Lab Manual

for

MECHANICAL WORKSHOP

(Pr.3)

3rd Semester, Electrical Engg.

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Study of Venturimeter

Aim of the Experiment:

To study the venturimeter

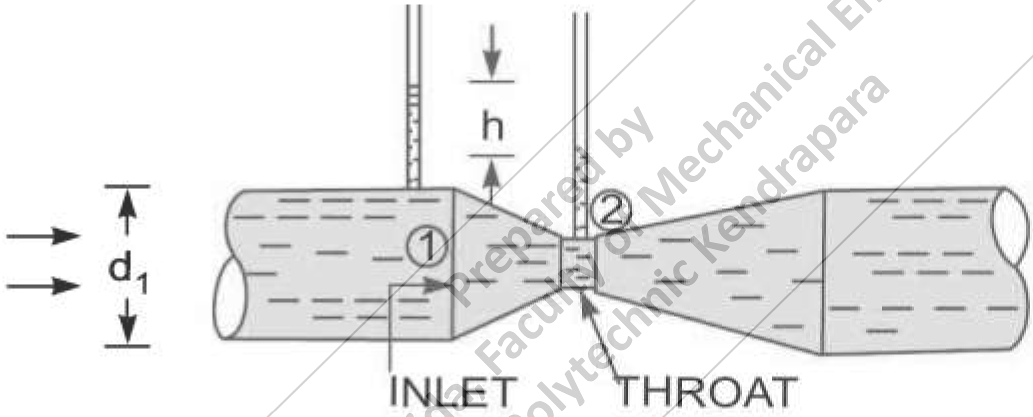
Tools/Equipment/Machinaries needed:

Venturimeter

Theory:

A venturimeter is a device used for measuring the rate of a flow of a fluid flowing through a pipe. It consists of three parts :

(*i*) A short converging part, (*ii*) Throat, and (*iii*) Diverging part. It is based on the Principle of Bernoulli's equation.



Venturimeter.

Expression for rate of flow through venturimeter

Consider a venturimeter fitted in a horizontal pipe through which a fluid is flowing (say water), as shown in Fig. 6.9.

Let d_1 = diameter at inlet or at section (1),

p_1 = pressure at section (1)

v_1 = velocity of fluid at section (1),

a = area at section (1) = $\frac{\pi}{4} d_1^2$

and d_2, p_2, v_2, a_2 are corresponding values at section (2).

Applying Bernoulli's equation at sections (1) and (2), we get

$$\frac{p_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} + z_2$$

As pipe is horizontal, hence $z_1 = z_2$

$$\therefore \quad \frac{p_1}{\rho g} + \frac{v_1^2}{2g} = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} \quad \text{or} \quad \frac{p_1 - p_2}{\rho g} = \frac{v_2^2}{2g} - \frac{v_1^2}{2g}$$

But $\frac{p_1 - p_2}{\rho g}$ is the difference of pressure heads at sections 1 and 2 and it is equal to h or $\frac{p_1 - p_2}{\rho g} = h$

Substituting this value of $\frac{p_1 - p_2}{\rho g}$ in the above equation, we get

$$h = \frac{v_2^2}{2g} - \frac{v_1^2}{2g}$$

Now applying continuity equation at sections 1 and 2

$$a_1 v_1 = a_2 v_2 \quad \text{or} \quad v_1 = \frac{a_2 v_2}{a_1}$$

Substituting this value of v_1 in equation (6.6)

$$h = \frac{v_2^2}{2g} - \frac{\left(\frac{a_2 v_2}{a_1}\right)^2}{2g} = \frac{v_2^2}{2g}\left[1 - \frac{a_2^2}{a_1^2}\right] = \frac{v_2^2}{2g}\left[\frac{a_1^2 - a_2^2}{a_1^2}\right]$$

or $$v_2^2 = 2gh \frac{a_1^2}{a_1^2 - a_2^2}$$

$\therefore$ $$v_2 = \sqrt{2gh \frac{a_1^2}{a_1^2 - a_2^2}} = \frac{a_1}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gh}$$

$\therefore$ Discharge, $$Q = a_2 v_2$$

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

Equation (6.7) gives the discharge under ideal conditions and is called, theoretical discharge. Actual discharge will be less than theoretical discharge.

$\therefore$ $$Q_{\text{act}} = C_d \times \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh}$$

where C_d = Co-efficient of venturimeter and its value is less than 1.

Conclusion:

The venturimeter has been studied successfully and the discharge through it has been derived.

Study of Pressure Measuring Devices such as

(a) Piezo-meter (b) Simple Manometer

Aim of the Experiment:

To study the (a) Piezo-meter and (b) Simple Manometer

Tools/Equipment/Machinaries needed:

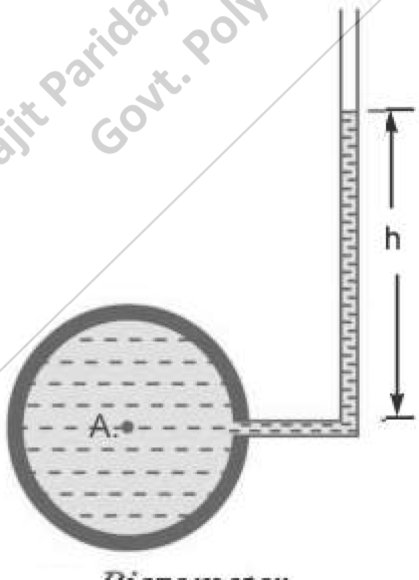
a) Piezo-meter
b) Simple Manometer

Theory:

a) *Piezo-meter*

It is the simplest form of manometer used for measuring gauge pressures. One end of this manometer is connected to the point where pressure is to be measured and other end is open to the atmosphere The rise of liquid gives the pressure head at that point.
If at a point A, the height of liquid say water is h in piezometer tube, then pressure at A

$$= \rho \times g \times h \ \frac{\text{N}}{\text{m}^2}.$$



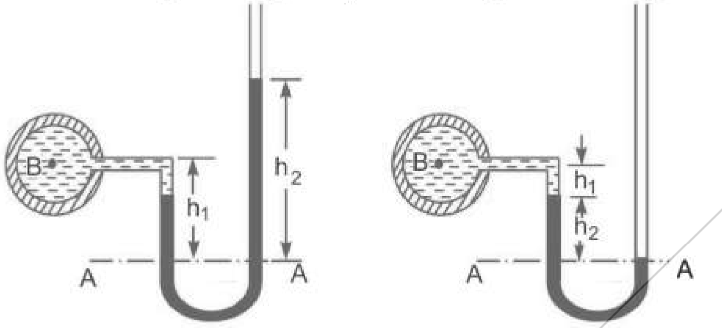
Piezometer.

b) *Simple Manometer*

A simple manometer consists of a glass tube having one of its ends connected to a point where pressure is to be measured and other end remains open to atmosphere. Common types of simple manometers are :

1. Piezometer,`
2. U-tube Manometer, and
3. Single Column Manometer.

U-tube Manometer. It consists of glass tube bent in U-shape, one end of which is connected to a point at which pressure is to be measured and other end remains open to the atmosphere as shown in Fig. 2.9. The tube generally contains mercury or any other liquid whose specific gravity is greater than the specific gravity of the liquid whose pressure is to be measured.



(a) For gauge pressure (b) For vacuum pressure

U-tube Manometer.

(*a*) **For Gauge Pressure.** Let B is the point at which pressure is to be measured, whose value is p. The datum line is A-A.

Let h_1 = Height of light liquid above the datum line
h_2 = Height of heavy liquid above the datum line
S_1 = Sp. gr. of light liquid
ρ_1 = Density of light liquid = $1000 \times S_1$
S_2 = Sp. gr. of heavy liquid
ρ_2 = Density of heavy liquid = $1000 \times S_2$

As the pressure is the same for the horizontal surface. Hence pressure above the horizontal datum line A-A in the left column and in the right column of U-tube manometer should be same.

Pressure above A-A in the left column $= p + \rho_1 \times g \times h_1$

Pressure above A-A in the right column $= \rho_2 \times g \times h_2$

Hence equating the two pressures $p + \rho_1 g h_1 = \rho_2 g h_2$

$$\therefore \quad p = (\rho_2 g h_2 - \rho_1 \times g \times h_1).$$

(*b*) **For Vacuum Pressure.** For measuring vacuum pressure, the level of the heavy liquid in the manometer will be as shown in Fig. Then

Pressure above A-A in the left column $= \rho_2 g h_2 + \rho_1 g h_1 + p$

Pressure head in the right column above A-A $= 0$

$$\therefore \quad \rho_2 g h_2 + \rho_1 g h_1 + p = 0$$

$$\therefore \quad p = -(\rho_2 g h_2 + \rho_1 g h_1).$$

Single Column Manometer. Single column manometer is a modified form of a U-tube manometer in which a reservoir, having a large cross-sectional area (about 100 times) as compared to the area of the tube is connected to one of the limbs (say left limb) of the manometer as shown in Fig. . The other limb may be vertical or inclined. Thus there are two types of single column manometer as :

1. Vertical Single Column Manometer.
2. Inclined Single Column Manometer.

1. Vertical Single Column Manometer

Fig. shows the vertical single column manometer. Let X-X be the datum line in the reservoir and in the right limb of the manometer, when it is not connected to the pipe. When the manometer is connected to the pipe, due to high pressure at A, the heavy liquid in the reservoir will be pushed downward and will rise in the right limb.

Let Δh = Fall of heavy liquid in reservoir

h_2 = Rise of heavy liquid in right limb

h_1 = Height of centre of pipe above X-X

p_A = Pressure at A, which is to be measured

A = Cross-sectional area of the reservoir

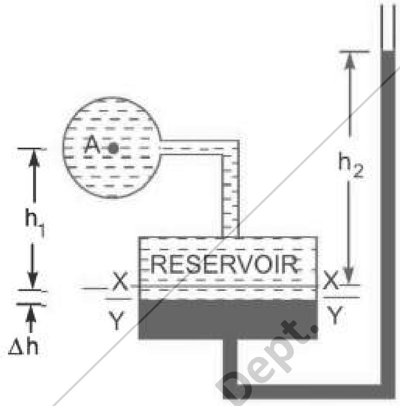
a = Cross-sectional area of the right limb

S_1 = Sp. gr. of liquid in pipe

S_2 = Sp. gr. of heavy liquid in reservoir and right limb

ρ_1 = Density of liquid in pipe

ρ_2 = Density of liquid in reservoir



Vertical single column manometer.

Fall of heavy liquid in reservoir will cause a rise of heavy liquid level in the right limb.

$$\therefore \quad A \times \Delta h = a \times h_2$$

$$\therefore \quad \Delta h = \frac{a \times h_2}{A} \quad \ldots(i)$$

Now consider the datum line Y-Y as shown in Fig. . Then pressure in the right limb above Y-Y.

$$= \rho_2 \times g \times (\Delta h + h_2)$$

Pressure in the left limb above Y-Y = $\rho_1 \times g \times (\Delta h + h_1) + p_A$

Equating these pressures, we have

$$\rho_2 \times g \times (\Delta h + h_2) = \rho_1 \times g \times (\Delta h + h_1) + p_A$$

or

$$p_A = \rho_2 g\,(\Delta h + h_2) - \rho_1 g(\Delta h + h_1)$$

$$= \Delta h[\rho_2 g - \rho_1 g] + h_2\rho_2 g - h_1\rho_1 g$$

But from equation (i), $\Delta h = \dfrac{a \times h_2}{A}$

$$\therefore \quad p_A = \frac{a \times h_2}{A}\,[\rho_2 g - \rho_1 g] + h_2\rho_2 g - h_1\rho_1 g$$

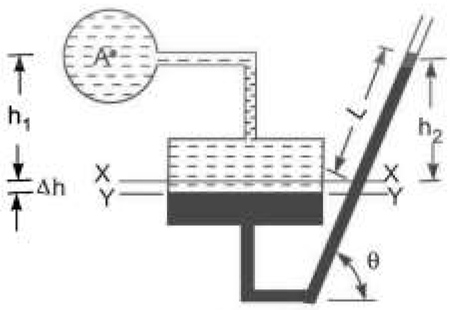
As the area A is very large as compared to a, hence ratio $\dfrac{a}{A}$ becomes very small and can be neglected.

Then $p_A = h_2\rho_2 g - h_1\rho_1 g$

From equation , it is clear that as h_1 is known and hence by knowing h_2 or rise of heavy liquid in the right limb, the pressure at A can be calculated.

2. Inclined Single Column Manometer

Fig. shows the inclined single column manometer. This manometer is more sensitive. Due to inclination the distance moved by the heavy liquid in the right limb will be more.



Inclined single column manometer.

Let L = Length of heavy liquid moved in right limb from X-X

θ = Inclination of right limb with horizontal

h_2 = Vertical rise of heavy liquid in right limb from X-X = $L \times \sin\theta$

From equation (2.10), the pressure at A is

$$p_A = h_2\rho_2 g - h_1\rho_1 g.$$

Substituting the value of h_2, we get

$$p_A = \sin\theta \times \rho_2 g - h_1\rho_1 g.$$

Conclusion:

The Peizo-meter and Simple Manometer has been studied successfully and the pressure has been calculated.

Model Study of Centrifugal Pumps, Francis Turbine, Kaplan Turbine and Pelton Wheel.

Aim of the Experiment:

To study Centrifugal Pumps, Francis Turbine, Kaplan Turbine and Pelton Wheel

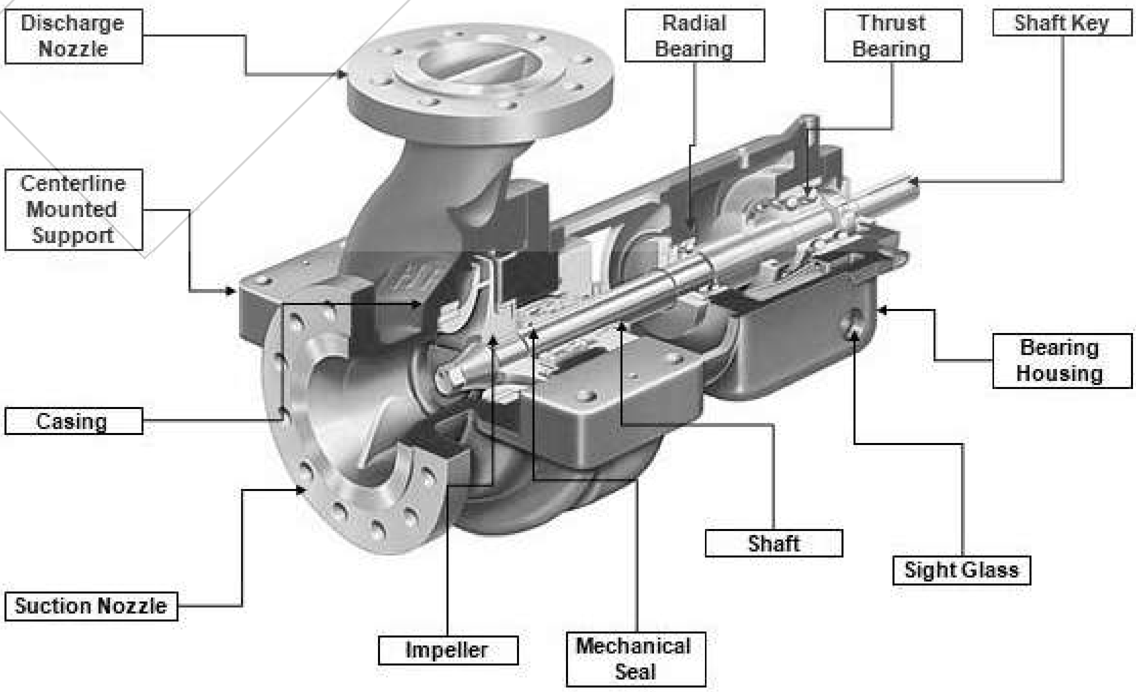
Tools/Equipment/Machinaries needed:

a) Centrifugal Pumps
b) Francis Turbine
c) Kaplan Turbine
d) Pelton Wheel

Theory:

a) *Centrifugal Pumps*

- The Hydraulic Machines which convert mechanical energy into hydraulic energy are called Pumps and it is in the form of pressure energy.
- The Hydraulic Machines which convert mechanical energy into pressure energy by means of centrifugal force acting on fluid.
- Acts as a reverse of an inward radial flow reaction turbine which means the flow is in radial outward direction.
- It works in the principle of forced vortex flow which means that when a certain mass of liquid is rotated by an external torque, the rise in pressure head of the rotating liquid takes place and at a point it is proportional to the square of tangential velocity of the liquid at the same point.



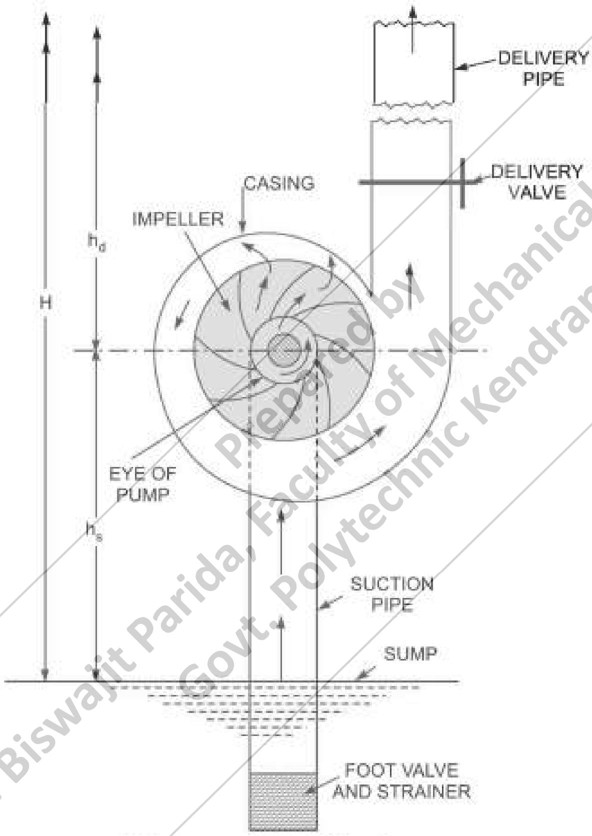
Main Parts

a) Impeller:

It is the rotating part of the centrifugal pump consisting of a series of backward curved vanes and is mounted on a shaft which is connected to the shaft of an electric motor.

b) Casing:

It is an air-tight passage surrounding the impeller and convert kinetic energy of water discharged at impeller outlet in to pressure energy before the water leaves the casing and enters the delivery pipe.



Main parts of a centrifugal pump.

i) Volute Casing:

It is of spiral type in which area of flow increases gradually and this decreases the velocity and increases the pressure of the water flowing through the casing. Loss of energy due to eddy formation.

ii) Vortex Casing:

A circular chamber is introduced between the casing and the impeller by which loss of energy due to a eddy formation reduced considerably and efficiency more than volute casing.

iii) Casing with Guide blades:

Impeller is surrounded by a series of guide blades mountain on a ring called diffuser and are designed in such a way that water enters the guide vanes without shock.

The area of the guide vanes increases, thus reducing the velocity of flow and subsequently increasing the pressure of water.

c) Suction Pipe with a Foot Valve and Strainer:

Suction pipe is a pipe whose one end is connected to the inlet of the pump and other end dips into water in a sump.

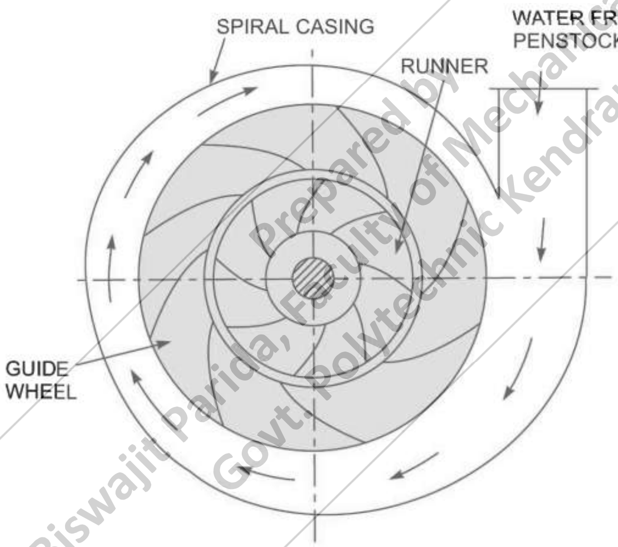
A foot valve is a non-return or one-way type of valve fitted at the lower end of the suction pipe. A strainer is also fitted at the lower end of the suction pipe.

d) Delivery Pipe:

is a pipe whose one end is connected to the outlet of the pump and the other end delivers the water at a required height.

b) Francis Turbine

- For **Francis Turbine,** the discharge at outlet is radial.
- turbines in which water flows in the radial direction
- the water may flow radially from outwards to inwards (inward radial flow turbine) or from inwards to outwards (outward radial flow turbine).



Main parts of a radial reaction turbines.

Main Parts

Casing-

Is made of spiral shaped concrete, cast steel or plate steel. In case of reaction turbine the casing and runner are always full of water.

Guide mechanism –

It consists of a stationary circular wheel all-round the runner of the turbine on which stationary guide vanes are fixed. The guide vanes allow the water to strike the vanes fixed on the runner without shock at inlet.

Runner -

It is a circular wheel made of cast steel or cast iron on which a series of radial curved vanes are fixed. The radial curved vanes are so shaped that the water enters and leaves the runner without shock.

Draft Tube

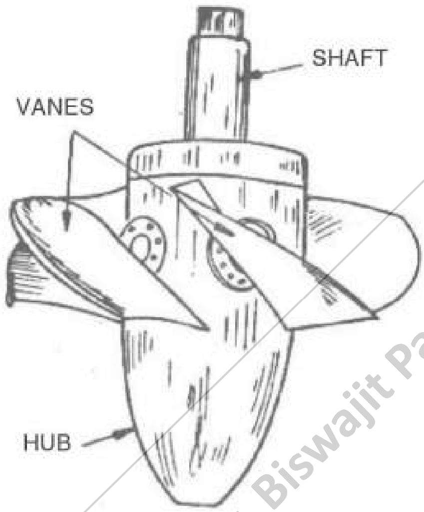
The tube is gradually increasing area which is used for discharging water from the exit of the turbine to the tail race.

c) ***Kaplan Turbine***

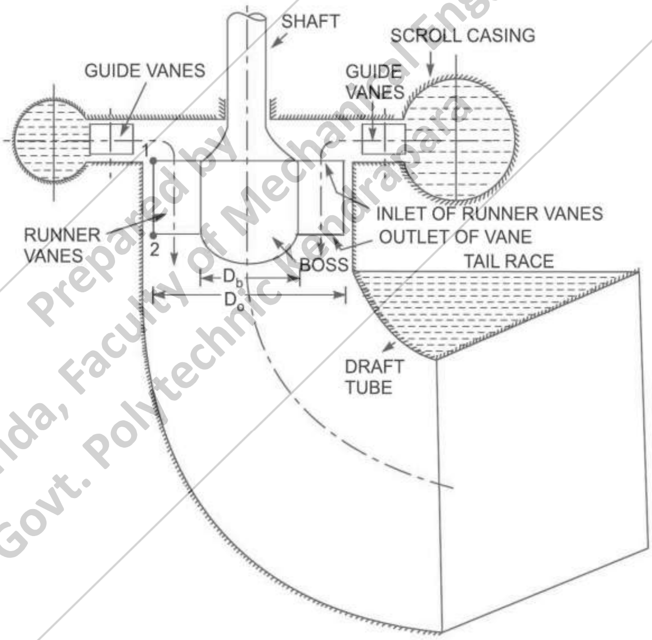
If the vanes on the hub are adjustable (by an Austrian engineer V Kaplan) & is suitable for, where large quantity of water at low head.

The main parts are

- Scroll Casing
- Guide Vanes Mechanism
- Hub With Vanes (Runner)
- Draft Tube



Kaplan turbine runner

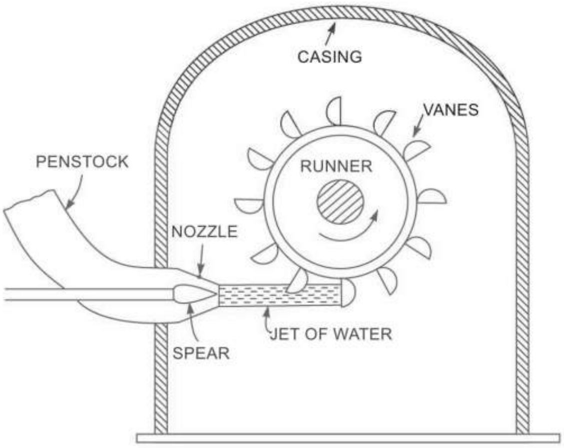


Main components of Kaplan turbine.

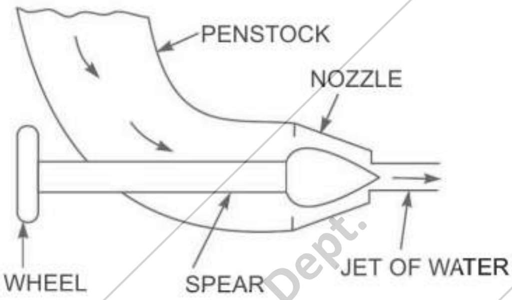
The water from penstock enters the scroll casing and then moves to the guide vanes. From the guide vanes, the water turns to 90 degree and flows axially through the runner

d) ***Pelton Wheel***

- is a tangential flow impulse turbine and the water strikes the pocket along the tangent of the runner
- the energy available at the inlet of the turbine is only kinetic energy and the pressure at the inlet and outlet of the turbine is atmospheric
- This turbine is used for high heads



Pelton turbine.



Nozzle and flow regulating arrangement

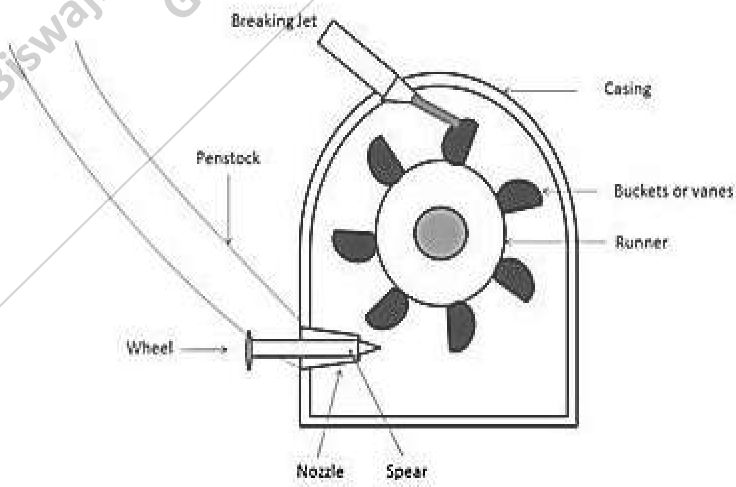
The amount of water striking the vanes of the runner is controlled by providing a spear in the nozzle which is a conical needle operated by hand wheel.

Runner with Vanes or Buckets

The runner consists of a circular disc (made of cast iron, cast steel or stainless steel) on the periphery of which a number of buckets evenly spaced are fixed and the shape of the buckets is of a hemispherical cup or bowl.

Casing

It is to prevent slashing of the water and to discharge water to tail race and made of cast iron or steel plates.



Breaking Jet

Due to inertia the runner goes on revolving for a long time even after the nozzle is completely closed by moving the spear in forward direction.

To stop the runner in a short time, a small nozzle is provided which directs the jet of water on the back of the veins which is called breaking jet

Conclusion:

The Centrifugal Pump, Francis Turbine, Kaplan Turbine and Pelton Wheel have been studied successfully.

Verification of Bernoulli's Theorem

Aim of the Experiment:

To Verify of Bernoulli's Theorem

Tools/Equipment/Machinaries needed:

Venturimeter

Theory:

Bernoulli's equation states that the "sum of the kinetic energy (velocity head), the pressure energy (static head) and Potential energy (elevation head) per unit weight of the fluid at any point remains constant" provided the flow is steady, irrotational, and frictionless and the fluid used is incompressible. This is however, on the assumption that energy is neither added to nor taken away by some external agency. The key approximation in the derivation of Bernoulli's equation is that viscous effects are negligibly small compared to inertial, gravitational, and pressure effects. We can write the theorem as

$$\textbf{Pressure head } (P) + \textbf{Velocity head } (V) + \textbf{Elevation } (Z) = \textbf{constant}$$

Where,

P =the pressure. (N/m^2)

g =acceleration due to gravity, m/s^2

ρ =density of the fluid, kg/m^3

Z =elevation from datum line, (m)

V =velocity of flow, (m/s)

Pressure head increases with decrease in velocity head.

$$\frac{P_1}{w} + \frac{{V_1}^2}{2g} + Z_1 = \frac{P_2}{w} + \frac{{V_2}^2}{2g} + Z_2 = constant$$

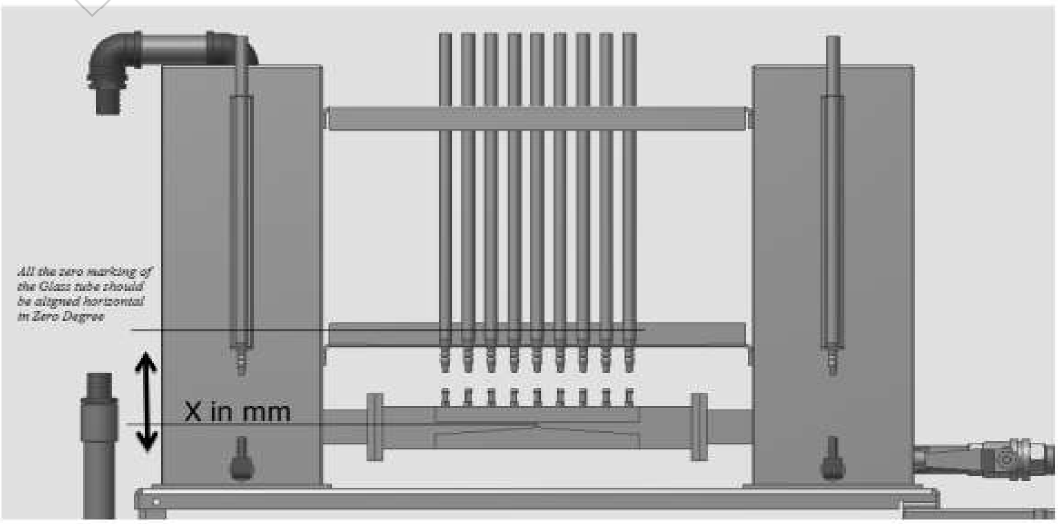
Where,

P/w =is the pressure head

Z =is the potential head

$V/2g$ =is the velocity head

Tapping Number	1	2	3	4	5	6	7	8	9
Flow Area in mm^2	194.74	167.72	141.82	115.36	88.76	115.36	141.82	167.72	194.74



Procedure:

1. Keep the bypass valve open and start the pump and slowly start closing valve.
2. The water shall start flowing through the flow channel. The level in the Piezometer tubes shall start rising.
3. Open the valve on the delivery tank side and adjust the head in the Piezometer tubes to steady position.
4. Measure the heads at all the points and also discharge with help of stop watch and measuring tank.
5. Varying the discharge and repeat the procedure.

Observations & Calculations

Sl. No.	Cross Section Area of Flow (A_i) in cm^2	Using Continuity equation $V_{ic} = \frac{Q}{A_i}$	Head at H_i in cm	Pressure Head ($H_i + x$) in cm	Velocity Head ($V^2/2g$) in cm/sec	Total Head (Pressure head + Velocity Head) in cm
1	1.95	74.15	21.50	21.5	2.8	24.3
2	1.68	86.1	20.8	20.8	3.78	24.58
3	1.42	101.82	20.4	20.4	5.28	25.68
4	1.15	125.17	19.2	19.2	7.99	27.19
5	1.06	136.79	16.9	16.9	9.54	26.44
6	1.15	125.17	17.1	17.1	7.99	25.09
7	1.42	101.82	18.5	18.5	5.28	23.78
8	1.68	86.1	19.2	19.2	3.78	22.98
9	1.95	74.15	19.5	19.5	2.8	22.3

FORMULAE:

(a) Discharge

$$Q = \frac{(AT * Df)}{t}$$

(b) Bernoulli's Equation

$$V_{ib} = \sqrt{2 * g * (H - H_i)}$$

(c) Continuity Equation

$$V_{ic} = \frac{Q}{A_i}$$

(d) Velocity Head

$$V_H = \frac{V_{ic}^{\ 2}}{(2 * g)}$$

Conclusion:

The Bernoulli's theorem has been verified successfully.

Study of Universal Testing Machine and Determination of Tensile Stress and Young's module of M.S specification.

Aim of the Experiment:

To study Universal Testing Machine and determine tensile stress and Young's module of Mild Steel specification.

Tools/Equipment/Machinaries needed:

- Universal Testing Machine
- Mild Steel Specimen
- Vernier Caliper/Micrometer
- Dial Gauge.

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Theory:

Various m/c and structure components are subjected to tensile loading in numerous application. For safe design of these components, there ultimate tensile strength and ductility one to be determine before actual use. Tensile test can be conducted on UTM.

A material when subjected to a tensile load resists the applied load by developing internal resisting force. These resistances come due to atomic bonding between atoms of the material. The resisting force for unit normal cross-section area is known as stress.

The value of stress in material goes on increasing with an increase in applied tensile load, but it has a certain maximum (finite) limit too. The minimum stress, at which a material fails, is called ultimate tensile strength. The end of elastic limit is indicated by the yield point (load). This can be sen during experiment as explained later in procedure with increase in loading beyond elastic limit original cross-section area (Ao) goes on decreasing and finally reduces to its minimum value when the specimen breaks.

ABOUT OF UTM & ITS SPECIFICATIONS :-

The tensile test is conducted on UTM. It is hydraulically operates a pump, oil in oil sump, load dial indicator and central buttons. The left has upper, middle and lower cross heads i.e; specimen grips (or jaws). Idle cross head can be moved up and down for adjustment. The pipes connecting the lift and right parts are oil pipes through which the pumped oil under pressure flows on left parts to more the cross-heads.

SPECIFICATIONS :-

1. Load capacity = 0-40000 kgf.
2. Least count = 8kgf.
3. Overall dimn. =
4. Power supply = 440V

PROCEDURE :-

1. The load pointer is set at zero by adjusting the initial setting knob.
2. The dial gauge is fixed and the specimen for measuring elongation of small amounts.

3. Measuring the diameter of the test piece by vernier caliper at least at three places and determine the mean value also mark the gauge length.
4. Now the specimen is gripped between upper and middle cross head jaws of the m/c.
5. Set the automatic graph recording system.
6. Start the m/c and take the reading.
7. The specimen is loaded gradually and the elongation is noted until the specimen breaks.

OBSEVATION :-

(I) Initial diameter of specimen d1 = ------

(II) Initial gauge length of specimen L1 = -----

(III) Initial cross-section area of specimen A1 = ----

(IV) Load of yield point Ft. = -----

(V) Ultimate load after specimen breaking F = -----

(VI) Final length after specimen breaking L2 = ------

(VII) Dia. Of specimen at breaking place d2 = -------

(VIII) Cross section area at breaking place A2 = ----

CALCULATION :-

(i) Ultimate tensile strength = ------

(ii) Percentage elongation % = ------

(iii)Modulus of elasticity E = --------

(iv) Yield stress = --------

(v) % reduction in area = -------

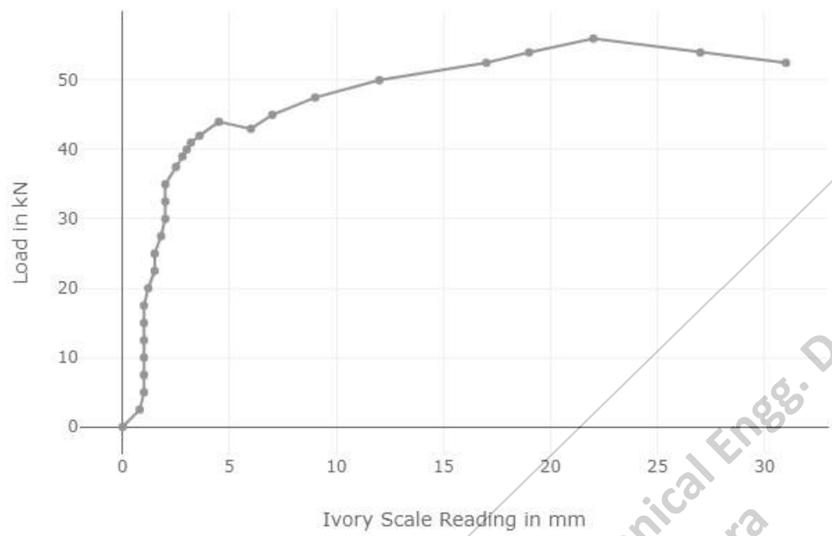
PRECAUTIONS :-

1. The specimen should be prepared in proper dimentions.
2. The specimen should be properly to get between the jaws.
3. Take reading carefully.
4. After breaking specimen stop to m/c.

CONCLUSION:

The UTM has been studied and Young's Modulus of MS specimen has been calculated.

Load Vs Ivory Scale Reading



Average Initial diameter d= 12.7mm Length of the specimen between the grips =200mm

Load in kN	Extensometer Reading in Division			Ivory Scale Reading(mm)
	A	B	Average	
-	-	-	-	-
2.5	2	1	1.5	0.8
5	2	2	2	1
7.5	3	3	3	1
10	5	4	4.5	1
12.5	7	6	6.5	1
15	8	6	7	1
17.5	9	7	8	1
20	10	8	9	1.2
22.5	11	10	10.5	1.5
25	12	11	11.5	1.5
27.5	13	12	12.5	1.8
30	15	14	14.5	2
32.5	16	15	15.5	2
35	17	16	16.5	2
37.5	18	17	17.5	2.5
39	19	18	18.5	2.8
40	19	19	19	3
41	-	-	-	3.2
42	-	-	-	3.6
44	-	-	-	4.5
43	-	-	-	6
45	-	-	-	7
47.5	-	-	-	9
50	-	-	-	12
52.5	-	-	-	17
54	-	-	-	19
56	-	-	-	22
54	-	-	-	27