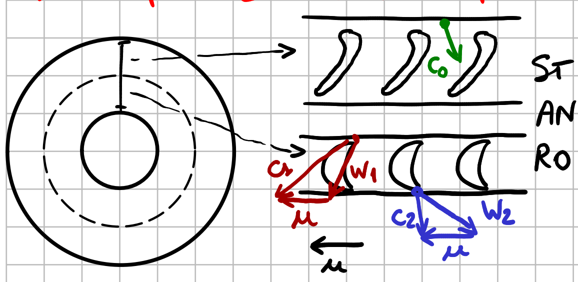
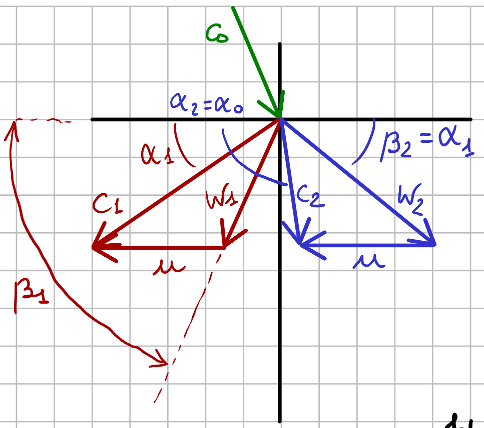
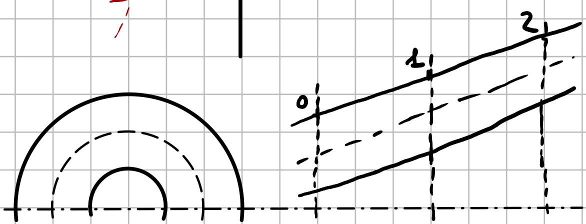
TRIANGOLI DI VELOCITÁ





TURBINA ASSIALE

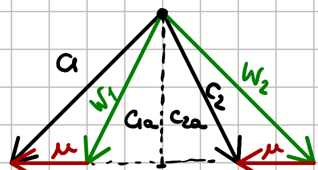
Sezione assiale: $\dot{m} = A \rho c_a$



Durante l'espansione:

ρ diminuisce
A aumenta
c_a quasi costante

$c_{1a} \approx c_{2a}$



STADIO IDEALE AD AZIONE

DEFINIZIONE: una MACCHINA AD AZIONE ha $R = \emptyset$

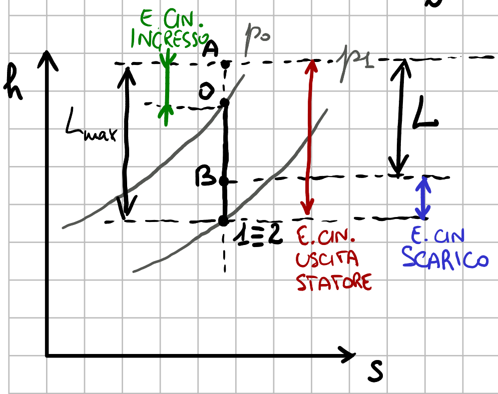
Si assume flusso assiale ($u_1 = u_2$, $c_2 \approx c_0$) e funzionam. ideale ($\Delta s = 0$)

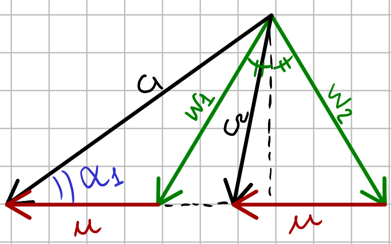
$$R = \emptyset \rightarrow \frac{w_2^2 - w_1^2}{(c_1^2 - c_2^2) - (w_1^2 - w_2^2)} = 0, \quad \|w_1\| = \|w_2\|$$

$$L = \frac{c_1^2 - c_2^2}{2} + \cancel{\frac{u_1^2 - u_2^2}{2}}^{\,0} - \cancel{\frac{w_1^2 - w_2^2}{2}}^{\,0} = \frac{c_1^2}{2} - \frac{c_2^2}{2}$$

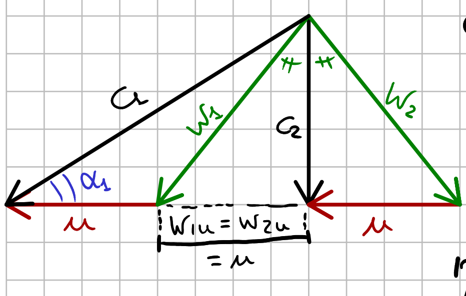
$$L_{max} = (h_0 - h_2) + \frac{c_0^2}{2} = L - \frac{\cancel{c_0^2} - c_2^2}{2} + \frac{\cancel{c_0^2}}{2} = \frac{c_1^2}{2}$$

$$\eta_p = \frac{L}{L_{max}} = \frac{c_1^2 - c_2^2}{c_1^2} \ [\%]$$





CONFIGURAZIONE OTTIMALE



$$c_{1u} = c_1 \cos(\alpha_1) = 2u \longrightarrow c_2 = c_1 \sin(\alpha_1) = 2u \tan(\alpha_1)$$

$$L = \frac{c_1^2 - c_2^2}{2} = \frac{c_1^2 \cos^2(\alpha_1)}{2} = 2u^2$$

$$\eta_p = \frac{c_1^2 - c_2^2}{c_1^2} = (1 - \sin^2(\alpha_1)) = \cos^2(\alpha_1)$$

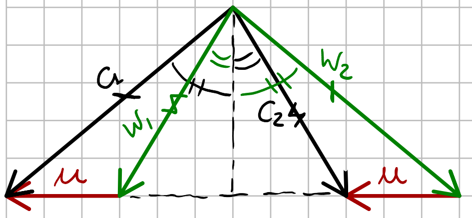
η_p é max per $\alpha_1 = \emptyset$, $\eta_p = 100\%$, $c_a = \emptyset$

Siccome $\alpha \neq 0$, in genere si adotta $10° < \alpha_1 < 15°$

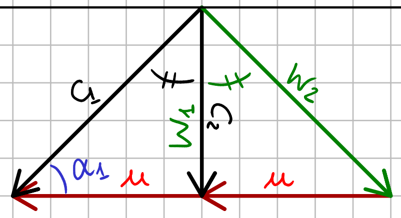
STADIO IDEALE CON R=0,5 (A REAZIONE)

Si consideri uno stadio tale che: $\begin{cases} \|w_1\| = \|c_2\| \\ \|w_2\| = \|c_1\| \end{cases} \cap \begin{cases} u_1 = u_2 \\ c_2 = c_0 \end{cases}$ (flusso assiale)

DUNQUE: $$R = \frac{\cancel{u_1^2 - u_2^2} + w_2^2 - w_1^2}{c_1^2 - c_0^2 + \cancel{u_1^2 - u_2^2} - w_1^2 + w_2^2} = \frac{w_2^2 - w_1^2}{2w_2^2 - 2w_1^2} = \frac{1}{2} = 0,5$$



CONFIG. OTTIMALE:



$$\begin{cases} c_1^2 - c_2^2 = u^2 \\ w_2^2 - w_1^2 = u^2 \end{cases} \text{(PITAGORA)} \longrightarrow \frac{u}{c_1} = \cos(\alpha_1) \longrightarrow c_2 = c_1 \sin(\alpha_1)$$

DUNQUE: $$\begin{cases} L = \frac{1}{2}(c_1^2 - c_2^2 + u_1^2 - u_2^2 - w_1^2 + w_2^2) = \frac{1}{2}(u^2 + u^2) = u^2 \\ L_{max} = (h_0 - h_2) + \frac{c_0^2}{2} = L - \frac{\cancel{c_0^2} - c_2^2}{2} + \frac{\cancel{c_0^2}}{2} = u^2 + \frac{c_2^2}{2} \end{cases}$$

$$\eta_p = \frac{u^2}{u^2 + \frac{c_2^2}{2}} = \dots \text{(RELAZ. TRIGONOMETRICHE)} = \frac{2\cos^2(\alpha_1)}{\cos^2(\alpha_1) + 1}$$

TURBINE AD AZIONE E REAZIONE A CONFRONTO

AZIONE $(R=0)$
$$\begin{cases} L = 2u^2 \\ \eta_p = \cos^2(\alpha_1) \end{cases}$$

REAZIONE CON $R=0,5$
$$\begin{cases} L = u^2 \\ \eta_p = \frac{2\cos^2(\alpha_1)}{\cos^2(\alpha_1) + 1} \end{cases}$$

Lo stadio ad azione permette di ottenere, a parità di velocità di rotazione u, il doppio del lavoro euleriano utile rispetto allo stadio a reazione R = 0,5. Tuttavia...

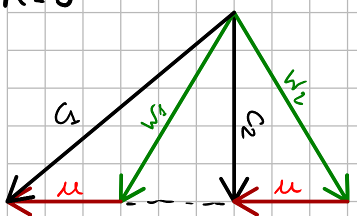
$$\frac{\eta_{p0}}{\eta_{p0,5}} = \frac{\cancel{\cos^2\alpha_1}}{2\cancel{\cos^2\alpha_1}}(\cos^2\alpha_1 + 1) = \frac{\cos^2\alpha_1 + 1}{2} \leq 1$$

A parità di angolo α_1, **la turbina a reazione R = 0,5 ha un rendimento di palettatura maggiore!**

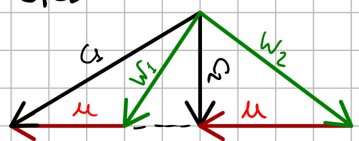
CASO LIMITE: per $\alpha_1 = \varnothing$ IN TEORIA $\eta_{p0} = \eta_{p0,5}$

TRIANGOLI DI VELOCITÀ (IDEALI) PER VARI VALORI DI R

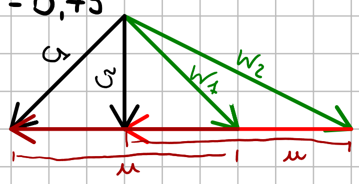
$R=0$



$R=0,25$



$R=0,75$



$R=0,5$