TED (15)-6022

REVISION 2015

(12)

SCORING INDICATORS

I - 1 The liquid comes out in the form of a jet from the outlet of a nozzle, which is fitted to a pipe through which the liquid is flowing under pressure If some plate, which may be fixed or moving, is placed in the path of the jet, a force is exerted by the jet on the plate. This force is obtained from Newton's second law of motion or from impulse-momentum equation. Thus impact of jet means the force exerted by the jet on a plate which may be stationary or moving. (2)

2.Hydraulic machines are defined as those machines which convert either hydraulic energy (energy possessed by water) into mechanical energy (which is further converted into electrical energy) or mechanical energy into hydraulic energy . (2)

3 .The governing of a turbine is defined as the operation by which the speed of the turbine is kept constant under all conditions of working. It is done automatically by means of a governor, which regulates the rate of flow through the turbines according to the changing load conditions on the turbine. (2)

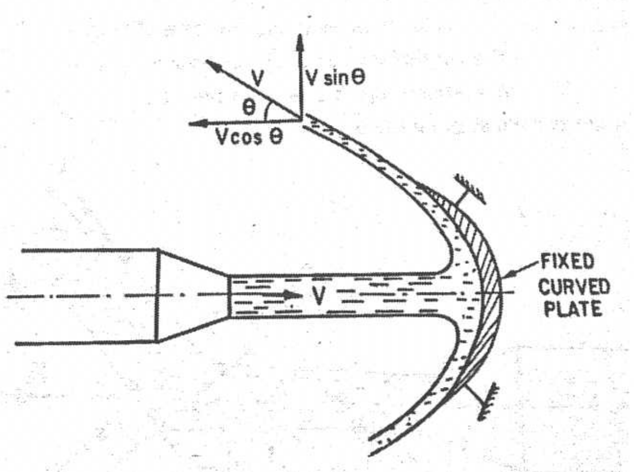
4. a)Radial flow turbine-inward flow, outward flow
   b)Axial flow reaction turbine (2)

5.**TURBINE**-A turbine is a device that is capable of absorbing energy from a given fluid stream and converting it to useful work. A turbine consists of a shaft or an axel which can be rotated around its own central cylindrical axis and blades attached to it.

PUMP- A pump is a device used to move gases, liquids or slurries from a lower pressure to higher pressure, and overcomes this difference in pressure at the expense of energy to the System..Hydraulic pumps convert mechanical energy from a prime mover (engine or electric motor). into hydraulic (pressure) energy. The pressure energy is used then to operate an actuator. Pumps push on a hydraulic fluid and create flow. (2)

II. 1.

Component of velocity in the direction of jet = $-V\cos\theta$.



VERSION - A

(– ve sign is taken as the velocity at outlet is in the opposite direction of the jet of water coming out from nozzle).

Component of velocity perpendicular to the jet = $V \sin \theta$

Force exerted by the jet in the direction of jet,

$$F_x = \text{Mass per sec} \times [V_{1x} - V_{2x}]$$

where V_{1x} = Initial velocity in the direction of jet = V

V_{2x} = Final velocity in the direction of jet = $-V \cos \theta$

$$\therefore \quad F_x = \rho a V[V - (-V \cos \theta)] = \rho a V[V + V \cos \theta]$$

$$= \rho a V^2 [1 + \cos \theta]$$

Similarly, $F_y = \text{Mass per sec} \times [V_{1y} - V_{2y}]$

where V_{1y} = Initial velocity in the direction of $y = 0$

V_{2y} = Final velocity in the direction of $y = V \sin \theta$

$$\therefore \quad F_y = \rho a V[0 - V \sin \theta] = -\rho a V^2 \sin \theta$$

2.

Sol. Given :

Diameter of nozzle, $d = 100 \text{ mm} = 0.1 \text{ m}$

Head of water, $H = 100 \text{ m}$

Co-efficient of velocity, $C_v = 0.95$

Area of nozzle, $a = \frac{\pi}{4}(.1)^2 = .007854 \text{ m}^2$

Theoretical velocity of jet of water is given as

$$V_{th} = \sqrt{2gH} = \sqrt{2 \times 9.81 \times 100} = 44.294 \text{ m/s}$$

But $C_v = \frac{\text{Actual velocity}}{\text{Theoretical velocity}}$

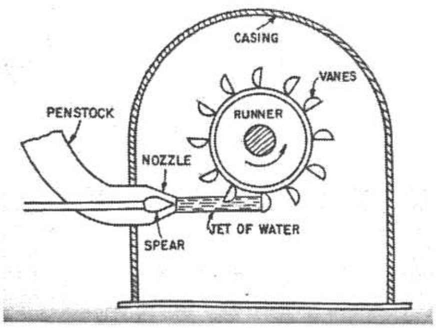
$\therefore$ Actual velocity of jet of water, $V = C_v \times V_{th} = 0.95 \times 44.294 = 42.08$ m/s.

Force on a fixed vertical plate is given by equation (17.1) as

$$F = \rho a V^2 = 1000 \times .007854 \times 42.08^2 \quad (\because \text{ In S.I. units } \rho \text{ for water} = 1000 \text{ kg/m}^3)$$

$= 13907.2$ N $=$ **13.9 kN. Ans.**

3. Main components
1. Nozzle and flow regulating arrangement
2. Runner and buckets
3. Watertight casing
4. Hydraulic brake/brake nozzle
5. Governor (Fig-3 marks)



(Brief explanation about all components). (3 marks)

4.

Impulse turbine	Reaction turbine
1. All the available hydraulic energy is converted into kinetic energy by an efficient nozzle.	1. Only the portion of the hydraulic energy is converted into kinetic energy before the water enters the turbine runner.
2. The jet of water impinges on the buckets with kinetic energy	2. The water passes over the moving vanes with potential or pressure energy
3. Pressure of water is atmospheric from inlet to the outlet of the turbine.	3. Pressure of water is not uniform thruoghout but varies from maximum to mimimum as it passes through the vanes.The pressure is negative(below atmospheric pressure) at the outlet end of the turbine.
4. The wheel must not run full. Air has free access between the vanes and wheel. The water may be admitted over the part of the circumference or over the whole circumference.	4. The wheel is always run full of water. Water flows into the wheel throughout its circumference.
5. The jet of water impinges from the nozzle strikes the buckets fixed to the periphery of the wheel.	5. The water is guided to the moving vanes at a proper angle by the guide vanes
6. All the vanes are not in action.Only the vanes infront of the nozzle are in action.	6. All the vanes are in action.
7. An air tight casing is not essential	7. An air tight casing is essential
8. This turbine is placed above tail race	8. This turbine is placed submerged below the tail race

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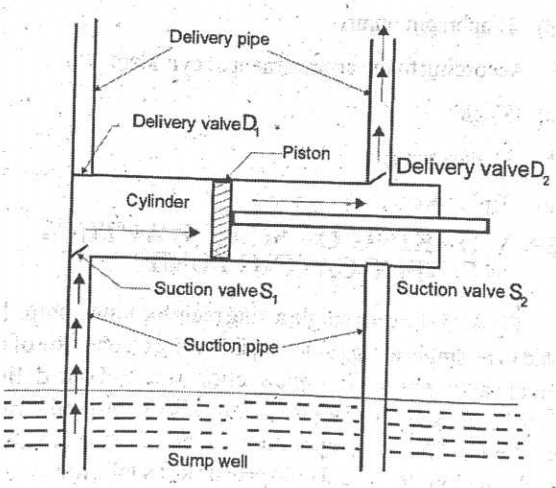
(Any 6 points..(1*6=6 marks)

5. In a double acting pump fluid acts on both Side of the pistons . It has two suction pipe and two delivery pipe as shown .Each suction and delivery pipe has one corresponding valve. Here suction and delivery oCcurs simultaneously. When the crank rotates from I. D C in clockwise direction, a vacuum is created on the left side of the piston and the liquid is sucked from the sump through the suction valve So open. At the same time, the liquid in the right side of the piston is pressed and a high pressure causes the delivery Valve D2 to open and the liquid is passed 0n to the discharge Side This operation continues till the crank reaches 0 .D. C .

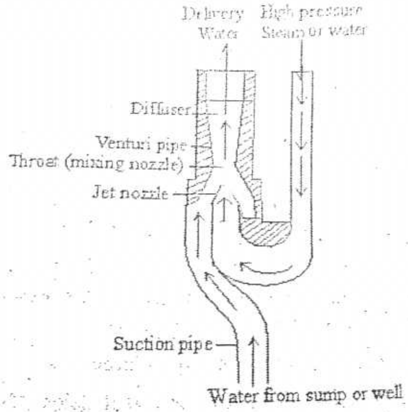
With further rotation of the crank, the liquid is sucked from the sump through the suction Valve S2 open and on the left side the liquid is forced through the delivery Valve D1 opens. When the crank reaches

I D C; the piston is in the extreme left position .Thus one cycle is completed and as the crank further rotates, cycle is repeated



. (FIG-3,brief explanation-3)

6. It is a pumping device works under the principle of Bernoulli's theorem. It is used for feeding



water to boiler against boiler pressure.

water under high pressure is passed through a pipe containing a nozzle at its end. The nozzle is placed in a venturi pipe as shown in the figure. While passing through the nozzle, most of the pressure energy of working medium (i.e., water or steam) is converted into kinetic energy. As a result, pressure around the nozzle drops much below atmospheric pressure. This causes flow water (to be delivered) to flow through the suction pipe. The two flow s meet in the throat of the venturi pipe . This portion is known as mixing nozzle. The mixing of the two flows in the mixing nozzle results in increase in pressure. (3+3)

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Kaplan turbine is an axial flow reaction turbine. It works under a low head of water and very high discharge. The Kaplan turbine can also be called a parallel flow turbine, since the flow from the inlet to the outlet is perfectly parallel to the sha ft of the turbine.
All component parts such as spiral casing, guide mechanism and draft tube of the Kaplan turbine are similar to those of Francis turbine. The only difference is in runner. In Kaplan runner, the number of blades only 3 to 6 or at the most 8 in exceptional cases. In Kaplan runner water strikes the blades axially. Unless in the Francis turbine, the runner blades are adjustable in a Kaplan turbine. If the runner blades are fixed it is called as propeller turbine.The runner of a Kaplan or a propeller turbine resembles the propeller of a ship.Less

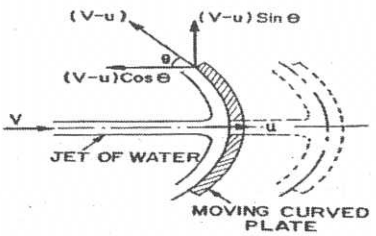
PART C

III (a). **Derivation**

V=absolute velocity of jet

a=area of Z

u=velocity of the plate in the direction of the jet



Relative velocity=(V-u)

Component of the velocity in the direction of jet

$$= -(V-u)\cos\theta$$

Component of the velocity in the direction perpendicular to the direction of the jet = $(V-u)\sin\theta$.

Mass of the water striking the plate $= \rho \times a \times$ Velocity with which jet strikes the plate

$$= \rho a(V-u)$$

∴ Force exerted by the jet of water on the curved plate in the direction of the jet,

F_x = Mass striking per sec × [Initial velocity with which jet strikes the plate in the direction of jet – Final velocity]

$$= \rho a(V-u)[(V-u)-(-(V-u)\cos\theta)]$$

$$= \rho a(V-u)[(V-u)+(V-u)\cos\theta]$$

$$= \rho a(V-u)^2[1+\cos\theta]$$

Work done by the jet on the plate per second

$= F_x \times$ Distance travelled per second in the direction of x

$$= F_x \times u = \rho a(V-u)^2[1+\cos\theta] \times u$$

$$= \rho a(V-u)^2 \times u\,[1+\cos\theta]$$

(Fig-4,Derivation-4)

(b) principle of Jet propulsion is applied to propulsion of ships. The ship carries pumps which take water from its surroundings. This water is discharged by forcing through the orifice at the back of the ship. The efficiency of ship depends upon the direction of the inlet orifice.

The Ship may have

1. Inlet orifice at right angles to the direction of its motion.
2. Inlet orifices faces the direction of motion

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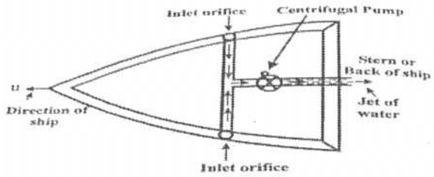
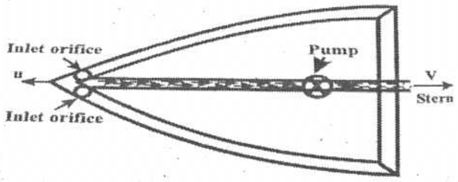


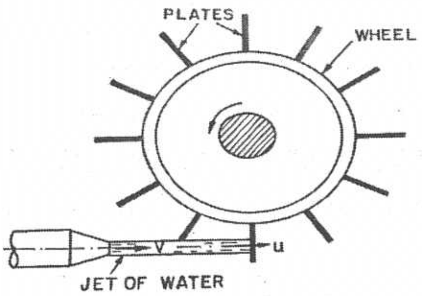
(a) Inlet orifices are at right angles.



(b) Inlet orifices facing the direction of ship.

OR

IV. (a)



∴ The force exerted by the jet in the direction of motion of plate,

$$F_x = \text{Mass per second [Initial velocity} - \text{Final velocity]}$$
$$= \rho aV[(V-u)-0] = \rho aV[V-u]$$

Work done by the jet on the series of plates per second

$$= \text{Force} \times \text{Distance per second in the direction of force}$$
$$= F_x \times u = \rho aV[V-u] \times u$$

Kinetic energy of the jet per second

$$= \frac{1}{2} mV^2 = \frac{1}{2}(\rho aV) \times V^2 = \frac{1}{2}\rho aV^3$$

∴ Efficiency, $$\eta = \frac{\text{Work done per second}}{\text{Kinetic energy per second}} = \frac{\rho aV[V-u] \times u}{\frac{1}{2}\rho aV^3} = \frac{2u[V-u]}{V^2}.$$

(3+5)

(b)

Sol. Given :

Diameter of the jet, $d = 7.5 \text{ cm} = 0.075 \text{ m}$

$\therefore$ Area, $a = \frac{\pi}{4}(.075)^2 = 0.004417$

Velocity of the jet, $V = 20 \text{ m/s}$

Velocity of the plate, $u = 8 \text{ m/s}$

Angle of deflection of the jet $= 165°$

$\therefore$ Angle made by the relative velocity at the outlet of the plate,

$$\theta = 180° - 165° = 15°.$$

(i) Force exerted by the jet on the plate in the direction of the jet is given by equation (17.17) as

$$F_x = \rho a(V-u)^2(1+\cos\theta)$$

$$= 1000 \times .004417 \times (20-8)^2[1+\cos 15] = \mathbf{1250.38\ N.} \quad \textbf{Ans.}$$

(ii) Work done by the jet on the plate per second

$$= F_x \times u = 1250.38 \times 8 = 10003.04 \text{ N m/s}$$

$\therefore$ Power of the jet $= \frac{10003.04}{1000} = \mathbf{10\ kW.}$ **Ans.**

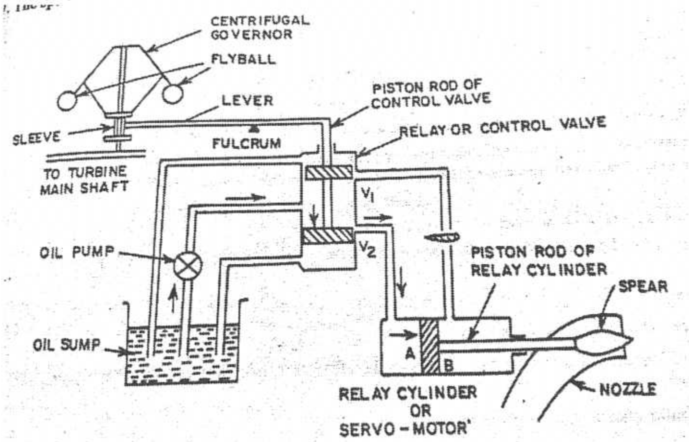
(iii) Efficiency of the jet $= \frac{\text{Output}}{\text{Input}} = \frac{\text{Work done by jet/sec}}{\text{Kinetic energy of jet/sec}}$

$$= \frac{1250.38 \times 8}{\frac{1}{2}(\rho a V) \times V^2} = \frac{1250.38 \times 8}{\frac{1}{2} \times 1000 \times .004417 \times V^3}$$

$$= \frac{1250.38 \times 8}{\frac{1}{2} \times 1000 \times .004417 \times 20^3} = 0.564 = \mathbf{56.4\%.} \quad \textbf{Ans.}$$

UNIT II

V. (a)



When the load on the generator decreases, the speed of the generator increases. This increases the speed of the turbine beyond the normal speed. The centrifugal governor, which is connected to the turbine main shaft, will be rotating at an increased speed. Due to increase in the speed of the centrifugal governor, the fly-balls move upward due to the increased centrifugal force on them. Due to the upward movement of the fly-balls, the sleeve will also move upward. A horizontal lever, supported over a fulcrum, Connects the sleeve and the piston rod of the control valve. As the sleeve moves up, the lever turns about the fulcrum and the piston rod of the control valve moves downward. This Closes the Valve V1 and opens the valve V2 as shown in Fig.

(b).

Power developed,P=2000 KW

Working ahead H=100M

Overall efficiency η=85 % = 0.85

Coefficient of velocity CV=0.98

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Efficiency =p /wQH

So discharge Q=ρwHη=2000/9.81*100*0.85

=2.3985 m³/s

Velocity of jet, $V = C_v\sqrt{2gH} = 0.98\times\sqrt{2\times9.81\times100}$

$= 43.4086$ m /s

Discharge through the jet, Q = Area of jet × Velocity of jet

$$= \frac{\pi}{4}d^2V$$

∴ Diameter of the nozzle jet, $d = \sqrt{\frac{4Q}{\pi V}}$

$$= \sqrt{\frac{4\times2.3985}{\pi\times43.4086}} = 0.2652\text{m}$$

$$= \mathbf{265.2\ mm}$$

(Data-2,calculation-3, Result-2)

OR

VI.(a).

Water power-power possessed by water at inlet--WP=wQH=ρgQH

Brake power-power developed by the turbine due to its running

Shaft power-actual power available at the shaft of the turbine runner as output

Overall efficiency-ratio of power available at the turbine shaft to the power supplied by the water at the inlet of the turbine

(With brief explanation). (2*4 marks)

(b)

Working head of the turbine, $H = 200$ m

Diameter of pipe, $d = 100$ mm $= 0.1$ m

Discharge through the pipe, Q $= 1.25\ m^3/s$

Coefficient of velocity, $C_v = 0.97$

Velocity of jet, $V = C_v\sqrt{2gH}$

$$= 0.97\times\sqrt{2\times9.81\times200}$$

$= 60.7626 \text{ m/s}$

Discharge through the jet, Q = Area of jets $\times$ Velocity of jet

$$= \frac{\pi}{4} d^2 n \times V$$

$$\therefore \text{Number of jets, } n = \frac{4Q}{\pi d^2 V}$$

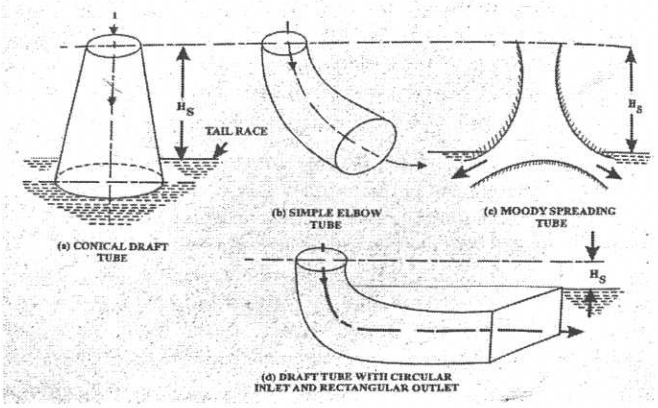
$$= \frac{4 \times 1.25}{\pi \times (0.1)^2 \times 60.7626} = \mathbf{2.6 \text{ say } 3}$$

(Data-2, calculation-3,result-2)

UNIT----III

VII (a)

Conical draft tubes, spreading draft tubes, simple elbow draft tubes, elbow draught tube with circular inlet and rectangular outlet

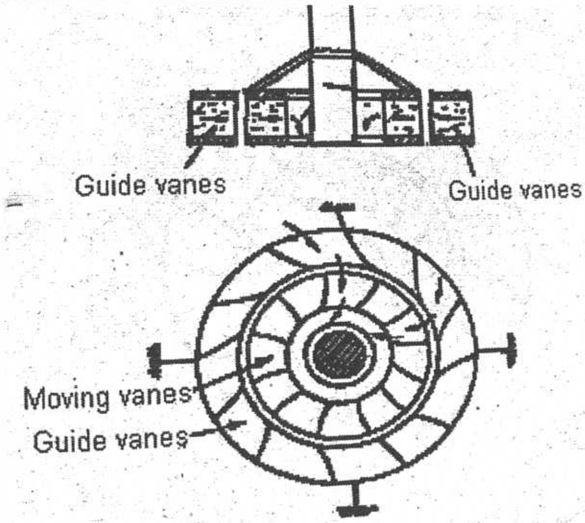


(Explanation-4,Fig-4)

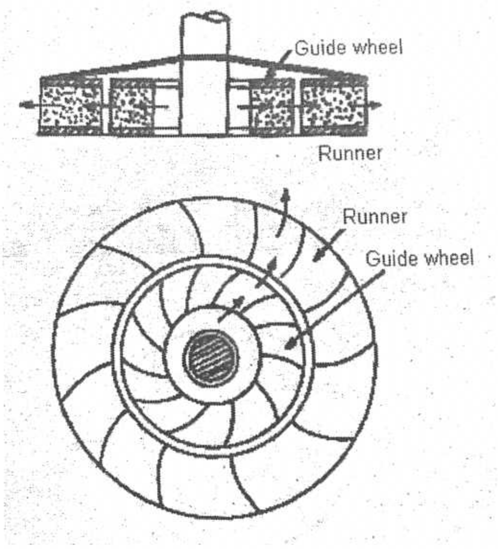
(b). Radial flow reaction turbine.. water flows in radial direction. If the floor is towards the axis of rotation-inward flow reaction turbine.

If the floor is away from the axis of rotation-outward flow reaction turbine

<u>Inward flow reaction turbine</u>



Outward flow reaction turbine



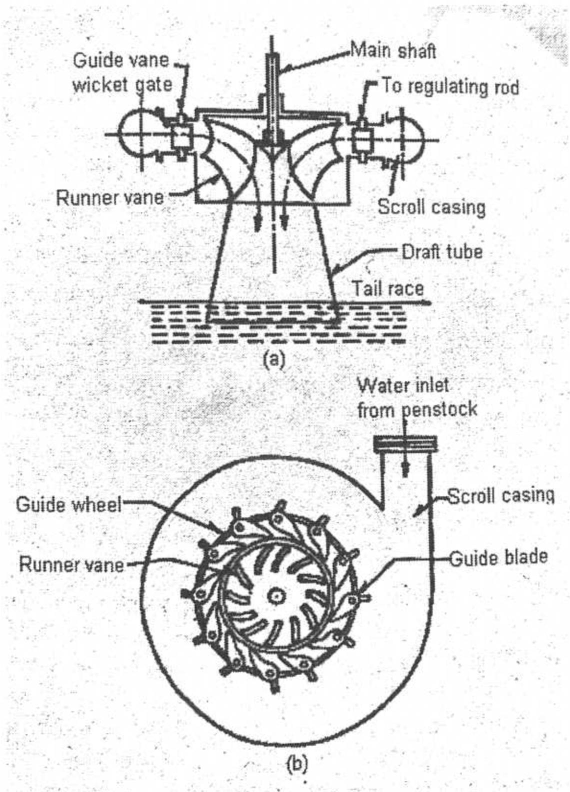
(fig-4,explanation-4)

OR

VIII(a)

Francis turbine-inward radial flow type. Works under medium head. Water enters the runner radially and leaves axially. Part of hydraulic energy transformed into kinetic energy and trust remains pressure energy.

Main components.. spiral casing, guide mechanism, runner or impeller, draft tube& governor



(4+4)

(b) Head of the turbine H=25 M

Speed of the turbine N=200RPM

Discharge Q =9m3/s

Overall efficiency, η_o = 90% = 0.9

Power generated, $P = \eta_o \times w\,Q\,H = 0.9 \times 9.81 \times 9 \times 25$

$= \mathbf{1986.525\ kW}$ *(Ans)*

The specific speed of a turbine is given by the equation,

$$N_s = \frac{N\sqrt{P}}{H^{5/4}} = \frac{200 \times \sqrt{1986.25}}{(25)^{5/4}}$$

$= \mathbf{159.45}$ ***(SI units)*** *(Ans)*

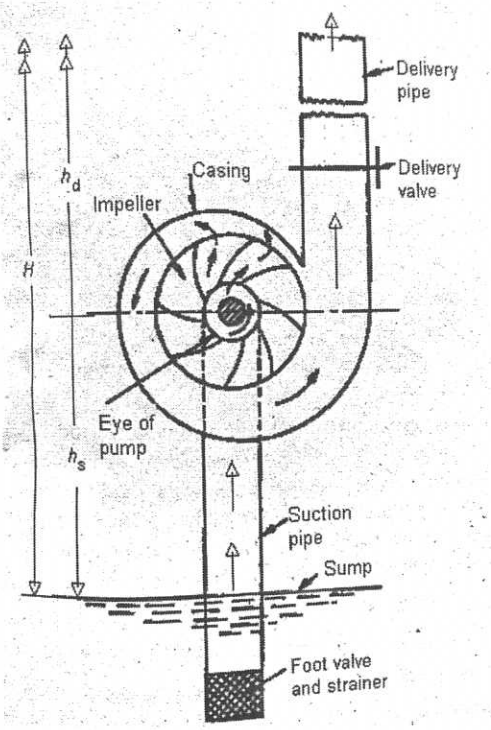
As specific speed is between 50 - 260,

$\therefore$ **Francis turbine is suitable** *(Ans)*

(Data-2,calculation-3, Result-2)

UNIT IV

(a)



(Brief explanation about components-4 marks, figure 4 marks)

(b)

Discharge of the pump, $Q = 0.05\ m^3/s$

Head of water, $H = 40$ m

Shaft power of the pump, $P = 32$ kW

Power required to drive the centrifugal pump, $P = \dfrac{wQH}{\eta_o}$

$$\text{Overall efficiency}, \eta_o = \frac{wQH}{P} = \frac{9.81 \times 0.05 \times 40}{32} = 0.6131$$

$$= \mathbf{61.31\ \%} \qquad (\textit{Ans})$$

(Data-2,calculation-3, Result-2)

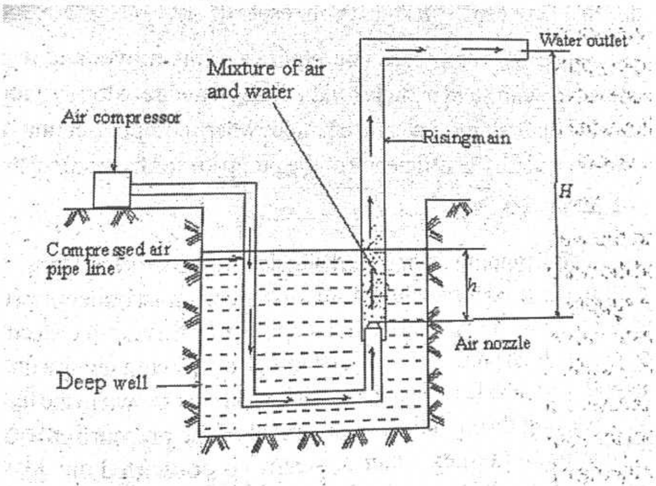
OR

X.(a). **Priming**..The entire operation of completely filling suction pipe, casing and a portion of delivery pipe upto delivery valve with liquid to be pumped is called priming .It is done to remove the entrapped air in the pump. If air is present, sufficient pressure cannot be developed .

If the impeller is run in air, negligible pressure is generated because of low density of air and hence no water is lifted by the pump. Hence it is very essential to remove the air from suction pipe and casing.

Cavitation .In any region of fluid flow, there is chance of formation of vapour bubbles . When the pressure of the flowing fluid is less than its Vapour pressure, the fluid starts boiling and vapour bubbles are formed .When these vapour bubbles moves towards a zone of high pressure, they condense and finally collapse. sudden collapsing of these vapour bubbles in a region of high pressure may, create a very high pressure as high as 101 bar ,thereby a tremendous shock (pitting action)on the adjacent wall This may cause a local mechanical failure of the solid surface. The growth and decay of vapour bubbles adversely affect the performance of a hydraulic machine and the ultimate effect may be the break-down of the machine itself due to severe pitting and ; . erosion of blade surface in reglon of cavitation This phenomenon is called as cavitation (3½+3½)

(b) **Air lift pump.**



An air lift pump is a simple pumping device used to lift water from a deep well or sump by utilising the compressed air.

It consists of an air compressor and an air pipe line titted with nozzle at the one end. and an open vertical delivery pipe or raising main encloses the nozzle.The nozzle is located h meter below the water level surface as shown in Figure. The compressed air is introduced at the bottom of the rising main and it issues from a set of air nozzles in the form a line spray. The air mixes with the rising main and reduces the density of air-water mixture. As soon as the pressure of the column of air-water mixture in the rising main of height 'H' becomes less than the pressure due to the height of water column h in the deep well, the water begins to flow at the outlet of the rising main. The flow rate depends upon the density of mixture in the raising main / delivery pipe. (4+4)