MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

CIVIL ENGINEERING DEPARTMENT
Fluid Mechanics Laboratory

STUDY OF FLOW CHARACTERISTICS OVER A BROAD CRESTED WEIR DETERMINATION OF COEFFICIENT OF DISCHARGE & LOSS COEFFICIENT

AIM:- To determine the coefficient of discharge of the broad crested weir.

APPARATUS:- A long open channel fitted with a broad – crested weir inlet pipe with a vlave for regulation of discharge, collecting tank, point gauge, stop watch.

THEORY AND SIGNIFICANCE:- If the dimension of the weir crest along the direction of flow (called its breadth) is greater thank twice the head causing flow, the weir is classified as a broad crested weir. In face, there being two limits to, upper and lower, it can be stated that for a broad crested weir $2H \leq 3H$.

A broad crested weir or a hump is one of the several examples of control section formation. A control section is defined as a section of critical depth. Since it represents the maximum possible flow for a given system it is of extreme importance to a design engineer.

PROCEDURE:-

1. Take the point gauge readings corresponding to the channel bed x_1 (mm) and the top of the broad crested weir y_1 (mm).
2. Open the inlet valve and allow a suitable low discharge initially. Note down the water surface elevations on the point gauge scale u/s (x_3 mm)
3. Collect 100 mm of water in the collecting tank and note down the time of collection t (s).
4. Gradually increase the discharge in six stages and repeat steps 2 and 3.

SPECIMEN CALCULATIONS:-

1. Height of weir above channel bed $h_w = (x_1 - x_2)/1000$ m
2. Head over the weir $H = (x_3 - y_1)/1000$ m
3. Volume of water collected = 0.064 m^3
4. Time of collection = t (s)
5. Discharge $Q_a = 0.064/t$ m^2/s
6. Area of the approach channel = area = $b \times (x_3 - x_1)/1000$
   Approach velocity $V_1 = Q_a/\text{area}$
   Velocity head = $V_12/2g$ and $Ho = H + V_12/2g$
7. $V_2 = Q_a/(b\ h)$

8. $Qt = 1.705 \times b \times H_o^{1.5}$

GRAPHS:- Plot the following graph

i) Q vs. H_o

PRECAUTIONS:-

1. Allow sufficient time for the flow to stabilize each time the discharge is increased or decreased.
2. The increase in discharge must be gradual and in approximately equal steps.

RESULT:-

1. Coefficient of discharge:
   Under free flow conditions Cd1 =

2. from log – log graph the value of K= ____ n = _____

NOTE:- Your record should also include (i) A neat dimensional sketch of the experimental set up (ii) comments on your results

Max. possible discharge (m^3/s)												
C_{d1}												
$Ho = H + V_1^2/2g$												

S.no	Channel bed level X_1 (mm)	Weir top level Y_1	u/s reading	Depth = $(X_1 - X_3)$	Vol. of water collected m^3	Time of collection (s)	Discharge Q (m^3/s)	V_1 = Q/area (m^3/s)	$V_1^2/2g$

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STUDY OF FLOW CHARACTERISTIC OF A VENTURI FLUME

AIM:- To study the characteristic of flow past a venture flume and to calibrate it.

APPARATUS:- A long open channel fitted with a venture flume, inlet pipe with valve collecting tank, point gauge and a stop watch.

THEORY AND SIGNIFICANCE:- A venture flume is used to create critical flow conditions. Such a condition corresponds to the maximum flow that can occur for a given system. Under critical flow condition the discharge carried but the stream becomes independent of the channel roughness and other uncontrolled factors.

In case of venture flume the critical flow conditions are obtained by means of lateral contraction of the channel. If the flow is critical a standing wave is formed on the down stream side of the contracted passage of throat. Such a flume is called a critical flow venture flume or the standing wave venture flume. Under this category the most extensive employed one is the Parshall flume designed by P.L PARSHALL in 1920.

However, the venture flume can also function in the absence of critical flow conditions. If such is the case a standing wave does not form on the down stream side of the throat.

The discharge equation is obtained by applying the continuity equation and equating the specific energies at the section 1-1 and 2-2.

$$A_1U_1 = A_2U_2$$

$E_s = d_1 + U_1^2/2g = d_2 + U_2^2/2g$

Solving these one obtained: $Q = \frac{A_1A_2 \times \sqrt{2gh}}{\sqrt{(A_1^2 - A_2^2)}}$

Where $h = (d_1 - d_2)$m

For maximum discharge, i.e. critical flow conditions the discharge equation becomes”

$$Q = 1.706\, b_2\, E_s^{3/2}$$

Where Es is the specific energy u/s side of the flume

The above equation are based on the assumption that there is no energy loss between the section 1-1 and 2-2 and the velocities are constant and normal to them. Calling this discharge as the theoretical discharge.

$$Q_a = C_d \times Q_t$$

Where C_d is the coefficient of discharge.

PROCEDURE:-

1. Open the valve and allow discharge into the channel.
2. Note down the normal and contracted channel widths, b_1 and b_2.
3. Keeping the point gauge in contact with the channel bed at sections 1-1 and 2-2 and note down the initial point gauge readings. Let them be x and y
4. Bring the point gauge in contact with the water surface at sections 1-1 and 2-2 and note down readings x_1 and y_1
5. Collect 10 cm of water in the collecting tank and note down the time of collection t s.
6. Repeat the experiment for six different discharges.

SPECIMEN CALCULATION:-

1. $d1 = (x - x_1)/1000$ and $d_2 = (y - y_1)/1000$
   Calculate the areas A_1 and b_1d_1 and $A_2 = b_2d_2$
   Calculate $h = (d_1 - d_2)$ m

2. Area of the collecting tank = 0.64 m^3.
   Time of collecting = t s.

3. Calculate the theoretical discharge Q_t.
4. Coefficient of discharge $C_d = Q_a/Q_t$.

GRAPH:- Plot the following graphs:

1. Q vs Es

RESULT:- Coefficient of discharge Cd =

Width of the channel b_1 = 0.25 m
Width of contraction b_2 = 0.10 m
Area of collection tank = 0.64 m^2
Height of collection = m
$g = 9.81$ m/s^2

Time of collectio	Actual discharg	A_1 (m_2)	A_2 (m^2)	Theoretical	Cd	Hydraulic jump	Velocity V vs (s)	$V^2/2g$	Specific energy	Theoretical	Cd

S.no	u/s point guage	u/s depth x_1 (mm)	Throat point	Throat depth y_1	Head h (m) d_1 –	Volume of water

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STUDY OF PERFORMANCE CHARACTERISTICS OF STANDING WAVE

AIM:- To study the characteristics of a standing wave or hydraulic jump.

APPARATUS:- A long horizontal rectangular flume (prismatic) with u/s and d/s control gates (sluice gates), collection tank, point gauge on a trolley (operation) and a stop watch.

THEORY AND SIGNIFICANCE:- The formation of hydraulic jump is a very interesting phenomenon in open channel flows, which was first described by the Italian engineer Bedone (1818) was the first researcher in this area.

A hydraulic jump is formed when a supercritical stream flow has it velocity changed reduced to sub critical. The super critical stream (also called rapid or torrential) jump up to its alternate depth, which will be the sub critical stream. The distinction between supercritical and sub critical flow is based on the Froude number defined as the ratio of the ratio of the internal forces to gravity forces and is computed by

$$Fr = U/\sqrt{gD}$$

Where
u = mean velocity of flow in m/s
D = hydraulic depth = A/T (m)
For a rectangular channel D = y
If

$Fr < 1$	flow if defined as sub critical
$Fr = 1$	flow is defined as critical
$Fr > 1$	flow is defined as super critical

TYPES OF A HYDRAULIC JUMP:-

The classification of hydraulic jumps in a rectangular channel based upon the initial Froude no. Fr1 as don't by

i) $1{:}0 < Fr1 < 1.7$ UNDULAR JUMP
For this : y2 is very small : $E/E1 = 0$

ii) $1.7 < Fr1 < 2.5$ WEAK JUMP
water surface is smooth after the jump $\Delta E/E1$ range from 5 to 18%

iii) $2.5 < Fr1 < 4.5$ OSCILLATING JUMP

every dissipation is moderate, being 45% at Fr1 = 4.5 no obstruction is designed to operate in

This range because of the uncertainty involved.

iv) $4.5 < Fr1 < 9.0$ STEADY JUMP
jump action is fully developed
$\Delta E/E1$ range from 45% to 70%

v) $Fr_1 > 9.0$ STRONG/CHOPPY JUMP
water surface does not become level after the jump
$\Delta E/E_1 > 70\%$

i) The initial and sequent depths of a hydraulic jump i.e. y_1 and y_2 are connected by the formula

$$\frac{y_2}{y_1} = \frac{1}{2}\left(-1 + \sqrt{8F^2r_1 + 1}\right)$$

ii) The energy loss is defined in a jump is given by

$$\Delta E = E_L = (E_1 - E_2) = \frac{(y_2 - y_1)^3}{4\, y_1 y_2}$$

iii) Jump height: the difference between the depths after and before the jump is called the height of the jump Hj.

$$Hj = (Y_2 - Y_1)$$

This can be made dimensionless as shown below where Hj/E = relative height
Y_2/E_1 = relative sequent depth

Among the several uses of the hydraulic jump, a few are listed below

1. To dissipate energy of the water flowing over dams, weirs etc.
2. To recover head on the d/s of a measuring flume and thus maintain high water level in the channel for the purpose of irrigation.
3. To increase the weight of an apron and thus reduce the uplift pressure under a masonary structure by raising the water depth on the apron.
4. To mix chemicals used for water purification and to aerate water for city water supplies etc.

PROCEDURE:-

1. Open the inlet valve and allow water to collect in the supply tank. After building up the maximum head regulate the inlet valve to maintain it constant.
2. Adjust the d/s gate and obtain a jump in the middle of the channel.
3. Note down the depth of the water before and after the jump.
4. Collect 100 mm height of water in the collecting tank and note down the time of collection 't' s.
5. Repeat the above steps from 9 discharge reducing the discharge after each set of observations.

SPECIMEN CALCULATION:-

1. Volume of water collected = 0.064 m^3
   Time of collection = t s
   Discharge Q = 0.064/t m^3/s

2. Let y1 and y2 be the depths before and after the jump.
   $u_1 = Q/(b\ y_1)$ and $u_2 = Q/(b\ y_2)$
   Where b = channel width = 0.25 m

3. $Fr_1 = u_1/\sqrt{(g\ y_1)}$ and $Fr_2 = u_2/\sqrt{(g\ y_2)}$
4. compute the specific energies $E_1 = Y_1 + u_1^2/(2g)$ and $E_1 = Y_2 + u_2^2/(2g)$
   and $\Delta E = (E_1 - E_2)M$
5. relative energy loss = $(\Delta E/E_1)$ x 100%
   Efficiency = (E_2/E_1) x 100%
6. compute:
   Jump height hj = $(Y_2 - Y_1)$
   Related height hj/E1, Y1/E1 relative initial depth and Y_2/E_1. relative sequent depth.

GRAPHS: Plot the following graphs.

1. $(\Delta E/E_1)$ vs Fr_1
2. $(E2/E_1)$ vs Fr_1

RESULTS:- Compare the plots with the published ones and comment on the discrepancies if any

Width of the channel = 0.25 m
Area of collecting tank = 0.04 m^2
$E = (Y + V^2/2g)$
$\Delta E = (E_1 - E_2)$

U_2 (m/s)	Fr_1	Fr_2	E_1 (m)	E_2 (m)	ΔE (m)	$\Delta E/E_1$ %	E_2/E_1 %	h	Y_2/Y_1	H_j / E_1	Y_1 / E_1	Y_2 / E_2

S.No	Initial depth Y_1(m)	Sequent depth Y_2(m)	Volume of water collected (m^3)	Time of collection (s)	Discharge (m^3)	U_1 (m/s)

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STUDY OF THE MOMENTUM PRINCIPLE – IMPACT OF JETS

AIM:- To study the application of the momentum principle for the impact of jet on vanes.

APPARATUS:- A rectangular chamber with transport sides fitted with a nozzle arrangement for attaching plates and weights, collecting tank, pressure gauge at the inlet section and a stop watch.

THEORY AND SIGNIFICANCE:- When a jet of liquid impinges on a solid surface (either stationary or moving), the fluid stream changes its direction and glides over the surface. The striking jet possesses momentum, which results in a force being applied to the solid surface, as the momentum change due to a change in a direction of velocity. This force can be computed from the Newton's impulse momentum theorem:

$$\Sigma F_T = \zeta Q(V_2 - V_1)$$

Where $(V_1 - V_2)$ is the change in velocity.

However, in case of impact of jet of real fluid the actual force of impact on the solid surface will be less then the theoretical force. This is due to several reasons, chief among them are

1. Resistance offered due to viscous forces and the forces that arise due to turbulence. These forces dissipate some energy.
2. Change in direction of flow being gradual, the fluid particles move in a cured path and a non uniform velocity distribution across the cross section results.
3. A small portion if the impinging liquid jet may be thrown away from the mainstream due to turbulence and consequently a reduction in the force occurs. The ratio of the actual force to the theoretical force is called the VANE COEFFICIENT and given by K = Fa/Ft

   In case of a flat plate impinged on by a jet the actual force of impact is given by

   $$Fa = K F_T$$

Where K, ρ, g, have the usual meaning
For a hemispherical cup = 1800 as the jet gets deflected by 1800 hence

$F_T = 2\, \zeta\, Q\, V$

The momentum theorem has wide application in engineering problems. Examples are Flow through turbines, pumps and other rotodynamic machine. It is also applicable for analysis of flow through pipe bends, curved channels, hydraulic jump, hydraulic ram and many power generating hydraulic machines.

PROCEDURE:-

1. Adjust the counter weight of the scale so that it takes the horizontal position after putting the pan.
2. Open the valve to the maximum and note down the pressure indicated by the gauge P Kg/m^2. The beam should be in the horizontal position.
3. Bring back the scale to the horizontal position by adding weight to the pan on the other end of the scale. Note down the total weight added, W kg.
4. Collect 0.10 m of water in collecting tank and note down the time t sec.
5. Repeat the experiment for at least six different discharges.
6. Change the flat plate, replacing it with the given hemispherical cup, and repeat steps 1 to 5.

SPECIMEN CALCULATIONS:

1. Pressure recorded = p kg/cm^2 converting it to the meter of water head, h = 10 x p m of water velocity of the jet V = √2gh m/s. where g is the acceleration due to gravity = 9.81 m/s^2.
2. Volume of water collected = 0.1 A m3, A = 0.25 m^2
   Time of collection = t s
   Discharge Q = 0.1A/tm^3/s
   ρQVxo = Ft
   Where 0.26 m is the level arm
3. Weight added = W kg = mass x g
4. Determine K from relation
   W x 0.52 = Fth x 0.26
   W x 0.52 = K Ft x 0.26

NOTE:- For the hemispherical cup M_1 = 2Qm Vx0.26 N-m.

GRAPH:- Plot the following graph: Fa vs H and find K
RESULT:- Give the value of K from experimental result and also the graphical calculation.

Area of collecting tank = 0.25 m^2
Type of plate: flat plate / hemispherical cup

Velocity (m/s)	Volume of water coll. (m^3)	Time of coll. s	Discharge (m^3/s)	Qm (kg/s)	$F_T = \zeta Q(V_2 - V_1)$	Weight W_1 kg	Weight added in Newton $W_1 x g$	Fa=2 x wt	Vane coefficient $K = F_a / F_T$

S.No	Pressure in Kg/cm^2	Pressure in m of water head h

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STUDY OF PERFORMANCE CHARACTERISTICS OF A SINGLE STAGE CENTRIFUGAL PUMP

AIM:- To study the performance characteristics of a constant speed, single stage centrifugal pump.

APPARATUS:- Centrifugal pump setup with energy meter, pressure and vaccum gauges and stop watch.

THEORY AND SIGNIFICANCE:- A pump is a device used to convert mechanical energy into hydraulic energy. Hence, it is used to raise liquids from a lower level to a higher level or simply to overcome frictional losses in long distance pipelines.

There are two kings of pumps, positive displacement and dynamic or momentum-change pumps. There is several of each type in use in the world today.

The centrifugal pump is a dynamic pump with radial exit flow.

The centrifugal pump is so called because the pressure increases within its rotor due to centrifugal action in an important factor in its operations. It consists of an impeller rotating within a casing. Fluid enters axially through the eye of the casing, is caught up in the impeller blades, and is whirled tangentially and radially outward until it leaves through all circumferential parts of the impeller into the diffuser part of the casing. The fluid gains both velocity and pressure while passing through the impeller. The doughnut-shaped diffuser or scroll of the casing decelerates the flow and further increases the pressure.

Centrifugal pumps provide a higher flow rate than positive displacement pumps (reciprocating pumps) and a much steadier discharge but ineffective in handling high viscosity liquids. They also require priming.

There pumps can be driven with a constant speed motor or a variable speed motor. But the usual practice is to employ a constant speed motor.

If only impeller is used the pump is called a single stage centrifugal pump

If: H_d = pressure head at the delivery and
H_s = pressure head at the suction and
H_g = difference in the height of the two gauges

Then static head $H = H_s + H_d + H_g$

The manometer head Hm is defined as the total head, including frictional losses and velocity head across the pump. Neglecting frictional losses, the Hm terms becomes

$H_m = (H_d + Z_d + U_d 2/2g) – (H_s + Z_s + U_s 2/2g)$

If section and delivery pipe diameter are equal, $U_d = U_s$
Also as Z_s is negative, $H_g = Z_d + Z_s$
Hence, $H_m = H_d + H_s + H_g = H$
The output of power is given by the relation $Po = \rho\ QgH_m$ in W
Where ρ = density
The input power is the power of the motor and is obtained from the energy meter revolutions as

$$Pi = (n/t_e) \times (3600/N_e) \times 1000 \text{ in W}$$

Where t_c = time taken for 'n' number of energy meter revolutions.
N_e = Energy meter constant (rev/kwh)

The overall efficiency is given by = $(P_o/P_i)x100\%$

The head versus discharge curve for a pump is a useful plot for it can be transformed into that for some other speed by means of similarity laws.

$Q \alpha n$
$H \alpha n^2$
$P \alpha n^3$

NON DIMENSIONAL PARAMETERS
Flow coefficient = $Q/ (ND^3)$
Head coefficient = $gH/ (N^2D^2)$
Power coefficient = $Pi/ (\rho N^3D^5)$

However, the efficiency of the pump drops off as the relative speed is varied away from the optimum.

PROCEDURE:-

1. Open the discharge valve and adjust it so that a convenient minimum first reading can be obtained on both the pressure and vaccum gauge.
2. Note down the pressure and vaccum gauge readings x and y kg/sq.cm, vaccum gauge readings can be in mm of Hg.
3. Note down H_i and H_g of orifice
4. Note down the time te for n number of energy meter revolutions.

5. Gradually increase the discharge and repeat steps 2 to 4 for 8 or 9 different discharges.

SPECIMEN CALCULATIONS:-

1) Pressure gauge readings = X x kg/cm^2
   Pressure in meter of water head = (x) x 10 m (H_d)
   Vaccum gauge reading = y kg/sq.cm or y mm of H_g
   Vaccum in meter of water head = y x 10 m (H) or (yx13.6)/1000 if y is in mm
   Different in the height of the two gauges = H_g m
   $H_m = H_d + H_s + H_g$ m

2) Discharge $Q = 3.348 \times 10^{-3} \times \sqrt{10x(H_i - H_o)}$
3) Power output $P_o = \rho \times Q\ Hm$ W where = 9810 N/m^3
4) Power input $P_i = (n/t_e)x(3600x1000/N_e)$ W
   Where N_o = energy meter constant = 240 rev/KWH
5) Overall efficiency = $P_o/P_i \times 100\%$
6) Specific speed ns = $\sqrt{N}$ Q/(Hm 0.75)
7) Compute the dimensionless parameters flow coefficient, head coefficient and power coefficient.

GRAPHS:- Plot the following graphs:

1. Manometric head Hm vs discharge Q
   Overall efficiency vs discharge Q
Power input P_i vs discharge Q
On one sheet

1. $g/H(N^2D^2)$, $P/(\rho N^3D^5)$, vs. $Q/(ND^3)$

RESULTS:- Study the characteristics curves and comment on them. Obtain the optimum discharge, head and power input combination from the graphs.

NOTE:- Your record should also include (i) A neat dimensional sketch of the experimental set up (ii) comments on your results

Area of the collecting tank A = 0.64 m2
Height of collection h = m
Difference of height between = m
Pressure gauge hg = m
Diameter of impeller = m

Discharge Q (m^3/s)	Time for in rev. te (s)	Output Po (W)	Input Pi (W)	Overall efficiency (Po/Pi)x 100%	Specific speed Ns	Q/ND^3	gH/N^2D^2	Pi/N^3D^5p

S.No	Pump speed in rpm	Pressure gauge Kg/cm^2 reading	Vaccum gauge reading Kg/cm^2	Hd m of water head	Hs m of water head	Hm in m of water head	Hi	Ht

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STUDY OF PERFORMANCE CHARACTERISTICS OF A DOUBLE STAGE CENTRIFUGAL PUMP

AIM:- To study the performance characteristics of a constant speed double stage centrifugal pump.

APPARATUS:- Double stage centrifugal pump setup with pressure and vaccum gauges, energy meter connections, collecting tank and stopwatch.

THEORY AND SIGNIFICANCE:- The theory of a single stage centrifugal pump holds good for a double stage pump too. As already stated, a pump is used to lift liquids to a higher level. However, if the head increases very much an ordinary centrifugal pump fails to deliver the required discharge.

This deficiency can be overcome by introducing additional impellers. These additional impellers can be combined in two different way giving rise to two distinct types of combinations.
i) Impeller in series
ii) Impeller in parallel.

When the impellers (two or more) are arranged in series it serves to increase the head. If the discharge has to be increased then they can be arranged in parallel.

Two pumps are said to being series if the discharge of one is passed through the other such that the head raised by the former is augmented by the second and the total head is given by $H = H_1 + H_2$

Two pumps are said to be in parallel if the two deliver discharges Q_1 and Q_2 are supply to a common main to pump a total discharge given by $Q = Q_1 + Q_2$

The formula developed for a single stage centrifugal pump is valid for a double stage pump too.

Static head $H = H_s + H_d + H_g$ = manometric head Hm
Power output Po = ρ QgHm in watt.
Where Q is the discharge from the pump.

The input Pi is the power of the motor and is obtained from the energy meter revolutions as follows:

$Pi = (n \times 3600 \times 1000)/(N_e \times t_e)$watt.

Ne = energy meter constant i.e. revolution/KWH

Overall efficiency = (Po/Pi)x100%

PROCEDURE:-

1. Switch on the pump. Open the discharge valve and adjust it so that a convenient minimum first reading can be obtained.
2. Note down the pressure and vaccum gauge readings in kg/cm2 i.e. x and y
3. Collect hw mm of water in the collecting tank and note down the time of collection tw s.
4. Note down the time to for n number if energy meter revolutions.
5. Gradually increase the discharge and repeat the above steps for 9 different discharges.

SPECIMEN CALCULATIONS

1. Pressure gauge readings = x kg/cm^2

Pressure in meter of water head = 10 x m = H

If vacuum gauge reading = y kg/cm^2

Then vaccum in meter of ware head = 10y m.

If vaccum is in mm of Hg = Hs = (y x 136)/1000

Difference in the height of the two gauges = Hg m.

Manometric head Hm = (Hg = 0.17 m)

2. Discharge Q = volume of water collected/ time of collections/ time of collections

$Q = (A \times hw)/tw\ m^3/s$

3. Power output Po =ρQgh

Where ρ = density = 1000 kg/m^3

4. Power input pi = (n/te)x(3600x1000/Ne) W

Where Ne = energy meter rating = 240 rev/kwh.

5. overall efficiency = (Po/Pi)x100%

6. Specific speed is given by $Ns = N\sqrt{Q}/H^{3/4}$

7. Compute the following dimensionless terms:

Flow coefficient = $Q/(ND^3)$

Head coefficient = $gH/(N^2D^2)$

Power coefficient = $Pi/(N^3D^5)$

Where D is the diameter of the impeller

GRAPHS:- Plot the following graphs.

I) Manometric head Hm vs discharge Q
II) Overall efficiency no vs discharge Q
III) Power input Pi vs discharge Q on the sheet
IV) Q/ND^3 vs gH/N^2D^2
V) Q/ND^3 vs No = efficiency
VI) $Q/(ND^3)$ vs $Pi/(N^3D^5)$ on the sheet

RESULTS:- Study the characteristic curves and comments on them. Obtain the optimum discharge an head combination from the graph.

Area of the collecting tank A = 0.64 m^2
Height of collection h = m
Difference of height between = cm
Pressure gauge hg = m
Diameter of impeller = m

Output Po (W)	Input Pi (W)	Overall efficiency (Po/Pi)x100%	Ns	Q/Nd^3	gH/N^2D^2	Pi/N^3D^5p

S.No	Pump speed in rpm	Pressure gauge kg/cm^2	Vacuum gauge reading	Hd m of water head	Hs in m of water head	Hm of water head	Volume collected (m^3)	Time of coll. Tw (s)	Discharge $Q(m^3/s)$	Time for in rev. te (s)

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STUDY OF PERFORMANCE CHARACTERISTICS OF PELTON WHEEL

AIM:- To study the performance characteristics of a Pelton wheel, under constant head condition under three different spear settings.

APPARATUS:- Pelton wheel setup with pressure gauge, orifice meter connected to a pressure gauge measuring discharge, generator for electrical loading.

THEORY AND SIGNIFICANCE:- A hydraulic turbine is a device which takes away energy from the following fluid and converts it to some form of mechanical energy.

An impulse turbine is one in which the total drip is pressure of the fluid takes place in one or more stationary nozzle and there is no change in pressure of the fluid as it flows through the rotating wheel.

The energy of the fluid entering the rotor is in the form of kinetic energy of the jet. Hence, the head H is given by

$$H = Hm + Z + U2\ p/2g$$

Where
Hm = pressure head in the supply pipeline as measured by the gauge
Z = datum head of the pressure gauge above the centerline on nozzle
U = velocity of flow in the pipe at the cross section where the pressure gauge is connected.

The water power is obtained from the expression.

$Pi = p\ Qgh$ which happens to be the input in this case. The discharge Q is measured by means of a orifice installed in the pipeline.

The output of power is measured from the brake drum readings and is called the brake power,

$$Po = \frac{A \times V}{0.82}$$

Where
A = amp from digital reading
V = volts from digital reading

The specific quantities, called unit speed (Nu), unit discharge (Q) and unit power (Pu) can be calculated from the following expressions

$Nu = N/\sqrt{H}$, $Qu = Q/H$ and $Pu = Po/H^{3/2}$

These quantities express the operational features of hydraulic turbines. The unit quantities are theoretical features for a head of 1 m for the same turbine.

PROCEDURE:-

1. Switch on the centrifugal pump to supply water to the turbine, observe all the precautions before doing so,
2. Operate the wheel connected to the spear and set the spear opening to 100% i.e. fully open setting.
3. Start from small load – 3 bulbs suited on pointmeter.
4. Open the inlet valve (sluice value) and observe the pressures on the gauge provided, select the desired pressure and note down the gauge reading in Kg/cm^2.
5. Note down the pressure gauge readings of orifice meter.
6. Note down the speed RPM from digital meter.
7. Change the load as indicated in the table and repeat steps 3 to 7. Switch on one bulb at a time.
8. Change the spear setting to 60% and 30% of fully open positions and repeat steps 3 to 8.

SPECIFICATIONS AND RELEVANT DATA:

1. Pipe diameter = 50 mm.
2. orifice diameter = 36.3 mm
3. Discharge equation

   $Qa = 3.348 \times 10^{-3} \sqrt{H}$, where H is head on orifice meter

   Where
   $h = hm \left(\frac{Sm}{S} - 1\right)$
   hm = pressure difference in m of mercury
   Sm = 13.56
   S = 1.00

SPECIMEN CALCULATION:-

1. a) Pressure gauge reading = P kg/cm^2. pressure in m of water head = 10 P m of water b) Datum elevation Z = o m
2. Difference of pressure in from gauge in m connected to orifice meter Discharge Q = 3.348 x $\sqrt{H}$ x 10^{-3} m^3/h
3. H_T = head on turbine = (Pr x 10)m
4. water power Pi = p Qghd watt – QgHT
5. current A = A amp, Voltage V = V volts
6. N = turbine rpm
7. Power developed Po = AxV/0.82 is generator n
8. Overall efficiency = P_2/F_1 x 100%
9. compute the following quantities:

a) specific speed Ns = $N\sqrt{Q}/(gh)^{0.75}$
b) Unit speed Nu = $n/\sqrt{H}$
c) Unit discharge Qu = $Qu/\sqrt{H}$
d) Unit power Pu = $Po/H^{1.5}$

GRAPHS:- Plot the following graphs for all the three spear settings on three different graph sheets.

1. Unit discharge Qu vs unit speed Nu
2. Unit power Pu vs unit speed Nu
3. Overall efficiency No vs unit speed Nu

RESULTS:- Study the above curves and comment on them.

PRECAUTIONS:-

1. Set the spear opening to zero and close the sluice valve before starting the turbine.
2. start from a low load and proceed to higher loads.
3. open the cooling water inlet valve when the turbine is running under load.
4. before shutting down the unit observe the following points.

a) Switch off all bulbs.
b) Close the spear opening.
c) Close manometer cocks and supply valve.

Discharge Q = 3.348x10-3	Ht pressure gauge reading on turbine	Pi=ρQght (watts)	A	V	Po = (AV/0.82)	Overall efficiency (%)	Specific speed Ns	Nu	Qu	Pu

S.No	Spear setting	Pressure gauge readings (kg/cm2)	Turbine speed (rpm)	Inlet pressure gauge reading	Throat pressure gauge reading	Ho

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TILTING FLUME

AIM:- To draw the specific energy diagram for a constant discharge, using Tilting Flume.

APPARATUS:- Tilting Flume, point gauge, collecting tank and stop watch.

THEORY:- Specific energy of water flowing in an open channel is defined as the total energy with respect to channel bed.

$$Es = Y + V^2/2g$$

Where y is the depth of water and V is average velocity of flow assuming θ = small and ∞ = 1.
The discharge through the channel is maximum, where specific energy is minimum. The plot between specific energy (E_s) and depth of flow (y) is known as specific energy diagram. The concept of specific energy is important in the design of transitions and open channel flow problems.

The depth corresponding to minimum specific energy is called critical depth (y_c), and the flow is critical with $F_{r1} = 1$
If the $y > y_c$ the flow is sub critical with $F_{r1} < 1$
If the $y < y_c$ the flow is super critical with $F_r > 1$

PROCEDURE:-

1) Open the valve and allow the flow to stabilize.
2) Determine the depth of flow with point gauge, with help of initial and final gauge reading.
3) Note down time of collection for 10 cm rise in collecting tank.
4) By closing the collecting tank valve
5) Repeat the procedure for different stops, for same discharge

GRAPHS:-

Plot the graph between E_s and y and fine y_c and compare with theoretical value of y_c.

$y_c = ((q^2)/g)^{1/3}$ Where q = Q/B B = 0.25 m

Width of the channel = 0.25 m
Height of collection = 0.1 m

S. No	Slope of the channel mm	Initial point 1 gauge reading mm	Final point gauge reading mm	Depth of water flow Y	Area (m^2)	Velocity of water coll. (m/s)	Time of coll. (s)	Discharge (m^3/s)	Velocity m/s	Velocity head $V^2/2g$	$E=Y+V^2/2g$	Fr =	State of flow