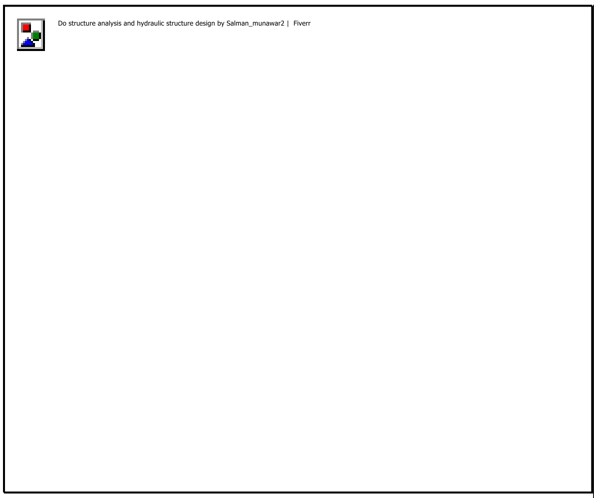
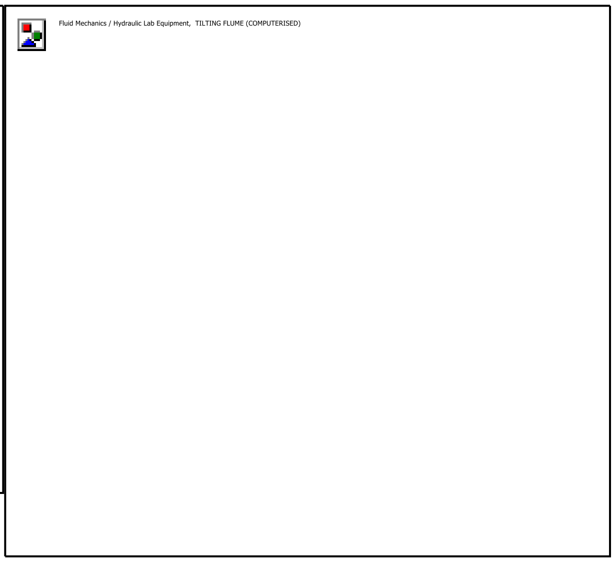
HYDRAULIC ENGINEERING

LAB MANUAL





Sustainability Cluster

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PREFACE

Hydraulic Engineering plays a very important role in development of a nation, life of people, and in aspect of nature. With this importance keep in mind, we are tried to simplify the experimentally and practical work for learner. This laboratory manual is help to all learners of hydraulic engineering lab, works in projects and research.

Hydraulic engineering as a sub-discipline of civil engineering is concerned with the flow and conveyance of fluids, principally water and sewage. This area of civil engineering is intimately related to the design of bridges, dams, channels, canals, and levees, and to both sanitary and environmental engineering.

It is necessary to study the behavior of static and moving water for the safety of water retaining structures like dams, percolation tanks; canals etc. The scope of hydraulics is in Hydrology and water resources department like.

For trying to makes it's simple and easily understanding for student, in this lab manual each experiment divided into two parts i.e. theory study and Practical work. In theory section it's give you useful theoretical knowledge about each particular experiment. In theoretical section divided into different parts like, Objective, application, precaution, questions and references. And other section which is used in practically divided in experimentally procedure, Apparatus, observation and result.

Mr. Vipin Kumar
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Sustainability Cluster

Hydraulic Engineering

List of Experiments

S. No	Name of the Experiment	No of sessions	CO addressed
1	To determine the coefficient of discharge for flow over a board crested weir	1	CO1
2	To study the characteristics of a hydraulic jump on a horizontal floor and sloping glacis	1	CO1
3	To determine Manning's coefficient of roughness n for the bed of a given flume	1	CO1
4	To study the characteristics of Kaplan Turbine	1	CO2
5	To study the characteristics of Pelton Wheel Turbine	1	CO2
6	To study the scouring phenomenon around a bridge pier.	1	CO3
7	To study the scouring phenomenon for flow past a spur	1	CO3
8	To calibrate triangular weir	1	CO4
9	To study the flow over a hump placed in an open channel	1	CO4
10	To study the characteristics of flow over a free over fall in a channel and also to determine the end depth	1	CO1
11	To study the characteristics of Gear Pump	1	CO1
12	To study the characteristics of Centrifugal Pump	1	CO1

Course Outcomes

CO1	Apply the concept of non-uniform flow in an open channel
CO2	Demonstrate the characteristics of different types of Turbines
CO3	Demonstrate characteristics of different types of pumps
CO4	Interpret the phenomenon of scouring

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EXPERIMENT NO. 01

Coefficient of Discharge from Board Crested Weir

OBJECTIVE

To determine the coefficient of discharge for flow over a board crested weir.

APPARATUS

- Tilting Flume
- Broad Crested Weir

It consists of an open rectangular channel. A honeycomb wall is provided at inlet. A broad crested weir is also provided in the channel. It has a smooth or rounded U/S corner. A pointer gauge can be moved on the side walls of the channel. A pipe whose outlet is controlled by a value supplies water.

APPLICATIONS

A weir having a broad crest is known as a broad crested weir. It is different from the sharp crested weir. In the case of a sharp crested weir, the flowing water touches only the U/S edge and flows clear of D/S edge while in a broad crested weir, water flows over the crest touching both the U/S and D/S edges.

If the width of crest is greater than half the depth of flow over the crest, then the weir behaves as a broad crested weir. There are two types of broad crested weirs, sharp corner at U/S end & smooth corner at U/S end. The first type is undesirable as an air pocket is formed in this case which causes cavitations. No cavitation's occurs in the second type of weir. The water surface drops from H on U/S of a weir to h over the crest of weir, due to reduction in the area of flow of water (and consequent increase in the velocity of water). The equation of discharge over a broad crested weir is given by,

$$Q = 1.7 C_d L H^{3/2}$$

Where H is head of water U/S of broad crested weir, L is length of crest of the broad crested weir and C_d is coefficient of discharge which varies from 0.85 to 1.0.

PROCEDURE

1. Pass maximum discharge and observer the profile of water. Select a section where the profile is horizontal.
2. Adjust the position of the sluice gate. When the flow becomes steady, note the pointer gauge reading over the water surface at the section fixed in (1) above.
3. Take the pointer gauge reading over the crest of weir also.
4. Collect suitable amount of water and measure the time.
5. Repeat steps (2) and (4) for different discharges.
6. Take about ten set of readings.

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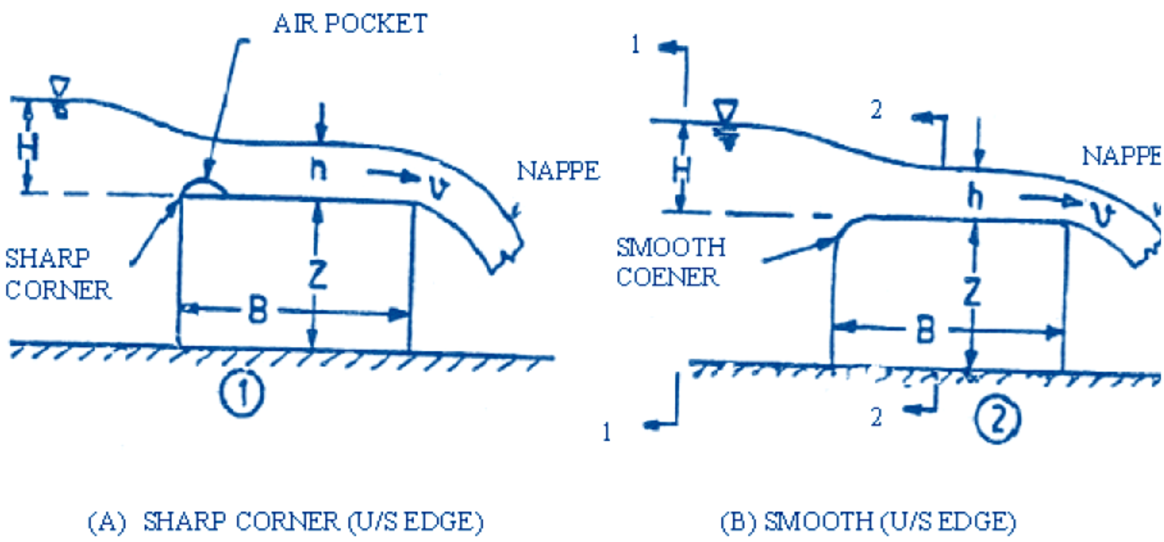

Figure 1 Broad Crested Weir (A) sharp corner (B) Smooth corner

OBSERVATION & CALCULATION

Width of flume, b =
Length of broad crested weir, L =
Width of broad crested weir B =
Pointer gauge reading of crest of broad crested wire, h_1 =
Dimensions of collecting tank, =
Area of collecting tank, =

Table 1 Observation table Discharge through Broad crested weir

Sr. No.	Discharge Measurement				Pointer reading for head over broad crested weir h_2 (cm)	Head over the broad crested weir $h_1 - h_2$ = H (cm)	Coefficient of discharge, C_d
	Initial (cm)	Final (cm)	Time, t (sec)	Discharge V/t = Q (m^3/s)			
1.							
2.							
3.							
4.							
5.							
6.							

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Sample Calculations: -

If V is volume of water (in m^3) collected in t second then discharge, $Q = V/t$ in m^3/s.

If h_1 = pointer gauge reading over the crest of the weir and h2 is the pointer gauge reading for head over the Broad Crested weir, then

$$H = h_1 - h_2$$

Coefficient of discharge can be determined as, $C_d = Q/(1.7LH^{3/2})$.

Graphs: -

1. On an ordinary graph paper, plot the profiles of flow over the broad crested weir.
2. On a log-log graph paper, plot H v s Q with H on A-axis and Q on Y-axis.

RESULT

Mean Coefficient of discharge for the broad crested weir, C_d = ……………………

PRECAUTION

1. Pointer gauge reading must be taken at a section where the water surface has no curvature.
2. To measure discharge, sufficient quantity of water must be collected.

QUESTIONS

1. What is a weir?
2. When the crest of a weir can be called broad?
3. Why do you provide rounded corners on the U/S of broad crested weir?
4. What is the basic difference regarding the flow over a sharp crested and broad crested weir?
5. How is a weir different from a dam?
6. What is the practical use of a weir?
7. What is the value of coefficient of discharge for a broad crested weir?

REFERENCES

1. IS: 13084 (1991): Liquid Flow Measurement in Open Channels - Round-nose Horizontal Broad-crested Weirs
2. Fluid Mechanics and Hydraulic Machines by Dr. R.K Bansal.

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EXPERIMENT NO. 02

Hydraulic Jump on horizontal floor and Sloping Glacis

OBJECTIVE: -

To study the characteristics of a hydraulic jump on a horizontal floor and sloping glacis.

APPARATUS

- Hydraulic Tilting Flume
- Horizontal floor and Slope glacis Model

It consists of a glass-walled rectangular flume having a sluices gate at the inlet end, a tail gate at the downstream end, and top rails for the movement of pointer gauge. A sluice value is provided near the outlet end of the supply pipe. Scale is also required.

APPLICATIONS

When supercritical flow meets subcritical flow, there forms what is known as hydraulic jump which is accompanied by violent turbulence, eddy formation, air entrainment and surface undulations? Hydraulics jump is a very useful means to dissipate the excess energy of flowing water which otherwise would cause damages downstream. Consider the flow situation, in which section 1 is in supercritical zone and section 2 is in subcritical zone. Assuming the channel bed to be horizontal, friction force to be negligible and flow to be two dimensional, one can write, using the momentum equation,

$$P_1 - P_2 = \rho q (V_2 - V_1) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where, q = Q/B in which B is the width of channel and P represents the hydrostatic force. Writing down the values of P1 and P2 for rectangular channel, in Eqn. (1), one gets,

$$\rho g h_1^2 / 2 - \rho q h_2^2 / 2 = (V_2 - V_1) \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where, ρ is the mass density of water, from the continuity equation

$$q = V_2 h_2 = V_1 h_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Combining Eqn. (2) and (3) and then, solving for h_2/h_1 one obtains,

$$h_2 / h_1 = \frac{1}{2}\left[-1 + \sqrt{1 + 8F_{r1}^2}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

In which $F_{r1} = V_1 / \sqrt{g h_1}$ and is termed as Froude's Number of the incoming flow at section 1. h_2 and h_1, as related by Eqn. 4, are known as conjugate or sequent depths. A jump forms when Eqn. 4 is satisfied.

Because of eddies (or rollers), and flow decelerations that accompany the jump, considerable head loss occurs. This loss, h_n may be calculated by using the energy equation, thus,

$$h_n = (h_1 + V_1^2 / 2g) - (h_2 + V_2^2 / 2g) \ldots\ldots\ldots\ldots\ldots (5)$$

From Eqn. (3) and (5), it can be shown that,

$$h_n = (h_2 - h_1)^3 / 4 h_1 h_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Height of jump, h_j is defined as the difference between the depths after and before the jump, i.e.

$$h_j = h_2 - h_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

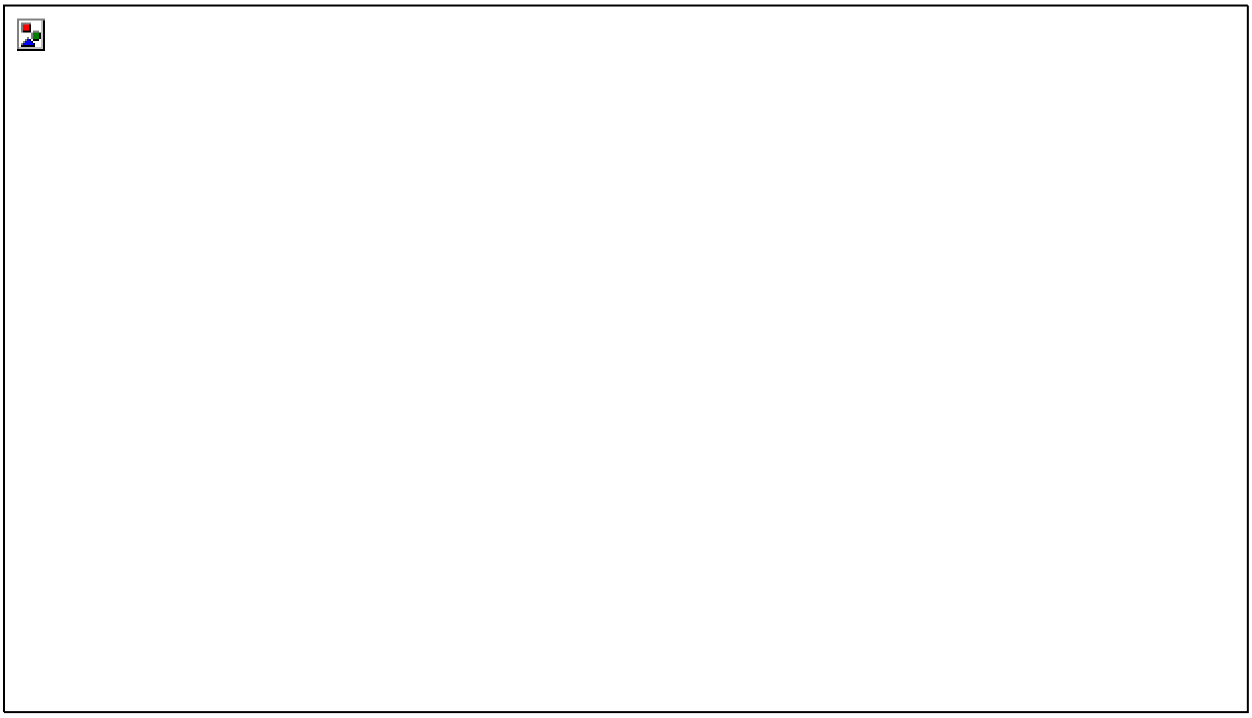

Figure 2 Hydraulic Jump

PROCEDURE:

1. Adjust the supply value, sluice gate and the tall gate so that there forms a stable hydraulic jump in the flume.
2. Take the pointer gauge readings for the bed level and water surface elevations at pre-jump section and post-jump section.
3. Measure the discharge.
4. Repeat steps (1) to (3) for other positions of valve, sluice gate and tail gate.

OBSERVATION & CALCULATION

Dimensions of the collecting tank, width = ………… mm,
Breadth = ………… mm
Plan area of the collecting tank, A = ……….. mm²

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Table 2 Observation Table for Hydraulic Jump

Run No. ↓	Discharge measurement				Pre-jump depth h_1	Post-jump depth h_2	$V_1 = Q/Bh_1$	h_2/h_2	$V_2 = Q/Bh_2$	$F_{r1} = V_1/\sqrt{gh_1}$	$E_1 = h_1+V_1^2/2g$	$E_2 = h_2+V_2^2/2g$	H_1/E_1	H_2/E_2
	Initial level H_1	Final level H_2	Time T sec)	Discharge Q (m^3/s)										
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Unit →														
1														
2														
3														
4														
5														

Computations: -

Calculate discharge in Col.5. Velocities before jump and after jump are determined in columns 8 and 10 respectively. Then calculate Froude's no. before jump. Obtain values specific energy before and after jump in columns 12 and 13.

RESULT

Graphs to be prepared:

1. Plot h_2/h_1 v/s F_{r1} on an ordinary graph paper. On the same plot also draw the line represented by Eq. 4.
2. Prepare a graph between h_1/E_1 v/s h_2/E_2 for various values of F_{r1}.

PRECAUTION

1. Take measurement carefully without error.
2. Operation of sluice gate with safety.

QUESTIONS

1. Differentiate between hydraulic jump and standing wave.
2. How does length of friction blocks affect the formation of hydraulic jump?
3. How is hydraulic jump useful in practice?
4. How is conjugate depth different from alternate depth?

REFERENCES

1. Fluid Mechanics and Hydraulic Machines by Dr. R.K Bansal.

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EXPERIMENT NO. 03

Manning's Coefficient of Roughness

OBJECTIVE

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

APPARATUS

- Hydraulic Tilting Flume
- Artificially made rough plate in the tilting flume.
- Trowel

APPLICATIONS

An open channel said to be uniform if the depth of flow does not change from section to section at any instant of time. This means that the depth everywhere in the reach under consideration is the same at any instant of time. One primary condition for the uniform flow to exist is that the driving force is equal to the resisting force.
For uniform flow in open channel, the men velocity, V is given as

$$V= (1/N)\ m^{2/3}\ i^{1/2}$$

Where, N is the manning's coefficient of roughness, m is the hydraulic radius and i the slope of the channel bed.

PROCEDURE

Place the artificially roughened in the central portion of the flume.

1. Select three different sections in the plate.
2. Open the supply valve; adjust the discharge and the tail gate so as to get a suitable valve of depth of flow in the flume.
3. Wait until the flow becomes uniform.
4. Measure the discharge by help the orifice meter provided in the discharge line.
5. Repeat step3 & step4 for other values of discharge.

OBSERVATION & CALCULATION

Width of the flume =
Slope of the flume =
Initial pointer gauge reading for
1. The bed level at section 1, y1. (cm) =
2. The bed level at section 2, y2. (cm) =
3. The bed level at section 3, y3. (cm) =

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Table 3 Observation Table of Manometer and Discharge

	Run no.	1	2	3	4
Discharge measurement	Left limb h1(cm)				
	Right limb h2(cm)				
	h =(h1-h2)				
	DISCHARGE , Q				

Table 4 Observation Table of Manning Coefficient

Pointer gauge for the water surface elevation at 1.section 1 2.section 2 3.section 3 Depth of flow at section 2 Y2=y2f-y2i Depth of flow at section 3 Y3=y3f-y3i Mean depth of flow Area of flow cross section, A=Bh Wetted parameter, P=B+2h Hydraulic radius, R=A/P Velocity of flow, V= Q/A Manning's coefficient Average value of roughness				

RESULT

Average value of roughness…… =
Manning's coefficient………… =

PRECAUTION

1. Reading must be taken in steady or nearby steady conditions.
2. Discharge must be varied very gradually from a higher to smaller values.

QUESTIONS

1. What is Manning's Coefficient of roughness?
2. What are the factors affecting Manning's roughness coefficient?

REFERENCE

1. Fluid Mechanics and Hydraulic Machines by Dr. R.K Bansal.

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EXPERIMENT NO. 04

Efficiency of Kaplan Turbine

OBJECTIVE

To study the characteristics of Kaplan Turbine.

APPARATUS

- Kaplan Turbine
- Tachometer

APPLICATIONS

Kaplan-type hydraulic turbine in which the positions of the runner blades and the wicket gates are adjustable for load change with sustained efficiency, it is a purely axial flow turbine with a vertical shaft disposition. Which was designed and developed by the Australian engineer Viktor Kaplan, Kaplan turbine has adjustable runner blades with less number of blades (i.e. 3 to 8 blades). Kaplan turbines are now widely used throughout the world in high-flow, low-head power production.
Victor Kaplan obtained his first patent for an adjustable blade propeller turbine in 1912. But the development of a commercially successful machine would take another decade. Kaplan struggled with cavitations problems, and in 1922 abandoned his research for health reasons.

Figure 3 Internal parts of Kaplan Turbine

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CONSTRUCTION DETAILS OF KAPLAN TURBINE

Components of the Kaplan turbine:-

- Scroll casing: – It is the cashing in which we pass the water to the runner in the turbine.
- · Guide vanes: – It is the blade in which guides the water and control the water passage (i.e. how much the water flow goes in the turbine).
- · Draft tube: – After passing through the runner, the water is discharged to the tail race through a gradually expanding tube.
- · Runner: – It is an important part of the turbine which is connected to the shaft of the generator and consist movable vanes and hub (boss).
- · Hub (Boss):- It is the part of the runner in which blades are mounted.

WORKING OF KAPLAN TURBINE

The Kaplan turbine is an inward flow reaction turbine, which means that the working fluid changes pressure as it moves through the turbine and gives up its energy. The design combines radial and axial features.

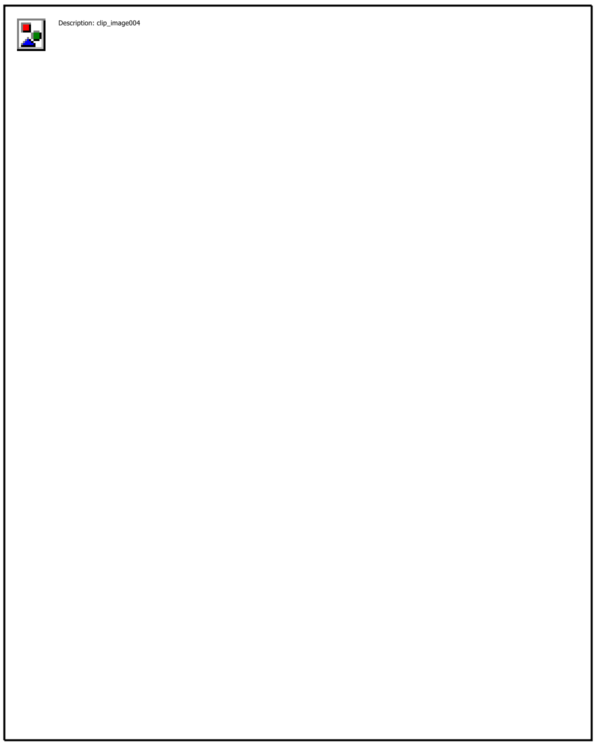

Figure 4 Section of a generator of Kaplan Turbine

The inlet is a scroll-shaped tube that wraps around the turbine's wicket gate. Water is directed tangentially, through the wicket gate, and spirals on to a propeller shaped runner, causing it to spin.

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The outlet is a specially shaped draft tube that helps decelerate the water and recover kinetic energy.

The turbine does not need to be at the lowest point of water flow, as long as the draft tube remains full of water. A higher turbine location, however, increases the suction that is imparted on the turbine blades by the draft tube. The resulting pressure drop may lead to capitation.

Variable geometry of the wicket gate and turbine blades allows efficient operation for a range of flow conditions. Kaplan turbine efficiencies are typically over 90%, but may be lower in very low head applications.

APPLICATIONS

- Kaplan turbines are widely used throughout the world for electrical power production. They cover the lowest head hydro sites and are especially suited for high flow conditions.
- Inexpensive micro turbines are manufactured for individual power production with as little as two feet of head.
- Large Kaplan turbines are individually designed for each site to operate at the highest possible efficiency, typically over 90%. They are very expensive to design, manufacture and install, but operate for decades.

VARIATIONS

The Kaplan turbine is the most widely used of the propeller-type turbines, but several other variations exist:
Propeller turbines have non-adjustable propeller vanes. They are used in low cost, small installations. Commercial products exist for producing several hundred watts from only a few feet of head.

PROCEDURE

1. Keep the runner vane at required opening (say 4/8th).
2. Keep the guide vanes at required opening (say 2.5/8th).
3. Prime the pump if necessary.
4. Close the main valve and then start the pump.
5. Open the valve for required discharge when the pump motor switches from 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 vacuum gauge readings.
9. Note the orifice meter pressure readings from manometer.
10. Repeat the experiments for other loads.
11. For constant speed tests, the main sluice valve has to be adjusted to vary the inlet head and discharge for varying loads (at given guide vane opening position).
12. The experiment can be repeated for other guide vane positions.

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OBSERVATION & CALCULATION

Guide Vane	= 2.5"	Input total head H	= 10 (P + V/760) m of water
Aero Foil	= 4/8"	Orifice meter dH	= 0.126 (h1 – h2) m of water
Orifice meter Const.	= 0.1013	Discharge Q	= 0.1013 $(dH)^{0.5}$ cu.m/sec
Brake drum dia	= 0.3 m	Input Power I	= 9.81 x Q x H KW
Rope dia	= 0.006 m	Brake drum net wt. T= (T1 – T2) kg	
Equivalent drum dia	= 0.306 m	Turbine output O = 3.14 x D x N x T/ (102 x 60) KW	
			= 0.000162 NT KW
		Efficiency	= Output/Input x 100 %

I. To determine discharge:

Orifice meter Manometer reading 1 = h1 m of Hg
Orifice meter manometer reading 2 = h2 m of Hg
Pressure difference (dH) = (h1-h2) × 12.6 m of water
Orifice meter equation (Q) = $0.1013\sqrt{dH}$ m^3/sec
Orifice meter inlet dia. (D) = 262mm
Throat dia. Ratio (B) = 0.76
Discharge (Q) = $Cd \times A \times B^2 \times \sqrt{(2 \times 9.81 \times dH) / (1 - B^4)}$

Where, Cd – Orifice discharge coefficient- 0.6 and A is inlet area – $3.14 \times D^2/4$

II. To determine inlet head of water:

Turbine Pressure gauge reading = P kg/cm^2
Turbine vacuum gauge reading = V mm of Hg
Total Head H = 10(P+V/760) m of water

III. Input to the turbine:

Input Power = 1000 QH/75HP
= 9.81QH KW

IV. Turbine Output:

Brake drum diameter = 0.40m.
Rope diameter = 0.01m.
Equivalent drum diameter = 0.415m.
Weight on spring balance 1 = T_1 kg.
Weight on spring balance 2 = T_2 kg.
Resultant load - T = $(T_1 – T_2)$ kg.
Speed of the turbine = N rpm.
Output Power = (3.14×D×N×T)/ (75×60) HP
= (3.14×D×N×T)/ (102×60) KW
= 0.000162 NT KW

Turbine Efficiency = $\frac{\text{Output}}{\text{Input}}$

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Table 5 Observation Table of Kaplan Turbine

Sl. No.	**Inlet Pressure P Kg./sq. cm**	**Outlet Vacuum V mm of Hg**	**Total Head H m of water**	**Orifice meter manometer readings**			**Flow rate Q cu. m/sec**	**Speed N rpm**	**Wt. on spring balance T1 kg**	**Wt. on spring balance T2 kg**	**Net Wt. T kg**	**Turbine Output O KW**	**Turbine Input I KW**	**Efficiency %**
				h 1 cm of Hg water	h 2 cm of Hg	dH m of water								

RESULT

Efficiency of Kaplan turbine= %

PRECAUTION

1. Reading must be taken in steady or nearby steady conditions.
2. Discharge must be varied very gradually from a higher to smaller values.

QUESTIONS

1. What type of flow is used in Kaplan turbine?
2. How many blades are in Kaplan turbine?
3. What is mean of Efficiency of Kaplan Turbine?

REFERENCE

1. Fluid Mechanics and Hydraulic Machines by Dr. R.K Bansal.

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EXPERIMENT NO. 05

Pelton Wheel Turbine

OBJECTIVE

To study the characteristics of Pelton Wheel Turbine.

APPARATUS

- Pelton wheel Turbine
- Tachometer

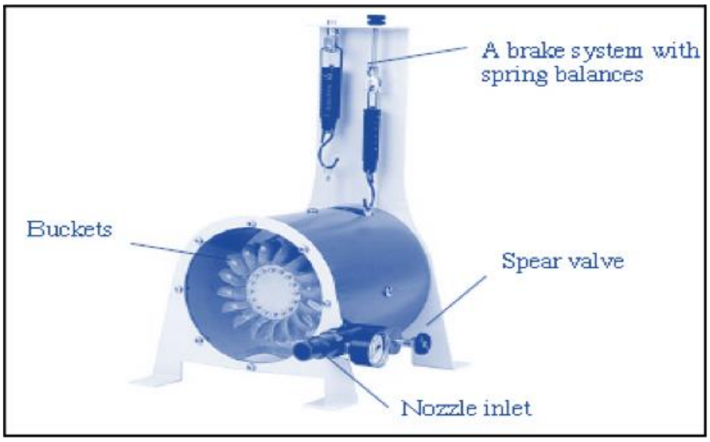

Figure 5 Pelton Wheel Turbine Internal Section

APPLICATIONS

Pelton turbine is an impulse Turbine used to utilize high heads of water for generation of electricity. All the available pressure head is converted into kinetic energy by means of a spear and nozzle arrangement. The water leaves the nozzle in jet formation. The jet of water then strikes the buckets of the Pelton wheel runner. These buckets are in the shape of double cups, joined at the middle portion in a knife- edge. The jet strikes the knife – edge of the buckets with least resistance and shock. Then the jet glides along the path of the cup, and the jet is deflected through more than 160 to 170 deg. While passing along the buckets, water is deflected causing a change in momentum of the water jet and hence an impulsive force is supplied to the cups. As a result, the cups attached to the runner moves, rotating the shaft. The specific speed of the Pelton wheel varies from 10 to 100.

The Pelton wheel is supplied with water under high pressure by a centrifugal pump. The water flows through a Venturimeter to the Pelton wheel. A gate valve is used to control the flow rate to the turbine. The Venturimeter with pressure gauges connected to is used to determine the flow rate of water in the pipe. The nozzle opening can be decreased or increased by operating the spear wheel at the entrance side of turbine.

The Turbine is loaded by applying tension to the brake drum belt. The inlet head is read from the pressure gauge. The speed of the turbine is measured with a tachometer.

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PROCEDURE:

1. Keep the nozzles opening at about 3/8th open position.
2. Prime the pump if necessary.
3. Close the delivery gate valve completely and start the pump.
4. After the motor starter has changed to delta mode and the motor is running at normal speed, open the delivery gate valve until the Venturimeter pressure gauges indicate a differential pressure of about 0.6 kg/cm^2. com – this corresponds to the design flow rate.
5. Note the turbine inlet pressure in the pressure gauge fixed in the nozzle bend. If the pressure is higher or lower than 4.6 kg/cm^2 (design head is 46 m of water), adjust the delivery gate valve and/or nozzle opening to set to design inlet pressure. At the same time, ensure that the flow rate does not exceed the design value as large flow rates (indicated by larger pressure differences in the Venturimeter pressure gauges) will overload the motor.
6. Note the speed of the turbine.
7. Note the Venturimeter pressure gauge readings.
8. Load the turbine by increasing the tension in the belt by rotating the screw rod hand wheel. Open the brake drum cooling water gate valve for cooling the brake drum.
9. Repeat the experiment for different loads.

   For constant speed tests, at lower loads the flow rate and inlet pressure in reduced by closing the delivery gate valve.

OBSERVATION & CALCULATION

Nozzle opening	=	3/8”
Venturimeter Constant	=	0.0055
Brake drum dia.	=	0.4m
Rope dia.	=	0.015m
Equivalent drum dia	=	0.41m

Calculations:

Input total head H = 10(P) m of water

Venturimeter dH = 10(P1-P2)

Discharge Q =0.0055(dH)$^{0.5}$ m^3/sec

Input Power I = 9.81xQxH KW

Brake drum net wt. T = (T1-T2) Kg

Turbine output O = 3.14xDxNxT/(102x60) KW

= 0.000213NT KW

Efficiency = Output/Input x 100%

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Table 6 Observation of Pelton Wheel Turbine

Sl. No.	Inlet Pressure P Kg./sq. cm	Total Head H m of water	Venturimeter Pressure Gauge readings			Flow rate Q cu. m/sec	Speed N rpm	Wt. on spring balance T1 kg	Wt. on spring balance T2 kg	Net Wt. T kg	Turbine Output O KW	Turbine Input I KW	Efficiency %
			P 1 Kg./sq. cm	P 2 Kg./sq. cm	dH Kg./sq. cm								

Calculation:

I. To determine discharge:

Venturimeter line pressure gauge readings = P1 kg/sq.com

Venturimeter throat pressure gauge reading = P2 kg/sq.com

Pressure difference (dH) = (P1-P2) x 10 m of water

Venturimeter equation (Q) = $0.0055\ (dH)^{0.5}\ m^3/sec$

Note: Venturimeter inlet dia. (D) = 6.5mm

Throat dia. ratio (B) = 0.6

Discharge Q $= CdxAxB^2x\ (2x9.81xdH)/\ (1-B^4)^{0.5}$

Where, Cd-venturimeter discharge coefficient – 0.98

A – Inlet area – $3.14xD^{2/4}$

II. To determine Head:

Turbine Pressure gauge reading = P kg/sq.cm

Total Head H = Px10m of water

III. Input to the turbine:

Input = 9.81 QH KW

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IV. Turbine Output:

Brake drum diameter	=	0.40m.
Rope diameter	=	0.015m.
Equivalent drum diameter	=	0.415m
Weight on spring balance 1	=	T1 g.
Weight on spring balance 2	=	T2 Kg.
Resultant load - T	=	(T1 – T2) kg
Speed of the turbine	=	N RPM
Turbine Output	=	(3.14xDxNxT)/(102x60)KW
Turbine Output	= 0.000213 NT KW	

RESULT

Efficiency of a palton wheel Turbine = %

PRECAUTION

1. Reading must be taken in steady or nearby steady conditions.
2. Discharge must be varied very gradually from a higher to smaller values.

QUESTIONS

1. What type of flow is used in Pelton Wheel turbine?
2. How many blades are in Pelton Wheel turbine?
3. What is mean by Efficiency of Kaplan Turbine?
4. Which principle of applicable of Pelton Wheel turbine?

REFERENCE

1. Fluid Mechanics and Hydraulic Machines by Dr. R.K Bansal.

https://doi.org/10.5281/zenodo.6612674

EXPERIMENT NO. 06

Scouring Phenomenon around a Bridge Pier

OBJECTIVE

To study the scouring phenomenon around a bridge pier.

APPARATUS

- Hydraulic Tilting Flume
- Bridge pier Modal

APPLICATIONS

Rivers are natural flowing systems, which cannot be controlled by man-made structures. Construction of a bridge pier across a river obstructs the flow. The flowing water in the river erodes the sediment around the bridge piers and the process of erosion is known as scour. All bridges and structures associated with waterways are potentially at risk of failure from hydraulic scour.

Scour

It is the lowering of the level of the river bed by the erosive action of the flowing water resulting in exposing the foundations of a bridge. The amount of this reduction below an assumed natural level is termed the depth of scour or scour depth.

General Scour

It occurs irrespective of the existence of the bridge and can occur as long term or short term scour.

Constriction Scour

It may occur if the bridges or it approaches cause a constriction of flow.

Local Scour

It results directly from the impact of the structure on the flow it can occur as either clear water Scour or live bed scour. Both constrictions as well as local scour are also localized scour. The local scour is a function of the type of structure.

Total Scour = General scour + Constriction Scour + Local Scour

(i) Clear Water Scour
    It occurs when the bed material on the upstream side of scour at rest.

(ii) Live Bed Scour
    It occurs when there is general sediment transport by the river.

Mechanism of Scour

The major cause of local scour around a bridge pier is a primary horseshoe vortex occurring at leading edge of the pier. It is a forced vortex occurring due to three-dimensional separation of the flow at the sediment-water-pier interaction junction.

It has established and acknowledged by almost all investigators on the subject that development of an adverse pressure gradient at the upstream of a flow structure-bed interaction junction causes a three dimensional separation of flow. Because of the separation, a shear layer rises towards the pier, causing a reverse roller in the lower filaments. This ground roller divides and spirals downstream past the pier due to oncoming approach low and high velocities on both the sides of the pier. The ground roller together with spiral downstream motion is known as the horseshoe vortex system because of its shape in plan.

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The horseshoe Vortex is responsible for scrapping sediment from in front of the pier and releasing it downstream of the pier.

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PROCEDURE

1. To start the experiment on a day, the sediment bed was leveled along the flow direction.
2. Then Pier model was firmly inserted in the sediment bed in such a way that it may not fall due to impact of flowing water even after development of scour hole.
3. After inserting the pier model into the sediment bed then the flow was started.
4. Scour depth readings were taken by pointer gauge generally at the time of 1, 3, 5, 8, 10, 15, 20, 25 and 30.
5. The static profile of the scour hole on the sediment bed was recovered by taking readings along lines drawn at 0º, 90º and 180º of the cylindrical pier, with respect to external surface of the pier.

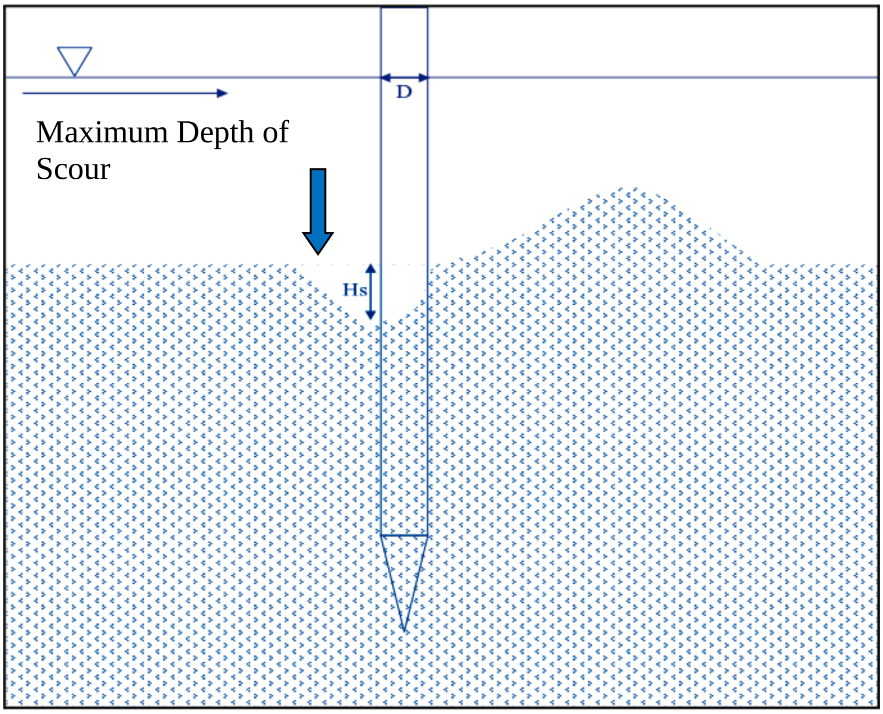

Figure 6 Scouring around Bridge Pier

OBSERVATION & CALCULATION

Measure the Depth of Scouring Around = mm

RESULT

Scour Depth = mm

PRECAUTION

1. Reading must be taken in steady or nearby steady conditions.
2. Discharge must be varied very gradually from a higher to smaller values.

REFERENCE

1. Fluid Mechanics and Hydraulic Machines by Dr. R.K Bansal.

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EXPERIMENT NO. 07

Scouring Phenomenon for Flow past a Spur

OBJECTIVE

To study the scouring phenomenon for flow past a spur

APPARATUS

- Hydraulic Tilting Flume
- Flow past Spur

The set –up consists of a rectangular channel having loss coarse material (which can result in sufficient scour for the available flow conditions on the bed). A slot is suitably provided downstream of the entrance section on one of the side walls of the channel. An iron sheet simulating a spur is inserted in this slot at a desired angle. The angle of spur can be varied by using different spur sheets. Arrangements for controlling and measuring the discharge should also be provided

APPLICATIONS

Spurs are used as river training devices. When the flow has to be diverted to a desired path (For bank protection) a spur or a series of spurs can be used for the purpose. These are built transverse to the river flow extending from a bank into the river to the required extent. Scour is invariably caused around the spur. The Extent of the scour depends on flow characteristics, channel characteristics, sediment characteristics and geometric characteristics of the spur (including the angle that the spur makes with the bank) Downstream of the spur and in the vicinity of the bank from which it projects; there exists a separation pocket the length of which is termed as the protected length. .

PROCEDURE:

1. Level the channel bed.
2. Establish uniform flow conditions. Insert one of the spur sheets at desired angle.
3. Note the scour depth d s at different times for about 30 minutes at which time equilibrium scour depth may be assumed to have reached. Also measure the profile of scour.
4. Measure the discharger.
5. Using paper pieces or aluminum powders find the extent of separation pocket and thus the protected length.
6. Repeat steps 1 to 5 for other spur sheets at different angles.

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Graphs to be prepared: -

1. Plot scour depth, Ds v/s time, t for all the spurs steadied.

Also plot the profile of scour in the form of contours and side sections and brought to a position on the potentiometer such that the signal on oscilloscope has minimum possible width (zero position) on voltage scale.

1. On the same potential we can also find equipotential lie without disturbing the null switch in nearby areas.
2. Place the probe at the other grid points successively and note down x,y and the corresponding %age of voltage.
3. Once the exact patterns of equipotential line are obtained, the streamlines can be drawn by graphical method.
4. Remove the copper plates from these sides to the other sides. However, by reversing the process and making the flow boundaries out of the conducting material and the end equipotential lines from non-conducting material, another set of equipotential lines can be obtained.
5. Repeat the step from 4 to 8.

Figure to be prepared:

On the graph sheet sketch the plan of the model for which observations were taken. Mark on it with pencil, the grid point numbers and corresponding %age of potential .Draw the lines by interpolation, representing 25%, 50%, and 75% potential lines. The boundaries A and A' of the model, are lines for 100% and 0% potential. Similarly, for sketching another set of equipotential lines, the boundaries B and B' are to be treated as lines of 100% and 0% potential. The voltage interval is to be so chosen that the plot results into two sets of equipotential lines intersecting orthogonally and the figures so formed are approximately square. This completes the drawing of the flow of net.

OBSERVATION & CALCULATION

Sketch the flow geometry on a graph sheet and mark on it the grid point numbers.

Table 7 Observation Table of Flow past Spur

Grid point No.	**X**	**Y**	**Voltage when copper plates are at**		**Grid point No.**	**X**	**Y**	**Voltage when copper plates are at**	
			A-A'	B-B'				A-A'	B-B'
1. **2.** **3.** **4.**									

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EXPERIMENT NO. 08

Triangular Weir

OBJECTIVE

To calibrate triangular weir

APPARATUS

- Notch Apparatus
- Triangular weir modal

A triangular weir is fixed in a small steel flume. Supply to this flume is made through a supply pipe in which a valve is fitted to regulate the supply. To dampen the fluctuations in the water level in the flume, two or more screens are placed immediately downstream of the flow inlet section. Other equipment needed is a pointer gauge (to measure the head H).

APPLICATIONS

A weir is used for the measurement of discharge in free surface flows. A weir is an orifice placed at the water surface so that the head on its upper edge is zero. Hence, the upper edge can be eliminated, leaving only the lower edge named as weir crest. A weir can be of different shapes- rectangular, triangular, trapezoidal etc. A triangular weir is particularly suited for measurement of small discharges.

The rate of flow over a triangular weir mainly depends on the head H, relative to the crest of the weir; measured upstream at a distance about 3 to 4 times H from the crest. For a triangular weir with its apex angle Φ, the rate of flow Q is obtained from the equation,

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

Here Cd is termed the coefficient of discharge of triangular weir.

PROCEDURE

1. Open the supply valve so that water flows over the weir. Let the flow stabilize.
2. Note the water surface level with the pointer gauge (pointer gauge should be located at about 3 to 4 times the likely maximum head over the weir).
3. Measure the discharge.
4. Repeat steps 1 to 3 for different values of discharges.

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OBSERVATION & CALCULATION

Initial reading of the pointer gauge (when water level is at the weir crest level) Gi =
Apex angle of the triangular weir Ǿ =

Table 8 Observation Table of Triangular Weir

Run No. ↓	Discharge Measurement				Head measurement		Cd
				Q	Gr	H = Gr - Gi	
Unit →							

Gr is the final water surface reading on the pointer gauge.

RESULT

Average value of Cd =

Plot Q (on Y axis) v/s H on a log –log graph paper. Fit in a straight line with a slope of 2.5 for the plotted data points. This is the calibration graph of the given triangular weir. Select a point on the straight line and the substitute its coordinates Q and H in the discharge equation, and obtain the average value of Cd.

PRECAUTION

1. Pointer gauge reading must be taken at a section where the water surface has no curvature.
2. To measure discharge, sufficient quantity of water must be collected.

QUESTIONS

1. What is a weir?
2. When the crest of a weir can be called broad?
3. Why do you provide rounded corners on the U/S of broad crested weir?
4. What is Cavitations?
5. What is the basic difference regarding the flow over a sharp crested and broad crested weir?
6. How is a weir different from a dam?
7. What is the practical use of a weir/
8. What is the value of coefficient of discharge for a broad crested weir?

REFERANCES

1. Fluid Mechanics and Hydraulic Machines by Dr. R.K Bansal.

https://doi.org/10.5281/zenodo.6612674

EXPERIMENT NO. 09

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

OBJECTIVE

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

APPARATUS

It consists of a glass walled horizontal rectangular flume about 4mlong,0.2m wide, and 0.40m deep having a honey comb wall at the inlet end, tail gate at the outlet end, and top rails for the movement of pointer gauge . Two suitably curved wooden humps of about 25 mm & 50 mm radius with their flat surface on the flume bed are used as humps pointer gauge and a scale are additional equipment needed

APPLICATIONS

Let a hump of small height Δz be placed on the bed of a rectangular channel carrying a discharge Q under uniform flow conditions as shown in fig. as a result of this, flow conditions In the vicinity of the hump are no more uniform. The specific energies E1 &E2 at sections 1&2 are related as follows

$$E2 = E1 - \Delta z$$

Where, $E1 = h_1 + v_1^2/2g + q^2/2gbh_1^2$

&

$$E_2 = h_2 + v_2^2/2g = h_2 + q^2/2gbh_2^2$$

In which, B is the width of channel. Here the energy loss between sections 1 &2 has been considered negligible.

By increasing value of Δz suitably, the flow conditions, for a given discharge, over the hump can be made critical i.e., Froude number, v2/ is unity. Let this height be Δz (Δz) c .if Δz exceeds (Δz) c .the flow conditions upstream will be modified and the flow conditions over the hump will be that of critical state. New conditions of flow on the upstream of the hump will be given as,

$$E1' = Ec + \Delta z$$

Where E_1' is the new value of E_1

If Δz< (Δz) c, the upstream condition remain unaffected &eq 31.1holds good, if Δz = (Δz) c, the upstream conditions remain unchanged but the flow over the hump is in critical state then,

$$E2 = Ec = E1 - (\Delta z)\ c$$

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PROCEDURE

1. Establish uniform flow with depth flow about 150 mm in the flume by adjusting discharge and the tail gate position
2. Measure the depth of the flow in the absence of any hump at few locations from slightly upstream of the hump location to the downstream of the hump location along the center line of the flume
3. Place hump no.1 on the bed transverse to the flow leaving no gap between the flume boundary and the hump
4. Take pointer gauge readings for water surface and bed elevations at different stations upstream and downstream of the hump along the center line of the flume
5. Measure the discharge
6. Replace hump no.1 by hump no.2 and recent steps (4) and (5)

OBSERVATION & CALCULATION

Discharge, Q =
Width of flume, b =

Table 9 Observation Table of Flow over a hump in an Open Channel

Location (x)								
H								
V=q/bh								
$E=h+v^2/2g$								

Location (x)	Hump no.1		Hump no. 2	
	Depth (h)	Sp. energy E	Depth (h)	Depth (h)

Figure to prepared and further computations
Plot on a graph paper the following;
(1) The longitudinal water surface profile showing the hump on the bed
(2) The specific energy curve E v/s h for the discharge, q using $E=h+[q^2/(2gA^2)]$
(3) The experimental observation on E v/s h curve.

RESULT

PRECAUTION

1. Pointer gauge reading must be taken at a section where the water surface has no curvature.
2. To measure discharge, sufficient quantity of water must be collected.

QUESTIONS

REFERANCES

1. Fluid Mechanics and Hydraulic Machines by Dr. R.K Bansal.

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EXPERIMENT NO. 10

Flow Over a free over fall in an Open channel

OBJECTIVE

To study the characteristics of flow over a free overfall in a channel and also to determine the end depth.

APPARATUS

It consists of a glass-walled rectangular flume about 3 m long 20 mm wide, and 30 mm deep having a honeycomb wall at the entrance and top rails for the movement of the pointer gauge . A sluice valve is provided near the outlet end of the supply pipe. Pointer gauge and a scale are also required.

APPLICATIONS

When the bottom of a channel is discontinued, as shown in fig. 35.1, the specific energy concepts indicate that the section of minimum energy should be the critical flow section and, hence, the depth of flow at the end of the channel (section of minimum energy) must be equal to the critical depth. In practice, however, this is not true. Rouse has found that for rectangular channels, the critical depth, h_c obtained on the basis of parallel flow assumption, occurs a short distance (3 to 4 h_c) upstream from the channel end and the end of depth h_e (also known as brink depth and is the "true" critical depth) is about 71.5% of the critical depth h_c. This departure theoretical prediction is on account of the fact that the specific energy derivations are based on the assumption of parallel flow and are only approximately applicable to situations, such as in the vicinity of a fall, where the streamlines are curvilinear, as a result of which the pressure distribution is non-hydrostatic.

PROCEDURE

1. Take pointer gauge readings for the flume bed elevation along the centre line of the flume starting from the fall (i.e. end of the channel) to well upstream where the flow will become almost uniform even for the highest value of available discharge.
2. Open the sluice valve and let the flow become steady.
3. Take pointer gauge readings for the flume bed elevation along the centre line of the flume starting from the brink to sufficiently upstream where the flow is almost parallel. Also measure the discharge.
4. Repeat steps 2 and 3 for other different openings of the sluice valve.

Note: Sections for taking the pointer gauge readings in steps 1 and 3 above should, preferably the same.

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OBSERVATION & CALCULATION

Width of flume, B =

Table 10 Observation Table of Flow over a free over fall in a channel

Run No.													
Discharge Q													
q = Q/B													
hc = $(q^2/g)^{1/3}$													
x	hi	hf	h = hf – hi	h/hc	x/hc	hf	h=hf-hi	h/hc	x/hc	hf	h=hf-hi	h/hc	x/hc

x = Distance upstream of fall
hi = Pointer gauge reading for elevation of flume bed
h = Depth of flow
hf = Pointer gauge water surface elevation

RESULT

Plot h/hc v/s x/hc on a simple graph paper for all three runs. Here hc = $(q^2/g)^{1/3}$.

PRECAUTION

1. Pointer gauge reading must be taken at a section where the water surface has no curvature.
2. To measure discharge, sufficient quantity of water must be collected.

QUESTIONS

REFERANCES

1. Fluid Mechanics and Hydraulic Machines by Dr. R.K Bansal.

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EXPERIMENT NO -11

Computerized Gear Pump

OBJECTIVE: - To Study the characteristics of gear pump.

APPARATUS

- Gear Pump

INTRODUCTION:

In general, a pump may be defined as a mechanical device which, when interposed in a pipe line, converts the mechanical energy supplied to it from some external source into hydraulic energy, thus resulting in the flow of liquid from lower potential to higher potential.

The pumps are of major concern to most engineers and technicians. The types of pump vary in principle and design. The selection of the pump for any particular applications is to be done by understanding their characteristics. The most commonly used pumps for domestic, agriculture and industries are; Centrifugal, Piston, Axial flow (stage pumps), Air jet, Diaphragm and Turbine pumps. Most of these pumps fall into the main class, namely; Rotodynamic, Reciprocating (positive displacement), Fluid (air) operated pumps.

While the principle of operation of other pumps is discussed elsewhere, the gear pump which is of present concern falls into the category of Rotodynamic pumps. In this pump, the liquid is made to rotate in a closed chamber. This pump consist of two identical inter meshing spur pinions working in a fine clearance inside a casing. One of the pinions keyed to driving shaft. Alternatively one of the pinions can be integral with the driving shaft. The other pinion revolves idly. These pumps compared to reciprocating pumps are simple in construction, more suitable for handling viscous, turbid (muddy) liquids, can be directly coupled to high speed electric motors (without any speed reduction) & easy to maintain. But, their hydraulic heads at low flow rates is limited, and hence not suitable for very high heads compared to reciprocating pump of same capacity. The present testing allows the students to understand and draw the operating characteristics at various heads, flow rates and speeds.

SPECIFICATIONS:

* Electrical Services	:	230V, 15A, 1ph, 50Hz, AC with Neutral & Earth connection.
* Pump	:	Gear pump and Vane pump, 1HP. Maximum Speed-2440 rpm.
* Pressure Gauges	:	0-7 Kg /cm^2 range connected before Delivery valve.
* Vacuum Gauge	:	0-760mm of Hg, connected after suction valve
* Energy Meter	:	Single Phase, Energy meter constant: 3200 Rev/KW-Hr.
* Speed Indicator	:	0-9999 RPM (Digital Type).
* Control Valves	:	Suction and Delivery.
* Total Head	:	8 – 12 m.
* Collecting Tank	:	with Butterfly valve.

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DESCRIPTION:

The present test rig is a self-contained unit operated on closed circuit basis. The pump, electric AC motor, collecting-measuring tank set, control panel are mounted on rigid frame work with anti-vibration mounts. The following are the provisions incorporated with the unit.

1. For conducting the experiments at three or two speeds using AC Motor.
2. The speed is indicated on digital RPM indicator with selector switch
3. To measure overall input power to the AC Motor using Energy meter.
4. The delivery and suction head are measured by using pressure & vacuum gauges.
5. For changing the Pressure (Delivery Head) and Vacuum (Suction Head) by operating the valves.
6. The flow rate is calculated using measuring (collecting) tank.
7. The overflow and butterfly valve are provided in collecting / measuring tank for recirculation of water for closed circuit operation.
8. Change the belt to different speed positions and repeat the experiment.
9. Repeat the experiment for the different Discharge

CONTROL PANEL FRONT CONSISTS OF:

1. M.C.B with MAINS ON INDICATOR
2. CONSOLE ON SWITCH
3. SELECTOR SWITCH for MOTOR direction
4. ENERGY METER (3200 rev/ kw-h)
5. PRESSURE GAUGE
6. VACCUM GAUGE (0-760mm of Hg).
7. DIGITAL RPM INDICATOR WITH SELECTOR SWITCH

COLLECTING TANK:

- AREA 0.115m^2.
- Over flow provision in case of excessive collection of water.
- Butterfly valve for closing and opening of water instantaneously to the sump tank.

[Note: Every cm raise of water equals]

OPERATING INSTRUCTIONS:

All the necessary instrumentation along with its accessories is readily connected. It is just enough to follow the instructions below:

Fill the sump tank with clean oil (SAE20-40).

1. Keep the delivery and suction valves open.
2. Connect the power cable to 1 ph, 220V, 15 Amps.
3. Select the Pump on which experiment to be conducted by changing selector switch position and set required speed using step cone pulley arrangement.
4. Keep the delivery valve fully open after priming.
5. Switch-ON the Mains, MCB so that the Mains-ON indicator glows. Now switch-ON the motor.

6. Note down the speed using digital RPM indicator using selector switch
7. Note down the pressure Gauge, Vacuum Gauge and time for number of blinks of Energy meter.
8. Operate the butterfly valve to note down the collecting tank reading against the known time, and keep it open when the readings are not taken.
9. Repeat the experiment for different openings of the delivery valve (Pressure and Flow rate), note down the readings as indicated in the tabular column.
10. Repeat the experiment for different speeds so that the pressure gauge reading are shown and repeat the steps (4 & 9).
11. After the experiment is over, keep the delivery valve open and switch-OFF the mains.
12. Calculate the results using formulae given and tabulate it.
13. Draw the graphs of Head Vs Discharge.

PRECAUTIONS

1. Don't start the pump if the voltage is less than 180V.
2. Don't forget to give neutral and earth connections to the unit.
3. Frequently (at least once in three months) grease/oil the rotating parts.
4. At least once in a week, operate the unit & avoid clogging of moving parts.
5. Don't exceed 4 kg/cm^2 on pressure gauge reading and never fully close the delivery valve.
6. In case of any major fault, it is suggested to contact the manufacturer before taking up any major repairs.

TABULAR COLUMN

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CALCULATION AND OBSERVATION

Table 11 Observation Table for Gear pump

Speed/valve position	Delivery Pressure "P" in Kg/cm^2	Suction Pressure "Pv" in mm of Hg	Time for "n"revsof energy meter, "t" in	Rise in water level R in mm	Time Taken "t"Sec	Total Head "H"in m	Discharge Qa in m^3/sec	Power output, P_{pump} in KW	Hp KW	Hp shaft in KW	Efficiency
1											
2											

FORMULAE TO BE USED:

Basic data / constants

1HP = 745 Watts

$1kg/cm^2$ = 760mm of hg (10m of water)

Density of water, =

1 Electrical power as indicated by Energy meter:

HP_{elec} = KW

HP_{shaft} = HP_{elec} in KW

n = Number of revolution of energy meter

t = is the time taken by the energy meter for n revolutions, in seconds.

0.70 Transmission Efficiency

2. Discharge Rate (Q) IN m3/sec.

Q = ……….cc/sec

Q = **m^3/s**

Where, (A) = $0.127m^2$ is the area of collecting tank.

(R) = the rise of level water collected in mm.

(T) = time taken in second s for R mm rise of water.

3. Total Head (H) in mtr.

$H = p_2 - p_1$

P_1 = Pressure at inlet section

P_2 = Pressure at outlet section

4. Hydraulic Power (Delivered by the pump)

HP pump =

Graph: - Total Head Vs Discharge.

EXPERIMENT NO- 12

Computerized Centrifugal Pump

OBJECTIVE: - To Study the characteristics of centrifugal pump.

INTRODUCTION:

In general a pump may be defined as a mechanical device which, when interposed in a pipe line, converts the mechanical energy supplied to it from some external source into hydraulic energy, thus resulting in the flow of liquid from lower potential to higher potential.

The pumps are of major concern to most engineers and technicians. The types of pump vary in principle and design. The selection of the pump for any particular applications is to be done by understanding their characteristics. The most commonly used pumps for domestic, agriculture and industries are; Centrifugal, Piston, Axial flow (stage pumps), Air jet, Diaphragm and Turbine pumps. Most of these pumps fall into the main class, namely; Rotodynamic, Reciprocating (positive displacement), Fluid (air) operated pumps.

While the principle of operation of other pumps is discussed elsewhere, the centrifugal pump which is of present concern falls into the category of Rotodynamic pumps. In this pump, the liquid is made to rotate in a closed chamber (volute casing) thus creating a centrifugal action which gradually builts up the pressure gradient towards outlet, thus resulting in the continuous flow. These pumps compared to reciprocating pumps are simple in construction, more suitable for handling viscous, turbid (muddy) liquids, can be directly coupled to high speed electric motors (without any speed reduction) & easy to maintain. But, their hydraulic heads at low flow rates is limited, and hence not suitable for very high heads compared to reciprocating pump of same capacity. But, still in most cases, this is the only type of pump which is being widely used for agricultural applications because of its practical suitability. The present testing allows the students to understand and draw the operating characteristics at various heads, flow rates and speeds, using different size of impellers.

SPECIFICATIONS:

* Electrical Services	:	230V, 15A, 1ph, 50Hz, AC with Neutral & Earth connection.
* Pump	:	Centrifugal pump (Kirloskar make), 1.5 HP.
	:	Maximum Speed-2880 rpm.
* Pressure Sensor	:	0-2 bar connected before delivery valve.
* Vacuum Sensor	:	-1-+1 bar, connected after suction valve
* Control Valves	:	Suction and Delivery.
* Speed Indicator	:	0-9999 RPM (Digital Type).
* AC Wattmeter	:	Single Phase, 0-9999 W (Digital Type).
* Total Head	:	8 – 12 m.
* Collecting Tank	:	0.127m^2 with Butterfly valve.

DESCRIPTION:

The present test rig is a self-contained unit operated on closed circuit basis. The pump, electric AC motor, collecting-measuring tank set, control panel are mounted on rigid frame work with anti-vibration mounts. The following are the provisions incorporated with the unit.

1. For conducting the experiments at three or two speeds using AC Motor and a drive controller.
2. The speed is indicated on digital RPM indicator.
3. To measure overall input power to the AC Motor using Wattmeter.
4. The delivery and suction head are measured by using pressure & vacuum sensors which are connected to a pressure scanner. For changing the Pressure (Delivery Head) and Vacuum (Suction Head) by operating the valves.
5. The flow rate is calculated using measuring (collecting) tank and flow sensor which is connected within the delivery line.
6. The overflow and butterfly valve are provided in collecting /measuring tank for recirculation of water for closed circuit operation.
7. Change to different speed positions by using the drive controller and repeat the experiment either manually or by using computer interface software.
8. Repeat the experiment for the different Discharge.

CONTROL PANEL FRONT CONSISTS OF:

1. Mains on
2. Console on
3. Wattmeter
4. AC drive controller
5. Flow indicator
6. Pressure scanner
7. Digital rpm indicator

COLLECTING TANK:

- Area 0.127m^2.

  [Note: Every cm raise of water equals]

- Over flow provision in case of excessive collection of water.
- Butterfly valve for closing and opening of water instantaneously to the sump tank.

Note:
Valve operation:

Clockwise rotation = Valve close
Anti-clockwise rotation = Valve open

HYPERTERMINAL CONNECTION

- Select the hyper terminal software provided in the cd.
- Connect the RS 485 cable to the equipment and the computer hardware either directly or by using a USB adapter.
- Once the Hyper terminal software is open, a dialog box is opened asking for the new connection.
- Type any characters in the name selection and select an icon.
- Once the name and icon is selected another dialog box will open asking the connect using option.
- Select the required COM port selection.
- Enter the following data in the com port selection
    - Bit per second : 9600
    - Data bits : 7
    - Parity : Even
    - Stop bits : 1
    - Flow control: None
- Select OK and press the CAPS LOCK on the keyboard and check for the connection
- If the connection is OK close and save the hyper terminal connection

OPERATING INSTRUCTIONS:

All the necessary instrumentation along with its accessories is readily connected. It is just enough to follow the instructions below:

1. Fill the sump tank with clean water.
2. Keep the delivery and suction valves open.
3. Connect the power cable to 1 ph, 220V, 15 Amps.
4. Meanwhile , switch -ON the Computer & keep it ready with the Observation Menu.
5. To go to Centrifugal pump test in computer follow the route, **Start** > **Programs** > **Centrifugal Pump** > **Application.**
6. Now on software screen click on the **Comm Sett** , Computer port setting dialog box will open, now select the required connected port and press OK.
7. After the computer port selection click on **Start Test** . A dialog box with the file name will be displayed, select the required file path and press OK. In the data indicator tab of the software all the values will start indicating as shown in the control panel.

8. Set the speed of the pump either by adjusting the knob in the control panel or in the software.

9. Keep the delivery valve fully open after priming.

10. Once all the values are displayed on the software as per the values indicated in the digital indicators of the control panel click **Log Data** and all the data will be logged in the data tabulation tab of the software along with performance graphs.

11. Log different values at different loadings by clicking **Log Data** Icon at different intervals.

12. As the test is running, the computer will carry out all the Calculations and Tabulations with the Menu Display . Repeat the same procedure for other speed condition.

13. To save the data click on the **Stop Test** and all the logged data will be saved in the defined file path (Excel file format) selected at the time of starting the test.

14. To retrieve the recorded data click on **View file**.. and select the file used and press OK. All the logged data will be displayed in the software along with the graphs. Use the arrow keys to view the combustion graphs at different loads.

15. After the experiment is over, keep the delivery valve open and switch-OFF the mains.

PRECAUTIONS:

1. Don't start the pump if the voltage is less than 180V.
2. Don't forget to give neutral and earth connections to the unit.
3. Frequently (at least once in three months) grease/oil the rotating parts.
4. At least once in a week, operate the unit & avoid clogging of moving parts.
5. Replace the water possibly once in a month.
6. Don't exceed 1.5 kg/cm^2 on pressure gauge reading and never fully close the delivery valve.
7. In case of any major fault, it is suggested to contact the manufacturer before taking up any major repairs.

FORMULAE TO BE USED:

Basic Data / Constants

1 HP	=	745 watts
1 kg/cm^2	=	760mm of Hg (10m of water)
Density of water," ρ_w"	=	9810 N/m^3
Area of Collecting Tank	=	0.127 m^2

Electrical Power as indicated by Energy Meter:

Hp_{elec} = ______ in KW.

1. Discharge Rate "Q" in m^3/sec.

Q = _____ cc/sec

Q = m^3/s

Where, "A" = 0.127m^2 is the area of Collecting Tank.

"R" = the Rise of level water collected in mm.

"T" = time taken in seconds for 'R' mm rise of water.

Total Head 'H' in mtr.

H $= p_2 - p_1$

P_2 = Pressure at outlet section

P_1 = Pressure at inlet section

Hydraulic Power (Delivered by the Pump)

HP_{Pump} **=** **KW**

Where, 'W' = 9810 N/m^3.

'Q' = From Formulae-3.

'H' = From Formulae-4.

2. Pump Efficiency.

%η_{pump} =

DATA DISPLAY AND TABULATION

Table 12 Observation Table of Centrifugal Pump

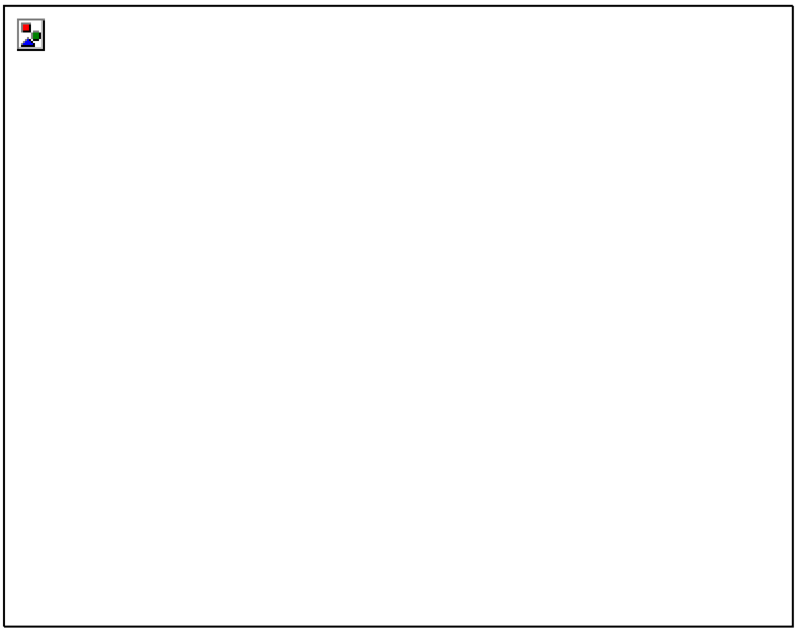
S. No.	Input Power (W)	Speed (RPM)	Flow Rate (LPM)	Suction Pressure (bar)	Delivery Pressure (bar)	Discharge (Cu.m/s)	Total Head (m)	Output Power (kw)	Efficiency (%)
1									
2									
3									
4									
5									
6									

<u>GRAPHS</u>

1. Speed vs Discharge.

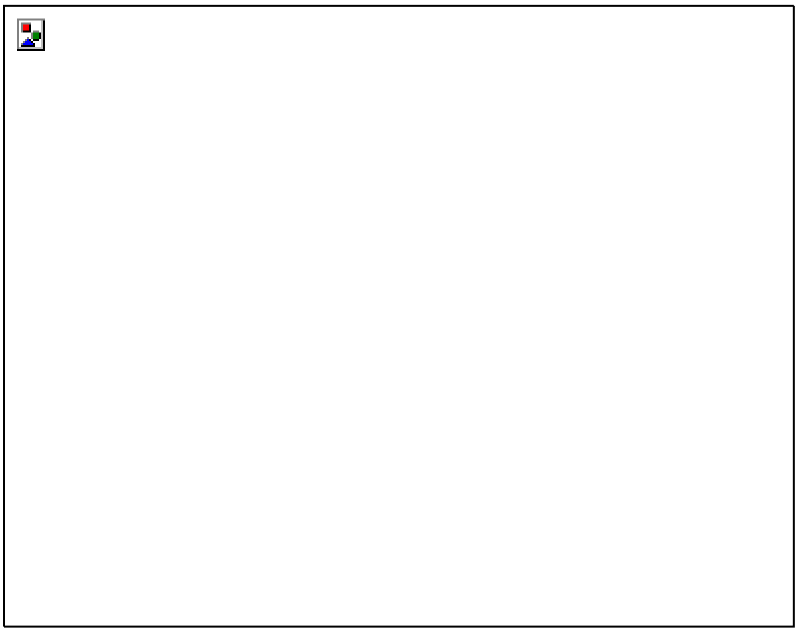
2. Speed vs Power output.

3. Speed vs Efficiency



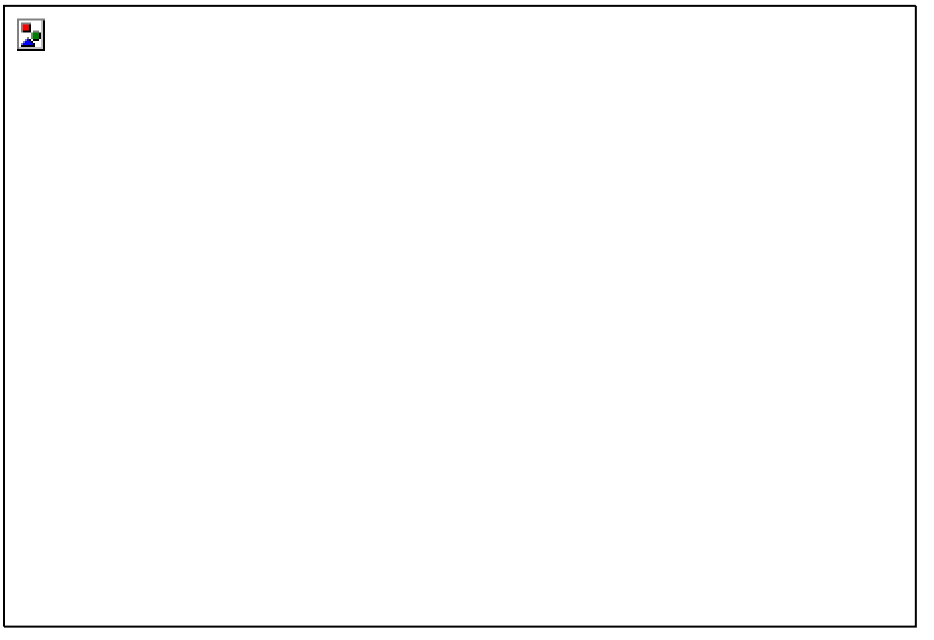
4. Power Output vs Efficiency

5. Power output vs Discharge.



6. Discharge vs Efficiency.

7. Discharge vs Total head.



8. Discharge vs Input power.