rho_m}{\rho_w} - 1 \right)$

   ρ_m = Density if manometric liquid (mercury) = 13600 Kg/m^3
   ρ_w = Density of water =1000 Kg/m^3

3. Theoretical Flow rate

   $$Q_{theoretical} = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}} \quad m^3/sec$$

   a_1 = Area of the pipe = $\Pi D_1^2/4 \quad m^2$
   a_2 = Area at the nozzle = $\Pi D_1^2/4 \quad m^2$

4. Actual Flow Rate

   Q actual = (area of tank x H)/t $\quad m^3/sec$

5. Co-efficient of discharge C_d

   $$Cd = Q_{actual} / Q_{theoretical}$$

RESULT:

EXPERIMENT NO:3 - Determination of Coefficient of discharge for a small orifice by a constant head method.

Apparatus: Inlet tank which is fed from on overhead tank through a pipe network sharp edge orifice, hook gauge attached to the inlet tank, Stop watch, Scale etc.

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.

$$Q_{ac} = \frac{V}{\Delta t} = \frac{A.\Delta H}{\Delta t}$$

Coefficient of velocity = Actual velocity/Theoretical velocity

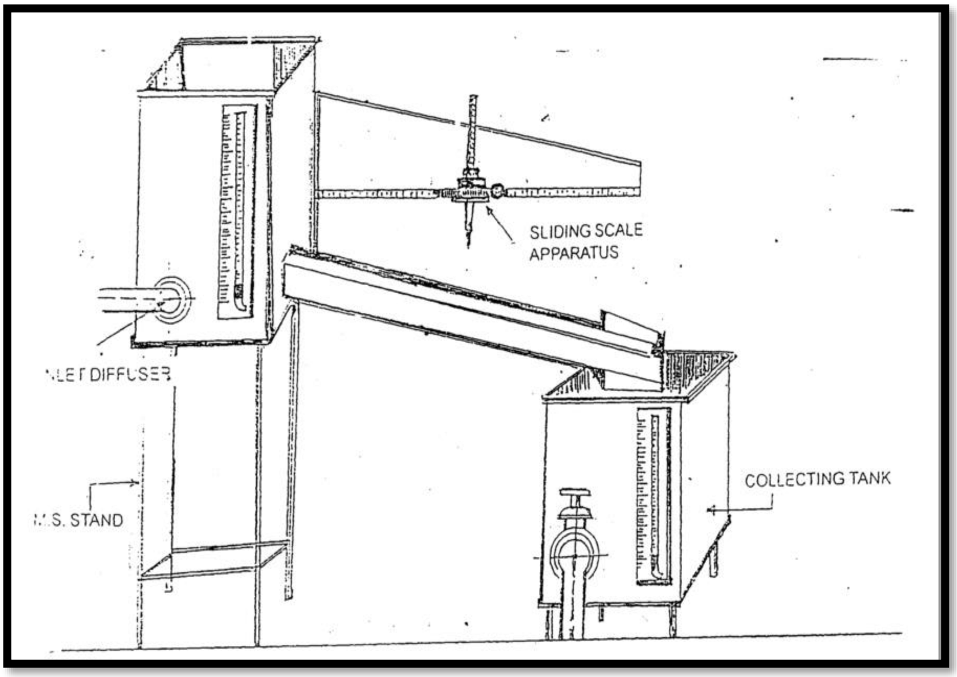


Figure 3: Orifice and Mouth piece Apparatus

Procedure:

1. Fit the given orifice to the supply tank.
2. Note down the dimensions of the supply and measuring tanks using a scale.
3. Measure the diameter of the given orifice using vernier calipers.
4. Open the regulating valve fitted to the supply pipe and adjust it to maintain a constant head in the tank.

5. Note down the time taken for a rise of 0.1 m of water level in the measuring tank.

6. Repeat the procedure for different heads.

Observations:

1. **Diameter of the orifice (d) = 6 mm, 8 mm, 10 mm.**
2. **Diameter of the mouth piece (d) = 6 mm, 8 mm, 10 mm.**
3. **Measuring tank area: 0.25 * 0.5 m^2.**

Model Calculations:

1. Actual discharge: $Qact = \frac{A*R}{T}$

   Where,

   A= cross sectional area of measuring tank = (l_m * b_m) = ……m^2.

2. R= Rise of water column in measuring tank = --------- m.
3. t = Time taken for 'R' units rise of water column in measuring tank =------- sec.
4. Therefore Q act = -------------- m3/s.
5. Theoretical discharge = (Q th) = a_o * √ (2gh).

   Where,

   a_o = Cross-sectional area of the orifice = (π/4)d^2 = --------- m^2.

   h = Constant head in the supply tank = ------------- m.

   Therefore Q t h = -------------- m3/s.

6. Coefficient of discharge Cd = Q act/Q t h = ------------.

Observation Table:

Sl. no	Constant head in supply tank (H) in 'm'	X in meter	Y in meter	Time taken for R units rise of water in measuring tank (t) in 'sec'	Actual discharge (Q act) in 'm3/s'	Theoretical discharge (Q t h) in 'm3/s'	Coefficient of discharge (C d)	Co-efficient of velocity (Cv)

Average Value of Cd = --------.

7. **Co-effcient of velocity** =

   $Cv = \sqrt{\frac{X^2}{4YH}}$

   Where H= total head.

X =Horizantal point length

Y= Verticalpoint length

8. **Co-efficient of Contraction:**

   C.d = C.v * C.c

   C.c = C.d / C.v

RESULT:

EXPERIMENT NO: 4 - Determination of Coefficient of discharge for a small orifice by a Variable head method.

Apparatus: Inlet tank which is fed from on overhead tank through a pipe network sharp edge orifice, hook gauge attached to the inlet tank, Stop watch, Scale etc.

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.

$$Q_{ac} = \frac{V}{\Delta t} = \frac{A.\Delta H}{\Delta t}$$

Coefficient of velocity = Actual velocity/Theoretical velocity

Procedure:

1. Fit the given orifice to the supply tank.
2. Note down the dimensions of the supply and measuring tanks using a scale.
3. Measure the diameter of the given orifice using vernier calipers.
4. Open the regulating valve fitted to the supply pipe and adjust it to maintain a constant head in the tank.
5. Note down the time taken for a rise of 0.1 m of water level in the measuring tank.
6. Repeat the procedure for different heads.

Observations:

1. Diameter of the orifice (d) = 6 mm, 8 mm, 10 mm.
2. Diameter of the mouth piece (d) = 6 mm, 8 mm, 10 mm.
3. Measuring tank area: 0.25 * 0.5 m^2.

Model Calculations:

1. Actual discharge: $Qact = \frac{A*R}{T}$

   Where,

   A= cross sectional area of measuring tank = (l_m * b_m) = ……m^2.
2. R= Rise of water column in measuring tank = --------- m.
3. t = Time taken for 'R' units rise of water column in measuring tank =------- sec.
4. Therefore Q act = ------------- m3/s.
5. Theoretical discharge = (Q th) = a_o * √ (2gh).

Where,

a_o = Cross-sectional area of the orifice = $(\pi/4)d^2$ = --------- m^2.

h = Constant head in the supply tank = ------------- m.

Therefore Q t h = -------------- m3/s.

6. Coefficient of discharge Cd = Q act/Q t h = ------------.

Observation Table:

Sl. no	Variable head in supply tank (H) in 'm'	X in meter	Y in meter	Time taken for R units rise of water in measuring tank (t) in 'sec'	Actual discharge (Q act) in 'm3/s'	Theoretical discharge (Q t h) in 'm3/s'	Coefficient of discharge (C d)	Co-efficient of velocity (Cv)

Average Value of Cd = --------.

7. **Co-effcient of velocity** =

Cv = $\sqrt{\frac{X^2}{4YH}}$

Where H= total head.

X =Horizantal point length

Y= Verticalpoint length

8. **Co-efficient of Contraction:**

C.d = C.v * C.c

C.c = C.d / C.v

RESULT:

EXPERIMENT NO: 5 - Determination of Viscosity of a Fluid.

Apparatus required: - Redwood viscometer, Thermometer, 50cc measuring flask, Stop watch, Heater, Oil, etc

Theory: - Viscosity is the resistance offered in the fluids. This resistance is due to the internal friction. This property is important for lubrication of engine components and bearing parts. If viscosity is low, the oil becomes too thin which results in high friction in the component. If it is too thick, that will increase the power loss. The viscosity varies with temperature also; hence lubricating oil has to be selected based on the application.

Procedure: -

1. Clean the oil cup using suitable solvent (petrol) and dry the cup before the test being started.
2. Fill the given oil in the cup up to the marking.
3. Fix the thermometer to measure oil temperature and water temperature.
4. Weigh the cleaned and dried 50 ml measuring flask and keep below the jet of the viscometer.
5. Heat the water bath slowly in a uniform rate and stir the oil continuously.
6. Lift the ball valve when the temperature of the oil reached desired value and start the stop watch.
7. Note down the time for 50ml oil collection and weigh the flask with oil.
8. Repeat the experiment for different temperature and tabulate the data.
9. calculate absolute and kinematic viscosity and plat the graph of viscosity V/S temperature.

Formulae Used: -

Density of the given oil is "ρ" = (W2-W1)/50 in gm/cc

Kinematic Viscosity $\nu = (0.00247\ T - 0.65/T)\ 10^{-4}$ in m^2/s

Absolute Viscosity $\mu = \nu * \rho$ in Pa/s

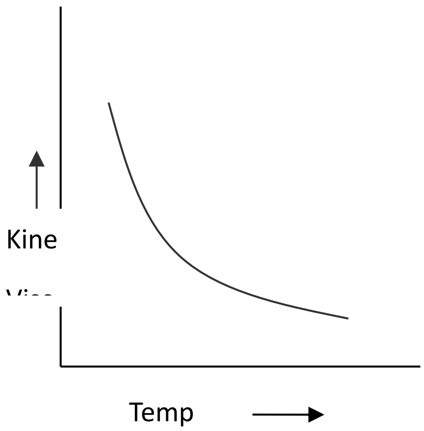
$$\text{Red wood No} = \frac{100 * T * (W2 - W1)}{535 * 0.915}$$

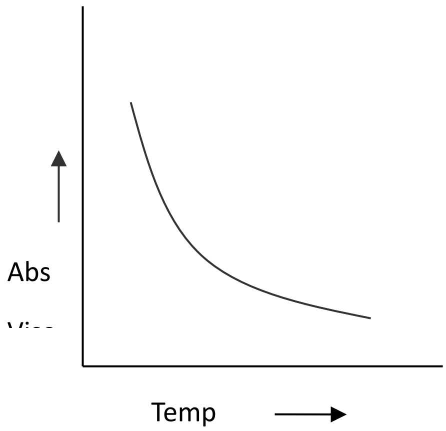
Observation & Tabulation: -

Type of oil used: -

Weight of the empty flask: -

SL NO	Temp In 0^0C	Time for 50 cc of oil collection T in sec	Wt of the flask with oil W_2 in gms	Density "ρ" In gm/cc	Kinematic viscosity m^2/s	Absolute viscosity Pa/s	Redwood No
1							
2							
3							





RESULT:

1. Kinematic viscosity of the given oil is___________
2. Absolute viscosity of the given oil is ___________

EXPERIMENT NO: 6 - Calibration of contracted Rectangular Notch.

Apparatus: Channel with rectangular notch, point gauge, Collecting tank, Stop watch, Scale etc.

Theory:

A notch is a device used for measuring rate of flow of a liquid through a small channel or a tank. Notch can be defined as in opening in the side of a tank or a small channel in such that the liquid surface in the tank or channel is below the top edge of the opening. The sheet of water flowing through a notch is called nappe. The bottom edge of a notch over which the water flows is known as sill.

Classification of notches:

1. According to the shape of the opening
   a. Rectangular notch
   b. Triangular notch
   c. Stepped notch

PROCEDURE:

1. Connect the equipment to the electrical power source and ascertaining the direction of rotation of the pump in proper direction.
2. Fill filtered cleared water into the sump tank up to ¾th its full capacity.
3. Fix the desired notch in its position i.e., notch at the downstream end of the channel with wing nuts. Mount the hook gauge assembly.
4. Start the pump with the help of electrical switch and observe water flowing in the channel. Wait till the water level raises to the Crest level of the notch fixed at the downstream end.
5. Stop the pump and wait till the excess water above the Crest level drops into the sump tank. Lower the hook gauge to water level.
6. Adjust the vernier scale "0" (zero) to any whole number of main scale division and lock it.
7. Bring the hook gauge point exactly to the water level, note it as initial level, which is also called as Crest level and record it.
8. Start the pump and adjust the flow of water to any desired rate by operating the by-pass valve. Now the water flows over the Crest of the notch and falls in to the sump tank.
9. Allow the water flow to reach a steady state. Raise the drowned hook gauge point to the present water level and record the final level which indicates the head of

water flowing over the notch.

10. Tabulate the recorded readings.
11. Vary the flow rate in steps, note and record and the final level of water over the notch at each step (allow the flow of water to reach steady state at each step).
12. Follow step 12 to 17 for repeating the experiment. After the experiment is over stop the pump, drain the channel and keep it clean and dry.
13. Tabulate all the readings calculate and draw a conclusion.

Observation:

Area of tank, A = x _____ = cm^2

Width of rectangular Notch, b = ___cm

Time required to collect water to a depth ΔH = Δt = constant = ____**sec.**

Observation Table:

Sl. No.	**Point Gauge Reading**			**Discharge Measurement**				**C_d = Q_{act}/ Q_{the}**
	Initial (cm)	**Final (cm)**	**Diff. (H) (cm)**	**ΔH (cm)**	**Δt (sec)**	Q_{act}	Q_{the}	
01.								
02.								
03.								

Sample Calculation :

* Volume of water collected in tank.= $V = A.\Delta H$ = _______x______=______cm^3

* Actual Discharge = $Q_{ac} = \frac{V}{\Delta t} = \frac{A.\Delta H}{\Delta t} =$ __________ =_________cm^3/s

* Theoretical Discharge = $Q_{th} = \frac{2}{3} b\sqrt{2.g}(H)^{3/2} = \frac{2}{3}(\qquad)\sqrt{2\times 981}(\qquad)^{3/2}$

Q_{th} =___________cm / s

* Coefficient of Discharge = $C_d = \frac{Q_{ac}}{Q_{th}} =$ _______ = ________

* Mean Coefficient of Discharge = $C_{d\,mean} = \frac{\quad + \quad + \quad + \quad}{5}$ = _____

Result : Coefficient of discharge (C_d) for rectangular notch was found to be __________

EXPERIMENT NO: 7 - Verification of Bernoulli's equation.

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

Theory: The Bernoulli's theorem states that the total energy of non-Viscous in compressible fluid in a steady state of flow, remains constant along a stream line Daniel Bernoulli's enunciated in 1738 that is "In any stream flowing steadily without friction, the total energy contained in a given mass is some at energy contained in a given mass is some at energy point in its path of flow." 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 shown in fig. 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 = $\frac{P}{w} + \frac{V^2}{2.g} + Z$ **= Constant**

Where,

P / w = Pressure energy

V^2 / 2g = Kinetic energy

Z = Potential energy

Procedure:

1. Open the measuring tank valve fully, to keep the tank empty. Close the outlet valve.
2. Open the inlet valve and let water rise to some height 'h1' in the inlet tank. Measure this height on the piezometer.
3. Now open the outlet valve slightly and maintain height $h2 < h1$ to maintain the flow rate.
4. Thus adjust the outlet valve fill the water level remains constant at 'h', and also readings on each of the piezometer.
5. Check if reading is correctly written. Close the measuring tank valve. Measure the discharge, i.e. note rise in water level in 5 or 10 sec., write these and also measure and note length and breadth of the tank. This completes on run. Take at least three runs by changing the discharge.
6. Note down the area of the conduit at various gauge points.
7. Open the supply valve and adjust the flow so that the water level in the inlet tanks remains constant.
8. Measure the height of water level (above an arbitrarily selected suitable plane) in different remains constant.
9. Measure the discharge of the conduit with the help of measuring tank. Repeat steps 2

to 4 for two more discharges.

10. Plot graph between total energy and distance of gauge points starting from u/s side of conduit.

Observation :

Area of collecting tank = A = L x B =_______x________=_________cm^2

Difference in water level in collecting tank = Δh =_________cm

Time required for rise of water level by 10 cm = Δt =_________sec.

Discharge = $Q_{ac} = \frac{Volume\ \ Of\ \ Water}{Time} = \frac{A.\Delta H}{\Delta t} =$ __________ = __________ m^3/sec

Observation Table:

Sl. No.	Piezometric head (cm)	Duct area (a) cm^2	Velocity cm/sec	Velocity Head cm	Total Energy cm
01.					
02.					
03.					

Sample Calculation :

* Discharge = $\mathbf{Q_{act}} = = \frac{A.\Delta H}{\Delta t} =$ __________ cm^3/sec

* Duct area = a = 4 x L =______x______=__________cm^2

* Velocity = $V = \frac{Q}{a} =$ __________ = __________ cm/sec

* Velocity head = $\frac{V^2}{2.g} =$ __________ = __________ cm

* Total head = $\frac{P}{w} + \frac{V^2}{2.g} + Z = (\quad + \quad + \quad) =$ __________ cm

* Draw the graph : a) No. of tubes to - $\frac{P}{w} + Z$ cm

b) No. of tubes to - $\frac{V^2}{2.g}$ cm

c) No. of tubes to - $\frac{P}{w} + \frac{V^2}{2.g} + Z$ cm

RESULT:

EXPERIMENT NO: 8 - Pipe friction apparatus with loss of head on pipe fittings.

[pipe fittings, such as bends, elbows, sudden expansions, and contractions]

Apparatus: It is a closed-circuit unit. A main frame houses all pipe fittings with pipe, control valves, pump, sump, measuring tank, manometer, manifold, etc. Fittings: Pipe 1-1-inch NB fitted with Reducer collar, Enlarging Collar, 90º Elbow.

Theory:

A pipe friction apparatus with loss of head on pipe fittings is a tool used to demonstrate and measure the pressure drop (head loss) that occurs when fluid flows through pipes and their associated fittings. It helps analyze the effects of factors like pipe diameter, length, fluid velocity, and roughness on frictional losses in a piping system. This apparatus is crucial for understanding major and minor losses in fluid mechanics and hydraulics.

PROCEDURE:

1. Fill clean and soft water in to sump up to ¾ its fill level.
2. Remove air trapped form the manifold by using air vent valves, and close the valves.
3. Open butterfly valve.
4. Open bypass valve fully.
5. Open first ball valve for first pipe fitting set and close other valve.
6. Switch ON pump, water starts flowing in the pipe line.
7. Open all the valves fitted on the manometer and remove all air bubbles if any present and then close air vent cocks.
8. Now adjust bypass valve by closing and allowing more water into the pipe line.
9. Close butterfly valve and observe water rise through piezometer.
10. Note down time required for h cm (10cm) of rise in water level.
11. Open butterfly valve (measuring tank discharge valve).
12. Open both mini ball valves for each fitting (entry and exit) and ensure other mini ball valves are closed.
13. Note down manometer readings.
14. Similarly note down manometer readings for other pipe fittings.
15. Open ball valve of the second pipeline keeping all the valves fitted on the pipe line fully open.
16. Note down manometer readings (entry & exit) and for all the valves fitted in the pipeline by opening respective entry and exit valves one set at a time.
17. Similarly record the manometer readings for other valves.

18. Note down time required for 10cm rise of water level in the tank for each valve at the set flow rate.
19. Entire experiment can be repeated for different flow rate by adjusting bypass valve.
20. Calculate discharge in each case.
21. Tabulate Discharge and head loss in each case.

Observation:

1.	Inner Diameter of 1 inch NB pipe [D1]	= 0.027m
2.	Diameter of Reducing Pipes [D2]	= 0.015 m (Contraction)
3.	Density of water ρw	= 1000 Kg/m^3
4.	Density of Manometric fluid (mercury)	= 13600 Kg/m^3
5.	Acceleration due to gravity g	= 9.81 m/sec^2
6.	Cross sectional area of Measuring tank	= 0.125 m^2

Tabular column:

Sl.No.	Type of fitting	Manometer		Time for 10 cm (H) rise of water sec 't'	Q m^3/sec	V m/sec	Hf = $Kc*v^2/2g$
		L1	L2				
1	Sudden Expansion [Dia of pipe at Sudden Expansion]						
2	Sudden Contraction [Dia of pipe at Sudden Contraction]						
3	90^o Bend [pipe dia]						

The value of 'Kc' (co-efficient of friction) for different pipe fittings:

Sl.No	Name of pipe fitting	Value of K
1.	Sudden Contraction	0.036 (for both)
2.	Sudden Expansion	0.036 (for both)
3.	90^o Bend	0.45

Calculation:

Area of pipe = $\Pi/4 \times d^2$ m^2

Discharge, Q = $A \times H / t$ m^3/sec

Velocity, V = Q / A m/sec

Head Loss, Hf = $Kv^2/2g$

RESULT:

EXPERIMENT NO: 9 - Determination of Coefficient of loss of head in a sudden contraction and friction factor.

Apparatus: It is a closed-circuit unit. A main frame houses all pipe fittings with pipe, control valves, pump, sump, measuring tank, manometer, manifold, etc. Fittings: Pipe 1-1-inch NB fitted with Reducer collar.

Theory:

Sudden contractions in a pipeline occur when there is a sudden decrease in the cross-sectional area of a portion of the pipe. Just like any pipe component, these contractions cause pressure losses in the fluid, which can be quantified using loss coefficients. 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. This reduction in pipe diameter creates a constriction or narrowing in the pipeline, as shown in the diagram below.

Figure 4: sudden contraction in a pipeline

The coefficient of loss of head in a sudden contraction, often denoted as 'Kc', quantifies the head loss due to the abrupt change in pipe diameter. It's a component of minor losses in pipe flow analysis. The friction factor, 'f', in the Darcy-Weisbach equation, quantifies head loss due to friction in straight pipe sections. Both are crucial for understanding energy losses in pipe systems.

Head Loss Due to Sudden Contraction:

- A sudden contraction in a pipe causes a localized head loss due to the flow constriction and subsequent expansion.
- The flow contracts to a smaller cross-section (vena contracta) before expanding to fill the larger pipe.
- The head loss due to this phenomenon is given by: Hc = Kc * (v^2 / 2g), where:
  - 'Hc' is the head loss.
  - 'Kc' is the loss coefficient for sudden contraction.
  - v is the average velocity in the smaller pipe.

- g is the acceleration due to gravity.

- The loss coefficient ‘Kc’ is influenced by the ratio of the smaller pipe's area to the larger pipe's area (A2/A1). For a very large upstream pipe compared to the downstream pipe, ‘Kc’ approaches 0.5.

Friction Factor in Pipe Flow:

- The Darcy-Weisbach equation is used to calculate head loss due to friction in a pipe: ‘H_f’ = f * (L/D) * (v^2 / 2g), where:
  - H_f is the head loss due to friction.
  - f is the Darcy friction factor.
  - L is the length of the pipe.
  - D is the pipe diameter.
  - v is the average flow velocity.
  - g is the acceleration due to gravity.

Tabular column:

Sl. No.	Type of fitting	Manometer		Time for 10 cm (H) rise of water sec ‘t’	Q m^3/sec	V m/sec	Kc = Hf * 2g/v^2	f = Hf * D * 2g/ (L* v^2)
		L1	L2					
1	Sudden Contraction [Dia of pipe at Sudden Contraction]							

Observation:

1.	Inner Diameter of 1 inch NB pipe [D1]	= 0.027m
2.	Diameter of Reducing Pipes [D2]	= 0.015 m (Contraction)
3.	Density of water ρw	= 1000 Kg/m^3
4.	Density of Manometric fluid (mercury)	= 13600 Kg/m^3
5.	Acceleration due to gravity g	= 9.81 m/sec^2
6.	Cross sectional area of Measuring tank	= 0.125 m^2

Calculation:

Area of pipe	$= \Pi/4 \times d^2$	m^2
Discharge, Q	$= A \times H / t$	m^3/sec
Velocity, V	$= Q / A$	m/sec

Result:

EXPERIMENT NO: 10 - Estimation of Major loss/Minor losses for a given flow system.

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

Introduction:

Friction is defined as the internal resistance offered by the inner surface of the pipe to the layer of water flowing through closer to the inner surface. This is also called as "ROUGHNESS FACTOR". This internal friction offered for the flow is the cause for reduction in the head through which the water can be raised without friction. Here by determining the head loss due to friction for a known length and diameter of the pipe for a particular range of flow, we can determine friction factor.

Friction factor f = (2 x g x dp x ΔH) / (4 x L x V^2)

Where L = Length of the pipe, m

V = Mean velocity of flow, m/sec

ΔH = Head of water, m

g = Acceleration due to gravity, m/sq.sec

f = Friction factor = Coefficient of friction

dp= Diameter of pipe

Procedure:

1. Note down the diameter of pipe (d).
2. Note the density of manometric liquid (ρ_m) and that of fluid (water) flowing through a pipe i.e. (ρ_w).
3. Connect the U – tube manometer to the pipe in between two pressure tappings.
4. Start the flow and adjust the control valve in pipe line for required discharge.
5. Measure the pressure difference at two points A & B of a pipe by means of a U– tube manometer.
6. By collecting the water in collecting tank for a particular period of time.
7. Determine the velocity of flow (V) and frictional head loss (hf) by using appropriate equations.
8. Determine the friction factor (f) in pipe by using Darcy – Weisbach formula.
9. Change the flow rate by adjusting the control valve & repeat the process for at least five times.
10. Find out the mean friction factor (f) mean of the pipe.
11. Plot a graph of velocity of flow (V) on y – axis verses frictional head loss (hf) on x –

axis which shows a straight line.

Observations:

Diameter of Pipes	D_1 = 27mm, D_2 = 19mm D_3 = 5mm
Length B/w extreme pressure tapings	L = 1.5m
Density of Water [ρw]	1000 Kg/m^3
Density of Mercury [ρm]	13,600 Kg/m^3
Acceleration due to gravity [g]	9.81 m/sec^2
Area of the Measuring tank	A = $0.125m^2$

Tabular column:

Sl. No.	Pipe ID mm	Manometer		Time for 10 cm (H) rise of water in	Discharge Q m^3/sec	Velocity 'v' m/sec	Friction Factor 'f'
		L1	L2				
1							
2							
3							

Calculation:

Area of pipe, d = $\Pi/4 \times d^2$ m^2

Discharge, Q = A x H / t m^3/sec

Velocity, V = Q / A m/sec

Head Loss, H_f = $Kv^2/2g$

Manometric Head, Hm = ΔH = [L1 - L2 / 1000] * ρm / ρw

Friction factor (Coefficient of friction), 'f' = 2x g x d_p x ΔH / 4 x L x V^2

Results:

EXPERIMENT NO: 11 - Determination of state of flow in a closed conduit using Reynolds Experiment.

Apparatus: Reynold's experimental arrangement, Collecting tank, Stop watch, Scale, colour dye (Potassium Permagnet) etc.

Theory: The classification of flow is based mainly on viscosity of a fluid or liquid. The viscosity that is seen earlier depends upon velocity gradient (dx, dg) is considered through Reynolds Number defined as below.

Formula : $R_e = \frac{\rho.V.D}{\mu}$

Where :

Re = Reynold's number (Dimensionless Parameter).
V = Average velocity in cm / sec
D = Diameter of pipe in cm.
ρ = Mass density of fluid (Kg / m^3)
μ = Dynamic viscosity (N - s / m^2 or Kg / m. sec)

Laminar Flow: A flow is said to be laminar when the various fluid particles move in layer with one layer of fluid living smoothly over on adjacent layer. A laminar flow is one in which the fluid particles move in layers or laminar with one layer sliding over the other. Therefore, there is no exchange of fluid particles from one layer to the other and hence no transfer of later of momentum to be adjacent layers. The particles, in the layer having lower velocity, obstruct the fluid particles in the layer with higher velocity. This obstruction force is called viscous resistance or viscosity. The laminar flow is one in which fluid layers glide over each another. It has low velocity and high viscous resistance.

Turbulent Flow: There is a continuous transfer of momentum to adjacent layers. Fluid particles occupy different relative position at different places. It is one in which, the particles get thoroughly mixed on (called turbulence). The turbulent flow has higher velocity. The flow in canals, pipes and rivers is usually turbulent flow.

Sr. No.	Type of Flow	Reynolds Number
01.	Laminar Flow	< 2100
02.	Transition Flow	2100 – 3000
03.	Turbulent	> 3000

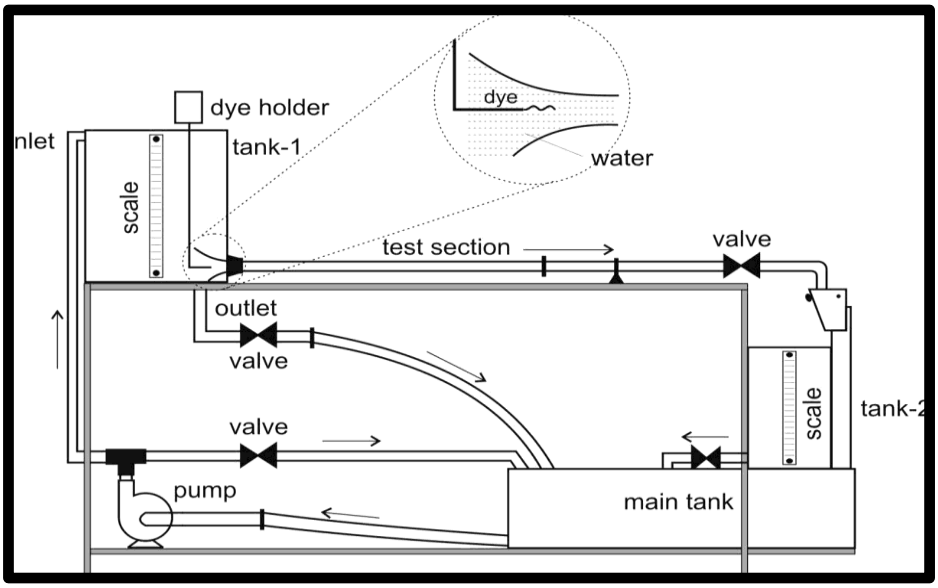


Figure 5: Experimental setup

Experimental Procedure:

1. Turn on the water, and partially open the discharge valve at the base of the apparatus.
2. Open and adjust the dye injector valve to obtain a fine filament of dye in the flow down the glass tube. If the dye is dispersed in the tube reduced to water flow rate by closing the discharge valve and adjusting the supply as necessary to maintain the constant head. A laminar flow condition should be achieved in which the filament of dye passes down the complete length of the tube without disturbance.
3. Then measure the flow rate by timing the collection of a known quantity (volume) of water from discharge pipe. This will help you to determine the velocity of the water in the pipe.
4. Slowly increase the flow rate by opening the discharge valve until disturbances of the dye filament are noted. This can be regarded as the starting point of transition to turbulent flow. Increase the discharge as required to maintain constant head conditions. Do not miss to sketch the dye condition and measure the flow rate for each of your trials.
5. If necessary, increase the flow rate as described above until the disturbances increase such that the dye filament becomes rapidly diffused. Small eddies will be noted just above the point where the dye filament completely breaks down. This can be regarded as the onset of fully turbulent flow.
6. Now you should close the dye injector valve in order to finalize your experiment.

Observation :

Diameter of pipe = D = ___________ cm

Area of pipe = a = $\frac{\pi . D^2}{4} = \frac{\pi .(\quad)^2}{4}$ = __________ cm^2

Area of collecting Tank = A = ________x________=________cm^2

Dynamic viscosity μ = 10^{-6} N - s / m^2 or Kg / m. sec

Observation Table:

Sl. No.	H1 (cm)	H2 (cm)	ΔH (cm)	Time t (Sec)	Discharge Q = A.ΔH/ Δt	Velocity V = Q/a	Re = ρ.V.D/ μ	Type of Flow
01.								
02.								
03.								
04.								

Sample Calculation :

* Depth of water collected in collecting tank = ΔH = $H_2 - H_1$

ΔH = __________ - _________

ΔH = __________cm

* Discharge = $Q = \frac{A.\Delta H}{\Delta t}$ = ___________ = ___________ cm^3 / sec

* Velocity of flow in pipe = $V = \frac{Q}{a}$ = ______________ = ___________ cm / sec

* Reynolds number = $R_e = \frac{\rho . V . D}{\mu}$ = ____________ = ___________

Result : For the first discharge the Reynold's number is found to be ________ therefore the flow will be _________________________

For second discharge the Reynold's number found to be _________ therefore the flow will be ________________________

For third discharge the Reynold's number found to be _________ therefore the flow will be ________________________

EXPERIMENT NO: 12 - Impact of Jet over a flat surface. [to verify the momentum equation].

Apparatus: Scale, measuring weights, collecting tank, impact of jet apparatus, (i.e., nozzle vane, transparent cylinder etc.)

Theory: Momentum equation is based one Newton second law of motion which states that the algebraic sum of external force applied to central volume of fluid in any distance. The external forces included the component of weights of the fluid and of forces exerted externally open the boundary surface of the control volume.

If a vertical water jet moving with velocity 'V' is made to strike a target which is free to move in vertical direction then the force will be exerted on the target by the impact of jet. According to momentum equation this force (which is also equal to the force required to bring back the target in its original position) must be equal to the rate of change of momentum of the jet flow in the direction.

Procedure:

1. Note down the dimension as area of collecting tank, mass density of water and diameter of nozzle.
2. The flat plate is inserted.
3. When the jet is not running, note down the reading of upper disc.
4. The water supply is admitted to the nozzle and the flow rate adjusted to its max valve.
5. As the jet strikes the vane, position of upper disc is changed. Now place the weights to bring back the upper disc to its original position.
6. The procedure is repeated for each valve of flow by reducing water supply.
7. The procedure is repeated for 4 to 5 reading.

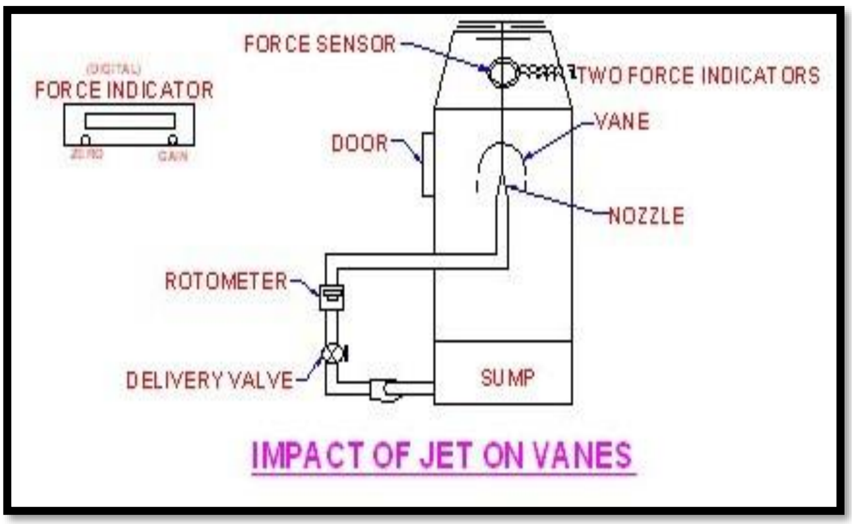


Figure 6: Impact of jet on vane setup.

Formulae used:

Q = Rota meter reading /1000* 60 m^3/sec

v = Q/ a m/sec

Where,

ρ= density of water

v=velocity of jet angle

Q=discharge

a= area of nozzle ($\pi d^2/4$)

Tabular column:

Sl no	Type of vane used	Actual discharge $[m^3/sec]$ Q	Velocity of jet [m/sec] V	Actual force F_{act}	Theoretical force F_{the}	Co-efficient of impact

CALCULATION:

Actual discharge Q = $\frac{A * R}{t}$

Velocity of jet at the nozzle, v = Q / a

Area of nozzle, a = (πd^2 /4), where d= 6mm, 8 mm, 10 mm.

Theoretical normal force, F_{th} = $\rho \times a \times V^2 / g$

Actual force, F_a = load cell reading.

Co-efficient of impact = Kt = F_a / F_{th}

Result:

Viva Question

1. Differentiate between Absolute and gauge pressures.

   Absolute pressure is zero-referenced against a perfect vacuum, so it is equal to gauge pressure plus atmospheric pressure. Gauge pressure is zero-referenced against ambient air pressure, so it is equal to absolute pressure minus atmospheric pressure.

2. Mention two pressure measuring instruments.

   Instruments used to measure and display pressure in an integral unit are called pressure meters or pressure gauges or vacuum gauges. A manometer is a good example, as it uses a column of liquid to both measure and indicate pressure.

3. What is the difference weight density and mass density?

   Density is defined as mass divided by volume. Mass density, usually just called "density", ismass (the amount of matter) per volume, while weight density is the amount of gravity exerted per volume.

4. What is the difference between dynamic and kinematic viscosity?

   Dynamic viscosity is measure of fluid's resistance to shear flow when some external force is applied. ... Kinematic viscosity is ratio of dynamic viscosity to density of that fluid. It is measure of fluid's resistance to shear flow under the weight of gravity.

5. Differentiate between specific weight and specific volume.

   specific weight, it is the ratio of weight of an object to the object's volume. In the case of specific gravity, it is the ratio of an objects density to the density of water. Specific weight has units of force per volume, such as lbf/ft3. ... Both are very similar to density (mass per volume)

6. Define relative density.

   The ratio of the density of a substance to the density of a standard, usually water for a liquid or solid, and air for a gas.

7. What is vacuum pressure?

   Vacuum pressure is the difference between the atmospheric pressure and the absolute pressure.

8. What is absolute zero pressure?

   Generally absolute zero pressure is the point where there exists a minimum temperature i.e zero. That can be possible only when molecular momentum of a system becomes zero. ... Hence absolute zero pressure can be obtained.

9. Write down the value of atmospheric pressure head in terms of water and Hg.

1 atmospheric pressure is equal to 10.33 meter under water. For under water pressure is define by this equation, P = density of water * gravitational acceleration * height underwater.

One atm. equals 760.0 mm Hg,

10. Differentiate between laminar and turbulent flow.

Laminar Flow: the flow of a fluid when each particle of the fluid follows a smooth path, paths which never interfere with one another. One result of laminar flow is that the velocity of the fluid is constant at any point in the fluid. Turbulent Flow: irregular flow that is characterized by tiny whirlpool regions.

11. How will you classify the flow as laminar and turbulent?

While laminar flow is "orderly" turbulent flow is "Random" and "Chaotic". It is also found that a flow in a pipe is laminar if the Reynolds Number (based on diameter of the pipe) is less than 2100 and isturbulent if it is greater than 4000.

12. Mention few discharge measuring devices.

Different types of fluid flowmeters - Orifices, Venturies, Nozzles, Rotameters, Pitot Tubes, Calorimetrics, Turbine, Vortex, Electromagnetic, Doppler, Ultrasonic, Thermal, Coriolis.

13. Draw the venturimeter and mention the parts.

The main parts of a venturimeter are:

A short converging part: It is that portion of the venturi where the fluid gets converges. Throat: It is the portion that lies in between the converging and diverging part of the venturi to increase the velocity of the fluid and temporarily lower its static pressure.

Diverging part: It is the portion of the venturimeter (venturi) where the fluid gets diverges.

14. Why the divergent cone is longer than convergent cone in venturimeter?

Since flow separation is not experienced whileconverging, the converging section is shorter. Maximum value of cone angle of converging section is as such to avoid vena contracta such that flow area is minimum at throat. ... For a venturi, its always better to keep a smaller divergence angle since the flow is subsonic

15. Compare the merits and demerits of venturimeter with orifice meter.

Orifice meter:

Advantages of Orifice meter:

- The Orifice is small plates and easy to install/remove.

- Offer very little pressure drop from which 60% to 65% is recovered.
- The orifice meter can be easily maintained.
- Measures a wide range of flows.
- They have a simple construction.
- They have easily fitted between the flanges.
- They are the most suitable for most gases and liquids.
- They are cheap, The price does not increase dramatically with size.

Disadvantages of orifice meter:

- Requires homogeneous fluid.
- Requires single phase liquid
- It requires the flow of axial velocity vectors.
- It causes a pressure drop in the fluid.
- Its accuracy is affected by the density, pressure and viscosity of the fluid.
- The range of measurement of viscosity limits of fluids.
- It requires straight conduits to ensure accuracy is maintained.
- The pipe must be totally special for the measurement of the flow of liquids.
- They have low range capacity.

Venturi meter:

Advantages of venturi meter:

- Less chance of getting stuck with sediment.
- The discharge coefficient is high.
- Its behaviour can be predicted perfectly.
- It can be installed vertically, horizontally, inclined.
- They are more precise and can be used for a wide range of flows.
- About 90% of the pressure drop can be recovered.

Disadvantages of venturi meter:

- They are large in size and, therefore, where space is limited, they cannot be used.
- Initial costs, installation and expensive maintenance.
- Requires a long placement length. That is, the venturi meter must be driven by a straight tube that has no connections or misalignments to avoid turbulence in the flow, for satisfactory operation.

- It can not be used in pipes of less than 7.5 cm in diameter.
- Maintenance is not easy.
- It can not be modified to measure the pressure beyond a maximum speed.

16. Why Cd value is high in venturimeter than orifice meter?

In Venturi meter losses are less so coefficient of discharge is higher whereas in orifice meter due to no convergent and divergent cones there are more losses and hence its coefficient of discharge is less. In venturi meter losses are low due to steam line shape of the diffuser and the pressure gradient is not abrupt as in case of orifice meter.

17. What is orifice plate?

An orifice plate is a device used for measuring flow rate, for reducing pressure or for restricting flow (in the latter two cases it is often called a restriction plate). Either a volumetric or mass flow rate may be determined, depending on the calculation associated with the orifice plate.

18. What do you mean by vena contracta?

Vena contracta is the point in a fluid stream where the diameter of the stream is the least, and fluid velocity is at its maximum, such as in the case of a stream issuing out of a nozzle, (orifice). (Evangelista Torricelli, 1643). It is a place where the cross section area is minimum.

19. Define coefficient of discharge.

In a nozzle or other constriction, the discharge coefficient (also known as coefficient of discharge) is the ratio of the actual discharge to the theoretical discharge,

20. Define co-efficient of contraction of orifice meter.

It is defined as the ratio of the area of the jet at vena-contracta to the area of the orifice.

21. Define co-efficient of discharge of orifice meter.

It is defined as the ratio of the actual discharge from an orifice to the theoretical discharge from the orifice.

22. Write down Darcy -weisback's equation.

$$H_f = f \frac{L}{D} \frac{v^2}{2g}$$

where:

f = friction factor (unitless)
L = length of pipe (ft)
D = diameter of pipe (ft)
v = fluid velocity (ft/sec)
g = gravitational acceleration (ft/sec^2)

23. What is the difference between friction factor and coefficient of friction?

Friction is measured in newtons whereas co-efficient of friction is dimensionless. Friction Force is defined as a force resisting the relative motion of two bodies. The bodies are pressed against each other with the Normal Force. Then, coefficient of friction = Friction Force divided by Normal Force.

24. What do you mean by major energy loss?

Major energy losses: The viscosity causes loss of energy in the flows, which is known as frictional loss or major energy loss and it is calculated by the following formula; Darcy-weisbach formula.

25. List down the type of minor energy losses.

Minor losses in pipe flow are a major part in calculating the flow, pressure, or energy reduction in piping systems. Liquid moving through pipes carries momentum and energy due to the forces acting upon it such as pressure and gravity. Just as certain aspects of the system can increase the fluids energy, there are components of the system that act against the fluid and reduce its energy, velocity, or momentum. Friction and minor losses in pipes are major contributing factors.

a. Sudden expansion
b. Sudden contraction
c. Bend in pipe
d. Pipe fitting
e. An obstruction in pipe

26. Define the terms impact of jet and jet propulsion?

Force generated by a jet of water deflected by an impact surface is measured and compared to the. momentum change of the jet.

propulsion of a body produced by the forwardly directed forces of the reaction resulting from the rearward discharge of a jet of fluid especially : propulsion of an airplane by jet engines.

27. Write the expression for efficiency of a series of moving curved vane when a jet of water strikes the vanes at one of its tips?

Force exerted by the jet in the direction of motion of plate

F_X = Mass striking the series of plate per second x [Initial velocity – final velocity] $F_X = \rho aV [(V-u)-0] = \rho aV (V-u)$

Efficiency = Work done per second / Kinetic energy per second

Efficiency = $\rho aV (V-u) \times u / (1/2) \times \rho aV^3$

Efficiency = $2u (V-u)/V^2$

28. Define equilent pipe?

Equivalent pipes refer to imaginary pipes which are used to determine the head loss and flow of discharge considering that the flow of discharge and head loss in the actual piping system is same as that of the equivalent pipe.

29. Define hydraulic gradient and total energy lines?

Hydraulic gradient line. Hydraulic gradient line is basically defined as the line which will give the sum of pressure head and datum head or potential head of a fluid flowing through a pipe with respect to some reference line. Hydraulic gradient line = Pressure head + Potential head or datum head. H.G.L = $P/\rho g + Z$.