FLUID MECHANICS AND HYDRAULIC MACHINES

LAB MANUAL

INDEX

VENTURIMETER

AIM:

To determine coefficient of discharge for a given venturimeter

THEORY:

Venturimeter is a device invented by Ciemens Herchel in 1887 and named by him after Venturi, who experimented with diverging tubes for the measurement of rate of flow in pipe lines. The basic principle on which Venturimeter works is that by reducing the cross-sectional area of the flow passage, a difference of pressure is created and the measurement of the pressure difference enables the determination of the discharge through the pipes. The fluid flowing the pipe is led through a contracting section to a throat which has a smaller cross section area than the pipe, so that the velocity is accomplished by a fall in N/m^2. The magnitude of which depends up on the rate of flow so that by measuring the pressure drop, the discharge can be calculated. Beyond the throat the fluid is in a pipe of slowly diverging section, the pressure increasing as velocity falls.

In a water distribution system and in processing industries it is necessary to measure the volume of liquid flowing through a pipe line. The Venturimeter is introduced in the pipeline to achieve this. Hence knowledge of the value of the coefficient of discharge of the Venturimeter is a must. The velocity of flow through a Venturimeter is obtained by applying Bernoulli's theorem. The theoretical discharge can be calculated by using the velocity obtained.

$$Q=\frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$$

Where a_1 = Cross sectional area of a pipe

a_2 = Cross sectional area at throat of venturimeter

h = Differential pressure head between entrance and Throat of venturimeter

g = Gravitational acceleration

The actual discharge is determined by collecting water over a known period of time.

Coefficient of discharge for Venturimeter $(C_d) = \frac{Actual Discharge}{Theoretical Discharge}$

APPARATUS:

- Venturimeter
- Differential manometer
- Collecting tank with piezometer
- Scale
- Stop watch

PROCEDURE:

- Record the diameter of inlet (d_1) and throat (d_2) of the Venturimeter. As certain that manometric fluid levels in the manometer limbs are the same.
- Start the motor, Open the gate valve , allow the water to flow through pipe full
- Reject the air bubbles if any by slowly raising the pinch cock
- Note the manometric fluid levels h_1 and h_2 in the two limbs of the manometer
- Measure the diameter of the collecting tank
- Collect the water in collecting tank say 1 cm or 2 cm and note down the initial reading.
- Collect the water in the collecting tank up to the level more than 3/4 of the collecting tank and note down the rise(R) of water level and corresponding time (t)taken to rise that level
- Repeat the above procedure by gradually increasing the flow and note down the required readings.
- The observations are tabulated and coefficient of discharge of venturimeter is computed

OBSERVATIONS AND RECORDING:

1. Diameter of venturimeter (d_1)…………………cm
2. Diameter of venturimeter at throat (d_2)…………………cm
3. Diameter of collecting tank (D)…………………..cm
4. Specific gravity of manometric fluid S = ………………

CALCULATION:

1. Area of cross section at inlet $(a_1) = \frac{\pi}{4} d_1^{\,2}$ …………….cm^2
2. Area of cross section at throat $(a_2) = \frac{\pi}{4} d_1^{\,2}$ ……………cm^2
3. Area of collecting tank $(A) = \frac{\pi}{4} D^2$ …………………………cm^2
4. Rise of water level in the collecting tank (R) = …………cm
5. Volume of water collected in Tank (V) = $A \times R$ = …………cm^3
6. Actual discharge $(Q_a) = \frac{V}{t}$ ………………………………$cm^3/\sec$
7. Theoretical Discharge $Q_t = \frac{(a_1 a_2 \times \sqrt{2gh})}{\sqrt{(a_1^{\,2} - a_2^{\,2})}}$ ………….. $cm^3/\sec$

8 Coefficient of discharge for Venturimeter $C_d = \frac{Q_a}{Q_t}$

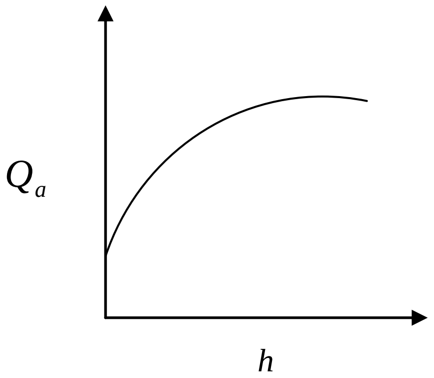
TABULAR FORM

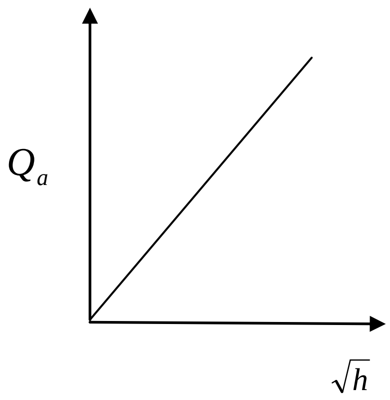
S.No.	Manometer reading			Rise of water level in the collecting tank R cm	Time for collecting R cm rise of water, t sec.	Area of collecting tank A cm^2	Volume of water collected $V_t = A \times R\ cm^3$	Actual Discharge $(Q_a) = \frac{V}{t}\ cm^3/\sec$	Theoretical discharge $Q_t = \frac{(a_1 a_2 \times \sqrt{2gh})}{\sqrt{(a_1^2 - a_2^2)}}$ $cm^3/\sec$	Coefficient of discharge for Venturimeter $C_d = \frac{Q_a}{Q_t}$
	h_1 cm	h_2 cm	$h = (h_1 - h_2)(S-1)\ cm$ of water							

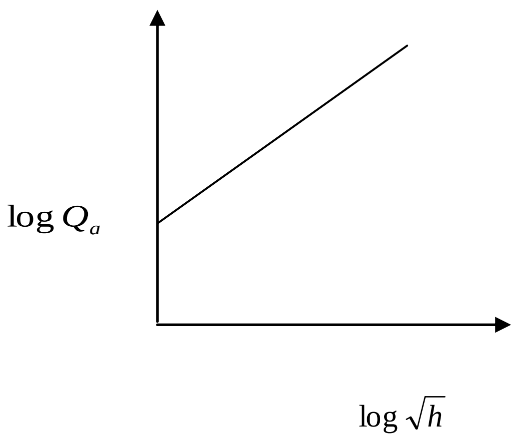
MODEL GRAPHS:

- A calibration curve between differential pressure head H on X-axis and actual discharge Q_a on Y-axis is drawn.
- A graph for Q_a on X-axis and $\sqrt{h}$ on Y-axis is plotted. The graph is a straight line passing through the origin. $Q_a = K\sqrt{h}$

  where K is a constant for a given meter.
- $C_d = \frac{K}{C}$ where C = $\frac{a_1 a_2 \sqrt{2g}}{\sqrt{a_1^{\;2} - a_1^{\;2}}}$ and from graph K = $Q_a / \sqrt{h}$
- C_d is determined by a logarithmic plotting between $\log_{10}{}^{H}$ on X-axis and $\log_{10}{}^{Q}$a on Y-axis. It is a straight line intercepting the Y-axis. The intercept above X-axis is $\log_{10}{}^{K}$ and $C_d = \frac{K}{C}$





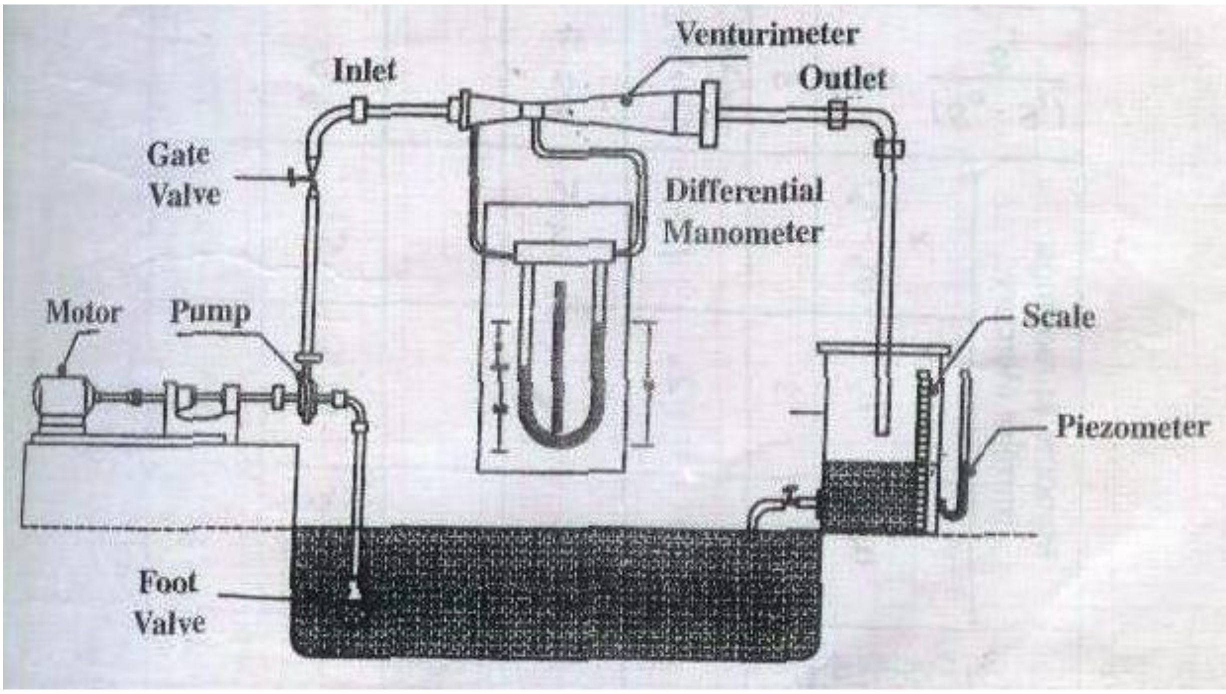


PRECAUTIONS:

1. Conform that there are n ... of water
2. Readings should be note ... rror

RESULT:

1. Coefficient of discharge theoretically = ………
2. Coefficient of discharge from $\log Q_a$ Vs $\log \sqrt{h}$ =……
3. Coefficient of discharge from Q_a Vs $\sqrt{h}$ =…..



VENTURI METER

ORIFICEMETER

AIM:

To determine coefficient of discharge for a given orifice meter.

THEORY:

Orifice meter is used to measure the discharge in any closed surface. Orifice meter works on the principle that by reducing the cross section area of the flow passage, a pressure difference between the two sections is developed and this difference enables the determination of the discharge through the pipe.

In a water distribution system and in processing industries it is necessary to measure the volume of liquid flowing through a pipe line. The orifice meter is introduced in the pipeline to achieve this. Hence knowledge of the value of the coefficient of discharge of the orifice meter is a must. Orifice meter consists of a flat circular plate with a circular hole called orifice, which is concentric with the pipe axis pressure tapings are connected to pipe wall on the both sides of the plate. So that the difference in the fluid pressure on both sides of the orifice plate are measured. As the fluid passes through the orifice meter, a lot of eddies are formed and there is a loss of energy due to which the actual discharge Q_a, is far less than Q_{th} and is given by

$$Q_{Th} = \frac{C_d a_1 a_2 \sqrt{2g(h_1 - h_2)}}{\sqrt{a_1^2 - a_2^2}}$$

Where C_d is the coefficient of discharge

a_1 is the cross section area of pipe

a_2 is the cross section area of orifice

$H = h_1 - h_2$ = difference in piezometric readings of upstream and down stream of orifice plate.

The actual discharge Q_a is determine by collecting water over a know period of time.

Coefficient of discharge for orifice meter $C_d = \frac{Actual\ Discharge}{Theoretical\ Discharge}$

APPARATUS:

- Orifice meter setup
- Differential manometer
- Collecting tank with piezometers
- scale

PROCEDURE:

- Record the diameter of inlet (d_1) and throat $(d_2)$of the Venturimeter. As certain that manometric fluid levels in the manometer limbs are the same.
- Start the motor ,Open the gate valve , allow the water to flow through pipe full
- Reject the air bubbles if any by slowly raising the pinch cock
- Open the inlet and outlet Nipples to allow water into the two limbs of the manometer
- Note the manometric fluid levels h_1 and h_2 in the two limbs of the manometer
- Measure the diameter of the collecting tank
- Collect the water in collecting tank say 1 cm or 2 cm and note down the initial reading.
- Collect the water in the collecting tank up to the level more than 3/4 of the collecting tank and note down the rise(R) of water level and corresponding time (t)taken to rise that level
- Repeat the above procedure by gradually increasing the flow and note down the required readings.

OBSERVATIONS AND RECORDING:

1. Diameter of pipe (d_1)………………… cm
2. Diameter of orifice meter (d_2)……………… . cm
3. Diameter of collecting tank (D)………………….. cm

CALCULATION:

1. Area of cross section of inlet $(a_1) = \frac{\pi}{4} d_1^{\ 2}$ …………… cm^2

2. Area of cross section of orifice meter $(a_2) = \frac{\pi}{4} d_1^{\ 2}$ …………… cm^2

3. Area of collecting tank $(A) = \frac{\pi}{4} D^2$ ………………………… cm^2

4. Rise of water level in the collecting tank (R) = ………… cm

5. Volume of water collected in Tank (V) = $A \times R$ = ………… cm^3

6. Actual discharge $(Q_a) = \frac{V}{t}$ ……………………………… $cm^3/\sec$

7. Theoretical Discharge

$$Q_t = \frac{\left(a_1 a_2 \times \sqrt{2gh}\right)}{\sqrt{\left(a_1^{\ 2} - a_2^{\ 2}\right)}} \text{ …………..} \; cm^3/\sec$$

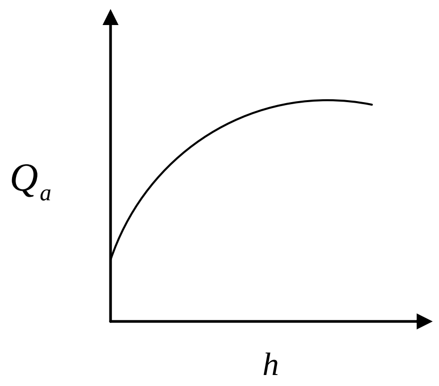
8. Coefficient of discharge for orifice meter $C_d = \frac{Q_a}{Q_t}$

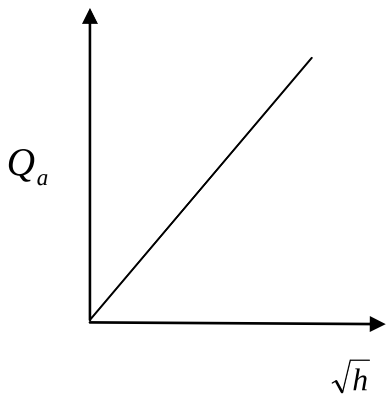
TABULAR FORM

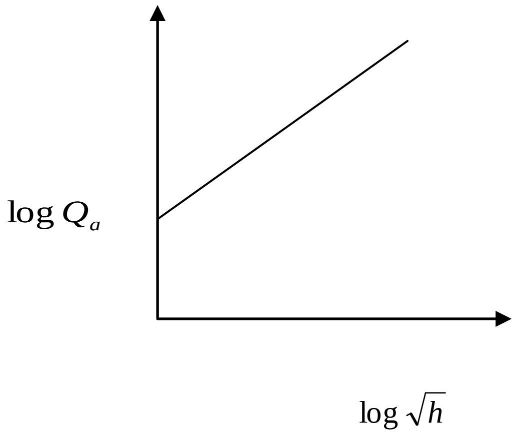
S.No	Manometer reading			Rise of water level in the collecting tank R cm	Area of collecting tank A cm^2	Volume of water collected $V_t = A \times R$ cm^3	Actual Discharge $(Q_a) = \frac{V}{t}$ $cm^3/\sec$	Theoretical discharge $Q_t = \frac{(a_1 a_2 \times \sqrt{2gh})}{\sqrt{(a_1^2 - a_2^2)}}$ $cm^3/\sec$	Coefficient of discharge for orificemeter $C_d = \frac{Q_a}{Q_t}$
	h_1 cm	h_2 cm	$h = (h_1 - h_2)(S - 1)$ cm						

MODEL GRAPHS:

1. A graph between on Q_a on Y-axis and √H on X-axis is drawn. It is a straight line passing through origin. $C_d = \frac{K}{C}$ where $C = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$
2. A graph is drawn between Q_a and Q_{th} and the value of C_d is determined.
3. Draw a graph between $Q_a \ Vs \ h$
4. Draw a graph between $\log Q_a \ Vs \ \log \sqrt{h}$







PRECAUTIONS:

1. Conform that there are no air bubbles in the flow of water
2. Readings should be noted without any parallax error

RESULT:

1. Coefficient of discharge theoretically = ………
2. Coefficient of discharge from $\log Q_a \ Vs \ \log\sqrt{h}$ =……
3. Coefficient of discharge from $Q_a \ Vs \sqrt{h}$ =…..

ORIFICE

AIM : To determine coefficient of discharge, coefficient of velocity, & coefficient of contraction of the small orifice.

THEORY:

Orifice is an opening having a closed perimeter made in the walls of a tank containing fluid through which the fluid may be discharged. The discharged fluid from the tank through the orifice comes out in the form of a free jet in the process the total energy of the fluid in tank is converted to kinetic energy as the jet issues out in the atmosphere.

The jet cross section initially contracts to a minima and then expands partly due to the resistance offered by the surrounding atmosphere and partly due to inertia of fluid particles. The section which has the minimum area is known as “VENA CONTRACT”. The contraction and expansion of jet results in loss of energy. The ratio between area of jet of vena contraction and the area of orifice is known as coefficient of contraction (C_c). The value depends upon the shape and size on the orifice on the head causing flow. Diameter of jet at vena contract is measured by contracting gauge.

$$C_c = \frac{a_c}{a_a} = \frac{Area\ of\ jet\ at\ V_c}{Area\ of\ orifice}$$

The actual velocity at vena contract is smaller then the theoretical velocity due to frictional resistance at orifice edges. The ratio between actual velocity and critical velocity of jet is known as coefficient of velocity for a vertical orifice is determined experimentally by measuring the horizontal and vertical coordinates of issuing jet. Water flows through an orifice under constant head. Let v be the actual velocity. Consider a small particle of water at vena contract, suppose it falls through a vertical distance ‘y’ in horizontal distance ‘x’ in time‘t’.

$$x = vt,\ y = \frac{1}{2}gt$$

$$V = \sqrt{\frac{gx}{2y}} \qquad V_{th} = \sqrt{2gh}$$

$$C_v = \sqrt{\frac{gx^2}{2y \times 2gH}} = \frac{x}{\sqrt{4yH}}$$

Since actual area of the jet is less than the area of orifice and actual velocity is less than the theoretical velocity; therefore actual discharge is lesser than the discharge and the discharge is called the coefficient of discharge C_d

$$C_d = \frac{Q_a}{Q_{th}} = \frac{Q_a}{Q\sqrt{2gH}}$$

Actual discharge $Q_a = C_v \sqrt{2gH} \times C_c \times a$

$$C_d = \frac{C_v \times C_c \times a \times \sqrt{2gH}}{a\sqrt{2gH}}$$

$$C_d = C_v \times C_c$$

Experimental procedure:-

1. After priming the pump, start the pump and slowly close the by pass valve and water starts flowing into orifice tank.
2. Adjust the over flow pipe to get a constant head above the orifice with minimum overflow.
3. Using contracting gauge find the diameter of the jet at vena contract and hence the coefficient of contraction C_c.
4. Adjust the points for measuring x and y coordinates at the jet knowing the head causing H. C_v is determined.
5. Collect certain quantity of fluid in the measuring tank foe unit time. Hence actual discharge can be calculated.
6. Repeat the experiment for different heads over orifice for different diameters of orifice.

OBSERVATIONS:

Area of cross section of collecting tank = m^2

Diameter of orifice d = cm

X correction = cm

Y correction = cm

Area of orifice, $a = \frac{\pi}{4} \times d^2$ = m^2

CONSTANT HEAD METHOD:

S.No	Head H cm	Discharge volume	Time sec			Discharge $m^3/\sec$		$C_d = \frac{Q_a}{Q_{th}}$
			T_1	T_2	Avg	Q_a	Q_{th}	

FALLING HEAD METHOD:

S.No	Initial Reading H_1 cm	Final Reading H_2 cm	Time sec	$C_d = \frac{K}{T}\left(\sqrt{H_1} - \sqrt{H_2}\right)$

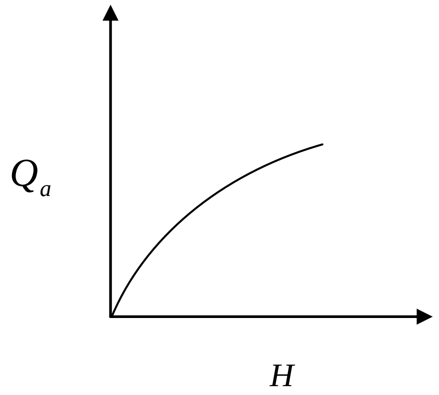
MODEL GRAPHS

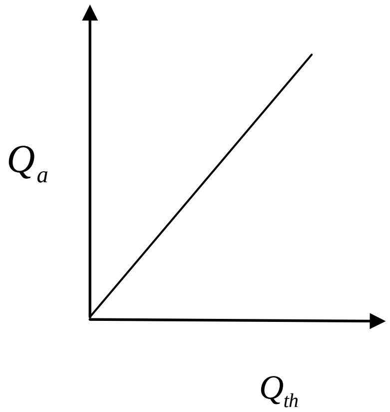
Draw a graph between Q_a Vs H

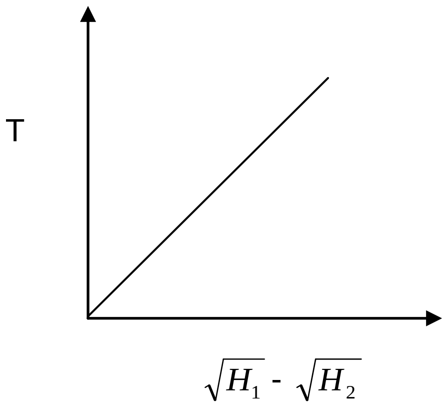
Draw a graph between Q_a Vs Q_{th} graph

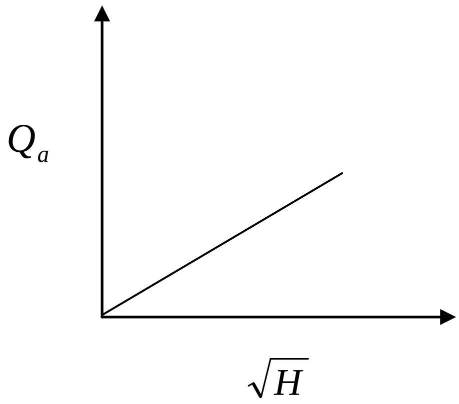
Draw a graph between Q_a Vs $\sqrt{H}$ graph

Draw a graph between T Vs $\sqrt{H_1}$ - $\sqrt{H_2}$









Results:

C_d ion =

C_d rvations =

C_d =

C_d from Q_a Vs $\sqrt{H}$ graph =

C_d from T Vs $\sqrt{H_1} - \sqrt{H_2}$ =

EXTERNAL MOUTH PIECE

AIM:

To determine the coefficient of discharge by falling head method.

DESCRIPTION:

Mouthpiece is a short tube attached to an orifice. By attaching a tube of length 3-d to 5-d where d is the diameter of the mouthpiece, the discharge through the mouthpiece increases by about 30% over small orifice for the same head of liquid. The co-efficient of discharge is obtained the ratio Q_a/Q_t .

For constant head method $Q_t = a\sqrt{(2gH)}$

For falling head method $C_d = \frac{2\ A_b\ (\sqrt{H_1} - \sqrt{H_2})}{Ta\sqrt{2}\ g}$

APPARATUS:

- Mouthpiece fixed to a balancing tank,
- Collecting tank
- Stop watch,

PROCEDURE:

1. Fit the required mouth piece to the side of the tank, close the drain cock
2. Start the motor and allow the water in to the tank.
3. The balancing tank is filled with water completely by opening the inlet valve fixed on the pipeline. After filling the balancing tank, the inlet valve is closed completely
4. As the water flows through the mouthpiece, the head of water gradually falls. After closing the inlet valve, the stopwatch is started when the water level reaches a convenient level on the scale and stopped when the head of water falls by 10 cm. The water level in the balancing tank is read through the piezometer tube on the scale. .
5. The balancing tank is again filled with water completely to the when the head of water level attains the above initial scale reading, the stop watch is started and time not for a fall of head by 20 cm
6. The procedure is repeated for other observations, increasing the fall head by 10 cm for each observation. The initial head and terminal head are recorded as H_1 and H_2 respectively.

7. The observations are tabulated and coefficient of discharge of external mouth piece is computed

OBSERVATIONS:

Type of mouth piece : External mouth piece

Diameter of mouthpiece d =------------------------- cm

Size of balancing tank b =------------------------- cm

CALCULATIONS:

Area of balancing tank A_b =------------------------- cm^2

Area of mouth piece a =------------------------- cm^2

Initial head over mouth piece H_1 =------------------------- cm

Final head over mouth piece H_2 =------------------------- cm

Coefficient of discharge $C_d = \dfrac{2\,A_b\,(\sqrt{H_1} - \sqrt{H_2})}{Ta\sqrt{2\,g}}$

TABULAR FORM

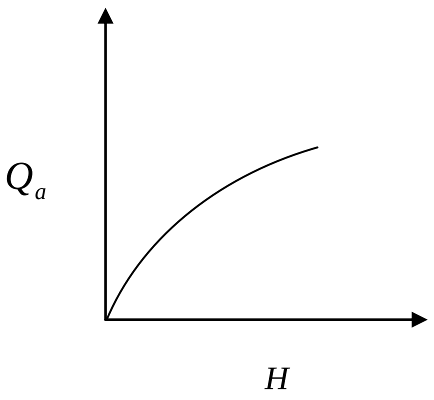
S.No.	Head over Mouth Piece		Time taken for head to fall from H_1 to H_2 T sec	$\sqrt{H_1}$ cm	$\sqrt{H_2}$ cm	$\sqrt{H_1}$ - $\sqrt{H_2}$ cm	$C_d = \dfrac{2\,A_b\,(\sqrt{H_1} - \sqrt{H_2})}{Ta\sqrt{2\,g}}$
	Initial H_1 cm	Final H_2 cm					

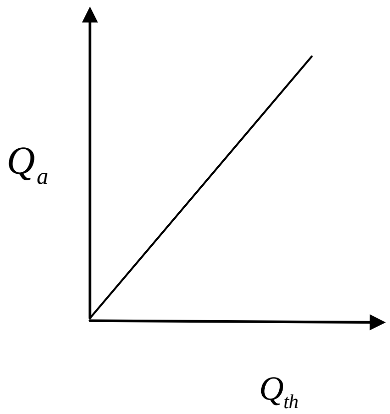
GRAPHS:

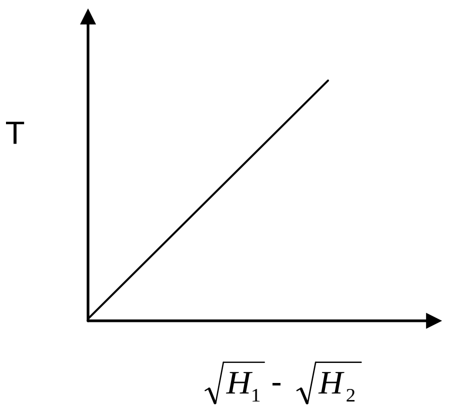
- A graph between T on x-axis and $\sqrt{H_1} - \sqrt{H_2}$ on y - axis is drawn. The value of the constant,

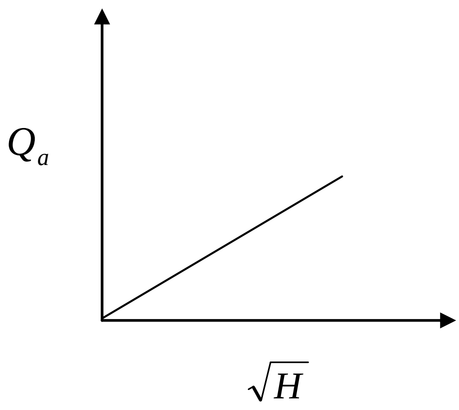
$$K = \frac{2\ A_b}{a\sqrt{2\ g}} \text{ is determined, } C_d = \frac{K\ (\sqrt{H_1} - \sqrt{H_2})}{T}$$

- Draw a graph between Q_a Vs H
- Draw a graph between Q_a Vs Q_{th} graph
- Draw a graph between Q_a Vs $\sqrt{H}$ graph









RESULTS:

Coefficient of discharge C_d = ------------------

C_d from Q_a Vs H =

C_d from Q_a Vs Q_{th} graph =

C_d from Q_a Vs $\sqrt{H}$ graph =

C_d from T Vs $\sqrt{H_1}$ - $\sqrt{H_2}$ =

RECTANGULAR NOTCH

AIM:

To determine coefficient of discharge of Rectangular Notch

APPARATUS:

- rectangular Notch setup
- Differential manometer
- Collecting tank with piezometer
- Scale
- Stop watch

THEORY:

A notch may be defined as an opening provided in the side of a tank such that the fluid surface in the tank is below the top edge of the opening. The water flowing through the notch is known as nappy. The bottom edge of a notch over which the water flows is known as the sill and its height above the bottom of the tank or channel is known as crest height. The notches are usually classified according to the shape of openings. The edges of the notch are leveled on the down stream side so as to have sharp edged sides and crest, resulting minimum contract with the flowing liquid.

DESCRIPTION:

The equipment consists of supply tank supported on a strong iron stand. Perforated sheets are fixed to the up stream side to serve as baffles when water flows through baffles, the oscillations are damped out and a steady and smooth flow is guaranteed.

The front side of the supply tank is provided with interchangeable notch plates, which can be screwed to the tank front. An inclined Piezometre is fixed to one side of the tank, which serves the purpose of finding the levels of water surface.

A collecting tank is used to determine the actual discharge. Water is supplied to the main channel from water through a gate valve, which is employed for regulation of discharge. A drain cock is provided at the bottom side of the channel.

PROCEDURE:

- Fit the required notch, Close the drain cock
- Allow water in the channel
- Regulate the gate valve so that water just flows over the sill.
- Take reading in the inclined piezometer.
- Allow more water and the discharge is maintained constant by regulating the gate valve.
- Take the reading in inclined piezometer.
- Measure the diameter of the collecting tank
- Collect the water in collecting tank say 1 cm or 2 cm and note down the initial reading.
- Collect the water in the collecting tank up to the level more than 3/4 of the collecting tank and note down the rise(R) of water level and corresponding time (t)taken to rise that level
- Repeat the above procedure for different heads.
- The observations are tabulated and coefficient of discharge of rectangular notch is computed

OBSERVATION

- Diameter of the collecting tank (D) = ` cm
- Width of the notch (b) = cm
- Inclination of Piezometer (α) =

CALCULATION:

Area of the collecting tank $A = \frac{\pi}{4} \times d^2$ ………….. cm^2

Rise of water level (R) = ………….. cm

Volume of water collected $V_t = A \times R$ …….. cm^3

Actual discharge $Q_a = \frac{V_t}{t}$ ………………… $cm^3/\sec$

Net head $(h) = (h_1 - h_2) \times \sin\alpha$ …………………….. cm

Theoretical discharge $Q_a = \frac{2}{3}\sqrt{2g} \times b \times h^{3/2}$ ………….. $cm^3/\sec$

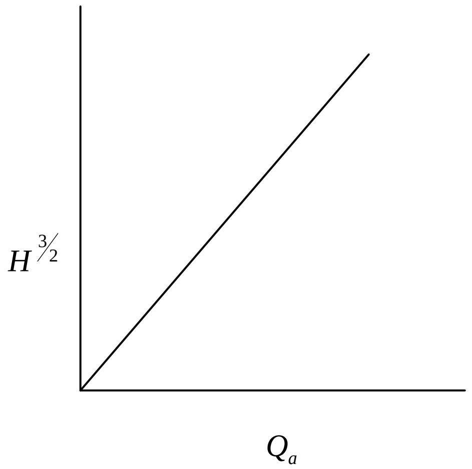
Coefficient of discharge $C_d = \frac{Q_a}{Q_t}$

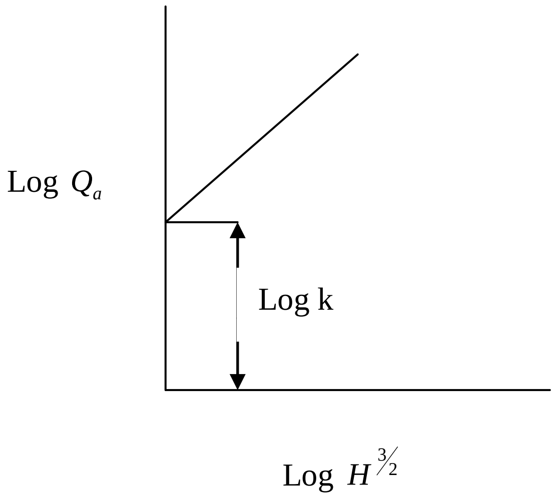
TABULAR FORM

S.No	Name of the notch	Piezometer reading		Net head $(h)=(h_1-h_2)\times\sin\alpha$ cm	Rise of water level in the collecting tank R cm	Time taken to rise R cm t $\sec$	Volume of water collected V_t = A x R cm^3	Actual Discharge $Q_a = \frac{AR}{t}$ $cm^3/\sec$	Theoretical Discharge $Q_a = \frac{2}{3}\sqrt{2g}\times b\times h^{3/2}$ $cm^3/\sec$	Coefficient of discharge $C_d = \frac{Q_a}{Q_t}$
		Initial h_1 cm	Final h_2 cm							
1										
2										
3										
4										
5										

MODEL GRAPHS:

- A calibration curve between the head on the notch $H^{3/2}$ on x-axis and Q_a on Y-axis is drawn.
- A straight line graph between Q_a on X-axis and $H^{3/2}$ on Y-axis is drawn. From the graph the values of $K = \frac{Q_a}{H^{3/2}}$ is determined. C_d = K/C, where $C = \frac{2}{3} L\sqrt{2g}$
- A graph between Log^{H}_{10} on X-axis and $\log_{10}^{Q_a}$ on Y-axis is drawn.
- The intercept of the straight line on Y-axis measured from X-axis gives the value of $\log_{10}^{k}$



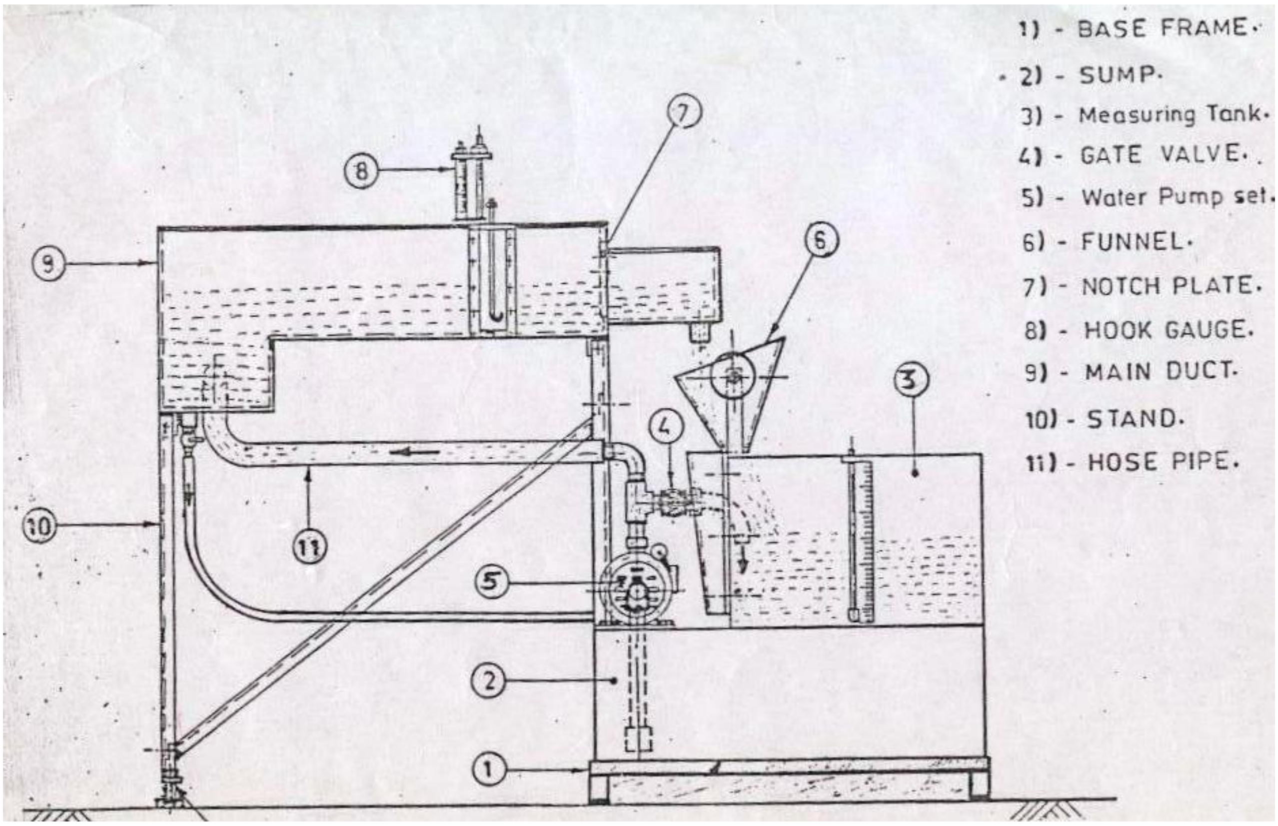


PRECAUTIONS:

1. Readings should be taken with out parallax error
2. Sill level reading should be taken exactly

RESULT:

1. Average coefficient of discharge experimentally equal to ………………..
2. Coefficient of discharge from graph Q_a Vs $h^{5/2}$ ………………………………
3. Coefficient of discharge from graph log Q_a Vs log $h^{5/2}$ ……………….



RECTANGULAR NOTCH

V-NOTCH

AIM:

To determine the coefficient of discharge of a V- Notch

THEORY:

A notch may be defined as an opening provided in the side of a tank such that the fluid surface in the tank is below the top edge of the opening. The water flowing through the notch is known as nappy. The bottom edge of a notch over which the water flows is known as the sill and its height above the bottom of the tank or channel is known as crest height. The notches are usually classified according to the shape of openings. The edge of the notch is leveled on the down stream side so as to have sharp edged sides and crest, resulting minimum contract with the flowing liquid.

DESCRIPTION:

The equipment consists of supply tank supported on a strong iron stand. Perforated sheets are fixed to the up stream side to serve as baffles when water flows through baffles, the oscillations are damped out and a steady and smooth flow is guaranteed.

The front side of the supply tank is provided with interchangeable notch plates, which can be screwed to the tank front. An inclined Piezometre is fixed to one side of the tank, which serves the purpose of finding the levels of water surface.

A collecting tank is used to determine the actual discharge. Water is supplied to the main channel from water through a gate valve, which is employed for regulation of discharge. A drain cock is provided at the bottom side of the channel.

APPARATUS:

- Triangular Notch setup
- Differential manometer
- Collecting tank with piezometer
- Scale
- Stop watch

PROCEDURE:

- Fit the required notch, Close the drain cock
- Allow water in the channel
- Regulate the gate valve so that water just flows over the sill.
- Take reading in the inclined piezometer.
- Allow more water and the discharge is maintained constant by regulating the gate valve.
- Take the reading in inclined piezometer.
- Measure the diameter of the collecting tank
- Collect the water in collecting tank say 1 cm or 2 cm and note down the initial reading.
- Collect the water in the collecting tank up to the level more than ¾th of the collecting tank and note down the rise(R) of water level and corresponding time (t)taken to rise that level
- Repeat the above procedure for different heads.
- The observations are tabulated and coefficient of discharge of rectangular notch is computed

OBSERVATION

- Diameter of the collecting tank (D) = cm
- Angle of V- Notch (θ) =
- Inclination of Piezometer (α) =

CALCULATION:

Area of the collecting tank $A = \frac{\pi}{4} \times d^2$ ………….. cm^2

Rise of water level (R) = ………….. cm

Volume of water collected $V_t = A \times R$ …….. cm^3

Actual discharge $Q_a = \frac{V_t}{t}$ ……………… $cm^3/\sec$

Net head $(h) = (h_1 - h_2) \times \sin\alpha$ ……………………. cm

Theoretical discharge $Q_a = \frac{8}{15}\sqrt{2g}\,tan\frac{\theta}{2} \times h^{5/2}$ ………….. $cm^3/\sec$

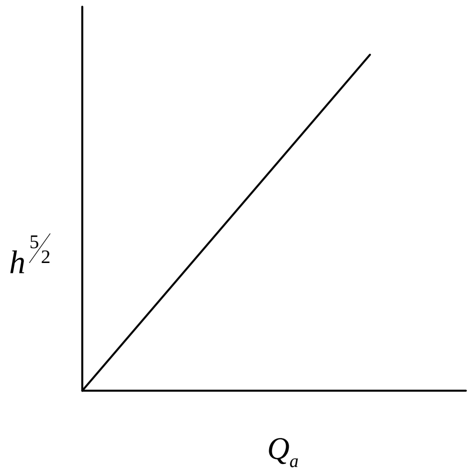
Coefficient of discharge $C_d = \frac{Q_a}{Q_t}$

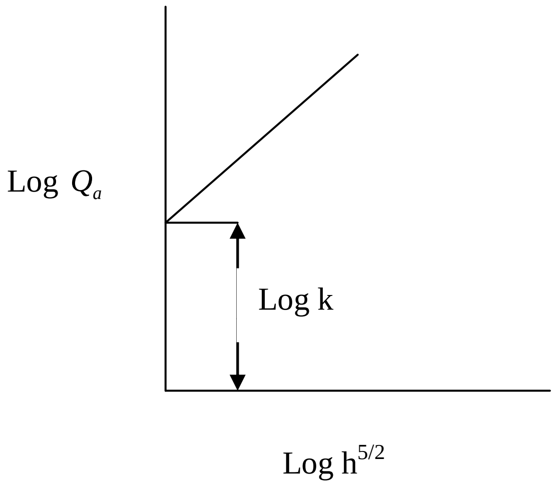
TABULAR FORM

S.No	Name of the notch	Piezometer reading		Net head $(h) = (h_1 - h_2) \times \sin\alpha$ cm	Rise of water level in the collecting tank R cm	Time taken to rise R cm t sec	Volume of water collected V_t = A x R cm^3	Actual Discharge $Q_a = \frac{AR}{t}$ $cm^3/\sec$	Theoretical Discharge $Q_a = \frac{8}{15}\sqrt{2g}\tan\frac{\theta}{2} \times h^{5/2}$ $cm^3/\sec$	Coefficient of discharge $C_d = \frac{Q_a}{Q_t}$
		Initial h_1 cm	Final h_2 cm							
1										
2										
3										
4										
5										

MODEL GRAPHS:

- A calibration curve between the head on the notch H on x-axis and Q_a on Y-axis is drawn.
- A straight line graph between Q_a on X-axis and $H^{5/2}$ on Y-axis is drawn. From the graph the values of $K = \frac{Q_a}{H^{5/2}}$ is determined. $C_d = K/C$, where $C = \frac{8}{15}\sqrt{2g}\,\text{Tan}\frac{\theta}{2}$
- A graph between Log^{H}_{10} on X-axis and $\log^{Q_a}_{10}$ on Y-axis is drawn.
- The intercept of the straight line on Y-axis measured from X-axis gives the value of $\log^{k}_{10}$



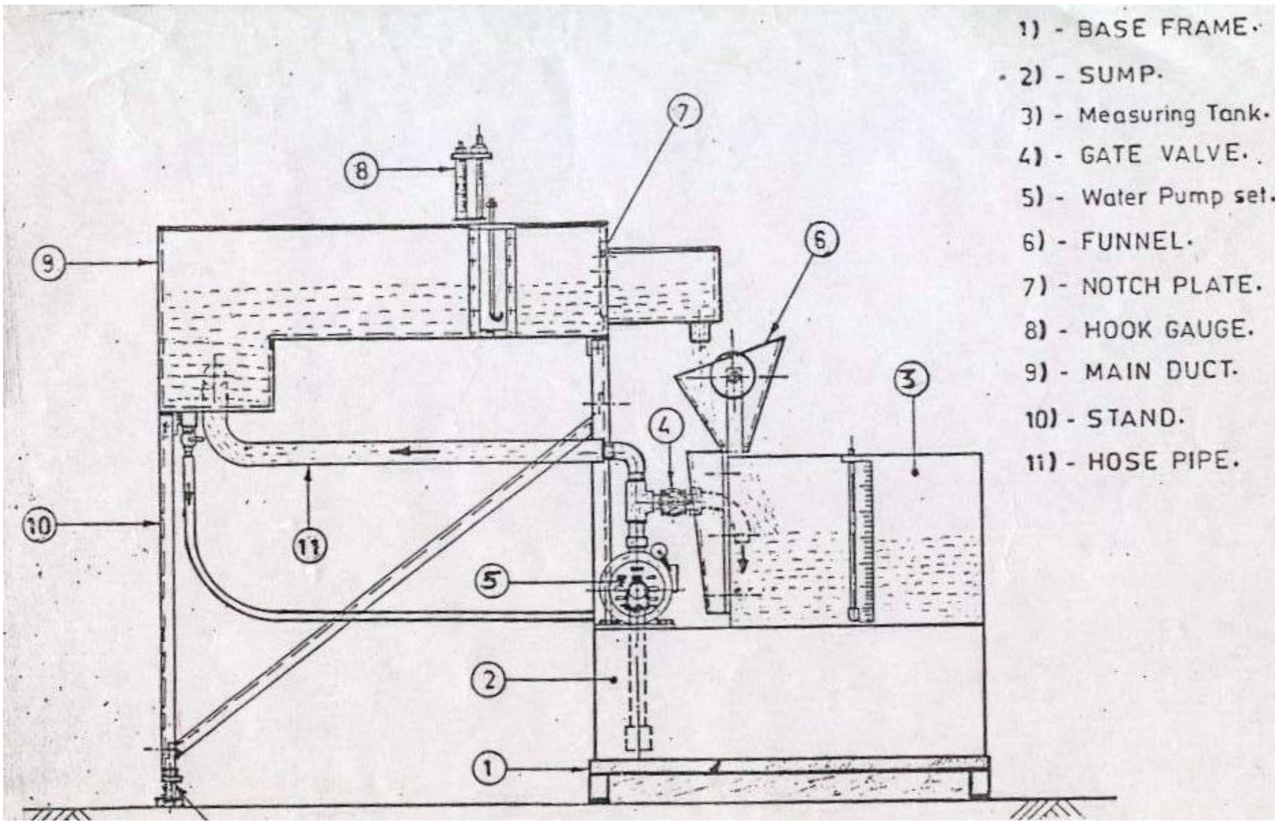


PRECAUTIONS:

1. Readings should be taken with out parallax error
2. Sill level reading should be taken exactly

RESULT:

1. Average coefficient of discharge experimentally equal to ………………..
2. Coefficient of discharge from graph Q_a Vs $h^{5/2}$ ....
3. Coefficient of discharge from graph log Q_a Vs log $h^{5/2}$ ....


1) - BASE FRAME.
2) - SUMP.
3) - Measuring Tank.
4) - GATE VALVE.
5) - Water Pump set.
6) - FUNNEL.
7) - NOTCH PLATE.
8) - HOOK GAUGE.
9) - MAIN DUCT.
10) - STAND.
11) - HOSE PIPE.

V NOTCH

VERIFICATION OF BERNOULLI'S THEOREM

AIM: Experimental Verification of Bernoulli's theorem

DESCRIPTION:

The apparatus consists of a receiving cylinder to store water to the required head, a closed conduit of uniformly varying cross - section, number of piezometers take along the path of the conduit to measure the pressure head at the point, and a controlling valve to control rate of flow of water. A collecting tank is provided to find out the actual discharge. According to Bernoulli's theorem, the sum of pressure head, velocity head and elevation head is constant for all points along a continuous conduit of frictionless flow.

$$\frac{P}{W}+\frac{V^2}{2g}+Z=C$$

APPARATUS:

1. Bernoulli's equipment
2. Stop watch
3. Meter scale

PROCEDURE:

1. Open the gate valve and allow the water to flow through receiving cylinder
2. Slowly open outlet gate valve and adjust the supply such that for a particular head in the receiving cylinder, the inflow and outflow are equal.
3. Note the height of water in receiving cylinder.
4. Note the height of water above the center of conduit in each tube.
5. Find out the rise of water level in the collecting tank for 10sec.
6. Calculate the area of cross–section of the conduit at points where the pressure heads are measured.
7. Change the discharge and repeat the procedure.

OBSERVATION:

1. Area of cross –section of flow at different points, $a_1, a_2 \ldots\ldots a_8$ = cm^2
2. Diameter of the collecting tank (D) = …………….cm
3. Elevation head, Z …………….cm

CALCULATIONS

1. Area of cross section of collecting tank, A = $\frac{\Pi}{4}(D^2)$ =… cm^2

2. Height of water in the receiving cylinder (R) = …………. cm

3. Volume of water collected in the tank $V_t = A \times R$ =……… cm^3

4. Actual discharge $Q_a = \frac{V_t}{t}$ ………… $cm^3/\sec$

5. Velocity of flow at a point $v = \frac{Q_a}{a}$ ……………… $cm/\sec$

6. Velocity head at point $= \frac{V^2}{2g}$ ……………… cm

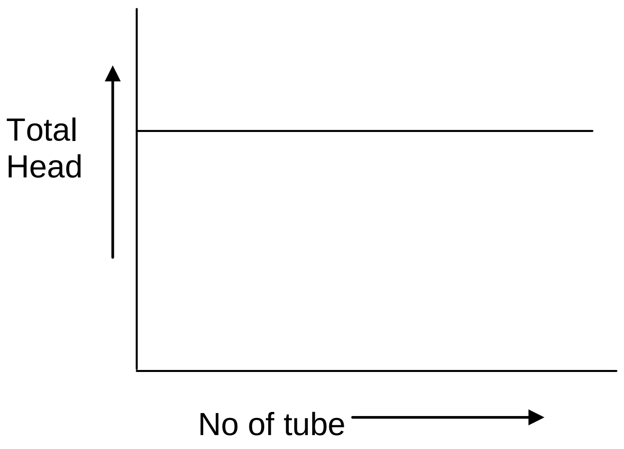
7. Pressure head at the point $\frac{P}{W}$ = …………….. cm

8. Total head at the point = $\frac{P}{W} + \frac{V^2}{2g} + 0$ …………….. cm

TABULAR FORM

S.No	Height of water level in the receiving cylinder cm	Piezometer tube No.	Pressure head $\frac{P}{W}$ cm	Rise of water level in the collecting tank for $10\sec$ $R\ cm$	Area of collecting tank a cm^2	Volume of water collected V cm^3	Area of flow A cm^2	Actual Discharge $Q_a = \frac{V_t}{t}$ $cm^3/\sec$	Velocity $v = \frac{Q_a}{a}$ $cm/\sec$	Velocity head $\frac{V^2}{2g}$ cm	Total head $\frac{P}{W} + \frac{V^2}{2g}$
1		1 2 3 4 5 6 7 8									
2		1 2 3 4 5 6 7 8									
3		1 2 3 4 5 6 7 8									

MODEL GRAPHS

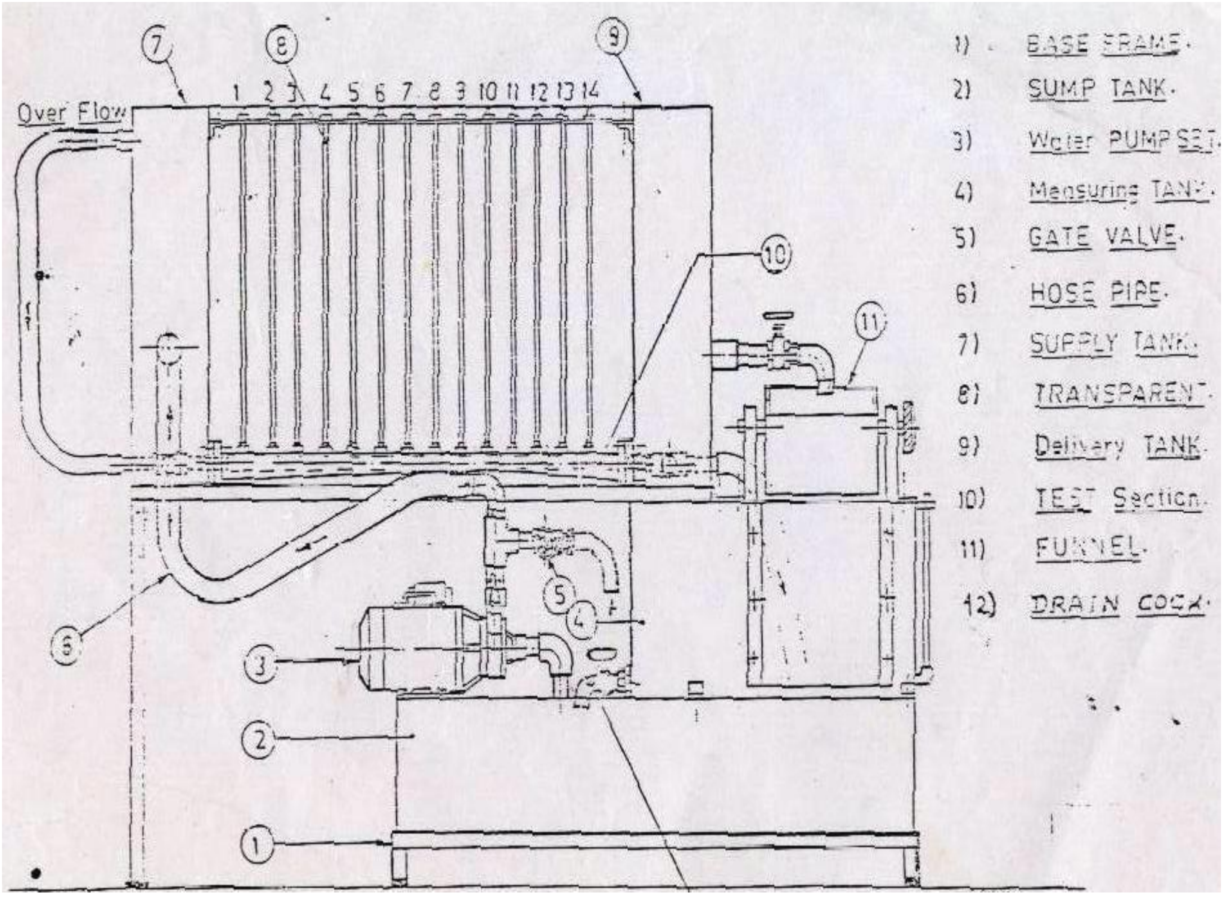


PRECAUTIONS:

1. Note down the readings with out parallax error

RESULT:

Bernoulli's theorem is verified experimentally



BERNOULLI'S APPARATUS

LOSSES IN PIPES DUE TO FRICTION

AIM:

To determine the co-efficient of friction for a given pipe

THEORY:

The fluid flow through a pipe line is characterized by energy losses. Energy loss is characterized as major energy loss and minor energy losses. Major energy loss is due to the friction and minor energy loss is due to the change in pipe line geometry. Energy loss due to friction is much more than the minor losses so that minor losses can be neglected. While the nature of flow depends upon the flow Reynolds's number, the frictional resistance offered to the flow of fluid depends essentially on the roughness of the surface of the conduct carrying the flow. in laminar flow the frictional resistance is due to viscous resistance of the fluid to flow. in turbulent it is due to the resistance offered by viscosity of fluid and surface roughness of the conduct.

The frictional resistance varies with

- With the degree of roughness of surface with which fluid comes in contact.
- With the extent of area of surface coming in contact with the fluid
- Directly as the velocity in laminar flows and as the square of velocity in laminar flows and as the square of velocity in turbulent flow
- Directly as the density of fluid
- Inversely as the velocity of fluid

The friction loss for a pipe line is determined by Darcy – Weisbach equation which is capable to both laminar and turbulent flow in a pipe line.

The loss of head due to friction is given by the Darcy's Formula. $h_f = \frac{4flv^2}{2gd}$

The coefficient of friction $f = \frac{h_f\ 2gd}{4lv^2}$

APPARATUS:

- Pipe friction apparatus with pipes of different diameters fitted with inlet and outlet Nipples.
- U-Tube manometer
- collecting tank
- Stopwatch
- Metre scale

EXPERIMENTAL PROCEDURE

1. Connect the U-Tube manometer to the pressure tapings of the pipe for which coefficient of friction is to be determined.
2. Start the motor ,Open the inlet valve to allow uniform flow through the pipe
3. Reject the air bubbles if any by slowly raising the pinch cock
4. Open the inlet and outlet Nipples to allow water into the two limbs of the manometer.
5. Note the manometric fluid levels h_1 and h_2 in the two limbs of the manometer
6. Measure the diameter of the collecting tank
7. Collect the water in the collecting tank up to the level more than 3/4 of the collecting tank and note down the rise(R) of water level and corresponding time (t)taken to rise that level
8. Repeat the above procedure by gradually increasing the flow and note down the required readings.

OBSERVATION AND RECORDING

1. Diameter of the collecting tank (D) …..…. cm
2. Diameter of the pipe (d)…..………cm
3. Length of the pipe (l)……….. cm

CALCULATION:

1. Area of collecting tank $(A) = \frac{\pi D^2}{4}$ ……. cm^2

2. Rise of water level in the collecting tank (R) =….. cm

3. Volume of water collected in the tank (V) = $A \times R$ ………. cm^3

4. Discharge $(Q_{act}) = \frac{A\ X\ R}{t}$ ………… $cm^3/\sec$.

5. Area of the Pipe $(a) = \frac{\pi d^2}{4}$ ……..cm^2

6. Velocity of flow (v) = Q_{act}/a ……….$cm/\sec$.

7. Coefficient of friction $f = \frac{h_f\ 2gd}{4lv^2}$

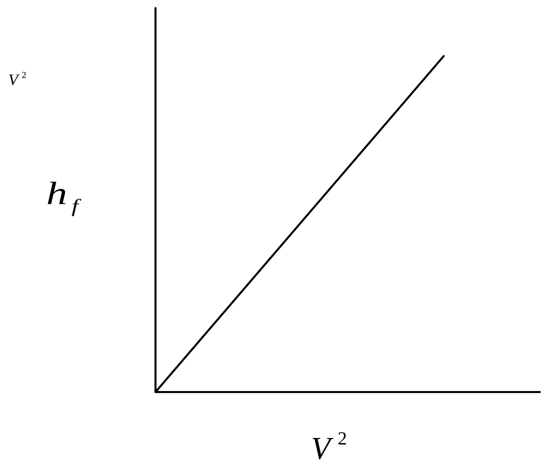
TABULAR FORM

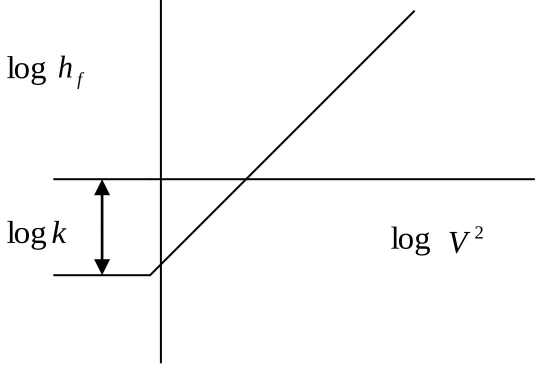
S. No	Manometer reading			$h_f = h(s-1)$ cm of water	Rise of water level in the collecting tank R cm	Time for collecting R cm rise of water, t sec.	Area of collecting tank A cm^2	Volume of water collected $(V) = A \times R$ cm^3	Actual Discharge $Q_a = V/t$ cm^3/sec	Velocity $(v) = Q_a/a$ cm/sec	$f = \frac{h_f\ 2gd}{4lv^2}$
	h_1 cm	h_2 cm	$h = h_1 - h_2$ cm								
1											
2											
3											
4											
5											

Avg (f) =

MODEL GRAPHS:

1. Draw a graph between h_f Vs V^2
2. Draw a graph between $\log h_f$ Vs $\log V^2$



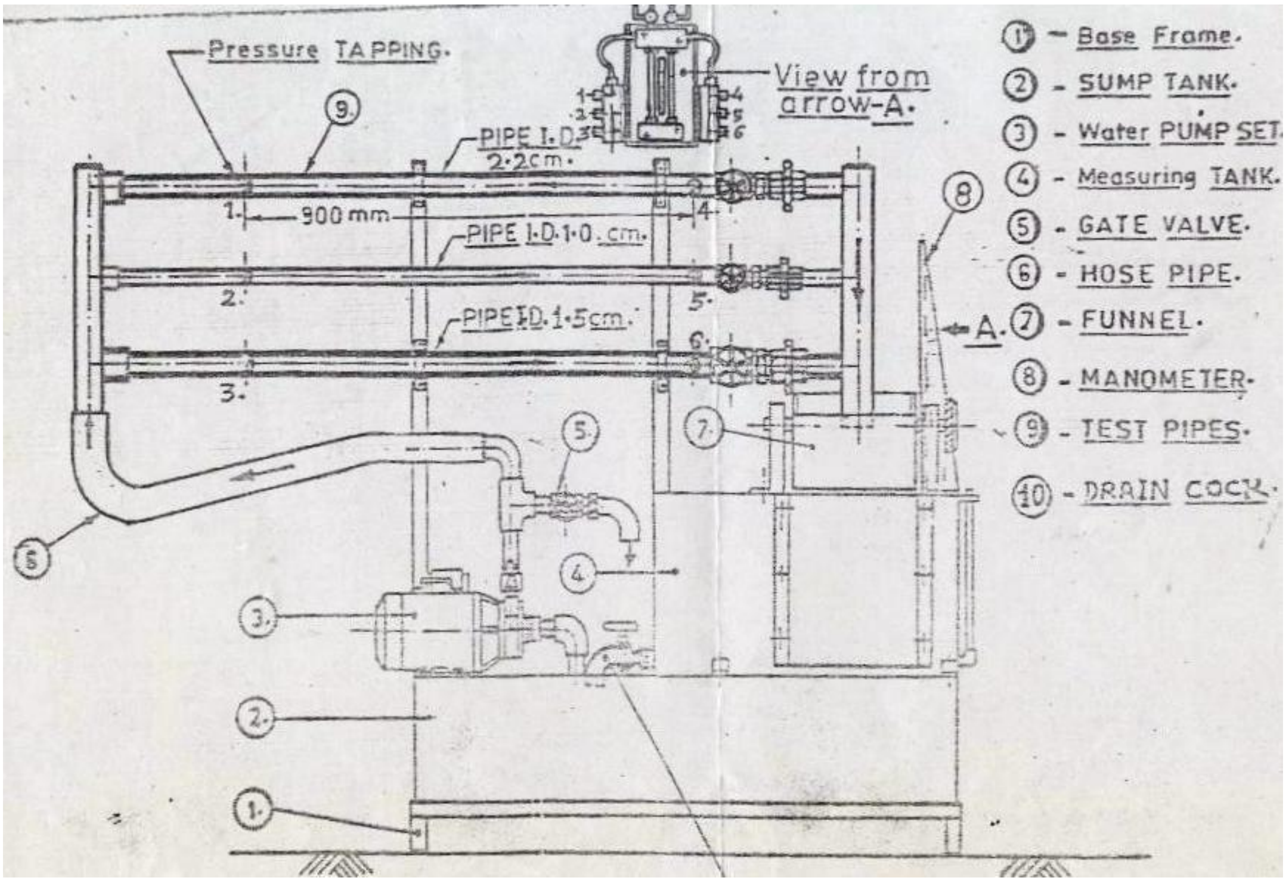


PRECAUTIONS:

1. Readings should be taken with out parallax error
2. Remove the air bubbles from the manometer tubes

RESULT:

1. Average coefficient of friction experimentally ……………
2. Coefficient of friction from graph h_f Vs V^2 ………………….
3. Coefficient of friction from graph $\log h_f$ Vs $\log V^2$ ………………



LOSSES IN PIPE

MINOR LOSSES IN A PIPE

AIM:

To determine form (minor) losses in pipe.

INTRODUCTION:

In most of the pipe flow problems, the flow is steady and uniform, and the loss of head due to friction is predominant. In edition to the loss of head due to friction, the loss of head is also occurs whenever there is change in the diameter or direction, or there is any obstruction in the flow. These losses are called form losses or minor losses.

The form losses are usually small and insignificant in long pipes but for pipes of small length, they are quit large compared to the friction loss. In some small length pipes, they mat be even more predominant than that due to friction.

EXPERIMENTAL SETUP:

The set-up consists of a small diameter pipe which suddenly changes to a large diameter pipe. After a certain a length, the large diameter reduces to a small diameter. The small diameter pipe has a 90^0 bend. Suitable pressure tapping points are provided to measure the loss of head with an inverted U-tube manometer. The loss of head can be determined by connecting the manometer across the section where the changes occur in the flow.

The pipe is connected to a constant-head supply tank. The water is collected in measuring tank for the determination of the discharge.

THOERY:

The form losses are usually expressed as

$$H_L = K\left[\frac{V^2}{2g}\right]$$

Where,

V is the mean velocity of flow,

K is the form loss factor, which depends upon the type of obstruction or change, the type of flow and the velocity, etc.

The loss of head due to sudden expansion is usually determined by the Borda-carnot equation,

$$H_L = \frac{(V_1 - V_2)^2}{2g}$$

Where

V_1 is the velocity in the smaller pipe and

V_2 is the velocity in the larger pipe,

Eq (a) can be expressed as

$$H_L = K_e \left[\frac{V_1^{\ 2}}{2g} \right]$$

Where,

K_e is the coefficient for sudden expansion. The value of K_e depends upon $\frac{d_1}{d_2}$ ratio. For gradual expansion (diffusers), the value of K_e depends upon the $\frac{d_1}{d_2}$ ratio and the angle of divergence.

The loss of head due to sudden contraction is usually expressed as

$$H_L = K_c \left[\frac{V_1^{\ 2}}{2g} \right]$$

Where

V_1 is the velocity in small pipe.

The value of K_c is usually about 0.3 to 0.5.

For gradual contractions, the loss of head is considerly small.

The loss of head at a bend can be expressed as

$$H_L = K_b \left[\frac{V^2}{2g} \right]$$

The value of K_b depends upon the angle of bend, the ratio of the radius of curvature of the bend to the diameter of the pipe (i. e. r/D ratio), and the roughness of the pipe.

For a 90^0 bend, the value of K_b usually varies between 0.60 and 0.90.

PROCEDURE:

1. Measure the diameter of pipes. Also measure the dimensions of the collecting tank.
2. Open the inlet valve.
3. Connect the manometer across the sections for which the loss of head due to sudden expansion is to be measured.
4. Gradually adjust the exit valve. When the flow becomes steady, measure the manometric deflection (h).
5. Take the initial reading of the measuring tank and start the stop watch. Note the rise in water level for a suitable time period.
6. Repeat steps 4 and 5 for different discharges.
7. Repeat steps 3 to 6 for the loss of head due to sudden contraction.
8. Repeat steps 3 to 6 for the loss of head due to bend.

OBSERVATIONS AND CALCULATIONS:

Diameter of the smaller pipe, $D_1 =$

Diameter of the larger pipe, $D_2 =$

Dimensions of the measuring tank:

$L =$ $B =$ $A =$

SUDDEN EXPANSION

S. No.	Discharge Measurement						Loss of head		V_1	$\frac{V_1^2}{2g}$	V_2	$\frac{V_2^2}{2g}$	K_e
	Initial Level	Final Level	Rise in Level	Volume	Time	Q	Deflection (h)	$hf = (1 - \frac{s_1}{S_1})h$					
1													
2													
3													
4													

SUDDEN CONTRACTION

S. No.	Discharge Measurement						Loss of head		V_1	$\frac{V_1^2}{2g}$	V_2	$\frac{V_2^2}{2g}$	K_c
	Initial Level	Final Level	Rise in Level	Volume	Time	Q	Deflection (h)	$hf = (1 - \frac{s_1}{S_1})h$					
1													
2													
3													
4													

PRECAUTIONS:

1. There should be no air bubble in the inverted U-tube and its Tapings.
2. Readings should be taken when the flow is steady.
3. Collect adequate quantity of water for the determination of discharge.

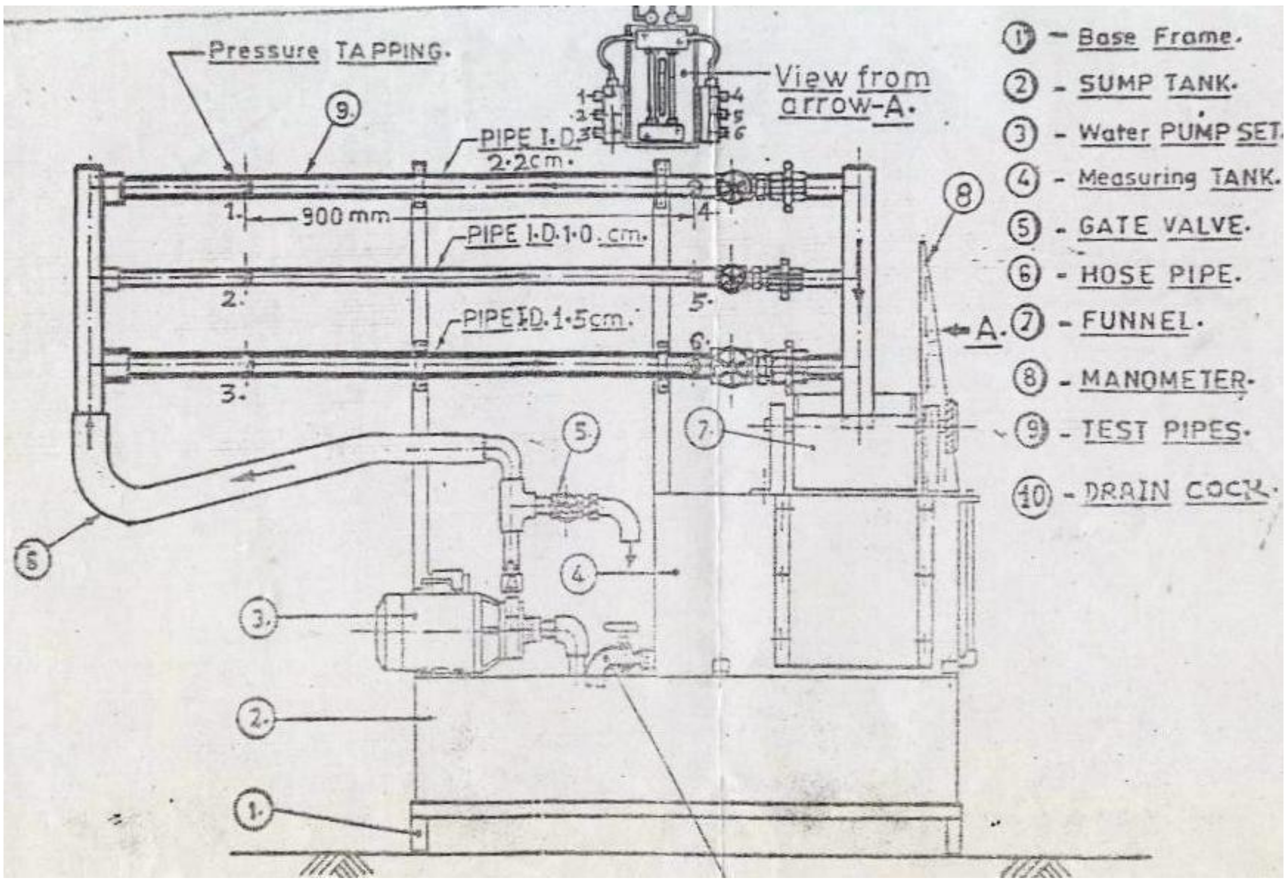
RESULT:

Average values of factor K for

a) Sudden expansion, K_e =

b) Sudden contraction K_c =

c) 90^0 bend, K_b =



MINOR LOSSES IN PIPE

PELTON WHEEL

AIM:

Determination of efficiency of Pelton wheel at constant head.

APPARATUS: Pelton wheel test rigs, tachometer and weights.

DESCRIPTION:

Pelton wheel is an impulse turbine which is used to utilize high heads for generation of electricity. It consists of a runner mounted on a shaft. To this a brake drum is attached to apply brakes over the speed of the turbine. A casing is fixed over the runner. All the available head is converted into velocity energy by means of spear and nozzle arrangement. The spear can be positioned in 8 places that is, 1/8, 2/8, 3/8, 4/8, 5/8 6/8, 7/8 and 8/8 of nozzle opening. The jet of water then strikes the buckets of the Pelton wheel runner. The buckets are in shape of double cups joined at middle portion. The jet strikes the knife edge of the buckets with least resistance and shock. The jet is deflected through more than 160^o to 170^o. While the specific speed of Pelton wheel changes from 10 to 100 passing along the buckets, the velocity of water is reduced and hence the impulsive force is supplied to the cups which in turn are moved and hence the shaft is rotated. The supply of water is arranged by means of centrifugal pump. The speed of turbine is measured with tachometer.

PROCEDURE:

1. Keep the nozzle opening at about $3/8^{th}$ open position
2. Prime the pump if necessary
3. Close the deliver gate valve completely and start the pump.
4. Allow water in the turbine, and then the turbine rotates.
5. Adjust the deliver gate valve opening and note the Turbine inlet pressure.
6. Note the venturimeter pressure gauge readings.
7. Load the turbine by putting weights.
8. Note the speed of the turbine.
9. Note weight on hanger, W_1 and spring balance weight W_2 and weight of hanger W_0
10. Repeat the experiment for different loadings.

OBSERVATIONS:

- Venturimeter inlet Diameter, d_1= 0.065 m
- Venturimeter inlet area, $a_1 = \frac{\pi}{4} \times d_1^{\ 2}$
- Venturimeter throat diameter ,d_2= 0.039m
- Venturimeter throat area, $a_2 = \frac{\pi}{4} \times d_2^{\ 2}$
- Speed (N) = rpm
- Diameter of brake drum , D = 0.4 m
- Diameter of rope = 0.015 m

CALCULATION:

- Inlet Pressure, P = Kg/cm^2
- Total Head, H = $10 \times P$ m of Water
- Venturimeter inlet pressure, P_1 = Kg/cm^2
- Venturimeter throat pressure, P_2= Kg/cm^2
- Venturi Head , dH = 10 $\times (p_2 - p_1)$ m of water
- Discharge $Q_{act} = C_{d.} \frac{a_1 a_2 \sqrt{2gdH}}{\sqrt{a_1^2 - a_2^2}} = m^3/\sec$

$= 0.0055 \times dH^{0.5}$

$C_d = 0.98$

1 Output Power [O.P] = $\frac{2\Pi NT}{60 \times 1000}$ …… KW

Where,

N = Rated speed ….. Rpm,

W_0 = Weight of hanger = 1.0 kg

W_1 = Weight on hanger ………. kg

W_2 = spring balance reading ……….kg

R_e = Effective brake drum radius = (R + r) … m

Where R is Brake drum radius

r is Rope radius

F = Net Load = $[(W_1\text{-}W_2) + W_0] \times 9.81$ ……… N

T = (F * R_e)…………N-m

- Input Power, I.P = $\frac{W \times Q_a \times H}{1000}$ …………… KW

Where W = Specific weight of water =9810 N/m^3

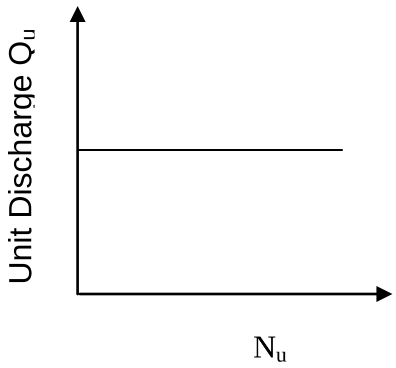
Efficiency of Turbine, $\eta = \frac{O.P}{I.P} \times 100$

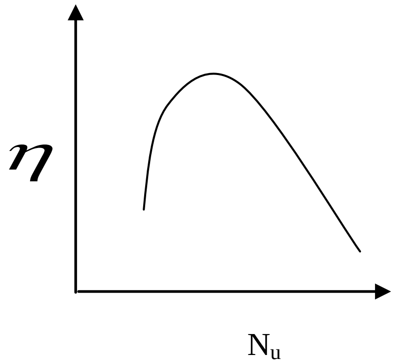
TABULAR FORM

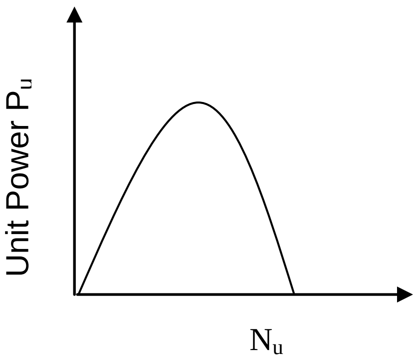
S. No.	Inlet pressure P kg/cm^2	Head H m of water	Venturimeter Reading			Discharge Q_{act} m^3/sec	Speed N , rpm	Weight on hanger W_1 Kg	Spring balance W_2 Kg	Net weight F, N	O.P KW	I.P KW	$\eta = \frac{O.P}{I.P} \times 100$
			P_1 kg/cm^2	P_2 kg/cm^2	dH m of water								

GRAPHS:

1. Unit Speed Vs η
2. Unit Speed Vs Unit Output power
3. Unit Speed Vs Unit Discharge

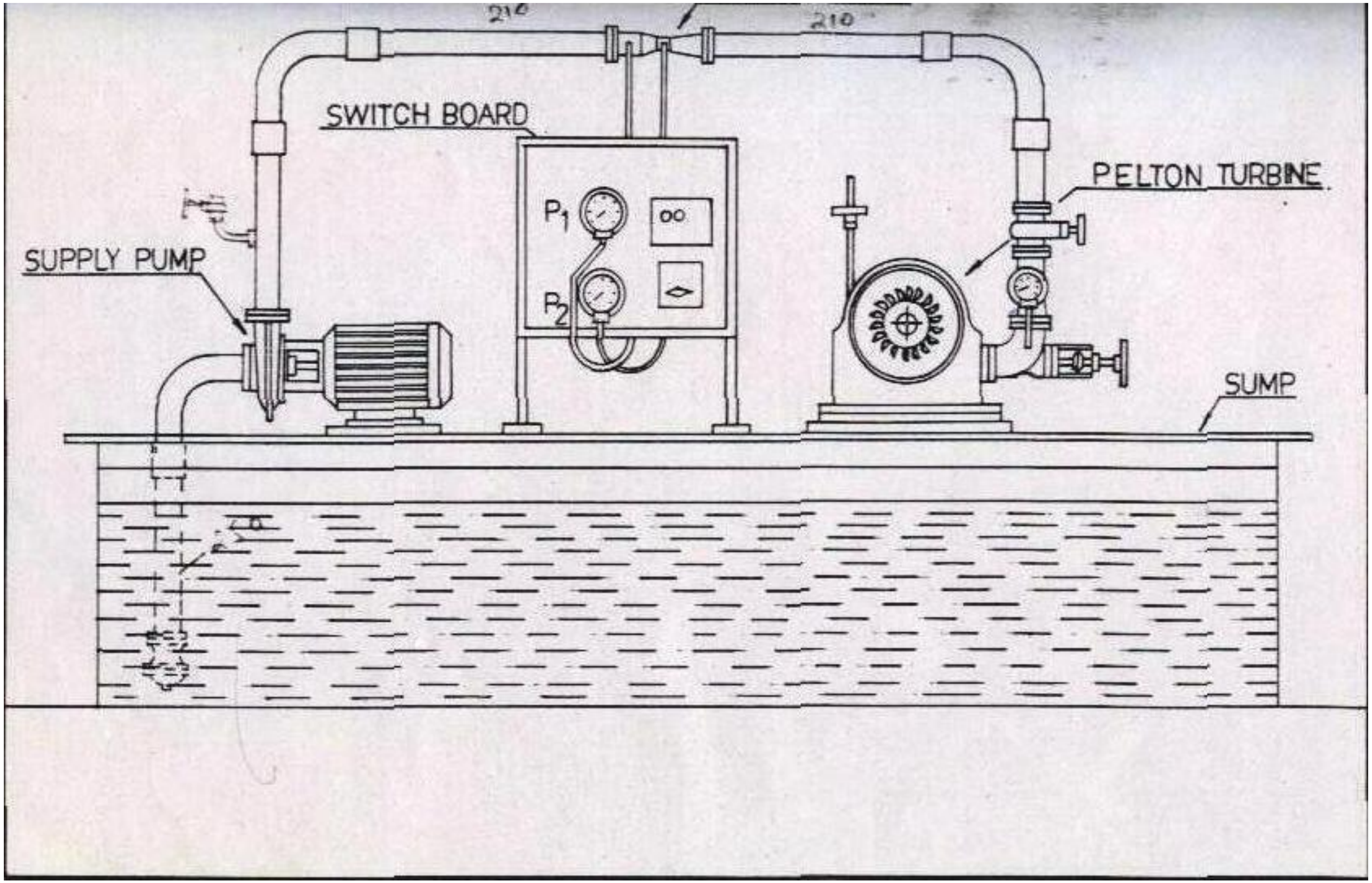






RESULT

The efficiency of Pelton wheel Turbine at constant head =____



PELTON WHEEL TURBINE

RECIPROCATING PUMP

AIM:

To determine the efficiency of a reciprocating pump and plot the operating characteristics of the Pump

DESCRIPTION:

Single acting reciprocating pump which consists of a piston which moves forwards and backwards in a close fitting cylinder. The movement of piston is obtained by connecting rod. The crank is rotated by means of electric motor suction and delivery pipes with suction valve are connected to the cylinder the suction and delivery valves are one way or non return valves. Which allow the water to flow in one direction by rotating the crank in the position θ= 0^o to 180^0 and $180^0 – 360^0$ we get the valves.

Discharge (Q) = $\frac{ALN}{60}$

Weight of water per sec = $\rho \times g \times Q$

Work done = $\frac{[\rho g \times ALN \times (h_s + h_d)]}{(60 \times 1000)} \ldots\ldots\ldots kw$

PROCEDURE:

1. Switch on the pump and open the discharge valve of the pump fully
2. After steady state is attained note down the suction pressure and delivery pressure
3. Note down time taken for 20revolutions in the energy meter
4. Measure the diameter of the collecting tank
5. Collect the water in collecting tank say 1 cm or 2 cm and note down the initial reading.
6. Collect the water in the collecting tank up to the level more than ¾th collecting tank and note down the rise(R) of water level and corresponding time (t) taken to rise that level
7. Operate the delivery valve and change the flow rate
8. Repeat the procedure for different flow rate by regulating discharge valve from maximum to minimum

OBSERVATIONS

Diameter of collecting tank (D) =……………………… m

Energy meter constant , K = --------------------

CALCULATION:

- Suction head (h_s) = $\frac{S_m \times P_s}{S_w \times 1000}$ …………… m of water

  S_m = Specific Gravity of mercury = 13.6

  S_w = Specific Gravity of Water = 1

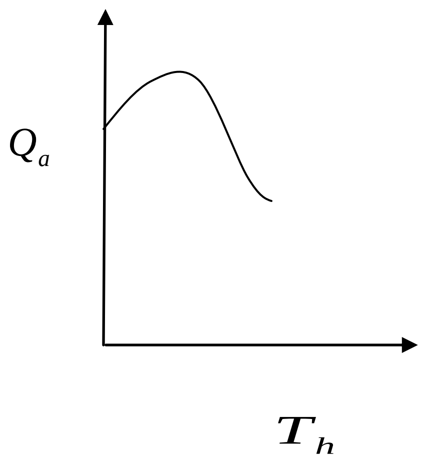
- Discharge head (h_d)= P_d x10……………………… m of water
- Total head (T_h) = $(h_s + h_d)$= …………………… . m of water
- Area of collecting tank (A)= $\frac{\pi}{4} \times D^2$ ……………………… m^2
- Rise of water level in the collecting tank (R) = ……….. m
- Volume of water collected in Tank (V) = $A \times R$= ……….. m^3
- Time taken for collecting R m rise of water (t)=……….. sec
- Actual discharge (Q_a) = $\frac{V}{t}$ ………………………………… m^3/sec
- Output power (O.P) = $\frac{(W \times Q \times T_h)}{1000}$ ………. kw
- Number of Revolutions of energy meter (n)=
- Time taken for 'n' number of revolutions of the energy meter (t_m)= ……. sec
- Indicated power (IP)= $\frac{(3600 \times n)}{(k \times t_m)}$ … kw
- Efficiency of pump , $\eta = \frac{O.P}{I.P} \times 100$

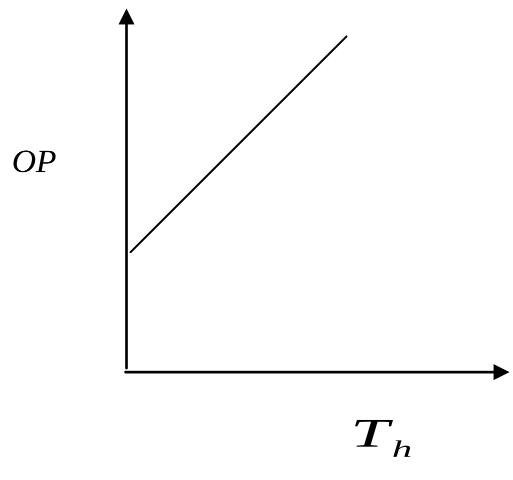
TABULAR FORM

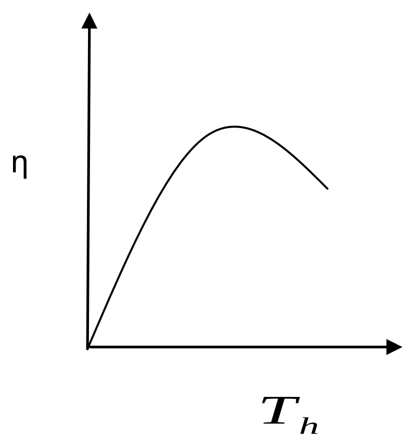
S. No.	Suction pressure		Discharge pressure		Total head (T_h) = $(h_s + h_d)$ m of water	Rise of water level in collecting tank (R) m	Time for collecting R m rise of water, t sec.	Volume of water collected (V) = $A \times R$ m^3	Discharge (Q_a) = $\frac{V}{t}$ $m^3/\sec$	Time taken for 20 rev of energy meter t_m sec	I.P $\frac{(3600 \times n)}{(k \times t_m)}$ kw	O. P $\frac{(W \times Q_a \times T_h}{1000}$ kw	$\eta = \frac{O.P}{I.P} \times 100$
	p_s mm of Hg	h_s m of water	p_d kg/cm^2	h_d m of water									

MODEL GRAPHS

1. Draw a graph between T_h Vs Q_a
2. Draw a graph between $O.P$ Vs T_h
3. Draw a graph between η Vs T_h





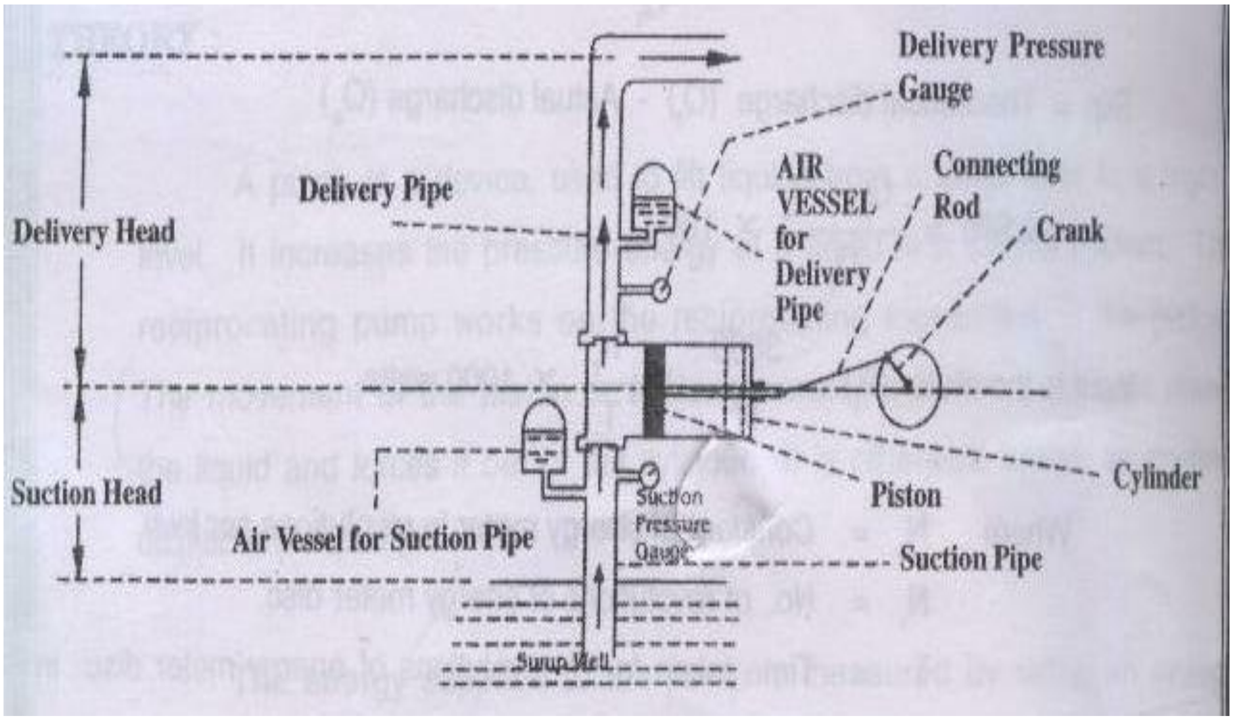


PRECAUTIONS :

- Reading should be taken without any parallax error
- The suction and delivery valves are completely opened before experiment started

RESULT

- The average efficiency of Reciprocating pump=……………



RECIPROCATING PUMP

SINGLE STAGE CENTRIFUGAL PUMP

AIM:

To determine the efficiency of a single stage centrifugal pump and plot the operating characteristic curves.

THEORY:

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 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 built 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.

DESCRIPTION :

The present Pump Test Rig is a self-contained unit operated on Closed circuit (Re circulation) basis. The Centrifugal pump, AC Motor, Sump tank, Collecting tank, and Control panel are mounted on rigid frame work with Anti-vibration mounts and arranged with the following provisions:

- For conducting the experiments at three speeds using AC Motor.
- To measure overall input power to the AC motor using Power meter.
- For recording the Pressure & Vacuum.
- For recording the speed using Digital RPM Indicator.
- For changing the Pressure (Delivery Head) and Vacuum (Suction Head) by operating the valves.
- For measuring the discharge by Collecting Tank – Piezo meter provision.
- For recirculation of water back to the sump tank by overflow provision.

SPECIFICATIONS:

Electrical Supply	:	230V, 15A, AC, 1 Phase, 50 Hz
Motor	:	AC Motor, 2 HP, 1500 RPM.
Centrifugal Pump	:	2 HP, 3000 RPM (Max.) - Kirloskar Make.
Pressure Gauges	:	2 kg/cm^2
Vacuum Gauge	:	0 - 760 mm of Hg
Energy Meter	:	To measure input power.
Speed Indicator	:	0 - 9999 RPM (Digital Type).
Control Valves	:	For Suction & Delivery.
Measuring Tank Size	:	0.242 m^2

APPARATUS

- Centrifugal pump
- Collecting tank with piezometer
- Pressure gauge
- Suction gauge
- Stop watch
- Energy meter
- Meter scale

PROCEDURE

1. Fill in the Sump Tank with clean water.
2. Keep the delivery valve closed and suction valve open, after initially priming the pump.
3. Switch-ON the Mains, so that the Mains-ON Indicator glows. Now, Switch-ON the Starter.
4. Open the delivery valve slightly, so that the delivery pressure is readable.
5. 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.
6. Note down the Discharge Pressure, Suction pressure gauge readings
7. Note down Time for 'n' number of revolutions of Energy meter.
8. Repeat the experiment for different openings of the Delivery Valve.
9. After the experiment is over, keep the delivery valve in closed position.

OBSERVATIONS

Energy Meter Constant ,K = 750 Rev/KWH

Area of Collecting Tank, A = 0.242 m^2

CALCULATION:

- Input Power (I.P)

$$P_{elect} = \frac{(n \times 3600)}{(K \times t)} \quad = \quad \text{KW}$$

$$P_{shaft} = P_{elect} \times 0.75 \quad = \quad \text{KW}$$

Where, Transmission Efficiency is taken as 75%.

- Discharge Rate $Q_{act} = \frac{(A \times R)}{t} =$ $m^3/\sec$

Where, A = 0.242 m^2 is the area of Collecting Tank,

R = the height of water collected in m

t = the time taken in seconds for collecting R m rise of water.

➢ Suction head (h_s) = $\frac{S_m \times p_s}{S_w \times 1000}$ …………… m of water

S_m = Specific Gravity of mercury = 13.6

S_w = Specific Gravity of Water = 1

➢ Discharge head (h_d)= p_d x10……………… m of water

➢ Total head (T_h) = $(h_s + h_d)$= ……………… m of water

- Output Power (Delivered by the Pump)

$$P_{pump} = \frac{(W \times Q_a \times T_h)}{1000} \quad = \qquad kw$$

Where, Specific weight of water, W = 9810 N/m^3

Q_{act} Actual Discharge .

T_h,, Total Head

- Pump Efficiency

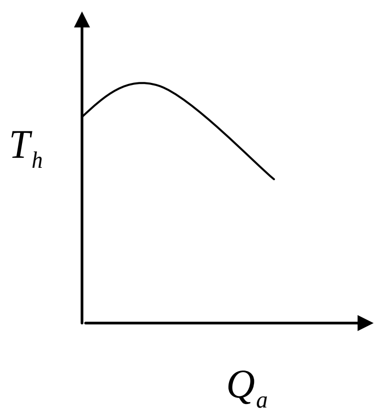
$$\eta_{pump} = \frac{O.P_{pump}}{I.P_{shaft}} \times 100$$

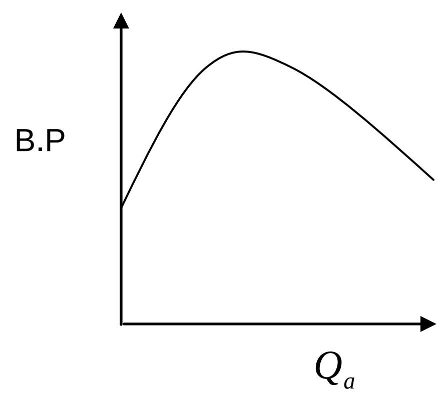
TABULAR FORM

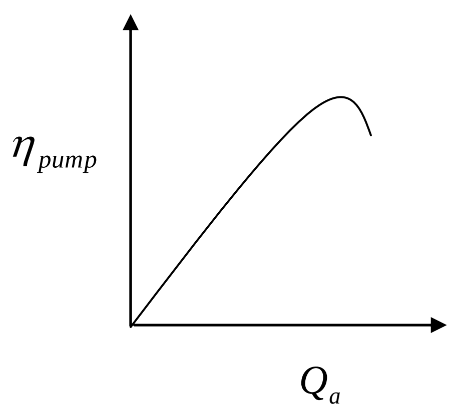
S. No.	Suction pressure		Discharge pressure		Total head (T_h) = $(h_s + h_d)$ m of water	Rise of water level in collecting tank (R) m	Time for collecting R m rise of water, t sec.	Volume of water collected (V) = $A \times R$ m^3	Discharge (Q_a) = $\frac{V}{t}$ m^3/sec	Time taken for 20 rev of energy meter t_m sec	I.P $\frac{(3600 \times n)}{(k \times t_m)}$ kw	O.Pelec $P_{pump} = \frac{(W \times Q \times H)}{1000}$ kw	O.Pshaf= O.Pelec x 0.75 kw	$\eta_{pump} = \frac{O.P_{pump}}{I.P_{shaft}} \times 100$
	p_s mm of Hg	h_s m of water	p_d kg/cm	h_d m of water										

MODEL GRAPHS

1. Discharge Vs Total Head
2. Discharge Vs Pump output
3. Discharge Vs Pump efficiency





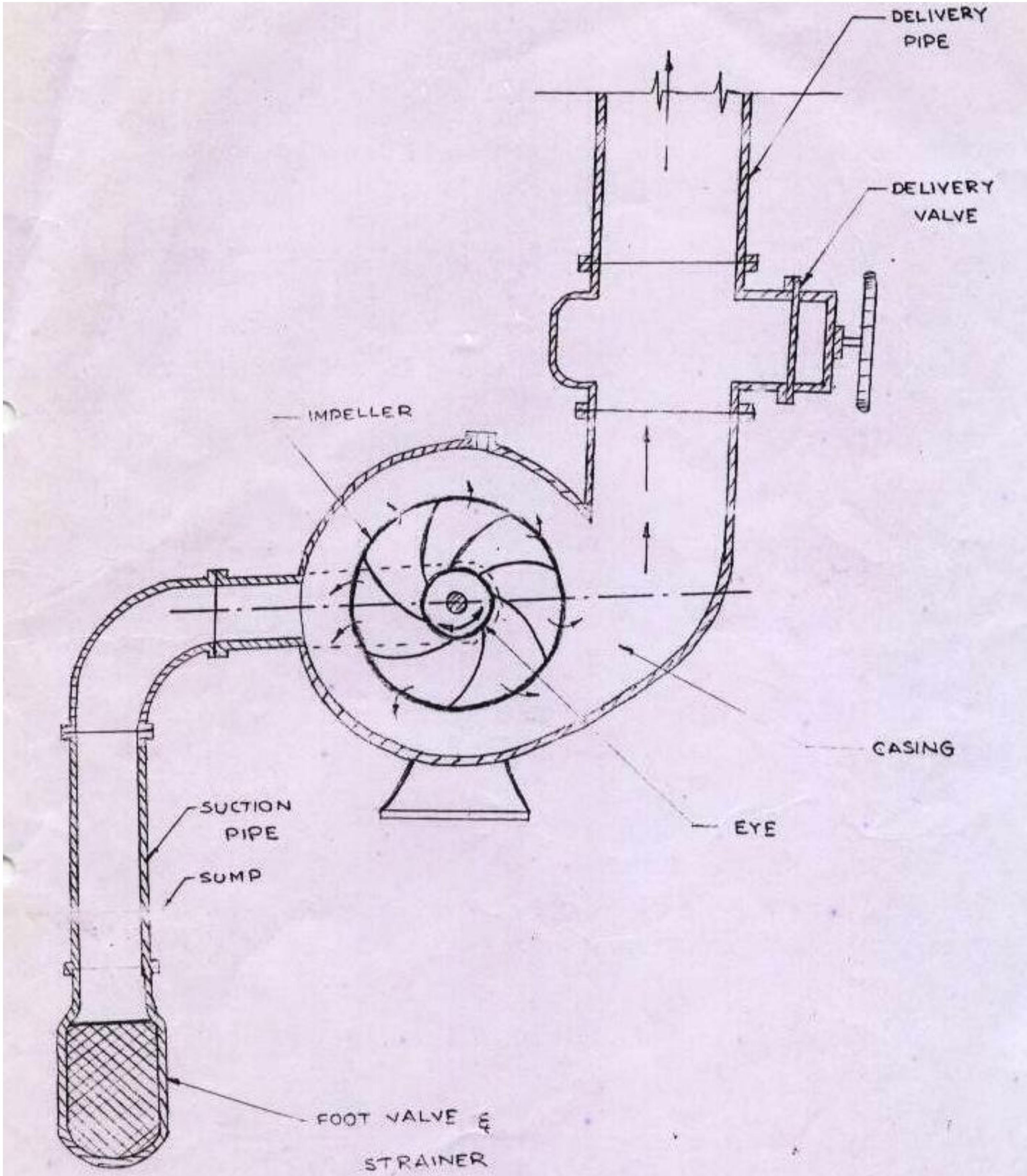


PRECAUTIONS:

- Reading should be taken without any parallax error
- The delivery valves id completely closed before experiment started

RESULT

- The average efficiency of Centrifugal pump=……………



SINGLE STAGE CENTRIFUGAL PUMP

-

MULTI STAGE CENTRIFUGAL PUMP

AIM: To determine the efficiency of a multi stage centrifugal pump and plot the operating characteristic curves.

THEORY:

A pump may be defined as a mechanical device which mean interposed in a pipe line, converts 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.

A centrifugal pump consists of an impeller in a volute casing. The impeller has number of vanes (curved) to the eye of the pump a suction pipe is connected. At the other end of this pipe a foot valve with a strainer is connected. The water enters at the centre and flows out ward to the periphery of the impeller. In the delivery side of a pipe a delivery pipe with a valve is fixed. The energy supplied to the motor is measured by means of an energy meter. Suction and delivery pressure gauges are fitted to suction and delivery pipes respectively near the pump.

A centrifugal pump may be driven with a constant speed or a variable speed motor.

The flow rate can be adjusted by operating the valve provided on the delivery pipe line. The pressure drops a cross the pump is measured by the pressure gauges. These centrifugal pumps are coming under rotodynamic pumps type and these centrifugal pumps are used for more discharge and its working on the principle of forced vortex. The main parts are impeller, casing suction pipe with strainer delivery pipe, foot step valve with strainer.

In the case of centrifugal pump, work is done by the impeller on the water. The expression for the work done by the impeller on the water is obtained by drawing velocity triangles at inlet and outlet of the impeller on the same way as for a turbine. The water enters the impeller radially at inlet for best efficiency of the pump. Which means the absolute velocity of water at inlet makes an angle of 90^0 with the direction of motion of impeller at inlet and work done by the impeller

$$\frac{1}{g}\left(vw_1u_1 - vw_2u_2\right)$$

APPARATUS

Centrifugal pump

Collecting tank with piezometer

Pressure gauge

Suction gauge

Stop watch

Energy meter

Meter scale

PROCEDURE

1. Keep the delivery valve in closed and suction valve open position
2. Start the motor
3. Close the delivery valve slightly, so that the delivery pressure is readable.
4. Read the delivery pressure and suction pressure
5. Note down the time taken to 5 revolutions of energy meter
6. Measure the diameter of the collecting tank
7. Collect the water in collecting tank say 1cm or 2cm and note down the initial reading.
8. Collect the water in the collecting tank up to the level more than ¾th of the collecting tank and note down the rise(R) of water level and corresponding time (t)taken to rise that level
9. Operate the delivery valve and change the flow rate
10. Repeat the experiment for different openings of the delivery valve

SPECIFICATIONS

- Electric service : 180-250V AC, 3-Phase, 50Hz with earth connections
- Motor : 1Hp, 1440Rpm
- Centrifugal pump : 1hp, 2-stage- Suguna motor
- Belt size A40
- Pressure gauge : $2 \, {}^{kg}\!/_{cm^2}$
- Suction gauge : 0 - 760 mm of h_g
- Watt meter : BHEL made
- Control valves : for suction and delivery
- Measuring tank : $300mm \times 300mm$

OBSERVATIONS

Diameter of collecting tank (D) =……………………… m

Energy meter constant = --------------------

CALCULATION:

- Suction head (h_s) = $\dfrac{S_m \times p_s}{S_w \times 1000}$ …………… m of water

  S_m = Specific Gravity of mercury = 13.6

  S_w = Specific Gravity of Water = 1

- Discharge head (h_d)= p_d x10……………… m of water

- Total head (T_h) = $2(h_s + h_d)$= ……………… m of water

- Area of collecting tank(A)= $\dfrac{\pi}{4} \times D^2$ ………… m^2

- Raise of water level in the collecting tank (R) = ………… m

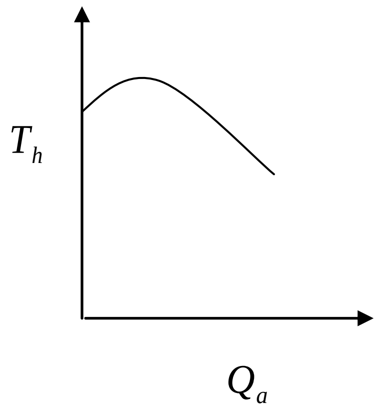
- Volume of water collected in Tank(V) = $A \times R$ = ……….. m^3
- Time taken for collection of 'R' m rise of water(t)=………..sec
- Actual discharge (Q_a) = $\frac{V}{t}$ ………………………………… m^3/sec
- Output power(OP) = $\left(\frac{w \times Q_a \times T_h}{1000}\right)$………… kw
- Number of Revolutions(n)= 5
- Time taken for 5 revolution of the meter scale(t_m)= …….sec
- Input power(IP)= $\frac{(3600 \times n)}{(k \times t_m)}$ … kw
- Efficiency of pump , $\eta = \frac{O.P}{I.P} \times 100$

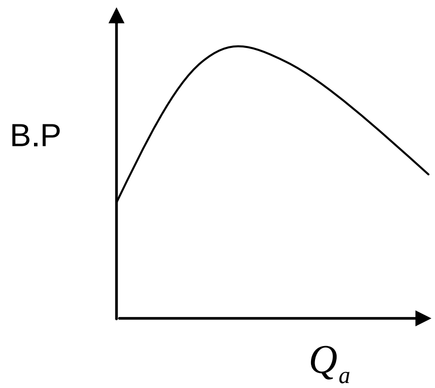
TABULAR FORM

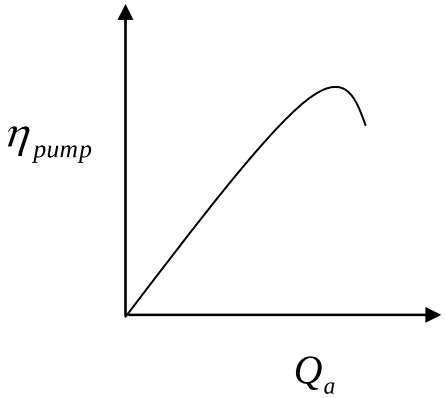
S. No.	Suction pressure		Discharge pressure		Total head (T_h) = $2(h_s + h_d)$ m of water	Rise of water level in collecting tank (R) m	Time for collecting R m rise of water, t sec.	Volume of water collected (V) = $A \times R$ m^3	Discharge (Q_a) = $\frac{V}{t}$ $m^3/\sec$	Time taken for 'n' rev of energy meter scale t_m sec	I/P power $\frac{(3600 \times n)}{(k \times t_m)}$ kw	Output Power $\frac{(W \times Q_a \times T_h)}{1000}$ kw	$\eta = \frac{O.P}{I.P} \times 100$
	p_s mm of Hg	h_s m of water	p_d kg/cm^2	h_d m of water									

MODEL GRAPHS

1. Draw a graph between T_h Vs Q_a
2. Draw a graph between BHP Vs Q_a
3. Draw a graph between η Vs Q_a





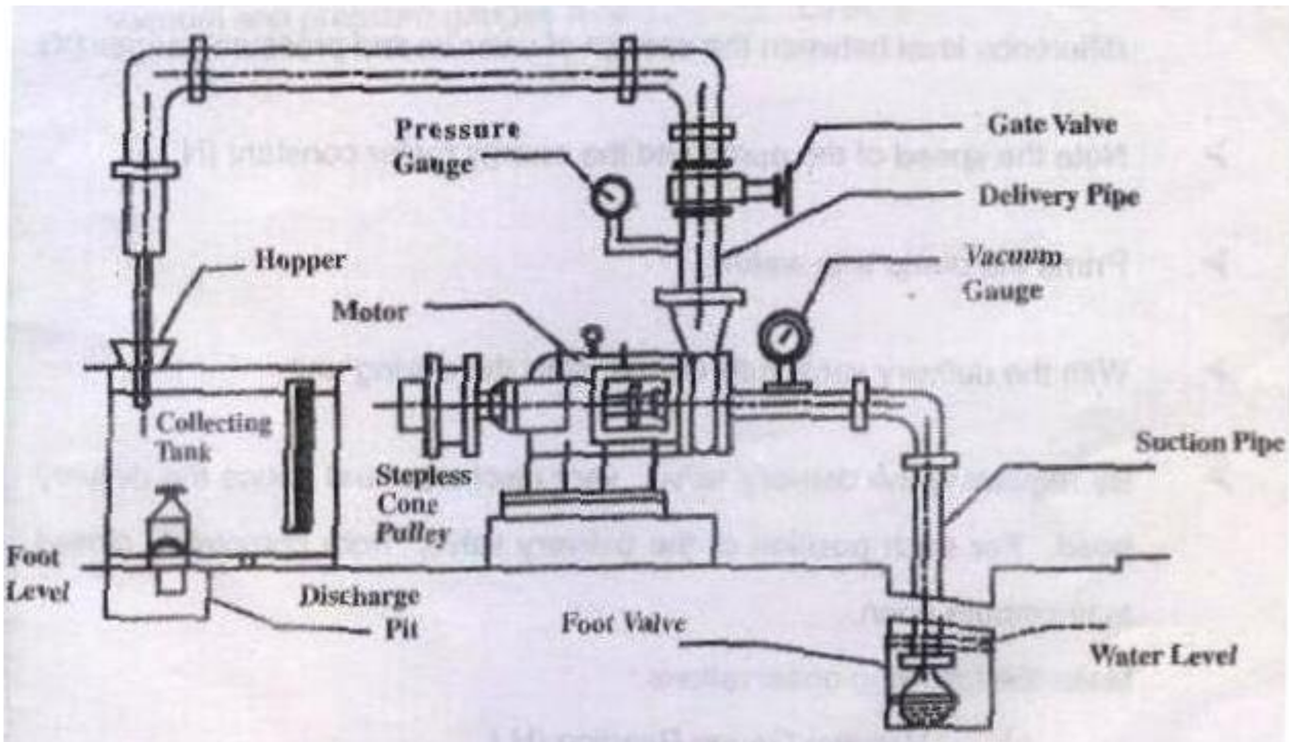


PRECAUTIONS :

- Reading should be taken without any parallax error
- The delivery valve is completely opened closed before experiment is started

RESULT

- The average efficiency of multistage Centrifugal pump=……………



MULTI STAGE CENTRIFUGAL PUMP

FRANCIS TURBINE

AIM:

Determine the efficiency of Francis Turbine at constant head

APPARATUS:

Francis turbine test rig, tachometer and weights.

DESCRIPTION:

Francis turbine consists of runner mounted on a shaft and enclosed in a spiral casing with guide vanes. The cross section of flow between the guide vanes can be varied, known as gate opening. It can be adjusted ¼, ½, ¾, or full gate opening. A brake drum is fixed to the turbine shaft. By means of this drum the speed of the turbine can be varied. The discharge can be varied by operating a throttle valve on the pipe line. The water after doing work leaves the turbine through a draft tube and flows down into the tail race. A Venturimeter is fitted to the pipe for measuring discharge.

PROCEDURE:

1. Keep the guide vane at required opening (say $3/8^{th}$)
2. Prime the pump if necessary.
3. Close the main gate valve and start the pump.
4. Open the gate valve for required discharge
5. Open the brake drum cooling water gate valve for cooling the brake drum.
6. Note the Venturimeter pressure gauge readings
7. Note the inlet pressure gauge & outlet vacuum gauge readings
8. Note weight on hanger, W_1 and spring balance weight W_2 and weight of hanger W_0.
9. Measure the turbine runner speed in rpm with tachometer.
10. Repeat the experiment for different loadings.

OBSERVATIONS:

- Venturimeter inlet Diameter, d_1= 0.1 m
- Venturimeter inlet area, $a_1 = \frac{\pi}{4} \times d_1{}^2$
- Venturimeter throat diameter ,d_2= 0.06 m
- Venturimeter throat area, $a_2 = \frac{\pi}{4} \times d_2{}^2$
- Speed (N) = rpm
- diameter of brake drum , D = 0.3 m
- Diameter of rope = 0.015 m

CALCULATION:

- Inlet Pressure, P = Kg/cm^2
- Outlet Vacuum, V = mm of Hg
- Total Head, H = $10 \times \left(P + \frac{V}{760} \right)$ m of Water
- Venturimeter inlet pressure, P_1 = Kg/cm^2
- Venturimeter throat pressure, P_2 = Kg/cm^2
- Venturi Head , dH = 10 $\times (p_2 - p_1)$ meters of water
- Discharge Q_{act} = $C_{d.} \frac{a_1 a_2 \sqrt{2gdH}}{\sqrt{a_1^2 - a_2^2}} = m^3/\sec$

  = 0.0131 x $dH^{0.5}$
- C_d =0.98

1 Output Power [O.P] = $\frac{2\Pi NT}{60 \times 1000}$ …… KW

Where,

N = Rated speed ….. Rpm,

W_0 = Weight of hanger = 1.0 kg

W_1 = Weight on hanger ………. kg

W_2 = spring balance reading ……….kg

R_e = Effective brake drum radius = (R + r) … m

Where R is Brake drum radius

r is Rope radius

F = Net Load = $[(W_1\text{-}W_2) + W_0] \times 9.81$ ……… N

T = (F * R_e)…………N-m

- Input Power, IP = $\frac{W \times Q_a \times H}{1000}$ …………… KW

Where

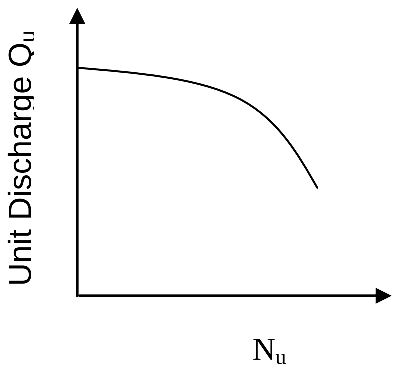
W = Specific weight of water =9810 N/m^3

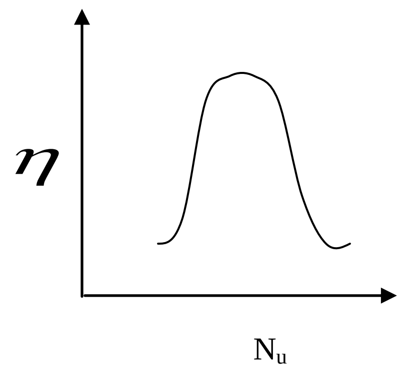
- Efficiency of Turbine $\eta = \frac{O.P}{I.P} \times 100$

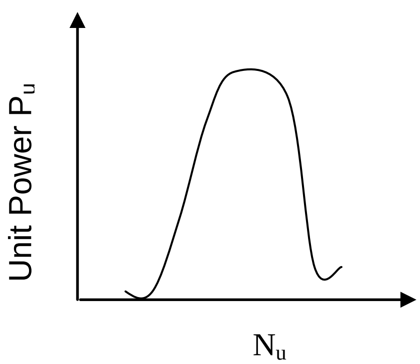
S. No.	Inlet pressure P kg/cm^2	Outlet Vacuum V mm of Hg	Total Head, H meter of water	Venturimeter Reading			Discharge Q_{act} m^3/sec	Speed N, rpm	Weight on hanger W_1 Kg	Spring balance W_2 Kg	Net weight ,F N	O.P Kw	I.P Kw	$\eta = \frac{O.P}{I.P} \times 100$
				P_1 kg/cm^2	P_2 kg/cm^2	dH m of water								

GRAPHS:

1. Unit Speed *Vs* η
2. Unit Speed *Vs* Output power
3. Unit Speed *Vs* Unit Discharge

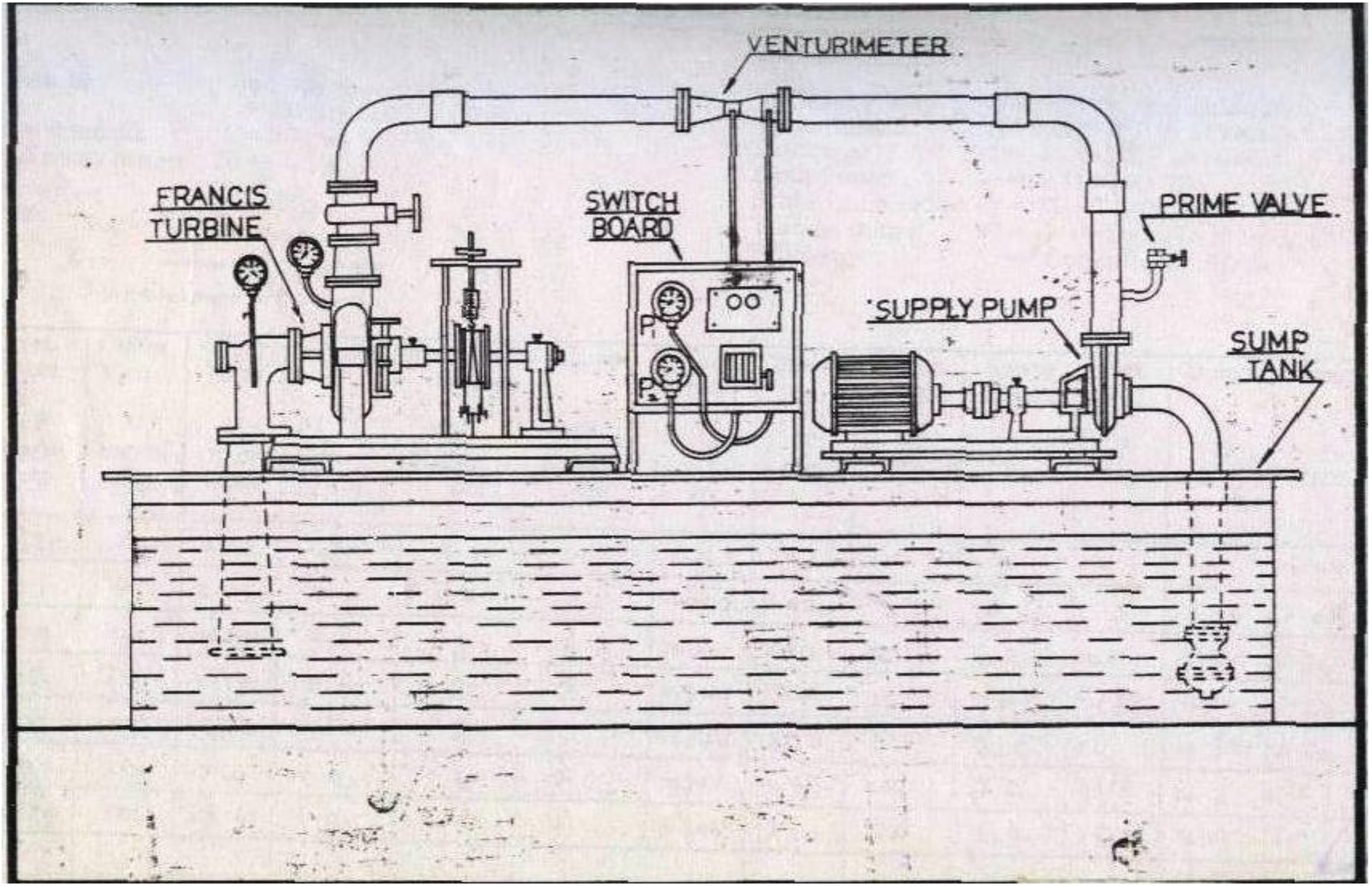






RESULT

The efficiency of Francis Turbine at constant head =____



Francis Turbine

STUDY OF IMPACT OF JET ON VANES

AIM:

To conduct an experiment on the Jet on vane apparatus and determine the efficiency of jet

THEORY:

The study of impact of a jet of water is essential to understand the principle of an impulse turbine such as Pelton Wheel Turbine. When high pressure water from a source such as a dam flows through a nozzle in the form of a jet, the entire pressure energy of the water is converted into kinetic energy at the nozzle. When this jet of water hits a vane positioned in front of it, the vane deflects the jet and due to the change in the momentum of the water jet, a force is imparted to the vane by the water.

EXPERIMENTAL SETUP:

The equipment consists of a high efficiency gun metal nozzle fitted to a 25 mm diameter pipe supply line with a gate valve. Vertically above the nozzle, a gun metal vane is fitted to a bracket of a differential lever which balances the upward force of the jet from the nozzle. The lever is provided with an adjustable no load screw mechanism. The force due to the jet on the lever is counter balanced by weights placed on a hanger. Different types of vanes can be fitted to the bracket.

The complete assembly is enclosed in a framed structure housing with two leak proof transparent sides for visual observation. The water deflected by the vane is collected in the collecting tank of the hydraulic bench.

For experimental purposes, two brass nozzles with nozzle outlet diameters of 8mm and 10mm and two gunmetal vanes of the following shape are provided.

1. Semi-circular vane (180^0 Angle of deflection)
2. Horizontal flat vane (90^0.angle of deflection)

EXPERIMENTAL PROCEDURE:

1. Fit the required vane on the lever.
2. Measure the differential lever arms and calculate the ratio of lever arms (2.0 in this case)
3. Balance the lever systems by means of counter weight for no load.
4. Place a weight on the hanger.
5. Open the gate valve and adjust the jet, so that the lever arm is balanced.
6. Collect water in the collecting tank.
7. Note (a) the pressure gauge reading – P.
   (b) The weight placed – W.
   (c) Time for 5 cm. rise in the collecting tank –t
8. Repeat the procedure for different loads

CALCULATIONS:

Area of collecting tank (A) = $0.5 \times 0.5\ sq.m$

Rise in water level (R) =

Time taken (t) = ------- sec

Actual flow rate (Q_a) = $\frac{AR}{t}\ m^3/\sec$

Actual mass flow rate (m) = $\rho \times Q\ kg/\sec$

where, ρ = Mass density of water = 1000kg/m^3

Nozzle diameter (d) = ---------------- m

Nozzle area (a) = $\Pi \frac{d^2}{4}\ sq.m.$

Jet velocity (v) = $\frac{Q_a}{a}\ m/\sec$

Theoretical lifting force = Change in momentum per sec. In vertical direction

$$F_{th} = m \times v \times (Sin\theta_1 - Sin\theta_2)$$

For Horizontal flat vane, θ_1 = 90^0 and θ_2 = 0^0

F_{th} = $m \times v$ …….N

For semi circular vane θ_1 = 90^0 and θ_2 = - 90^0.

F_{th} = $2 \times m \times v$ ……N

Actual lifting force = $W \times$ lever arm ratio

F_{act} = 2.0 W

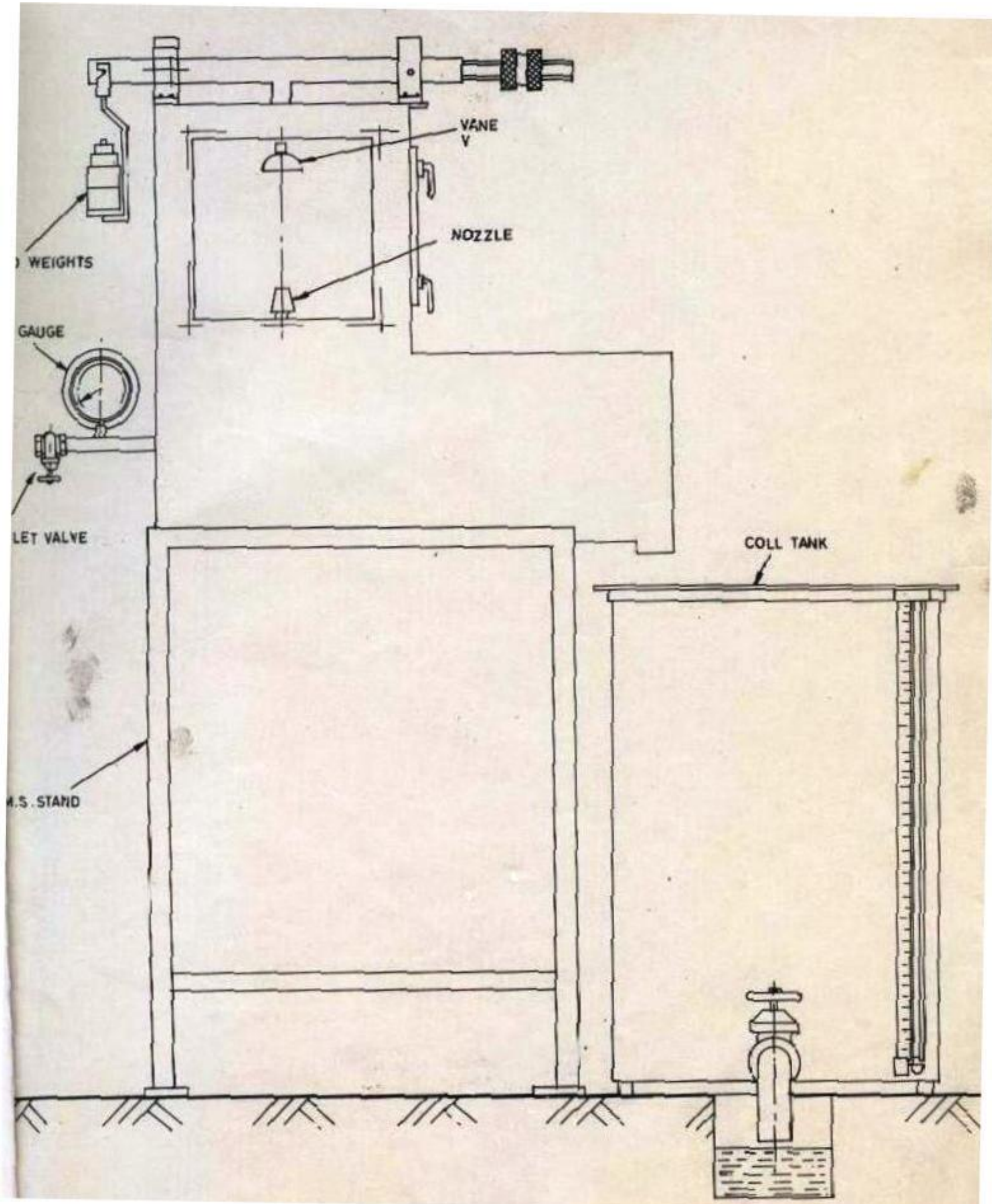
Where, W is the weight placed on hanger ………N

Jet efficiency = $\frac{F_{act}}{F_{th}}$

S.No.	Pressure		Rise water level collected in collecting tank, R m	Time for collecting R m. Rise of water, t sec.	Volume of water collected, V m^3	Actual Discharge, $Q_a = \frac{V}{t}$ m^3/Sec	Velocity $v = \frac{Q_a}{a}$ m/Sec	Mass flow rate, m = $\rho \times Q_a$ Kg/Sec.	Weight on hanger, W, N	$\eta = \frac{F_{act}}{F_{th}} \times 100$
	Pressure P Kg/cm^2	Head H_1, m of water								

RESULT:

The efficiency of the Jet is **=** ______________________



IMPACT OF JET ON VANES

TURBINE FLOWMETER

AIM : To the calibrate the given Turbine flow meter .

THEORY:

The modern axial turbine flowmeter, when properly installed and calibrated, is a reliable device capable of providing the highest accuracies attainable by any currently available flow sensor for both liquid and gas volumetric flow measurement. It is the product of decades of intensive innovation and refinements to the original axial vaned flow meter principle.There are two approaches described in the current literature for analyzing axial turbine performance. The first approach describes the fluid driving torque in terms of momentum exchange, while the second describes it in terms of aerodynamic lift via airfoil theory. The former approach has the advantage that it readily produces analytical results describing basic operation, In a hypothetical situation, where there are no forces acting to slow down the rotor, it will rotate at a speed which exactly maintains the fluid flow velocity vector at the blade surfaces.

PROCEDURE:

1. Fill the sump tank with water.
2. Switch on the power switch, “Mains On” starts glowing as well as digital flow indicator.
3. Start the pump using supply pump starter, Regulate the valve and set the water flow near to the maximum flow using Rotameter.(Almost 25 LPM)
4. Note down the time taken each 20 cm rise in water level in the Piezometer for the above setting .
5. Observe the digital flow indicator, note down the reading in pulse per second shown at the upper indication.
6. Now using the equation given calculate the factor and enter it in the indicator using button “SET”. Once set button is pressed, using upper arrow and downward arrow button factor can be fed to the indicator. Now press “ENT” button to get the discharge in LPM through the Turbine meter.
7. To get different set of readings ,using valve set different flow rate at Rota meter

(e.g.: 5, 10 etc.) and also Note down the time taken each 20 cm rise in water level in the Piezometer

8. Calculate the actual discharge from the equation. Plot the graphs given. Repeat the experiment for different discharge.

OBSERVATIONS:

Area of collecting tank A = 0.085 m^2

TABULAR FORM

S. No	Rota meter Reading LPM	Flow rate (turbine flow meter) Q_T in LPM	Pulse/ sec	Rise of water level in collecting tank R in cm	Time for 'r' cm rise of water in collecting tank in sec	Actual discharge Q_{cal} in LPM	Deviation ($Q_{cal} - Q_T$)

CALCULATIONS:

- Pulse/sec =

- Calculation for the “Factor”:

$$\text{Factor} = \frac{Q_{rotameter}}{Turbine\ Flow\ Meter\ Rotation\ In\ pulse/s}$$

- Rise of water level in collecting tank R = cm

- Time for 'R' cm rise of water in collecting tank t = sec

- Actual Discharge Q_{cal}

$$Q_{cal} = \frac{(A \times R \times 60000)}{(100 \times t)} = \quad \text{LPM.}$$

Where, R is the rise of water level in collecting tank in *cm,*

t is the time for R *cm,* rise of water rise in collecting tank in sec

PRECATIONS :

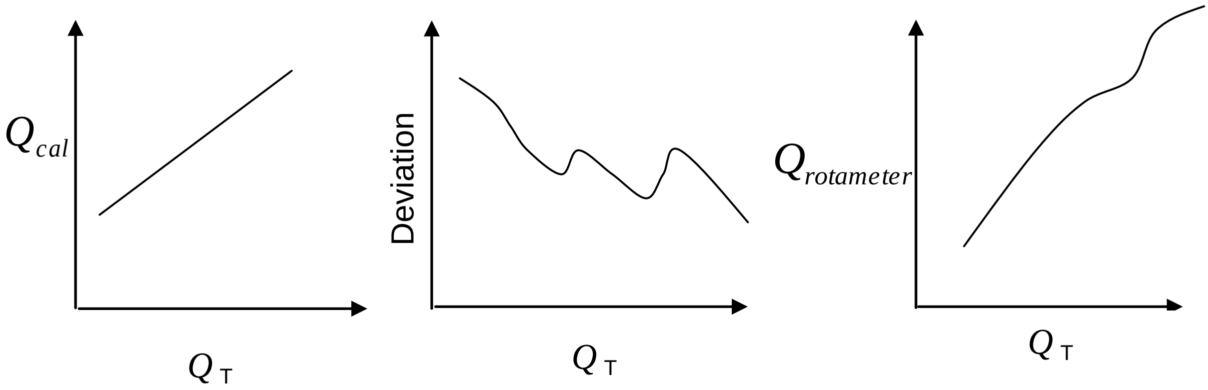
- Reading should be taken without any parallax error
- Each time before starting the experiment initial setting is must

MODEL GRAPHS:

Draw a graph between Q_T *Vs* Q_{cal}

Draw a graph between Q_T *Vs* Deviation

Draw a graph between Q_T *Vs* $Q_{rotameter}$



RESULT:

KAPLAN TURBINE

AIM:

Determine the efficiency of Kaplan Turbine at constant head

APPARATUS:

Kaplan turbine test rig, tape and hook gauge

THEORY

Hydraulic (or Water) turbines are the machines, which use the energy of water (Hydro-Power) and convert it into mechanical energy. Thus the turbines become the prime mover to run the electrical generators to produce the electricity, Viz, Hydro-electric power.

The turbines are classified as Impulse & Reaction types. In impulse turbine, the head of water is completely converted into a jet, which impulses the forces on the turbine. In reaction turbine, it is the pressure of the following water, which rotates the runner of the turbine. Of many types of turbine, the pelton wheel, most commonly used, falls into the category of impulse turbines. While Francis & Kaplan falls in category of reaction turbines.

Normally, Pelton wheel (impulses turbine) requires high head & low discharge, while the Francis & Kaplan (reaction turbines) require relatively low heads and high discharge. These corresponding heads and discharges are difficult to create in laboratory size turbine from the limitation of the pumps availability in the market. Nevertheless, at least the performance characteristics could be obtained within the limited facility available in the laboratories. Further, understanding various elements associated with any particular turbine is possible with this kind of facility.

DESCRIPTION:

Kaplan turbine, the reaction type which is of present concern consists of main components such as propeller (runner) scroll casing and draft tube. Between the scroll casing and the runner, the water turns through right angle into axial direction and passes through the runner and thus rotating the runner shaft. The runner has four blades, which can be turned about their own axis so that the angle inclination may be adjusted while the turbine in motion. When runner blade angles are varied, high efficiency can be maintained over wide range of operating conditions. In the other words even at parts loads, when a low discharge is following through the runner, a high efficiency can be attained in case of Kaplan turbine, whereas this provision does not exist in Francis and propeller turbines where, the runner blade angles are fixed and integral with hub.

The actual experimental facility supplied consists of a centrifugal pump set, turbine unit, sump tank, notch tank arranged in such a way that the whole unit works on re circulating water system. The centrifugal pump set supplies the water from the sump tank to the turbine through gate valve, which has the marking to the meter the known quantity of water. The water after passing through the turbine units enters the collecting tank through the draft tube. The water then flows back to the sump tank through the notch tank with copulate notch for the measurement of flow rate. Additionally, the provision is also made to estimate the rate of flow of water using the "Bend Meter ".

Electrical AC generator connected to lamp tank achieves the loading of the turbine. The provision for; measurement electrical energy AC voltmeter and ammeter turbine speed (digital RPM indicator), Head on the turbine (pressure gauge), are built-in on to the control panel.

SPECIFICATIONS:

Supply Pump / Motor Capacity	: 10 hp 3 ph, 440V, 50Hz, AC.
Turbine	: 150 mm dia. Propeller with fourblades.
Run-away speed	: 2500 rpm (approx.).
Max. Flow of water	: 2500 1pm (approx.).
Max. Head	: 10 mts. (approx.).
Loading	: AC generators
Provisions	: Flow rate by Rectangular notch, Notch, C_d = 0.6 (assumed).
Pressure gauge of range	: 0 – 2 kg/cm^2
Vacuum gauge	: 0-760 mm of Hg
Electrical load	: change by toggle switch (maximum Connected load: 2000 watts).
Electric Supply	**:** 3 ph, 440V, AC, 30A, with Neutral& Earth.

PROCEDURE:

1. Keep the gate closed.
2. Keep the electrical load at maximum, by keeping all the switches at ON – position.
3. Press the green button of the supply pump starter and then release.
4. Slowly, open the gate so that turbine rotor picks up the speed and Attains maximum at full opening of the gate**.**
5. Note down the voltage and current, speed, pressure, vacuum on the control panel, head over the notch, and tabulate results.
6. Close the gate & then switch off the supply water pump set.
7. Follow the procedure described below for taking down the reading for evaluating the performance characteristics of the Kaplan turbine.

❖ **TO OBTAIN CONSTANT SPEED CHARACTERISTICS:**

(Operating Characteristics)

1. Keep the gate opening at maximum.
2. For different electrical loads on turbine / generator, change the gate position, so that the speed is held constant. Say at 1500 rpm. See that the voltage does not exceed 250V to avoid excess voltage on Bulbs.
3. Reduce the gate opening setting to different position and repeat (2) for different speed 1500 rpm, 1000 rpm and tabulate the results.
4. The above readings will be utilized for drawing constant speed characteristics
   i. Percentage of full load *Vs* Efficiency.
   ii. Efficiency and BHP *Vs* Discharge characteristics.

❖ **TO OBTAIN CONSTANT HEAD CHARACTERISTICS:**

(Main Characteristics)

1. Select the guide vane angle position.
2. Keep the gate closed, and start the pump.
3. Slowly open the gate and set the pressure on the gauge.
4. For different electrical loads, change the rotor pitch position and maintain the constant head and tabulate the results given in Table – II.

TO OBTAIN RUN-AWAY SPEED CHARACTERISTICS:

1. Switch OFF the entire load on the turbine and the voltmeter.
2. Keep propeller vane angle at optimum position (Head, h = 0.75 kg/cm^2)
3. Slowly open the gate to maximum and note down the turbine speed. This is the run-away speed, which is maximum.

NOTE : Run-away speed is also influenced by the tightening in gland packing of the turbine shaft. More the lightness, less the run-away speed

❖ **PERFORMANCE UNDER UNIT HEAD – UNIT QUANTITIES:**

In the order to predict the behavior of a turbine working under varying conditions and to facilitate the comparison between the performances of the turbines of the same type but having different outputs and speeds and working under different heads, it is often convenient to express the test results in the terms of certain unit quantities.

.

Unit Speed, $N_u = N\sqrt{H}$

Unit Power, $P_u = \frac{P}{\sqrt[3]{H}}$

Unit Discharge, $Q_u = \frac{Q}{\sqrt{H}}$

PRECAUTIONS:

1. Do not start pump set if the supply voltage is less than 300V
2. To start and stop the supply pump, always keep Gate closed.
3. Gradual opening and closing of the Gate Valve is recommended for smooth operation.
4. Fill the water enough so that the pump does not choke.

OBSERVATIONS:

- Energy meter constant = 1200 Rev/kwh
- Width of rectangular notch :b = 0.498 m
- Efficiency of generator ` = 70%

CALCULATION:

- Delivery Pressure, P = kg / cm^2
- Suction Pressure, P_v = mm of hg
- Head on the turbine , T_h = $10\left(P+\frac{V}{760}\right)$ m of water
- Energy meter revolutions, n =
- Time for 'n' revolutions of Energy meter, t_m = sec
- Head over Notch, h = m
- Discharge, Q_a = $C_d \times \frac{2}{3} \times \sqrt{2g} \times h^{\frac{3}{2}}$ m^3/ Sec.
- Hydraulic Input, P_{hyd} = $\frac{W \times Q_a \times T_h}{1000}$. . ...KW
- Turbine (Electrical) Output, P_{elect} = $\frac{n \times 3600}{K \times t_m}$ KW
- Turbine Output , P_{shaft} = $\frac{P_{elec}}{0.7}$ KW
- Efficiency = $\frac{P_{shaft}}{P_{hyd}} \times 100$
- Unit Speed, $N_u = N\sqrt{H}$ =
- Unit Power, $P_u = \frac{P}{\sqrt[3]{H}}$ =
- Unit Discharge, $Q_u = \frac{Q}{\sqrt{H}}$ =

Constant Head Characteristics

S.No.	Turbine Speed, N, rpm	Head on Turbine		Net Head on Turbine 'T$_h$, m of water	Head over Notch 'h' in m of water	Discharge (Flow Rate) 'Q$_a$' m^3/sec	No. of Bulbs on	No. of Revolution of energy meter, n	Time for n revolution of energy meter, t sec.	Hydraulic input power KW	Turbine Electrical output BP_{elcl}	Turbine output BP_{shaft}	$\eta = \frac{P_{shaft}}{P_{hyd}} \times 100$
		Pressure 'P' in Kg/cm^2	Vacuum 'P_v' in $mm\ of\ H_g$										

Constant Speed Characteristics

Turbine Speed in RPM	Head on Turbine		Net Head on Turbine 'H' in mts	Head over Notch (Flow Rate), 'h' in mts	Discharge (Flow Rate) 'Q' in $m^3/\sec$	Load on Generator		Wattage of Bulb in action	Energy meter reading Time For 5 Rev in sec	HP_{hyd}	BHP	$\%\eta_{tur}$
	Pressure 'P' in Kg/cm^2	Vacuum 'P_v' in $mm\ of\ H_g$				'V' Volts	'I' Amps					

Unit Quantities Under Unit Head

Net Head on Turbine 'H' in mts	Unit Speed N_u	Unit Power P_u	Unit Discharge Q_u	Specific Speed N_s	$\%\eta_{tur}$

GRAPHS:

1. Unit Speed Vs η
2. Unit Speed Vs Unit Output power
3. Unit Speed Vs Unit Discharge

RESULT

The efficiency of Kaplan Turbine at constant head =____