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CO1	Explain various fluid properties and behavior of fluid in static and dynamic mode
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Experiment 1

AIM: To verify Bernoulli's equation experimentally.

To plot the graph between total energy vs distance.

INTRODUCTION:

Bernoulli's theorem state that when there is a continuous connection between particles of flowing mass o liquid, the total energy at any section of flow will remain the same provided there is no reduction or addition of energy at any point.

THEORY:

This is the energy equation and is based on the law of conservation of energy. This equation states that at two sections of flow field the total energy remain the same. Provided that only for steady flow. This equation is expressed as:

DESCRIPTION:

A test section made of Perspex, of varying cross section is provided, which is having covering and diverging section. Piezometre tubes are fitted on this test section at specified points. Discharge through test section can be measured with the help of hydraulic bench.

UTILITIES REQUIRED:

- Electricity Supply: Single Phase, 220 V AC, 50Hz, 5-15 Amp combined socket with earth connection
- Water Supply: Initial Fill.
- Floor Drain
- Floor Area 1.50m*1.50m

NOMENCLATURE:

NO.	Column Heading	Units	Type
A	Area of measuring tank	m^2	given
A	Cross sectional area at test point(A1-A7)	m^2	given
D	Diameter of the test point (d1-d7)	mm	given
E	Total Energy at particular point(E1-E7)	m	calculated

G	Acceleration due to gravity	m/sec^2	given
H	Piezometric tube reading at particular point(h1-h7)	m	measured
$\frac{P}{\rho g}$	Pressure energy per unit weight of fluid or pressure head at particular point($\frac{p1}{\rho g}$ to $\frac{p7}{\rho g}$)	m	calculated
Q	Discharge through test section	m^3/sec	calculated
R	Rise in water level in measuring tank	m	calculated
R1	Final level of measuring tank	cm	measured
R2	Initial level of measuring tank	cm	measured
S	Distance from reference point at particular point(S1-S7)	m	given
T	Time taken for R	sec	measured
$\frac{V^2}{2g}$	Kinetic energy per unit weight or kinetic head at particular point($\frac{V1^2}{2g}$-$\frac{V7^2}{2g}$)	m	calculated

EXPERIMENTAL PROCEDURE:

STARTING PROCEDURE:

1. Place the accessory on top tray of the hydraulic bench.
2. Clean the apparatus and make it free from dust.
3. Close the drain valve provided.
4. Fill sump tank of hydraulic bench ¾ with clean water and ensure that no foreign particles are there.
5. Open the bypass valve of hydraulic bench.
6. Connect the flexible pipe to the water inlet of the accessory through the quick release coupling (coupler provided at end of flexible pipe is to be connected to plug provided at the inlet of the accessory).
7. Connect the electric supply to the pump.
8. Set the flow by control valve provided at the end of test section and the bypass valve.
9. Measure the flow of water, using measuring tank &stop watch.
10. Note down the piezometer tube reading at particular discharge.
11. Take the readings at different flow rates.

CLOSING PROCEDURE:

1. When experiment is over switch off the supply to the pump.
2. Wait for one minute so that calculated water from the accessory main drain.
3. Disconnect the coupler from the plug of accessory and hang it at the back side of the top tray with the help of hook provided.
4. Drain the measuring tank and sump tank.

OBSERVATION:

Data			
Acceleration due to gravity g=9.81 m/sec^2			
Sr. no. of test points	Dia. Of test points d (d1-d7) (m)	Cross section area of test points a(a1-a7)(m^2)	Distance of test points from reference point s(s1-s7)(m)
1	28.0	6.16 E-4	0.04
2	23.5	4.34 E-4	0.0785
3	18.5	2.69 E-4	0.092
4	14.0	1.54 E-4	0.1105
5	18.5	2.69 E-4	0.13585
6	23.5	4.34 E-4	0.1562
7	28.0	6.16 E-4	0.19155

Observation Table										
Sr no.	R1 (cm)	R2 (cm)	t (sec)	h1 (cm)	h2 (cm)	h3 (cm)	h4 (cm)	h5 (cm)	h6 (cm)	h7 (cm)
1.										
2.										
3.										
4.										
5.										
6.										
7.										

CALCULATIONS:

R= $\frac{R1-R2}{100}$(m)

V=$\frac{A*R}{t}(m^3/sec)$

V1=$\frac{Q}{a1}$(m/sec)

V2=$\frac{Q}{a2}$(m/sec)

V3=$\frac{Q}{a3}$(m/sec)

V4=$\frac{Q}{a4}$(m/sec)

V5=$\frac{Q}{a5}$(m/sec)

V6=$\frac{Q}{a6}$(m/sec)

V7=$\frac{Q}{a7}$(m/sec)

$\frac{p1}{\rho g} = \frac{h1}{100}$(m)

$\frac{p2}{\rho g} = \frac{h2}{100}$(m)

$\frac{p3}{\rho g} = \frac{h3}{100}$(m)

$\frac{p4}{\rho g} = \frac{h4}{100}$(m)

$\frac{p5}{\rho g} = \frac{h5}{100}$(m)

$\frac{p6}{\rho g} = \frac{h6}{100}$(m)

$\frac{p1}{\rho g} = \frac{h1}{100}$(m)

E1= $\frac{p1}{\rho g} + \frac{V1^2}{2g}$(m)

E2= $\frac{p2}{\rho g} + \frac{V2^2}{2g}$(m)

E3= $\frac{p3}{\rho g} + \frac{V3^2}{2g}$(m)

E4= $\frac{p4}{\rho g} + \frac{V4^2}{2g}$(m)

E5= $\frac{p5}{\rho g} + \frac{V5^2}{2g}$(m)

E6= $\frac{p6}{\rho g} + \frac{V6^2}{2g}$(m)

E7= $\frac{p7}{\rho g} + \frac{V7^2}{2g}$(m)

Plot the graph E (E1 to E7) Vs. S (S1 to S7)

PRECAUTIONS AND MAINTENANCE:

- Always keep accessory from dust
- Always use clean water
- Drain the accessory completely after experiment
- Never fully close control valve while adjusting the flow
- Never run the apparatus if power supply is less than 200 Volts and above 250 Volts.

TROUBLE SHOOTING:

If leakage anywhere in the accessory, tight the pipe fittings.

CONCLUSION:

Experiment 2

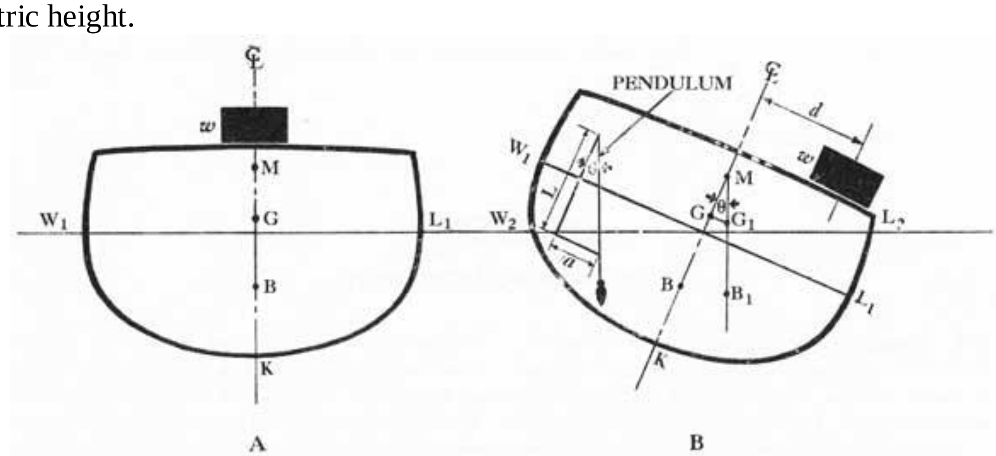
AIM: To determine the meta-centric height with angle of ship model

INTRODUCTION:

META-CENTRE:
It is defined as the point about which a body starts oscillating when the body is tilted by a small angle. The meta- centre may also be defined as the point at which the line of action of the force of buoyancy will meet the normal axis of the body when the body is given a small angular displacement. It is denoted by 'M'.

META-CENTRIC HEIGHT:
The distance between the meta-centre (M) of a floating body and the centre of gravity (G) of the body is called meta-centric height

THEORY:
DETERMINATION OF META-CENTRIC HEIGHT:
For a body to be in equilibrium on the liquid surface the two forces gravity force (W) and buoyant force (Fb) must lie in the same vertical line. If the point M is above G, the floating body will be in stable equilibrium. If slight angular displacement is given to the floating body in clockwise direction, the center of buoyancy shifts from B to B' such that the line of action of Fb through B' cuts the axis at M, which is called the meta – center and the distance GM is called the meta-centric height.



The buoyant force Fb through B' and weight w through G constitute a couple acting in anti-clockwise direction and thus bringing the floating body in the original position. To determine the meta-centric height of a floating body, we know the center of gravity of floating body. Place the known weight (w) over the center of the body.
The weight w is moved across the vessel towards right through a distance x. The body will be tilted. The angle of tilt θ is measured by means of a plumb line and a protractor attached on the body. The new center of gravity of the body will shift to G' as the weight w has been moved

towards the right .the center of buoyancy will change to B’ as the body has tilted. Under equilibrium, the moment caused by the movement of the load w through a distance x must be equal to the moment caused by the shift of the center of gravity from G to G’.

Thus The moment due to change of centre of gravity is

$= GG_1 \text{ X } W = W \text{ X } GM \tan\theta$

The moment due to movement of weight w is

$= wx = W \text{ X } GM \tan\theta$

Hence GM = $\frac{wx}{\mathrm{GM}\tan\theta}$

Where,
W = Weight of body including w
G = Centre of gravity of body
B = Centre of buoyancy of the body
M = Meta-centre of the body
w = Applied weight
x = Distance moved by weight w
θ= Angle of tilt

DESCRIPTION:

A ship model is allowed to float in a small tank having water. Removable steel strips placed in the model for the purpose of changing the weight of the model. Displacement of weight is measured with the help of a scale. By means of a pendulum the angle of tilt can be measured on a graduated arc. For tilting the model, a cross bar with movable hangers is fixed on the model. Pendulum and graduated arc are suitably fixed at the center of the cross bar.

UTILITIES REQUIRED:

1. Water supply (Initial fill).
2. Drain required.
3. Floor Area Required: 1 m x 0.5 m.

NOMENCLATURE:

GM = Metacentric height, m
w = Wt. of hanger + applied weight, kg
W = Total weight, kg
WA = Applied weight. kg
WH = Wt. of hanger, kg
WS = Weight of ship model including strips, kg
x = Distance of point (Weight applied) from centre, cm
θ = Angle of tilt in degree.

EXPERIMENTAL PROCEDURE:

Starting Procedure:

1. Close the valve provided.
2. Fill tank .th with clean water and ensure that no foreign particles are there.
3. Float the ship model in water and wait till it became stable.
4. Fix known weight to be applied at the hanger.
5. Apply weight with hanger at any side on the slot provided.
6. Measure the angle of tilt by the scale provided.
7. Repeat the experiment for different position of weight applied.
8. Repeat the experiment for different weights.

Closing Procedure:

1. Remove the weight with hanger from the ship model.
2. Drain water from all tanks with the help of given drain valves.

OBSERVATION & CALCULATION:

DATA:

W_S = __________ kg

W_H = ________ kg

OBSERVATION TABLE:

Sr. No.	W_A kg	X cm	θ	Metacentric height	Remarks

CALCULATIONS:

w =W_H +W_A, kg=…………….kg

W =Ws + w, kg=……………...kg

GM = $\frac{wx}{\text{GM} \tan \theta}$ = …………. cm

Plot the graph Metacentric height v/s θ

PRECAUTION & MAINTENANCE INSTRUCTIONS:

1. Always keep apparatus free from dust.
2. Always use clean water.
3. Drain the apparatus after experiment is over.

TROUBLESHOOTING:

1. Set the pointer to zero at default condition, manually if required.

CONCLUSION:-

EXPERIMENT 3

AIM: To determine the co-efficient of discharge for Orifice meter.

INTRODUCTION:

If a construction is placed in a closed channel carrying a stream of fluid, there will be increase in velocity, and hence increase in Kinematic Energy, at the constriction, from an energy balance, as given by Bernoulli's Theorem, there must be a corresponding reduction in pressure. Rate of discharge from the construction can be calculated by knowing this pressure reduction, the area available for flow at the construction, the density of fluid, and the co-efficient of discharge. The last named is defined as the ratio of actual flow to the theoretical flow.

THEORY:

ORIFICEMETER:

An Orifice meter consists of a flat circular plate with a circular hole called Orifice, which is concentric with the pipe axis.

DESCRIPTION:

The apparatus consists of a venture meter and an orifice meter, fitted in pipeline of the accessory. Flow can be regulated by control valve and by pass valve. The pressure tapings are provided at inlet and throat of venture meter and inlet and outlet of orifice meter. Pressure tapings are connected to a differential manometer. The setup can be connected to Hydraulic Bench with flexible pipe line.

UTILITIES REQUIRED:

- Electricity Supply: Single Phase, 220 V AC, 50Hz, 5-15 Amp combined socket with earth connection
- Water Supply: Initial Fill.
- Floor Drain
- Floor Area 1.50m*1.50m
-

NOMENCLATURE:

Nom	Column of Heading	Units	Type
a_{1a}	Area at inlet	m^2	Calculated
a_2	Area at orifice	m^2	Calculated
C_d	Coefficient of discharge		Calculated
d_1	Diameter of pipe	m	Given
d_2	Diameter of orifice	m	Given
g	Acceleration due to gravity	m/sec^2	Given
H	Loss of head	m	Calculated
h_1, h_2	Manometer reading at both points	cm	Measured
Q_a	Actual discharge (from Hydraulic Bench)	m^3/sec	Calculated
Q_t	Theoretical discharge	m^3/sec	Calculated

EXPERIMENTAL PROCEDURE:

STARTING PROCEDURE

1. Place the accessory on the top trey of hydraulic bench.
2. Clean the apparatus and make it free from dust.
3. Close the drain valves provided.
4. Fill sump tank of hydraulic bench ¾ with Clean Water and ensure that no foreign particles are there.
5. Open the bypass valve.
6. Contact the flexible pipe to the water inlet of the accessory through the quick release coupling.
7. Connect the electric supply to the pump.
8. Open flow control valve to be tested test section.
9. Set up flow control valve provided at the end of test section and the bypass valve.
10. Remove air from manometer with the help of valves provided on it.
11. Measure the flow of water, using Measuring Tank & Stop watch.
12. Note down the manometer reading at a particular discharge.
13. Take the readings at different flow rates.

CLOSING PROCEDURE:

1. When experiment is over switch OFF the supply to the pump.
2. Wait for one minute so that circulated water from the accessory may drain.
3. Disconnect the coupler from the plug of the accessory and hang it at the back side of the top trey with the help of hook provided.
4. Drain the measuring tank & sump tank.

OBSERVATION:

DATA	
Acceleration due to gravity g = 9.81m/sec²	Diameter at the inlet d1=0.028m

OBSERVATION TABLE					
Sr.no.	h1, cm	h2, cm	R1, cm	R2,cm	T,sec
1.					
2.					
3.					

CALCULATIONS:

$R=R_1-R_2/100$, m=----------m

$Q_a=A*R/t$, m^3/s=------------m^3/s

$H=h_1-h_2/100$, m=-----------m of water

$a_1=\pi/4d_1^2$, m^2=--------------m^2

$a_2=\pi/4d_2^2$,m^2=--------------m^2

$Q_t= a_1a_2(2gH)^{1/2}/(a_1^2-a_2^2)^{1/2}$, m^3/s =-----------m^3/s

$C_d= Q_a/Q_t$=----------

PRECAUTIONS AND MAINTENANCE:

- Always keep accessory from dust
- Always use clean water
- Drain the accessory completely after experiment
- Never fully close control valve while adjusting the flow
- Never run the apparatus if power supply is less than 200 Volts and above 250 Volts.

TROUBLESHOOTINGS:

If leakage anywhere in the accessory, tight the pipe fittings.

CONCLUSION:

EXPERIMENT 4

OBJECTIVE: To study the discharge over different type of notches.

AIM: To determine the co-efficient of discharge 'c_d' of different notches:

Rectangular notch

V Notch - 45°

V Notch - 60°

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 the water flows is known as the sill or crest.

THEORY:

CO-EFFICIENT OF DISCHARGE:

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

$$C_d = \frac{Q_a}{Q_t}$$

DISCHARGE OVER A RACTANGULAR NOTCH:

$$Q_t = \frac{2}{3} \times C_d \times L \times \sqrt{2 \times g} \times [H]^{3/2}$$

DICHARGE OVER TRINGULAR NOTCH:

$$Q_t = \frac{8}{15} \times C_d \times \tan\frac{\theta}{2} \times \sqrt{2 \times g} \times [H]^{5/2}$$

DESCRIPTION:

The accessory consists of a flow channel. A set of three knife edge notch plates made of brass is provided. One of them is rectangular, other is ‘V’ notch having angle 60° and third ‘V’ notch having angle 45°. The notches are interchangeable. A pointer is provided to measure the height of water level over the crest of the notch. Discharge through notches can be measured by hydraulic bench.

UTILITIES REQUIRED:

- Electricity Supply: Single Phase, 220 V AC, 50Hz, 5-15 Amp combined socket with earth connection
- Water Supply: Initial Fill.
- Floor Drain
- Floor Area 1.50m*1.50m

NOMENCLATURE:

Nom	Column Heading	Units	Types
A	Area of measuring tank	M^2	Given
C_d	Co-efficient of discharge for rectangular notch and triangular notch		Calculated
G	Acceleration due to gravity	m/sec^2	Given
H	Water head over crest, m	M	Calculated
H	Liquid level flow at particular height, cm	cm	Measured
h_c	Crest height, cm	cm	Measured
L	Width of the rectangular notch in meter, cm	m	Given
Q	Actual discharge, m^3/sec	m^3/sec	Calculated
R	Rise of water level in measuring tank, cm	m	Calculated
R_1	Final level of water in measuring tank, cm	Cm	Measured
R_2	Initial level of water in measuring tank, cm	cm	Measured
T	Time for R, sec	sec	Measured
θ	Angle of V – notch, Radian	Radian	Given

EXPERIMENTAL PROCEDURE:

STARTING PROCEDURE:

1. Place the accessory on the top tray of hydraulic bench.
2. Close all the valves provided.
3. Fill sump tank of hydraulic bench ¾ with clean water and ensure that foreign particles are there.
4. Fix desired notch at the outlet of flow channel.
5. Open by-pass valve of hydraulic bench.

6. Ensure that all on/off switches given on the panel are Off position.
7. Now switch on the main power supply.
8. Switch on the pump.
9. Operate flow control valve and by-pass valve to fill the flow channel up to no discharge occurs through notch.
10. Fully open by-pass valve and close the flow control valve and wait for level water in floe channel becomes stable.
11. Measure the height of water level at no flow condition (crest height).
12. Regulate flow of water through channel with the help of flow control valve and by-pass valve.
13. Record the height of water level in the channel with the help of pointer Gauge.
14. Measure flow rate using measuring tank and stop watch.
15. Repeat the experiment for different flow rate.
16. Repeat the experiment for other notches.

CLOSING PROCEDURE:

1. When experiment is over, switch off pump.
2. Switch off power supply to panel.
3. Open bypass valve and flow control valve.
4. Drain water from all tanks with the help of provided drain valves.

OBSERVATION:

H.1 DATA:	
Acceleration due to gravity g=9.81 m/sec^2	V-notch 45°,θ =0.7854 Radian
V-notch 60°,θ =1.0472 Radian	Rectangular Notch Length L = 0.070 m

OBESERAVATION TABLE: V - Notch				
h_c =______cm				
Sr.No	h(cm)	R_1(cm)	R_2(cm)	t(sec)
1.				
2.				
3.				
4.				

OBESERAVATION TABLE: V - Notch
h_c =______cm

Sr.No	h(cm)	R_1(cm)	R_2(cm)	t(sec)
1.				
2.				
3.				
4.				

OBESERAVATION TABLE: Rectangular Notch

h_c =______cm

Sr.No	h(cm)	R_1(cm)	R_2(cm)	t(sec)
1.				
2.				
3.				
4.				

CALCULATION:

$$H = \frac{h - h_0}{100}, \text{ m}$$

$$R = \frac{R_1 - R_2}{100}, \text{ m}$$

$$Q = \frac{A \times R}{t}, \text{ m}^3/\text{sec}$$

$$C_d = \frac{3Q}{2L\sqrt{2g} \times (h)^{3/2}} \text{(For rectangular notch)}$$

$$C_d = \frac{15Q}{8 \times \tan(\frac{\theta}{2}) \times \sqrt{2g} \times (h)^{5/2}} \text{(For triangular notch)}$$

PRECAUTIONS AND MAINTENANCE:

- Always keep accessory from dust
- Always use clean water
- Drain the accessory completely after experiment
- Never fully close control valve while adjusting the flow
- Never run the apparatus if power supply is less than 200 Volts and above 250 Volts.

TROUBLE SHOOTING:

If leakage anywhere in the accessory, tight the pipe fittings.

CONCLUSION:

EXPERIMENT 5

AIM: To determine the different types of flow Patterns by Reynolds's experiment.

INTRODUCTION:

From an engineering viewpoint, many variables that affect velocity profile cannot be evaluated for all possible flow meter and for all pipe conditions. For this reason, steady flow and a fully developed flow profile as defined by a Newtonian, homogeneous fluid, are initially assumed. Co-efficient variation can then be predicted with the dimensionless Reynolds number. This number has been found to be an acceptable correlating parameter that combine the effect of viscosity, density and pipeline velocity.

THEORY:

In Reynolds experiments, the ratio of inertia to viscous forces was observed to be dimensionless and related to viscosity, average pipeline velocity, and geometrically similar boundary conditions. For a homogeneous Newtonian fluid, this dimensionless ratio is Re is expressed as:

$$Re = \frac{DV\rho}{\mu} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where, $v = \frac{\mu}{\rho}$

$$Re = \frac{DV}{v} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where,

ρ	=	Density of fluid in kg/m^3
μ	=	Viscosity of fluid in N-sec/m^2
V	=	Average velocity of fluid flow in m/sec.
D	=	Diameter of glass tube in m
v	=	Kinematic viscosity of fluid, m^2/sec

Re <2100 for laminar flow

Re >4000 for turbulent flow

Re = 2100-4000 in transition zone

When the day filament flow in the Reynolds experiment, it indicates critical states of flow, and the corresponding Reynolds number is called the critical Reynolds number Re = 2000, beyond which the flow in transition state and then becomes turbulent.

Depending upon the relative magnitude of viscous and inertial forces, flow can occur in two different manners. Laminar flow is defined as a line, which lie in the direction of flow at every point at a given instant. Transition flow is defined as a flow in which the streamlines needs not be straight as the flow steady as long as this criterion is fulfilled. Eddies generated in the initial zone of instability spread rapidly throughout the fluid, thereby producing a disruption of the entire flow pattern. The result is fluid turbulence superimposed upon the primary motion of translation, producing what is called turbulent flow.

DESCRIPTION:

The apparatus consists of sump tank with centrifugal pump, a glass tube with one end having bell mouth entrance connected to a constant head tank. At the other end of the glass tube a valve is provided to regulate flow. Flow rate of water can be measured with the help of measuring cylinder and stop watch, supplies with the set-up. A needle is introduced centrally in the bell mouth. Dye is fed to the needle from a small container, placed at the top of constant head tank, through polythene tubing.

UTILITIES REQUIRED:

- Electricity Supply: Single Phase, 220 V AC, 50Hz, 5-15 Amp combined socket with earth connection
- Water Supply: Initial Fill.
- Floor Drain
- Floor Area 1.50m*1.50m
- Chemical required: Dye($KMnO_4$) – 10gm

NOMENCLATURE:

Nom	Column Heading	Unit	Type
A	Cross-section area of glass tube	m^2	Calculated
D	Diameter of glass tube	m	Given
Q	Discharge	m^3/sec	Calculated

Re	Reynold's number		Calculated
T	Time taken for Vo	sec	Measured
V	Average velocity of fluid flow	m/sec	Calculated
Vo	Volume of water collected in measuring cylinder	ml	Measured
V	Kinematic viscosity of water	m^2/sec	Given

EXPERIMENTAL PROCEDURE:

STARTING PROCEDURE:

1. Place the accessory on the top tray of hydraulic bench.
2. Close all valves.
3. Fill the sump tank 3/4 with clean water and ensure that no foreign particles are there.
4. Prepare dye solution (KMnO4 in water) in a beaker. Put this solution in dye vessel after ensuring that there are no solid particles in solution.
5. Open by pass valve.
6. Ensure that On/Off switch given on the panel is at OFF position.
7. Switch ON the main power supply and then switch on the pump.
8. Open control valve for water supply to the constant head tank, partially closed by pass valve and wait till overflow occurs.
9. Regulate minimum flow of water through glass tube by partial opening of control valve provided at the end of tube.
10. Then adjust the flow of dye through needle buy knob, so that a fine colour thread is observed.
11. Note the flow pattern observed (laminar, transition or turbulent).
12. Measure flow rate using measuring cylinder and stop watch.
13. Repeat the experiment for different flow rate.

CLOSING PROCEDURE:

1. Switch of pump.
2. Switch of power supply to panel.
3. Drain the apparatus completely by drain valve.

OBSERVATION:

DATA:
Kinematic viscosity of water at ambient temp. v= 1.01E-06 m^2/sec

Dia. Of glass tube d	= 0.010 m

OBSERVATION TABLE			
Sr. No.	T(sec)	Vo(ml)	Observation Flow Type (Laminar/Transition/turbulent)
1			
2			
3			
4			
5			

CALCULATION:

$$Q = \frac{Ve\times10^{-6}}{t}\ (m^3/\text{sec})$$

$$a = \frac{\pi}{4}d^2\ (m^2)$$

$$V = \frac{Q}{a}(m^3/\text{sec})$$

$$Re = \frac{d\times V}{v}$$

PRECAUTIONS AND MAINTENANCE:

- Always keep accessory from dust
- Always use clean water
- Drain the accessory completely after experiment
- Never fully close control valve while adjusting the flow
- Never run the apparatus if power supply is less than 200 Volts and above 250 Volts.

TROUBLESHOOTING:

- If leakage anywhere in the accessory, tight the pipe fittings.

CONCLUSION:

EXPERIMENT 6

AIM: To determine the Friction factor for the different pipes

INTRODUCTION:

When a fluid is flowing through a pipe, the fluid experiences some resistance due to which some of the energy of fluid is lost. This loss of energy in the pipelines comes under major energy *losses* and minor energy losses. In long pipelines the friction losses are much larger than the minor losses and hence, the latter are often neglected. The losses due to friction in the pipelines are known as the major energy losses. The friction in the pipelines is due to a viscous drag between the stream bends of fluid. The stream bends of adjacent to the solid surface are always at rest relative to the wetted surface. The viscous is due to the molecular attraction between the molecules of the fluid.

THEORY:

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

- The area of the wetted surface
- The density of the fluid
- The surface roughness
- It increase with the square of the velocity

It is independent of the fluid pressure

The loss of head in pipe due to friction is calculated from Darcy- weisbach equation which has been given by: $h_f = \frac{4fLV^2}{2gd}$ where

h_f = loss of head due to friction
f = Friction Factor
L = distance between pressure point
V = mean velocity of fluid
d = diameter of pipe
g = acceleration due to gravity

DESCRIPTION:

The apparatus consist of two pipes of different diameter for which common inlet connection is provided with control value of 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 to the friction. Discharge is messured with the help of hydraulic bench.

UTILITIES REQUIRED:

- ❖ Electricity Supply: Single Phase, 220 V AC, 50Hz, 5-15 Amp combined socket with earth connection
- ❖ Water Supply: Initial Fill.
- ❖ Floor Drain
- ❖ Floor Area 1.50m*1.50m

NOMENCLATURE:

Nom	Column Heading	Unit	Type
A	Area of measuring Tank	m^2	Given
a	Cross- section area of pipe	m^2	Calculated
d	Inside diameter of pipe	m	Given
F	Friction factor		Calculated
G	Acceleration due to gravity	m/sec^2	Given
h_1, h_2	Monometric reading at both side	cm	Measured
h_f	Head losses	m of water	Calculated
L	Distance between pressure taping	m	Given
Q	Discharge	m^3/sec	Calculated
R	Rise of water level in measuring tank	m	Calculated
R_1	Final level of water in measuring tank	cm	Measured
R_2	Initial level of water in measuring tank	cm	Measured
t	Time taken for R	Sec	Measured
V	Velocity of fluid	m/ sec	Calculated

EXPERIMENTAL PROCEDURE

STARTING PROCEDURE

1. Place the accessory on the top tray of hydraulic bench
2. Close all the valves provided
3. Fill sump tank of hydraulic bench $3/4$ with clean water and ensure that no foreign particles are there.
4. Open by- pass valve of hydraulic bench.
5. Ensure that On/Off switch given on the panel of hydraulic bench is at OFF position.
6. Switch on the main power supply.
7. Switch on the main power supply.
8. Operate the Flow Control Valve for $3/4$" pipe or for$1/2$" pipe and by pass valve to regulate the flow of water in the desired test Section.
9. Connect the pressure taps of related test section to manometer.
10. Open valve provided on the Manometer, slowly to release the air in manometer.
11. When there is no air in the manometer, close air release valve.
12. Adjust water flow rate in desired section with the help of control volume.
13. Record the manometer reading, in case of pressure above scale in any tube apply air pressure by hand pump to get readable reading.
14. Measure the flow of water, discharged through desired test section, using stop watch and measuring tank.
15. Repeat the experiment for different flow rates of water by operating control valve 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 secondly desired test section.
17. Repeat the same procedure for other test section.

CLOSING PROCEDURE:

1. When experiment is over, Switch off pump
2. Switch off power supply to panel
3. Drain the tanks with the help of given drain valves.

OBSERVATION:

H.1 Data	
Distance between pressure tapings L For pipe 1” = 1m For pipe 1/2" = 1m	Inside Diameter of pipe d For pipe 1” = 0.0254m For pipe 1/2" = 0.016m
Acceleration due to gravity g= 9.81m/sec^2	

H.2 Data

Test pipe= 1’						Test pipe=1/2"					
Sr. No	h_1 (cm)	h_2 (cm)	R_1 (cm)	R_2 (cm)	t (sec)	Sr. No	h_1 (cm)	h_2 (cm)	R_1 (cm)	R_2 (cm)	t (sec)
1.						1.					
2.						2.					
3.						3.					
4.						4.					

CALCULATIONS:

$$R=\frac{R_1-R_2}{100}(\text{m})$$

$$Q=\frac{A\times R}{t}(\text{m}^3/\text{sec})$$

$$a=\pi\frac{d^2}{4}\ (\text{m}^2)$$

$$v=\frac{Q}{a}\ (\text{m/sec})$$

$$h_f=\frac{h_1-h_2}{100}\ (\text{m})$$

$$f = \frac{h_1 2gd}{4LV^2}$$

PRECAUTIONS AND MAINTENANCE:

- Always keep accessory from dust
- Always use clean water
- Drain the accessory completely after experiment
- Never fully close control valve while adjusting the flow
- Never run the apparatus if power supply is less than 200 Volts and above 250 Volts.

TROUBLESHOOTING:

If pump get jam, open the back covers & rotates the shaft manually

CONCLUSION:

EXPERIMENT 7

AIM: To determine the loss coefficients for different pipe fittings.

INTRODUCTION:

Loss of head due to change in cross section, bends, elbows, valves and fitting of all types fall into the category of minor losses in pipe lines. In long pipe lines the friction losses are much larger than there minor losses and hence the latter are often neglected. But, in shorter pipelines their consideration is necessary for the correct estimate of losses.

THEORY:

When there is any type of bend in pipe, the velocity of flow changes, due to which the separation of the flow from the boundary and also formation of eddies, takes place. Thus the energy is lost.

The losses of had due to fitting in pipe:

$$h_L = k_L \, (V^2/2g)$$

The minor losses in contraction, Band, Elbow, Ball valve, Gate valve can be expressed as:

$$h_L = K_L \, (V_1^2/2g)$$

The minor losses in enlargement can be expressed as:

$$h_L = K_L \, \{ (V_1 - V_2)^2/2g \}$$

Where

h_L= Minor loss or head loss.

K_L= Loss coefficient.

V= Velocity of fluid.

V_1= Velocity of fluid in pipe of small Diameter.

V_2= Velocity of fluid in pipe of large Diameter.

DESCRIPTION:

The apparatus consists of pipe line different fittings. Bend, sudden expansion, sudden contraction, elbow, Bell valve and gate valve are provided as fittings. Pressure taping are provided at inlet and outlet of these fitting at suitable distance. A differential manometer fitted in the line gives head loss due to fittings. Supply to the pipeline is made through centrifugal pump, which deliver water from sump tank. Discharge is measured with the help of hydraulic bench.

UTILITIES REQUIRED:

- Electricity Supply: Single Phase, 220 V AC, 50Hz, 5-15 Amp combined socket with earth connection
- Water Supply: Initial Fill.
- Floor Drain
- Floor Area 1.50m*1.50m

NOMENCLATURE:

Nom	Column Heading	Units	Type
A	Area of measuring tank of hydraulic bench	m^2	Given
a_1	Cross-sectional area of Small diameter pipe	m^2	Calculated
a_2	Cross sectional area of Large diameter Pipe	m^2	Calculated
d_1	Small diameter of pipe	m	Given
d_2	Large diameter of pipe	m	Given
G	Acceleration due to gravity	m/sec^2	Given
h_1 , h_2	Manometric reading at both points	cm	Measured
h_L	Head loss	m of water	Calculated
K_L	Loss coefficient		Calculated
Q	Discharge	m^3/sec	Calculated
R	Rise of water level in measuring tank.	m	Calculated
R_1	Final level of water in measuring tank	cm	Measured
R_2	Initial level of water in measuring tank	Cm	measured
t	Time taken for R	sec	measured
V_1	Velocity of fluid in pipe of small diameter	m/sec	calculated
V_2	Velocity of fluid in pipe of large diameter	m/sec	calculated

EXPERIMENTAL PROCEDURE:

STARTING PROCEDURE:

1. Place the accessory to be tested on the top trey of hydraulic bench.
2. Close all the valves provided.
3. Fill sum tank of hydraulic bench ¾ with clean water and ensure that no foreign particles are there.
4. Open by pass valves o hydraulic bench.
5. Connect the pressure taps of related test section to manometer.
6. Ensure that ON/OFF switch given on the panel of hydraulic bench is at OFF position.
7. Switch ON the main power supply and switch ON the pump.
8. Open flow control valve of pipe line of the accessory.
9. Open Valve provided on the manometer, slowly to release the air in manometer.
10. When there is no air in the manometer, close air release valve.
11. Record the manometer reading, in case of pressure above scale in any tube apply air pressure by had pump to get readable reading.
12. Repeat same procedure for different flow rates of water, operating control valve of accessory and by pass valve of hydraulic bench.
13. Measure the flow of water, discharged through desired test section, using stop watch and measuring tank.
14. Repeat the experiment for other fittings of accessory by following same procedure.

CLOSING PROCEDURE:

1. When experiment is over, Switch off pump.
2. Switch off power supply to panel.
3. Drain the apparatus completely with the help of drain valves provided.

OBSERVATION:

Data	
Large pipe diameter d_2 =0.028m	Acceleration due to gravity g= 9.81m/sec^2
Small pipe diameter d_1=0.016m	

Observation Table					
Sr. No.	h_1 (cm)	h_2 (cm)	R_1 (cm)	R_1 (cm)	t (sec)
Sudden Contraction					
1.					
2.					
3.					
Sudden Expansion					
1.					
2.					
3.					
Bend					
1.					
2.					
3.					
Elbow					
1.					
2.					
3.					
Ball Valve					
1.					
2.					
3.					
Gate Valve					
1.					
2.					
3.					

CALCULATION:

$R= R_1-R_2/100$ (m)

$Q = A*R/t$ (m^3/sec)

$a_1= \pi/4d_1^2$ (m^2)

$a_2=\pi/4d_2^2$ (m^2)

$V_1=Q/a_1$ (m/sec)

$V_2=Q/a_2$ (m/sec)

$h_L = h_1 - h_2/100 (m)$

$K_L = 2gH_L/V_1^2$ (For sudden contraction, Band, Elbow, Ball valve, Gate valve)

$K_L = 2gH_L/(V_1 - V_2)^2$ (For sudden enlargement)

PRECAUTIONS AND MAINTENANCE:

- Always keep accessory from dust
- Always use clean water
- Drain the accessory completely after experiment
- Never fully close control valve while adjusting the flow
- Never run the apparatus if power supply is less than 200 Volts and above 250 Volts.

TROUBLESHOOTING:

If leakage are found in pipe line or accessory tight the fitting properly.

CONCLUSION:

Experiment - 8

IMPACT OF JET ON VANES

1. OBJECTIVE

Study of hydraulic force.

2. AIM:

To study the effect of force on following type of vanes:

- Hemispherical Vane
- Flat Plate Vane
- Flat Plate Inclined at angle 30^0 to the jet
- Curved vane

3. INTRODUCTION:

When a plate is placed in the path of jet, the jet exerts a force on the plate. This force can be calculated from the impulse-momentum equation. Momentum equation is based on Newton's Second low of motion, which states that "**The algebraic sum of external force applied to control volume of fluid in any direction is equal to the rate of change of momentum in that direction.**" The external forces include the components of the weight of the fluid and of the forces exerted externally upon the boundary surface of the control volume.

4. THEORY:

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

Due to impact of the jet on the flat stationary plate, the entire velocity of the jet is destroyed and due to the rate of change of momentum, force act on the plate. The jet after striking will move along the plate. But the plate is at the right angles to the jet. Hence the components of the velocity of the jet in the directions of the jet after striking it will be zero.

The force exerted by the jet on the **flat plate in the direction of the jet.**

F_x = Rate of change of momentum in the direction of force

$$= \frac{\text{Final mommeum} - \text{Initial momemtum}}{\text{Time}}$$

$$= \frac{\text{Mass} * \text{Final velocity} - \text{Mass} * \text{Initial velocity}}{\text{Time}}$$

$$= \frac{\text{Mass}}{\text{Time}} * (\text{Final velocity} - \text{Initial velocity})$$

$$= \rho \text{Av} * [\text{v} - 0]$$

$$= \rho \text{Av}^2$$

Similarly, for **Hemispherical vane**:

$$F_x = \rho a V^2 (1 + \cos\theta)$$

Assuming $\theta = 0$

So, $F_x = 2\,\rho \mathrm{a} V^2 \sin\theta$

Flat Plate Inclined at angle θ to the jet

$$F_x = \rho a V[(V\sin\theta) - 0]$$

So, $F_x = \rho a V^2 \sin\theta$

Similarly, for **curved vane**:

$$F_x = \rho a V[V - (-V\cos\theta)]$$

$$F_x = \rho a V^2 (1 + \cos\theta)$$

Assuming $\theta = 0$

So, $F_x = 2\,\rho a V^2$

5. DESCRIPTION:

The experimental setup primarily consists of a nozzle through which a water jet emerges vertically in such a way that it may be conveniently observed through the transparent sheet. It strike the target vane positioned above it. The force applied on the vane by the jet can be measured by applying weights to different positions of the weighing balance with graduated scale counteract as a reaction force for the impact of jet. Vanes are interchangeable i.e. flat plate, hemispherical plate, curved plate & inclined plate.

Arrangement is made for balancing the weighing scale and also the movement of the plate under the action of the jet. A collecting tank is used to find the actual discharge & velocity through the nozzle.

6. EXPERIMENTAL PROCEDURE:

1. Clean the apparatus and make All Tanks free from dust.
2. Close the drain valves provided.
3. Fix desired vane on the apparatus.
4. Balance the weighing scale with the help of side weight arrangement.
5. Fill sump tank $^{3}/_{4}$ with clean water and ensure that no foreign particle are there.
6. Ensure that all of On/OFF switches given on the panel are at off Position.
7. Now switch on the main power supply (220 V AC,50Hz).
8. Switch on the pump.
9. Put known value of weight to the weight hanger.
10. Now regulate the control valve so that the applied weight on the top is counter balanced by the impact of jet.
11. Measure flow rate using measuring Tank & Stop Watch.
12. Repeat the experiment by sliding the weight hanger to different position.
13. When experiment is over, Switch off Pump.
14. Switch off Power Supply to Panel.
15. Drain water from all three tanks with the help of given drain valves.

7. FORMULAE:

Rate of change of momentum in the direction of force:

1. **For Flat plate vane (Theoretical Force)**
   $F_X = \rho \times a \times V^2$
2. **For Hemispherical vane(Theoretical Force)**
   $F_X = 2 \times \rho \times a \times V^2$
3. **Flat Plate Inclined at angle ɵ to the jet(Theoretical Force)**
   $F_X = \rho \times a \times V^2 \sin\theta \; (\theta = 30^\circ)$
4. **For curved vane(Theoretical Force)**
   $F_X = 2 \times \rho \times a \times V^2$
5. **Velocity of jet,**

   V= $\frac{Q}{a}$ m/sec

6. **Discharge**,

   Q= $\frac{A \times R}{t}$ m^3/sec

7. **Actual Force**,

   F_{act}= W * g

8. **Load due to jet,**

   W= $\frac{W_{1} \times x_{1}}{x_2}$

9. **Error (%),**

   Percentage of Error = $\frac{F_x}{F_{th}} \times 100$

8. OBSERVATION & CALCULATION :

DATA :

Diameter of nozzle d = 0.01 m

Area of cross section of nozzle, a = $\pi d^2/4$ = ---------- m^2

Area of measuring tank A = 0.09 m^2

Density of water at ambient conditions = 1000 kg / m^3

Applied weight W_1 = -------- Kg

Distance of application of load from fulcrum x_1 = ---------- m

Distance of vane from fulcrum x_2 = ---------- m

9. OBSERVATION TABLE :

Sr. no.	Weight applied (Kg.)	Distance of application of load from fulcrum x_1	Rises of level in Measuring tank R (cm)	Time for R, t (sec.)
1				
2				
3				

CALCULATION TABLE:

Sr. No.	W(Kg)	Actual force F_x	Discharge $Q(m^3/s)$	Velocity of jet V(m/s)	Theoretical force F_{th}	Error (%)
1						
2						
3						

10. NOMENCLATURE:

Q = actual discharge in $\mathbf{m^3/s}$

F_x = Rate of change of momentum (Actual force), **N**

F_{th} = Theoretical force, **N**

W = Total weight, **Kg**

ρ = Density of water, $\mathbf{Kg/m^3}$

V	=	velocity of jet, **m/s**
R	=	Rise of water level in measuring tank, **cm**.
T	=	Time for R, **sec**
A	=	area of measuring tank**, m^3**
a	=	area of cross section of nozzle, **m^3**
W_1	=	Applied weight
W	=	load due to jet
X_1	=	Distance of application of load from fulcrum
X_2	=	Distance of vane from fulcrum

11. PRECAUTIONS & MAINTANCE INSTUCTIONS:

1. Never switch on main power supply before ensuring that all the on/off switches gives on the panel are at off position.
2. Never run the pump at low voltage i.e. less than 180 Volts.
3. Never fully close the delivery and By-pass line valves simultaneously.
4. Always keep apparatus free from dust.
5. Frequently grease/oil the rotating parts, once in three months.
6. Always use clean water.
7. If apparatus will not be in use for more than one month, drain the apparatus completely

12. TRUBLESHOOTINGS:

1. If pump gets jam, open the back cover of pump and rotate the shaft manually.
2. If pump gets heat up, switch off the main power for 15 minutes and avoid closing the flow control valve and by pass valves simultaneously.

Experiment No-09

Aim: To understand Pelton wheel Turbines.

1. INTRODUCTION:

Hydraulic turbine is a prime mover (a machine which uses the raw energy of a substance and converts into mechanical energy) that uses the energy of flowing water and converts it into the mechanical energy (in the form of rotation of the runner). This mechanical energy is used in running an electric generator which is directly coupled to the shaft of the hydraulic turbine; from this electric generator, we get electric power which can be transmitted over long distances by means of transmission lines and transmission towers. The hydraulic turbines are also known as 'water turbines' since the fluid medium used in them is water.

2. CLASSIFICATION OF HYDRAULIC TURBINES

The hydraulic turbines are classified as follows:

1. According type of energy at inlet of the turbine
    a. Impulse turbine
    b. Reaction turbine
2. According to the direction of the flow of water
    a. Tangential flow turbine
    b. Radial flow turbine
    c. Axial flow turbine
    d. Mixed flow turbine
3. According to the head at the inlet of the turbine
    a. High head turbine
    b. Medium head turbine

c. Low head turbine

4. According to the specific sped of the turbine

    a. Low specific speed turbine
    b. Medium specific speed turbine
    c. High specific turbine

If at the inlet of the turbine, the energy available is only kinetic energy, the turbine is known as impulse turbine. As the water flows over the vanes, the pressure is atmospheric from inlet to outlet of the turbine. In the impulse turbine, all the potential (pressure) energy of water is converted into kinetic (velocity) energy in the nozzle before striking the turbine wheel buckets. Hence an impulse turbine requires high head and low discharge at the inlet. The water as it flows over the turbine blades will be at the atmospheric pressure. The impulse turbine may be radial flow or tangential flow type.

If at the inlet of the turbine, the water possesses kinetic energy as well as pressure energy, the turbine is known as reaction turbine. As the waters flows through the runner, the water is under pressure and the pressure energy goes on changing into kinetic energy. The runner is completely enclosed in an air tight casing and the runner and casing is completely full of water.

If the water flows along the tangent of the runner, the turbine is known as tangential flow turbine. If the water flows in the radial direction through the runner, the turbine is called radial flow turbine. If the water flows from outwards to inwards, radially the turbine is called inward radial flow turbine, on the other hand, if the water flows radially from inwards to outwards, the turbine is known as outward radial flow turbine.

If the water flows through the runner along the direction parallel to the axis of rotation of the runner, the turbine is called axial flow turbine. If the water flows through the runner in radial direction but leaves in the direction parallel to axis of rotation of the runner, the turbine is called mixed flow turbine.

3. PELTON WHEEL OR IMPULSE TURBINES

The pelton wheel or pelton turbine is a tangential flow impulse turbine. The water strikes the bucket along the tangent of the runner. The energy available at the inlet of the turbine is only kinetic energy. The pressure at the inlet and outlet of the turbine is atmosphere. This turbine is used for high heads and is named after L.A. Pelton, an American Engineer.

4. CONSTRUCTION AND WORKING OF PELTON WHEEL TURBINE

A pelton wheel consists of a rotor, at the periphery of which is mounted equally spaced double hemispherical or double ellipsoidal buckets. Water is transferred from a high head source through penstock which is fitted with a nozzle, through which the water flows out as a high speed jet. A needle spear moving inside the nozzle controls the water flow through the nozzle and at the same time provides a smooth flow with negligible energy loss. All the available potential energy is thus converted into kinetic energy before the jet strikes the buckets of the runner. The pressure all over the wheel is constant and equal to atmosphere, so that energy transfer occurs due to purely impulse action.

The pelton turbine is provided with a **casing** the function of which is to prevent the splashing of water and to discharge water to the tail race.

When the nozzle is completely closed by moving the spear in the forward direction the amount of water striking the runner is reduced to zero but the runner due to inertia continues revolving for a long time. In order to bring the runner to rest in a short time, a nozzle (brake) is provided which directs the jet of water on the back of buckets; this jet of water is called **braking jet**.

Speed of the turbine runner is kept constant by a governing mechanism that automatically regulates the quantity of water flowing through the runner in accordance with any variation of load.

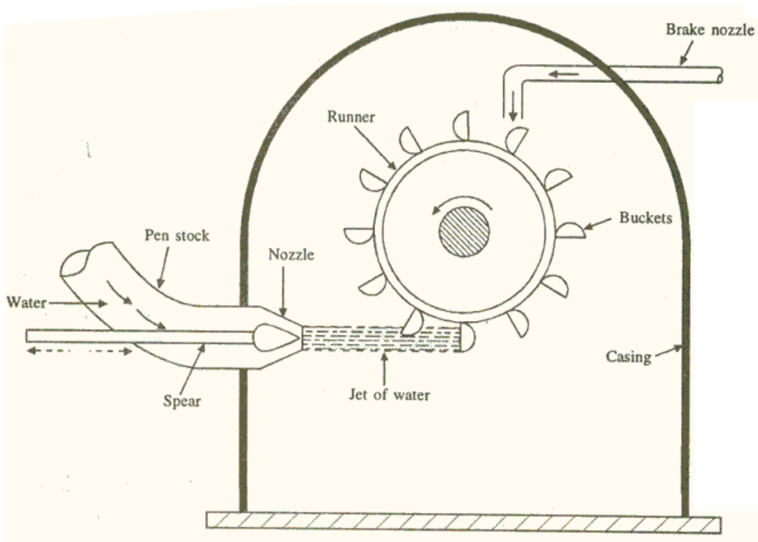


Fig. 1.19 Pelton wheel turbine

Fig.1.19 shows a schematic diagram of a pelton wheel. The jet emerging from the nozzle hits the splitter symmetrically and is equally distributed into the two halves of hemispherical bucket as shown. The bucket centre line cannot be made exactly like a mathematical cusp, partly because of manufacturing difficulties and partly because the jet striking the cusp invariably carries particles of sand and other abrasive material which tend to wear it down.

Working

Water at high pressure from the penstock pipe enters the nozzle provided with a spear. The pressure energy of water is converted into velocity energy, as it flows through the nozzle. By rotating the hand wheel, the spear is moved to control the quantity of water flowing out of the nozzle. When the spear is pushed forward into the nozzle, the amount of water striking the buckets is reduced.

The jet of water at high velocity from the nozzle strikes the buckets at the center of the cup. The impulsive force of the jet striking on the buckets causes the rotation of the wheel in the direction of the striking jet. Thus, pressure energy of the water is converted into mechanical energy. The pressure inside the casing is atmospheric.

The pelton wheel operates under a high head of water. Therefore it requires less quantity of water. Draft tubes are not usually used with it.

Experiment - 10

Aim: To understand Francis Turbines.

Francis Turbine

1. INTRODUCTION:

If at the inlet of the turbine, the water possesses kinetic energy as well as pressure energy, the turbine is known as reaction turbine. As the waters flows through the runner, the water is under pressure and the pressure energy goes on changing into kinetic energy. The runner is completely enclosed in an air tight casing and the runner and casing is completely full of water.

If the water flows along the tangent of the runner, the turbine is known as tangential flow turbine. If the water flows in the radial direction through the runner, the turbine is called radial flow turbine. If the water flows from outwards to inwards, radially the turbine is called inward radial flow turbine, on the other hand, if the water flows radially from inwards to outwards, the turbine is known as outward radial flow turbine.

2. CONSTRUCTION AND WORKING OF REACTION TURBINES

The main parts of a radial flow reaction turbine are: Casing, guide mechanism, runner and draft tube.

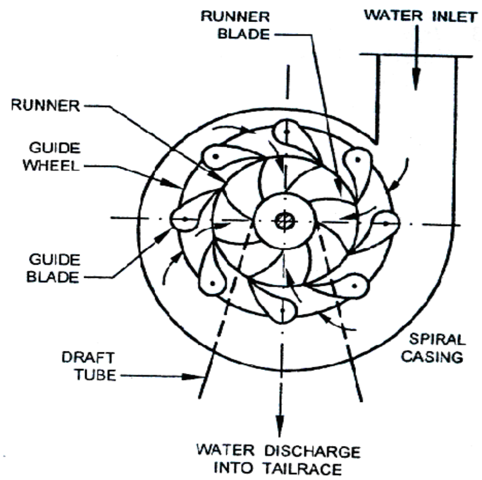


Fig. 1.20 Francis Turbine

Casing: As mentioned above that in case of reaction turbine, casing and runner are always full of water. The water from the penstocks enters the casing which is of spiral shape in which area of cross section of the casing goes on decreasing gradually. The casing completely surrounds the runner of the turbine. The casing as shown in fig.1.20 is made of spiral shape, so that the water may enter the runner at constant velocity through out the circumference of the runner. The casing is made of concrete, cast steel or plate steel.

Guide mechanism: It consists of a stationary circular wheel all round the runner of the turbine. The stationary guide vanes are fixed on the guide mechanism. The guide vanes allow the water to strike the vanes fixed on the runner without shock at inlet. Also by a suitable arrangement, the width between two adjacent vanes of guide mechanism can be altered so that the amount of water striking the runner can be varied.

Runner: It is a circular wheel on which a series of radial curved vanes are fixed. The surfaces of the vanes are made very smooth. The radial curved vanes are so shaped that the water enters and leaves the runner without shock. The runner is made of cast steel, cast iron or stainless steel. They are keyed to the shaft.

Draft tube: The pressure at the exit of the runner of a reaction turbine is generally less than atmospheric pressure. The water at exit cannot be directly discharged to the tail race. A tube or pipe of gradually increasing area is used for discharging water from the exit of the turbine to the tail race. This tube of increasing area is called draft tube.

Working

First, water enters the guide blades, which guide the water to enter the moving blades. In the moving blades, part of the pressure energy is converted into kinetic energy, which causes rotation of the runner. Water leaving the moving blades is at a low pressure. Thus, there is a pressure difference between the entrance and the exit of the moving blades. This difference in pressure is called reaction. Pressure acts on moving blades and causes the rotation of the wheel in the opposite direction.

3. INWARD RADIAL FLOW REACTION TURBINE

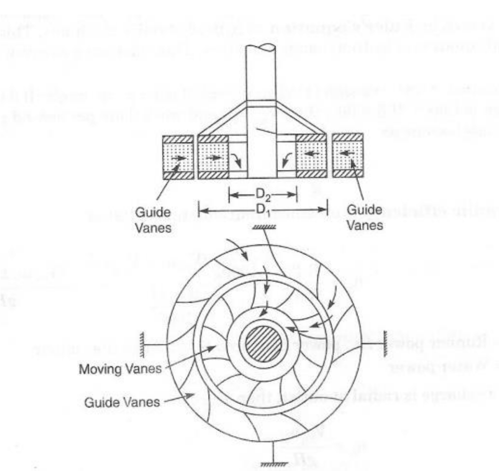


Fig.1.21 Inward flow reaction turbine

Fig.1.21 shows inward flow reaction turbine, in which case the water from casing enters the stationary guiding wheel. The guiding wheel consists of guide vanes which direct the water to enter the runner which consists of moving vanes. The water flows over the moving vanes in the inward radial direction and is discharged at the inner diameter of the runner. The outer diameter of the runner is the inlet and the inner diameter is the outlet.

4. OUTWARD RADIAL FLOW REACTION TURBINE

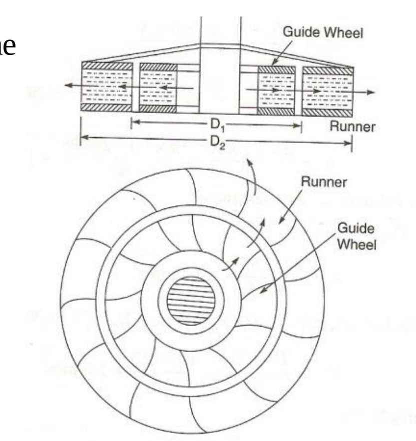


Fig. 1.22 Outward flow reaction turbine

Fig.1.22 shows outward radial flow reaction turbine in which the water from the casing enters the stationary guide wheel. The guide wheel consists of guide vanes which direct water to enter the runner which is around the stationary guide wheel. The water flows through the vanes of the runner in the outward radial direction and is discharged at the outer diameter of the runner. The inner diameter of the runner is inlet and the outer diameter is the outlet.

5. FRANCIS TURBINE

Francis turbine was developed by the American engineer Francis in 1850. It is an inward flow radial type reaction turbine. It operates under medium head.

Working principle

Francis turbine consists of a spiral casing, fixed guide blades, runner, moving blades and draft tube.

The spiral casing encloses a number of stationary guide blades. The guide blades are fixed around the circumference of an inner ring of moving blades. Moving blades are fixed to the runner.

Water at high pressure from the penstock pipe enters the inlet in the spiral casing. It flows radially inwards to the outer periphery of the runner through the guide blades. From the outer periphery of the runner, water flows inwards through the moving blades and discharges at the center of the runner at a low pressure. During its flow over the moving blades, water imparts kinetic energy to the runner, causing the rotation of the runner.

Draft tube is a diverging conical tube fitted at the center of the runner. It enables the discharge of water at low pressure. The other end of the draft tube is immersed in the discharging side of the water called tail race.

Experiment - 11

Aim: To understand Kaplan Turbines.

1. INTRODUCTION:

Kaplan turbine is a low head reaction turbine, in which water flows axially. It was developed by German Engineer Kaplan in 1916.

All the parts of the Kaplan turbine (viz, spiral casing, guide wheel and guide blades) are similar to that of the Francis turbine, except the runner blades, runner and draft tube. The runner and runner blades of the Kaplan turbine resemble with the propeller of the ship. Hence, Kaplan turbine is also called as Propeller Turbine.

2. WORKING PRINCIPLE

Water at high pressure enters the spiral casing through the inlet and flows over the guide blades. The water from the guide blades strokes the runner blades axially. Thus, the kinetic energy is imparted by water to the runner blades, causing the rotation of the runner. The runner has only 4 or 6 blades.

The water discharges at the center of the runner in the axial direction into the draft tube. The draft tube is of L shape with its discharging end immersed into the tail race.

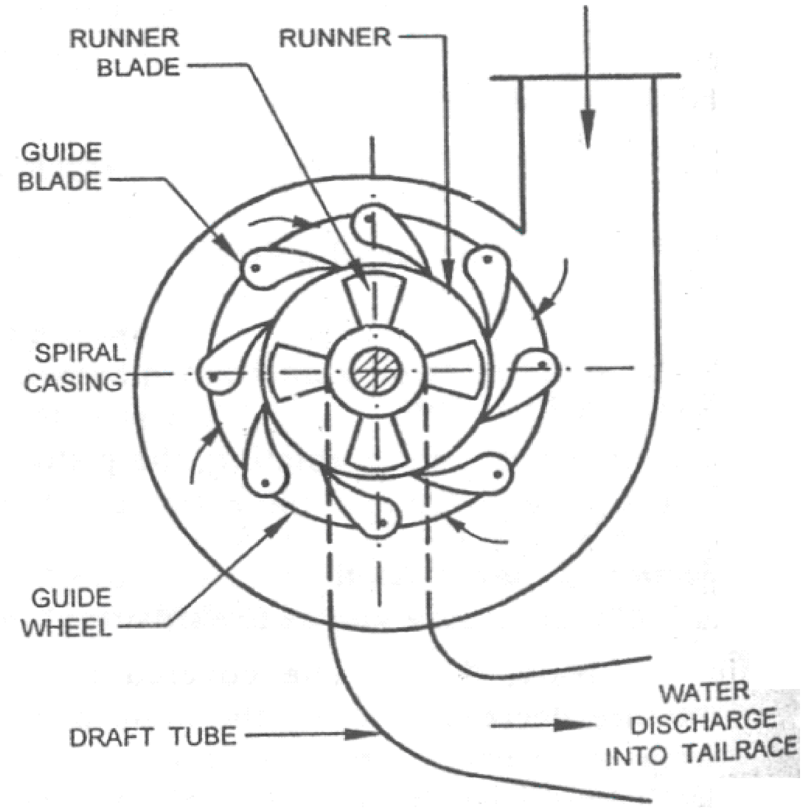


Fig. 1.23 Kaplan Turbine

Experiment No-12

Aim: Study about Centrifugal pump.

INTRODUCTION:

A centrifugal pump is a mechanical device designed to move a fluid by means of the transfer of rotational energy from one or more driven rotors, called impellers. Fluid enters the rapidly rotating impeller along its axis and is cast out by centrifugal force along its circumference through the impeller's vane tips. The action of the impeller increases the fluid's velocity and pressure and also directs it towards the pump outlet. The pump casing is specially designed to constrict the fluid from the pump inlet, direct it into the impeller and then slow and control the fluid before discharge.

Working of a centrifugal pump

The impeller is the key component of a centrifugal pump. It consists of a series of curved vanes. These are normally sandwiched between two discs (an enclosed impeller). For fluids with entrained solids, an open or semi-open impeller (backed by a single disc) is preferred (Figure 1).

Figure 1. Impeller Types (l to r): Open, Semi-Enclosed (or Semi-Open), Enclosed.

Fluid enters the impeller at its axis (the 'eye') and exits along the circumference between the vanes. The impeller, on the opposite side to the eye, is connected through a drive shaft to a motor and rotated at high speed (typically 500-5000rpm). The rotational motion of the impeller accelerates the fluid out through the impeller vanes into the pump casing.

There are two basic designs of pump casing: volute and diffuser. The purpose in both designs is to translate the fluid flow into a controlled discharge at pressure.

In a volute casing, the impeller is offset, effectively creating a curved funnel with an increasing cross-sectional area towards the pump outlet. This design causes the fluid pressure to increase towards the outlet (Figure 2).

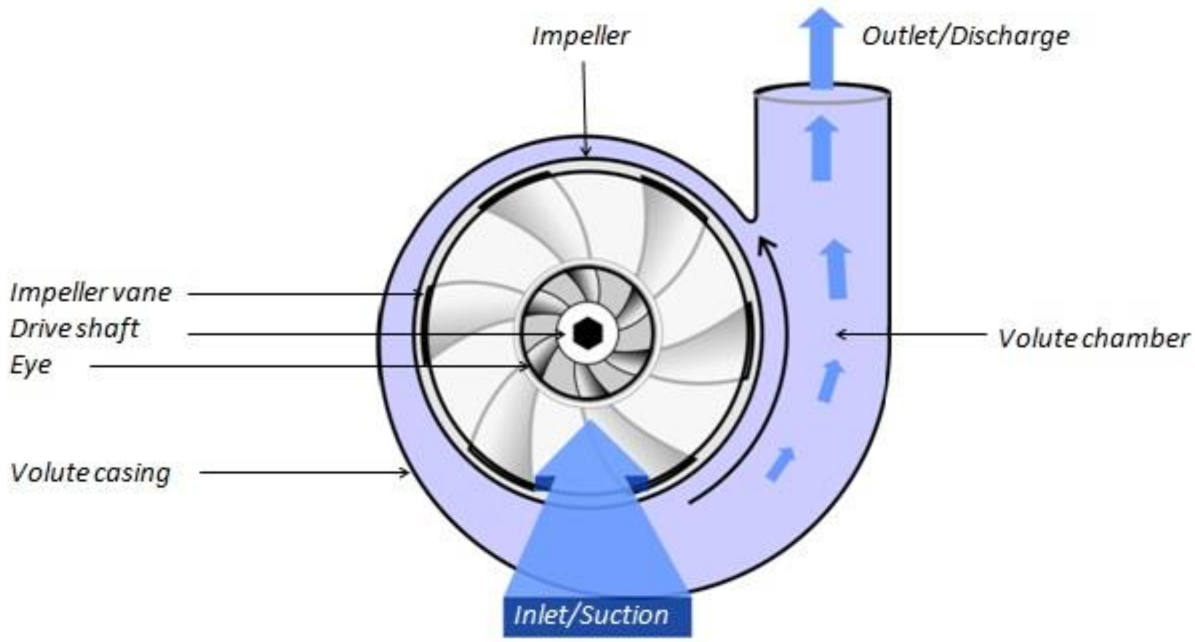


Figure 2. Volute case design

The same basic principle applies to diffuser designs. In this case, the fluid pressure increases as fluid is expelled between a set of stationary vanes surrounding the impeller (Figure 3). Diffuser designs can be tailored for specific applications and can therefore be more efficient. Volute cases are better suited to applications involving entrained solids or high viscosity fluids when it is advantageous to avoid the added constrictions of diffuser vanes. The asymmetry of the volute design can result in greater wear on the impeller and drive shaft.

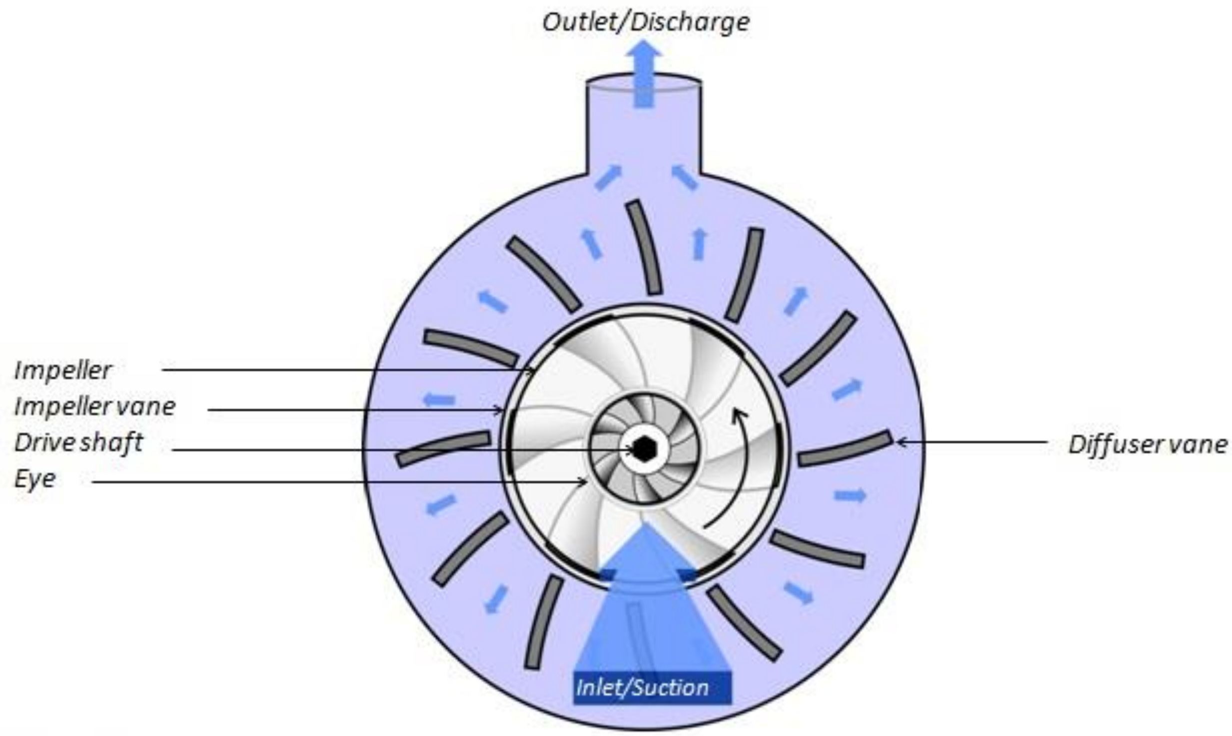


Figure 3. Diffuser case design

Main features of a centrifugal pump

There are two main families of pumps: centrifugal and positive displacement pumps. In comparison to the latter, centrifugal pumps are usually specified for higher flows and for pumping lower viscosity liquids, down to 0.1 cP. In some chemical plants, 90% of the pumps in use will be centrifugal pumps. However, there are a number of applications for which positive displacement pumps are preferred.

Limitations of a centrifugal pump

The efficient operation of a centrifugal pump relies on the constant, high speed rotation of its impeller. With high viscosity feeds, centrifugal pumps become increasingly inefficient: there is greater resistance and a higher pressure is needed to maintain a specific flow rate. In general, centrifugal pumps are therefore suited to low pressure, high capacity, pumping applications of liquids with viscosities between 0.1 and 200 cP.

Slurries such as mud, or high viscosity oils can cause excessive wear and overheating leading to damage and premature failures. Positive displacement pumps often operate at considerably lower speeds and are less prone to these problems.

Any pumped medium that is sensitive to shearing (the separation of emulsions, slurries or biological liquids) can also be damaged by the high speed of a centrifugal pump's impeller. In such cases, the lower speed of a positive displacement pump is preferred.

A further limitation is that, unlike a positive displacement pump, a centrifugal pump cannot provide suction when dry: it must initially be primed with the pumped fluid. Centrifugal pumps are therefore not suited to any application where the supply is intermittent. Additionally, if the feed pressure is variable, a centrifugal pump produces a variable flow; a positive displacement pump is insensitive to changing pressures and will provide a constant output. So, in applications where accurate dosing is required, a positive displacement pump is preferred.

The following table summarises the differences between centrifugal and positive displacement pumps.

Pump Comparison: Centrifugal vs Positive Displacement

Property	Centrifugal	Positive Displacement
Effective Viscosity Range	Efficiency decreases with increasing viscosity (max. 200 Cp)	Efficiency increases with increasing viscosity
Pressure tolerance	Flow varies with changing pressure	Flow insensitive to changing pressure
	Efficiency decreases at both higher and lower pressures	Efficiency increases with increasing pressure
Priming	Required	Not required
Flow (at constant pressure)	Constant	Pulsing
Shearing (separation of emulsions, slurries, biological fluids, food stuffs)	High speed damages shear-sensitive mediums	Low internal velocity. Ideal for pumping shear sensitive fluids

Applications for centrifugal pumps

Centrifugal pumps are commonly used for pumping water, solvents, organics, oils, acids, bases and any 'thin' liquids in both industrial, agricultural and domestic applications. In fact, there is a design of centrifugal pump suitable for virtually any application involving low viscosity fluids.

Type of centrifugal pump	Application	Features
Canned motor pump	Hydrocarbons, chemicals where any leakage is not permitted	Sealless; impeller directly attached to the motor rotor; wetted parts contained in can
Magnetic drive pump		Sealless; impeller driven by close coupled magnets
Chopper/grinder pump	Waste water in industrial, chemical and food processing/ sewage	Impeller fitted with grinding teeth to chop solids
Circulator pump	Heating, ventilation and air conditioning	Inline compact design
Multistage pump	High pressure applications	Multiple impellers for increased discharge pressures
Cryogenic pump	Liquid natural gas, coolants	Special construction materials to tolerate low temperatures
Trash pump	Draining mines, pits, construction sites	Designed to pump water containing solid debris
Slurry pump	Mining, mineral processing, industrial slurries	Designed to handle and withstand highly abrasive slurries