FLUID MECHANICS

LAB MANUAL

S.E. (Mechanical)

Semester-IV

Department of Mechanical Engineering

Graduate School of Technology
SIES
RISE WITH EDUCATION

SIES GST, Nerul, Navi Mumbai

GENERAL INSTRUCTIONS

1. Always wear an apron before entering the laboratory to protect from laboratory hazards. At regular intervals get the apron washed.
2. Always carry the workbook, calculator, graph pages, pen, pencil, eraser and scale when coming for practical.
3. Loose items of apparel should be avoided when you are working around moving machinery. Hair that is longer than shoulder length should be gathered into a protective net or otherwise confined when the student is working in the laboratory.
4. Keep your working laboratory bench clean of everything. Nothing should be lying on the bench.
5. Don’t eat or drink or talk while working in the lab.
6. No equipment is to be operated until the approval of the instructor has been obtained at the start of class. Only the equipment pertaining to the assigned experiment is to be operated. Further no operating equipment will be left unattended.
7. The laboratory floor must be kept dry, clean and uncluttered at all times. Any spills should be cleaned up immediately.
8. Spilled mercury should be regathered as completely as possible and disposed of properly. Your instructor should be immediately notified in event of a mercury spill.
9. Be aware of possible electrical hazards. All electrical devices should be properly grounded. Frayed or otherwise hazardous electrical cords should be reported and replaced or repaired.
10. Any accident or hazardous situation must be reported to the Laboratory Supervisor immediately.
11. Wash hands before and after performing an experiment with disinfectant soap.
12. Students shall conduct themselves safely and responsibly.

LIST OF EXPERIMENTS

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EXPERIMENT NO. 1

STABILITY OF FLOATING BODIES

DATE OF PERFORMANCE:

STABILITY OF FLOATING BODY

Aim:

To determine the Metacentric height for the given ship model.

Apparatus:

Ship model, movable weights, water tank

Theory:

When a body is immersed in fluid, it is subjected to an upward force which tends to lift up the body. This is called buoyancy and the upward force is called buoyant force. Archimede's principle states that when a body is immersed in a fluid, wholly or partially, it is buoyed or lifted up by a force which is equal to the weight of the fluid displaced by the body. When a body is floating in liquid, it is acted upon by two forces, viz. weight of body acting downwards through center of gravity and upward force acting through center of buoyancy. Both these forces are equal and opposite in direction and the body is in equilibrium. Center of buoyancy of a body is centroid of the volume of liquid displaced. If the body is titled slightly then position of center of gravity remains the same but center of buoyancy occupies the new center of buoyancy it intersects the line joining initial center of buoyancy and center of gravity at a point, known as meta center. The distance between meta center and center of gravity is called meta center height.

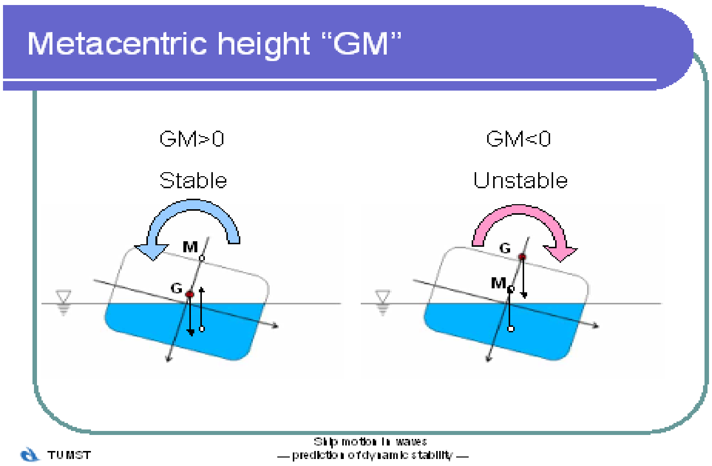


Fig. 1.1 Stability of submerged body

Stability of a floating body depends upon the metacentic height. If meta center lies above the center of gravity, the slight angular displacement of body causes to form a restoring couple, which stands to bring the body to its original position. This is called stable equilibrium.

When metacentre lies below the center of gravity then slight angular displacement of body causes to form a couple which tends to increase the angular displacement further. This is called unstable equilibrium. When meta centre lies exactly on centre of gravity then slight angular displacement does not create any couple, hence body remains in its new position. This is called neutral equilibrium. Hence in design of ships care has to be taken to keep the meta centre well above the centre of gravity so that ship is in stable equilibrium.

Procedure:

1. Fill up the water in the tank.
2. Keep the ship floating over the water.
3. See that plumb indicates zero reading.
4. Measure the displacement of weight and distance indicated by plumb.
5. Repeat the procedure for different displacement of weight.

Observation and Tabulation:

Sr. No	Weight (N)	displacement, ‘x’ m	Angle of Heel, θ^0	G.M (m)
1				
2				
3				

Average G.M =

Calculations:

Weight of the ship, W= 6.250 kg

$$\text{Metacentric height (GM)} = \frac{w.x}{W.\tan\theta}$$

Sample Calculations:

Result and conclusion:

EXPERIMENT NO. 2

TO VERIFY BERNOULLI'S EQUATION EXPERIMENTALLY

DATE OF PERFORMANCE:

BERNOULLI'S THEOREM APPARATUS

Aim: To verify Bernoulli's equation experimentally.

Theory: Energy is defined as the capacity to do work. It exists in various forms and can change from one form to another. The different forms of energy of flowing liquid are:

i) Potential energy (Potential Head),

ii) Kinetic energy (Velocity Head), and

iii) Pressure energy (Pressure Head).

Potential Energy (Potential Head): It is the energy possessed by a liquid particle by virtue of its position. It is due to configuration or position above some suitable height or datum line. It is denoted by 'z'.

Kinetic energy (Velocity Head): It is the energy possessed by a liquid particle by virtue of its velocity and is due to the velocity of flowing liquid. It is measured as $v^2/2g$, where 'v' is the velocity of flow and 'g' is acceleration due to gravity.

Pressure energy (Pressure Head): It is the energy possessed by a liquid particle by virtue of its existing pressure. It is due to the pressure of liquid and measured as p/w, where 'p' is intensity of pressure and 'w' is the specific weight of liquid.

Total Energy (Total Head): It is the sum of potential energy, kinetic energy and the pressure energy. It is denoted as 'E' and mathematically it is expressed as,

E = Potential Energy + Kinetic Energy + Pressure Energy

$$E = z + \frac{v^2}{2g} + \frac{p}{w}$$

Bernoulli's Theorem: It states that in a steady, ideal flow of an incompressible fluid, the total energy at any point of the fluid is constant. The total energy consists of pressure energy, kinetic energy and potential energy or datum energy. These energies per unit weight of the fluid are:

Pressure energy = $\frac{p}{\rho g}$

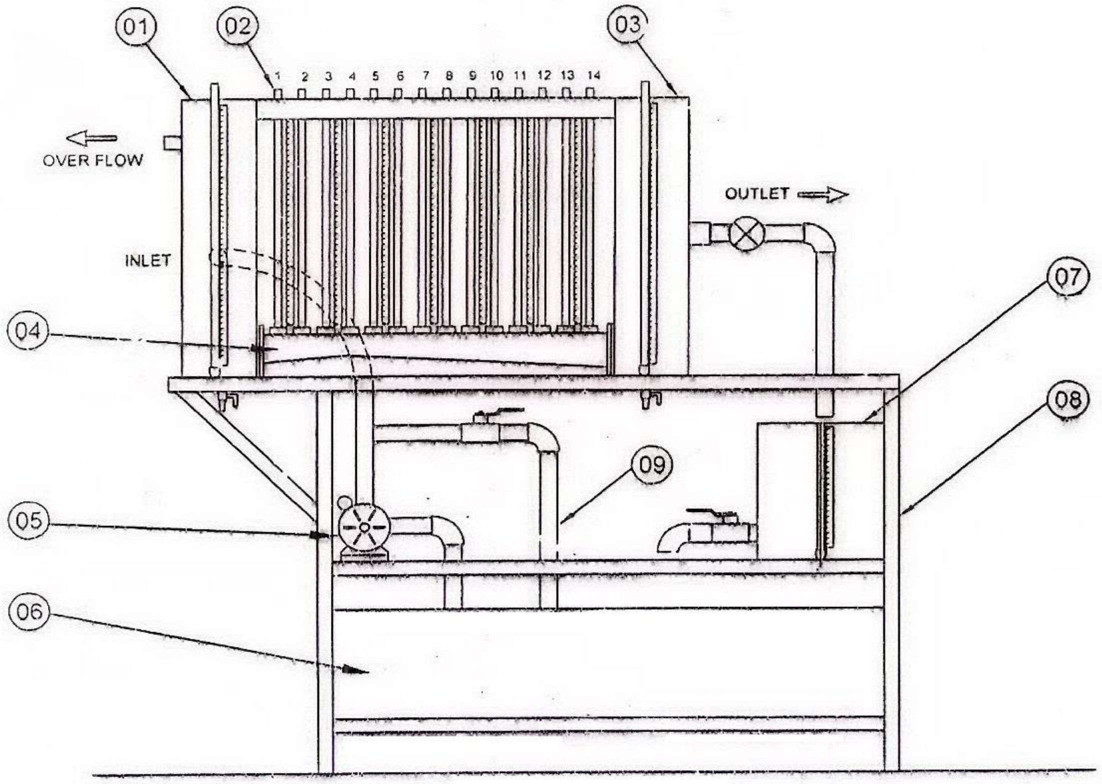
Kinetic energy = $\dfrac{v^2}{2g}$

Potential energy = z

Thus mathematically, Bernoulli's theorem is written as,

$$\frac{p}{\rho g} + \frac{v^2}{2g} + z = \text{Constant}$$

The above equation is known as Bernoulli's equation.



01 SUPPLY TANK 02 TRANSPERANT TUBES 03 DELIVERY TANK 04 TEST SECTION

05 PUMP MOTOR 06 SUMP TANK 07 MEASURING TANK 08 MAIN FRAME 09 BYPASS

BERNOULLI'S THEOREM APPARATUS

Apparatus: The equipment is designed as recirculation type set-up. It has a sump tank, monoblock pump, supply tank, delivery tank and measuring tank for water circulation. The apparatus mainly consists of a supply tank and delivery tank, which are connected to a perspex flow channel. The channel tapers for a length of 25 cm and then gradually enlarges for the remaining length of 50 cm. Piezometer tubes are fixed at a distance of 5 cm (centre to centre) for measurement of pressure head.

Procedure:

1. Keep the bye-pass valve fully open and start the pump and slowly start closing the bye-pass valve.
2. The water will start flowing through the flow channel and the level in the piezometer tubes shall go on increasing.
3. Open the valve on the delivery tank side and adjust the head in the piezometer tubes to get a steady position.
4. Measure the heads at all the points and also discharge in the measuring tank by keeping the drain valve of measuring tank closed. Measure the time taken for collecting 5cm (or 10 cm) of water by stop-watch.
5. Change the discharge (flowrate) and repeat the procedure as above. Take another set of readings.
6. Prime the pump, if it does not suck water from the sump tank. This will happen in case the unit is started after a gap of long period (say after few months).
7. Plot the following graphs:
   i) No. of piezometer tube vs. pressure head
   ii) No. of piezometer tube vs. velocity head
   iii) No. of piezometer tube vs. total head

Observation table:

Piezo meter tube number	Area 'A' of flow cm^2	Measuring Tank Reading 'Z' cm	T' time in sec	Discharge 'Q' in cm^3/s	Pressure head $P/\rho g$ cm	Velocity 'V' in cm/s	Velocity head $V^2/2g$ in cm	Total head $P/\rho g+V^2/2g$ in cm
1	5.00							
2	4.25							
3	3.50							
4	2.50							
5	3.00							
6	3.03							
7	3.75							
8	4.125							
9	4.50							

Calculations:

Result:

Conclusion:

EXPERIMENT NO. 3

TO DETERMINE THE COEFFICIENT OF DISCHARGE FOR A GIVEN VENTURIMETER

DATE OF PERFORMANCE:

VENTURIMETER

Aim: To determine the coefficient of discharge for a given venturimeter.

Theory: A venturimeter is a device used for measuring the rate of a flow of a fluid flowing through a pipe. It consists of three parts:

i. A short converging part,
ii. Throat
iii. Diverging part

It is based on the principle of Bernoulli's equation. Venturimeter works on the principle that by reducing the sectional area of the flow passage, a pressure head at two different points is measured and finally by using continuity equation, discharge is determined.

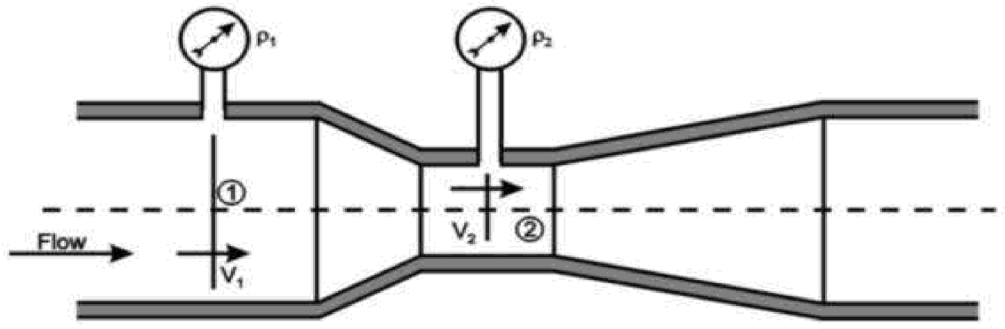


Diagram of venturimeter

Apparatus: The equipment is designed as recirculation type set-up with a standard venturimeter and orifice meter fitted in the pipeline. A sump tank, pump, piping, valves,U-tube differential manometer, measuring tank is provided as basic set-up for water circulation. A venturimeter of d/D ratio 0.5 is provided in the line. Connections of pressure tapings are given to the differential manometer.

Procedure:

1. Initially make petrol pipe connections of venturimeter as follows:
   i) Connect right hand side (inlet or pump side) connection to right hand side of the 'T' of the manometer board facing front side.
   ii) Connect left hand side (discharge side or measuring tank side) connection to left hand side of the 'T' of the manometer board facing front side.

2. Connect the manometer block with petrol pipe to brass nipples (right and left) of top side of the 'T'.
3. Keep all the brass cocks in closed position.
4. Keep the bye-pass valve and gate valves of venturimeter, orifice meter line and measuring tank fully open and start the pump.
5. Close gate valve of orifice meter. That means venturimeter is in line for experimentation.
6. Slowly start closing the bye-pass valve. Rotameter will start showing some reading.
7. See that water is fully flowing in the pipe of Venturimeter.
8. Now open the brass-cock of venturimeter on 'T' connection of manometer board. Do not open over-flow cocks.
9. Slowly and simultaneously open the over-flow cocks. Air bubbles are to be removed by opening the overflow cocks slowly. Ensure that the water is flowing through both the overflow pipes.
10. To remove air bubbles and to ensure water is flowing through both the over-flow pipes, slowly go on closing gate valves of venturimeter. Due to this back pressure will be created and this will help to remove the air bubbles from the water through both the over-flow tubes.
11. Once the air bubbles are removed, slowly and simultaneously close the over-flow cocks.
12. Now take the readings of manometer. Measure with the help of stop clock, the time required for achieving 5 cm height of water column of the measuring tank. This will enable to calculate the flow rate of the water. Remember before taking the measuring tank reading, gate valve should be in closed position.
13. Enter the readings in the observation table.
14. Take the readings for different flow rates and enter them in the observation table.
15. After finishing the experiment switch-off the pump, open the gate valve of measuring tank and open the by-pass valve.

Observation:

Diameter of inlet of venturimeter, d_1 = 26 mm

Diameter of throat of venturimeter, d_2 = 13 mm

ObservationTable:

Sr. no.	h' in cm mercury (cm)	h in meters of water h=h'(13.6-1) (cm)	Measuring tank reading Z (cm)	Time t (s)	Discharge Q_{act} (cm^3/s)	Discharge Q_{th} (cm^3/s)	Co-efficient of discharge C_d
1							
2							
3							

Calculations:

Actual discharge (flowrate) Q_{act},

$$Q_{act} = \frac{Volume}{Time} = \frac{A \times Z}{t} = \frac{L \times B \times Z}{t} \text{ cm}^3\text{/s}$$

where,

L = Length of measuring tank in centimeters,

B = Breadth of measuring tank in centimeters,

Z = Height (level) in piezometer tube of measuring tank in centimeters which is under Consideration,

t = time taken for collection of water for decided height in seconds, say for 'Z' cm.

Area at inlet of the venturimeter a_1,

$$a_1 = \frac{\pi}{4} d_1^2 \text{ cm}^2$$

Area at throat of the venturimeter a_2,

$$a_2 = \frac{\pi}{4} d_2^2 \text{ cm}^2$$

Theoretical discharge (flowrate) Q_{th},

$$Q_{th} = \frac{a_1 . a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gh} \text{ cm}^3\text{/s}$$

Now, coefficient of discharge, $C_d = \frac{Actual\ Discharge}{Theoretical\ Discharge} = \frac{Q_{act}}{Q_{th}}$

Result:

Conclusion:

ORIFICE METER

Aim: To determine the coefficient of discharge for a given orifice meter.

Theory: An orifice meter is a device used for measuring the rate of a flow of a fluid flowing through a pipe. It is a cheaper device as compared to venturi meter. It also works on the same principle as that of venturi meter. It consists of a flat circular plate which has a circular sharp edged hole called orifice, which is concentric with the pipe. The orifice diameter is kept generally 0.5 times the diameter of the pipe, though it may vary from 0.4 to 0.8 times the pipe diameter. A differential manometer is connected at section 1, which is at a distance of about 1.5 to 2.0 times the pipe diameter upstream from the orifice plate, and at section 2, which is at a distance of about half the diameter of the orifice on the downstream side from the orifice plate.

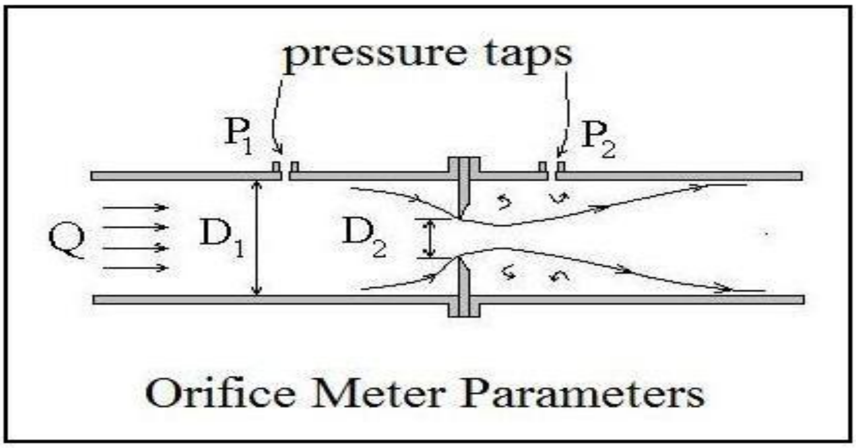


Fig 1 orifice meter

Apparatus: The equipment is designed as recirculation type set-up with a standard orifice meter and venturimeter fitted in the pipeline. A sump tank, pump, piping, valves, U-tube differential manometer, measuring tank is provided as basic set-up for water circulation. A orifice meter of d/D ratio 0.5 is provided in the line. Connections of pressure tapings are given to the differential manometer.

Procedure:

1. Initially make petrol pipe connections of orifice meter as follows:
   i) Connect right hand side (inlet or pump side) connection to right hand side of the 'T' of the manometer board facing front side.

ii) Connect left hand side (discharge side or measuring tank side) connection to left hand side of the ‘T’ of the manometer board facing front side.

2. Connect the manometer block with petrol pipe to brass nipples (right and left) of top side of the ‘T’.
3. Keep all the brass cocks in closed position.
4. Keep the bye-pass valve and gate valves oforifice meter, venturimeter line and measuring tank fully open and start the pump.
5. Close gate valve of venturimeter. That means orifice meter is in line for experimentation.
6. Slowly start closing the bye-pass valve. Rotameter will start showing some reading.
7. See that water is fully flowing in the pipe of orifice meter.
8. Now open the brass-cock of orifice meter on ‘T’ connection of manometer board. Do not open over-flow cocks.
9. Slowly and simultaneously open the over-flow cocks. Air bubbles are to be removed by opening the overflow cocks slowly. Ensure that the water is flowing through both the overflow pipes.
10. To remove air bubbles and to ensure water is flowing through both the over-flow pipes, slowly go on closing gate valves of orifice meter. Due to this back pressure will be created and this will help to remove the air bubbles from the water through both the over-flow tubes.
11. Once the air bubbles are removed, slowly and simultaneously close the over-flow cocks.
12. Now take the readings of manometer. Measure with the help of stop clock, the time required for achieving 5 cm height of water column of the measuring tank. This will enable to calculate the flow rate of the water. Remember before taking the measuring tank reading, gate valve should be in closed position.
13. Enter the readings in the observation table.
14. Take the readings for different flow rates and enter them in the observation table.
15. After finishing the experiment switch-off the pump, open the gate valve of measuring tank and open the by-pass valve.

Observation Table:

Diameter of inlet of orifice meter, d_1 = 25 mm

Diameter of throat of orifice meter, d_2 = 12.5 mm

Observation Table:

Sr. no.	Difference of liquid column x (cm)	Differential pressure head h (cm)	Measuring tank reading Z (cm)	Time t (s)	Discharge Q_{act} (cm^3/s)	Discharge Q_{th} (cm^3/s)	Co-efficient of discharge C_d
1							
2							
3							

Calculations:

Let, h = Difference in column of manometer,

S_h = Specific gravity of manometric liquid (heavier - mercury) = 13.6

S_o = Specific gravity of liquid flowing through pipe (water) = 1

Differential pressure head h,

$$h = x\left(\frac{S_h}{S_o} - 1\right) = x(13.6 - 1) \text{ cm}$$

Actual discharge (flow rate) Q_{act},

$$Q_{act} = \frac{Volume}{Time} = \frac{A \times Z}{t} = \frac{L \times B \times Z}{t} \text{ cm}^3\text{/s}$$

Where,

L = Length of measuring tank in centimeters,

B = Breadth of measuring tank in centimeters,

Z = Height (level) in piezometer tube of measuring tank in centimeters which is under

Consideration,

t = time taken for collection of water for decided height in seconds, say for ‘Z’ cm.

Area at inlet of the orifice meter a_1,

$$a_1 = \frac{\pi}{4} d_1^2 \text{ cm}^2$$

Area at throat of the orifice meter a_2,

$$a_2 = \frac{\pi}{4} d_2^2 \text{ cm}^2$$

Theoretical discharge (flow rate) Q_{th},

$$Q_{th} = \frac{a_1 . a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gh} \text{ cm}^3\text{/s}$$

Now, coefficient of discharge C_d,

$$C_d = \frac{Actual \ Discharge}{Theoretical \ Discharge} = \frac{Q_{act}}{Q_{th}}$$

Result:

Conclusion:

EXPERIMENT NO. 5

TO CALIBRATE THE GIVEN ROTA METER

DATE OF PERFORMANCE:

FLOW MEASUREMENT BY ROTAMETER

Aim: To calibrate the given rotameter and draw its calibration curve.

Apparatus: The apparatus consists of a fluid circuit which includes sump tank, monoblock pump, rotameter and measuring tank connected in series with the help of pipeline to form a fluid flow circuit. Further, control valves are provided to regulate the flow of water (or any liquid). A stop watch is provided in order to measure the time taken for filling the tank with water up to a specific desired level.

Theory: Rotameter is an instrument used for fluid flow measurement. Rotameter is a variable area flow meter. In head flow meters the restriction size remains constant, due to which the differential pressure across it varies with the differential flow rate through it. But in variable area flow meters the restriction size or flow area of restriction is allowed to vary with the fluid flow rate so as to maintain the differential pressure across it constant. Thus any change in the fluid flow rate can be measured in terms of change of flow area, hence the name variable-area flow meter.

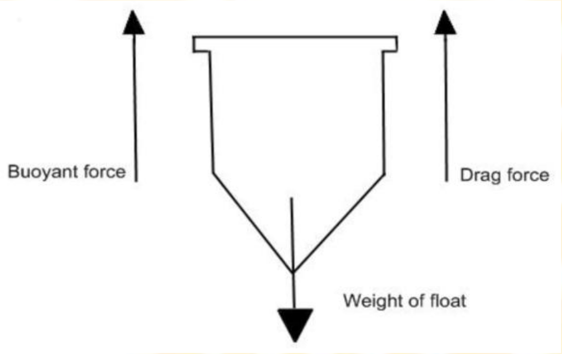


Fig. 1.1 Forces acting upon a rotameter float

Construction: Rotameter consists of a tapered glass tube mounted vertically with smaller end on lower side. The glass tubes are used for metering low temperature and pressure fluids, but for high temperature and pressure service metal tubes are used. A float is installed in the tube after the meter is mounted in the flow line. Floats are usually made of corrosion resistant metals like aluminum, bronze, monel, nickel, stainless steel etc. Usually a series of slanting notches are cut in the underside of the float rim that gives rotation to float so as to reduce the friction. Float material decides the flow-range of the rotameter. Float may have different float shapes. Flow scale is marked on the glass-tube or it is mounted close to the metering tube. Rotameter is installed in the pipe line by means of flanges or threads alongwith the inlet and outlet piping supports in brackets. The meter must be installed vertically within about 2 geometrical degrees so as to centre the float in the fluid stream.

Working: When no fluid flows through rotameter float rests at the bottom of the tube. As fluid enters the lower side of the tube, float rises due to buoyant and differential pressure force and allows fluid to flow through annular space between float edge and the metering tube. As fluid flow rate increases, float rises in the tube, thus increasing the flow area keeping differential pressure across it constant. On the other hand as fluid flow rate decreases, float falls in the tube, thus decreasing the flow area with constant pressure drop across the float. At given flow rate, float stabilizers at certain fixed position in the tube. The variation in flow area with fluid flow rate can be measured in terms of change in float position. Thus any change in fluid flow rate through rotameter can be measured in terms of change in float position on the scale calibrated in terms of flow rate.

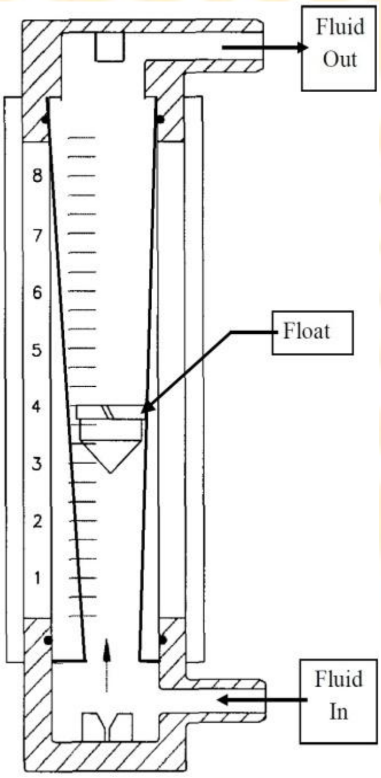


Fig 2Rotameter

Procedure:

1. Start the pump.
2. Operate the valve for flow of fluid through rotameter apparatus and keep it slightly open.

3. Slowly adjust the valve so that the flow of fluid through rotameter is sufficient enough so that the float shows displacement.
4. Measure the flowrate of fluid and corresponding float position in rotameter.
5. The flowrate can be calculated by knowing the time taken for filling the tank for a known level. Hence measure the time taken for filling of tank upto a particular level.
6. Increase the flowrate by opening the valve further.
7. Take the reading for different flow rates.
8. Plot a graph of float position vs. flowrate.

Observation Table:

Obs. No.	Flowrate by Rotameter Q_a (m^3/s)	Measuring Tank reading Z (mm)	Time t (s)	Flowrate Q_a (m^3/s)	Difference in Flowrate Q_a (m^3/s)
1					
2					
3					
4					

Calculations:

To measure discharge (flowrate) Q_a,

$$Q_a = \frac{Volume}{Time} = \frac{L \times B \times Z}{t} \text{ m}^3/\text{s}$$

Where,

L = Length of measuring tank in meters,

B = Breadth of measuring tank in meters,

Z = Height (level) in piezometer tube of measuring tank in meter which is under consideration,

t = time taken for filling of water in tank till decided height in seconds, say for ‘Z’ mm.

Result:

Conclusion:

EXPERIMENT NO. 6

TO DETERMINE MINOR LOSSES FOR FLOW THROUGH PIPES (PIPE FITTINGS)

DATE OF PERFORMANCE:

LOSSES IN PIPES (PIPE FITTTINGS) APPARATUS

Aim: To determine minor losses for flow through pipes (pipe fittings).

Theory: Minor losses are the losses of head due to large number of pipe fittings such as bends, elbows, joints, valves, sudden expansion and contraction in pipe diameter. In a pipeline these fittings cause localized energy losses (pressure head) due to their shape and these losses are classified as minor losses. Minor losses are usually neglected, as they are insignificant if they are less than 5% of the frictional losses.

Loss of head due to sudden enlargement: This is energy loss due to sudden enlargement. Sudden enlargement in diameter of pipe results in formation of eddies by the flowing liquid at the corners of the enlarged pipe. Because of eddies formation, loss of head takes place.

*Loss of head due to sudden contraction:*This is energy loss due to sudden contraction. It does not take pace due to the sudden contraction but it is due to the sudden enlargement, which takes place just after vena-contracta.

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

Apparatus: The equipment is designed as recirculation type set-up. The apparatus consists of circuit of pipes with bend and elbow, a sudden expansion and sudden contraction fitting. Pressure tappings are provided at inlet and outlet of these fittings under test. A differential manometer with manifolds, provided with the unit measures the pressure loss of individual fittings. This circuit of pipes with the fittings is mounted on the sump tank and measuring tank. A mono block pump fitted on the sump tank recirculates the water.

Procedure:

1. Connect all pressure tappings to the common manometer, through block.
2. Allow steady flow of water through the test specimen. Flow can be varied by a valve provided in the line.
3. The pressure loss of a particular fitting be noted down on manometer by opening respective cocks on the manometer board. Make sure that other cocks are in closed position.

4. Collect the water in measuring tank by closing the drain valve and note down the time required for collection of 5 cm of water.
5. Now vary the discharge by opening or closing the delivery valve on the bye-pass and carry out above mentioned procedure.

Observation Table:

Diameter of larger pipe, d_1 = 2.8 cm

Diameter of smaller pipe, d_2 = 1.58 cm

Sr. no.	Specimen under test	Difference of liquid column x (cm)	Differential pressure head h (cm)	Measuring tank reading Z (cm)	Time t (s)	Discharge Q (cm^3/s)	V_L (cm/s)	V_S (cm/s)	H (cm)
1.	Sudden contraction								
2.	Bend								
3.	Elbow								
4.	Sudden expansion								

Calculations:

Let, h = Difference in column of manometer,

S_h = Specific gravity of manometric liquid (heavier - mercury) = 13.6

S_o = Specific gravity of liquid flowing through pipe (water) = 1

Differential pressure head h,

$$h = x\left(\frac{S_h}{S_o} - 1\right) = x(13.6 - 1) \text{ cm}$$

Discharge (flow rate) Q,

$$Q = \frac{Volume}{Time} = \frac{A \times Z}{t} = \frac{L \times B \times Z}{t} \text{ cm}^3/\text{s}$$

where,

L = Length of measuring tank in centimeters,

B = Breadth of measuring tank in centimeters,

Z = Height (level) in piezometer tube of measuring tank in centimeters which is under Consideration,

t = time taken for collection of water for decided height in seconds, say for ‘Z’ cm.

Cross-sectional area of larger pipe a_1,

$$a_1 = \frac{\pi}{4} d_1^2 \text{ cm}^2$$

Cross-sectional area of smaller pipe a_2,

$$a_2 = \frac{\pi}{4} d_2^2 \text{ cm}^2$$

Velocity of water at inlet V_L,

$$V_L = \frac{Q}{a_1} \text{ cm/s}$$

Velocity of water at outlet V_S,

$$V_S = \frac{Q}{a_2} \text{ cm/s}$$

Loss of head due to sudden enlargement H_e,

$$H_e = \frac{(V_S - V_L)}{2g} \text{ cm}$$

Loss of head due to bend and elbow H_b,

$$H_b = k \times \frac{V_s^2}{2g} \text{ cm} \qquad \text{(Assume k = 0.6)}$$

Loss of head due to sudden contraction H_c,

$$H_c = \left(\frac{1}{C_c - 1}\right)^2 \times \frac{V_S^2}{2g} \text{ cm}$$ (Assume $C_c = 0.62$)

Result:

Conclusion:

EXPERIMENT NO. 7

CALCULATION FOR DARCY'S FRICTION FACTOR

DATE OF PERFORMANCE:

CALCULATION FOR DARCY'S FRICTION FACTOR

Aim:

To determine the Darcy friction factor and head loss due to friction

Theory:

The analysis of loss of energy of the fluid flow due to friction is very important to decide the pump requirement in the applications. Loss due to friction is also called as Major loss.

Friction losses are very dependent upon the **viscosity** of the liquid and the **amount of turbulence** in the flow. Head loss due to friction can be calculated by using the Darcy-Weisbach equation. The friction factor for the fluid flow can be determined by using a MOODY CHART if the relative roughness of the pipe and the Reynolds Number of the flow can be determined. Darcy's equation can be used to calculate frictional losses.

The Darcy equation gives the head loss in turbulent flow for a circular pipe.

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

Where:

f is the friction factor

l, is the length of pipe being consider

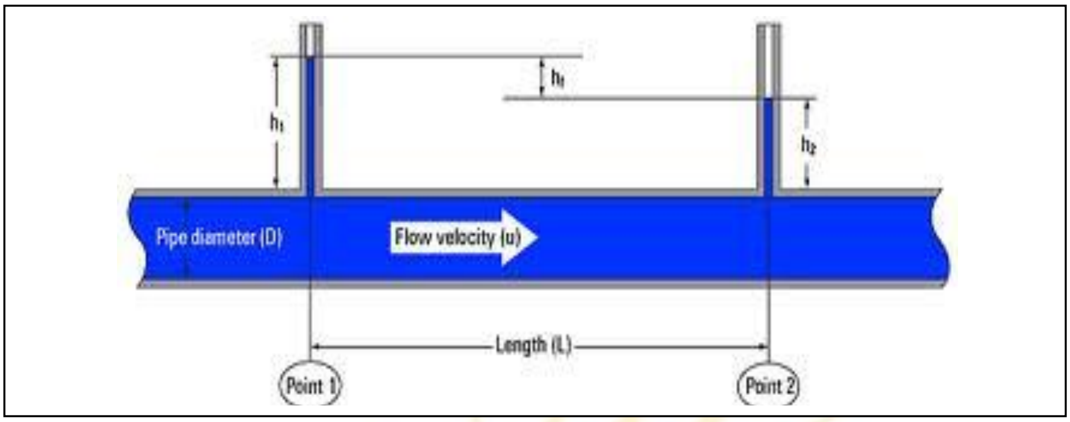
d, is the pipe diameter

v, is the mean velocity of the fluid

The friction factor f depends on the velocity of flow, the pipe diameter, the fluid density and viscosity and the roughness of the pipe.

For laminar flow, f= 64/Re, where Re is the Reynold's number.

Diagram:



Procedure:

1. Initially close all the knobs.
2. Open the selective knobs where we will have to measure the energy loss.
3. After opening the knobs, the differential manometer will show as the deflection.

Observations and calculations:

Diameter of smaller pipe, D_1= 2.8 cm

Diameter of larger pipe, D_2 = 1.58 cm

Measuring tank volume = 400mm X 300mm X 300mm

To find the velocities, V_1 and V2, Flow rate Q, should be determined as,

$$Q = \frac{\text{measuring tank area} \times \text{height of water collected}}{\text{Time (T)}} \ m^3/\text{sec}$$

Sample Calculation:

Results and Conclusion:

EXPERIMENT NO. 8

REYNOLDS NUMBER

DATE OF PERFORMANCE:

REYNOLDS NUMBER

Aim: To study the significance of Reynolds number for different types of flow.

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

Re= ρ V D/ μ

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 / m3)

μ = Dynamic viscosity (N - s / m2 or Kg / m. sec)

Reynolds carried out experiments to decide limiting values of Reynolds number to quantifiably decide wheeler the flow is laminar, turbulent or transition. The flows on visualize by passing a streak of dye and observing its motion.

- *Laminar Flow:* A flow is said to be laminar when the various fluid particles moves in layer with one layer of fluid living smoothly over on adjacent layer. A laminar flow is one in which the fluid particles moves 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.
- *Transition Flow:* The transition flow has intermediate properties between the laminar and turbulent flow. In laminar the forces should be considered to calculate the friction

loss and in the turbulent flow only the internal forces are considered because the effect of viscous force is negligible as compared to internal forces.

Reynolds carried out experiments to decide limiting values of Reynolds number to quantifiably decide whether the flow is laminar, turbulent or transition. These limits are as below.

Sr. No.Type of Flow Reynolds Number

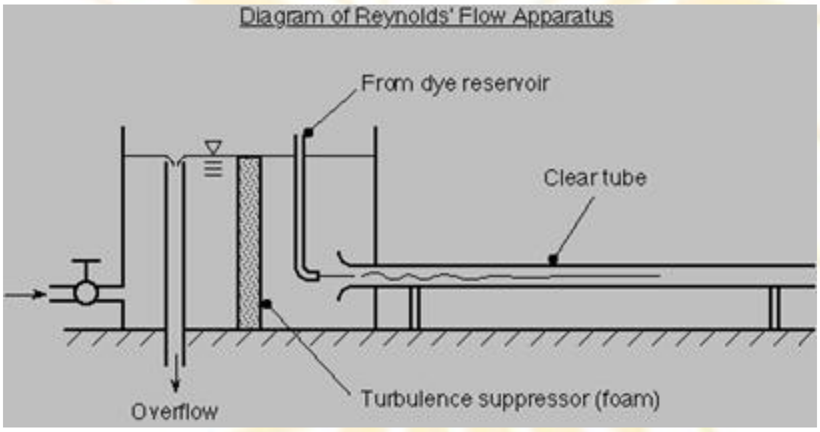
01. Laminar Flow < 2100

02. Transition Flow 2100 -4100

03. Turbulent > 4100

The flow can be visualized by passing a streak of dye and observing its motion. Inthe laminar, low velocity flow the streak line is only slightly zig – zag. In the turbulentflow, the dye thoroughly mixes up in the flow. Thus passing through a glass pipe and observing the velocity at different mixing stages of the dye is the principle on whichReynolds apparatus is based.

Experimental setup of Reynolds number:



Significance:

1. Quantifies the relative importance of inertial forces and viscous forces for given flow conditions
2. They are also used to characterize different flow regimes, such as laminar or turbulent flow

Conclusion:

EXPERIMENT NO. 9

TO DETERMINE VISCOSITY USING STOKES LAW

DATE OF PERFORMANCE:

VISCOSITY MEASUREMENT BY STOKE'S LAW

Aim: To find the viscosity of a fluid by using Stokes law.

Apparatus: Cylinder, metal spheres of different size, given liquid.

Theory: The movement of particle through fluid requires all external force acting on particle. These forces act on particle moving through fluid.

1. External force (gravitational force) (Fg)
2. Buoyancy force which acts parallel to the gravitational force (F_b).
3. The drag force which appears whenever there is a motion between particle and fluid. (F_d)

Consider, the particle of mass is moving through fluid under action of external force F_g. Let velocity of particle be u, the buoyant force on particle be F_b, and the drag force be F_d.

The resultant force on particle is,

$F_g = F_b + F_d \ldots (1)$

But,

Fg= mg

$F_b = mg(\rho_p - \rho_l)$

Therefore,

$mg = mg\left(\rho_p - \rho_l\right) + F_d \ldots (2)$

By Stoke's law the drag force acting on a spherical particle of diameter dp is given by,

$F_d = 3\pi\mu u_t d_p / g \ldots (3)$

Substituting eq (3) in eq (2) and also m= (π/6) $d_p^3\ \rho_p$ we get the expression for terminal velocity,

$u_t = \frac{dp^2\ \left(\rho_p - \rho_l\right)g}{18\mu} \ldots (4)$

Eqn. (4) is appreciable for particle having N_{Re} less than 30.

Where,

ρ_p = density of particle

ρ_l = density of fluid

u_t = terminal velocity

μ= viscosity of the fluid

m= mass of spherical particle

dp= diameter of particle

g= acceleration due to gravity

Procedure:

1. Measure the diameter of spherical balls with the help of micro screw gauge.
2. Measure the density of material of metal balls.
3. Gently drop one ball in to the cylinder filled with viscous fluid and note the time taken to travel the distance as marked by 2 bends.
4. Knowing terminal velocity (u_t) from knowledge of time taken by balls to travel, the known distance viscosity can be calculated.
5. Repeat the same procedure for finding viscosity of the other fluid.

Observation:

1) Density of oil = gm/cc
2) Density of sphere= gm/cm^3
3) Distance travelled = cm
4) Specific gravity =

Observation table:

Sr. no	Dia. of particle (m)	Distance travelled (m)	Time (sec)	Velocity u_t (m/s)	Viscosity Kg.s/m^2	Avg. viscosity Kg.s/m^2
1						
2						
3						
4						

Calculations:

Result:

Conclusion:

EXPERIMENT NO. 10

CALIBRATION OF PRESSURE GAUGE

DATE OF PERFORMANCE:

CALIBRATION OF PRESSURE GAUGE

***Aim**:*

The calibration of a pressure gauge.

Apparatus:

Deadweight Pressure Gauge calibration set up

Theory:

Pressure gauges are used for measurement of pressure and are suitable for all clean and non-clogging liquid and gaseous media. Bourdon gauge consists of a hollow metal tube with an oval cross section, bent in the shape of a hook. One end of the tube is closed, the other open and connected to the measurement region. If pressure (above local atmospheric pressure) is applied, the oval cross section will become circular, and at the same time the tube will straighten out slightly. The resulting motion of the closed end, proportional to the pressure, can then be measured via a pointer or needle connected to the end through a suitable linkage. Calibration is the name of the term applied to checking the accuracy or the working condition of the concerned device. So, the calibration of Bourdon Pressure Gauge refers to the checking of its accuracy or reliability in taking a reading. The apparatus used for this purpose is called the Dead-Weight Gauge Tester. The working of this gauge tester can be understood easily with the help of the following diagram.

In this figure gauge A is the one to be calibrated. We can at any stage disengage the gauge by closing the valve.

Let,

Weight of Plunger = W

Cross-sectional Area of the stem of Plunger = A

Therefore, Pressure exerted on the fluid = P = W/A

According to Pascal's Law, pressure is transmitted equally in all direction. Therefore pressure encountered at the inlet of Gauge 'A' is the same as P

Now, if Pressure registered by Gauge 'A' = PA = P Within experimental limits,

Then the gauge is working properly. If not, then there is some problem which must be detected and accounted for.

Figure:-

Operating Instructions:

1. Fix the gauge to be tested on one end of the Dead-Weight Gauge tester and make sure that the valve is fully opened. Meanwhile close the other valve tightly so that no leakage of fluid is ensured.

2. Next, gently place the load corresponding to known pressure on the middle spindle ensuring that the spindle should not touch the edges of the cylinder.

3. Turn the handle of the screw plunger slowly to increase the pressure on the oil. Just as the applied mass is raised slowly, stop for some time for the system to attain equilibrium,

4. Take the reading from the gauge. Record both the applied and registered pressure in a table of values.

5. Now place some weights on the middle spindle so that the applied pressure is varied. Then, repeat the above mentioned procedure until there are at least six readings. Record them all in the table.

6. Repeat the procedure while reducing the weights on the middle spindle. And record the readings.

Observation:

Sr. No	Applied Pressure [P]	Pressure in Gauge [P_A]			Error
		Loading	Unloading	Mean	
01					
02					
03					
04					
05					
06					
07					
08					

Graph:

Plot the graph applied pressure ‘P’ on X axis and Mean Gauge pressure on Y axis.

Conclusion: