LAB MANUAL

SESSION: 2020-21

SUBJECT CODE: KCE 453
HYDRAULICS & HYDRAULIC MACHINE LAB

BRANCH –CIVIL ENGINEERING

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LIST OF EXPERIMENTS

EXPERIMENT NO: 01

AIM: To determine the Manning's coefficient of roughness 'n' for the bed of a given flume.

EXPERIMENTAL SETUP:

For conducting this experiment long hollow rectangular channel is used with bed slope adjustments, point gauge is kept on upstream side of channel to measure the depth of water. Inlet pipe is provided with flow regulating arrangement. Outlet of channel is directly taken to the measuring tank which is provided with piezometer tube arrangement outlet is provided with measuring tank.

THEORY:

In open channel water flows under atmospheric pressure, when water flows in an open channel, resistance is offered to it, which causes loss of energy. A uniform flow will be developed if the resistance is balanced by the gravity forces. The magnitude of the resistance when other physical factors of the channel are kept unchanged depends on the velocity of the flow. The following formulae are used to measure the velocity are :

Manning's formula is $V= (1/N)*R^{2/3}S_O^{1/2}$

Where N is manning's roughness coefficient

R is hydraulic mean radius

S_o is channel bottom slope

The relation between chezy and manning's formula is

$C = (1/N)R^{1/6}$

PROCEDURE:

1. Remove all the obstructions in the channel
2. Prepare the unit for open channel experiment by lifting both the gates so that there is no obstruction to the flow of water.
3. By screwing up the wheel of the tilting arrangement the required slope for the channel can be attained. Note the readings in the vertical scale as shown.
4. Allow the water in the channel, so that the water flows along the open channel at the steady condition.
5. With the help of the point gauge, find the head of water in the channel. Let it be y=__________ m
6. Take manometer reading L.
7. Calculate the discharge by using formula,

$$Q_{act} = Cd.a \sqrt{(2gh)}.$$

8. Repeat Steps 1 to 6 for different readings. i.e. head of water and for different channel slope.

OBSERVATIONS:

1. Width of channel " B "= 30 cm
2. Diameter of orifice "d"= 4.8 cm
3. Area of orifice "a" = 18.09 cm^2
3. Length of channel= 6 m = 6000 mm

OBSERVATION TABLE:

S.NO	BED SLOPE(So)	C.B.	W.S	DIFF. "Y" (cm)	Manometer Reading " **h'** "	h	Qact	Hydraulic Depth "R"	V=Q/a	C	1/N	N
1	5/6000											
2	10/6000											
3	15/6000											
4	20/6000											
5	25/6000											
6	30/6000											

SAMPLE CALCULATIONS:

1. Y = W.S. - C.B
2. h = **h'** *(13.6-1)
3. Q_{act} = Cd.a √(2gh)
   Where Cd= 0.611; g= 981 cm/s^2
4. R= Area / Wetted Perimeter = B*Y/ B+2Y
5. Velocity = Qact/Area
6. V=C $\sqrt{(RS_o)}$
7. V= (1/N)*$R^{2/3}S_O^{1/2}$

RESULTS:

1. Average value of manning's constant =N=______

EXPERIMENT NO.: 02

Objective: To study the velocity distribution in an open channel and to determine the energy and momentum correction factors.

Introduction:

The velocity varies over the cross section of an open channel. The velocity distribution curve is required for the study of many open channel flow problems such as computation of discharge , mean velocity, Manning's n, energy correction factor α, and the momentum correction factor β.

The velocity at any point is generally measured with a pitot-static tube or a velocity meter, and is given by

$$v = C\sqrt{2g(l\sin\theta)\left(\frac{\rho_m}{\rho_w}-1\right)}$$

where

C is the coefficient of the pitot-static tube (=1.0)

l is the deflection of the manometer

θ is the inclination of the manometer tubes.

ρ_m and ρ_w are the densities of the manometer liquid and water, respectively.

The set-up consists of a rectangular tilting flume. The water is supplied from an overhead water tank through a 100 mm diameter pipe. Gates with rack and pinion arrangement are provided at the inlet and exit sections for controlling the flow. The inlet portion of the flume is provided with the baffle walls (or honey comb walls) to calm the flow. The flume is provided with rails on top of the side walls on which a trolley can move to and fro. The pitot-static tube (if provided) and the pointer gauge are provided on the trolley. The flume can be tilted with a screw jack provided for this purpose to give the required slope. For the measurement of discharge, a large collecting tank is provided at the downstream end of the flume.

Introduction and Theory:

The discharge Q can be computed from the velocity distribution curve a

$Q = \int v\,dA = B\int v\,dy$ where B = width of the flume Thus the discharge can be computed as

$$Q = B\sum v\Delta y = B\times(\text{the area of the velocity})$$

The mean velocity V can be computed as

$$V = \frac{Q}{A}$$

$$= \frac{B\sum v\Delta y}{B\times Y} = \frac{(\text{area of the velocity diagram})}{Y}$$

where Y = depth of flow

From the Manning's formula

$$V = \frac{1}{n}R^{2/3}S^{1/2}$$ where n is the Manning's coefficient

R = Hydraulic radius = $\frac{A}{P} = \frac{BY}{B+2Y}$

S = Bed slope

For glass n is about 0.010

The kinetic energy correction factor α is given by

$$\alpha = \frac{\int v3dA}{V2A}$$

$$= \frac{\sum v^3\Delta y}{V^3Y} = \frac{(\text{area of } v^3 \text{ diagram})}{V^3Y}$$

The momentum correction factor (β) is given by

$$\beta = \frac{\int v3dA}{V2A}$$

$$= \frac{\sum v^2\Delta y}{V^2Y} = \frac{(\text{area of } v^2 \text{ diagram})}{V^2Y}$$

The value of α for the turbulent flow is generally from 1.05 to 1.40

The value of β for the turbulent flow is generally from 1.01 to 1.20

Procedure:

1. Measure the width of the flume.
2. Take the pointer gauge at the water surface to determine the depth of flow (Y).

3. The width of the flume is divided into segments of equal width (b) for the measurement of velocity. Because of symmetry the measurements may be taken only on the segments on one side of the centre line.
4. Bring the pitot-static tube trolley (or place the current meter) over the centerline of the segment no.1. Take the manometer reading(l) (or velocity meter readings) and the pointer gauge readings at 8 to 10 points between the bed and water surface.
5. Shift the trolley to the centre of the other segments, one by one, and repeat step 5.
6. Measure the discharge by noting the water level rise in a collecting tank, and recording the area of collecting tank and time taken for the level rise.
7. Repeat steps 2 to 8 for different discharges.

Observations and Computations:

Temperature of water =

Inclination of manometer attached to the pitot-static tube (θ) =

Pointer Gauge reading when the point touches the bed (G_0) =

Diameter of the pitot-static tube, (d) =

Width of the flume, (B) =

No. of segments, =

Width of each segment, (b) =

Discharge Measurement:

Area of collecting tank, A = ( ) cm^2

S.No	Water levels of collecting tank		Difference, $h=(h_2 - h_1)$ (cm)	Volume, $V=A\times h$	Time reqd. to raise w.L. from h_1 to h_2 . t (sec)	Q= V/t (cm^3/s)
	Initial, h_1 (cm)	Final, h_2 (cm)				
1						
2						
3						
Average , Q						

Depth of flow:

Pointer Gauge at the water surface (G) =

Depth of flow, $Y = G - G_0 =$

Velocity Measurement:

S.No.	Gauge Reading, (G)	Depth, y	Velocity			
			Segment,1	Segment,2	Segment,3	Segment,4
1						
2						
3						
4						
5						
6						
7						

Graphs to plot:

1. Plot v vs y curve for each segment.
2. Plot v^2 vs y curve for each segment.
3. Plot v^3 vs y curve for each segment.

Compute mean velocity, V = (area of v-y plot)/Y

$V_1 =$, $V_2 =$, $V_3 =$, $V_4 =$, Average V =

Compute momentum correction factor, (β) = (area of v^2-y plot)/ Y

$\beta_1 =$, $\beta_2 =$, $\beta_3 =$, $\beta_4 =$, Average β =

Compute energy correction factor, α = (area of v^3-y plot)/Y

$\alpha_1 =$, $\alpha_2 =$, $\alpha_3 =$, $\alpha_4 =$, Average α =

Discharge Q = BYV

Compare this discharge with the measured discharge.

Manning's n

$$n_1 = \frac{R_1^{2/3} S^{1/2}}{V_1}, \quad n_2 = \frac{R_2^{2/3} S^{1/2}}{V_2}, \quad n_3 = \frac{R_3^{2/3} S^{1/2}}{V_3}, \quad n_4 = \frac{R_4^{2/3} S^{1/2}}{V_4},$$

Average , n= $\frac{n_1 + n_2 + n_3 + n_4}{4}$ Alternatively, average , n= $\frac{R^{2/3} S^{1/2}}{V}$

Results:

Average value of α =

Average value of β =

Average value of n =

EXPERIMENT NO.: 03

Objective:

To study the flow characteristics over a hump placed in an open channel.

Apparatus Used:-

Tilting flume , Large chamber to study flow , Controlling meter to vary slope., Hook gauge/point gauge to measure the depth , Broad crested weirs/humps with different depth.

Principle:-

HUMP:

The raised bed of the channel at a certain location is called as hump.

WEIR:

It is the structure constructed across a river at a suitable location. It is commonly used to raise the water level at a river to divert the required amount of water into an off taking canal. Weir can be gated or ungated. Gated weir is called as barrage.

EFFECT OF HUMP HEIGHT ON THE DEPTH OF FLOW:

Height of hump is less than critical hump height then there will be sub-critical flow over the hump, downstream of the hump and upstream of the hump. Depth of flow over the hump will decrease by certain amount as there is a slight depression in the water surface. Further increase in the height of hump will create more depression of water surface over the hump until finally the depth becomes equal to the critical depth. When the hump height will be equal to critical depth then there will be critical flow over the hump, sub-critical on the upstream side and super critical just downstream of the hump.

CRITICAL HUMP HEIGHT:

The minimum hump height that causes the critical depth over the hump is called as critical hump height.

CASE 1:

¬ y1 = y0

¬ y1 > y2> yc

¬ y1, y2 > yc

The flow conditions will be sub critical. At downstream depth is recovered after a long distance.

Procedure:-

1. Fix the slope of the flume.

2. Set the discharge in the flume having uniform flow.

3. Introduce a hump in the flume at certain location.

4. Note depth of flow at upstream side of hump, over the hump and downstream side of the hump at certain point.

5. Repeat steps 2-4 for the other discharges.

6. Repeat the same procedure for different depth of hump.

7. Predict the type of flow at every section.

8. Compare depths with critical depth for every discharge value and report the type of flow.

9. Draw flow profile over the humps, upstream and downstream of the humps.

Result:-

Type of weir	Length(mm)	Width(mm)	Height(mm)
Round corner			
Sharp corner			
Wedged Shaped			

Width of channel = ________________
Length of Channel = _______________

Table of Calculations

Surface Profiles

EXPERIMENT NO.: 04

Objective:

To study the flow through a horizontal contraction in a rectangular channel.

Apparatus Used:-

Hydraulic bench, Notches, Rectangular, Hook and point gauge, Calibrated collecting tank, Stop watch

Principle:-

In open channel hydraulics, weirs are commonly used to either regulate or to measure the volumetric flow rate. They are of particular use in large scale situations such as irrigation schemes, canals and rivers. For small scale applications, weirs are often referred to as notches and invariably are sharp edged and manufactured from thin plate material. Water enters the stilling baffles which calms the flow. Then, the flow passes into the channel and flows over a sharp-edged notch set at the other end of the channel. Water comes of the channel in the form of a nappe is then directed into the calibrated collection tank. The volumetric flow rate is measured by recording the time taken to collect a known volume of water in the tank.A vertical hook and point gauge,mounted over the channel is used to measure the head of the flow above the crest.

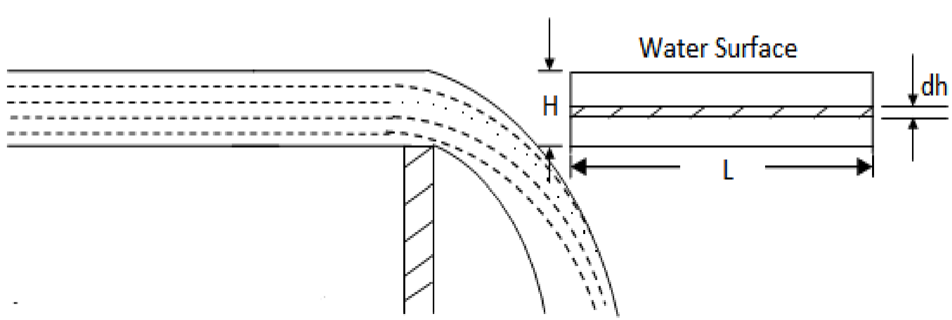


Fig : Rectangular weir

Procedure:-

1. Keep the runner vane at require opening

1. Keep the guide vanes at required opening
2. Prime the pump if necessary
3. Close the main sluice valve and them start the pump.
4. Open the sluice valve for the required discharge when the pump motor switches from star to delta mode.
5. Load the turbine by adding weights in the weight hanger. Open the brake drum cooling water gate valve for cooling the brake drum.
6. Measure the turbine rpm with tachometer.

OBSERVATION:

breadth of the rectangular notch =

Area of collecting tank(A)=

Result:-

EXPERIMENT NO.: 05

Objective:

To calibrate a broad-crested weir.

Apparatus Used:-

A channel or flume to provide a flow passage**,** A broad crested weir, Hook-gauge to measure the head over the crest over the crest of weir, stop watch.

Principle:-

A weir is an opening in the side walls of a tank. It is same as an orifice without having an outer boundary. If the head is reduced the liquid flows with its level below the top of the orifice. The wall above the liquid level is superfluous and can be removal.

The difference between a large orifice and weir is that liquid flows through the orifice while it flows over the weir. The flow of liquid coming out of orifice is called jet while that comes through the weir is called 'nape, sheet or vein'.

The relation between H and h for maximum discharge is, h = 23 H
Theoretical discharge, Qt = 1.705 L H32 in m3/sec
Where,
L = Length of the weir measured parallel to width of channel in meters

H = Constant head over the crest on the upstream of channel in meters.

H = (h2-h1).

Actual discharge,Qa = Internal plan area of collecting tank x rise in collecting tank/ time of collection (t) in m3/sec.

Procedure:-

1. Open the control valve and allow the water level to rise up to the skill level of the weir.
2. Adjust the tip of the hook gauge such that it coincides with water surface and note the reading on hook gauge scale as h1on u/s.
3. Note the time required for known rise of water level.

4. Keeping the length and width of the collecting tank as default values repeat the experiment by adjusting flow of water and hook gauge.

Observation1:

5. Open the control valve and allow the water level to rise up to the skill level of the weir.

6. Adjust the tip of the hook gauge such that it coincides with water surface and note the reading on hook gauge scale as h1on u/s.

Observation2:

6. Operate the control valve such that water flows over the weir to some height.

7. Again adjust the tip of the hook gauge such that it coincides with water surface and note the water level by means of hook gauge as h2.

Observation3:

1. Note the time required for known rise of water level.

2. Keeping the length and width of the collecting tank as default values repeat the experiment by adjusting flow of water and hook gauge.

Result:

Average coefficient of discharge of a broad crested weir.

EXPERIMENT NO:6

AIM- To study the characteristics of free hydraulic jump.

Aim: To draw the characteristic curves of a Hydraulic Ram at constant valve lift and constant supply head.

Model:

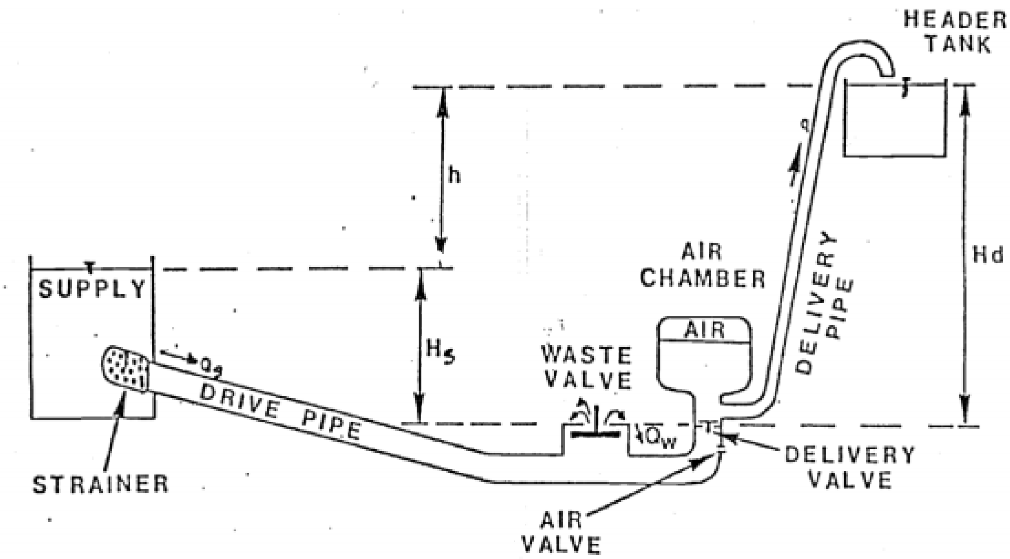


Fig. Hydraulic Ram Pump

Tools required: Stop watch and measuring scale etc.

Procedure:

1. Allow water into supply tank
2. Keep the valve in delivery pipe partially closed
3. Start the hydraulic ram by reciprocating the waste valve twice of thrice
4. Keep the supply head constant by controlling suitably the inflow into the supply reservoir
5. Adjust delivery valve so that pressure gauge reads, say about 20m. of water
6. Calculate the total discharge in Kg/min passing through ram by measuring the head over rectangular notch and assuming C d = 0.62. This discharge is waste water W_w
7. Note down the useful water pumped per minute into the collecting tank. This discharge is useful water = W_u

8. Note down the time taken for 50 beasts and calculate per minute
9. Repeat the experiment for six different delivery heads at intervals of 3 to 4m water.

   Let H_s be the supply head in m. of water and H_d the delivery head in m. of water. H_s are the height of water surface in the reservoir above waste valve. H_d is the pressure gauge reading and difference in level between the center of the gauge and waste valve.

Model Calculations:

(a) Rankin Efficiency $= \dfrac{W_u (H_d - H_s)}{W_w H_s}$ choosing supply water surface as datum

(b) D 'Abuissons' Efficiency $= \dfrac{W_u H_d}{(W_w + W_u) H_s}$

choosing the datum plane as that passing through waste valve.

Graphs:

The following graphs are drawn.

H_d Vs D 'Abuissons' Efficiency

H_d Vs Waste Water/min = W_w

H_d Vs Beats/min.

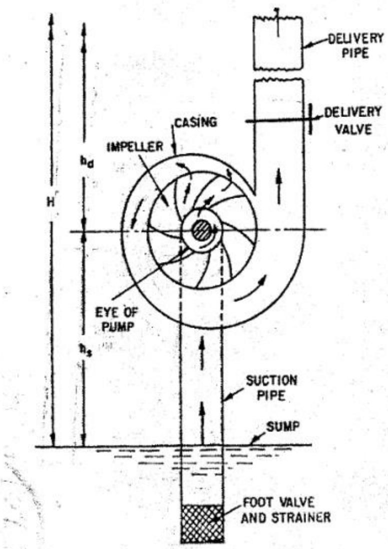
H_d Vs Useful water/min = W_u

H_d Vs Rankine Efficiency

Result:-

EXPERIMENT NO:07

AIM-: To study centrifugal pump and their characteristics.



Principal parts of a centrifugal pump

APPARATUS-: Centrifugal Pump Set – Up, Stop Watch, Meter Scale, etc.

THEORY-: The hydraulic machine which converts mechanical energy into hydraulic energy is called as the pump. The hydraulic energy is in the form of Pressure Energy. If Mechanical Energy is converted into pressure energy by means of Centrifugal Force which is acting on fluid. This hydraulic machine is called as a Centrifugal Pump. A Centrifugal Pump consists of an impeller which is rotating inside a spiral/volute casing. Liquid is admitted to the impeller in an axial direction through a central opening in it side called the Eye. It then flows radially outward & is discharged around the entire circumference into a casing. As the liquid flows through the rotating impeller, energy is imparted to the fluid, which results in increase in both: the Pressure Energy, and the Kinetic Energy. The name of pump Centrifugal is derived from the fact that, the discharge of liquid from the rotating impeller is due to the centrifugal head created in it when a liquid mass is rotated in a vessel. This results in a pressure rise throughout the mass, the rise at any point being proportional to the square of the Angular Velocity & the distance of the point from the axis of rotation.

PROCEDURE-:

1) Switch on the motor and check the direction of rotation of pump in proper direction.
2) Keep the discharge valve full open and allow the water to fall in main tank.

3) No doubt the speed of the motor is controlled by the hand tachometer.
4) The readings of suction and discharges are noted.
5) Note the power consumed by pump from energy meter.
6) Measure the discharge of the pump in the measuring tank by diverting the flow.
7) Take few readings by varying the discharge.

PRECAUTIONS-:

1) Priming is necessary if pump doesn't give discharge.
2) Leakage should be avoided at joints.
3) Foot valve should be checked periodically.
4) Lubricate the swiveled joints & moving parts periodically.

SPECIFICATIONS-:

Pump type -: Centrifugal Pump Type

Motor Power -: 05 HP

Energy Meter -: Electrical

Vacuum Gauge -: 0 to 760 mm of Hg (0 to -30 PSi)

Pressure Gauge -: 0 to 2.1 kg / cm^2

Observations:

1. Area of measuring tank " A" =…..cm^2
2. X = ……..cm
3. N'= …..rpm

Observation Table -:

SR. NO.	M.T.R.			time	Qact	Pre. Guage			Vac. Guage	total head
	TR (cm)	FR (cm)	R (m)	t		Pd	Hd	Pv	H_v (m)	$H = H_d + H_v + X$
						(kg/cm2)	(m)	(mm hg)		

OUTPUT	SPEED	E.M.R.	INPUT	η %
WQH/75	N	5 REV		

Calculations -:

- R = Final Reading – Initial Reading = F.R. – I.R. (m)
- Actual Discharge (m^3/sec)
- Delivery head $H_d = P_d$ / W
- Suction head Hv =
- Total head **" H "** = $H_d + H_v$ + X
- Out put = W Q_{act} H/75
- Input = 3600 * 1.36 * 5/ N' t

EXPERIMENT NO:8

AIM: To study characteristics of Pelton Turbine.

APPARATUS:

1. Pelton Wheel Turbine
2. Nozzle & Spear Arrangement
3. Pressure Gauges (03 Nos. – Range = 00 – 07 kg/cm^2)

THEORY:

Pelton Wheel Turbine is an IMPULSE type of turbine which is used to utilize high head for generation of electricity. All the energy is transferred by means of Nozzle & Spear arrangement. The water leaves the nozzle in a jet formation. The jet of water then strikes on the buckets of Pelton Wheel Runner. The buckets are in the shape of double cups joined together at the middle portion. The jet strikes the knife edge of the bucket with least resistance and shock. Then the jet glides along the path of the cup & jet is deflected through more than 160 – 170 degrees. While passing through along the buckets, the velocity of water is reduced & hence impulse force is applied to the cups which are moved & hence shaft is rotated.The Specific Speed of Pelton wheel varies at constant head.

TEST REQUIREMENTS:

The Pelton Wheel is supplied with water at high pressure by Centrifugal Pump. The water is converged through Venturimeter to the Pelton Wheel. The Venturimeter with manometer connection is to be determined. The nozzle opening can be positioned and decreased by operating Spear wheel at the entrance side of turbine. The Spear wheel can be positioned in 8 places, i.e. 1/8, 2/8, 3/8, 4/8, 5/8, 6/8, 7/8, 8/8 of nozzle opening. The turbine can be loaded by applying loads on brake drums by means of placing the given loads on the loading arm also placing the given loads on the loaded turbine.

The speeds (r.p.m.) at the entrance can be measured with the help of Tachometer.

Procedure: -

1. Keeps the nozzle opening at the required position.
2. Do the priming & start the pump.
3. Allow the water in the turbine to rotate it.
4. Note down the speed of the turbine.
5. Take the respective readings in the respective pressure gauges.

6. Load the turbine by putting the weights.
7. Note down the dead weights.
8. Also note down the Head level.
9. Repeat the same procedure for different loading conditions.

OBSERVATION:

1. Diameter of Drum = 40 cms = 0.4 m
2. Diameter of Rope = 15 mm = 0.015 m
3. Total diameter (D) = 415 mm = 0.415 m
4. Hanger weight T_2 = 1 kg

OBSERVATION TABLE:

DEAD WT.	SPRING WT.	RESULT LOAD	BHP	IHP	%N
T_1	**T_2**	**T**			

SR	PRESSURE GUAGE			HEAD	Qact	SPEED	HEAD at INLET	
	P_1	P_2	P_P			N	P_i	H_i
1								
2								
3								
4								

Calculations:

1. $P = P_2 - P_1$
2. Head at penstock " H_p" = P_p / W (m)

3. $Q_{act} = 0.0055 \sqrt{H}$ (m^3/sec)
4. Head at inlet of turbine " H_i" = P_i / W (m)
5. Result load " T " = $T_1 + T_0 - T_2$
6. Brake horsepower
7. Input horsepower $\mathbf{Q_{act}\ H\ \eta\%}$
8. Efficiency

Graph: X-Axis: BHP

Y-Axis: Q_{act} , H, η %

RESULT:

From Observations:

1. Maximum Efficiency of the Pelton Wheel Turbine " η " = ……………………..%
2. Actual Discharge = Q_{act} = ………
3. Head at inlet of turbine = H_i = ……..
4. B.H.P. (output) = …………

From Observations:

1. Maximum Efficiency of the Pelton Wheel Turbine = ……………………..%
2. Actual Discharge = Q_{act} = ………
3. Head at inlet of turbine = H_i = ……..
4. B.H.P. (output) = …………

EXPERIMENT NO.: 09

Objective: -

To study characteristics of Francis Turbine.

Apparatus Used: -

Francis Turbine Test Rig, stop watch, tachometer.

Principle: -

. All the energy is transferred by means of Nozzle & Spear arrangement. The water leaves the nozzle in a jet formation. The jet of water then strikes on the buckets of Pelton Wheel Runner. The buckets are in the shape of double cups joined together at the middle portion.

FORMULAE

VENTURIMETER READING

h = (p1 - p2) x 10 (m)

Where

p1, p2 - venturimeter readings in kg / cm2

DISCHARGE

Q = 0.011 x √h (m3 / s)

BRAKE HORSEPOWER

BHP = (x D x N x T) / (60 x 75) (h p)

Where

N = Speed of turbine in (rpm)

D = Effective diameter of brake drum = 0.315m

T = torsion in [kg]

INDICATED HORSEPOWER

HP = 1000 x Q x H / 75 (hp)

Where

H – Total head in (m)

PERCENTAGE EFFICIENCY

% = B.H.P x 100 / I.H.P (%)

GRAPHS

The following graphs are drawn

1. BHP (vs.) IHP
2. BHP (vs.) speed
3. BHP (vs.) % efficiency

Calculation

Sl.	Gauge	Gauge		Discharge	on	balance		Speed
			Head				load	
	Reading	Reading			hanger	reading		
	P.S	***P1 P2 P***	***h***	***Q***	***W1***	***W2***	***W***	***N***
	kg/cm2	***Kg/cm2***		***m3/sec***	***Kg***	***kg***	***kg***	***rpm***
1								
2								
3								
4								
5								
6								

FRANCIS TUBRINE TEST RIG 1 kW, 1000 RPM (CLOSED CIRCUIT) DETAILS

Brake drum dia D = 0.2m
Rope Dia t = 0.015m
Effective radius of = (D/2 + t)
Brake drum Re = 0.115m
Weight of rope & hanger = 1kg
Guide vane opening =0.5 & "K" value : 9.11 x 10-310-3
Input total head H in m of water = Pressure gauge reading in kg/cm2x 10
Orificemeter Head h in m of water h= (p1-p2) x 10m of water
Discharge Q = K√h (h in m of water)
Input power IP=γ x H x Q kW (H in m of water)
Brake Drum net load W = (W1 + weight of rope & hanger) – W2 kg
Turbine output OP = (2π NWRe x 9.81)/ 60000 kW
Efficiency η = (output / input) x 100%
PUMP MODEL: CRI; LH3

Procedure:-

1. The Francis turbine is started
2. All the weights in the hanger are removed
3. The pressure gauge reading is noted down and this is to be Maintained constant for different loads
4. Pressure gauge reading is ascended down
5. The venturimeter reading and speed of turbine are noted down
6. The experiment is repeated for different loads and the reading are tabulated.

Result:- Thus the performance charactertics of the Francis wheel turbine are done and the maximum efficiency of the turbine is …………. %

Safety Precautions:-

1. Water flow should be steady and uniform.
2. The reading on the scale should be taken without any error.
3. The weight should be put slowly & one by one.
4. After changing the vane the flask should be closed tightly.

EXPERIMENT NO.: 10

Objective: -To study characteristics of Kaplan Turbine.

Apparatus Used: -
Kaplan Turbine, Supply Pump, Orifice meter, Pressure & Vacuum Gauge, Sump tank,Piping System.

Principle: -

The **Kaplan turbine** is a propeller-type water turbine which has adjustable blades. It was developed in 1913 by Austrian professor Viktor Kaplan, who combined automatically adjusted propeller blades with automatically adjusted wicket gates to achieve efficiency over a wide range of flow and water level.

The Kaplan turbine was an evolution of the Francis turbine. Its invention allowed efficient power production in low-head applications which was not possible with Francis turbines. The head ranges from 10–70 metres and the output ranges from 5 to 200 MW. Runner diameters are between 2 and 11 metres. Turbines rotate at a constant rate, which varies from facility to facility. That rate ranges from as low as 54.5 rpm to 429 rpm. The Kaplan turbine installation believed to generate the most power from its nominal head of 34.65 m is as of 2013 the Kaplan turbine generating 230 MW (Turbine capacity, 257 MVA for generator) with each of ten 8.6 m diameter runners.

FORMULAE: -

Input Power = γ QH in kW

Where

γ = Specific weight of water = 9.81 kN/m3 Q =
Discharge in m3/sec.

H = Supply head in meters.

Brake Power = 2π NT x 9.81/ 60000 kW
Efficiency = Output/ Input *100%

Where

N = Turbine speed in RPM.

T = Torque in kgm, (effective radius of the brake in meters (R)x
The net brake load in kg (W).

Re = 0.165m

GRAPHS

The following graphs are drawn.

1. BHP Vs IHP
2. BHP Vs speed
3. BHP Vs Efficiency

KAPLAN TUBRINE TEST RIG 1 kW, 1000 RPM (CLOSED CIRCUIT) DETAILS

Brake drum dia D = 0.3m

Input total head H in m of water = Pressure gauge reading in
kg/cm2x 10 Orificemeter Head p in m of water h= (p1-p2) x 10

Discharge Q = K√p (h in m of water)

Input power IP=γ x H x Q kW (H in m of water)

Brake Drum net load W = (W1 + weight of rope & hanger) – W2 kg Turbine output
OP = (2π NWRe x 9.81)/ 60000 kW

Efficiency η = (output / input) x 100%

Rope Dia t = 0.015m

Effective radius of = (D/2 + t) = 0.165m

Weight of rope & hanger = 1kg

Guide vane opening =0.8

Run away speed = 1750RPM

“K” value = 2.3652 x 10-2

Pumpset Brand & Model = CRI;1

Sl. No	**Pressure (H) Gauge Reading**	**Pressure Gauge Reading**	**Orifice meter Head**	**Discharge**	**Weight on hanger**	**Spring balance reading**	**Net load**	**Speed**	**output**	**Input**	**Eff.**
	P.S	***P1 P2 P***	***h***	***Q***	***W1***	***W2***	***W***	***N***			
	kg/cm2	***Kg/cm2***		***m3/sec***	***Kg***	***kg***	***kg***	***rpm***	***OP kW***	***IP kW***	***η %***
1											
2											
3											
4											
5											
6											

Procedure:-

1. Keep the runner vane at require opening
2. Keep the guide vanes at required opening
3. Prime the pump if necessary
4. Close the main sluice valve and them start the pump.
5. Open the sluice valve for the required discharge when the pump motor switches from star to delta mode.
6. Load the turbine by adding weights in the weight hanger. Open the brake drum cooling water gate valve for cooling the brake drum.
7. Measure the turbine rpm with tachometer

8. Note the pressure gauge and vaccum gauge readings
9. Note the orifice meter pressure readings.

RESULT:-

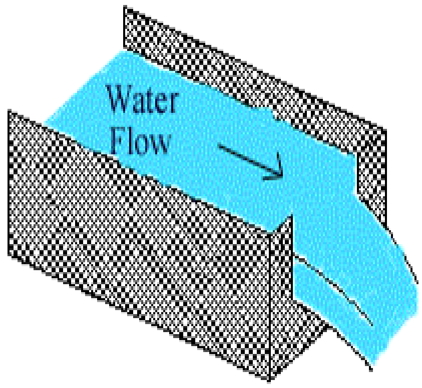
Thus the performance characteristic of the Kaplan Turbine is done and the maximum efficiency of the turbine is ………. %

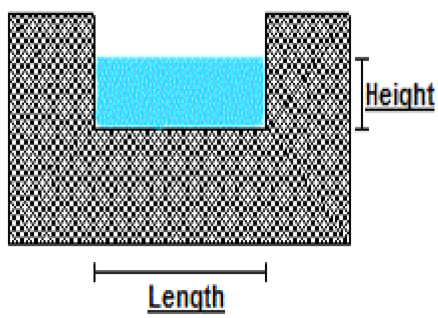
EXPERIMENT NO.: 11

Objective: - To determine coefficient of discharge for given rectangular notch.

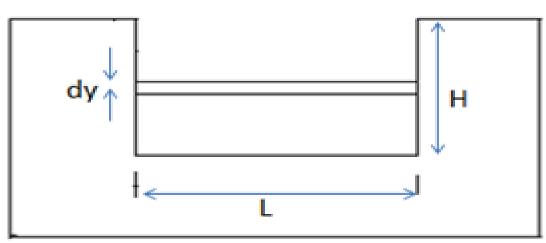
Apparatus Required: - Rectangular Notch, V- notch, hook gauge, measuring scale etc.

Theory: - A Notch is a device used for measuring the rate of flow of a liquid through a small channel or a tank. It may be defined as an opening in the side of a tank or vessel such as liquid surface in the tank is below the level of opening. Notches can be of different shapes such as triangular, rectangular, trapezoidal, stepped notch, etc. the bottom of the notch over which the water flows is known as crest or sill and the thin sheet of water flowing through the notch is known as nappe or vein. The edges of the notch are bevelled on the downstream side so as to have a sharp-edged sides and crest resulting in minimum contact with the flowing fluid.

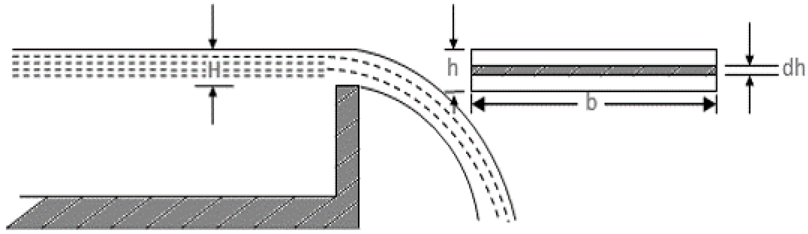




Classifications of notch: Rectangular notch: It takes its name from the shape of its notch. The discharge through a weir or notch is directly related to the water depth or head (H). This head is affected by the condition of the crest, the contraction, the velocity of approaching stream and the elevation of the water surface downstream from the weir.



Let us consider a horizontal strip of water of thickness dh at a depth of h from the water level as shown in figure.



Let,

H = Height of water above sill of notch b =

Width or length of the notch

Cd = Coefficient of discharge

$\therefore$ Area of the strip $= b \cdot dh$

The theoretical velocity of water through the strip $= \sqrt{2gh}$ Discharge through

the strip,

$$dq = C_d \times \text{Area of strip} \times \text{Theoretical velocity}$$
$$\Rightarrow dq = C_d \times b \cdot dh \times \sqrt{2gh}$$

the total discharge over the whole notch may be found out by integrating the above equation within the limits 0 and H.

$$Q = \int_0^H C_d \times b \cdot dh \sqrt{2gh}$$

$$\Rightarrow Q = C_d \times b\sqrt{2g} \int_0^H h^{1/2} \cdot dh$$

$$\therefore Q = \frac{2}{3} \times C_d \times b \cdot \sqrt{2g}\, H^{3/2}$$

Procedure:-

1. Start the pump by pressing start button.
2. Open the inlet valve and allow the water to fill in the channel till crest level.
3. Note the theoretical discharge of the Rectangular Notch.
4. Note actual discharge reading of the V- notch from the collecting tank.
5. Stop the pump by pressing the stop button.

Observation

Length of the collecting tank =

……. Breadth of the collecting tank

= ……..

Length of rectangular notch, L =

…… Number of end contractions, n

=… Angle of v notch =

Co- efficient of discharge for v-notch =

Theoretical discharge, Q_{th}=

………………

Actual discharge, Q_{act} = ………….

Results :-