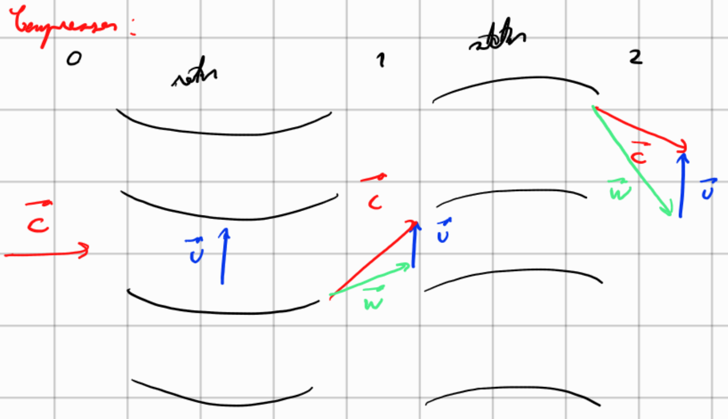
BLUE - Aerodynamics Workshop

Compressor :



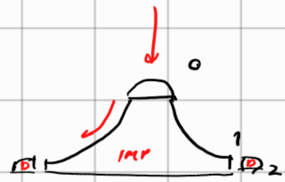
$\vec{c}$ → Air velocity

$\vec{U}$ → Referential speed

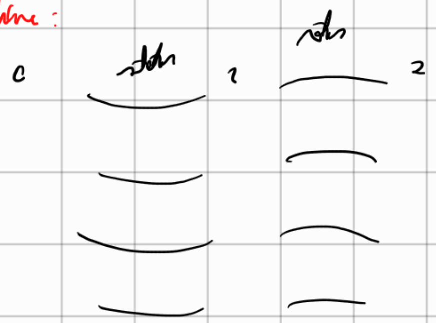
$\vec{U} = \vec{\omega} \times \vec{r}$

$U = \omega r$

$\vec{W}$ → Relative velocity



Turbine :



$h = c_p T$

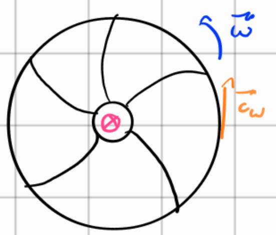
$h_{00} = h_{01}$

$h_{02} > h_{01}$ → compressor

$h_{02} < h_{01}$ → turbine

$h_0 = h + \frac{v^2}{2}$

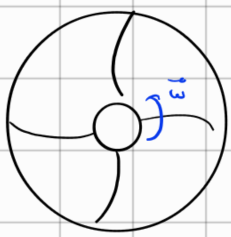
$T_0 = T + \frac{v^2}{2c_p}$

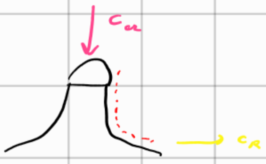


⊗ $\vec{C}_{ax}$ → Axial velocity

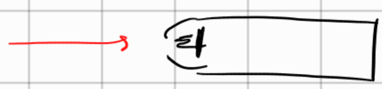
$\vec{C}_w$ → Tangential velocity

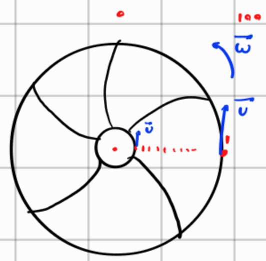
$\vec{C}_R$ → Radial velocity ⇒ constant





Impeller : Axial velocity → Radial velocity





"real" $\sigma \equiv$ slip factor

"ideal"

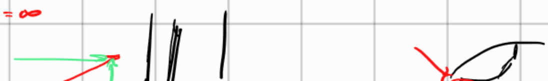
$c_w = \sigma U$

$U = \omega r$

$\sigma = 1 - \frac{0.63\pi}{z}$

z → numbers of blades

$\sigma_{ideal} = 1 \Rightarrow z = \infty$

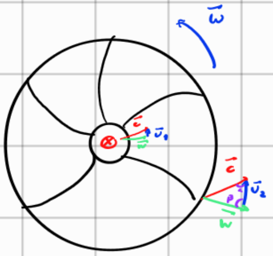


Work: $W = c_\omega U = \sigma U^2$

$$W = U_1 c_{w_1} - U_2 \cancel{c}_{w_2} = U_2 c_{w_2}$$
$\simeq 0 \ (r \simeq 0)$

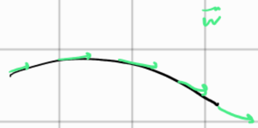
f → final
i → initial

$U = \omega r \qquad W = \omega (r_2 c_{w_2} - r_1 c_{w_1})$



U increases because radius (r) increases

$\vec{U}_2$ and $\vec{U}_1$ are perpendicular to $\vec{w}$ (and to the blade)



$\vec{c}$ → Absolute velocity

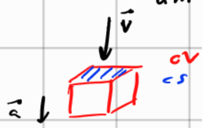
$$V = \sqrt{c_w^2 + c_x^2}$$

$$V_{total} = \sqrt{c_w^2 + c_R^2 + c_a^2}$$

$\dot{m} = \rho \bar{A} V_r$ ← relative velocity to the control surface (and is also normal to cs)
A → area

$$\Sigma M = \frac{dH}{dt} = \dot{m}_2 r_2 V_2 - \dot{m}_1 r_1 V_1$$
ΣM ← sum of torque

$$\frac{dB}{dt} = \frac{d}{dt}\int_{cv} \beta \rho \, dV + \int_{cs} \beta \rho (\vec{V_r} \cdot \vec{n}) \, dA \qquad \beta = \frac{dB}{dm}$$



$\vec{V}_r = \vec{V} - \vec{a}$

B → mass, energy, velocity, anything you want, ...

$B = m$

$$\frac{dm}{dt} = \dot{m} = \cancel{\frac{d}{dt}}\int_{cv} \rho \, dV + \int_{cs} 1 \cdot \rho (\vec{V_r} \cdot \vec{n}) \, dA$$
0
$\rho V dA$
$\rho V A$

$$\beta = \frac{dm}{dm} = 1$$

$$\left(\frac{dB}{dt}\right)_{system} = \Sigma M$$

Formulas:

$$T_f = T_i \left(\frac{P_2}{P_1}\right)^{\frac{K-1}{K}} \qquad \frac{P_2}{P_1} = r_p \text{ (pressure ratio)}$$

$$\eta_c = \frac{\dot{W}_{isentropic}}{\dot{W}_{real}}$$

$\gamma = k$

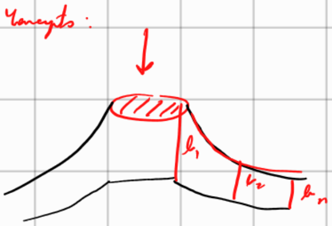
$$\eta_t = \frac{\dot{W}_{real}}{}$$

$\dot{w}_{isentropic}$

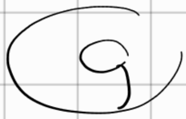
$$P_0 = \left(\frac{T_0}{T_1}\right)^{\frac{k}{k-1}} P_1 \qquad c_p = \frac{kR}{k-1}$$

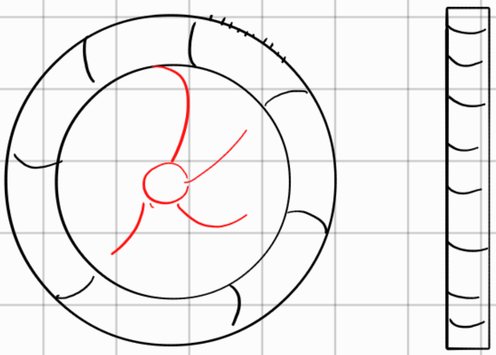
$$T_{02} = \frac{1}{\eta_c}\left(\frac{P_{02}}{P_{01}}\right)^{\eta_c \frac{k-1}{k}} T_{01}$$

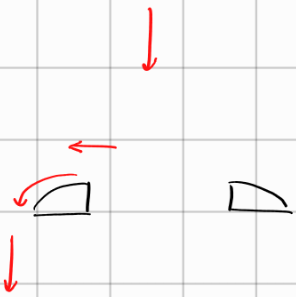
Concepts:

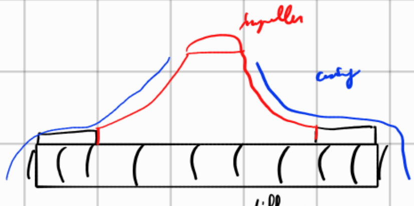


b = height of the blade









$\vec{H}$ (angular momentum) is conserved in the diffuser

$$\frac{d\vec{H}}{dt} = 0 \rightarrow c_{w2} D_2 = c_{w1} D_1$$

$$c_{w2} r_2 = c_{w1} r_1$$