Study Material

On

Hydraulic Machines and Industrial Fluid Power

Department of Mechanical Engineering

CAPITAL ENGINEERING COLLEGE

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(Affiliated to Biju Patnaik University of Technology, Odisha and SCTE & VT, Odisha, Approved by AICTE, New Delhi and Recognised by Govt. of Odisha)

01.02.2024, 2-2:55, F.M.H.M, 3rd B.Tech
Mech/Civil

Rabindra Kr. Behera ✓
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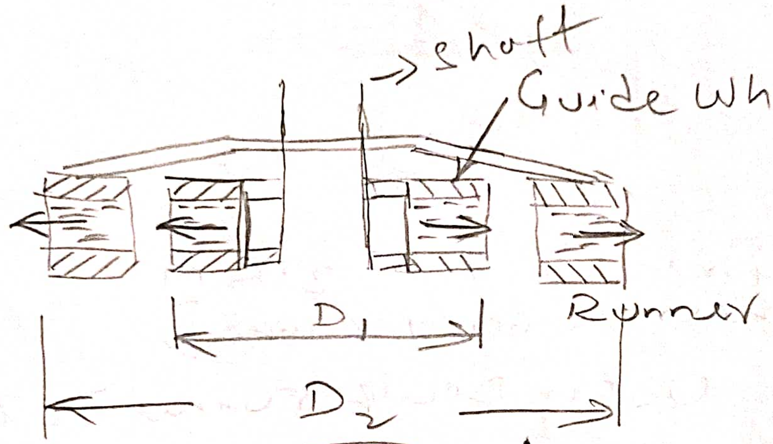
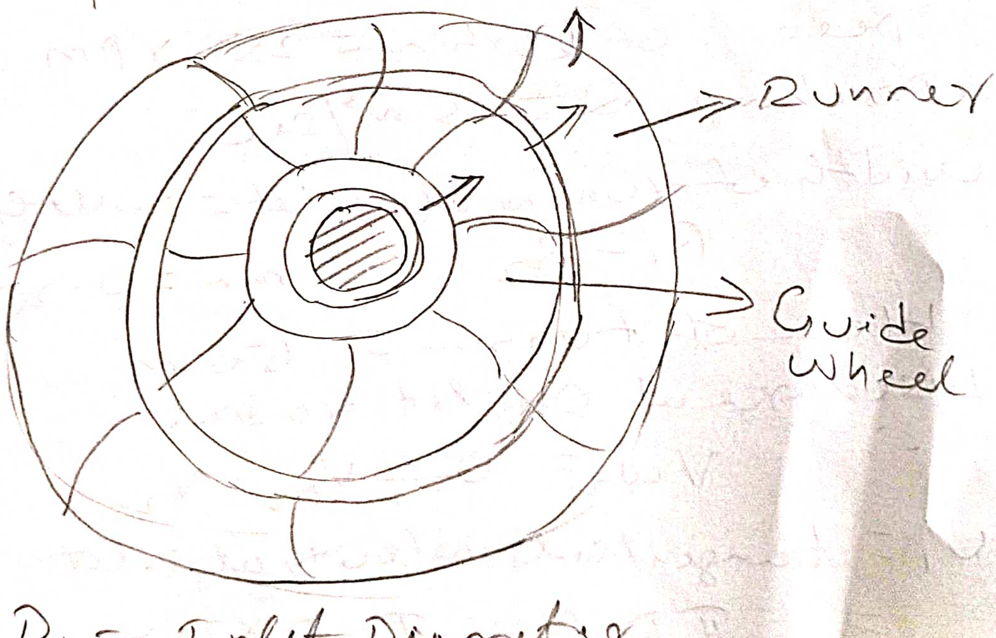
Subham Samal ✓

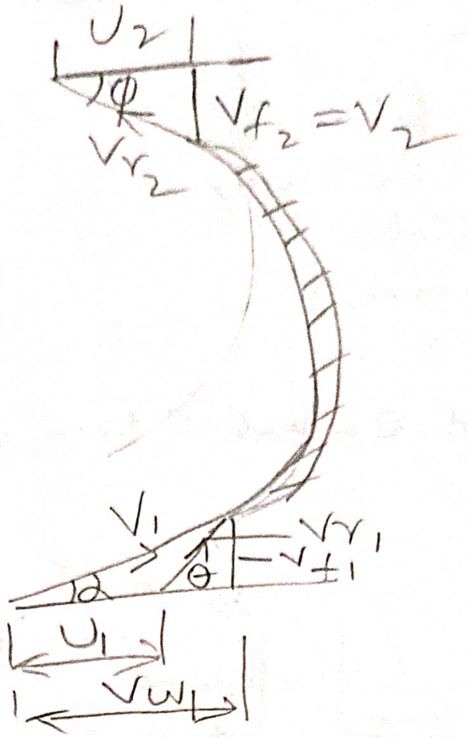
Outward Radial Flow Reaction Turbine





D_1 = Inlet Diameter
D_2 = Outlet Diameter of Runner

As $D_1 < D_2$, $U_1 < U_2$
U_1 & U_2 are tangential velocity of vanes



Data Given – $D_1 = 2.0$ m
(Internal dia of runner)

D_2 = Outer Dia of runner = 2.75 m

Speed of turbine = 250 rpm = N

Discharge $Q = 5\ m^3/sec$

Width of runner at inlet = width at outlet

$B_1 = B_2 = 250$ mm $= 0.25$ m

Head of turbine = 150 m

Discharge at outlet radial

$\therefore V_{w_2} = 0$, $V_{f_2} = V_2$

U_1 = tangential velocity at inlet

$= \frac{\pi D_1 N}{60} = \frac{\pi \times 2 \times 250}{60} = 26.179$

$\simeq 26.18$ m/sec

U_2 = tangential velocity of vane at outlet

$= \frac{\pi D_2 N}{60} = \frac{\pi \times 2.75 \times 250}{60} = 35.99$

$\simeq 36$ m/sec

$Q = \pi D_1 B_1 V_{f_1} = \pi D_2 B_2 V_{f_2}$

(Discharge)

$$V_{f_1} = \frac{5}{\pi \times D_1 \times B_1} = \frac{5}{\pi \times 2 \times 0.250} = 3.18 \text{ m/sec}$$

$$V_{f_2} = \frac{5}{\pi \times D_2 \times B_2} = \frac{5}{\pi \times 2.75 \times 0.25} = 2.315 \text{ m/sec}$$

$$H - \frac{V_2^2}{2g} = \frac{1}{g}\left[V_{w_1} U_1 \pm V_{w_2} U_2\right]$$

$$= \frac{1}{g} V_{w_1} U_1$$

$$150 - \frac{2.315^2}{2 \times 9.81} = \frac{1}{9.81}\left[V_{w_1} \times 26.18\right]$$

($V_2 = V_{f_2}$ since $V_{w_2} = 0$)

$150 - 0.273 = ~~2.73~~$ $2.668 \, V_{w_1}$

or $V_{w_1} = \dfrac{150 - 0.273}{~~2.73~~ \; 2.668} = 56.119$

From Inlet velocity triangle

$$\tan\theta = \frac{V_{f_1}}{V_{w_1} - U_1} = \frac{3.18}{56.119 - 26.18}$$

$= 0.10622$

$\theta = \tan^{-1} 0.10622 = 6.06^\circ$

Vane angle at inlet

$$\tan\phi = \frac{V_{f_2}}{U_2} = \frac{2.315}{36} = 0.0643$$

$\theta = \phi = \tan^{-1} 0.0643 = 3.679^\circ$

Vane angle at Outlet

02.02.2021, 2-2.55 Production Technology

3rd Dip (Mech).

Shraban Kumar Nayak
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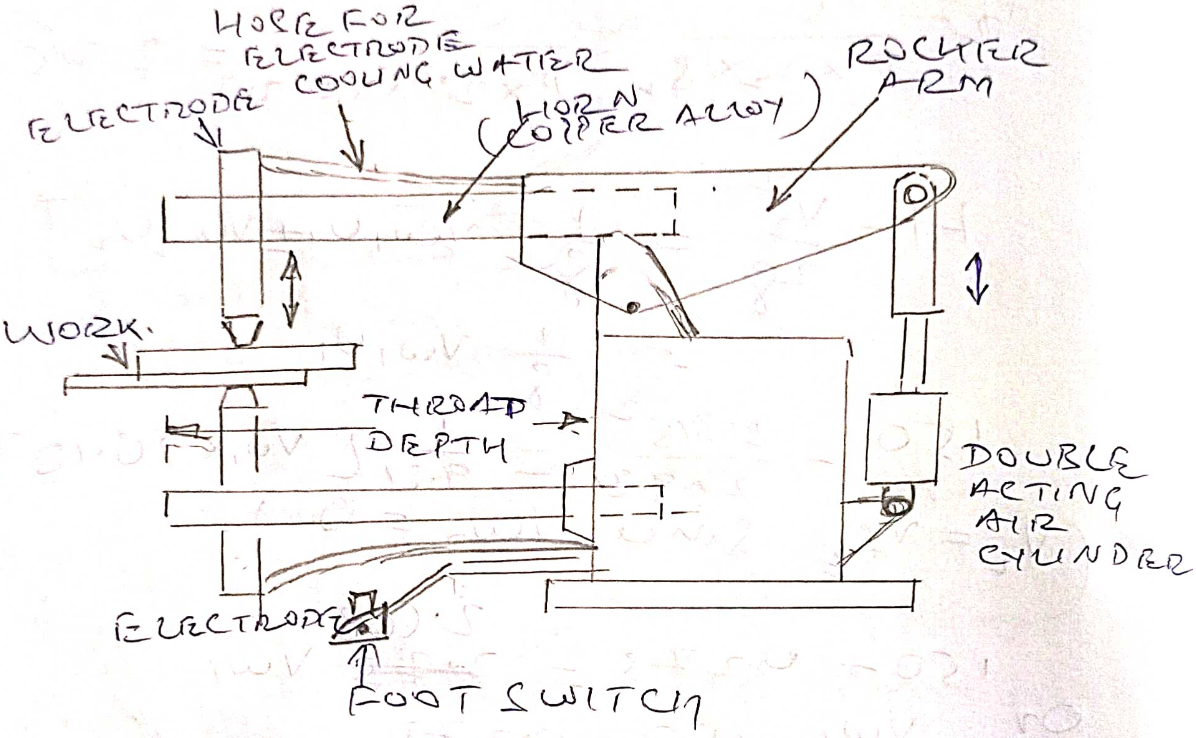

ROCKER-ARM SPOT WELDING M/C

3 Types Spot Welding Machines:

1. Standard Machine
2. Special Multi Electrode Machine
3. Portable welder

1. <u>Standard Machine</u>

2 types Standard Machines

1. Rocker Arm type
2. Press type spot or projection welder

1. Rocker Arm Type Machine:

(a) Foot type

(b) Air operated Machine

Foot treadle

02.02.2021, F.MHM, 3rd B.Tech
Mech/Civil, 3-3.55

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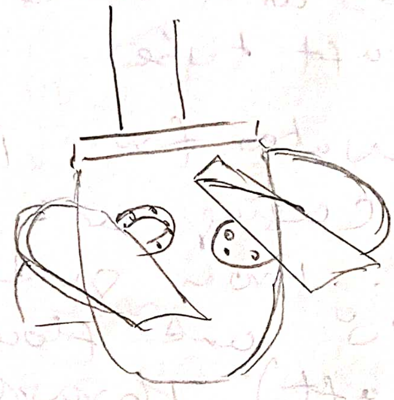


Axial Flow Reaction Turbine

If flow of water is ~~axial~~ parallel to axis of rotation of turbine, it is called axial flow turbine and if energy available at inlet are summation of kinetic energy & pressure energy it is called axial flow reaction turbine

In axial flow turbine the shaft of turbine is vertical. The lower end of shaft is larger diameter and it is called 'hub' or boss. The vanes are fixed on the ~~bo~~ hub. The hub also acts as runner

If the vanes are fixed on the hub (not adjustable) it is called propeller turbine

If the vanes are adjustable, the turbine is called Kaplan Turbine

It is designed by V. Kaplan an Austrian engineer

Main Parts of Kaplan turbine –

1. Scroll Casing
2. Guide Vane Mechanism
3. Hub with vanes (runner)
4. Draft tube

The water from penstock enters the Scroll casing and then moves to guide vanes. From guide vanes, the water turns 90° and flow axially (Prallel to shaft) through the runner,

D_o = Outer diameter of runner
D_b = Diameter of the hub
V_{f_1} = Velocity of flow at inlet

The discharge or flow through runner is given by

$$Q = \frac{\pi}{4}(D_o^2 - D_b^2) \times V_{f_1}$$

Some Important points for Kaplan Turbine

1. The peripheral velocity at inlet and outlet are equal

$$U_1 = U_2 = \frac{\pi D_o N}{60}, \quad N = \text{rpm of turbine}$$

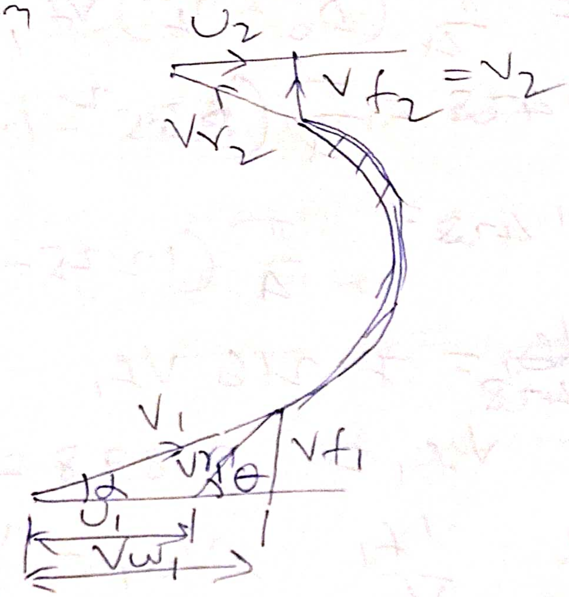
2. Velocity of flow at inlet & outlet are equal

$V_{f1} = V_{f2}$

3. Area of flow at inlet

$= \frac{\pi}{4}[D_o^2 - D_b^2]$

Soln. To problem given in class



Data given $H = 20$ m

Shaft power $=$ S.P $= 11772$ kW

Outer dia of runner $= D_o = 3.5$ m

Hub dia $D_b = 1.75$ m

Guide blade angle $= \alpha = 35°$

Hydraulic efficiency $\eta_h = 88\%$

Overall efficiency $= 84\%$

Velocity of whirl at outlet, $V_{w2} = 0$

$$\eta_o = \frac{S.P}{W.P}$$

$$W.P = \frac{\rho \times g \times Q \times H}{1000} \text{ kW}$$

$$0.84 = \frac{11772}{\frac{1000 \times 9.81 \times Q \times 20}{1000}}$$

$$0.84 = \frac{11772}{9.81 \times 20 \times Q}$$

or $$Q = \frac{11772}{0.84 \times 9.81 \times 20} = 71.428 \, m^3/sec$$

$$Q = \frac{\pi}{4}(D_o^2 - D_b^2) V_{f_1}$$

$$71.428 = \frac{\pi}{4}(3.5^2 - 1.75^2) V_{f_1}$$

or $$71.428 = \frac{\pi}{4}(12.25 - 3.0625) V_{f_1}$$

or $$71.428 = 7.216 \, V_{f_1}$$

or $$V_{f_1} = 9.898 \simeq 9.9 \, m/sec$$

$$\tan\alpha = \frac{V_{f_1}}{V_{w_1}}, \quad V_{w_1} = \frac{V_{f_1}}{\tan\alpha} = \frac{9.9}{\tan 35^\circ}$$

$$V_{w_1} = 14.138 \simeq 14.14 \, m/sec$$

$$\eta_h = \frac{V_{w_1} U_1}{g H}$$

$$0.88 = \frac{14.14 \times U_1}{9.81 \times 20}$$

$$U_1 = 12.21 \, m/sec$$

Runner vane angles at inlet θ

$$\tan\theta = \frac{V_{f_1}}{V_{w_1} - U_1} = \frac{9.9}{14.14 - 12.21}$$

$$\theta = 78.968^\circ$$

Runner vane angle at outlet, ϕ

$$\tan\phi = \frac{V_{f_2}}{U_2} = \frac{V_{f_1}}{U_1} \quad \left[\because V_{f_1} = V_{f_2},\ U_1 = U_2 \text{ for Kaplan Turbine}\right]$$

$$\phi = \frac{9.9}{12.21} = 39.035^\circ$$

Speed of Turbine

$$U_1 = U_2 = \frac{\pi D_o N}{60}$$

$$\therefore \quad 12.21 = \frac{\pi \times 3.5 \times N}{60}$$

$$\text{or} \quad N = \frac{12.21 \times 60}{\pi \times 3.5} = 66.626 \text{ rpm}$$

03.02.21, 1-1.55, F.MHM

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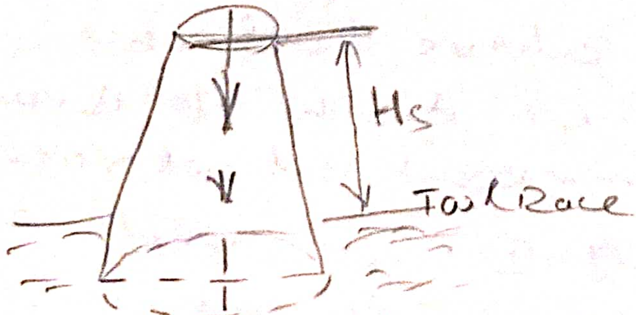
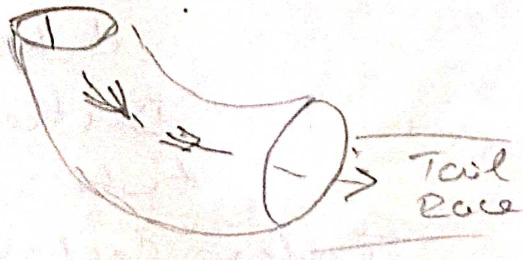
Draft Tube

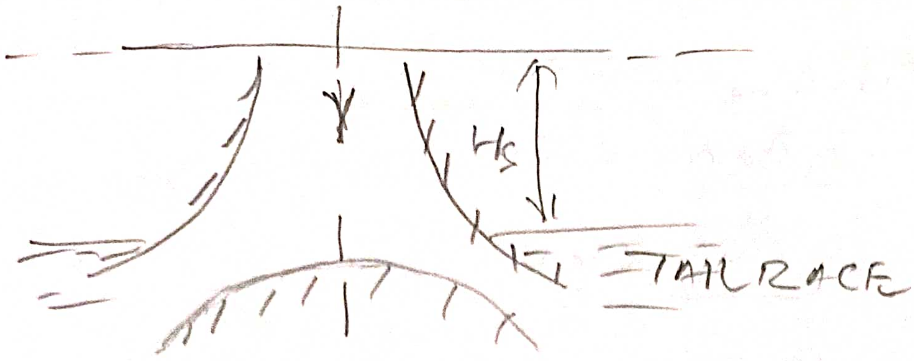
Types of Draft Tubes –

1. Conical Draft-Tube
2. Simple elbow tube
3. Moody Spreading tubes
4. Elbow draft tube with circular inlet and rectangular outlet

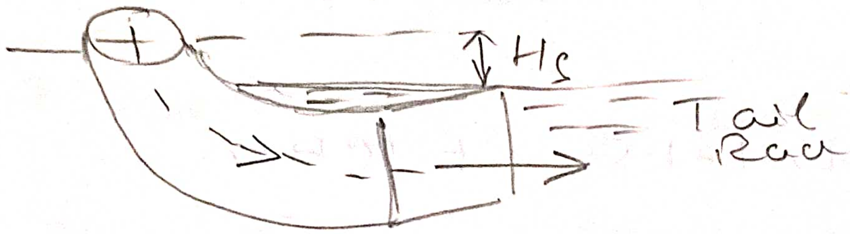


Conical Draft Tube





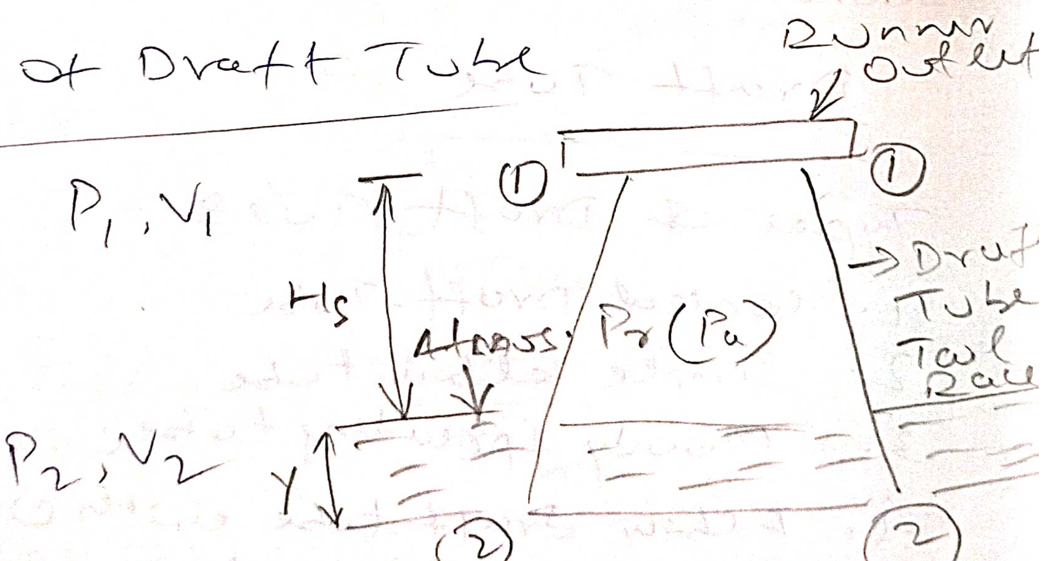
MOODY SPREADING TUBE



Draft tube with circular inlet and Rectangular Outlet

- Conical & Moody are more efficient
- & Simple elbow type & elbow with circular inlet & rectangular outlet require less space

Theory of Draft Tube



Let H_s = Vertical height of draft tube above tail race

Y = Distance or depth of draft tube immersed in tail race

Take section ①-① at inlet of draft tube and ②-② at outlet

as shown in figure
Assume datum line passing through 2-2
Apply Bernoulli's Equ to ①-① and 2-2

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2 + \text{head loss}$$

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + (H_s + X) = \left(\frac{P_a}{\rho g} + X\right) + 0 + h_f + \frac{V_2^2}{2g}$$

$$\frac{P_2}{\rho g} = \frac{P_a}{\rho g} + Y$$

P_a = Atmospheric Pressure on ~~tailr~~ tail race
Y = Pression head at bottom of tail race

or
$$\frac{P_1}{\rho g} = \frac{P_a}{\rho g} + h_f + \frac{V_2^2}{2g} - \frac{V_1^2}{2g} - H_s$$

$$\frac{P_1}{\rho g} = \frac{P_a}{\rho g} - H_s - \left[\frac{V_1^2}{2g} - \frac{V_2^2}{2g} - h_f\right]$$

Hence $\frac{P_1}{\rho g}$ < Atmospheric press head
P_1 < Atmospheric Pr.

Efficiency of Draft tube

The efficiency of draft tube is defined as the ratio of actual conversion of kinetic energy (head) into pressure head in the draft tube to the kinetic energy (head) at the inlet of draft tube

Mathematically, η_d = Actual

η_d = Actual conversion of Kinetic head into pressure head
/
Kinetic Head at inlet of draft tube

Let V_1 = Velocity of water at inlet draft tube

V_2 = Velocity of water at outlet of draft tube

h_f = Loss of head in draft tube

Actual conversion of Kinetic head to pressure head

$$= \left[\frac{V_1^2}{2g} - \frac{V_2^2}{2g}\right] - h_f$$

Kinetic head at inlet of Draft tube = $\frac{V_1^2}{2g}$

$$\eta_d = \frac{\left[\frac{V_1^2}{2g} - \frac{V_2^2}{2g}\right] - h_f}{\frac{V_1^2}{2g}}$$

03.02.2021, 3-3.55, Production Technology
3rd Dip Mech

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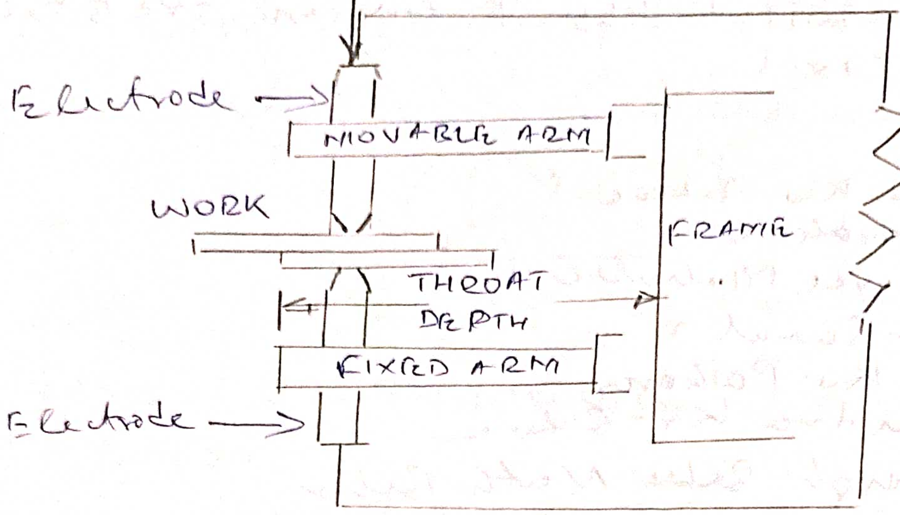
x Kartikeswar Maharana - Joined 3:40, left immed.
Rocker Arm Air Operated Machine

Press Type Spot Welding Machine



PRESS TYPE SPOT WELDING MACHINE

(ii) Special Multiple Electrode Machines

For high production jobs - 2 types of machines

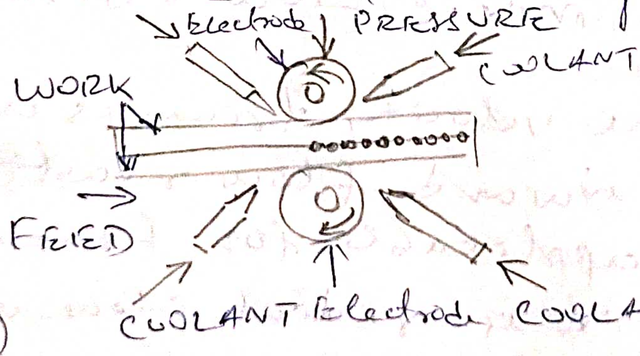
(i)

(ii)

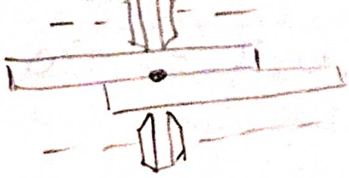
(iii) Portable Spot Welding Machine

2. Resistance Seam Welding - RSW

(a) STICH SEAM (SPACED SPOT)



(b) CONTINUOUS SEAM (OVERLAPPING SPOTS)



05.02.2021, 1-1.55 F-M HM, 3rd B.Tech
Mech/Civil

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Nrusingh ~~Behera~~ Nath Behera
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Francis Turbine

It is a inward flow reaction turbine. Discharge is radial at outlet. Developed by J. B. Francis, American Engineer. In modern francis turbine the water enters ~~at~~ is radial at the outer dia of runner direction and exit is axial direction at the outlet (Parallel to axis of rotation of ~~turb~~ turbine). modern francis turbine is a mixed flow turbine

The velocity triangles which is drawn for inward flow reaction turbine are applicable for Francis turbine. As it ~~is~~ is radial flow at outlet hence $V_{w_2} = 0$, $V_{f_2} = V_2$

work done by water jet on runner

$$= \rho a V [V_{w_1} u_1 \pm V_{w_2} u_2]$$

$$= \rho a V [V_{w_1} u_1] = \rho Q [V_{w_1} u_1]$$

Work done per second for unit wt of water striking per sec

$= \frac{F \cdot V}{g}$

$= \frac{\rho a V_1 [V_{w_1} u_1]}{\rho a V_1 \times g} = \frac{1}{g} [V_{w_1} u_1]$

Hydraulic efficiency

$= \frac{\rho a V_1 [V_{w_1} u_1]}{\rho a V_1 \times g \times H} = \frac{V_{w_1} u_1}{g H}$

Imortant points for Francis Turbine

1. Ratio of width of wheel to its diameter

$n = \frac{B_1}{D_1}$, B_1 = width of runner at inlet

$= 0.1$ to 0.4 $\quad D_1$ = Outer diameter of runner

2. Flow ratio is given by

Flow ratio $= \frac{V_{f_1}}{\sqrt{2gH}}$

This value will be between 0.15 to 0.3

3. Speed Ratio $= \frac{u_1}{\sqrt{2gH}}$ = value is 0.6 to 0.9

$\eta_o = 84\%$

$\eta_h = 93\%$

flow ratio $= 0.2$

breadth ratio $n = 0.1$

Outer diameter of the runner $= 2 \times$ inner diameter of runner

Thickness of vanes occupy 5% of the circumferential area of the runner

Velocity of flow is constant at inlet & Outlet

Discharge is radial at outlet

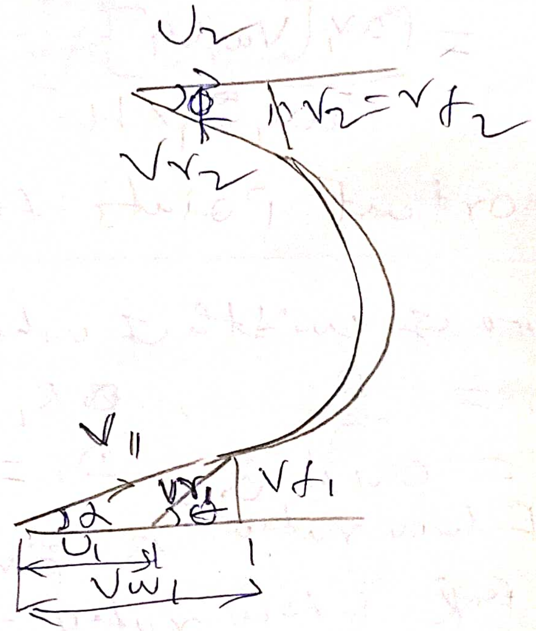
Determine

(i) Guide Blade Angle

(ii) Runner vane angle at inlet & outlet

(iii) Diameter of runner at inlet & outlet

(iv) Width of the wheel at inlet



Data given

Net Head $H = 60$ m

Speed $N = 700$ rpm

Shaft power, S.P $= 294.3$ KW

Overall efficiency $\eta_o = 84\% = 0.84$

Hydraulic efficiency $\eta_h = 93\% = 0.93$

Flow ratio

$$\frac{V_{f_1}}{\sqrt{2gH}} = 0.2$$

$$V_{f_1} = 0.2 \times \sqrt{2 \times 9.81 \times 60} = 6.862 \text{ m/sec}$$

$V_{f_2} = V_{f_2}$

Breadth ratio

$$\frac{B_1}{D_1} = 0.1$$

Outer diameter $D = 2 \times$ Inner diameter

$= 2 \times D_2$

Thickness of the vane
= 5% of circumferential area of runner

$= .95 \times \pi D_1 \times B_1$

Discharge is radial

$V_{w_2} = 0, \ V_{f_2} = V_2$

$$\eta_o = \frac{\text{Shaft Power}}{\text{Water Power}}$$

$$0.84 = \frac{294.3 \text{ kW}}{W.P}$$

$$\therefore W.P = \frac{294.3}{0.84} = 350.357 \text{ kW}$$

$$W.P = \frac{W.H}{1000} = \frac{\rho \times g \times Q \times H}{1000}$$

$$\therefore \frac{\rho \times g \times Q \times H}{1000} = 350.357$$

$$\text{or} \quad Q = \frac{350.357 \times 1000}{1000 \times 9.81 \times 60}$$

$= 0.5952 \text{ m}^3/\text{sec}$

Discharge

Q = Actual area of flow × Velocity of flow

$= 0.95 \times \pi \times D_1 \times B_1 \times V_{f_1}$

$0.5952 = 0.95 \times \pi \times D_1 \times 0.1 \times D_1 \times 6.862$

$$D_1^2 = \frac{0.5952}{(0.95 \times \pi \times 0.1 \times 6.862)}$$

$= 0.2906$

$D_1 = \sqrt{0.2906} = 0.54 \text{ m}$

But $\frac{B_1}{D_1} = 0.1$ (given)

$B_1 = 0.1 \times D_1 = 0.1 \times 0.54 = 0.054\ m = 54\ mm$ Ans

Tangential velocity of runner at inlet

$$U_1 = \frac{\pi D_1 N}{60} = \frac{\pi \times 0.54 \times 700}{60} = 19.79\ m/sec$$

Using relation for hydraulic efficiency

$$\eta_h = \frac{V_{w_1} U_1}{gH}, \text{ or } 0.93 = \frac{V_{w_1} \times 19.79}{9.81 \times 60}$$

$$\text{or } V_{w_1} = \frac{0.93 \times 9.81 \times 60}{19.79} = 27.66\ m/sec$$

∴ Guide Blade Angle (α):–

$$\tan\alpha = \frac{V_{f_1}}{V_{w_1}} = \frac{6.862}{27.66} = 0.248$$

$$\alpha = \tan^{-1} 0.248 = 13.928^\circ \quad \text{Ans.}$$

(ii) Runner Vane Angle at inlet (θ) and outlet ϕ

$$\tan\theta = \frac{V_{f_1}}{V_{w_1} - U_1} = \frac{6.862}{27.66 - 19.79} = 0.8719 \simeq 0.872$$

$$\theta = \tan^{-1} 0.872 = 41.08^\circ \quad \text{Ans}$$

From Outlet ~~triangle~~ velocity triangle

$$\tan\phi = \frac{V_{f_2}}{U_2} = \frac{V_{f_1}}{U_2} = \frac{6.862}{U_2}$$

$$\text{But } U_2 = \frac{\pi D_2 N}{60} = \pi \times \frac{D_1}{2} \times \frac{N}{60}$$

$$= \pi \times \frac{0.54}{2} \times \frac{700}{60} = 9.896\ m/sec$$

$$\therefore \tan\phi = \frac{6.862}{9.896} = 0.6934$$

$$\phi = \tan^{-1} 0.6934 = 34.737^\circ \quad \text{Ans}$$

(iii) Diameter of Runner at inlet & outlet

$$D_1 = 0.54\ m, \quad D_2 = \frac{D_1}{2} = 0.27\ m \quad \text{Ans}$$

(iv) Width of wheel at inlet

$B_1 = 54\ mm$ Ans

05.02.2021, 3-3.55, Production Technology
3rd Dip. Mechanical

Santosh Kumar Samal
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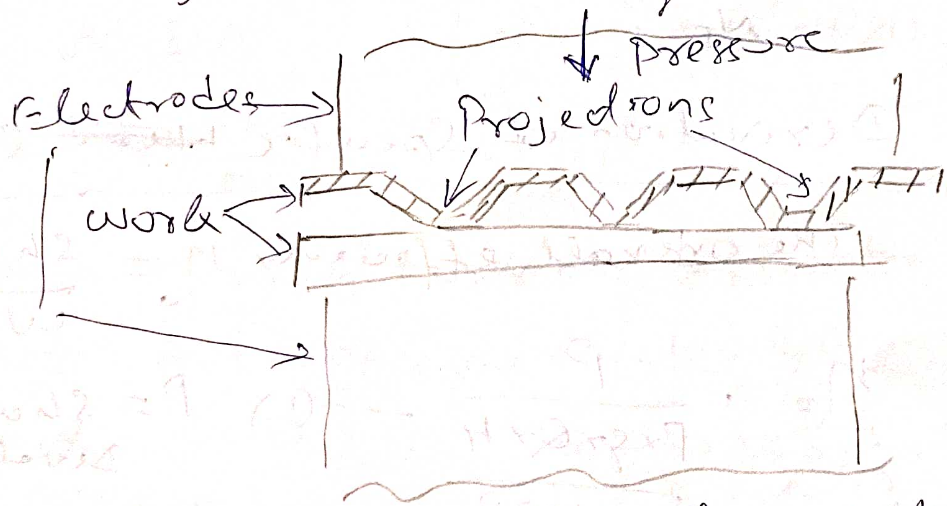
~~Stitch~~ ~~Stitch~~
(Stitch Seam or Space Spots)
Or Continuous Seam (Overlapping Seam)

3. Resistance Projection Welding —



Resistance Projection Welding
(RPW)

06.02.2021, 2-2.55, F.M.H.M, 3rd Mech /Civil

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Specific Speed of Turbine

N_s

Derivation of Specific ~~Head~~ Speed

The overall efficiency $\eta_o = \dfrac{\text{Shaft Power}}{\text{Water Power}}$

$$\eta_o = \frac{P}{\frac{\rho \times g \times Q \times H}{1000}} \quad \text{---(I)}$$

P = Shaft power Developed

Let

H = Head under which the turbine is working
Q = Discharge through turbine
P = Power Developed or Shaft power
D = Diameter of actual turbine
N = Speed of actual turbine
U = Tangential velocity of the turbine
N_s = Specific Speed of the turbine
V = Absolute velocity of water

$$P = \eta_o \times \frac{\rho \times g \times Q \times H}{1000} \quad \text{---- (II)}$$

(η_o, ρ and g are constant)

$\therefore P \propto Q \times H$

Relation between absolute velocity, tangential velocity and Head on the turbine

$U \propto V$ and $V \propto \sqrt{H}$ ~~[As $V = \sqrt{2gH}$]~~

$U \propto \sqrt{H}$ ----- (iii) [As $V = \sqrt{2gH}$]

The tangential velocity

$$U = \frac{\pi D N}{60}$$

$U \propto DN$ --- (iv)

$\sqrt{H} \propto DN$ [from eqn (iii) & (iv)]

Or $D \propto \frac{\sqrt{H}}{N}$ --- (v)

Discharge through turbine is given by

Q = Area of flow × Velocity

Area ∝ B × D   B = Breadth of runner

(B ∝ D)   D = Diameter of runner

$B \propto D$

Runner

∴ ~~Q ∝~~

Area $\propto D^2$

velocity $\propto \sqrt{H}$

∴ $Q \propto D^2 \sqrt{H}$

$\propto \left[\frac{\sqrt{H}}{N}\right]^2 \sqrt{H}$ from eqn (v)

$Q \propto \frac{H}{N^2} \sqrt{H}$

$Q \propto \frac{H^{3/2}}{N^2}$

∴ $P \propto \frac{H^{3/2}}{N^2} \times H$ [As $P \propto Q \times H$]

$P \propto \frac{H^{\frac{5}{2}}}{N^2}$

or $P = K \frac{H^{\frac{5}{2}}}{N^2}$ (K = constant of proportionality)

If $P = 1$ & $H = 1$,
N = Specific Speed = N_s

$1 = K \frac{1^{\frac{5}{2}}}{N_s^2}$

$N_s^2 = K$

Or $K = N_s^2$

$P = N_s^2 \frac{H^{\frac{5}{2}}}{N^2}$

or $N_s^2 = \frac{N^2 P}{H^{\frac{5}{2}}}$

$N_s = \sqrt{\frac{N^2 P}{H^{\frac{5}{2}}}}$

$N_s = \frac{N\sqrt{P}}{H^{\frac{5}{4}}}$

$$N_s = \frac{N\sqrt{P}}{H^{\frac{5}{4}}}$$

If P is taken as Horse Power
N_s will be in MKS unit
If P is taken as kW
N_s will be in S.I unit

Sl no	Specific Speed (MKS)	SI	Types of Turbine
1.	~~10-35~~ 10 to 35	8.5 to 30	Pelton wheel with single Jet
2	35 to 60	30 to 51	Pelton wheel with ~~2 or~~ two or more Jets
3.	60 to 300	51 to 225	Francis Turbine
4	300 - 1000	255 to 860	Kaplan or Propeller Turbine

<u>Soln</u>

Power = 7225 KW = P

Head = 25 mtr = H

Speed = N = 135 RPM

$$N_s = \frac{N\sqrt{P}}{H^{\frac{5}{4}}}$$

$$= \frac{135\sqrt{7225}}{25^{\frac{5}{4}}}$$

$$= \frac{135\sqrt{7225}}{55.9016} = 205.27 \text{ rpm}$$

Since the N_s lies between 51 to 225 so it is Francis Turbine

N = Speed of the impeller rpm

D_1 = Diameter of impeller at inlet

U_1 = Tangential velocity of impeller at inlet $= \frac{\pi D_1 N}{60}$

$U_2 = \frac{\pi D_2 N}{60}$

V_1 = Abs. velocity of water at inlet

V_{r_1} = Relative velocity of water at inlet

α = Angle made by V_1 at inlet with direction of motion of vane

θ = Angle made by V_{r_1} at inlet with direction of motion of vane

V_2, V_{r_2}, β and ϕ are corresponding values at outlet of vane

$U_1 = \omega R_1$, $U_2 = \omega R_2$

ω = Angular velocity of vane

Mass of water striking per second

$= \rho a V_1$, a = area of jet

V_1 = velocity of jet

Momentum of water striking per second in tangential direction at inlet

= Mass × Component of V_1 in the tangential direction

$= \rho a V_1 \times V_{w_1}$

Momentum of water at outlet per sec

$= \rho a V_1 \times V_{w_2}$

∴ Angular momentum per sec at inlet

$= \rho a V_1 \times V_{w_1} \times R_1$

Angular momentum per sec at outlet

$= \rho a V_2 V_{w_2} \times R_2$

T = Torque produced = change in Angular momentum

$T = \rho a v_1 [V_{w_1} R_1 - (- V_{w_2} R_2)]$

$= \rho a v_1 [V_{w_1} R_1 + V_{w_2} R_2]$

work done $= \rho a v_1 [V_{w_1} R_1 + V_{w_2} R_2] \omega$

$= \rho a v_1 [V_{w_1} R_1 \omega + V_{w_2} R_2 \omega]$

$= \rho a v_1 [V_{w_1} U_1 + V_{w_2} U_2]$

Since for centrifugal pump the water enters the impeller radially at inlet

$V_{w_1} = 0$

$\therefore$ work done $= \rho a v_1 [V_{w_2} U_2]$

work done per unit wt of water striking per sec $= \dfrac{\rho a v_1 [V_{w_2} U_2]}{\rho a v_1 \times g} = \dfrac{1}{g} [V_{w_2} U_2]$

08.02.2021, 1 – 2.15 F-MHM

3rd Mechanical / civil

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Rabindra Kr. Behera ✓

Naresh Sethi ✓

Jyotirmaya Behera ✓

Jyotirmayee Mohanty ✓

Turi Nayak ✓

Goutam ch. Behera ✓

Bhupendra Kr. Behera ✓

Subham Samal

Hydraulic Pumps

The hydraulic machine which convert mechanical energy to hydraulic energy are called pumps. The hydraulic energy is in form of pressure energy

If the conversion of mechanical energy to hydraulic energy by application of centrifugal force, then the machine is Centrifugal Pump

Centrifugal pump acts as reverse of inward flow reaction turbine. The flow is in radial outward direction. The water enters at ID of vane or runner and exit at the OD of runner.

Centrifugal Pump works on the principle of Forced vortex flow.
The theory of forced vertex flow is when a certain mass of ~~fluid~~ liquid is rotated by an external torque the rise of pressure head of the rotating ~~fluid~~ liquid takes place. This rise of pressure head is proportional to the square of tangential velocity of the liquid at that point
Mathematically we can write

$$\text{Rise of pressure head} = \frac{V^2}{2g} = \frac{\omega^2 r^2}{2g}$$

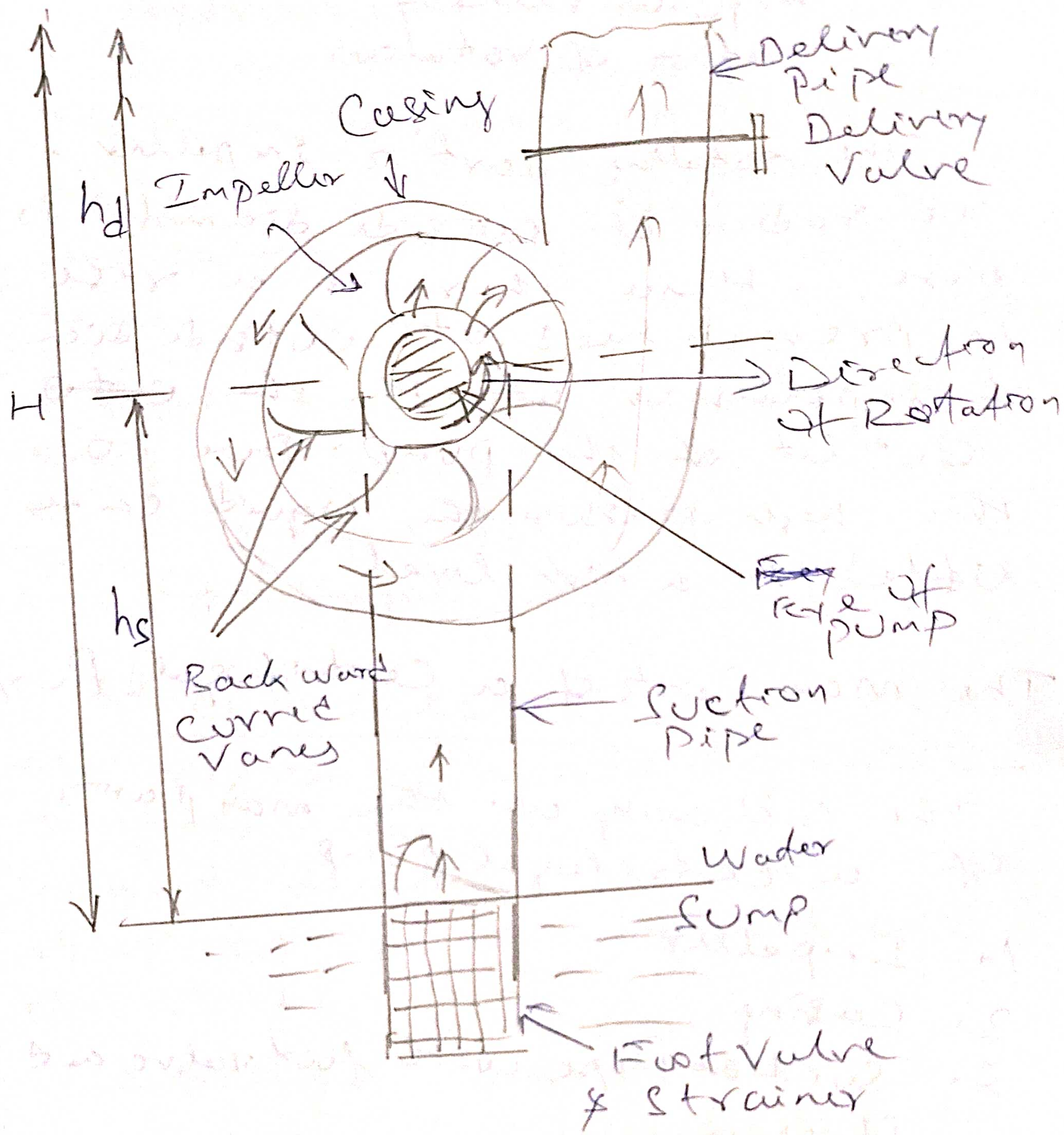
V = tangential velocity
ω = Angular velocity
r = radius of rotation

The rotating part is impeller. The radius at outside diameter is more, Hence there is a rise in pressure head at outside dia of impeller or at the the ~~outo~~ outlet of the pump. Due to this high pressure the liquid can be lifted to a high level

The main Parts of a Centrifugal Pump

The following are the main parts of a centrifugal pump

1. Impeller
2. Casing
3. Suction Pipe with foot valve and Strainer
4. Delivery Pipe



Main Parts of Centrifugal Pump

- Impeller - The rotating part of a centrifugal pump is called impeller. In consist of backward curved vanes. The impeller is mounted on a shaft which is connected to the shaft of an electric motor

2. Casing — Similar to casing of reaction turbine

3 types of casing commonly used

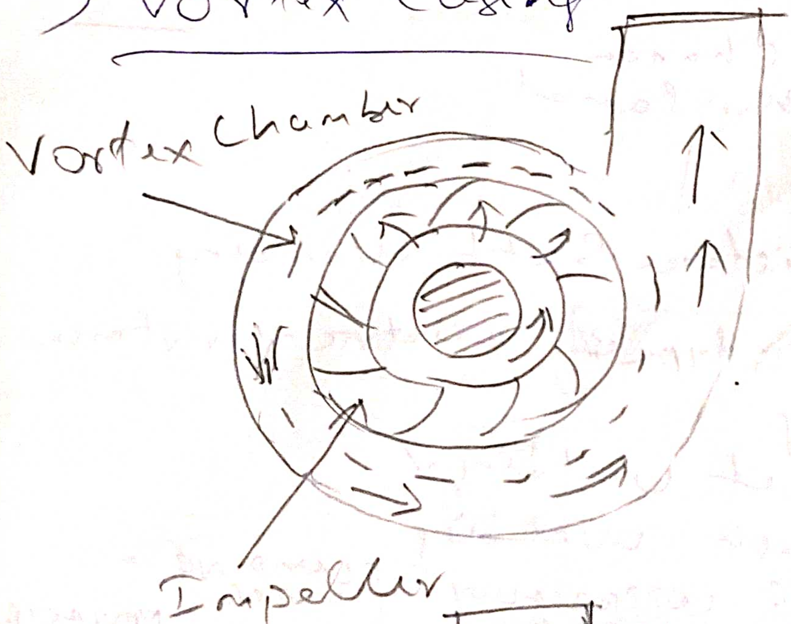
(i) Volute Casing
(ii) Vortex Casing
(iii) Casing with guide Blades.

(i) volute casing

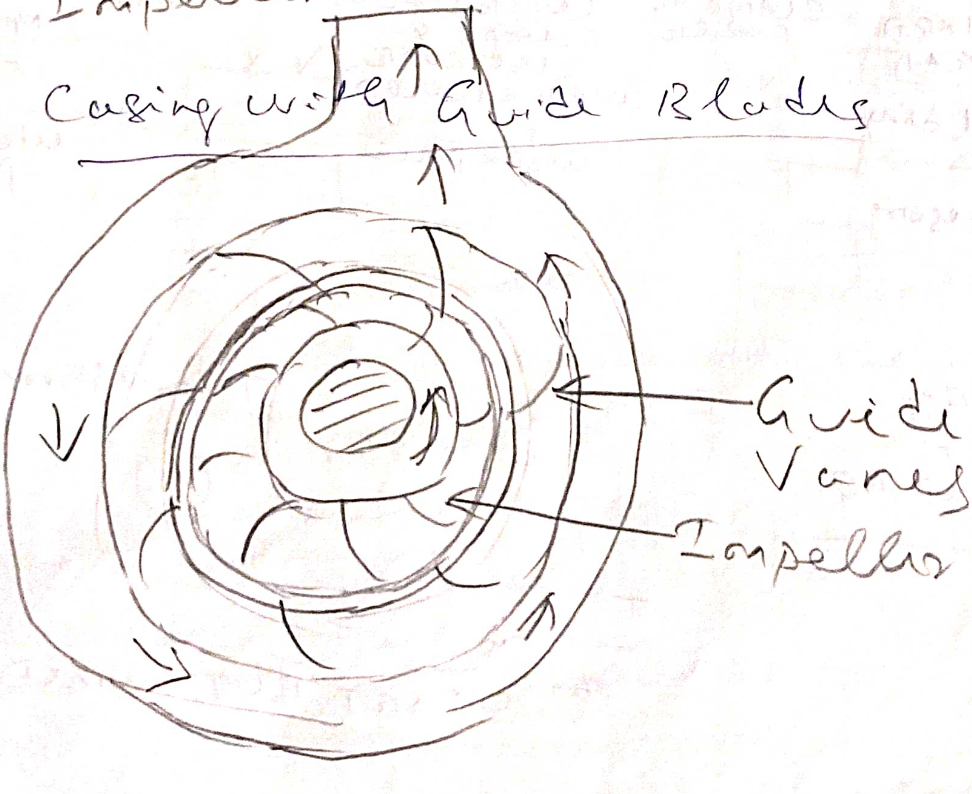
$$Q = AV$$

Eddies

(ii) Vortex casing



(iii) Casing with Guide Blades



3. Suction Pipe with Foot Valve & Strainer

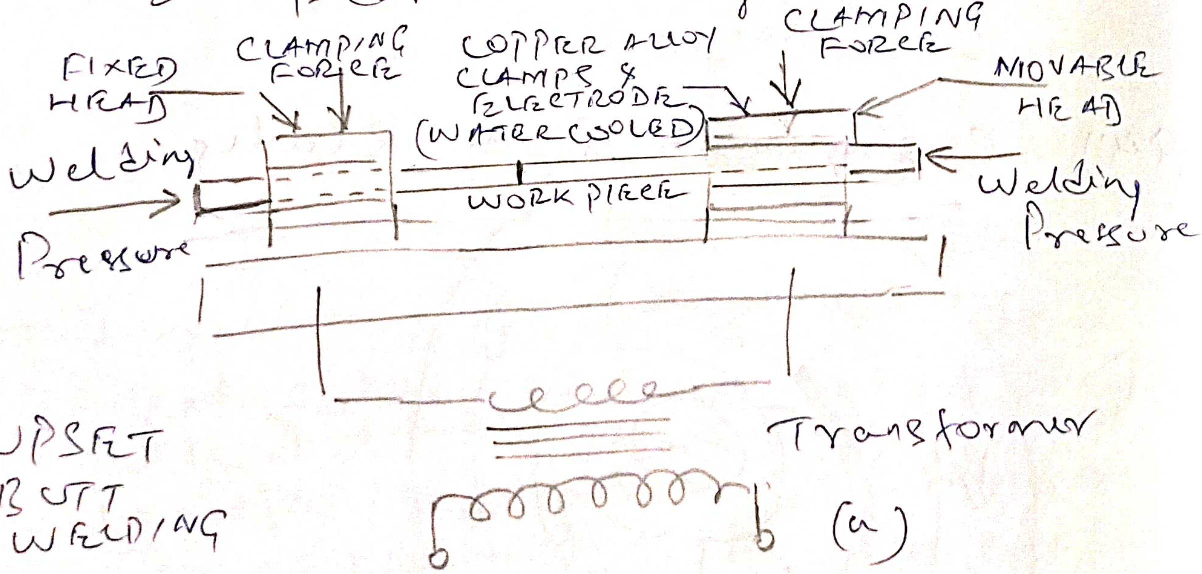
4. Delivery Pipe

08.02.2021
4-4.55 pm, Production Technology
3rd Diploma Mech.

Gatiram Chanda
Santosh Ku. Samal

Electric Resistance Butt Welding

There are 2 types of electric resistance butt welding
1. Upset Welding
2. Flash Welding

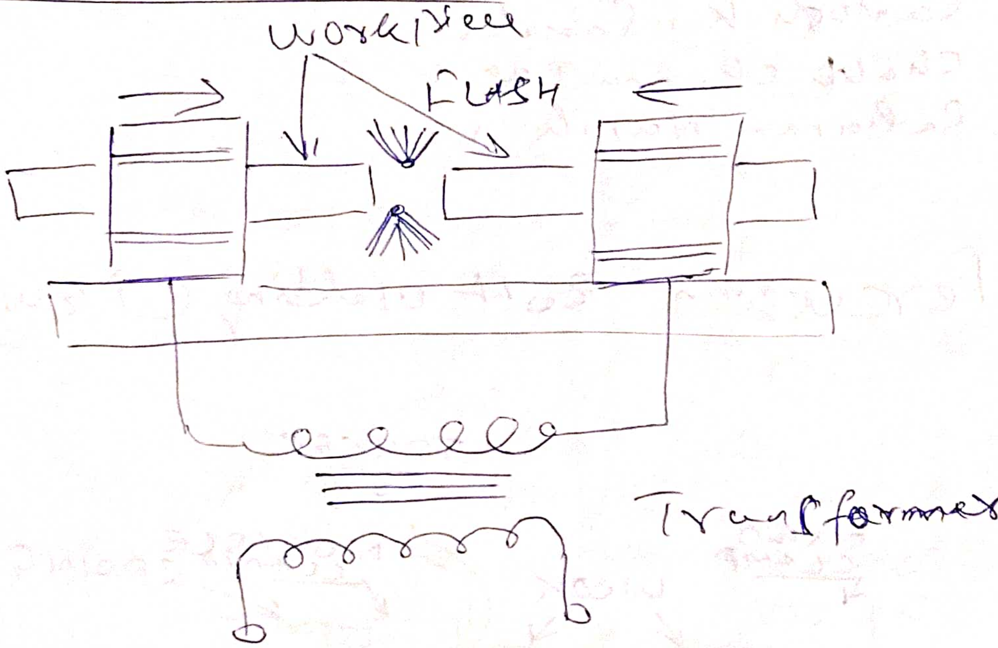


UPSET BUTT WELDING

(b) UPSET BUTT WELD

Contact Resistance $\propto \frac{1}{\text{Pressure}}$

Flash Butt Welding



(Resistance Flash Butt welding)

FLASH BUTT WELD

$$\eta_{man} \times \eta_m = \frac{g H_m}{V_{w_2} \times U_2} \times \frac{\frac{W}{g}\left(\frac{V_{w_2} U_2}{1000}\right)}{S.P}$$

$$= \frac{g H_m}{V_{w_2} U_2} \times \frac{W \times V_{w_2} U_2}{g \times 1000 \times S.P} = \frac{W \times H_m}{S.P \times 1000}$$

$$= \frac{\text{Wt. of water} \times \text{Manometric Head}}{\text{Shaft power}}$$

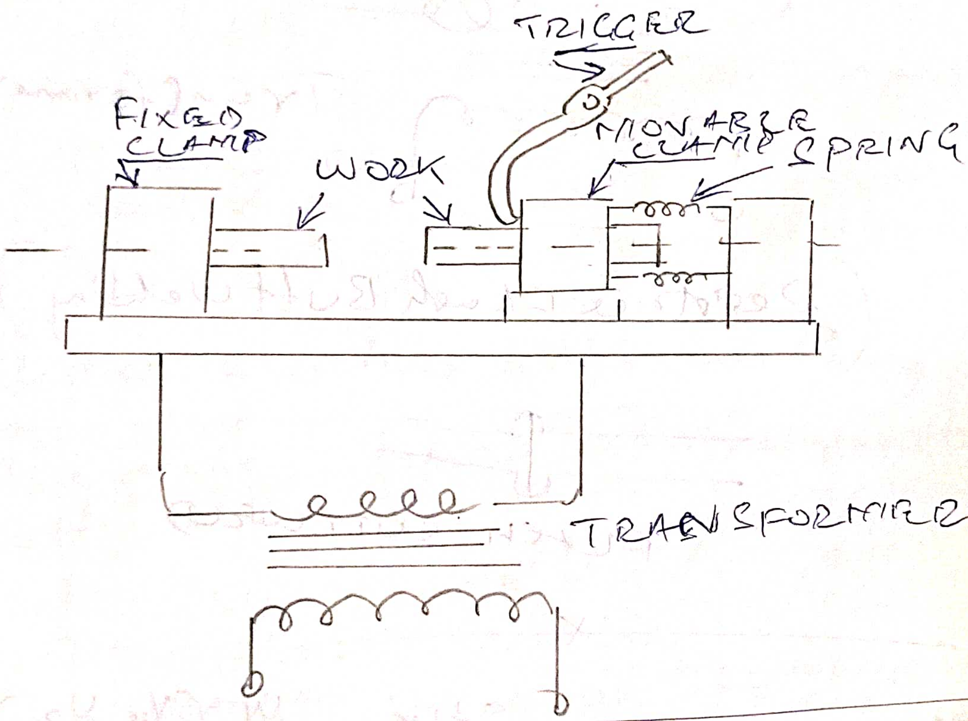
$$= \frac{\text{Output of pump}}{\text{Shaft Power}} = \eta_o$$

$$= \frac{\frac{W \times H_m}{1000}}{S.P} = \frac{\text{Power output by pump}}{\text{Shaft Power}} = \eta_o$$

09.02.2021, 2-2.55 Production Technology
3rd Dip Mech

Santosh Ku. Samal ✓
Bhakta Charana Das ✗
Balaram Nayak ✓

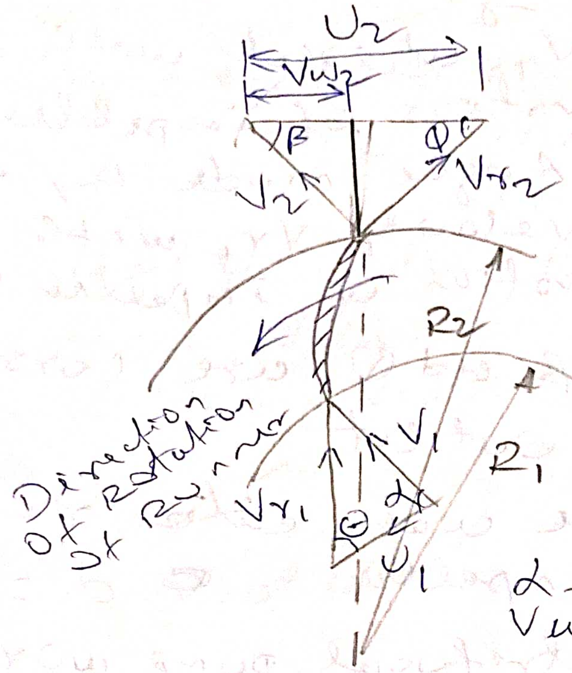
Percussion Butt Welding (PBW)



09.02.21, 3-3.55, F.M,HM, 3rd B.Tech
Mech / Civil

Tuni Nayak ✓
Jyotirmayee Mahalik ✓
Jyotirmayee Dehury ✓

Work done by centrifugal pump (or by impeller) on water



$\alpha = 90^\circ$
$V_{w_1} = 0$

Velocity triangle at inlet and Outlet

The water enters the impeller radially at inlet, which means the absolute velocity of water V_1 makes angle $(\alpha = 90^\circ)$ with tangential velocity U_1 of impeller, at inlet and $V_{w_1} = 0$

Let N = Speed of the impeller in rpm

D_1 = Diameter of impeller at inlet

U_1 = tangential velocity of impeller at inlet

$$= \frac{\pi D_1 N}{60}$$

U_2 = tangential velocity of impeller at outlet

$$= \frac{\pi D_2 N}{60}$$

V_1 = Absolute velocity of water at inlet

V_{r_1} = Relative velocity of water at inlet

α = Angle made by Abs. velocity V_1 at inlet with direction of motion of impeller U_1

θ = Angle made by relative velocity V_{r_1} with direction of motion of impeller U_1 at inlet

V_2, V_{r_2}, β and ϕ are corresponding values at outlet

As the water enters radially at inlet of impeller $\alpha = 90°$, $V_{w_1} = 0$

A centrifugal pump works on reverse of radially inward flow reaction turbine

For a inward flow reaction turbine the work done by water on runner per second per unit weight of water striking per second

$$= \frac{1}{g}\left[V_{w_1}U_1 - V_{w_2}U_2\right]$$

$\therefore$ work done by impeller of a centrifugal pump per unit wt. of water striking per second

$$= -\left[\text{Work done of turbine}\right]$$

$$= -\frac{1}{g}\left[V_{w_1}U_1 - V_{w_2}U_2\right]$$

$$= \frac{1}{g}\left[V_{w_2}U_2 - V_{w_1}U_1\right]$$

But $V_{w_1} = 0$ for centrifugal pump as the water enters radially

$\therefore$ work done by impeller per unit wt of of water striking per second

$= \frac{1}{g} V_{w_2} U_2$

Work done by impeller on water

$= \frac{W}{g} V_{w_2} U_2$, $\frac{W}{g}$ = Mass of water striking

W = ~~wt~~ weight of water = $\rho \times g \times Q$

Q = volume of water

Q = Area of flow × Velocity of flow

$= \pi D_1 B_1 V_{f_1} = \pi D_2 B_2 V_{f_2}$

B_1 & B_2 are width of impeller at inlet and outlet

V_{f_1} and V_{f_2} are velocity of flow at inlet and outlet

Deffinition of Heads and Efficiencies of a centrifugal pump

1. Suction Head ~~(ha)~~ (h_s) - It is the vertical height of the centre line of pump above the water surface in the tank or sump.
2. Delivery Head (h_d) - The vertical distance between the centre line of pump and the water surface of tank to which water to be delivered.
3. Static Head (H_s) - It is sum of ~~stat~~ suction head & delivery head

$$H_s = h_s + h_d$$

4. Manometric Head (H_m) - It is defined as the head against which the centrifugal pump has to work. It is expressed by following expressions

(a) H_m = Head imparted by impeller to the water — Loss of head in the pump

$= \frac{V_{w_2} U_2}{g}$ - Loss of head in the impeller & casing

$= \frac{V_{w_2} U_2}{g}$ if loss of head in pump is zero

(b) Hm = Total Head at the Outlet of the pump

− Total head at the inlet of the pump

$$\eta_{man} = \frac{g H_m}{V_{w_2} U_2} \times P$$

$$\eta_m = \frac{\frac{W}{g}\left(\frac{V_{w_2} U_2}{1000}\right)}{S.P}$$

$$\eta_{man} \times \eta_m = \frac{g H_m}{V_{w_2} U_2} \times \frac{W \times V_{w_2} U_2}{g \times S.P \times 1000}$$

$$= \frac{W H_m}{1000 \times SP} = \eta_o$$

10.02.2021, 1−1.55, F.M.H.M
3rd B-Tech, Mech / Civil

Tuni Nayak ✓
Jyotirmayee Mohallik ✓
~~Naresh~~ Nrusingha Nath Behera ✓
Dibya Ranjan Sethi ×

Manometric Head — It is defined as head against which a centrifugal pump has to work. It is denoted by 'Hm'. It can be expressed by 3 expression

~~(E)~~

(a) Hm = Head imparted by impeller to water − Loss of Head in the pump

$= \frac{1}{g}\left[V_{w_2} U_2\right]$ − Loss of head in impeller casing

$H_m = \frac{V_{w_2} U_2}{g}$ if there is no loss of head

(b) H_m = Total Head at the outlet of the pump − Total Head at inlet of the pump

$$= \left(\frac{P_o}{\rho g} + \frac{V_o^2}{2g} + Z_o\right) - \left(\frac{P_i}{\rho g} + \frac{V_i^2}{2g} + Z_i\right)$$

$\frac{P_o}{\rho g}$ = Pressure head at outlet of pump

$= h_d$

$\frac{V_o^2}{2g}$ = Kinetic head at outlet of pump

= Kinetic Head at delivery pipe

$= \frac{V_d^2}{2g}$

(V_d = Velocity of liquid in delivery pipe)

Z_o = Vertical height of outlet of pump from datum

$\frac{P_i}{\rho g}$ = Pressure head at inlet of pump

$= h_s$ = suction head

$\frac{V_i^2}{2g}$ = Kinetic head or velocity head at inlet of pump

$= \frac{V_s^2}{2g}$ = (V_s = Velocity of liquid in suction pipe)

$Z_i = Z_s$ = Vertical height of inlet of pump from datum

(c) $H_m = h_s + h_d + h_{fs} + h_{fd} + \frac{V_d^2}{2g}$

h_s = Suction head
h_d = delivery head
h_{fs} = frictional head loss in suction pipe
h_{fd} = frictional head loss in delivery pipe
V_d = velocity of liquid in delivery pipe

Efficiencies of Centrifugal Pump

The power is decreasing from the shaft of the pump to the impeller and then to water. The following are the important efficiencies of a centrifugal pump

(1) Manometric Efficiency η_{man}
(2) Mechanical Efficiency η_m
(3) Overall effiency η_o

(1) Manometric Efficiency — The ratio of the ~~man~~ manometric head to the head imparted by impeller to the water. Mathematically it can be expressed as

$$\eta_{man} = \frac{\text{Manometric Head}}{\text{Head imparted by impeller to water}}$$

$$= \frac{H_m}{\left(\frac{V_{w_2} U_2}{g}\right)} = \frac{g H_m}{V_{w_2} U_2}$$

Also the same result we can find by following

The power to water at outlet

$= \frac{W H_m}{100}$,

W = Weight of water ~~striking~~ discharge

H_m = Manometric Head

Power at the impeller $= \frac{W}{g} \times \frac{V_{w2} \times U_2}{1000}$ kW

$$\eta_{man} = \frac{\frac{W H_m}{1000}}{\left(\frac{W}{g} \times \frac{V_{w2} U_2}{1000}\right)}$$

$$= \frac{W H_m}{1000} \times \frac{1000 \times g}{W \times V_{w2} U_2} = \frac{g H_m}{V_{w2} U_2}$$

$$\eta_{man} = \frac{g H_m}{V_{w2} U_2}$$

(2) Mechanical Efficiency –

The ratio of the power available at the impeller to the power at the shaft of the pump is known as mechanical efficiency

$$\eta_M = \frac{\text{Power at the impeller}}{\text{Power at the shaft}}$$

Power at the impeller = work done by impeller per second

$$= \frac{W}{g} \frac{V_{w2} U_2}{1000} \text{ K.W}$$

$$\eta_M = \frac{\frac{W}{g} \frac{[V_{w2} U_2]}{1000}}{S.P}$$

S.P = Shaft power

(3) Overall efficiency (η_o)

It is defined as the ratio of power output of the pump to the power input of the pump

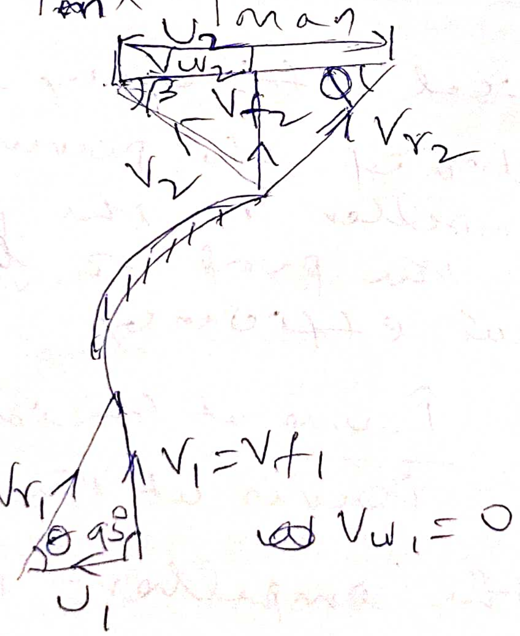
Power output $= \dfrac{\text{wt. of water lifted} \times H_m}{1000}$ k.w

$= \dfrac{W \times H_m}{1000}$

Power Input to the pump
= Power supplied by electric motor
= S.P (shaft power)

$\eta_o = \dfrac{\frac{W H_m}{1000}}{S.P}$

$\eta_o = \eta_{man} \times \eta_{man}$



Datas given
Internal diameter of impeller $D_1 = 200$ mm $= 0.2$ m
External diameter of impeller $D_2 = 400$ mm $= 0.4$ m

Impeller speed $N = 1200$ rpm
Vane angle at inlet $\theta = 20°$
Vane angle at outlet $\phi = 30°$
Water enters radially at inlet
$\alpha = 90°$, $V_{f_1} = V_1$

$V_{f1} = V_{f2}$

Tangential velocity $U_1 = \frac{\pi D_1 N}{60}$

$= \frac{\pi \times 0.2 \times 1200}{60} = 12.56$ m/sec

$U_2 = \frac{\pi \times 0.4 \times 1200}{60} = 25.13$ m/sec

① From inlet velocity Δ

$\tan\theta = \frac{V_{f1}}{U_1}$, $V_{f1} = U_1 \tan\theta$

$V_{f1} = 12.56 \times \tan 20 = 4.57$ m/sec

$V_{f2} = V_{f1} = 4.57$ m/sec

From outlet velocity Δ

$\tan\phi = \frac{V_{f2}}{U_2 - V_{w2}} = \frac{4.57}{25.13 - V_{w2}}$

$25.13 - V_{w2} = \frac{4.57}{\tan 30^\circ} = 7.915$ m/sec

$V_{w2} = 25.13 - 7.915 = 17.215$ m/sec

Work done per unit weight of water $= \frac{V_{w2} U_2}{g} = \frac{17.215 \times 25.13}{9.81}$

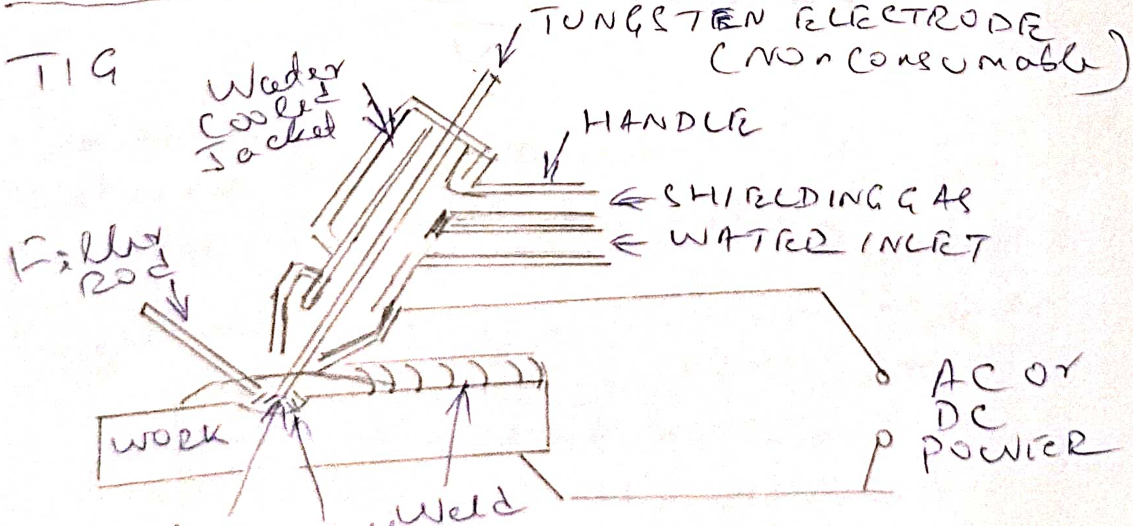
$= 44.099 \ \frac{Nm}{N}$

10·02·2021, 3-3·55 Production Technology
3rd Dip. Mech.

Balaram Nayak
Santosh Ku. Samal

Percussion Butt welding

TIG



(TIG WELDING)

GTAW Tung

10000 K

12.02.2021, 1-1.55 F.M.H.M, 3rd B.Tech

Mech/Civil

Dibya Ranjan Sethi ✗
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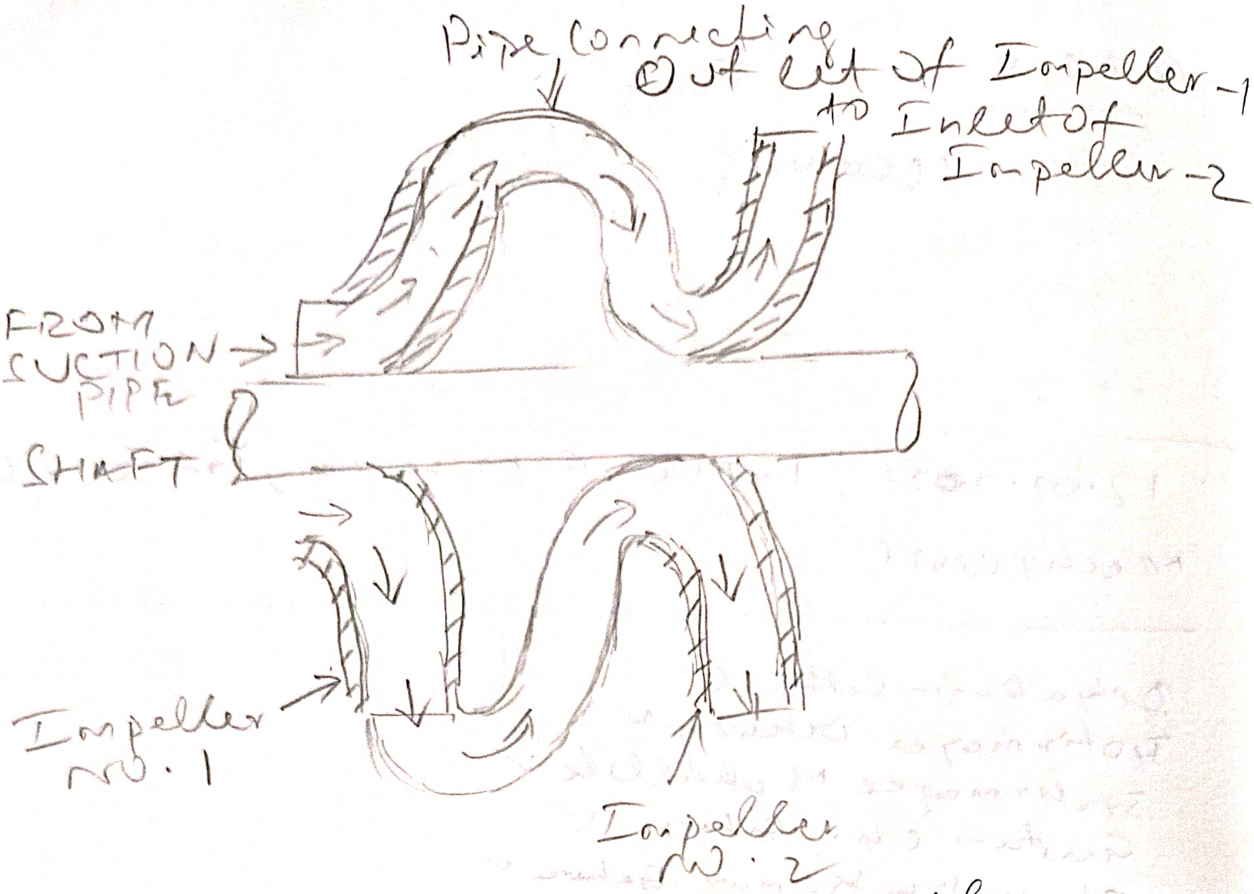
Jyotirmayee Mohallik ✓
Gautam Ch. Behera ✓
Bhupendra Kumar Behera ✓
Nrusingha Nath Behera ✓
Tuni Nayak ✗

Multistage Centrifugal Pump

If a centrifugal pump has two or more impellers, it is called multistage centrifugal pump. The function of Multistage Pump are

1. To produce high head
2. To discharge a large quantity of liquid

If a high head is to be developed, the impellers are connected in series. (On the same shaft). If the discharge is to be be increased then the impellers are connected in parallel



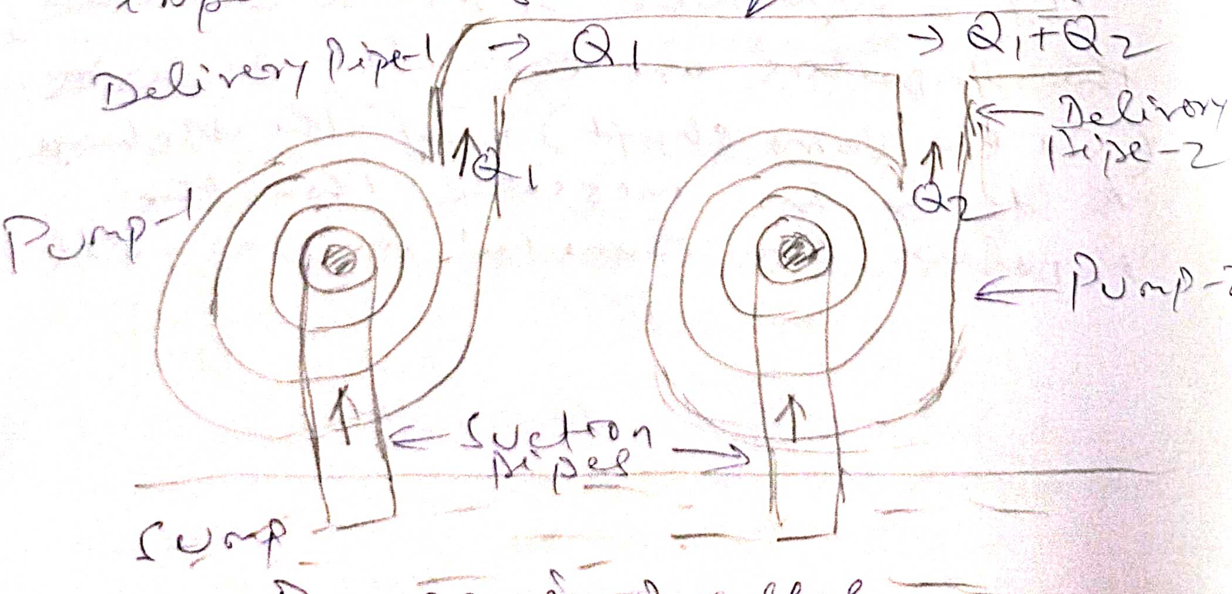
Two stage pump with impellers in series

Let n = Number of indentical impellers mounted on the same shaft

H_m = Head developed by each impeller

Total Head developed = $n \times H_m$

The discharge passing through each impeller is same.



Pumps in parallel

If n = Number of indentical pumps arranged in parallel

Q = Discharge from one pump

Total discharge = $n \times Q$

12-02-2021, 3-3.55 Production Tech

3, 1 Mech Diploma

NO STUDENT

Chiranjib Pradhan - Joined ~~approved~~ at 3.20 and left 3.35

Inert gas welding are generally of 2 types (1) Gas Tungsten Arc welding (GTAW) or also called ~~Tug~~ Tungsten Inert Gas welding (TIG)

(2) Gas Metal Arc welding (GMAW) Also its called metal inert gas welding (MIG)

(TIG)

13.02.2021, 2-2:55, F.M.H.M
3rd B.Tech Mech/Civil

Sourabh Ku. Dash, Jyotirmayee Mahakud
Tuni Nayak
Jyotirmayee Dehury
Nrusingha Nath Behera

Datas given No. of stages = 3
Dia of impeller at outlet $D_2 = 40$ cm $= 0.4$ m
width of impeller at outlet $B_2 = 2$ cm $= 0.02$ m
Vane angle at outlet $\phi = 45^\circ$
Reduction in area at outlet = 10% = 0.1
Area of flow $= 0.9 \times \pi \times D_2 \times B_2$
$= 0.9 \times \pi \times 0.4 \times 0.02$
$= 0.022619$ m^2 = 0.02262
Manometric Efficiency
$\eta_{man} = 90\% = 0.90$
Overall efficiency $\eta_o = 80\% = 0.8$
Speed = 1000 rpm

Discharge $Q = 50$ litrs/sec $= \frac{50}{1000} m^3$

$= 0.05\ m^3/sec$

Required (i) Head Generated by the pump

(ii) Shaft power

Velocity of flow at outlet

$$V_{f_2} = \frac{\text{Discharge}}{\text{Area}} = \frac{0.05}{0.02262}$$

$= 2.21\ m/sec$

Tangential velocity at outlet

$$U_2 = \frac{\pi D_2 N}{60} = \frac{\pi \times 0.4 \times 1000}{60}$$

$= 20.94\ m/sec$

From outlet velocity Δ

$$\tan \phi = \frac{V_{f_2}}{U_2 - V_{w_2}} =$$

$$\tan 45^\circ = \frac{2.21}{20.94 - V_{w_2}}$$

Or $20.94 - V_{w_2} = \frac{2.21}{\tan 45} = 2.21$

or $V_{w_2} = 20.94 - 2.21 = 18.73\ m/sec$

$$\eta_{man} = \frac{g H_m}{V_{w_2} U_2}$$

$$0.9 = \frac{9.81 \times H_m}{18.73 \times 20.94}$$

or $H_m = \frac{0.9 \times 18.73 \times 20.94}{9.81}$

$= 35.98$ mtr

It is a three stage pump

$\therefore$ Total Head $= 3 \times 35.98$

$= 107.94\ m$

Output of the pump

$$= \frac{\text{Wt. of water lifted} \times H_m}{1000} \text{ KW}$$

$$= \frac{\rho g \times Q \times 107.94}{1000}$$

$$= \frac{1000 \times 9.81 \times 0.05 \times 107.94}{1000}$$

$= 52.94457$ K.W

Overall efficiency

$$= \frac{\text{Output of Pump}}{\text{Input of pump}}$$

$$\eta_o = \frac{52.94}{\text{Shaft power}}$$

$$0.8 = \frac{52.94}{S.P}$$

or $S.P = \frac{52.94}{0.8} = 66.175$ KW

15.02.2021, 2-2.35, F-M HM

3rd B.Tech Mech / Civil

Dibya Ranjan Sethi ✓

Nrusingha Nath Behera ✓

Bhupendra Ku. Behera ✓

(2.35) Ritesh Kumar Barik ✓

Minimum Speed for Starting a centrifugal pump

If the pressure rise in the centrifugal pump is more than or equal to the manometric head (H_m), the pump will start delivering water. Otherwise there will be no discharge of water although the impeller may be rotating. The centrifugal pump works on the principle of forced vortex. In the forced vortex principle the rise in pressure head

is given as
$$= \frac{\omega^2 r_2^2}{2g} - \frac{\omega^2 r_1^2}{2g} \quad ---(1)$$

ω = Angular Speed of impeller

r_1 and r_2 are radius of impeller at inlet & outlet

$\omega r_1 = U_1$ & $\omega r_2 = U_2$

U_1 and U_2 are tangential velocity of impeller at inlet and outlet

$\therefore$ Head due to pressure rise in impeller
$$= \frac{U_2^2}{2g} - \frac{U_1^2}{2g}$$

The flow of water will commence if, the head due to pressure rise $\geq H_m$

(H_m = Manometric Head)

$$\frac{U_2^2}{2g} - \frac{U_1^2}{2g} \geq H_m$$

or Atleast the water will rise

if $$\frac{U_2^2}{2g} - \frac{U_1^2}{2g} = H_m \quad ---(2)$$

But we know that the manometric efficiency $\eta_{man} = \frac{g H_m}{V_{w_2} U_2}$

H_m = Manometric Head

V_{w_2} = velocity of whirl at outlet

U_2 = Tangential velocity of impeller at outlet

$$H_m = \frac{\eta_{man} \times V_{w_2} U_2}{g}$$

$$\frac{U_2^2}{2g} - \frac{U_1^2}{2g} = \eta_{man} \times \frac{V_{w_2} U_2}{g}$$

$$U_1 = \frac{\pi D_1 N}{60}, \quad U_2 = \frac{\pi D_2 N}{60}$$

D_1 and D_2 = Diameter of impeller at inlet & outlet

$$\frac{1}{2g}\left[\frac{\pi D_2 N}{60}\right]^2 - \frac{1}{2g}\left[\frac{\pi D_1 N}{60}\right]^2 = \eta_{man} \times \frac{V_{w_2} \pi D_2 N}{g \times 60}$$

Divide both sides by $\left(\frac{\pi N}{g \times 60}\right)$

$$\frac{1}{2g}\left(\frac{\pi D_2 N}{60}\right)^2 \times \frac{g \times 60}{\pi N} - \frac{1}{2g}\left(\frac{\pi D_1 N}{60}\right)^2 \times \frac{g \times 60}{\pi N}$$

$$= \eta_{man} \frac{V_{w_2} \times \pi D_2 N}{g \times 60} \times \frac{g \times 60}{\pi N}$$

or $$\frac{1}{2} \times \frac{\pi D_2^2 N}{60} - \frac{1}{2} \times \frac{\pi D_1^2 N}{60} = \eta_{man} \times V_{w_2} \times D_2$$

or $$\frac{\pi N}{120}\left[D_2^2 - D_1^2\right] = \eta_{man} \times V_{w_2} \times D_2$$

$$\boxed{N = \frac{120 \times \eta_{man} \times V_{w_2} \times D_2}{\pi (D_2^2 - D_1^2)}}$$

This is minimum starting speed of a centrifugal pump

Specific Speed of a Centrifugal Pump

It is define as the speed of a geometrically similar pump which would deliver one cubic meter of liquid per second against a head of one meter. It is donoted by " N_s "

Derivation of Specific Speed of Centrifugal pump

Let discharge = Q

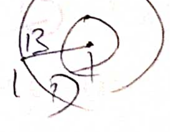
Q = Area of flow × velocity of flow

$Q = \pi \times D \times B \times V_f$ ---- (I)

D = Dia of impeller
B = width of impeller
V_f = velocity of flow

or $Q \propto D \times B \times V_f$

$B \propto D$



$\therefore Q \propto D \times D \times V_f$

$Q \propto D^2 V_f$ ---- (II)

$U = \frac{\pi D N}{60}$, ---- (III)

Hence $U \propto DN$

Relation between U, V_f and Head (H_m)

$U \propto V_f \propto \sqrt{H_m}$ ---- (IV)

$\sqrt{H_m} \propto DN$ from eqn (III) & (IV) or $D \propto \frac{\sqrt{H_m}}{N}$

Putting the value of D ~~from~~ in eqn. (II)

$$Q \propto \left(\frac{\sqrt{H_m}}{N}\right)^2 \times V_f$$

$$Q \propto \frac{H_m}{N^2} \times V_f$$

$$\propto \frac{H_m}{N^2} \times \sqrt{H_m} \quad (\text{as } V_f \propto \sqrt{H_m} \text{ eqn IV})$$

$$\therefore Q \propto \frac{H_m^{\frac{3}{2}}}{N^2}$$

or $Q = K \frac{H_m^{\frac{3}{2}}}{N^2}$, K = const. of proportionality

If $Q = 1$, $H_m = 1$, then $N = N_s$

$$\therefore 1 = K \frac{1^{\frac{3}{2}}}{N_s^2}, \text{ or } N = N_s^2$$

$$Q = N_s^2 \frac{H_m^{\frac{3}{2}}}{N^2}$$

$$\text{or } N_s^2 = \frac{Q \times N^2}{H_m^{\frac{3}{2}}}$$

$$\text{or } N_s = \frac{N\sqrt{Q}}{H^{\frac{3}{4}}}$$

Specific Speed

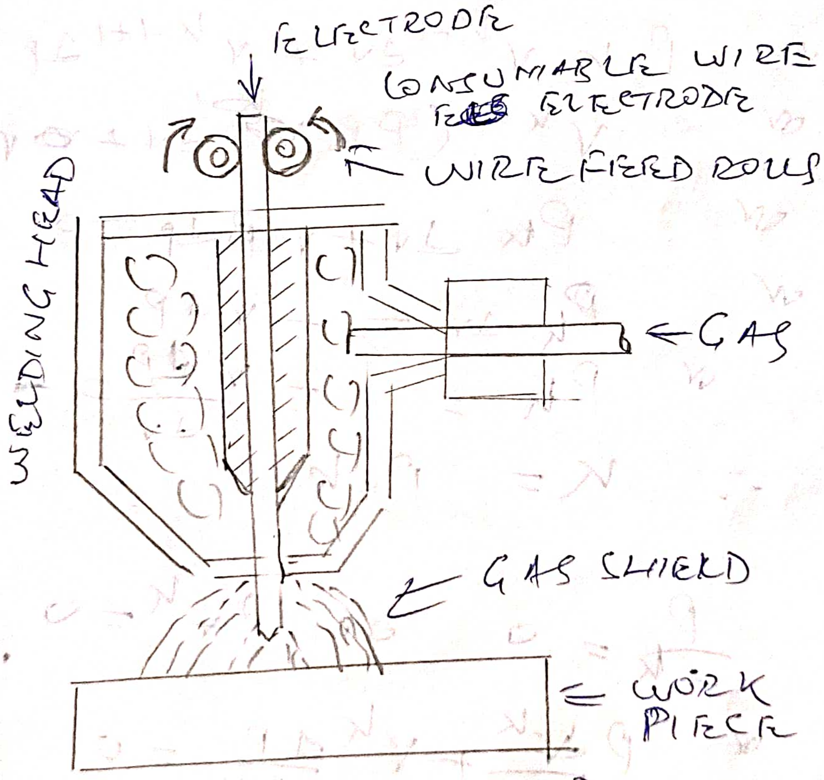
15.02.2021, 4-4.55 Production Technology
3rd Diploma, Mech.

Santosh ~~[illegible]~~ Ku. Samal.

(1) Gas Tungsten Arc Welding (GTAW)
Tungsten Inert Gas Welding (TIG)

Gas Metal Arc Welding (GMAW)
or
Metal Inert Gas Welding (MIG)

TIG



(MIG WELDING)

$$\frac{p}{\rho^k} = \text{constant}$$

or $p v^k = \text{constant}$

or $p \frac{d v^k}{d v^k} + v^k \frac{dp}{v^k}$

or $p v^k + v^k dp = 0$

or $p v^{k-1+1}$

or $$p \frac{dv^k}{dv} + v^k \frac{dp}{dv} = 0$$

or $$p\, k\, v^{k-1} + v^k \frac{dp}{dv} = 0$$

or $p k v^{k-1} \times dv + v^k dp = 0$

or $p.k\, v^{k-1} dv + v^{k-1+1} dp = 0$

or $v^{k-1} (p k\, dv + v\, dp) = 0$

or $p_k\, dv + v\, dp = 0$

or $p_k\, dv = -v\, dp$

or $$p_k = -\frac{v\, dp}{dv} = K$$

$\therefore K = p \times k$

$$\frac{p}{\rho^k} = 0 \quad \text{or} \quad p v^k = 0$$

or $$p \frac{dv^k}{dv} + v^k \frac{dp}{dv} = 0$$

or $$p.k\, v^{k-1} + v^k \frac{dp}{dv} = 0$$

or $$p_k v^{k-1} + v^k \frac{dp}{dv} = 0$$

or $p_k v^{k-1} dv + v^k dp = 0$

or $p_k v^{k-1} dv + v^{k-1+1} dp = 0$

or $p_k\, dv + v\, dp = 0$

or $$p_k = -\frac{v\, dp}{dv}$$

$$P_K = -V\frac{dP}{dV} = K$$

$$\therefore \quad P_K = K$$

IPR Webinar 26.03.21

Capital Engg. College

P. K. Gupta, Jt. Director MSME

~~Sato~~ Santosh Ku. Sahu – MSME Cuttack

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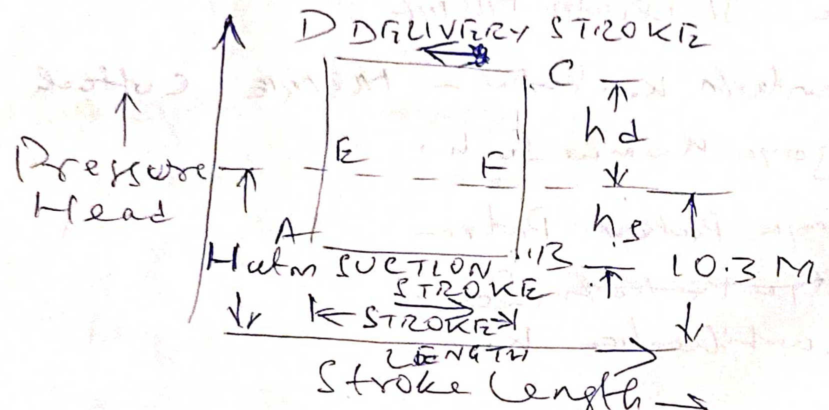
18.01.22, 8.30-9.20, HMIFP, 5th Diploma

Badal Kumar Barik
Shoban Kumar Nayak

Indicator Diagram, Reciprocating Pump



(Ideal Indicator Diagram)

Ideal Indicator Diagram

Let H_{atm} = Atmospheric pressure head
= 10.3 mtr of water.
L = Length of stroke.
h_s = Suction Head
h_d = Delivery Head

we know that the work done by the pump per second = $\frac{\rho g ALN}{60} \times (h_s + h_d)$

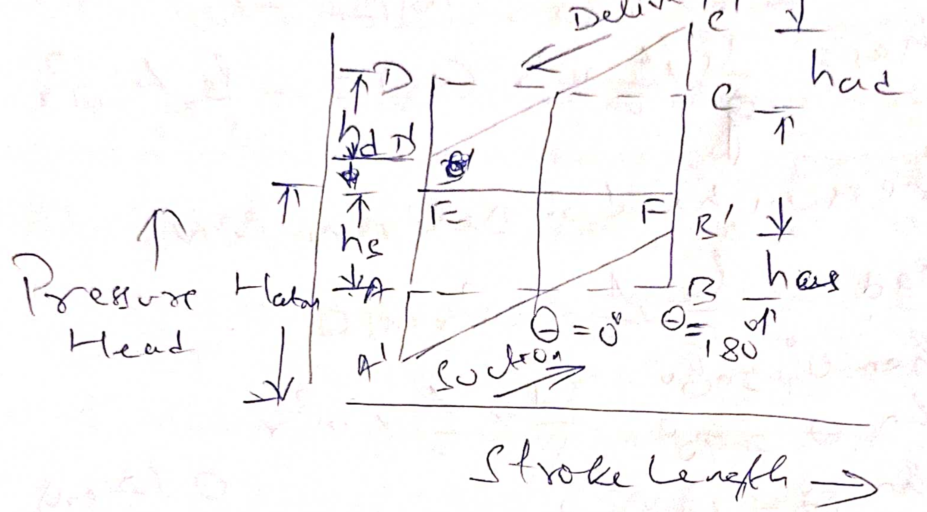
= $K \times L(h_s + h_d)$ where $K = \frac{\rho g AN}{60}$ = constant

∴ work done $\propto L \times (h_s + h_d)$

= $AB \times (BF + FC) = L \times (h_s + h_d)$

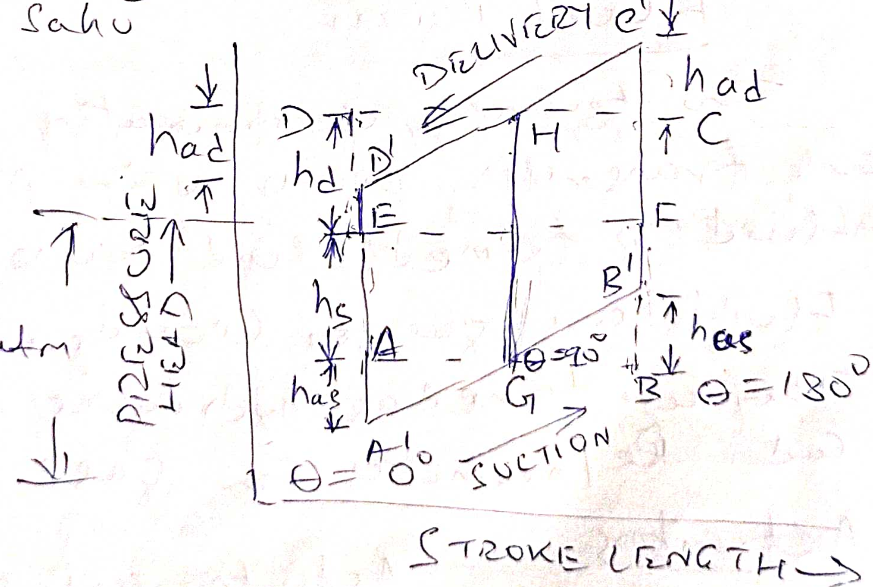
Hence work done by the pump
= Area of the indicator diagram

Effect of Acceleration in Suction and Delivery Pipe on Indicator Diagram



19.01.22, 11:30 - 12:20 PM HMIFP, 5th Diploma Mech.

Chaturbhuja Choudhury
Hitesh Sahu



Effect of Acceleration on Indicator Diagram

$h_{as} = \frac{l_s}{g} \frac{A}{a} \omega^2 r \cos\theta$ pressure head due to acceleration in suction pipe when $\theta = 0°$, $\cos\theta = 1$

$h_{as} = \frac{l_s}{g} \times \frac{A}{a} \omega^2 r$ Positive

when $\theta = 90°$ $\cos 90 = 0$

$h_{as} = \frac{l_s}{g} \frac{A}{a} \omega^2 r \times 0 = 0$, Zero

when $\theta = 180°$, $\cos\theta = -1$

$h_{as} = \frac{l_s}{g} \times \frac{A}{a} \omega^2 r (-1) = -\frac{l_s}{g} \times \frac{A}{a} \omega^2 r$, Negative

Pressure head in Delivery pipe

$h_{ad} = \frac{l_d}{g} \times \frac{A}{a} \times \omega^2 r \cos\theta$

when $\theta = 0°$ $= \frac{l_d}{g} \times \frac{A}{a} \times \omega^2 r$

when $\theta = 90°$ $= 0$ (Zero)

when $\theta = 180°$ $h_{ad} = \left(-\frac{l_d}{g} \times \frac{A}{a} \times \omega^2 r\right)$ Negative

Fluid Power

The technology of generating, controlling and transmitting power using pressurized fluid is termed Fluid power.

Fluids are gas or liquids.

They are termed as hydraulics for liquid and Pneumatics for gas.

Actuators - Actuator are devices which converts hydraulic energy to mechanical energy.

21.01.22, 11.30-12.20 PM AM, HMIFP, 5th Sem

Diploma

Hitesh Sahu

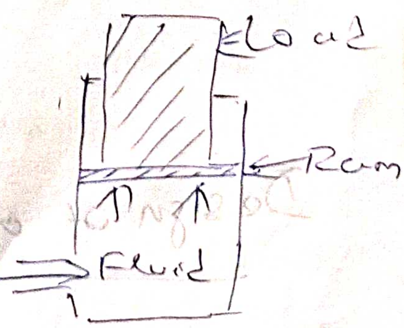
The Actuators: The actuators are devices which convert hydraulic energy into mechanical energy. The high pressurized fluids (oil or air) when passed through the actuators, converts the fluid energy into linear or rotary motion. when it converts energy to reciprocating motion they are termed as Cylinders and when they rotate and produce torque they are termed as motors.

Cylinders

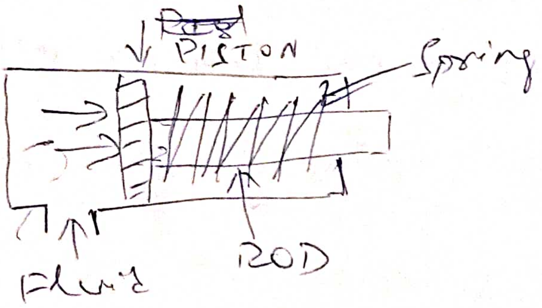
- These are linear actuators
- Output motion is straight line
- The hydraulic power is converted to linear mechanical power
- They are used basically for pushing pulling, tilting and pressing.

Types of Cylinders

1. Ram



2. Single Acting Cylinder



Single Acting Cylinder

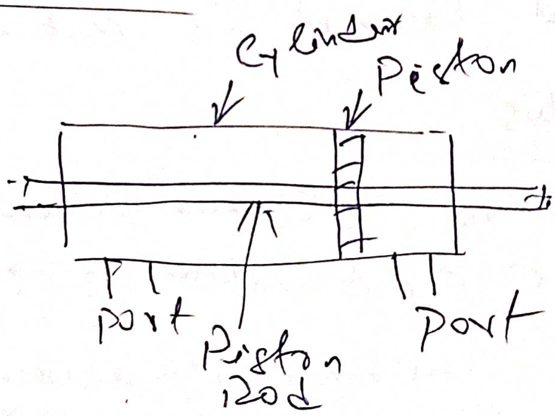
Double Acting Cylinder

21.01.2022, 10.30–11.20 HMIFP, 5th Sep. Mech

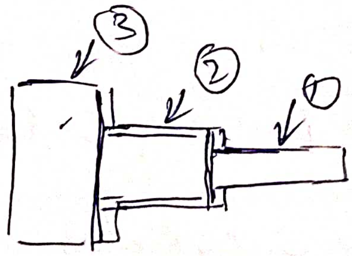
Hitesh Ku. Sahu

Double Rod Cylinder

Non differential Cylinder



Telescopic Cylinder



~~Telsto~~ Telescopic Cylinder (Three Cylinders)

Design of a Double Acting Actuator

Motors

These are rotary actuators

Torque = Force x Radius

Pressure control

The primary concern in a hydraulic system ~~as~~ is either
(i) Controlling the rate of flow
or (ii) controlling the ~~p~~ pressure level

(1) Relief valve (2) Unloading Valve
(3) Sequence valve. (4) Reducing valve
(5) Counter balance valve
(6) Brake valve

24.01.22, 10.30 - 11.20, HMIFP, 5th Diploma

No student joined till 10.45

25.01.22, 8.30 - 9.20 HMIFP, 5th Diploma

Rajesh Swain - left at 9.02 AM

Pressure control

(1) controlling the rate of flow or
(2) controlling the pressure level
Devices used to control the level of pressure
1. Relief Valve, (2) Unloading Valve

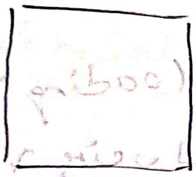
(3) ~~Set~~ Sequence Valve

(4) Reducing valve

(5) Counterbalance Valve

(6) Brake valve

The symbols specified by ANSI.
These symbols resembles each other and only their position in the circuit differentiate their functionality



~~Deleteve~~ Relife Valves

28.01.22, 10.30-11.20, HMIFP, 5th Dip. Mech