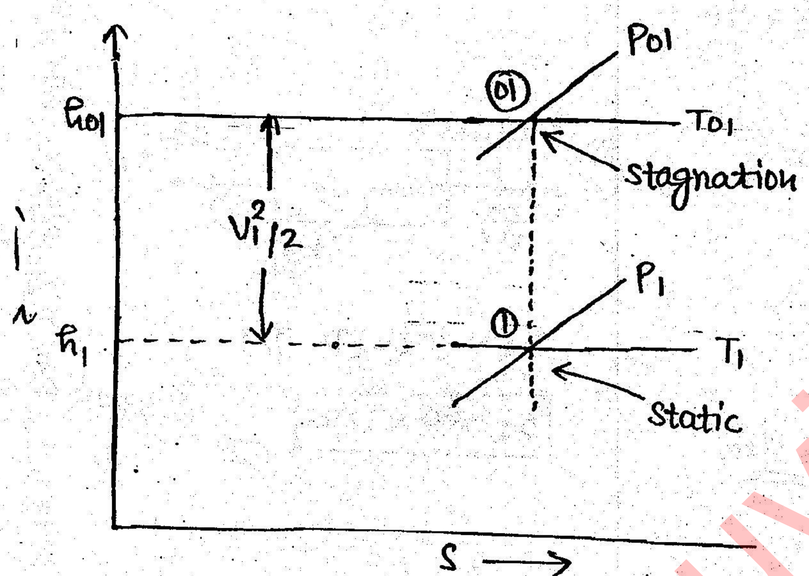
DYNAMIC COMPRESSOR :-

Stagnation state :-

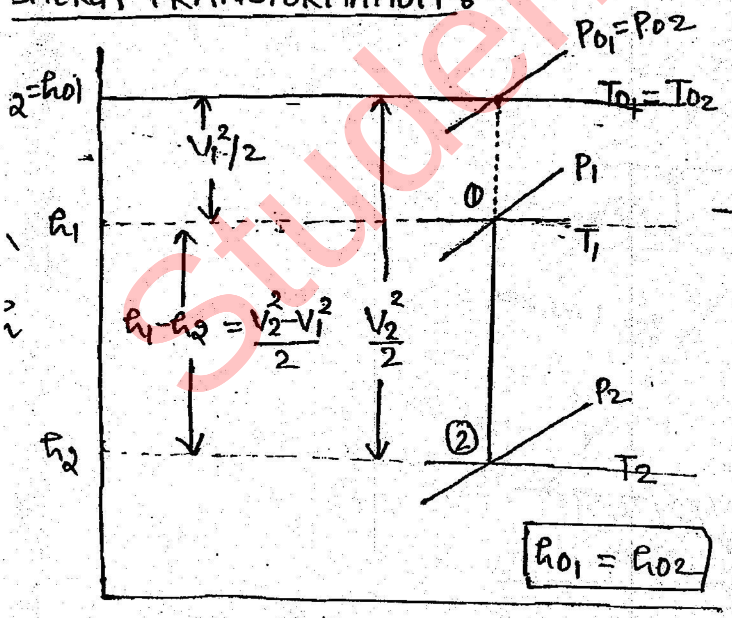


$$h_1 + \frac{V_1^2}{2} = 0 + h_{01}$$

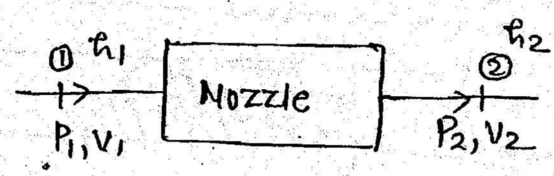
$$\boxed{h_{01} = h_1 + \frac{V_1^2}{2}}$$

The state of a fluid obtained when it is isentropically deaccelerated to zero velocity state is reffered as stagnation state.

ENERGY TRANSFORMATION :-



$V_2 >>> V_1$



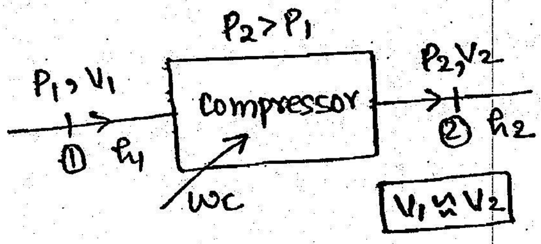
BY SFEE ① & ②

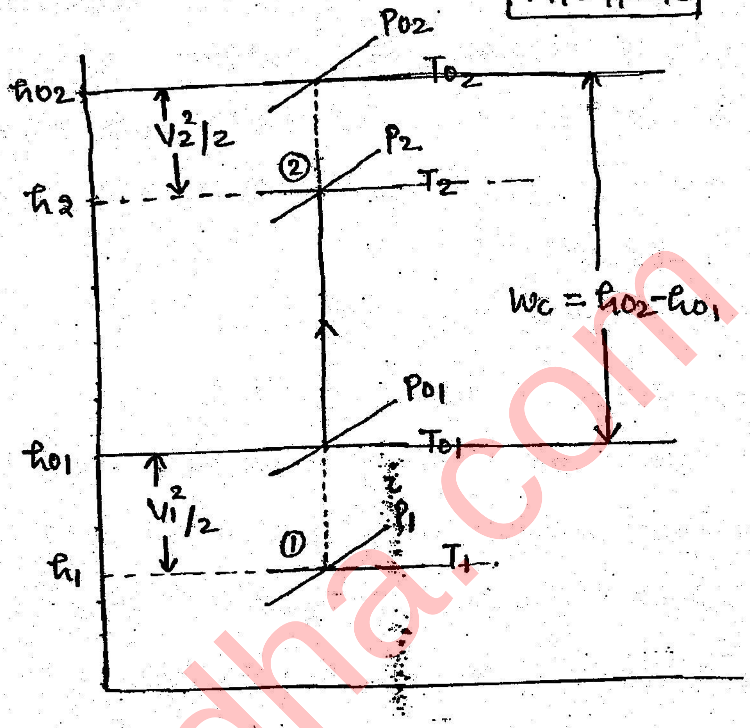
$$h_1 + \frac{V_1^2}{2} = h_2 + \frac{V_2^2}{2}$$

$$\boxed{h_1 - h_2 = \frac{V_2^2 - V_1^2}{2}}$$

ENERGY TRANSFER :-

LECTURE-5
17/09/2016





By SFEE

$$h_1 + \frac{V_1^2}{2} = h_2 + \frac{V_2^2}{2} - W_c$$

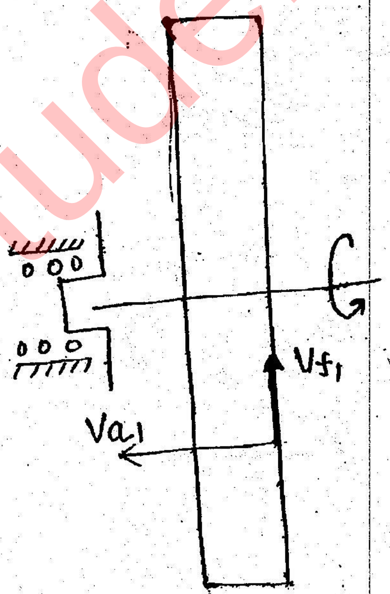
$$h_{01} = h_{02} - W_c$$

$$\boxed{h_{01} + W_c = h_{02}}$$

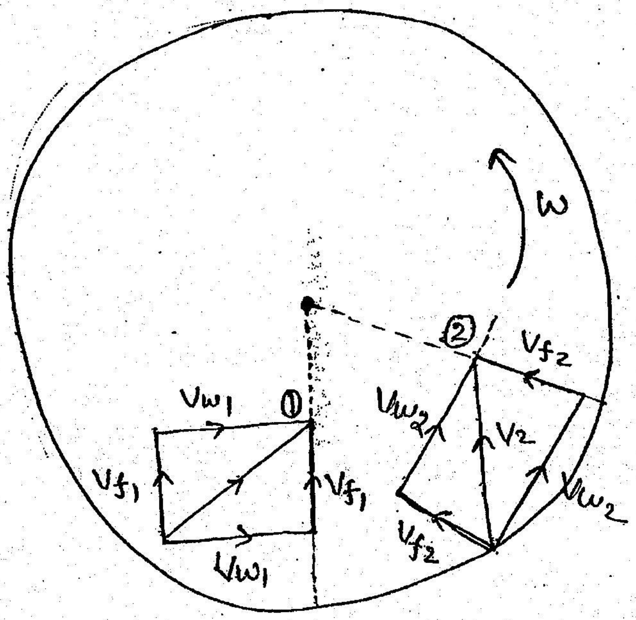
* For turbine ① above and ② below.

• Stagnation state work as a reference point to denote the total energy of fluid at any point. In energy transformation process stagnation enthalpy always remain constant but for energy transfer it increases for compressor and decreases for turbine.

PRINCIPLE OF ROTATING MACHINE :-



(Side view)



V_{a_1} = axial component of velocity.

let fluid enter and exit a rotor at section ① and ② at radius r_1 and r_2 repeetively under equalibrium condition when the rotor is rotating with constant angular velocity ω then absolute velocity at inlet and outlet are resolved into two component V_w (whirl or tangential component) and V_f (flow or radial component).

Rotor speed at Inlet, $u_1 = \omega r_1$

Rotor speed at outlet, $u_2 = \omega r_2$

Torque = Rate of change of angular momentum.

Angular momentum at inlet $= \dot{m} V_{w_1} \cdot r_1$

Angular momentum at outlet $= \dot{m} V_{w_2} \cdot r_2$

Torque $T = \dot{m}\,(V_{w_2} \cdot r_2 - V_{w_1} \cdot r_1)$

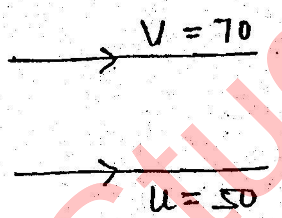
power $= T \cdot \omega = \dot{m}\,(V_{w_2} r_2 - V_{w_1} \cdot r_1)\omega$

$$\boxed{\text{Power} = \dot{m}\,(V_{w_2} u_2 - V_{w_1} \cdot u_1)} \leftarrow \text{Euler's Energy Equation}$$

$V_{w_1} u_1 > V_{w_2} u_2 \rightarrow$ Turbine

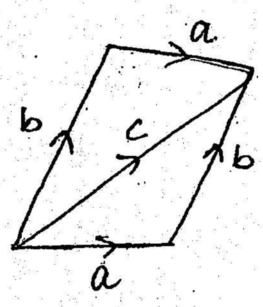
$V_{w_2} u_2 > V_{w_1} u_1 \longrightarrow$ compressor or pump.

VELOCITY DIAGRAM



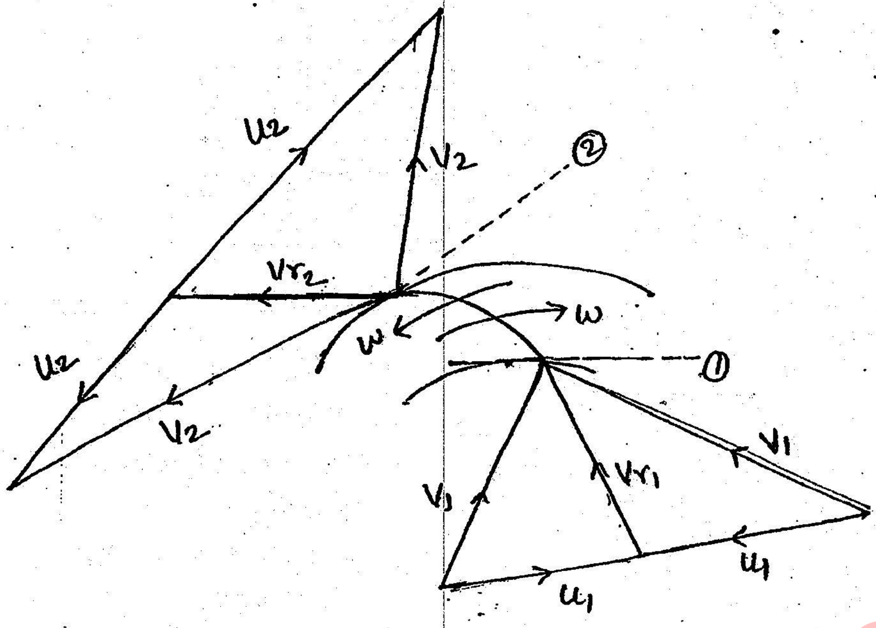
$$\boxed{\vec{a} + \vec{b} = \vec{c}}$$

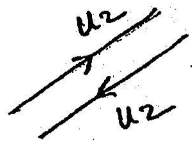
$$\boxed{\vec{b} + \vec{a} = \vec{c}} \text{ OR}$$



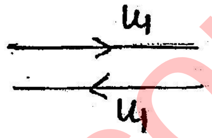
$$\boxed{\vec{V_r} = \vec{V} - \vec{u}}$$

$$\boxed{\vec{V} = \vec{V_r} + \vec{u}} \text{ OR } \boxed{\vec{V} = \vec{u} + \vec{V_r}}$$

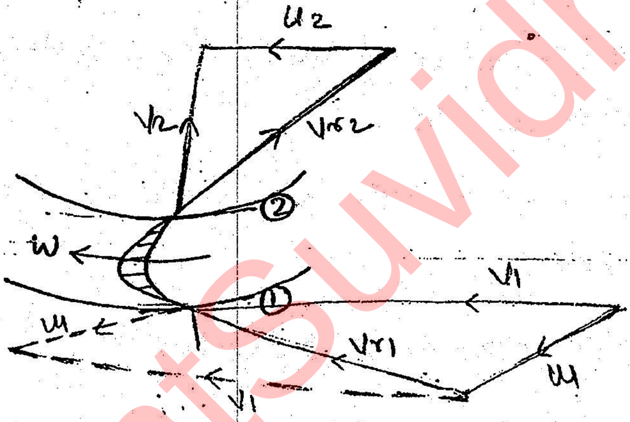


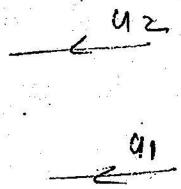


$$\boxed{\vec{u_1} + \vec{V_{r_1}} = \vec{V_1}}$$

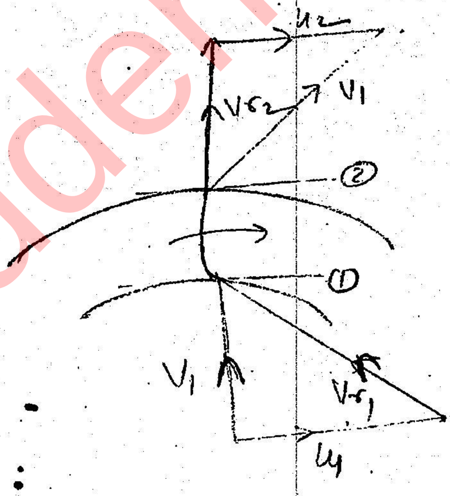


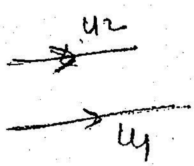
Ex:

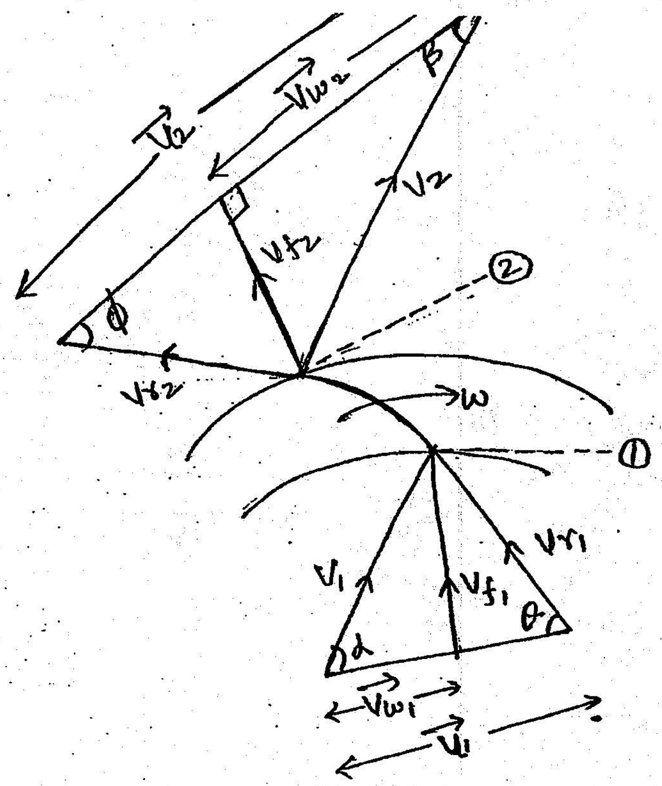




Ex:







$$\boxed{V_w \perp V_f}$$

$$\boxed{\vec{V} = \vec{V_r} + \vec{u}}$$

$$\boxed{\vec{V} = \vec{V_w} + \vec{V_f}}$$

(*) This is for compressor
∴ outlet velocity diagram is bigger than velocity diagram at inlet.
In case of turbine vice versa.

<u>where</u>:- $\alpha \rightarrow$ nozzle angle or fixed blade outlet angle or absolute velocity angle at inlet.

$\beta \rightarrow$ Diffuser inlet angle or fixed blade inlet angle or absolute velocity angle at outlet.

θ and $\phi \rightarrow$ Blade or vane angle at inlet and outlet.

$$\boxed{P = V_{w_2} \cdot u_2 - V_{w_1} u_1}$$

<u>From outlet Δ</u>

$$V_{f_2}^2 = V_2^2 - V_{w_2}^2$$

$$V_{f_2}^2 = V_{r_2}^2 - (u_2 - V_{w_2})^2$$

<u>on equating</u>

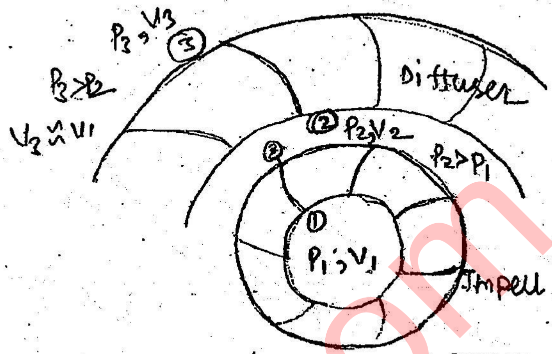
$$V_2^2 - V_{w_2}^2 = V_{r_2}^2 - u_2^2 - V_{w_2}^2 + 2V_{w_2}u_2$$

$$\boxed{V_{w_2} u_2 = \frac{V_2^2 + u_2^2 - V_{r_2}^2}{2}}$$

<u>Similarly from Inlet Δ</u>

$$\boxed{V_{w_1} u_1 = \frac{V_1^2 + u_1^2 - V_{r_1}^2}{2}}$$

$$\boxed{P = V_{w_2}u_2 - V_{w_1}u_1 = \left(\frac{V_2^2 - V_1^2}{2}\right) + \left(\frac{u_2^2 - u_1^2}{2}\right) + \left(\frac{V_{r_1}^2 - V_{r_2}^2}{2}\right)}$$



last two terms pressure increase करते हैं और वह impeller में ही होते हैं और Diffuser में 1st term होता है means जितनी Velocity Diffuser में घटती है उतना ही Pressure बढ़ जाता है।

$\left(\frac{V_2^2 - V_1^2}{2}\right) \Rightarrow$ Impulse effect

* It denotes the increase in kinetic energy of fluid in the impeller that we need to convert it into pressure energy into the Diffuser.

$\left(\frac{u_2^2 - u_1^2}{2}\right) \Rightarrow$ centrifugal effect.

* It denotes the rise in pressure in the impeller as fluid enters at a lower diamermeter and comes out at a higher diameter.

$\left(\frac{V_{r_1}^2 - V_{r_2}^2}{2}\right) \Rightarrow$ Diffusion or Reaction effect.

* It denotes the rise in pressure in the impeller because the fluid takes place in the diverging passage due to which relative velocity decreases from inlet to outlet with corresponding increase in static pressure.

CENTRIFUGAL COMRESSOR

It is a radial flow m/c in which air enters through the eye of impeller in an axial direction and moves through the impeller in a radially outward direction.

In the inlet casing there is a little drop in pressure with increase in velocity. while flowing through the impeller energy is transferred which increases the static pressure along with absolute velocity. Kinetic energy obtained in the impeller is transformed into pressure energy in the diffuser.