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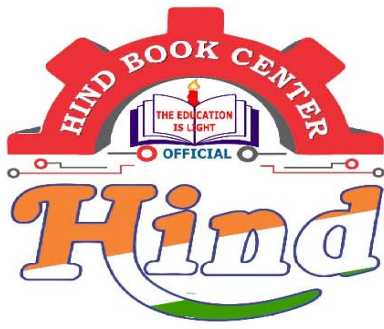
Fluid Mechenary

By- Amit Kakkar Sir

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Fluid



Dynamics of fluid

Energy Equation

F/M

Energy of fluid

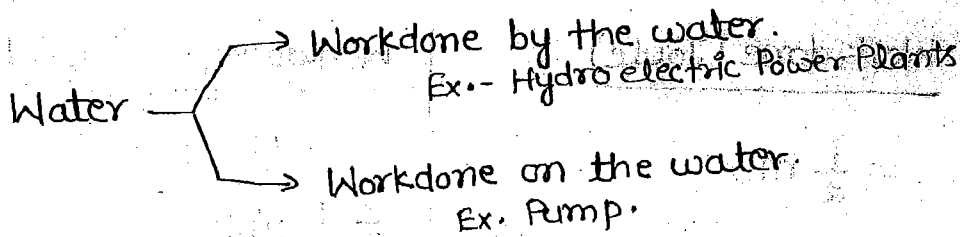
1st

$$P + \frac{1}{2} \rho v^2 + \rho g z \left] \begin{array}{l} \text{energy per} \\ \text{unit volume} \end{array} \right.$$

2nd

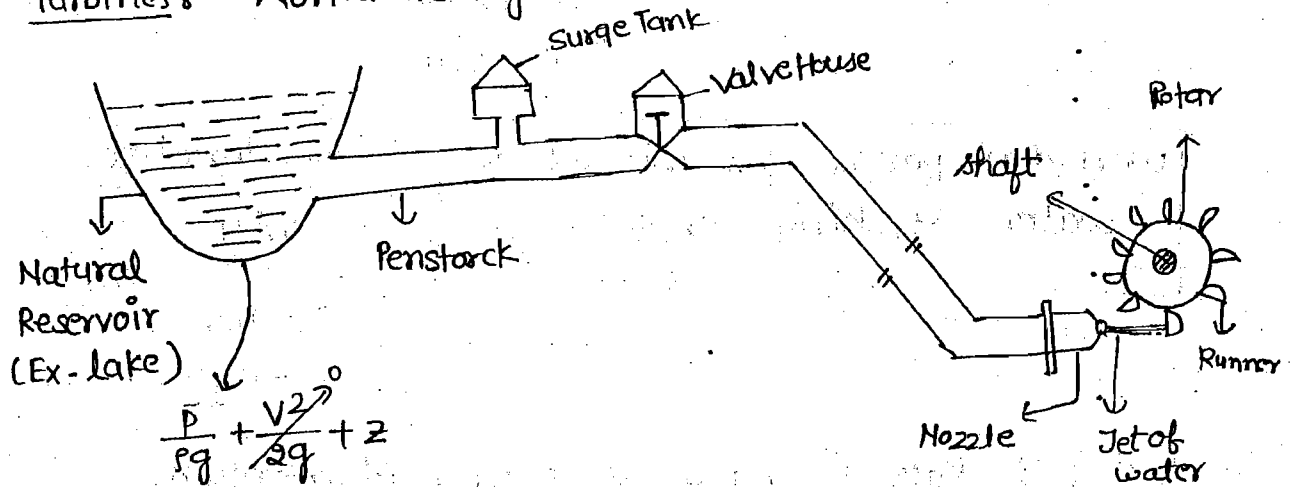
$$\frac{P}{\rho g} + \frac{v^2}{2g} + z \left] \begin{array}{l} \text{energy per unit} \\ \text{weight or load} \\ \text{form.} \end{array} \right.$$

H/M



Classification of Hydraulic Machines :-

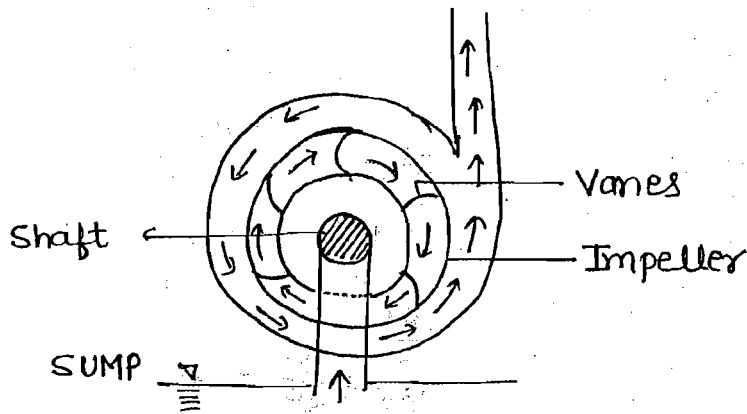
Turbines :- Workdone by the water.



Hydraulic Energy \Rightarrow Mechanical shaft Power \Rightarrow electricity
(electric Power)

Runner: Rotal having a series of vanes.

PUMP: Workdone on the water.



Electrical Energy \Rightarrow Mechanical shaft work \Rightarrow Hydraulic Energy.

Work done (Joule)

$$= \frac{1}{2} mv^2$$

$$= mgh$$

$$= Fx \cdot x$$

$\frac{1}{2}mv^2 = \frac{1}{2}\omega^2 r^2 m$
 mgh
 $Fx \cdot x$

Workdone/sec. (watt)

or
(Power)

$$= \frac{1}{2} mv^2$$

$$= mgh$$

$$= Fx \cdot u$$

$$P = T \cdot \omega$$

$\frac{1}{2}mv^2$
 mgh
 $Fx \cdot u$
 $P = T \cdot \omega$

workdone per sec. per unit wt. of water striking per sec. (m)	=	$\frac{\text{workdone/sec}}{mg}$
---	---	----------------------------------

when $H=30$ $mgh = \text{watt}$

Torque is Rate of change of angular Momentum.

where angular Momentum is moment of linear Momentum.

Cause of Workdone \Rightarrow Force

Newton's 2nd Law -

$$\vec{F}_{\text{ext.}} = \frac{d}{dt} (m \cdot \vec{v})$$

↓
system (water)

Force exerted on the water

$$\vec{F}_{\text{water}} = \dot{m} (\vec{v}_2 - \vec{v}_1) \quad \text{In pumps}$$

Force exerted by the water

$$\vec{F} = -\vec{F}_{\text{water}} \quad (\text{Newton's 3rd law})$$

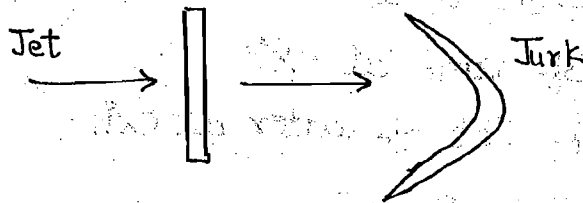
$$\vec{F} = \dot{m} (\vec{v}_1 - \vec{v}_2) \quad \text{In turbines}$$

\vec{v}_2 = Absolute Velocity of water at exit.

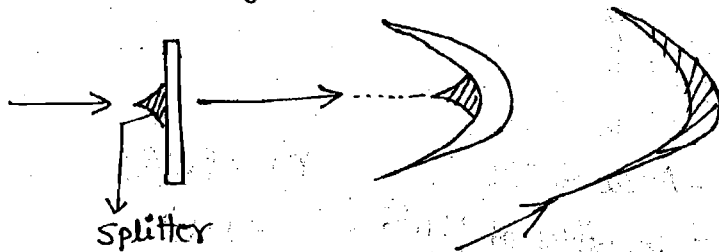
\vec{v}_1 = absolute velocity of water at inlet.

Dwt Requirement :-

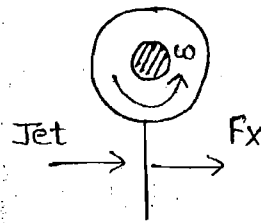
(1)



Smooth Entry \rightarrow

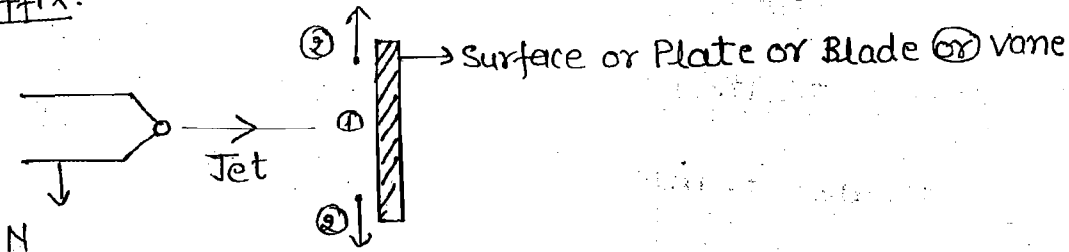


(2) force in -x-dirⁿ & not in y-dirⁿ
 otherwise misalignment of Rotar.



Impact of Jet :-

Suffix:



Entry at vane \Rightarrow ①

Exit from Vane \Rightarrow ②

At inlets:-

$V_1 \Rightarrow$ Absolute Velocity of Jet of water at inlet.

$u_1 \Rightarrow$ Absolute velocity of Vane at inlet.

$V_{r1} \Rightarrow$ Relative Velocity of Jet of water.

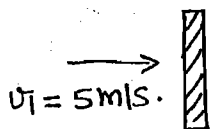
At exit:

$V_2 =$ Absolute velocity of Jet of water at exit.

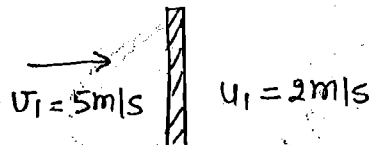
$u_2 =$ Absolute Velocity of vane at exit

$V_{r2} =$ Relative velocity of Jet of water at exit.

Mass Flow Rate Responsible for Force :



$$\begin{aligned} \dot{m} &= \rho a V_1 \\ &= \rho a (5) \end{aligned}$$



$$\begin{aligned} a &= \text{Area of Jet} \\ \rho &= \text{Density of fluid} \end{aligned}$$

$$\begin{aligned} \dot{m} &= \rho a V_{r1} \\ &= \rho a (5-2) \\ &= \rho a (3) \end{aligned}$$

The mass flow rate responsible for the force will be calculated on the basis of relative velocity.

Impact of Jet :

Aim :- Designing of the shape of Vanes.

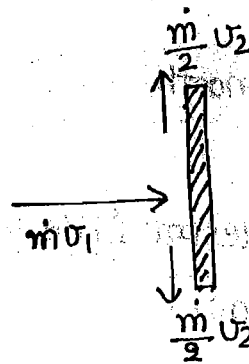
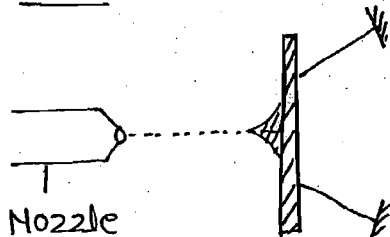
Requirement :

$$F_x = \dot{m} u_1$$

$$F_y = 0$$

Stationary Surface :

(1) Flat :-



Assume

Vane surface is smooth.

$$u_2 = u_1$$

Mass flow Rate Responsible for force -

$$\dot{m} = \rho a u_1$$

F_x = Initial Momentum/sec in the x-dirⁿ - Final Momentum/sec in the x-dirⁿ.

$$F_x = \dot{m} u_1 - 0 = \dot{m} u_1 = (\rho a u_1) \cdot u_1$$

$$F_x = \rho a u_1^2$$

F_y = Initial Momentum/sec in the y-dirⁿ - Final Momentum/sec in y-dirⁿ.

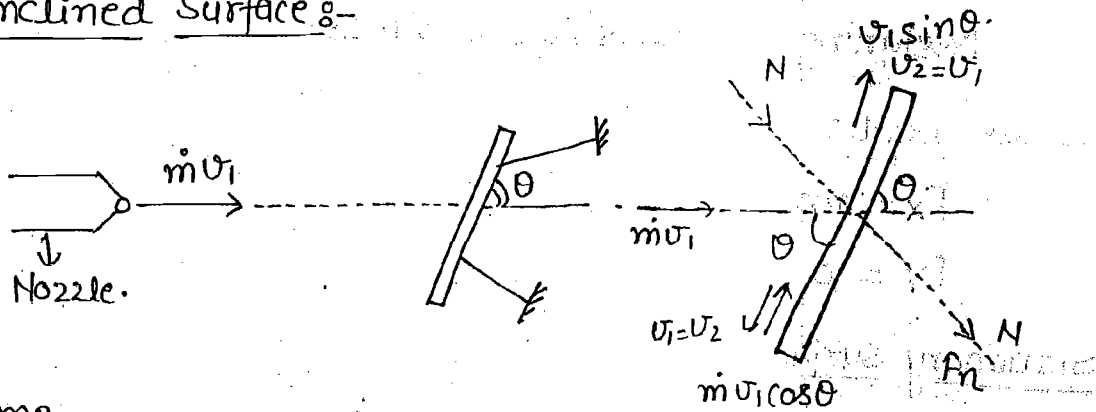
$$= 0 - \left[\frac{\dot{m}}{2} u_2 - \frac{\dot{m}}{2} u_2 \right] \quad \boxed{F_y = 0} \text{ as pipe is assumed smooth.}$$

$\{u_2 = u_1\}$

NOTE:

If a jet strikes at 90° then the forces will exist in the same dirⁿ.

(2) Inclined Surface:-



Assume

Vane surface is smooth

$$u_2 = u_1$$

mass flow rate responsible for force

$$\dot{m} = \rho a u_1$$

Now,

$F_n = \text{Initial Momentum/sec} - \text{Final Momentum/sec}$
at inlet in N-dirⁿ at exit in N-dirⁿ.

$$= \dot{m} u_1 \sin \theta - 0$$

$$F_n = \rho a u_1^2 \sin \theta$$

$$F_x = F_n \cos(90^\circ - \theta)$$

$$F_x = \rho a u_1^2 \sin^2 \theta$$

$$F_y = F_n \sin(90^\circ - \theta)$$

$$F_y = \rho a u_1^2 \sin \theta \cos \theta$$