Esercitazione 6 - Centrifugal Compressor

Exercise 1

$\dot{m} = 3 \; kg/s$

$$\left.\begin{array}{l} P_{OUT} = 5 \, bar \\ P_{in} = 1 \, bar \end{array}\right\} \beta = 5$$

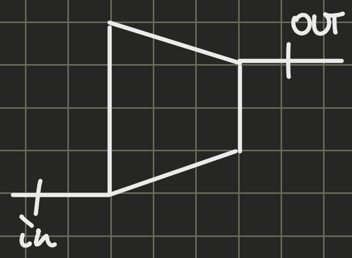
$T_{in} = 20°C = 293 K$

a) $\eta_{is} = 0.8$

$\ell = ?$

$$\left.\begin{array}{l} D = ? \\ n = ? \end{array}\right\} \text{From Balje}$$

Compressibility

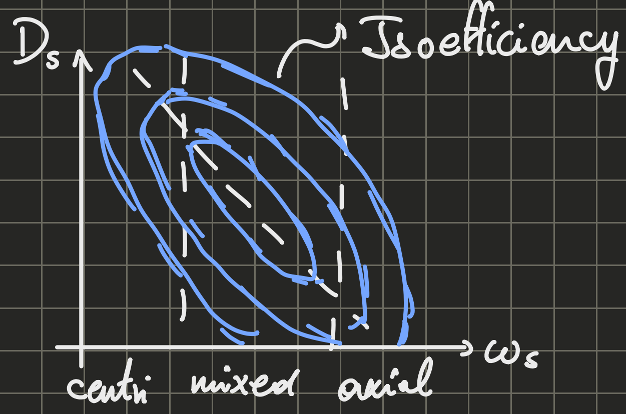


$$l = \Delta h + \cancelto{\approx 0}{\frac{\Delta v^2}{2}} = \Delta h_T \simeq \Delta h = c_p (T_{OUT} - T_{in})$$

$$l_s = c_p (T_{OUT,s} - T_{in}) = \frac{\gamma R}{\gamma - 1} T_{in} \left(\beta^{\frac{\gamma-1}{\gamma}} - 1 \right)$$

$$l_s = 171{,}9 \ \frac{kJ}{kg}$$

$$l = \frac{l_s}{\eta_s} = 214.9 \ \frac{kJ}{kg}$$



For thermal machines D_s, ω_s are not enough, we need to consider a β too.

Chain of change

$$P \longrightarrow T \longrightarrow \rho \longrightarrow V$$

$$\rho = \frac{P}{RT}$$

There is coupling between the energy balance and momentum balance, since ρ is an intermediary we need to consider the effects of the compressibility, this number is the Mach number.

Since we don't know everything specifically, we use the peripheral Mach number

$$M_u = \frac{\omega R_2 \rightarrow u_2}{\sqrt{\gamma R T_{T,in}}}$$

$$\beta = \beta(\dot{m}_A, M_u, \gamma, Re, shape)$$

$\hookrightarrow$ not φ

$\hookrightarrow$ not ψ

$$\omega_s = \frac{\omega\sqrt{Q}}{\Delta h_s^{3/4}}$$

$$D_s = D\,\frac{\Delta h_s^{1/4}}{\sqrt{Q}}$$

$$M_u = \frac{\omega_s D_s}{2}\sqrt{\frac{\beta^{\gamma-1}-1}{\gamma-1}}$$

$$= M_u(\underbrace{\omega_s, D_s}, \beta)$$

These two are fixed $\longrightarrow$ So we need to fix either M_u or β to define our system.

b) n

$$\eta_y = \frac{n}{n-1}\cdot\frac{\gamma-1}{\gamma}$$