DEPARTMENT OF
MECHANICAL ENGINEERING

LABORATORY MANUAL

MECHANICAL ENGINEERING
(CSMSS/ENGG/MECH/FMLAB/FM/BTMCL306)

CSMSS

CHH. SHAHU COLLEGE OF ENGINEERING

KANCHANWADI, CHHATRAPATI SAMBHAJINAGAR - 431011

	CSMSS CHH. SHAHU COLLEGE OF ENGINEERING		LABORATORY MANUAL
	COURSE OUTCOMES		
DEPARTMENT: MECHANICAL ENGINEERING			
LABARATORY NAME: FLUID MECHANICS LAB			
LABORATORY MANUAL NO.: CSMSS/ENGG/MECH/FMLAB/FM/BTMCL306		SEMESTER: III	YEAR: 2024-25
COURSE NAME: FLUID MECHANICS LAB		ISSUE DATE: 22/07/2024	PAGE: 1 OF 2

Course Name: FLUID MECHANICS LAB

Course Code: BTMCL306

Examination Scheme:

1. **Internal Assessment:** 60 Marks (CA 1 = 30 Marks and CA2 = 30 Marks)
2. **External Assessment:** 40 Marks

Course Outcomes

CO	CO Statement	BT Level
CO.1	Students will be able to **DEFINE** fluid properties and principles of fluid statics, including viscosity, surface tension, Pascal's law, and hydrostatic pressure.	Understand (Level 1)
CO.2	Students will be able to **Define** continuity and Bernoulli's equations and **USE** them to analyze fluid flow in devices such as Pitot tubes and Venturimeters.	Apply (Level 3)
CO.3	Students will be able to compare laminar and turbulent flow characteristics in pipes and **USE** Darcy's and Chezy's equations to calculate energy losses.	Apply (Level 3)
CO.4	Students will be able to **APPLY** concepts of lift, drag, and boundary layer theory to analyze forces on immersed bodies, predict flow separation, and propose boundary layer control methods.	Apply (Level 3)
CO.5	Students will be able to **APPLY** dimensional analysis techniques, including Rayleigh's method and Buckingham's π-theorem, to establish dimensional homogeneity.	Applying (Level 3)

	CSMSS CHH. SHAHU COLLEGE OF ENGINEERING	LABORATORY MANUAL
	MASTER LIST OF EXPERIMENTS	
DEPARTMENT: MECHANICAL ENGINEERING		
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MASTER LIST OF EXPERIMENT

SR. NO.	EXPERIMENT NO.	EXPERIMENT TITLE
1	01	Viscosity measurement using Red Wood Viscometer
2	02	Gauge and differential pressure measurements using various types of manometers, Bourdon type pressure gauge.
3	03	Determination of metacentric height of a floating body.
4	04	To study and verify Bernoulli's theorem.
5	05	Calibration of a selected flow measuring device.
6	06	To Calibrate the V-Notch for measurement of flow.
7	07	Determination of pressure drops in pipes of various pipe fittings etc.
8	08	Determination of Critical Reynolds number using Reynolds Apparatus.
9	09	Gear Pump Test Rig.
10	10	Nozzle and Diffuser Test Rig.

CHECKED BY:

Dr. Manish Kumar
Lab In-charge

APPROVED BY:

Dr. R.H.Shinde
HOD

	CHHATRAPATI SHAHU MAHARAJ SHIKSHAN SANSTHA's CHH. SHAHU COLLEGE OF ENGINEERING Kanchanwadi, Aurangabad **Department of Mechanical Engineering** **Practical Experiment Instruction Sheet**
Lab: FM	**Experiment No. : 01** Determination of viscosity by using Red wood Viscometer

Aim: - To determines of viscosity by using Red wood Viscometer and study its variation with temperature.

Apparatus:- Redwood Viscometer I, Thermometer (0°C to 100°C), Stop watch, 50 ml standard flask, oil sample

Theory:-Red Wood Viscometer is based on principle of laminar flow through capillary tube of standard dimension under falling head. The Viscometer consists of vertical cylinder with orifice of centre of base of inner cylinder. The cylinder is surrounded by water bath which can maintain temperature of liquid to be tested at required temperature. The water bath is heated by electric heater. The cylinder which is filled up to fix with liquid whose viscosity is to be determined is heated by water bath to desired temperature. Then orifice is opened and time required to pass 50 cc of liquid is noted. With this arrangement variation of Viscosity with temperature can be studied.

In case of Red Wood Viscometer Kinematic Viscosity and time required to pass 50 cc of liquid are co-related by expression, $\nu = C * t$

Where, ν (Nu) = Kinematic viscosity in stoke

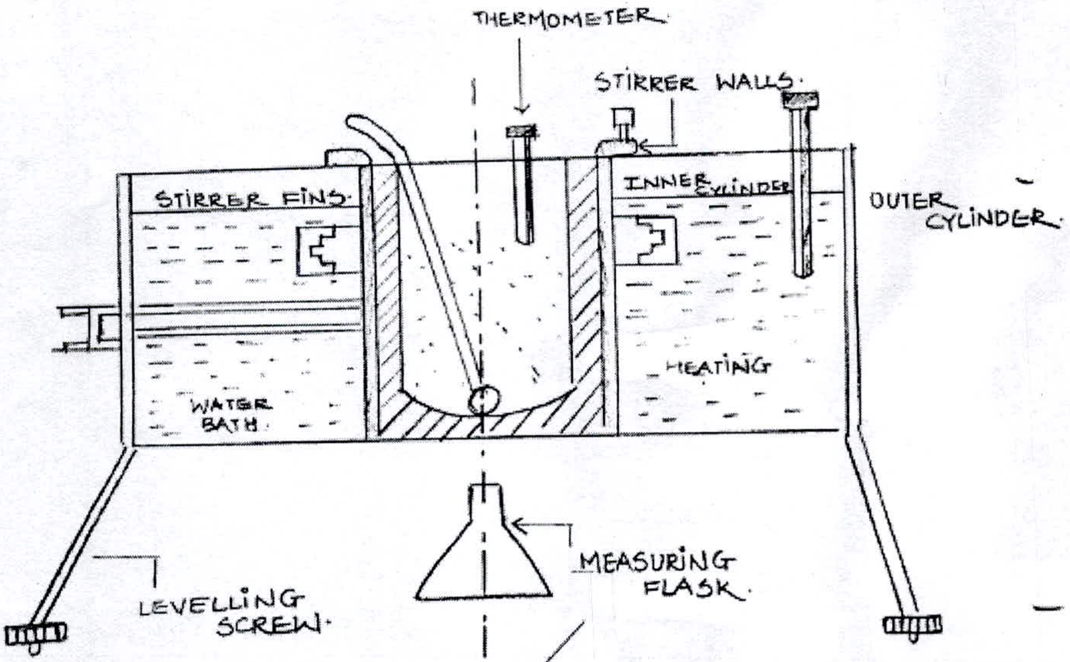
t: Time in seconds to collect 50 cc of oil.

C = Equipment Constant (To be found every time by using water)

Experimental Procedure:-

1. Clean the cylindrical oil cup and ensure the orifice tube is free from dirt.
2. Fill water bath.
3. Close orifice with ball valve and fill cylinder up to index mark.
4. Record steady temperature of oil.
5. By lifting ball valve, collect 50cc of liquid in measuring flak and measure time required for same.
6. Repeat procedure for different temperatures by heating oil with water bath.

Diagram:-



REDWOOD VISCOMETER

Observations:-

Observation Table

Sr. No.	Temperature in ^oC	Time to collect 50 cc of oil t (sec)	Kinematic Viscosity ν In stokes
1			
2			
3			
4			

Specimen Calculations:-

First we've to find Equipment constant, using water,

Kinematic Viscosity $v = C * t$

v for water at NTP = 0.801

Let $t = 25$ seconds.

Therefore,

$v = C * t$

$0.801 = C * 25$

$C = 0.03204$ (Using Water)

Then, after taking actual readings,

For 50^0 C,

$v_1 = C * t$

$v_1 = 0.03204 * 178 / 100$ (divide by 100 to convert it to Stokes or cm^2/s)

$v_1 = 0.057$ Stokes $= 0.057 * 10^{-4}\ m^2/s$

We know that,

$\mu_1 = \rho * v_1 = (940 * 0.057 * 10^{-4}) = 0.0535$ Poise ($\mu_{Oil} = 940\ kg/m^3$)

$\mu_2 = \rho * v_2 =$.......................... (μ= Dynamic Viscosity)

$\mu_3 = \rho * v_3 =$......................

Results:-

Kinematic viscosity of oil is _____ stokes

Conclusion:-

Kinematic Viscosity of oil decreases with increase in temperature.

Questions:-

- What is Dynamic and Kinematic Viscosity?
- Why it is important to study Viscosity?

Prepared by: Mr. D. A. More	Approved by: Head, Dept. of Mechanical Engineering.

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Department of Mechanical Engineering
Practical Experiment Instruction Sheet

Lab:- FM	**Experiment No. : 02** Study and performance of different pressure measuring instruments

Aim: - To study and performance on different types of pressure measuring devices.

Apparatus:- Different pressure measuring devices, necessary piping, water tank, collector tank and pump

Theory: - Pressure of a fluid is the normal force exerted by a fluid on a unit area. The pressure designated will be either an absolute pressure or a gauge pressure. Absolute pressure is measured relative to a perfect vacuum (absolute zero pressure), whereas gauge pressure is measured relative to the local atmospheric pressure. Absolute pressures are positive, but gauge pressure can be either positive (above atmospheric pressure) or negative (below atmospheric pressure) as shown in figure 1.

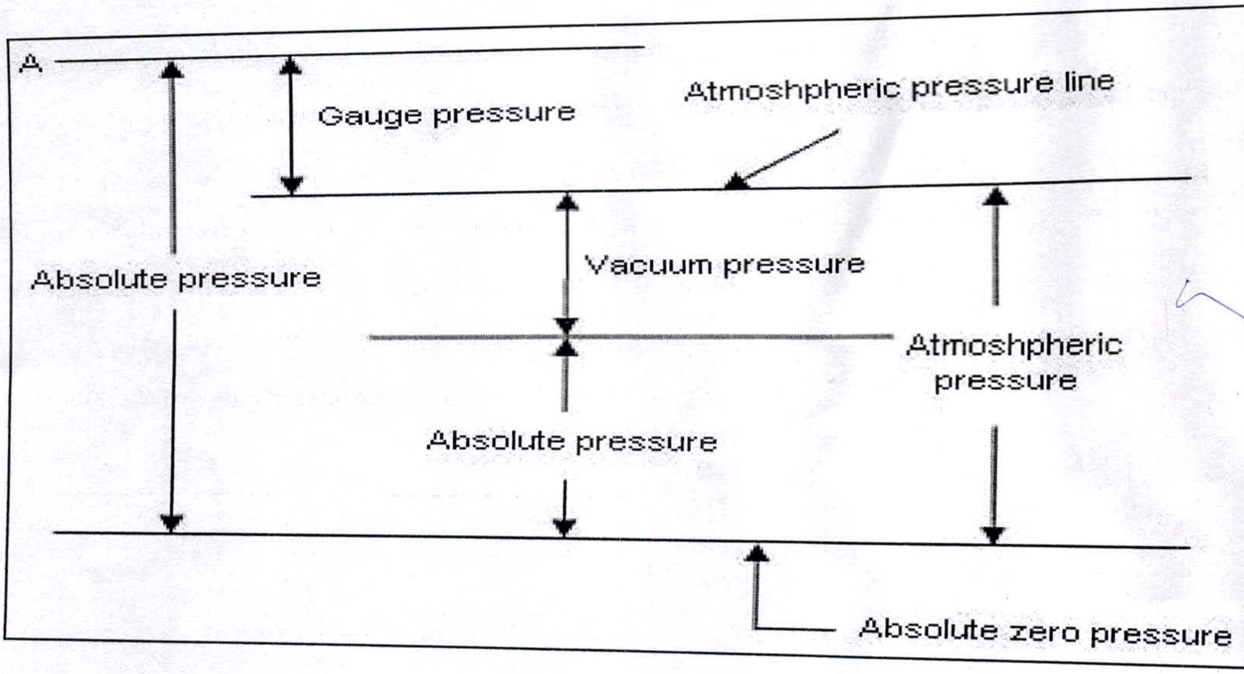


Figure No.1

PRESSURING MEASURING DEVICES

I MANOMETERS:

Manometers are defined as the devices used for measuring the pressure at appoint in fluid by balancing the column of fluid by same or another column of fluid.

They are classified as follows:

A. Simple manometer.
B. Differential manometer.

A. <u>Simple manometer.</u>

A simple manometer consists of a glass tube having one of its end connected to a point which pressure is to be measured and other end remains open to the atmosphere. Common types of simple manometer are as follows,

i) Piezometer.
ii) U-tube manometer.
iii) Single column manometer.

i) Piezometer.

It is a simplest form of manometer used for measuring gauge pressure. One end of manometer is connected to the point where pressure is to be measured and other end is open to the atmosphere. The rise of the liquid gives the pressure head of that point.

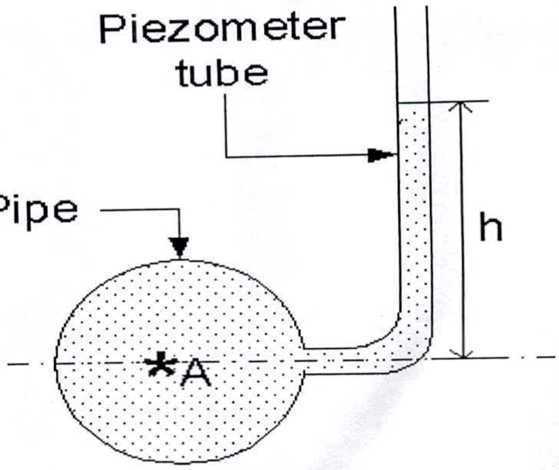


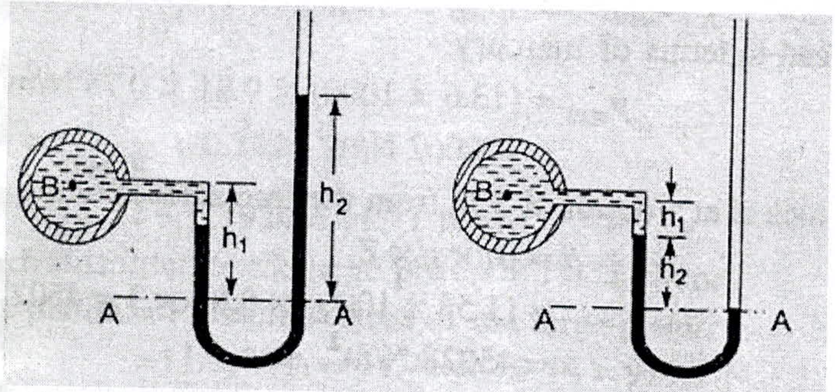
Figure No.2

Pressure at point A is given by

$P = \rho \times g \times h$. N/m^2

ii) U-tube manometer

It consists of a glass tube bent in U-shape. One end of which is connected to a point at which pressure is to be measured and other end remains open to the atmosphere, the tube generally contains mercury or any other liquid whose specific gravity is greater than specific gravity of the liquid whose pressure is to be measured.



a. For gauge Pressure:

Let B be the point at which pressure is to be measured the datum line is A-A.

Let h_1 – Height of liquid above datum line.
h_2 – Height of heavy liquid above datum line.
S_1 – Specific gravity of light liquid.
S_2 – Specific gravity of heavy liquid.

ρ_1 - Density of light liquid (S_1 X 1000)

ρ_2 - Density of heavy liquid (S_2 X 1000)

As the pressure is same for horizontal surface the pressure above horizontal datum line A-A in the left column and right column of the U-tube manometer should be same.

Pressure above A-A in left column = $\rho_1 h_1 g$

Pressure above A-A in right column = $\rho_2 h_2 g$

$$P + \rho_1 h_1 g = \rho_2 h_2 g$$

$$P = \rho_2 h_2 g - \rho_1 h_1 g$$

b. For vacuum pressure:

For measuring vacuum pressure the level of the heavy liquid is shown in the diagram.

Pressure above A-A in left column = $\rho_1 h_1 g + \rho_2 h_2 g + P$

Pressure above A-A in right column = 0.

$$\rho_1 h_1 g + \rho_2 h_2 g + P = 0.$$

$$P = -(\rho_1 h_1 g + \rho_2 h_2 g)$$

iii) Single column manometer:

Single column manometer is modified form of U-tune manometer in which a reservoir having a large cross-section (about 100 times) as compaired to the area of the tube is connected to one of the limbs (say left limbo of the manometer. Due to large cross section area reservoir for any variation in pressure, the change in the liquid in the reservoir will be very small which may be neglected and hence the pressure is given as the height of liquid in the other limb.

1. Vertical single column manometer.
2. Inclined single column manometer.

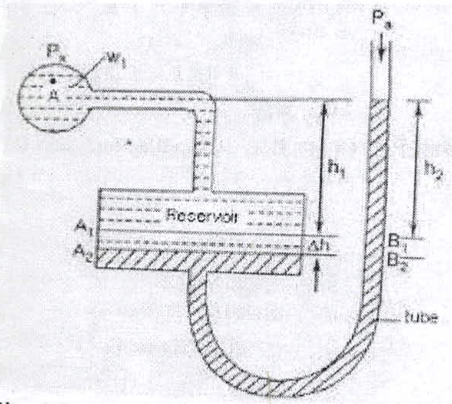


Fig. Vertical single column manometer

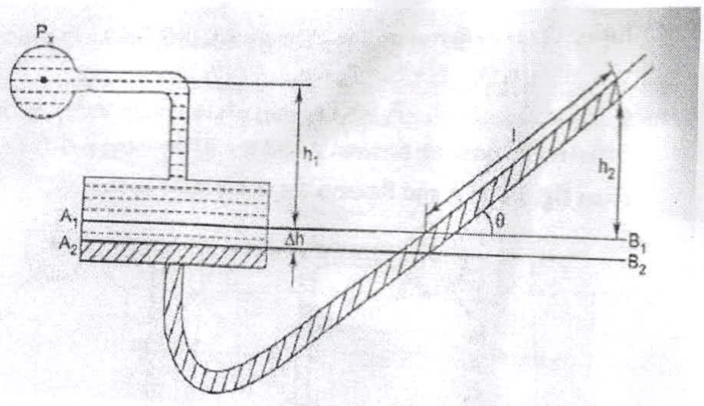


Fig. Inclined single column manometer

B. <u>Differential manometer:</u>

These manometers are the devices used for measuring the differences of pressure between two points in a pipe or in two different pipes. A differential manometer consists of a tube containing a heavy liquid whose two ends are connected to the point whose differences of pressure is to be measured most commonly used types of differential manometers are:

1) U-tube differential manometer.
2) Inverted U-tube differential manometer.

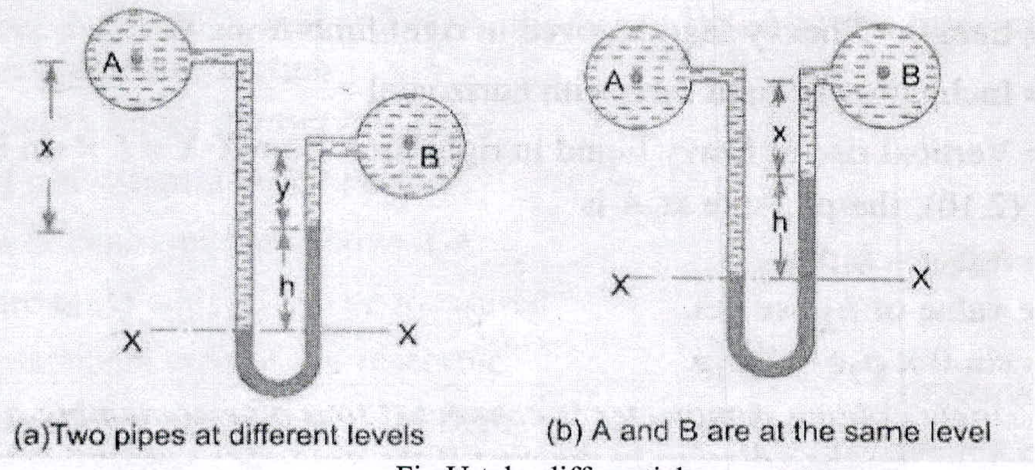


Fig.U-tube differential manometer

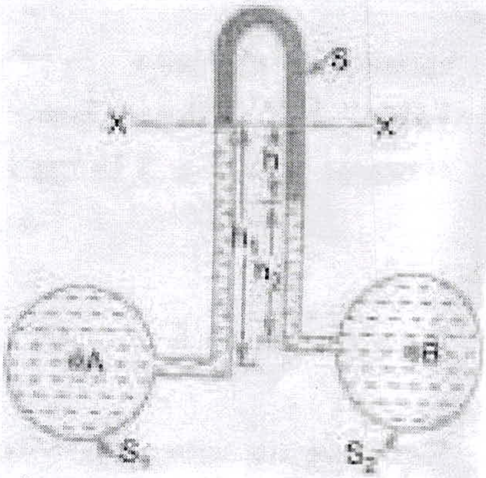


Fig. Inverted U-tube differential Manometer

II MECHANICAL GAUGES:

These measures the unknown pressure by balancing pressure against a mechanical element like dead weights spring a diaphragm etc.

1. Bourdon gauge:

Bourdon gauge is widely used because it is compact, robust, simple to use and gives precise readings. It consists of a tube which is elliptical in cross-section in the form of a question mark and is pressure resistant. It is closed at the free end A. The end 'B" is attached to the pressure tapping on application of pressure, the cross-section tends to become circular due to this connected by link 'L' to rack and pinion arrangement 'R' which causes measurement of pointer 'P' on calibrated dial 'D'. This device measures positive and negative pressure. The scale is calibrated in N/m^2 or mm of Hg or m of H_2O.

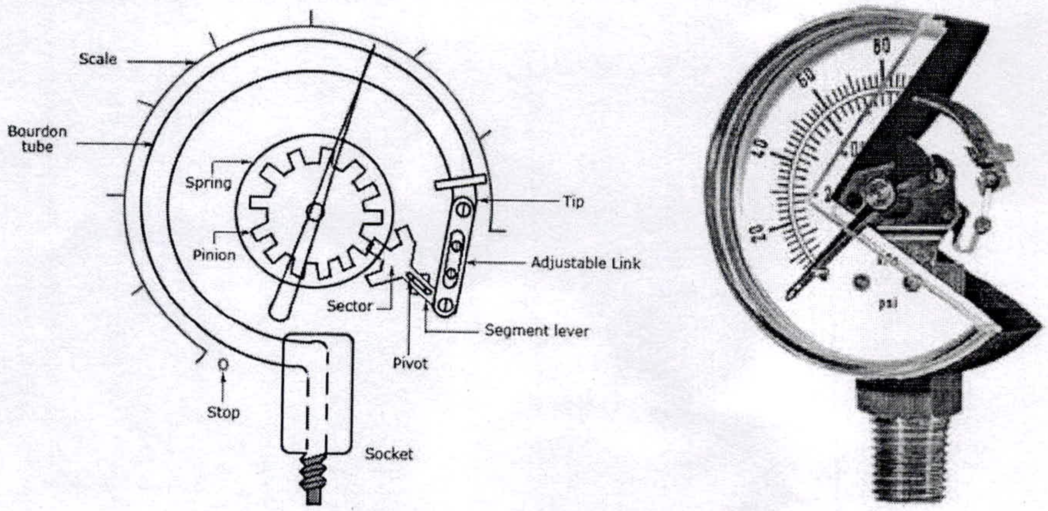


FIG. Bourdon tube pressure gauge

Other types of gauges are:

i) Bellow gauge.
ii) Diaphragm gauge.
iii) Dead weight gauge.

CONCLUSION:

Thus in this manner we have studied the construction and working of various manometer and pressure gauge.

Prepared by: Mr. D. A. More	**Approved by: Head, Dept. of Mechanical Engineering.**

Lab: FM	**Experiment No. : 02** **Determination of metacentric height by experimental method**

Aim:- To Determine the Metacentric Height of a Empty ship and Cargo Ship

Theory:-

Meta-center is defined as, the point about which the body starts oscillating when it is tilted (inclined) by a small angle.

Meta-center may also be defined as, the point at which the line of action of force of buoyancy will meet the normal axis of the body when the body is given a small angular displacement.

Meta-centric Height is defined as, the distance between the Metacenter of a floating body & center of gravity.

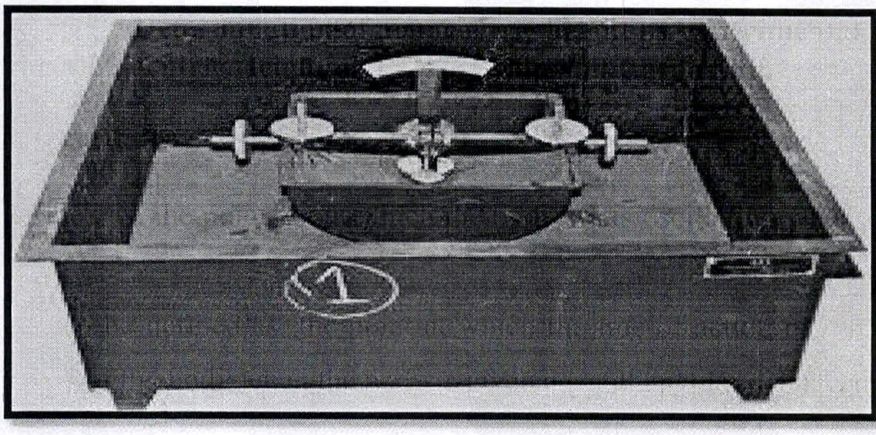


Fig.1.Practical setup for Meta-Centric Height

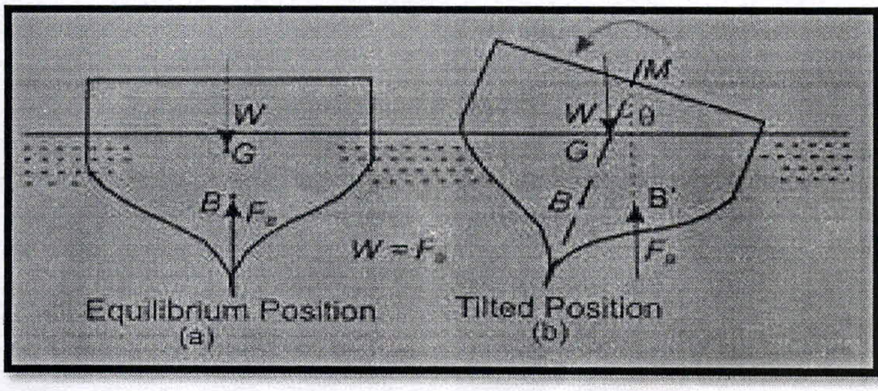


Fig.2.Position of Tilted body.

Experimental Procedure:-

1. Place the model of ship in the water tank.
2. Shift the movable weight to zero position and note the corresponding angle of rotation.
3. If it is on zero then its correct if not then notes the error and its direction.
4. Now shift the movable weight to either left or right side by 10cm. Note the angle against that reading.
5. Similarly shift the movable weight to 6.5 cm, 9 cm, 22 cm, 18 cm and note the corresponding value of angle.
6. Similarly, move the movable weight to the other side and take at least 6 readings accordingly.
7. Take mean of left and right angle and make a table of it.

Observations:-

W1 = Weight of the Hanging Load in grams Weight of the ship including balancing weight in grams

W2 = Weight of the ship including balancing weight in grams

W3 = Total weight W1+ W2 .

Observation Table:

For Empty Ship

Sr. No.	Distance of movable weight x in 'm'	Angle of Tilt θ	Meta-Centric Height GM in 'm'
1			
2			
3			

Specimen Calculations:-

W = F_B=Weight of water displaced by pontoon

$$W = mg$$

$$W = \rho\forall g$$

$$W = \rho A_t \times (h_2 - h_1)_g$$

GM = Metacentric Heights in centimeters.

$$GM = \frac{W1 \times x}{W3 \tan\theta}$$

Results:-

Metacentric Height of a Cargo Ship (GM) = ...cms.

Conclusion:-

As the angle of tilt (θ^0) increases, Metacentric Height (MG or GM) also ....increases / decreases.

Questions:-

- What is Meta-Center and Metacentric height?
- Why it is important to study Meta-centric height experiment?

Lab work:-

Draw diagram of empty-ship

Prepared by: Mr. D. A. More	Approved by: Head, Dept. of Mechanical Engineering.

Lab: FM

Experiment No. : 05

Verification of Bernoulli's theorem

Aim: - To verify Bernoulli's theorem

Theory:-

Bernoulli's equation :It state that 'In an ideal, steady, incompressible and irrotational flow the total energy(i.e. pressure energy, kinetic energy and potential energy) remains constant throughout the section).

Mathematically,

$$\frac{P}{\rho g} + \frac{V^2}{2g} + Z = Constant$$

Where,

$\frac{P}{\rho g}$ = pressure energy

$\frac{V^2}{2g}$ = kinetic energy

Z = potential energy

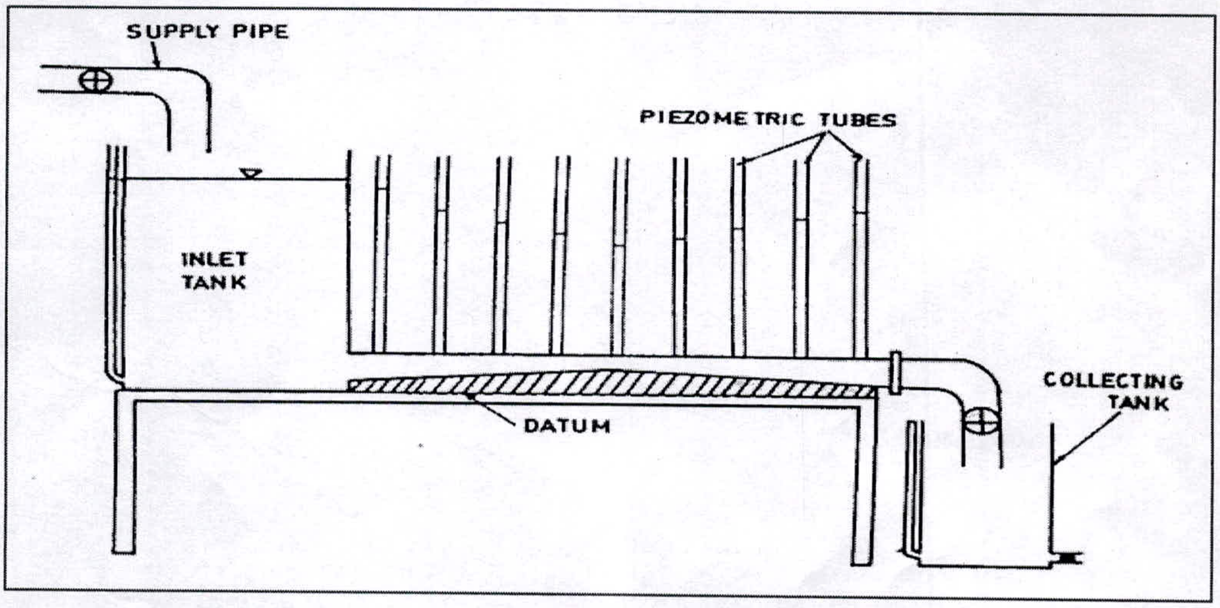


Fig.1 Bernoulli's Apparatus Setup

Experimental Procedure:-

1. Note down the area of cross section of the conduit at various piezometer points
2. Open the supply valve and adjust the flow so that the water level in the inlet tank remains at a constant level (i.e., flow becomes steady).
3. Measure the height of water level in different Piezometers.
4. Measure the discharge.
5. Repeat setups 2 to 4 for two more readings.

Observations:-

Actual discharge Q= m^3 of water collected per time
Stop watch and measuring scale etc

Observation Table

Tube No.	Diameter of Tube in '10^{-4} m^2'	Velocity V in 'm/s' $V = \frac{Q}{A}$	Velocity Head in 'm' $\frac{V^2}{2g}$	Pressure head in 'm' $\frac{P}{\rho g}$	Datum head in 'm' Z	Total Head in 'm' $\frac{P}{\rho g} + \frac{V^2}{2g} + Z$
1	9.64					
2	8.546					
3	7.29					
4	6.11					
5	4.97					
6	3.08					
7	4.97					
8	7.611					
9	7.29					
10	8.54					
11	9.65					

Specimen Calculations:-

i. Velocity, V=Q/A

ii. Velocity head = $V^2/2g$

iii. Pressure head = $(P/\rho g)$

iv. Datum head = Z

v. Total energy = $(P/\rho g)+Z+(V^2/2g)$

Results:-

Total energy line remains the same at different sections = ...m.

Conclusion:- In this way Bernaulli's theorem is verified and there is variation in total head due to friction

Questions:-

- Is constant in Bernoulli's equation same for all kinds of flow streamline flow potential. If so, why? If not, Why?
- Write Bernoulli's equation for real fluid flow.
- What are the assumptions made in Bernoulli's equation's derivation?
- What are the applications of Bernoulli's equation?

Lab work:-

- Know the Bernoulli's principle.
- Applications of Bernoulli's principle

Graphs:

1. Plot $(P/\rho g) + Z$ Vs distance of Piezometer tubes for some reference (on x-axis). Join the points by a smooth curve. This is known as the hydraulic line.
2. $E = (P/\rho g) + Z + (V^2/2g)$ Vs distance of piezometer tubes. Join the points smoothly. This is the total energy line.

Prepared by: Mr. D. A. More | **Approved by: Head, Dept. of Mechanical Engineering.**

Lab: FM	Experiment No. : 05 Measurement of flow by using orifice meter

Aim: - To determine coefficient of discharge for Orificemeter

Theory:-

Orifice meter: It is a device used for measuring the discharge in pipe only. It has circular hole.

Theoretical discharge by Orifice meter,

$$Q_{th} = \frac{a_0 a_1}{\sqrt{a_0^2 - a_1^2}} \times \sqrt{2gh}$$

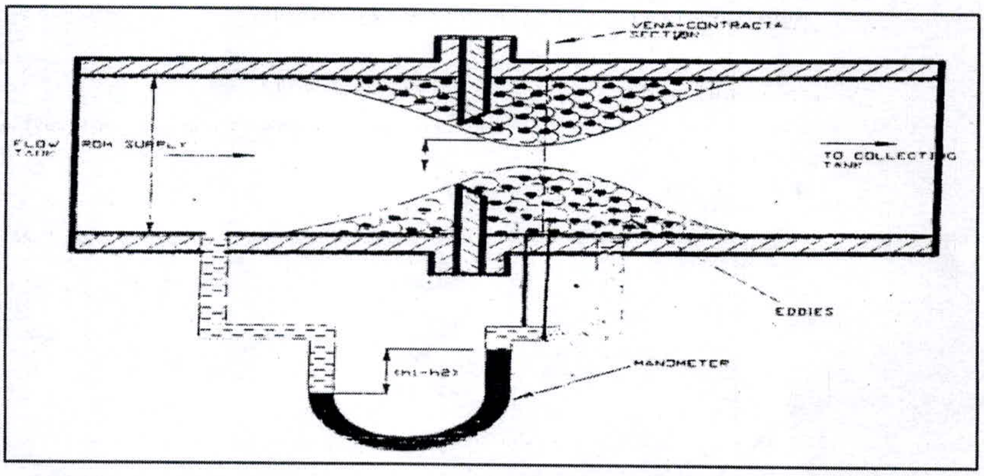


Fig. Orifice meter

Experimental Procedure:-

1. Select the desired Orifice meter whose coefficient of discharge is to be determined.
2. Connect the pressure tapings of the Orifice meter selected to the Piezometric tubes of the Manometer provided.
3. Open the regulating valve so that water starts flowing through the Orifice meter. Wait for sometime so that the flow gets stabilized.
4. Vent the manometer, if necessary.
5. Note down differential Manometer readings h_1 and h_2
6. Measure the actual discharge by observing the time taken to collect a predetermined volume of water. (Time taken for 10 cm rise of water column in the collecting tank may be noted and actual discharge found).
7. Repeat steps (5) and (6) for different flow rates (by adjusting regulating valve) and take at least

six different sets of observations.

Observations:-

1. Diameter of the pipe to which Orifice meter fitted, d_0 =
2. Diameter of the throat of the Orifice meter, d_1 =
3. Note: $d_0/d_1 = 0.62$.
4. Size of the collecting tank = $l_c \times b_c \times h_c$ =

Observation Table

Sr. No	Manometric reading		Time taken for rise of water level in measuring tank (t) in 'sec'	Actual discharge (Q_{act}) in 'm^3/s'	Theoretical discharge (Q_{th}) in 'm^3/s'	Coefficient of discharge (C_d)
	Right limb (h_1) in 'm'	Left limb (h_2) in 'm'				

Specimen Calculations:-

1. Actual discharge (Q_{act}) = AR/t Where

   A = Cross-sectional area of the collecting tank = $l_c \times b_c$ =

   R = Rise of water level in the collecting tank =

   t = Time taken for 'R' units of rise in water level

   Therefore,

$$Q_{th} = \frac{a_0 a_1}{\sqrt{a_0^2 - a_1^2}} \times \sqrt{2gh}$$

a_1 = Cross-section area of the inlet section of Orifice meter

= $(\pi/4)\, d_0^2$

a_2 = Cross-section area of the throat of Orifice meter = (Π/4)* d1

H= Equivalent pressure head in meters of flowing liquid S m

$$= \left(\frac{S_m}{S_f} - 1\right)(h_1 - h_2)$$

S_m = Specific gravity of manometric fluid = 13.6 for mercury

S_f = Specific gravity of fluid flowing in pipe = 1 for water

h_1 = Manometer reading in the right limb

h_2 = Manometer reading in the left limb

Therefore, Qth =

2. Coefficient of Discharge $C_d = Q_{act} / Q_{th} =$

Results:-

Coefficient of discharge of the Venturimeter from

1. Calculations = -----------.
2. Graph = --------------.

Conclusion:-

Relative advantages and limitations of an Orifice meter versus other flow meters?

Questions:-

- Can be the same calibration be used if the Orifice meter is inclined?
- Comment and discuss on the usefulness of this experiment based on the plots prepared

Lab work:-Draw diagram of Orifice meter

Prepared by: Mr. D. A. More	**Approved by: Head, Dept. of Mechanical Engineering.**

Lab: FM

Experiment No. : 05

Determine coefficient of discharge for Venturimeter

Aim:- To determine coefficient of discharge for Venturimeter

Theory:-

Venturimeter: It is a device used for measuring the discharge in pipe only. It has three section, namely i) Convergent cone ii) Divergent cone and iii) Throat.

Theoretical discharge by Venturimeter,

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

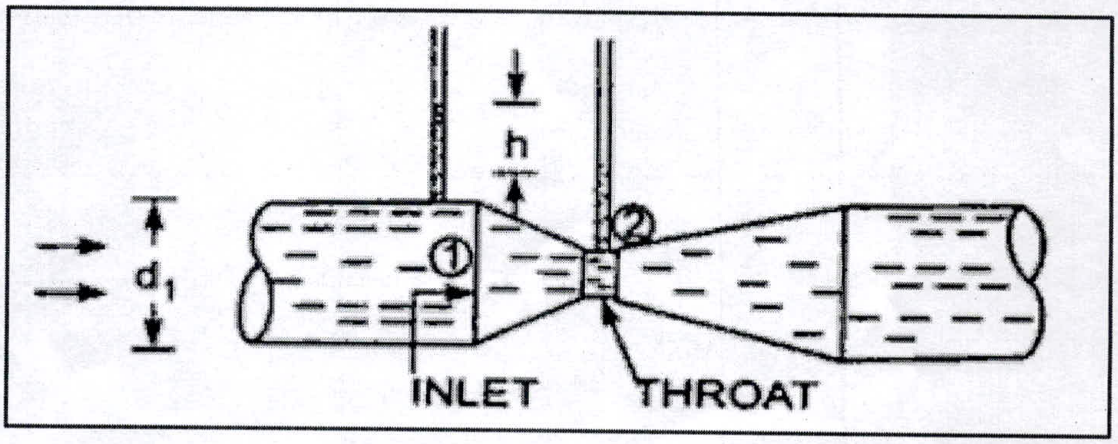


Fig. Venturimeter

Experimental Procedure:-

1. Select the desired Venturimeter whose coefficient of discharge is to be determined.
2. Connect the pressure tapings of the Venturimeter selected to the Piezometric tubes of the Manometer provided.
3. Open the regulating valve so that water starts flowing through the Venturimeter. Wait for sometime so that the flow gets stabilized.
4. Vent the manometer, if necessary.
5. Note down differential Manometer readings h_1 and h_2
6. Measure the actual discharge by observing the time taken to collect a predetermined volume of water. (Time taken for 10 cm rise of water column in the collecting tank may be noted and actual discharge found).

7. Repeat steps (5) and (6) for different flow rates (by adjusting regulating valve) and take at least six different sets of observations.

Observations:-

1. Diameter of the pipe to which Venturimeter fitted, d_1 =
2. Diameter of the throat of the Venturimeter, d_2 =
3. Note: $d_2/d_1 = 0.62$.
4. Size of the collecting tank = $l_c \times b_c \times h_c$ =

Observation Table

Sr. No	Manometric reading		Time taken for rise of water level in measuring tank (t) in 'sec'	Actual discharge (Q_{act}) in 'm^3/s'	Theoretical discharge (Q_{th}) in 'm^3/s'	Coefficient of discharge (C_d)
	Right limb (h_1) in 'm'	Left limb (h_2) in 'm'				

Specimen Calculations:-

1. Actual discharge (Q_{act}) = AR/t Where

A = Cross-sectional area of the collecting tank = l_c x b_c =

R = Rise of water level in the collecting tank =

t = Time taken for 'R' units of rise in water level

Therefore,

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

a_1 = Cross-section area of the inlet section of Orifice meter

$= (\pi/4)\, d1^2$

a_2 = Cross-section area of the throat of Orifice meter = $(\pi/4)$ d2

H= Equivalent pressure head in meters of flowing liquid S m

$$= \left(\frac{S_m}{S_f} - 1\right)(h_1 - h_2)$$

S m = Specific gravity of manometric fluid = 13.6 for mercury

S f = Specific gravity of fluid flowing in pipe = 1 for water

h 1 = Manometer reading in the right limb

h 2 = Manometer reading in the left limb

Therefore, Qth =

2. Coefficient of Discharge $C_d = Q_{act} / Q_{th} =$

Results:-

Coefficient of discharge of the Venturimeter from

1. Calculations = -----------.
2. Graph = --------------.

Conclusion:-

Relative advantages and limitations of a venturimeter versus other flow meters?

Questions:-

- Can be the same calibration be used if the venturimeter is inclined?
- Comment and discuss on the usefulness of this experiment based on the plots prepared

Lab work:-

Draw diagram of Venturimeter

Prepared by: Mr. D. A. More	Approved by: Head, Dept. of Mechanical Engineering.

Lab:- FM	Experiment No. : 08 Calibration of notch

Aim:-To calibrate the V-Notch for measurement of flow.

INTRODUCTION:

A notch is a device used for measuring the rate of a liquid through a small channel or a tank. It may be defined as an opening in the side of a tank or a small channel in such a way that the liquid surface in the tank or channel is below the top edge of the opening. The sheet of water flowing through the notch is called Nappe or Vein. The bottom edge of a notch over which the water flows, is known as the sill or crest.

THEORY:

Co-efficient of Discharge:

The ratio of actual discharge over a notch to the theoretical discharge is known as coefficient of discharge. Mathematically, Co-efficient of discharge:

$$Cd = \frac{\text{Actual Discharge}}{\text{Theoretical Discharge}}$$

Discharge over triangular Notch:

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

DESCRIPTION:

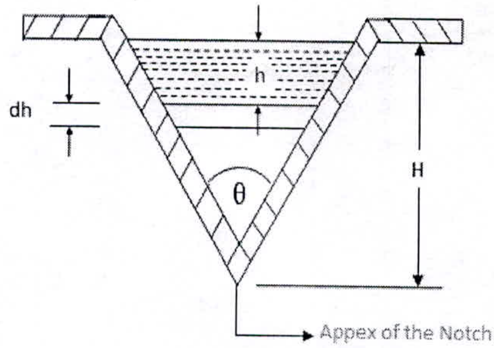


Fig : Triangular Notch

To find the co-efficient of discharge A set of two knife edged notch plates made up of Brass sheet is provided. One of them is 'V' notch having included angles 60°and the other is 'V' notch having included angles 45°. Depth of each notch is 105 mm. The notches are interchangeable. A pointer is provided to measure the height of water level over the crest of the notch.

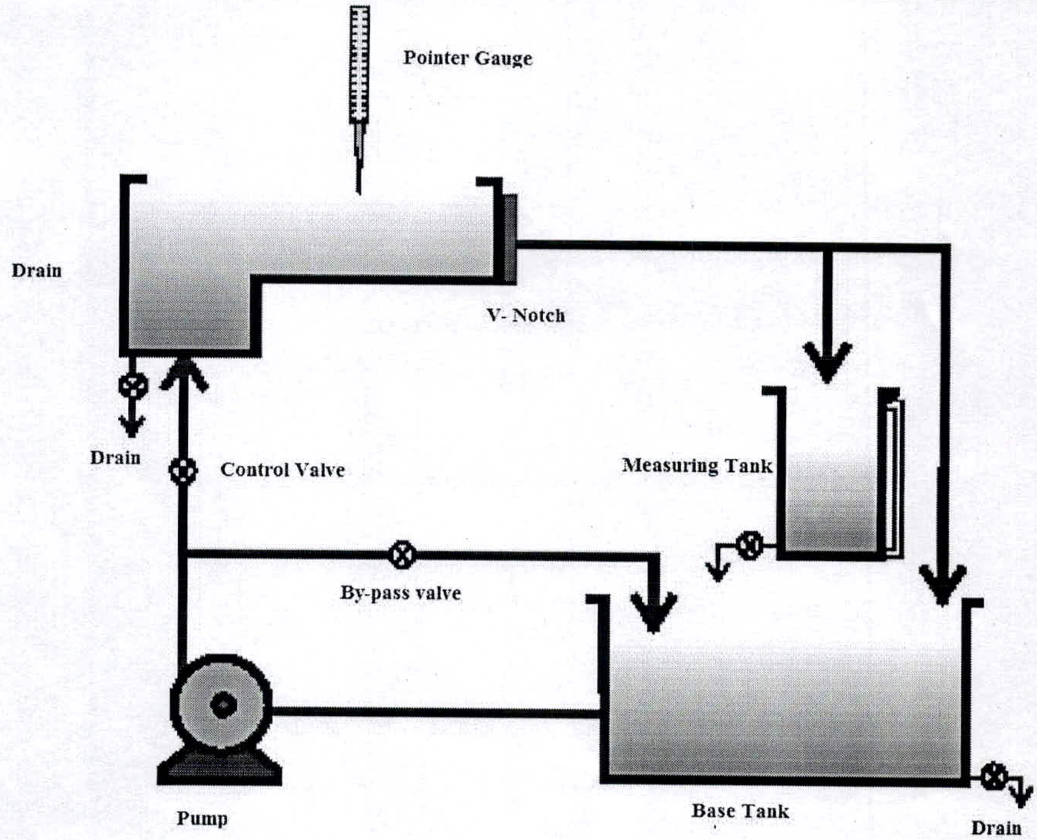


Figure: Schematic Diagram for Notch Apparatus

EXPERIMENTAL PROCEDURE:

a) Clean the apparatus and make free from dust.
b) Close the drain valves provided.
c) Close Flow Control Valve provided in water line.
d) Open By-Pass Valve.
e) Fix desired Notch on the flow channel.
f) Fill sump tank with clean water and ensure that no foreign particles are there.
g) Ensure that all On/Off Switches given on the Panel are at OFF position.
h) Now switch on the Main Power Supply.
i) Switch on the Pump.
j) Record crest height for notch.
k) Regulate Flow of water through channel with the help of given Flow Control Valve.
l) Record the height of water level in the channel with the help of pointer Gauge.
m) Measure Flow Rate using Measuring Tank and Stop Watch.

SPECIFICATION:

1) Length of measuring tank = 465 mm = 0. 465m
2) Width of measuring tank = 285mm = 0.285m
3) Height of water level measured = 100mm = 0.1m
4) Length of rectangular notch = 150mm = 0.15m
5) Θ for triangular notch = 90°

FORMULAE:

Actual Discharge:

$$Q_a = \frac{A \times R}{T} \; (cm^3/s)$$

Head over Crest:

$$H = (h - h_c) \text{ cm}$$

Theoretical discharge over triangular notch:

$$Q_{th} = 8/15 \tan \theta/2 \sqrt{2g}\, H^{5/2} (cm^3/s)$$

Coefficient of discharge:

$$Cd = \frac{Q_a}{Q_{th}}$$

NOMENCLATURE:

A = Area of measuring tank, cm^2

Cd = Co-efficient of discharge.

g = Acceleration due to gravity,

h = Water level in channel, cm

h_c= Crest height, cm

H = Water head over crest in cm

θ = Angle of V- notch, Radian

Q_{act}= Actual discharge in cm^3/s

Q_{th} = Theoretical discharge over notches.

R = Rise of water level in measuring tank, cm

T = Time for R

OBSERVATION TABLE:

Sr. No	h_1 in cm	h_2 in cm	$H = h_1 - h_2$ in cm	Time required for water rise in seconds
1				
2				
3				

CALCULATIONS & RESULT TABLE:

Sr. No	h_1 in cm	h_2 in cm	$H = h_1 - h_2$ in cm	Time required for water rise in seconds	Q_{actual} m^3/s	$Q_{theoretical}$ m^3/s	Coefficient of discharge C_d
1							
2							
3							

CONCLUSION:

Prepared by: Mr. D. A. More	**Approved by: Head, Dept. of Mechanical Engineering.**

Experiment No. : 06

Reynolds apparatus

AIM: To characterize Laminar and Turbulent flows by Reynolds apparatus

THEORY:

Reynolds Number:

It is defined as the ratio of inertia force to the viscous force of a flowing fluid.

Inertia force = Mass x Acceleration of flowing fluid.

= ρ x **volume** x **velocity / time**
= ρ x (volume/ time) x velocity
= ρ x AV x V
= ρAV^2

Viscous force = Shear stress x Area

= τ x A
= μ x (du/dy) x A
= μ x (V/L) x A

By definition of Reynolds Number

$$\mathbf{Re} = \frac{\text{Inertia Force}}{\text{Viscous Force}}$$

$$\mathbf{Re} = \frac{\rho AV^2}{\mu \times (V/L) \times A}$$

$$= \frac{\rho VL}{\mu}$$

n case of a circular pipe the linear dimension L is taken as diameter D. Hence Re for pipe flow becomes

$$Re = \frac{\rho VL}{\mu} = \frac{VD}{\nu}$$

The fluid flow may be laminar or turbulent depending upon whether

1. The velocity of flow is low/high
2. The area of cross section of flow passage is small/large

3. The density of fluid is low/high
4. The dynamic viscosity of fluid is low/high

The above four variables are grouped in the form of a non-dimensional parameter called as **Reynolds number, 'R_e'.**

It is observed by Reynolds in his experiment that the change of flow from laminar to turbulent occurs at any value greater than 2000.

Depending upon

1. Entry condition
2. Temperature of water
3. Stability of the water surface in the reservoir.

When a fluid flows through a pipe, the flow may be laminar or turbulent.At low fluid velocity the fluid moves without lateral mixing as though the serious of conductors are on one another. In such a flow the streamlines are defined as the imaginary lines in a mass of fluid in the direction of flow and the fluid particles are not mixing and they are flowing a well defined path such types flow is called laminar or streamlined flow. At high fluid velocity eddies formed in fluid and their motion causing lateral mixing and superimposing of turbulent on a primary motion of fluid, zig- zag motion of the fluid particles, the erratic motion of particles causes the flow turbulent.

Reynolds has done many experiments for fluid flowing through a pipe, Reynolds No is a ratio of Inertia force to Viscous force and has found that –If

Reynolds No < 2000 then the flow is laminar flow

2000< Reynolds No<4000 then the flow is Transitional flow

Reynolds No > 4000 then the flow is Turbulent

When the velocity of flowing fluid in the pipe gradually increases the Reynolds No increases

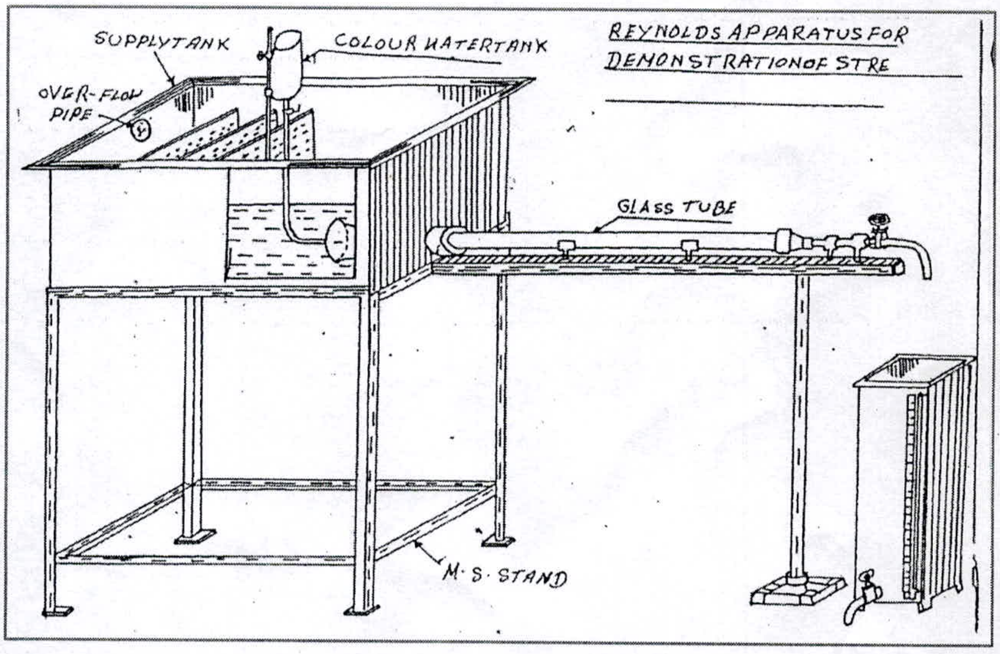
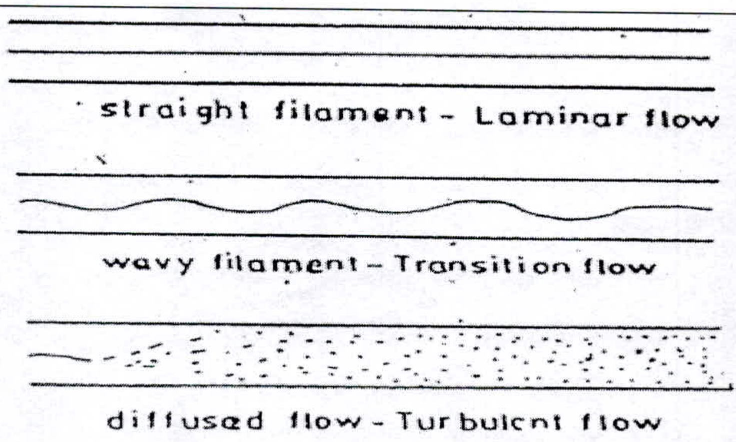


Fig.1 Reynolds Apparatus Setup



Experimental Procedure:-

1. Allow water to the supply tank to maintain a constant head with the help of overflow arrangement
2. Allow the colored water ray in the glass tube.
3. Note down the time (T) for R cm rise in the collecting tank.
4. Repeat the experiment for different discharges by varying gate valve.

Observations:-

Size of collecting tank =

Diameter of glass tube =

The discharge passing through the pipe

$$Q = VA$$

Where

Q = Discharge in m^3/s

V = Velocity of water in the in m/s

A = Area of the pipe in m2

Reynolds Number

$$Re = VD/\upsilon$$

Where,

V = Velocity in m/s

D = Diameter of the tube in meters

υ = Kinematic viscosity of water = 1×10^{-6} m^2/s at 20^0 C temp.

For :

Re > 4000 flow is turbulent

2000<Re < 4000 flow is transition

Re < 2000 flow is laminar

Observation Table

Sr.No.	Time taken for R cm rise T sec.	Discharge Q = AR/t m^3/s	Velocity (V) in glass tube (m/s)	Reynolds's number Re = VD/υ	Type of flow

Specimen Calculations:-

1. Q act = AR/t

   Where A = Cross-sectional area of the collecting tank = $l_c \times b_c$ = R = Rise of water level in the collecting tank =

   t = Time taken for 'R' units of rise in water level

   Therefore Q act =

2. Reynolds Number R_e = VD/υ

   Where V = Velocity in m/s

   D = Diameter of the tube in meters

   υ = Kinematic viscosity of water = 1×10^{-6} m^2/s at 20^oC temp.

   Therefore Re =

3. Type of flow:

Results:-

Reynolds Number = …………..m.

Type of flow = --------------

Conclusion:-

Type of flow____.

Questions:-

- How do you distinguish physically a laminar flow and turbulent flow?
- What is Reynolds number?
- How does Reynolds number helps in distinguish the nature of flow?
- What is critical Reynolds number for a pipe flow
- Under what circumstances the flow is expected to be laminar

Lab work:-

- What is effect of Reynolds number on friction factor?
- What are basic equations required in the derivation of Darcy whish back equation?

What do you mean by fully developed flow?

Prepared by: Mr. D. A. More	**Approved by: Head, Dept. of Mechanical Engineering.**

Lab:- FM

Experiment No. : 09

Major losses in pipes

Aim:-
1. To determine coefficient of friction for pipes.
2. To determine head lost in pipe friction.

THEORY:

A pipe is a closed conduit, generally of circular cross - section, used to carry water or any other fluid. When the pipe is running full, the flow is under pressure. But if the pipe is not running full, the flow is not under pressure. In such a case the atmospheric pressure exits inside the pipe.

While designing any pipe line system (It may be a water supply scheme or pipes in hydraulic circuits) the designer has to take into account the losses in the pipe & fitting. This is necessary to estimate total loss of head which will occur when the liquid will reach to the desired destination.

LOSS OF HEAD IN PIPES:

When the water is flowing in a pipe it experience some resistance to it s motion, whose effect is to reduce the velocity & ultimately the head of water available. Though there are many types of losses, yet the major loss is due to frictional resistance of the pipe only. The frictional resistance of the pipe depends upon the roughness of the inside pipe. It has been experimentally found that more the roughness of the inside surface of the pipe, greater will be the resistance. This is friction is known as fluid friction & the resistance is known as frictional resistance.

The losses are primarily of two types -

A)Major losses:-

These losses are due to friction. In the case of pipes longer than 1000 times the diameter.

B) Minor losses:-

1. Loss due to entry
2. Loss due to changes in cross - section of the pipe such as –
   a. **Sudden contraction.**
   b. **Sudden expansion.**
3. Loss due to change of direction. (Elbows, Bends)
4. Loss due to obstruction. (Valve, Diaphragm)
5. Loss due to exit.

In a long pipe the major loss of head is due to friction in the pipe only. The minor losses are so small, as compared to friction loss, that they may be neglected. But in the case of a short pipe, the minor losses, as compared to the friction loss, are of appreciable amount & thus cannot be neglected.

NOTE: In actual practice, the minor losses are neglected, until and unless mentioned in the example.

It is found that the total friction resistance to fluid flow depends on the following:

1. The area of the wetted surface
2. The density of the fluid
3. The surface roughness
4. It is independent of the fluid pressure
5. It increase with the square of the velocity

The loss of head in pipe due to friction is calculated from Darcy- Weisbach equation which has been given by:

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

h_f= Loss of head due to friction
f = Coefficient of friction
L = Distance between pressure point
v= Mean velocity of fluid
d = Diameter of pipe
g = Acceleration due to gravity

DESCRIPTION:

The apparatus consist of sump tank with centrifugal pump. Two pipes of different diameter for which common inlet connection is provided with control valve to regulate the flow, near the downstream end of the pipe. Pressure tapings are taken at suitable distance apart between which a manometer is provided to study the pressure loss due to the friction. Discharge is measured with the help of measuring tank and stopwatch.

UTILITIES REQUIRED:

1. Electricity Supply: single Phase , 220 VAC, 50Hz, 5-15 amp socket with earth connection.
2. Water Supply (Initial fill)
3. Floor Drain required
4. Floor Area Required: 1.5 m x 0.75 m.
5. Mercury (Hg) for manometer (250gm).

EXPERIMENTAL PROCEDURE:

Starting Procedure:

1. Close all the valves provided.
2. Fill Sump tank ¾ with clean water and ensure that no foreign particles are there.

3. Open by-pass valve.
4. Close all pressure taps of manometer connected to pipes.
5. Ensure that ON/OFF switch given on the panel is at OFF position.
6. Switch ON the main power supply.
7. Switch ON the Pump.
8. Operate the Flow Control Valve and by pass valve to regulate the flow of water in the desired Test Section.
9. Open the pressure taps of manometer of related test section, very slowly to avoid the blow of water on manometer fluid.
10. Now open the air release valve provided on the Manometer, slowly to release the air in manometer.
11. When there is no air in the manometer, close the air release valves.
12. Adjust water flow rate in desired section with the help of control valve.
13. Record the manometer reading.
14. Measure the flow of water, discharged through desired test section, using stop watch and measuring tank.
15. Repeat same procedure for different flow rates of water, operating control valve and by-pass valve.
16. When experiment is over for one desired test section, open the by-pass valve fully. Then close the flow control valve of running test section and open the control valve of secondly desired test section.
17. Repeat the same procedure for other test section.

Closing Procedure:

1. When experiment is over, close all manometers pressure taps first.
2. Switch OFF pump.
3. Switch OFF power supply to panel
4. Drain the tanks with the help of given drain valves.

OBSERVATION :

Area of measuring tank, A = $0.1\ m^2$

Specific gravity of Hg, = 13.6

Acceleration due to gravity g = $9.8\ m/s^2$

Inside diameter of pipe, d

For G I pipe (¾") = 0.022 m.

For G I pipe (½") = 0.016 m.

Cross section area of pipe,A

For G I pipe (¾") = $3.800 \times 10^{-4}\ m^2$

For G I pipe (½") = $2.0106 \times 10^{-4}\ m^2$

Distance between pressure points, L

For G I pipe (¾") = 1.4 m.

For G I pipe (½") = 0.9 m.

OBSERVATION TABLE :

Test pipe = (3/4")

Sr. No.	Pressure difference in h (cm)			Rise of water level in tank (cm)	Time taken for rise (sec)
	h_1	h_2	$(h_1 - h_2)$		
01					
02					
03					
04					

Test pipe = (1/2")

Sr. No.	Pressure difference in h (cm)			Rise of water level in tank (cm)	Time taken for rise (sec)
	h_1	h_2	$(h_1 - h_2)$		
01					
02					
03					
04					

CALCULATIONS :

Formulae:

1. Loss of head due to friction $h_f = \dfrac{4fLv^2}{2gd}$ also $h_f = \dfrac{h_1 - h_2}{100}$ m
2. Coefficient of friction: $f = \dfrac{h_f 2gd}{4Lv^2}$
3. Discharge (Q) : $Q = \dfrac{AxR}{t}$
4. Velocity of fluid: $v = \dfrac{Q}{A}$ m/s.

NOMENCLATURE:

A = Area of measuring tank, m^2

a = Cross-section area of pipe. m^2

d = Inside Diameter of pipe, m

f = Friction factor

g = Acceleration due to gravity , m/sec^2

h = Manometer difference, m

h_1, h_2 = Manometric reading at both points, cm

h_f = head losses, m of water .

L = Distance between pressure tapings, m

Q = Discharge, m^3/sec

R = Rise of water level in measuring tank, m

R_1 = Final level of water in measuring tank, cm

R_2 = Initial level of water in measuring tank, cm

T = Time taken for R, sec

V = velocity of fluid, m/sec

ρ_m = Density of manometer fluid (Hg), kg/m^3

ρ_w = Density of water, kg/m^3

RESULT TABLE

1. **Test pipe = (3/4")**

Sr. No.	h_f(m)	Discharge (Q) m^3/sec.	Velocity of fluid v (m/sec)	Friction factor $f_f = \frac{h_f 2gd}{4v^2 L}$
01				
02				
03				
04				

2. **Test pipe = (1/2")**

Sr. No.	h_f(m)	Discharge (Q) m^3/sec.	Velocity of fluid v (m/sec)	Friction factor $f_f = \frac{h_f 2gd}{4v^2 L}$
01				
02				
03				
04				

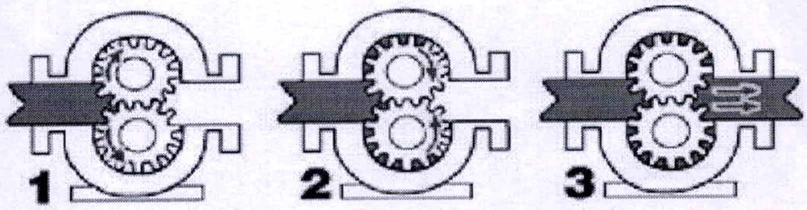
Prepared by: Mr. D. A. More	**Approved by: Head, Dept. of Mechanical Engineering.**

CHHATRAPATI SHAHU MAHARAJ SHIKSHAN SANSTHA's
CHH. SHAHU COLLEGE OF ENGINEERING
Kanchanwadi, Aurangabad
Department of Mechanical Engineering
Practical Experiment Instruction Sheet

Class: SE (MECH)	**Experiment No.: 09**
Semester: III	Study and performance of Gear Pump Test Rig.

Aim: To determine the best driving conditions of the gear oil pump at constant speed and to draw the characteristic curves.

Apparatus: - A rotary gear pump consists essentially of two intermeshing spur gears which are identical and which are surrounded by a closely fitting casing. One of the pinions is driven directly by the prime mover while the other is allowed to rotate freely. The fluid enters the spaces between the teeth and the casing and moves with the teeth along the outer periphery until it reaches the outlet where it is expelled from the pump. Each tooth of the gear acts like a piston or plunger of on reciprocating pump and hence the pump can be termed a positive displacement pump. Gear pump is widely used for cooling water and pressure oil to be supplied for lubrication to motors, turbine, machine tools etc.



Formulae

% Efficiency of the pump $= \frac{P0}{Pi} x100$

Output power from the pump $Po = \omega Q_a H_p$ Watts

Where ω - Specific weight of oil (0.8 x 9810 N/m3)

Q_a - Actual discharge from the pump (m3/s)

H_p - Total head in metres of oil

Actual discharge $Qa = \frac{A}{t}$

A - Area of the collecting tank in plan (Inner width x inner length) (m2) H - Rise of the liquid in collecting tank (m)

t - Time taken for 5 cm rise of liquid in the collecting tank (s)

Total head $Hp = Hs + Hd + x$

H_d = Delivery head in metres of oil
x = Difference in level between the centers of suction and pressure gauges.

Procedure

The pump is switched on. By adjusting the delivery valve, the pressure gauge is set. For this particular pressure gauge reading the time taken T for N_r revolution in the energy meter, time taken t for a particular volume in the collecting tank and the vacuum gauge reading are recorded. The experiment is repeated for different delivery pressures and the observations are tabulated. The internal plan dimension of collecting tank and energy meter constant are noted.

Observation

Speed of the pump = rpm

Energy meter constant= rev./ kwhr

Internal plan dimensions of the collecting tank Length l =

Breadth b= m

Difference in level between the centers of vacuum and pressure gauge x in m

Sl No.	Head (H_s) m of oil	Pressure (H_d) kg / m2	revolution of energy meter disc s	rise of liquid in the collecting tank s

Calculation Table

Sl. No	Total Head H_p	Actual Discharge	Input Power	Output Power	Efficiency

Result

The pump performance curves are drawn. The best driving condition is obtained corresponding to the maximum efficiency.

CONCLUSION:

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