S.Y. Diploma : Sem. IV

[ME]

Fluid Mechanics and Machinery

Time: 3 Hrs.] Prelim Question Paper Solution **[Marks : 70**

Q.1 Attempt any Five of the following: [10]

Q.1(a) Define specific weight. [2]

Ans.: It is the equilibrium pressure of a vapour above the liquid. OR
The pressure of the vapour resulting from evaporation of a liquid above a sample of liquid in a closed container.

Q.1(b) List different Properties of fluid. [2]

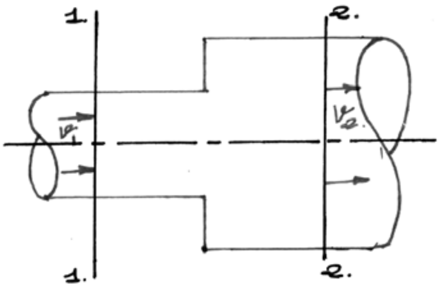
Ans.: **Properties of Fluid:**

1. Mass Density OR Density OR Specific mass
2. Weight density OR Specific Weight
3. Specific Volume.
4. Specific Gravity OR Relative Density
5. Viscosity
6. Surface Tension
7. Capillarity

Q.1(c) State the various minor losses in the pipe. [2]

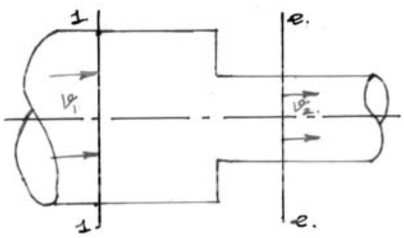
Ans.: Minor losses in pipe:

1. Loss due to sudden enlargement.



$$h_L = \frac{[V_1 - V_2]}{2.9}$$

2. Loss due to sudden contraction.

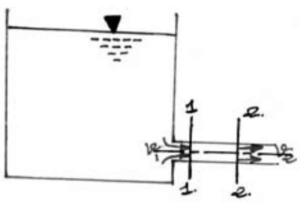


$$h_L = \left[\frac{1}{c_c} - 1\right]^2 . \frac{v_2^2}{2.9}$$

$$h_L = 0.5 . \frac{v_2^2}{2.9}$$

Where, c_c = Coefficient of contraction. [When c_c is not given]

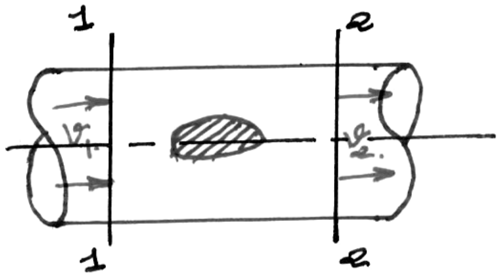
3. Loss at the entrance.



$$h_L = 0.5 . \frac{v_2^2}{29}$$

4. Loss at the exit.

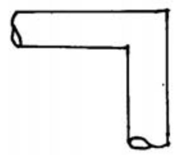
5. Loss due to sudden abstruction.



$$h_L = \frac{v^2}{29}\left[\frac{A}{c_c[A-a]}\right]^2$$

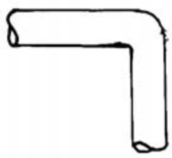
Where, a = Maximum area of obstruction
A = Area of Pipe
c_c = Co-efficient of contraction

6. Loss due to bent or Pipe fittings:

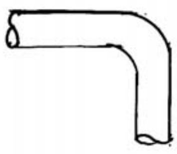


For Sharp Edge,
k = 1

$$h_L = \frac{K.V^2}{2.9}$$



For Elbow
k < 5



For Elbow
k > 5

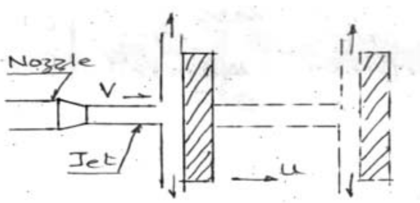
Q.1(d) State the applications of Centrifugal pump. (any two) **[2]**

Ans.: Application of Centrifugal pump:

1. In thermal Power Plants
2. Agriculture Purpose: Fertilizer, Fungicide & insecticide manufacturing.
3. Irrigation Purpose
4. Metal Treatment Processes
5. Drainage & drinking water system.

Q.1(e) Write the formula for force exerted by a jet on moving flat plate, when jet strikes the plate vertically at the centre. State the meaning of each term used in the formula. **[2]**

Ans.:



Arrangement is as shown in the figure
Force exerted by jet along the direction of jet –
$F = \rho A\,(v - u)\,[v - u) - 0]$
$F = \rho A(v- u)^2$ N
where v – Velocity of jet m/s u – Velocity of plate m/s
ρ – Mass density of water kg/m^3 A – area of jet m^2 d – Diameter of jet m

Q.1(f) State types of fluid flow. **[2]**

Ans.: Types of fluid flow:

1. Steady & Unsteady Flows
2. Uniform & Non-uniform Flows
3. Rotational & Irrotational Flows
4. Laminar & Turbulent Flows

Q.2 Attempt any THREE of the following: **[12]**

Q.2(a) Define : **[4]**

(1) absolute **(2) gauge**

(3) vacuum and **(4) Atmospheric pressure**

Ans.: **(1) Absolute pressure:** It is the algebraic sum of gauge pressure & atmospheric pressure. It is a zero referenced against a perfect vaccume

i.e $P_{ab} = P_{gauge} + P_{atm}$

(2) Gauge pressure: When pressure is measured with the help of pressure measuring instrument, either above or below atmospheric pressure, it is called as gauge pressure.

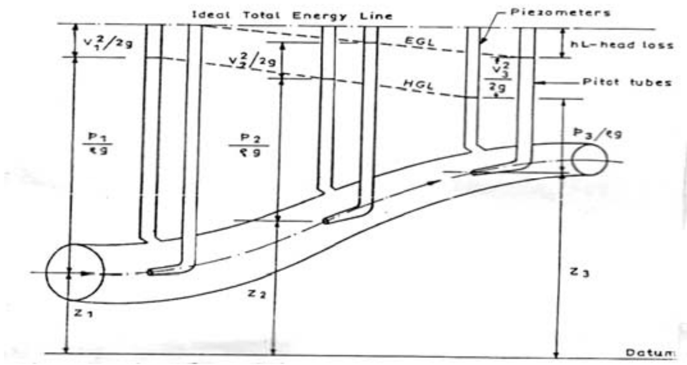
(3) Vaccum pressure: It is the pressure of fluid which is measured below atmospheric pressure. It is measured by vacuum gauge.

(4) Atmospheric pressure: The atmospheric air exerts a normal pressure upon all the surfaces with which it is in contact, & it is called as atmospheric pressure.

It varies with altitude & can be measured by means of a barometer.
Hence it is also called as barometric pressue.

Q.2(b) Explain hydraulic gradient line and total energy line. **[4]**

Ans.: Hydraulic gradient line and total energy line:



Hydraulic Gradient Line (HGL): It is the graphical representations of the longitudinal variation in piezometric heat at salient points of a pipe line.

Total hydraulic gradient = $P/\rho.g + z$

Total Energy Line (EGL): It is the graphical representations of longitudianal variation in total head at salient points of pipe line.

Total Energy Head = $P/\rho.g + v^2/2g + z$
These lines are as shown in the figure above.

Q.2(c) List types of manometers and explain any one of them with neat sketch. **[4]**

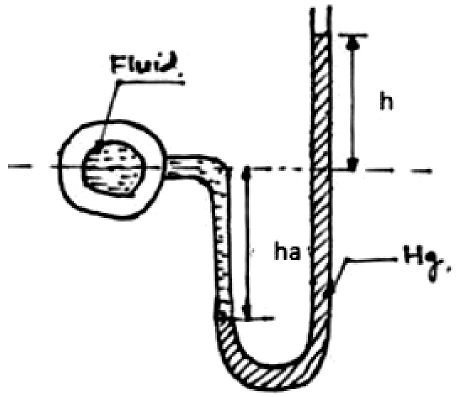
Ans.: Types of manometers: Following are the types of manometers

(a) Simple Manometer (b) Differential Manometer

Types of simple manometer:
(i) Piezometer
(ii) U-tube manometer
(iii) Single Column manometer

Types of Differential manometer:
(i) U-tube differential manometer
(ii) Inverted U-tube differential manometer

Working of any one of them with sketch



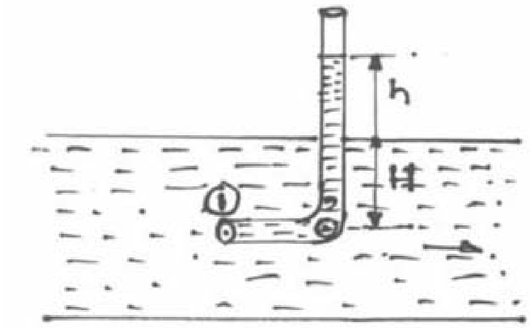
U-tube manometer

Q.2(d) Explain how Bernoulli's theorem can be applied to pitot tube. [4]

Ans.: Bernoulli's theorem as applied to Pitot tube:

Pitot tube is an instrument to determine the velocity of flow at required point in a pipe or a stream. In its simplest form, a Pitot tube consists of a glass tube bend at 90° as shown in the figure.

The lower end of the tube faces the direction of flow as shown in the figure. The liquid rises up in the tube due to the pressure exerted by the flowing liquid. By measuring the rise of liquid in the tube we can find out the velocity of the liquid flow.



PITOT TUBE

Let h = Height of the liquid in the pitot tube above the surface.
H = Depth of tube in the liquid, and

V = Velocity of the liquid.

Applying Bernoullis theorem for the section 1 and 2,
$H + v^2/2g = H + h$
Or $h = v^2/2g$
Therefore $v = \sqrt{2gh}$

Q.3 Attempt any THREE of the following: [12]

Q.3(a) Interpret whether the laminar or turbulent flow in following situation [4]
(i) Viscous liquid like oil travelling on smooth surface
(ii) Viscous liquid like Honey travelling on smooth surface
(iii) Municipal tap water at high pressure

Ans.:

Sr. No.	Laminar Flow	Turbulent Flow
1.	It is the fluid flow in which the fluid layers move parallel to each other and do not cross each other.	It is the fluid flow in which the fluid layers cross each other and do not move parallel to each other.
2.	The Laminar flow usually occur in the fluid flowing with low velocity.	The turbulent flow usually occur in fluid flowing with high velocity.
3.	The fluid flow is laminar when the value of Reynold's no. is less then 2000.	The fluid flow is turbulent when the value of Reynold's no. is more then 0.
4.	Eg. Movement of blood in human body.	Eg. Water supply pipes Artificial channels.

Q.3(b) Explain the phenomenon of "water hammer" in pipes also explain the procedure of reducing its effect. [4]

Ans.: When liquid flowing in a long pipe is suddenly stopped by closing the value fitted with pipe, momentum of flowing water will be destroyed converting it into sudden rise in pressure. This pressure moves through the pipe at high speed which creates noise known as knocking. This phenomenon of sudden rise in pressure in the pipe is known as water hammer.

Effects of water hammer:

- In elastic pipes, if there is increase in pressure pipe will expand but in non elastic pipes they will get burst.
- Joints in pipeline may open due to vibrations sets by water hammer.
- Pipes having large diameter and more length which carrying water from reservoir to turbine in hydropower plants are affected by water hammer.

Q.3(c) A reservoir built 4 km away from town has to supply water at the rate of 1000 lit/min. Calculate the size of supply pipe, if the loss of head due to friction and others in pipe is 20m. Assume coefficient of friction as 0.008. [4]

Ans.: Given $L = 4 \text{ km} = 4000 \text{ m}$

$$Q = 1000 \text{ lit/min} = \frac{1000 \times 40^3}{60} \frac{(m)^3}{s} = 0.01667 \text{ m}^3/\text{s}$$

$h_L = 20$ m

$F = 0.008$

To find d = ?

- Discharge through pipe

$Q = Av$

$$\therefore 0.01667 = \frac{\pi}{4} \cdot d^2 \times v$$

$$\therefore v = \frac{0.01667}{\pi \times d^2} \times 4 = \frac{0.0212}{d^2}$$

- Head loss

$$h_L = \frac{4f_L v^2}{2.9d} \qquad \text{[Neglecting minor losses]}$$

$$\therefore \quad 20 = \frac{4 \times 0.008 \times 4000 \times \left[\frac{0.0212}{d^2}\right]^2}{2 \times 9.81 \times d} = \frac{0.0029}{d^5}$$

$$\therefore \quad d = 0.171 \text{ m} = 171.09 \text{ mm}$$

Q.3(d) Draw inlet & outlet velocity diagram of impact of Jet when jet strikes tangentially at one of tips on moving curved vanes. [4]

Ans.:

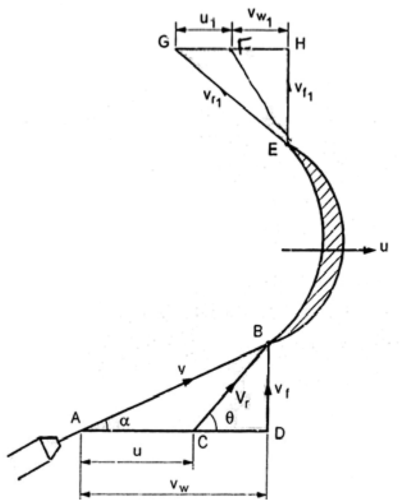


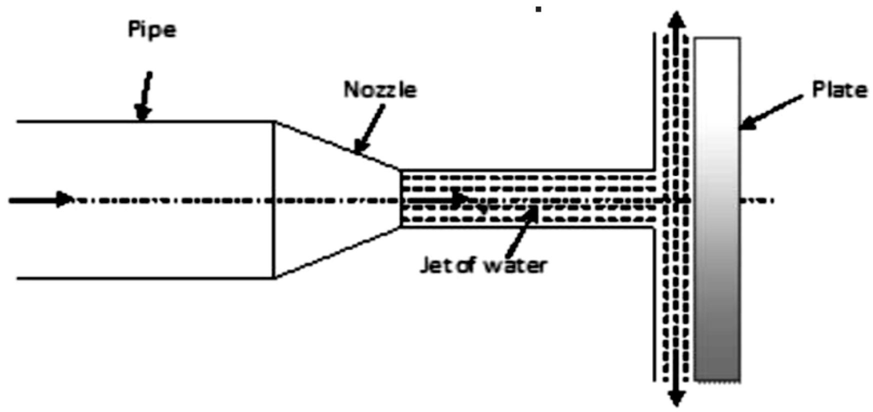
Fig.: Jet striking tangentially on an un-symmetrical

Q.4 Attempt any TWO of the following: [12]

Q.4(a) Obtain the expression for force exerted by the jet of water on fixed vertical plate. [6]

Ans.: Force exerted by the jet on a stationary vertical plate:

Consider a jet of water coming out from the nozzle strikes the vertical plate.



Let V = velocity of jet,

d = diameter of the jet,

a = area of x – section of the jet

The force exerted by the jet on the plate in the direction of jet.

Fx = Rate of change of momentum in the direction of force

Rate of change of momentum in the direction of force

= initial momentum – final momentum / time

= mass x initial velocity – mass x final velocity / time

= mass/time (initial velocity – final velocity)

= mass/sec x (veloctiy of jet before striking mass/sec x (velocity of jet before striking – final veloctiy of jet after striking)

= $\rho aV (V - 0) = \rho a V^2$

This is force exerted by the jet on a vertical plate.

Q.4(b) State different types of draft tube used in the reaction turbine. [6]

Ans.: Types of Draft Tube

(i) Conical tube

- It is simple divergent tube of increased area. It is also known as straight divergent tube. Refer Figure 1.
- It should be sufficiently immersed in water so that its outlet end remains in water even if the water level in tailrace falls by a small height.
- The angle of divergence should not be more than 9 to 10 degrees.
- This has an efficiency upto 90% and is most suited for Francis turbine.

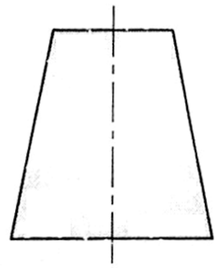


Fig. 1 : Conical draft tube

(ii) Moody spreading tube

- As shown in Figure 2 Moody spreading tube is a short vertical tube with two long horizontal tubes.
- It is suitable where conical tube is not able to give sufficient increase in area due to separation problem.
- It is helpful in reducing whirling action of water coming out from the runner and thus reduces eddy losses. Efficiency of such draft tube is 85%.

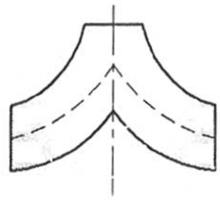


Fig.2 : Moody spreading tube

(iii) Simple elbow tube

- If a bend is given to the tube, sufficient increase in area can be made in lesser depth.
- It is useful where it is not possible to immerse the tube into the tailrace sufficiently below the level.
- This type has an advantage that it requires losses excavation for the installation. Its efficiency is only about 60%. Therefore it is rarely used.

Fig.3 : Simple elbow tube

(iv) Elbow tube with circular cross section at inlet and rectangular at outlet

- A simple elbow tube with circular cross section at inlet and rectangular at outlet is shown in figure 4.
- It is required where large excavation is necessary.
- This has large cross section at outlet which recovers more kinetic head at outlet.
- This type of tube generally used in Kaplan turbine and has efficiency of about 70%.

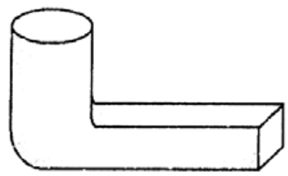


Fig.4 : Elbow tube with circular cross section at inlet and rectangular at outlet.

Q.4(c) Explain the construction & working of submersible pump with neat sketch. [6]

Ans.: Submersible Pump

- A submersible pump as a name indicates consists of electric motor and pump both are submerged in the water.
- By submerging electric motors, pumps, large economy can be and achieved by avoiding long shaft, large number of bearings and large sized rising main etc.
- The complications due to thrusts are also avoided.
- As it is a submersible pump, the only problem is to prevent the motor windings and other electrical connections to be spoiled by water coming in contact.
- For this purpose a special protection by suitable type of insulation is provided to prevent the flow of supporting water inside the assembly.

- These pumps are vertical centrifugal pumps with radial or mixed flow impellers. All the metallic bearings are water lubricated and protected against the sand.
- A non-return valve is fitted to a flange at the top of the pump.
- The suction housing of pump is situated between the pump and motor and provide with a performed strainer.
- Motor of the submersible pumps are wet squirrel cage type and are completely filled with water. Thrust bearings are provided for absorbing the axial thrust.
- The pump shaft is connected to motor shaft by muff coupling. Gate valve is provided at the top of the pump as a non-return valve to discharge the water.
- The total efficiency of these pumps is superior to conventional deep well pumps at much cheaper costs.

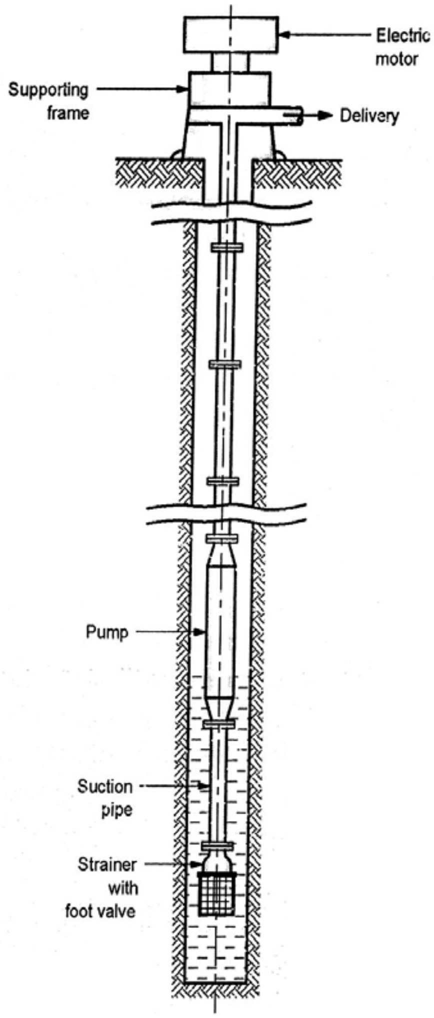


Fig.: Submersible pump

Q.4(d) A 300 mm × 150 mm venturimeter is inserted in a vertical pipe carrying water flowing in upward direction. A differential mercury manometer connected to inlet and throat gives reading of 200 mm. Find discharge through pipe. take Cd = 0.98. **[6]**

Ans.: d_1 = 300mm = 0.3m

d_2 = 150mm = 0.15m

c_d = 0.98

Reading of differential manometer

x = 200mm = 0.2m

Differential at head,

$$h = x\left[\frac{S_{Hg}}{S_w} - 1\right]$$

$$= 0.2\left[\frac{13.6}{1} - 1\right]$$

$$h = 2.52\text{m}$$

$a_1 = \pi/4 \times (0.3)^2 = 0.0706\text{m}^2$

$a_2 = \pi/4 \times (0.15)^2 = 0.0176\text{m}^2$

Discharge,

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

$$Q = 0.98\left[\frac{0.0706 \times 0.0176}{\sqrt{0.0706^2 - 0.0176^2}}\right] \times \sqrt{2 \times 9.81 \times (2.52)}$$

$Q = 0.12516\text{m}^3/\text{sec}$

Q = 125.18 lit/sec

Q.5 Attempt any TWO of the following: [12]

Q.5(a) Classify hydraulic turbines with example. [6]

Ans.: Classification of turbines

The hydraulic turbines are classified according to the type of energy available at the inlet of the turbine, direction of flow through the vanes, head at the inlet of the turbine and specific speed of the turbine. Thus the following are the important classification of the turbines:

1. According to the type of energy at inlet:
   (a) Impulse turbine, and (b) Reaction turbine
2. According to the direction of flow through runner:
   (a) Tangential flow turbine, (b) Radial flow turbine,
   (c) Axial flow turbine, and (d) Mixed flow turbine
3. According to the head at the inlet of turbine:
   (a) High head turbine, (b) Medium head turbine, and
   (c) Low head turbine.
4. According to the specific speed of the turbine:
   (a) Low specific speed turbine, (b) Medium specific speed turbine, and
   (c) High specific speed turbine.

Q.5(b) A pipe of diameter 340 mm & length 4000 m is used for transmission of power by water. The total head of inlet of pipe is 600 m. Find maximum power available at the outlet of pipe (take f = 0.006) [6]

Ans.: For maximum power transmission

$$h_f = \frac{H}{3} = \frac{600}{3} = 200 \text{ m} \quad \ldots \text{(i)}$$

We know, h_f = Head loss due to friction is,

$$h_f = \frac{4fLV^2}{2gd}$$

$$= \frac{4 \times 0.006 \times 4000 \times V^2}{2 \times 9.81 \times 0.34} = 14.39\ V^2 \quad \ldots \text{(ii)}$$

From Equations (i) and (ii)

$$14.39\ V^2 = 200$$

$$V^2 = \frac{200}{14.39}$$

$$V^2 = 13.898$$

$$V = 3.728 \text{ m/s}$$

Put, V value in Equation (ii)

$\therefore$ $h_f = 14.39\ V^2$

$= 14.39 \times (3.728)^2 = 199.99$ m

Discharge, $Q = AV$

$$= \frac{\pi}{4}(0.34)^2 \times 3.728 = 0.338 \text{ m}^3\text{s}$$

Maximum power = w × Q × Head at outlet of pipe

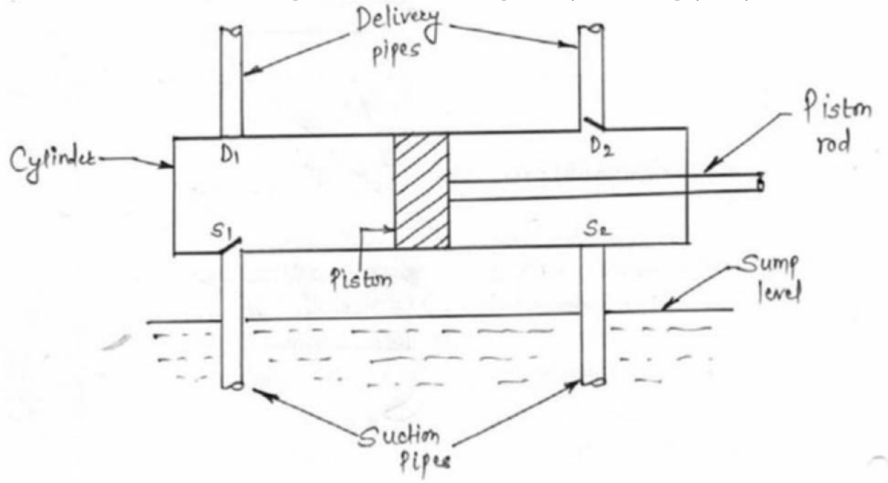
= 9810 × 0.338 × (600 – 199.99)

= 1326345.158

P = 1326.345 kW

Q.5(c) Explain with neat sketch construction and working of double acting reciprocating pump. [6]

Ans.: Construction and working of double acting reciprocating pump



1. In this pump the suction and delivery strokes occur simultaneously so it is called as double acting.
2. It consists of two deliver valve and two suction valves. The pump is usually placed above the liquid level in the sump.
3. When the crank rotates from IDC in the clockwise direction a vaccum is created on the left hand side of the piston and the liquid is sucked in from the sump through valve S_1.
4. At the same time the liquid on the right side of the piston is pressed and a high pressure causes the deliver D_2 to open and the liquid is passed on the discharge tank, this operation continues till the tank reaches the ODC.
5. With the further rotation of the crank the liquid is sucked in from the sump through the suction valves S_2 and is delivered to the discharge tank through the delivery valve D_1.
6. When the crank reaches the IDC the piston is in the extreme left position, thus one cycle is completed and as the crank further rotates cycles is repeated.

Q.6 Attempt any TWO of the following: [12]

Q.6(a) Draw the velocity diagram of pelton turbine & state relation for work done, power & efficiency. [6]

Ans.: Pelton wheel is an axial flow impulse turbine, water enters the wheel axially,

$\therefore \quad \theta = 0 \qquad \alpha = 0$

Thus inlet triangle reduces into a straight line.

$\therefore$ Relative velocity is given by

$v_r = v - u$ … from inlet velocity diameter.

And velocity of whirl is given by

$$v_w = v = \sqrt{2gh}$$

where v_r = Relative velocity of water and bucket at inlet.

v = Absolute velocity of entering water

H = Net head acting on the pelton wheel.

Velocity of flow at inlet $v_f = 0$

Assume < β as an acute angle, velocity triangle at outlet is drawn. As initially discussed $u = u_1$, i.e. velocity of vane at inlet and outlet tip is same.

If there is no friction

$$v_{r_1} = v_r = (v - u)$$

From outlet triangle, velocity of whirl at outlet.

$$v_{w_1} = v_{r_1} \cos\phi - u = v_r \cos\phi - u$$

$$= (v - u)\cos\phi - u$$

The work done/sec on wheel is to be found.

$\therefore$ Work done/sec $= \text{Force} \times \dfrac{\text{Distance moved}}{\text{Time}}$

$= \dfrac{w}{g}(\text{Initial relative velocity - Final relative velocity})$

$= \dfrac{w}{g}\left(v_w \pm v_{w_1}\right)$

Work done/sec = force $\times$ Distance moved / sec

$= \dfrac{w}{g}\left(v_w \pm v_{w1}\right) \times u$

but $v_w = v$

and $v_{w_1} = \{(v-u)\cos\phi - u\}$

$\therefore$ W.D. $= \dfrac{w}{g}\left[v \cdot u + (v-u)\cos\phi - u\right]$

Work done $= \dfrac{w}{g}(v-u)(1+\cos\phi)\,u$ ... (1)

Energy input to turbine is K.E.

Input energy $= \dfrac{w}{2g}v^2$ neglecting losses in nozzle.

Hydraulic efficiency is defined as the ratio of the work done by runner to the input.

$$\eta_{hyd} = \frac{\text{Work done}}{\text{Input energy}} = \frac{w/g\,(v-u)[1+\cos\phi]u}{\dfrac{w}{2g}v^2}$$

$$\eta_{hyd} = \frac{2(v-u)[1+\cos\phi]u}{v^2} \quad \text{... (2)}$$

The efficiency will be maximum when the work done is maximum, the energy supplied remaining constant. Hence in the expression the efficiency differentiating the number and equating to zero.

$$\frac{dn}{du} = \frac{d}{du}\left[2(1+\cos\phi)(v-u)u\right] = 0$$

$= v - 2u = 0$

$v = 2u$ or $u = \dfrac{v}{2}$

The ratio $\dfrac{u}{v}$ is called as speed ratio. For maximum efficiency speed ratio should be 0.5. In actual practice speed ratio from 0.45 to 0.47 is considered.

Substituting $u = \dfrac{v}{2}$ in Equation (2)

$$\eta_{hyd\ max.} = \frac{1+\cos\phi}{2} \quad \text{... (3)}$$

- Equation (3) shows that maximum hydraulic efficiency of pelton wheel occurs when the value of cos ϕ is maximum. The maximum value of cos ϕ is 1 and occurs at ϕ = 0.
- The angle of the vane tip ϕ = 0 means the jet has to deflect through 180° i.e. vane should be semicircular.
- In practice jet is deflected through 160° to 170° to avoid disturbance in jet coming out of nozzle.

Q.6(b) Draw an Indicator diagram of reciprocating pump showing the effect of acceleration head & friction head on suction & delivery pipe. **[6]**

Ans.: Effect of Acceleration in Suction and Delivery Pipe on indicator Diagram

h_{as} = Pressure head due to acceleration in suction

h_{ad} = Pressure head due to acceleration in delivery

- Thus from Fig. 1 the pressure head inside the cylinder during suction stroke will not be equal to 'h_s' as was the case of ideal indicator diagram, but it will be equal to sum of 'h_s' and 'h_{as}' as $\theta = 0°$.
- At the middle of suction stroke $\theta = 90°$ 'h_{as}' is zero and hence pressure head in the cylinder will be h_s below the atmospheric pressure head.
- At the end of suction stroke, $\theta - 180$ and 'h_{as}' is negative and hence the pressure head in the cylinder will be $(h_s - h_{as})$ which is below the atmospheric pressure head for suction stroke the indicator diagram will be shown by A/GB'.

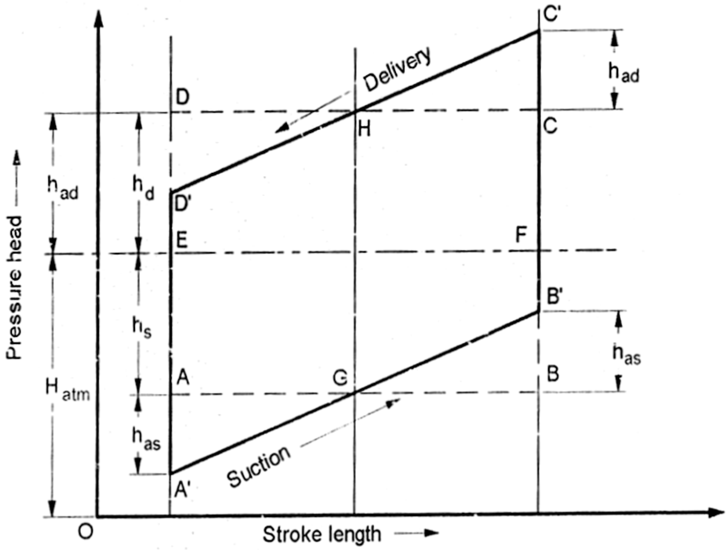


Fig. 1 : Effect of acceleration on indicator diagram

- Similarly delivery stroke's indicator diagram can be drawn. At the beginning of delivery stroke 'h_{ad}' is positive and hence pressure head in the cylinder will be $(h_d + h_{ad})$ which is above the atmospheric pressure head.
- At the middle of delivery stroke, $h_{ad} = 0$ and hence pressure head in the cylinder is equal to h_d above the atmospheric pressure head.
- At the end of delivery stroke, h_{ad} is negative hence, pressure in cylinder will be $(h_d - h_{ad})$ above the atmospheric pressure head.
- The indicator diagram for delivery stroke is represented by C' H D'.
- From Fig.2 due to acceleration in suction and delivery pipe indicator diagram changes but area remains same, so work done by pump is proportional to the area of indicator diagram.
- Hence the work done by the pump on the water remains same.

Effect of Friction and Delivery Pipes on Indicator Diagram

- At the beginning of suction and "delivery of stroke the θ is zero so $\sin\theta = 0$. Thus the head loss due to friction h_f is zero. And at the middle $\theta = 90°$ so sin (90) = 1. Hence friction losses in suction and delivery at middle is maximum, and at the end of suction and delivery $\theta = 180$, hence sin (180) is also zero.
- So head losses due to friction at end is zero as shown in Figure 2.

  h_{fd} = Head loss due to friction at delivery

  h_{fs} = Head loss due to friction at suction

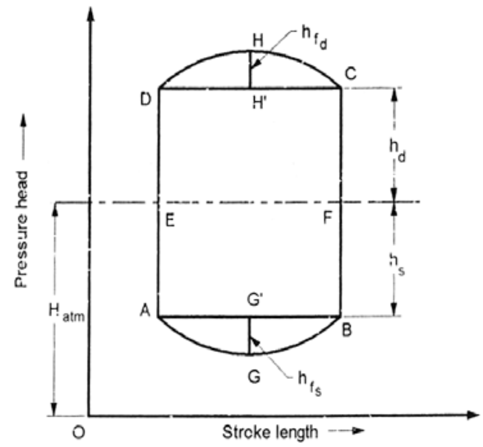


Fig. 2 : Effect of friction on indicator diagram.

Effect of acceleration and Friction in suction and delivery pipe

Effect of Acceleration and Friction in Suction and Delivery Pipes in **Indicator Diagram**

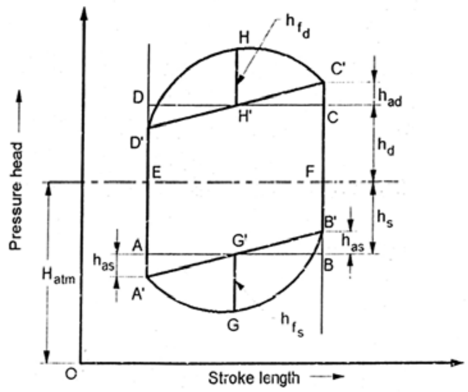


Fig. 3 : Effect of acceleration and friction in indicator diagram.

- The Figure 3 itself explains the combined effect of acceleration and friction on suction and delivery pipe during respective stroke as explained in previous separate figures.

Q.6(c) A Centrifugal pump has an impeller of outer diameter 30cm. The vane tips are radial at the outlet. For rotative speed of 1450 rpm, calculate net head developed. Also draw outlet velocity triangle. Assume manometric efficiency 82%. **[6]**

Ans.: Given d_o = 30 cm = 0.3m

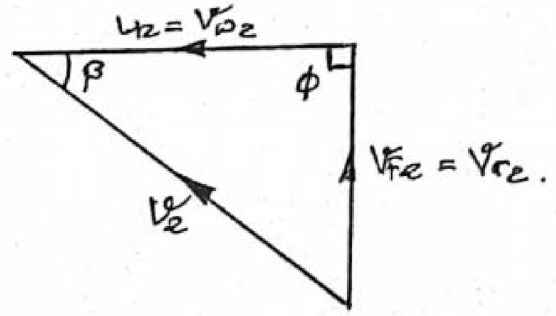
N = 1450 rpm

η_m = 82% = 0.82

To find : h = ?

(i) Velocity Triangle,

For vane tip radial at outlet,



Tangential velocity at outlet

$$\mu_Z = \frac{\pi \cdot d_0 \cdot N}{60} = \frac{\pi \times 0.3 \times 1450}{60}$$

$\therefore \quad \mu_Z = 22.78$ m/s

(ii) Relative Velocity of whiri at outlet

$V_{we} = \mu_Z = 22.78$ m/s [$\because$ Radial Vane tip]

(ii) Manometric efficiency,

$$\eta_m = \frac{Hm}{\left[\dfrac{Vwe \cdot \mu_Z}{g}\right]} = \frac{Hm \times 9.81}{22.78 \times 22.78} = Hm \times 0.0189$$

$\therefore \quad Hm = 43.36$ m

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