EXPERIMENT No.1

FLOW MEASUREMENT BY VENTURIMETER

1.1 AIM: To determine the co-efficient of discharge of the Venturimeter.

1.2 EQUIPMENTS REQUIRED: Venturimeter test rig and Stopwatch.

1.3 INTRODUCTION

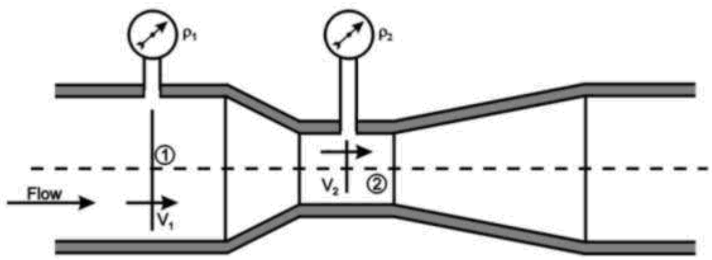


Fig.1. Venturimeter

In a Venturimeter there is first a converging section in which the cross sectional area for flow is reduced. Then there is a short section at the reduced diameter, known as the throat of the meter. Then there is a diverging section in which the cross sectional area for flow is gradually increased to the original diameter. The velocity entering the converging section is where the pressure is P1. In the converging section the velocity increases and the pressure decreases. The maximum velocity is at the throat of the meter where the minimum pressure P2 is reached. The velocity decreases and the pressure increases in the diverging section. There is a considerable recovery of pressure in the diverging section. However, because of frictional effects in the fluid, the pressure leaving the diverging section is always less than P1, the pressure entering the meter.

1.3.1 PRE-LAB QUESTIONS

1.3.1.1 Differentiate mass and volume flow rate?

1.3.1.2 Which property is remains same in the incompressible flow?

1.3.1.3 What is meant by discharge?

1.3.1.4 What is the use of Venturimeter?

1.4 PROCEDURE:

1.4.1. Switch on the power supply to the pump

1.4.2. Adjust the delivery flow control valve and note down manometer heads (h1, h2) and time taken for collecting 10 cm rise of water in collecting tank (t). (i.e. Initially the delivery side flow control valve to be kept fully open and then gradually closing.)

1.4.3. Repeat it for different flow rates.

1.4.4. Switch off the pump after completely opening the delivery valve.

1.5 FORMULA TO BE USED:

1.5.1 **The actual rate of flow**, $Q_a = A \times h / t$ (m^3/sec)

Where A = Area of the collecting tank = length x breadth (m^2)

h = Height of water (10 cm) in collecting tank (m),

t = Time taken for 10 cm rise of water (sec)

1.5.2 **The Theoretical discharge through Venturimeter,**

$\mathbf{Q_t} = (a_1 a_2 \sqrt{2gH}) / \sqrt{(a_1^2 - a_2^2)}$ m^3/sec

Where, H = Differential head of manometer in m of water

$= 12.6 \times h_m \times 10^{-2}$ (m)

g = Acceleration due to gravity (9.81m/sec^2)

Inlet Area of Venturimeter in m^2, $a_1 = \pi d_1^2 / 4$,

Area of the throat in m^2, $a_2 = \pi d_2^2 / 4$

1.5.3 **The co-efficient of discharge,**

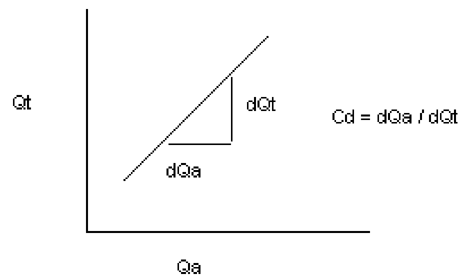
$\mathbf{C_d}$ = Actual discharge / Theoretical discharge = Q_a / Q_t

1.6 TABULATION:

Inlet Diameter of Venturimeter (or) Diameter of Pipe	d_1	= 20 or 25 mm
Throat diameter of Venturimeter	d_2	= 11.83 or 14.79 mm
Area of collecting tank, A = Length x Breadth		= 0.5 x 0.3 m^2

Sl. No.	Manometer Reading (cm)			Mano-meter Head H	Time for 10 cm rise T	Actual Discharge Q_a	Theoretical Discharge Q_t	Co-efficient of discharge C_d
	h_1	h_2	$h_m = h_1 \sim h_2$	m	sec	m^3/sec	m^3/sec	
1.								
2.								
3.								
4.								
5.								
							Average $\mathbf{C_d}$ value	

1.6.1 GRAPH:



Draw Q_a Vs Q_t.

Find C_d value from the graph and compare it with calculated C_d value from table.

1.7 POST-LAB QUESTIONS

1.7.1 How do you find actual and theoretical discharge?

1.7.2 What do you meant by throat of the Venturimeter?

1.7.3 List out the practical applications of Bernoulli's equation?

1.7.4 What is the use of U-tube manometer?

1.8 INFERENCES

1.9 RESULT

The co-efficient of discharge of Venturimeter = ……………. From Calculation

The co-efficient of discharge of Venturimeter = ……………. From Graph

EXPERIMENT No.2

FLOW MEASUREMENT BY ORIFICEMETER

2.1 AIM: To determine the co-efficient of discharge of the orifice meter.

2.2 EQUIPMENTS REQUIRED: Orifice meter test rig and Stopwatch.

2.3 INTRODUCTION

An orifice plate is a device used for measuring the volumetric flow rate. It uses the same principle as a Venturi nozzle, namely Bernoulli's principle which states that there is a relationship between the pressure of the fluid and the velocity of the fluid. When the velocity increases, the pressure decreases and vice versa. An orifice plate is a thin plate with a hole in the middle. It is usually placed in a pipe in which fluid flows. When the fluid reaches the orifice plate, with the hole in the middle, the fluid is forced to converge to go through the small hole; the point of maximum convergence actually occurs shortly downstream of the physical orifice, at the so-called *vena contracta* point. As it does so, the velocity and the pressure changes. Beyond the *vena contracta*, the fluid expands and the velocity and pressure change once again. By measuring the difference in fluid pressure between the normal pipe section and at the *vena contracta*, the volumetric and mass flow rates can be obtained from Bernoulli's equation. Orifice plates are most commonly used for continuous measurement of fluid flow in pipes. This experiment is process of calibration of the given orifice meter.

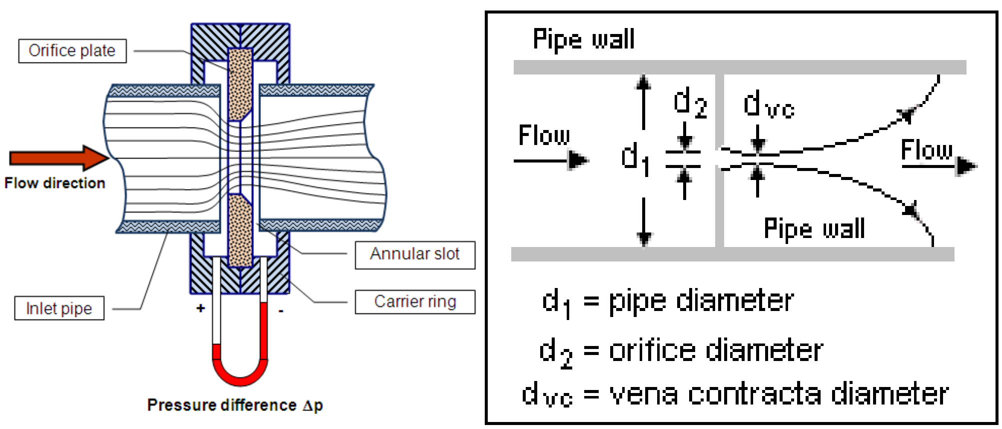


Fig.2. Orifice Plate

2.3.1 PRE-LAB QUESTIONS

2.3.1.1 Write continuity equation for incompressible flow?

2.3.1.2 What is meant by flow rate?

2.3.1.3 What is the use of orifice meter?

2.3.1.4 What is the energy equation used in orifice meter?

2.3.1.5 List out the various energy involved in pipe flow.

2.4 PROCEDURE

2.4.1 Switch on the power supply to the pump

2.4.2 Adjust the delivery flow control valve and note down manometer heads (h1, h2) and time taken for collecting 10 cm rise of water in collecting tank (t). (i.e. Initially the delivery side flow control valve to be kept fully open and then gradually closing.)

2.4.3 Repeat it for different flow rates.

2.4.4. Switch off the pump after completely opening the delivery valve.

2.5 FORMULA TO BE USED:

2.5.1 **The actual rate of flow**, $Q_a = A \times h / t$ (m^3/sec)

Where A = Area of the collecting tank = length x breadth (m^2)

h = Height of water (10 cm) in collecting tank (m),

t = Time taken for 10 cm rise of water (sec)

2.5.2 **The Theoretical discharge through orifice meter,**

$\mathbf{Q_t} = (a_1 a_2 \sqrt{2gH}\,) / \sqrt{(a_1^2 - a_2^2)}$ m^3/sec

Where, H = Differential head of manometer in m of water

$= 12.6 \times h_m \times 10^{-2}$ (m)

g = Acceleration due to gravity (9.81m/sec^2)

Inlet Area of orifice meter in m^2, $a_1 = \pi d_1^2 / 4$,

Area of the throat or orifice in m^2, $a_2 = \pi d_2^2 / 4$

2.5.3 **The co-efficient of discharge,**

$\mathbf{C_d}$ = Actual discharge / Theoretical discharge = Q_a/Q_t

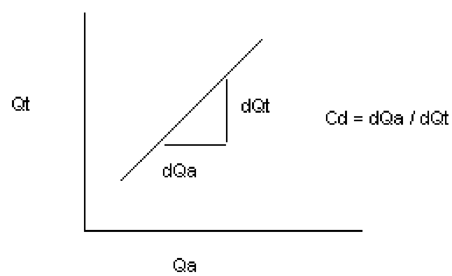
2.6 TABULATION

Size of Orifice meter:

Inlet Diameter d_1 = 20 or 25 mm,
Orifice Diameter d_2 = 13.41 or 16.77 mm,
Measuring area in collecting tank A = 0.5 x 0.3 m^2

Sl. No.	**Manometer Reading (cm)**			**Manometer Head H**	**Time for 10 cm rise T**	**Actual Discharge Q_a**	**Theoretical Discharge Q_t**	**Co-efficient of discharge C_d**
	h_1	h_2	$h_m = h_1 \sim h_2$	m	sec	m^3/sec	m^3/sec	
1.								
2.								
3.								
4.								
5.								
Average **C_d** value								

2.6.1 GRAPH:



Draw Q_a Vs Q_t.
Find C_d value from the graph and compare it with calculated C_d value from table.

2.7.1 POST-LAB QUESTIONS

2.7.2 How do you find actual discharge?

2.7.3 How do you find theoretical discharge?

2.7.4 What do you meant by co-efficient of discharge?

2.7.5 Define vena-contracta?

2.7.6 List out the Bernoulli's applications.

2.8 INFERENCES

2.9 RESULT

The co-efficient of discharge of orifice meter = ……………. From Calculation
The co-efficient of discharge of orifice meter = ……………. From Graph

EXPERIMENT No.3

VERIFICATION OF BERNOULLIS THEOREM

3.1 AIM: To verify the Bernoulli's theorem.

3.2 EQUIPMENTS REQUIRED: Bernoulli's Theorem test set-up and Stopwatch.

3.3 INTRODUCTION

Bernoulli's Theorem

According to Bernoulli's Theorem, in a continuous fluid flow, the total head at any point along the flow is the same. $Z_1 + P_1/\rho g + V_1^2/2g = Z_2 + P_2/\rho g + V_2^2/2g$, Since $Z1 - Z2 = 0$ for Horizontal flow, $h_1 + V_1^2/2g = h_2 + V_2^2/2g$ (Pressure head, $h = P_1/\rho g$). Z is ignored for adding in both sides of the equations due to same datum for all the positions.

3.3.1 PRE-LAB QUESTIONS

3.3.1.1 State Bernoulli's theorem?

3.3.1.2 What is continuity equation?

3.3.1.3 What do you meant by potential head?

3.3.1.4 What do you meant by pressure head?

3.3.1.5 What do you meant by kinetic head?

3.4 PROCEDURE

3.4.1 Switch on the pump power supply.

3.4.2 Fix a steady flow rate by operating the appropriate delivery valve and drain valve

3.4.3. Note down the pressure heads ($h_1 - h_7$) in meters

3.4.4. Note down the time taken for 10 cm rise of water in measuring (collecting) tank.

3.4.5. Switch off the power supply.

3.5 FORMULA TO BE USED:

3.5.1 Rate of flow $Q = Ah/t$

Where A: Area of measuring tank = Length x Breadth (m^2)

h: Rise of water in collecting tank (m) (i.e. h = 10 cm)

t: Time taken for 10 cm rise of water in collecting tank (sec)

3.5.2 Velocity of flow, $V = Q/a$,

Where a – Cross section area of the duct at respective piezometer positions ($a_1 - a_7$)

3.5.3 Hydraulic Gradient Line (HGL): It is the sum of datum and pressure at any point

HGL = Z + h

3.5.4 Total Energy Line (TEL): It is the sum of Pressure head and velocity head

$TEL = Z + h + V^2/2g$

3.6 TABULATIONS

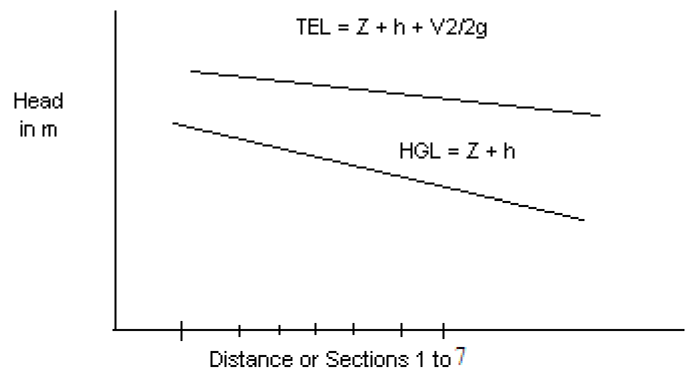
Area of measuring tank = 0.3×0.3 m^2

Assume Datum head Z = 0

Dimension at the section of the channel		**Cross - sectional Area a = h x b**	**Time for 10 cm rise t**	**Discharge Q=Ah/t**	**Velocity V=Q/a**	**Velocity Head $V^2/2g$**	**Piezometer Reading i.e. Pr. Head ($H=P/\rho g$)**	**Total Head $Z+H+V^2/2g$**
(h) $\times 10^{-3}$ m	(b) $\times 10^{-3}$ m	$\times 10^{-6}$ m^2	sec	m^3/sec	m/sec	M	$\times 10^{-2}$m	M
35	20							
32.5	20							
30	20							
25	20							
22.5	20							
18.5	20							
14	20							

3.6.1 GRAPH

Draw the graph: Distance of channel (Locations 1-7) Vs HGL, TEL



3.7 POST-LAB QUESTIONS

3.7.1 What do you meant by velocity head?

3.7.2 What do you meant by HGL?

3.7.3 What do you meant by datum head?

3.7.4 What is the use of piezometer?

3.7.5 Define TEL?

3.7.6 What is the reason for the slight decrease in the total energy head between the successive locations in the duct?

3.8 INFERENCES

3.9 RESULT

The Bernoulli's theorem is verified.

EXPERIMENT No.4

DETERMINATION OF PIPE FRICTION FACTOR

4.1 AIM: To determine the friction factor for the given pipe.

4.2 EQUIPMENTS REQUIRED: Pipe friction equipment and Stop watch.

4.3 INTRODUCTION

The major loss in the pipe is due to the inner surface roughness of the pipe. There are three pipes (diameter 25 mm, 20 mm and 15 mm) available in the experimental set up. The loss of pressure head is calculated by using the manometer. The apparatus is primarily designed for conducting experiments on the frictional losses in pipes of different sizes. Three different sizes of pipes are provided for a wide range of experiments.

4.3.1 PRE-LAB QUESTIONS

4.3.1.1. What do you meant by friction and list out its effects?

4.3.1.2. What do you meant by major loss in pipe?

4.3.1.3. Write down the Darcy-Weisbach equation?

4.3.1.4. What are the types of losses in pipe flow?

4.4 PROCEDURE

4.4.1. Switch on the pump and choose any one of the pipe and open its corresponding inlet and exit valves to the manometer.

4.4.2. Adjust the delivery control valve to a desired flow rate. (i.e. fully opened delivery valve position initially)

4.4.3 Take manometer readings and time taken for 10 cm rise of water in the collecting tank

4.4.4 Repeat the readings for various flow rates by adjusting the delivery valve. (i.e. Gradually closing the delivery valve from complete opening)

4.4.5 Switch of the power supply after opening the valve completely at the end.

4.5 FORMULA TO BE USED:

4.5.1 The actual rate of flow $Q = A \times h / t$ (m^3/sec)

Where A = Area of the collecting tank = length x breadth (m^2)

h = Height of water (10 cm) in collecting tank (m),
t = Time taken for 10 cm rise of water (sec)

4.5.2 Head loss due to friction, $h_f = h_m (S_m – S_f) / (S_f \times 100)$ in m

$$h_f = h_m \ (13.6 – 1) \times 10^{-2} \ (m)$$

Where S_m = Sp. Gr. of manometric liquid, Hg =13.6,
S_f = Sp. Gr. of flowing liquid, H_2O = 1
h_m = Difference in manometric reading = $(h_1 \sim h_2)$ in cm

4.5.3 The frictional loss of head in pipes (Darcy-Weisbach formula)

$$h_f = \frac{4f\,L\,V^2}{2\,g\,d}$$

Where f = Co-efficient of friction or friction factor for the pipe (to be found)
L = Distance between two sections for which loss of head is measured = 2 m
V = Average Velocity of flow = Q/a (m/s),
Area of pipe $a = \pi d^2 / 4 \ (m^2)$,
d = Pipe diameter = 0.020m or 0.025m
g = Acceleration due to gravity = 9.81 m/sec^2

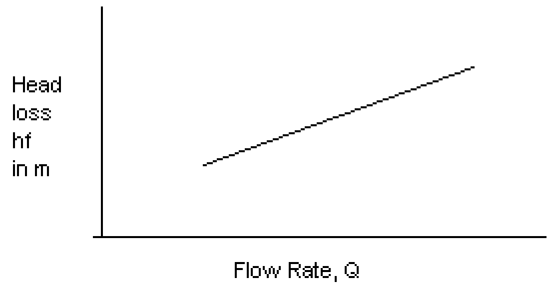
4.6 TABULATION

Length between Pressure tapping, L = 2 m
Pipe Diameter, d = 0.020 or 0.025 m,
Measuring tank area, A= 0.5 x 0.3 m^{2},

Sl.No.	**Pipe Dia**	**Manometer Reading**			**Head Loss**	**Time for 10 cm rise**	**Discharge**	**Velocity**	**Frictional factor**
	d	h_1	h_2	$h_m = (h_1 \sim h_2)$	h_f	T	Q	V=Q/a	f
	m	cm			M	sec	m^3/s	m/s	
1									
2									
3									
4									
5									
Average friction factor, f									

4.6.1 GRAPH

Draw the graph: **Q Vs h_f**



4.7 POST-LAB QUESTIONS

4.7.1 What is the relationship between friction head loss and pipe diameter?

4.7.2 What is the relationship between friction head loss and flow velocity?

4.7.3 What is the relationship between friction head loss and pipe length?

4.7.4 How is the flow rate and head loss related?

4.7.5 If flow velocity doubles, what happen to the frictional head loss?

4.8 INFERENCES

4.9 RESULT

The friction factor for the given pipe diameter of ……… m is = __________

EXPERIMENT No.5

DETERMINATION OF MINOR LOSSES DUE TO PIPE FITTINGS

5.1 AIM: To study the various losses due to the pipe fittings.

5.2 EQUIPMENTS REQUIRED: Minor losses test rig and Stopwatch.

5.3 INTRODUCTION

The various pipe fittings used in the piping applications are joints, bends, elbows, entry, exit and sudden flow area changes (enlargement and contraction) etc. The energy losses associated with these types of pipe fittings are termed as the minor losses due its lesser values compared to the major loss (pipe friction) in the pipe. The loss of head is indicated by the manometer connected across the respective pipe fitting.

5.3.1 PRE-LAB QUESTIONS

5.3.1.1 List out the various types of pipe fittings?

5.3.1.2 What do you meant by minor losses?

5.3.1.3 What are the types of losses in pipe flow?

5.3.1.4 What do you meant by entry loss?

5.3.1.5 What do you meant by exit loss?

5.4 PROCEDURE

5.4.1 Switch on the pump. Adjust the delivery valve to a desired steady flow rate.

5.4.2 Note down the time taken for 10 cm rise of water level in the collecting tank.

5.4.3 Choose any one of the pipe fittings (Elbow, bends, enlargement and contraction). e.g. Elbow

5.4.4 Open the levers (cocks) of respective pipe fitting to the manometer. Ensure other fitting levers should be closed. e.g. Open the entry and exit levers of Elbow (left & right side cocks at the top of the panel)

5.4.5 Note down the manometer head levels (e.g. h_1 & h2 for bend)

5.4.6 Now open the other two entry and exit levers of next pipe fitting. Then close the levers of first chosen pipe fitting. (e.g. Open the 2^{nd} left & right levers for Bend-2 and close the top levers of Bend-1)

5.4.7 Note down the manometer for the second pipe fitting. (e.g. h_1 & h2 for bend-2)

5.4.8 Repeat this procedure by opening the respective levers of sudden enlargement fitting after closing other levers (i.e. for sudden enlargement by opening the next down left & right cocks of sudden enlargement and then close the previous left & right cocks of Bend).

5.4.9 Repeat this procedure by opening the respective levers of sudden contraction fitting after closing other levers (i.e. for sudden contraction by opening the next down left & right cocks of sudden contraction and then close the previous left & right cocks of Sudden enlargement).

5.4.10 Ensure the readings taken for all pipe fittings and then switch off the pump.

5.5 FORMULA TO BE USED:

5.5.1. Discharge, Q = (A x h) / t ….. (m^3/s)

A = Area of tank in m^2 ,

h = 0.10 m / Rise water level in collecting tank (m),

t = Time taken for the 10 cm rise of water in collecting tank (sec)

5.5.2. Velocity, V = Discharge / Area of pipe = (Q/A) (m/s)

Where $A = \pi d^2/4$, d – Dia of pipe in m

5.5.3. Actual loss of head, h_f = $h_m \times 12.6 \times 10^{-2}$ (m)

5.5.4. Theoretical Velocity loss heads for pipe fittings

Velocity head loss for bend and elbow $h_v = V^2 / (2g)$

Velocity head loss for sudden enlargement $h_v = (V_1 - V_2)^2 / (2g)$

Velocity head loss for sudden contraction $h_v = 0.5 (V_2)^2 / (2g)$

Where V_2= velocity of smaller pipe

5.5.5. Loss co-efficient K = Theoretical Velocity head /Actual loss of head = h_v / h_f

5.6 TABULATION

Collecting Tank area, A = 0.5 m x 0.3 m, Pipe Diameter, d = 0.020 m or d = 0.025m

Pipe fittings	Manometer Reading (cm)			Time for 10 cm rise (sec)	Discharge (m^3/s)	Velocity (m/s)	Actual Loss of head, (m)	Loss of head (Theoretical) (m)	Loss co-efficient K
	h_1	h_2	$h_m = h_1 \sim h_2$	T	Q	V	h_f	h_v	h_v / h_f
Elbow									
Bend									
Sudden Enlarge (20-32 mm) (or) (25-40 mm)									
Sudden Contraction (32-20 mm) (or) (40-25 mm)									

5.7 POST-LAB QUESTIONS

5.7.1 What is the equation for head loss due to sudden enlargement?

5.7.2 What is the equation for head loss due to sudden contraction?

5.7.3 What is the equation for head loss due to bend?

5.7.4 What is the equation for head loss at entry of pipe?

5.7.5 What is the equation for head loss at exit of pipe?

5.7.6 Which Newton’s law is applicable to impulse turbine?

5.8. INFERENCES

5.9. RESULT

The various minor losses in pipe fittings are determined.

EXPERIMENT No.6
IMPACT OF JET OF WATER ON VANES

6.1 AIM: To determine the coefficient of impact of water jet on different vanes

6.2 EQUIPMENTS REQUIRED: Jet on vane apparatus, Weighing machine, Flat vane, Flat vane with oblique impact, conical vane and stop watch.

6.3 INTRODUCTION

Water turbines are widely used throughout the world to generate power. In the type of water turbine referred to as a Pelton wheel, one or more water jets are directed tangentially on to vanes or buckets that are fastened to the rim of the turbine disc. The impact of the water on the vanes generates a torque on the wheel, causing it to rotate and to develop power. Although the concept is essentially simple, such turbines can generate considerable output at high efficiency. To predict the output of a Pelton wheel, and to determine its optimum rotational speed, we need to understand how the deflection of the jet generates a force on the buckets, and how the force is related to the rate of momentum flow in the jet. In this experiment, we measure the force generated by a jet of water striking a flat plate or a hemispherical cup, and compare the results with the computed momentum flow rate in the jet.

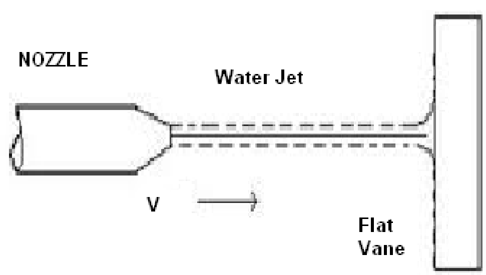


Fig.3. Impact of Water jet on flat vane

6.3.1 PRE-LAB QUESTIONS

6.3.1.1 What is the water jet?

6.3.1.2 What is the effect of water jet on vanes?

6.3.1.3 What do you meant by impact?

6.3.1.4 List out different types of vanes?

6.4 PROCEDURE

6.4.1 Switch on the power supply.

6.4.2 Open the gate valve and note down the reading from the pressure gauge.

6.4.3 Then note the time for 'h' m rise in collecting tank.

6.4.4 Repeat the procedure for different gate valve openings.

6.4.5 Take readings for different vanes and nozzles also.

6.5 FORMULA TO BE USED:

6.5.1 Actual discharge, Q = Volume of collecting tank/ time taken = A h / t

Where, A - Area of collecting tank = length x breadth

h - Water level rise in the collecting tank = 10 cm

t - Time taken for 'h' cm rise of water in the tank in sec

6.5.2 Theoretical force F_t = $[(\rho\ A_N\ V_N{}^2)]$ N

Density of water, ρ = 1000 kg/m^3

Area of nozzle, A_N = $(\pi/4)\ d^2$

Nozzle Diameter = 10 mm

Gravity, g = 9.81 m/s^2

6.5.3 Actual force F_a = $[(W \times L_1 / L_2)\ g]$ N

Fulcrum length L = 45.5 cm, L_1 = 38 cm, L_2 = 7.5 cm

6.5.4 Velocity V_N = $\sqrt{2gH}$

$H = (P/\rho g)$

6.5.5 Co-efficient of Impact, Ci = F_a / F_t

6.6 TABULATION

Measuring area in tank = 0.5 x 0.3 m^2

Diameter of jet = 10 mm

Type of vane = Flat vane / Conical vane

Sl. No.	Weight placed in pan, W $\times 10^{-3}$kg	Pressure gauge reading, P kg/cm^2	Time for 10 cm rise of water (sec)	Actual force, Fa in N	Discharge Q m^3/s	Theoretical Force, Ft in N	Co-efficient of impact, Ci
1	50						
2	100						
3	150						
4	200						
5	250						

6.7 POST-LAB QUESTIONS

6.7.1 How do you compare different vanes?

6.7.2 What do you meant by co-efficient of impact?

6.7.3 How do you measure the force of the jet?

6.7.4 How do you measure actual flow rate?

6.7.5 How do you measure theoretical flow rate?

6.8 INFERENCES

6.9 RESULT

The co-efficient of impact of the given vane = ____________

EXPERIMENT No.7

FLOW VISUALIZATION - REYNOLDS APPARATUS

7.1 AIM: To calibrate and demonstrate the flow visualization – laminar or turbulent flow.

7.2 EQUIPMENTS REQUIRED: Reynolds apparatus experimental set up and Stop watch.

7.3 INTRODUCTION

The flow of real fluids can basically occur under two very different regimes namely laminar and turbulent flow. The laminar flow is characterized by fluid particles moving in the form of lamina sliding over each other, such that at any instant the velocity at all the points in particular lamina is the same. The laminar near the flow boundary move at a slower rate as compared to those near the center of the flow passage. This type of flow occurs in viscous fluids, fluids moving at slow velocity and fluids flowing through narrow passages. The turbulent flow is characterized by constant agitation and intermixing of fluid particles such that their velocity changes from point to point and even at the same point from time to time. This type of flow occurs in low density fluids; flow through wide passage and in high velocity flows.

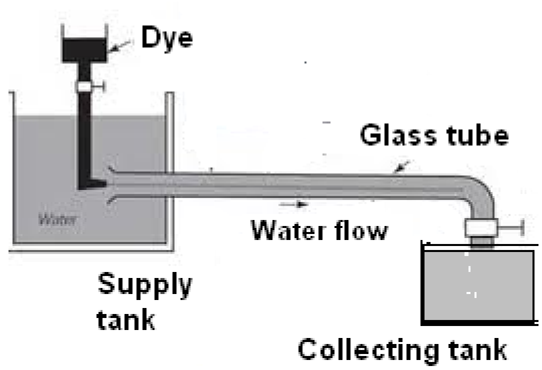


Fig.4. Reynolds apparatus Experimental Set-up

Reynolds conducted an experiment for observation and determination of these regimes of flow. By introducing a fine filament of dye in to the flow of water through the glass tube, at its entrance he studied the different types of flow. At low velocities the dye filament appeared as straight line through the length of the tube and parallel to its axis, characterizing laminar flow. As the velocity is increased the dye filament becomes wavy throughout indicating transition flow. On further increasing the velocity the filament breaks up and diffuses completely in the water in the glass tube indicating the turbulent flow. There are two different types of fluid flows laminar flow and Turbulent flow. The velocity at which the flow changes laminar to Turbulent is called the 'Critical Velocity'.

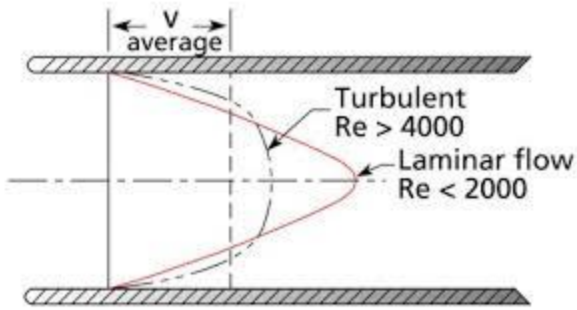


Fig.5. Types of internal (pipe) flow

Reynolds number determines whether any flow is laminar or turbulent. Reynolds number corresponding to transition from laminar to Turbulent flow is about 2000 - 4000.

7.3.2 PRE-LAB QUESTIONS

7.3.2.1 What do you meant by fluid?

7.3.2.2 What are the types of flow?

7.3.2.3 Define Reynolds number?

7.3.2.4 What is laminar flow?

7.3.2.5 What is turbulent flow?

7.4 PROCEDURE

7.4.1 Switch on the power supply. Adjust the water inflow slowly by flow control valve (delivery valve).

7.4.2 Then note the time taken for 1 liter water rise.

7.4.3 Inject a filament of dye into the water stream by opening the value from dye tank.

7.4.4 When the flow is laminar, the colored stream of dye does not mix with the stream of water and is apparent long the whole length of the pipe. Increase the velocity of the stream gradually by opening the flow control valve, to see the turbulent flow. The stream of dye begins to oscillate and then diffused. This velocity of water in the pipe is ‘Critical Velocity’.

7.5 FORMULA TO BE USED:

7.5.1 Discharge, Q = (V/ t (m^3/sec)

Where V- 1 liter
t - Time for 1 liter of water rise (sec)

7.5.2 Reynolds number for pipe flow, Re = (V D)/ υ

Where V= Velocity of the fluid (m/s),

D= diameter of the pipe (m)

υ = Kinematic viscosity of the fluid (m^2/s)

7.6 TABULATION

Volume of collecting tank = 1 liter

Diameter of pipe D = 20 mm, Kinematics viscosity of fluid (water) = 1.01 x 10^{-6} m^2/sec

Sl. No.	Time taken for 1 liter rise t sec	Discharge Q m^3/sec	Velocity V m/s	Reynolds number Re	Remarks (Laminar/ Turbulent flow)
1					
2					
3					
4					

7.7 POST-LAB QUESTIONS

7.7.1 What do you meant by stream and streak lines?

7.7.2 Mention the Reynolds no for laminar and turbulent flow?

7.7.3 What do you meant by steady and unsteady flow?

7.7.4 What do you meant by path line?

7.6.5 What do you meant by uniform and non-uniform flow?

7.8 INFERENCES

7.9 RESULT

The flow calibration and flow visualization test is conducted.

EXPERIMENT No.8

PERFORMANCE TEST ON AIR BLOWER TEST RIG

8.1 AIM: To conduct a performance test on the blower and to plot the following curves for Forward/ Backward/ Radial blades.

Efficiency Vs discharge

Input Vs discharge

8.2 EQUIPMENTS REQUIRED: Centrifugal Air blower test rig and Stop watch.

8.3 INTRODUCTION

The blower is a single stage centrifugal type. The air is sucked from atmosphere from suction side. The slightly compressed air passes through the spiral case, before it comes out through the outlet. Blower is used to discharge higher volumes of air at low pressures. The blowers are used in blast furnaces, cupolas, mines, air conditioning plants, etc.

The blower consists of the impeller fabricated to the shapes required. The vanes of the impeller is pressed out a sheet metal and riveted to the two shrouds thus forming into a unique unit. The other impellers are also fabricated in similar fashion and are easily mountable on the shaft. The casing is made of cast iron. The whole contour is volute in shape. The smooth contour helps in reducing eddy current losses along the path. The casing is designed such that it can be separated to facilitate mounting or interchanging of impellers.

The shaft is coupled to a motor which intern supported in the bearing block. The reaction excreted due to rotation can be measured by the spring balance and hence the input to the blower. The flow at inlet and the exit is measured by the manometer. The whole probe can be actuated by the screw mechanism. This render to draw the profile of the velocity along the diameter of the pipe Pitot tube used to find out the dynamic and static pressure in delivery side orifice, meter used to find out dynamic pressure in suction side and venture used to find out the quantity of flow rate, with mercury manometer.

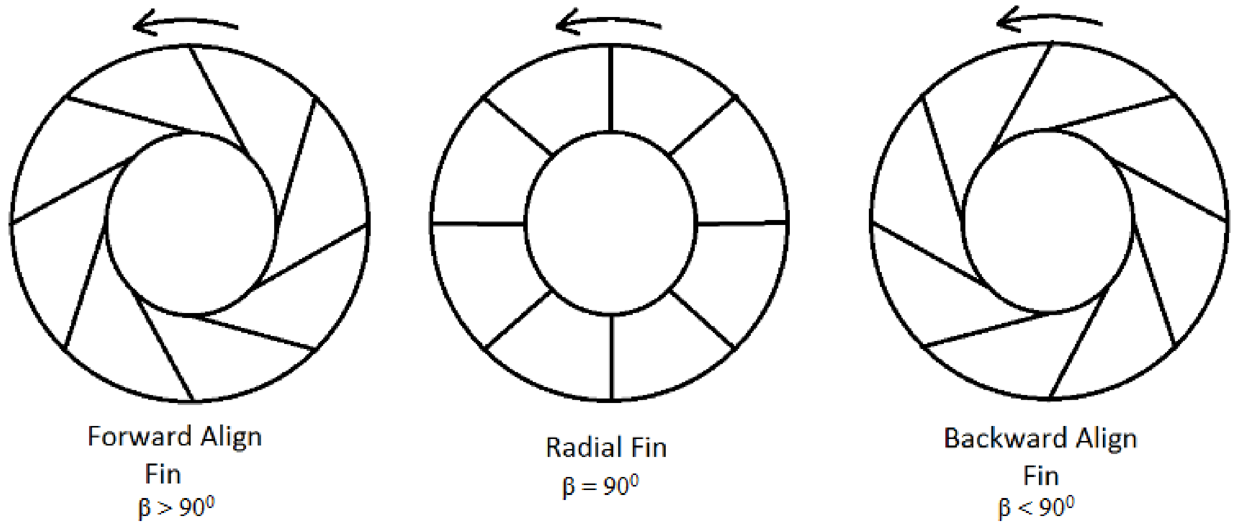


Fig.6. impeller vane angles

8.3.1 PRE-LAB QUESTIONS

8.3.1.1 What is the purpose of blower?

8.3.1.2 What do you meant by centrifugal force?

8.3.1.3 How the suction is created at the eye of rotor?

8.3.1.4 What is the use of casing?

8.3.1.5 What is purpose of orifice meter?

8.4 PROCEDURE

8.4.1 Ensure the complete opened position of delivery valve.

8.4.2 The blower or motor is started with the help of starter.

8.4.3 Vary the flow rate (discharge) by closing the delivery valve.

8.4.4 The levels of the fluids in the manometers are noted.

8.4.5 Measure the power consumed by the motor using energy meter corresponding to the time. Note down time in seconds for 5 pulse of the energy meter reading.

8.4.6 The experiment is repeated for different impellers and different valve position and the above readings are noted down.

8.4.7 Switch off the power supply after opening the delivery valve completely.

8.5 OBSERVATIONS

Diameter of pipe (d1) = 70 mm

Diameter of orifice (d2) = 50.4 mm

Coefficient of discharge (C_d) = 0.62

Water density (ρ_w) = 1000 kg / m^3

Density of air (ρ_a) = 1.225 kg / m^3

Energy meter constant (C) = 1600 lamp/kWhr

8.5.1 FORMULA TO BE USED:

8.5.1.1 Delivery head

$H_d = H_1 [\rho_w / \rho_a - 1]$ m

8.5.1.2 Suction head

$H_s = H_2 [\rho_w / \rho_a - 1]$ m

8.5.1.3 Orifice meter head

$H_o = H_3 [\rho_w / \rho_a - 1]$ m

8.5.1.3 Discharge of air

$Q = C_d (a_1 a_2 \sqrt{2gH_o}) / \sqrt{(a_1^2 - a_2^2)}$ m^3/sec

8.5.1.4 Power input

I/P = $[(5/t) \times (3600/C) \times \eta_m]$ kW

t = time taken for 5 pulse in energy meter in sec

Energy meter constant (C) = 1600 lamp/ kWhr

Motor efficiency (η_m) = 77.5%

8.5.1.5 Power output

O/P = $[\rho_a \, g \, Q \, H_d / 1000]$ kW

8.5.1.6 Efficiency of Blower

η = (Output / Input) x 100 %

8.5.2 TABULATION

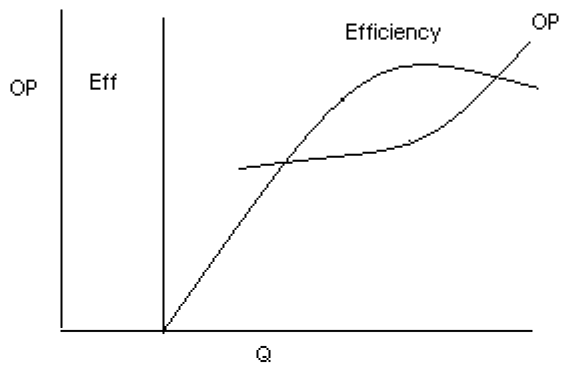
S. No	Impeller Type	Delivery head Manometer Reading (H_d)			Suction head Manometer Reading (H_s)			Orifice meter Manometer Reading (H_o)			Time taken for 5 pulse in Energy meter (sec)
		h_1 (cm)	h_2 (cm)	$H_1 = h_1 \sim h_2$ (cm)	h_1 (cm)	h_2 (cm)	$H_2 = h_1 \sim h_2$ (cm)	h_1 (cm)	h_2 (cm)	$H_3 = h_1 \sim h_2$ (cm)	
1											
2											
3											
4											
5											

Total delivery head (m)	Total orifice meter head (m)	Actual discharge (m^3/s)	Input power (Kw)	Output power (Kw)	Efficiency (%)

8.6 GRAPHS: The following graphs are plotted for the given impellers.

Discharge Q Vs Power Output

Discharge Q Vs Blower Efficiency



8.7 POST-LAB QUESTIONS

8.7.1 How the pressure increased in centrifugal blower?

8.7.2 What is chocking in centrifugal blower?

8.7.3 What do you meant by surging in centrifugal blower?

8.7.4 What do you meant by stalling in centrifugal blower?

8.7.5 List out the various applications of centrifugal blower

8.8 INFERENCES

8.9 RESULT

The performance test on centrifugal blower is completed and the performance characteristics are studied.

EXPERIMENT No.9

DETERMINATION OF VISCOSITY OF OIL USING RED WOOD VISCOMETER

9.1 AIM

To determine the viscosity of oil using red wood viscometer at different temperatures.

9.2 EQUIPMENT REQUIRED: Red wood viscometer, Stop watch, Thermometers, Sample of oil and 50ml measuring flask.

9.3 SPECIFICATIONS

Cylindrical oil cup

Height	= 90 mm
Diameter	= 46.5mm

Orifice

Diameter	=1.62 mm
Internal length	= 10 mm

9.4 INTRODUCTION

Viscosity is a measure of the internal resistance to motion of a fluid and is mainly due to the forces of cohesion between the fluid molecules. Viscosity is one of the most important properties of lubricating oil. The formation of a fluid film of a lubricant between the friction surfaces and the generation of frictional heat under particular conditions of load, bearing speed and lubricant supply mostly depend upon the viscosity of the lubricant and to some extent on its oiliness.

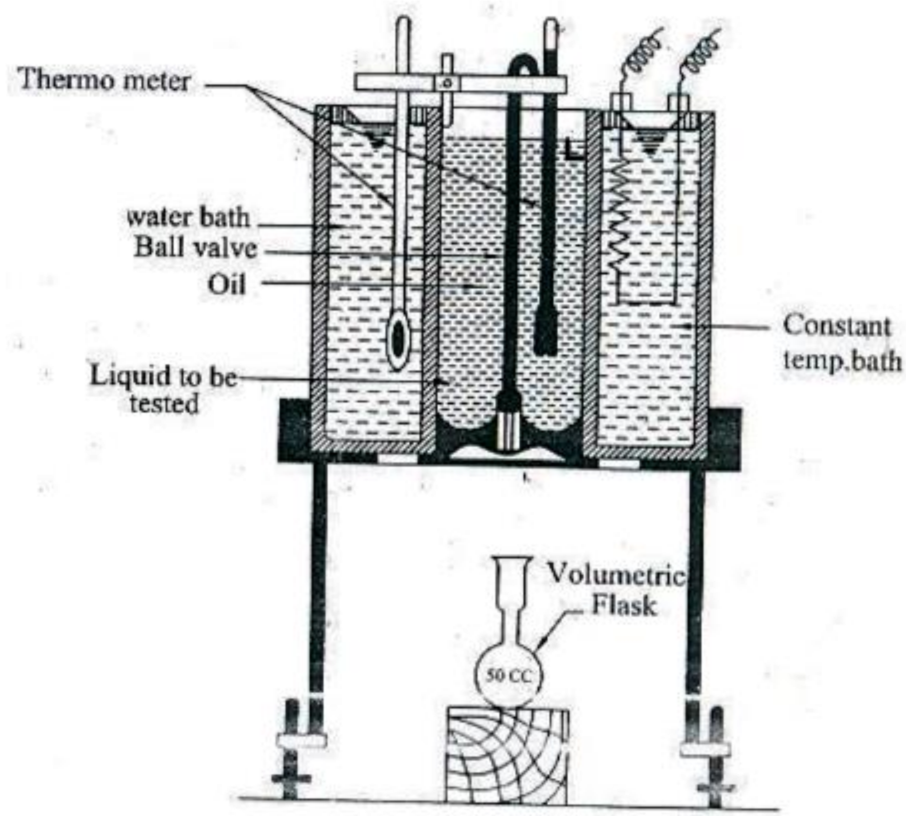
If the viscosity of the oil is too low, the fluid lubricant film cannot be maintained between the moving surfaces as a result of which excessive wear may take place. On the other hand, if the viscosity of lubricating oil is too high, excessive friction due to the shearing of oil itself would result. Hence, it is essential to have knowledge of the viscosity of lubricating oil. The viscosity of an oil decreases with increase of temperature as a result of decrease in intermolecular attraction due to expansion. In case of IC engines, the lubricant used must function both at low starting temperature as well as at very high operating temperatures. It is impossible to select oil having same viscosity over such a wide range of operating temperatures. However one can select oil whose variation in viscosity with temperatures is minimum. This variation can either by indicated by viscosity temperatures current or by means of viscosity index. Viscosity index is the numerical expression of the average slope of the viscosity temperature curve of lubricating oil between 100ºF to 210ºF.

Absolute dynamic viscosity may be defined as the tangential force per unit area required to maintain unit velocity gradient between two parallel planes in the fluid at unit distance apart. The units of absolute viscosity, μ in C.G.S system are poise and centipoises (1/100th of poise).

The ratio of absolute viscosity to density for any fluid is known as its Absolute Kinematics Viscosity. It is denoted by ν and in C.G.S. system its units are stokes and centistokes (1/100th of the stoke).

9.4.1 DESCRIPTION

The redwood viscometer consists of a cylindrical oil cup made up of brass. The cup is open at the upper end. It is fitted with an agate jet in the base contains an orifice. The upper surface of the agate is ground to concave depression into which a small silver plated brass ball attached to a stout wire can be placed in such a way that the channel is totally closed and no leakage of the oil from the cup through the orifice can take place. The cup is provided with a pointer which indicates the level up to which the oil should be filled in the cup. The lid of the cup is provided with an arrangement to fix a thermometer to indicate the oil temperature. The oil cup is surrounded by a cylindrical vessel containing water which serves as a water bath used for maintaining the desired oil temperature with the help of circular electrical immersion heater and stirrer. A thermometer is provided to measure the temperature of water. A stirrer with four blades is provided in the water bath to maintain uniform temperature in the bath and hence enabling uniform heating of the oil. The entire apparatus rests on a sort of tripod stand provided with leveling screw at the bottom of the three legs. The water bath is provided with an outlet for removing water as when needed.



9.5 POST-LAB QUESTIONS

9.5.1 Define kinematic viscosity.

9.5.2 What is the SI unit of kinematic viscosity and dynamic viscosity?

9.5.3 What is the cgs unit of kinematic viscosity and dynamic viscosity?

9.5.4 List the different types of apparatus used for measuring the viscosity of oil?

9.6 PROCEDURE

9.6.1 Level the instrument with the help of the leveling screws on tripod

9.6.2 Clean the cup and make it sure that the jet is free from dirt

9.6.3 Fill the water bath with water to the height corresponding to the tip of the indicator up to which the oil is filled in the cylindrical cup

9.6.4 Keep the brass bath in position so as to seal the orifice

9.6.5 Fill the oil carefully into the oil cup up to the tip of the indicator

9.6.6 Keep the 50ml flask in position below the jet

9.6.7 Switch ON the heating coil

9.6.8 Keep the oil and water well stirred and note their temperatures

9.6.9 When the temperature of the oil reaches 80ºC, switch of the heating coil remove the ball valve and simultaneously start taking time to collect 50 ml of oil in the flask

9.6.10 Replace the ball valve in position to seal the cup to prevent overflow of the oil in the flask

9.6.11 Refill the oil up to the indicator tip of the oil cup

9.6.12 Repeat the experiment at five elevated temperatures say, 70ºC,60ºC,& 50ºC and note their respective times at each temperature.

9.7 OBSERVATION

Room Temperature = …………..ºC

Type of oil used = …………..

Weight of the empty flask = …………..

9.7.1 TABULATION

S. No	Temperature of the oil in ºC	Time for collecting 50 ml of oil in sec (t)	Wt. of the measuring jar (W_1) in Kg	Wt. of the measuring jar + 50 CC of oil (W_2) in Kg	Density of oil (ρ) in Kg/m^3	Kinematic viscosity (ν) in m^2/s	Dynamic viscosity (μ) in Ns/m^2
1							
2							
3							
4							
5							

9.7.2 CALCULATIONS:

9.7.2.1 Density of the given oil (ρ)

$\rho = (W_2 - W_1/50\ ml) \times 10^3\ Kg/m^3$

9.7.2.2 Absolute kinematics viscosity (ν) is given by

$\nu = [C \times t - \beta / t] \times 10^{-6}\ (m^2/s)$

ν = Absolute kinematics viscosity

C = Viscometer constant

t = Redwood seconds

β = Co-efficient of kinetic energy may be determined experimentally or Eliminated by choosing long flow time

For Redwood viscometer the values for the constants are as below

Time of flow ,t	C	B
40 to 85 seconds	0.264	190
85 to 2000 seconds	0.247	65

9.7.2.3 The absolute dynamic viscosity (μ) is given by

$\mu = \nu \times \rho$ Ns/m^2

μ = Absolute dynamic viscosity

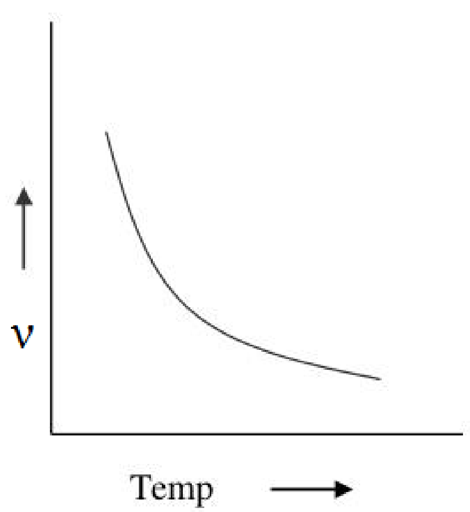
ν = Absolute kinematic viscosity

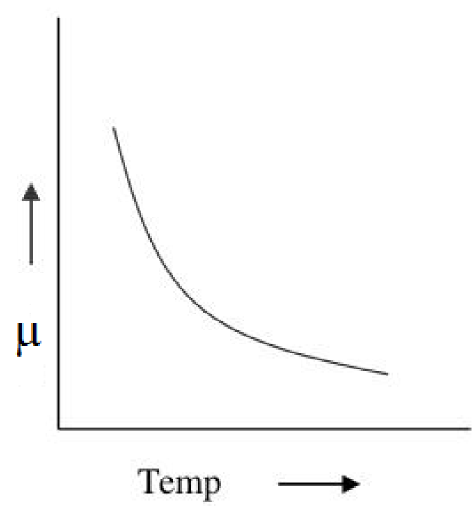
ρ = Density of oil

9.8 GRAPHS

Plot the following graphs

1. Kinematic viscosity Vs temperature
2. Dynamic viscosity Vs temperature





9.9 POST LAB QUESTIONS

9.8.1 Why does the viscosity of gas and liquid behave differently with change in temperature?

9.8.2 What is viscosity index? Where it is used?

9.8.3 What is the Newton's law of viscosity?

9.8.4 What is the significance of finding viscosity at different temperatures?

9.10 INFERENCES

9.11 RESULT

The Absolute kinematics and dynamic viscosity of the given sample oil were determined at different temperatures and the required graphs were drawn.

EXPERIMENT No.10

PERFORMANCE TEST ON TWO STAGE TWIN CYLINDER RECIPROCATING AIR COMPRESSOR

10.1 AIM

To conduct a performance test on the two stage reciprocating air compressor and determine the volumetric efficiency and isothermal efficiency at various delivery pressure. Also plot the following graphs.

Delivery pressure Vs Volumetric efficiency

Delivery pressure Vs Isothermal efficiency

10.2 EQUIPMENT REQUIRED Air compressor test rig and Stop watch.

10.3 SPECIFICATIONS

Orifice Diameter	:	15 mm
Bore diameter for LP cylinder	:	70 mm
Bore diameter for HP cylinder	:	50 mm
Stroke length for LP cylinder	:	85 mm
Stroke length for HP cylinder	:	85 mm
Compressor Speed	:	950 RPM

10.4 DESCRIPTION

An air compressor, as the name indicates, is a machine to compress the air and to raise its pressure. The air compressor sucks air from the atmosphere, compresses it and then delivers the same under a high pressure to a storage vessel. From the storage vessel, it may be conveyed by the pipe line to a place where the supply of compressed air is required. Since the compression of air requires some work to be done on it, therefore a compressor must be driven by some prime mover. The efficiency of any machine is the general term used for the ratio of work done to the energy supplied. The criterion for the thermodynamic efficiency of the reciprocating air compressor is isothermal. The reason is, due to the slow speed of the piston and cooling of the cylinder, the compression of air is approximately isothermal.

This two stage air compressor is a reciprocating V-type, driven by a prime mover through a belt. The test rig consists of a base on which the tank (storage vessel) is mounted. The suction is connected to the air-tank with a calibrated orifice plate through the water manometer. The outlet of the compressor is connected to the storage vessel. The temperature and pressure of the air compressed is indicated by the dial gauges. The input to the motor (prime mover) is recorded by an energy meter. The mechanical and electrical safety valve is also provided for additional safety.

10.5 PRE LAB QUESTIONS

10.5.1 Is reciprocating compressor a positive displacement machine? Justify.

10.5.2 What are important components of a two stage air compressor?

10.5.3 What is the approximate range of pressure in single stage and two stage air compressors?

10.5.4 What is single acting and double acting air compressor?

10.5.5 Compare Compressor, Blower and Fan.

10.6 PROCEDURE:

10.6.1 Close the delivery valve.

10.6.2 Check the manometer connections and fill the manometer with water up to half of the level.

10.6.3 Note down the temperature and pressure of atmospheric air.

10.6.4 Start the motor.

10.6.5 Open the delivery valve in order to maintain the given delivery pressure constantly.

10.6.6 Note down the manometer reading.

10.6.7 Note down the time taken for 5 pulse of energy meter light.

10.6.8 The delivery valve is closed to allow the pressure rise in the tank.

10.6.9 The experiment is repeated for different delivery pressures.

10.7 OBSERVATION

Co efficient of discharge (C_d) = 0.62, Area of orifice (a) = $(\pi /4)\ d^2$, diameter of orifice = 15mm

10.7.1 TABULATION

Sl No	Delivery pressure P_d	Manometer Head (cm)			Head of air H_a	Actual volume of air compressed	Time taken for 5 pulse in Energy meter	Theoretical volume of air compressed	Work input	Isothermal work done	η_{vol}	η_{Iso}
	Kg/cm^2	h_1 cm	h_2 cm	$H = h_1 \sim h_2$ cm	m	$(V_a)_{RT}$ m^3/s	sec	(V_T) m^3/s	kW	kW	%	%
1												
2												
3												
4												
5												

10.7.2 FORMULA TO BE USED:

10.7.2.1 Head of air (H_a)

$$H_a = H [\rho_w / \rho_a - 1] \text{ m}$$

ρ_w	=	Density of water
$(\rho_a)_{RT}$	=	Density of air at Room Temperature (RT)
(H)	=	Difference in manometry fluid height

10.7.2.2 Density of air

$$\rho_{air} = P_a / (R\, T_r) \text{ kg/m3}$$

Gas constant R	= 287 J/kg-k
Atmospheric pressure P_a	= 1.01325×10^5 N/m^2
Room temperature (T_r)	= $t_r + 273$ k

10.7.2.3 Actual volume of air compressed at Room temperature

$$(Va)_{RT} = C_d\, a \sqrt{2gH_a}$$

10.7.2.4 Theoretical volume

$$V_T = \frac{\pi (D_L)^2}{4} \times L \times \frac{N_c}{60} \text{ m}^3 / \text{sec}$$

D_L is the diameter of the LP cylinder = 0.070m

L is Stroke Length = 0.085m

N_c is speed of the compressor = 950 r.p.m

10.7.2.5 Volumetric efficiency

$(\eta_{vol}) = [(V_a)_{RT}/V_T)]\ 100$

10.7.2.6 Work input

$[(5/\ t) \times (3600/C) \times \eta_m \times \eta_t]$ kW

t = time taken for 5 pulse in energy meter in sec
η_m = motor efficiency = 0.88
η_t = belt transmission efficiency = 0.95
Energy meter constant (C) = 1600 lamp/kWhr

10.7.2.7 Isothermal work done

$W_{iso} = (Pa \times Va \ln r)/1000$ kW

Compression ratio $r = (P_d + P_a)/P_a$
P_d = delivery pressure in N/m^2

P_a = atmospheric pressure in N/m^2

10.7.2.8 Isothermal efficiency

$$\eta_{Iso} = \frac{Isothermal\ work}{compressor\ work}$$

10.8 GRAPHS

Draw the following graphs

i) Delivery pressure Vs Volumetric efficiency

ii) Delivery pressure Vs Isothermal efficiency

10.9 POST LAB QUESTIONS

10.9.1 What is volumetric efficiency?

10.9.2 Why the two stage air compressor preferred for higher pressures?

10.9.3 How we can improve the efficiency of air compressor?

10.9.4 What is the use of intercooler?

10.9.5 Discuss the applications of an air compressor

10.10 INFERENCES

10.11 RESULT

The test on 2 stage reciprocating air compressor is conducted for various delivery pressures and the efficiencies are calculated.