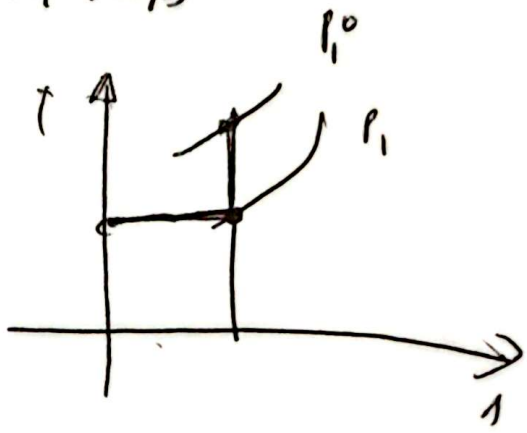
$\dot{m} = \rho_1 A_1 \cdot c_1 = 3\ kg/s$ $\quad A_1 = \frac{\dot{m}}{\rho_1 \cdot c_1}$; $T_1 = 299{,}5\ K$ ①

b)

$c_1 = \sqrt{2 c_p \cdot (T_1^0 - T_1)} = 31{,}69\ m/s$

(T_1^0: 300 K, T_1: 299,5 K)



$p_1^0 \cdot T_1^{0\ \frac{\kappa}{1-\kappa}} = p_1 T_1^{\frac{\kappa}{1-\kappa}}$

$p_1 = p_1^0 \cdot \left(\frac{T_1^0}{T_1}\right)^{\frac{\kappa}{1-\kappa}} = 0{,}90\ bar \cdot \left(\frac{300}{299{,}5}\right)^{\frac{1{,}4}{1-1{,}4}} = 0{,}8947\ bar$

$\rho_1 = \frac{p_1}{R T_1} = \frac{0{,}8947\ bar \cdot 101325\ Pa}{287\ \frac{J}{kg K} \cdot 299{,}5\ K} = 1{,}0546\ \frac{kg}{m^3}$

$A_1 = \frac{3\ kg/s}{1{,}0546\ \frac{kg}{m^3} \cdot 31{,}69\ m/s} = 0{,}089765870064\ m^2 =$

$= 897{,}65\ cm^2 = 0$

$r_1 = 16{,}90\ cm$

$$\rho_2 = \rho_0 \cdot \left(\frac{p_2}{p_{10}}\right)^{\frac{1}{\gamma}} \quad ; \quad \frac{p_2}{p_1^0} = \left(\frac{2}{1+\gamma}\right)^{\frac{\gamma}{\gamma-1}} =$$

$$p_2 = 0{,}90\,\text{atm} \cdot \dots = 0{,}4754\,\text{atm}$$

$$\rho_2 = 1{,}0591\ \frac{kg}{m^3} \cdot 0{,}5282817677 = 0{,}559503\ \frac{kg}{m^3}$$

$$\frac{T_2}{T_1^0} = \frac{2}{1+\gamma} \quad T_1^0 = \frac{5}{6} \cdot T_1^0 = 250\,K$$

$$c_2 = \sqrt{2\varphi\,(T_1^0 - T_2} = 316{,}94\ \frac{m}{s}$$

$$A_2 = \frac{\dot{m}}{\rho_2 \cdot c_2} = \frac{3\ kg/s}{0{,}559503\ \frac{kg}{m^2} \cdot 316{,}94\ m/s \cdot 35\sqrt{\rho_2}\ m/s}$$

$$= 0{,}0169177\ m^2 = 169{,}1779\ cm^2$$

$$\boxed{r_2 = 7{,}3383\ cm}$$

$p_3 = 0{,}07$ otw

$$\rho_3 = \rho_0 \cdot \left(\frac{p_3}{p_0}\right)^{\frac{1}{\gamma}} = 1{,}0591 \frac{kg}{m^3} \cdot \left(\frac{0{,}07\,otw}{0{,}9\,otw}\right)^{\frac{1}{1{,}4}} = 0{,}170874 \frac{kg}{m^3}$$

$$T_3 = \frac{p_3}{\rho_3 R} = 144{,}62\,K$$

$$c_3 = \sqrt{2q\left(T_1^0 - T_3\right)} = 558{,}71 \frac{m}{s}$$

$$Ma_3 = \frac{c_3}{\sqrt{\kappa R T_3}} = 2{,}32$$

$$A_3 = \frac{\dot{m}}{\rho_3 c_3} = 0{,}034\,42288946\,m^2 = 314{,}2288936\,cm^2$$

~~$D_3 = 10\,cm$~~

$D_3 = 10\,cm$

$$\varrho_c = \sqrt{ab} = a^{\frac{1}{2}} \cdot b^{\frac{1}{2}}$$

$$\frac{1}{\varrho_c} = a^{-\frac{1}{2}} \cdot b^{-\frac{1}{2}} = \sqrt{\frac{\kappa-1}{2\kappa} \cdot \frac{1}{T_0 c_p} \cdot}$$

$$\text{re} \quad \frac{p}{p_0} = \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma}{\gamma-1}} \Rightarrow$$

$$b = \left[\left(\frac{2}{\gamma+1}\right)^{\frac{\gamma}{\gamma-1}}\right]^{\frac{2}{\gamma}} = \left[\left(\frac{2}{\gamma+1}\right)^{\frac{1}{\gamma-1}}\right]^{\frac{1+\gamma}{\gamma}}$$

$$\frac{\gamma-1}{\gamma} \cdot \frac{2}{\gamma} + \frac{2}{\gamma} = \frac{\gamma-1+2}{\gamma} = \frac{\gamma+1}{\gamma}$$

$p T^{\gamma} = p_1^{\gamma} \cdot \varrho_1^{\gamma}$ $\qquad -\gamma = -\gamma + 1 - 1$

$p \cdot \varrho^{-\gamma} = c$

$$p_1 \cdot \varrho_1^{-\gamma} = p \cdot \varrho^{-\gamma} \Rightarrow \left[\varrho^{-\gamma}\right] = \left[\varrho_1^{-\gamma}\right] \cdot \left[\frac{p_1}{p}\right]^{-\frac{1}{\gamma}}$$

$$p_1 \varrho_1 \cdot \varrho_1^{(-1-\gamma)} = p \cdot \varrho^{-\gamma} \Rightarrow$$

$$\boxed{\varrho = \varrho_1 \cdot \left(\frac{p}{p_1}\right)^{\frac{1}{\gamma}}}$$

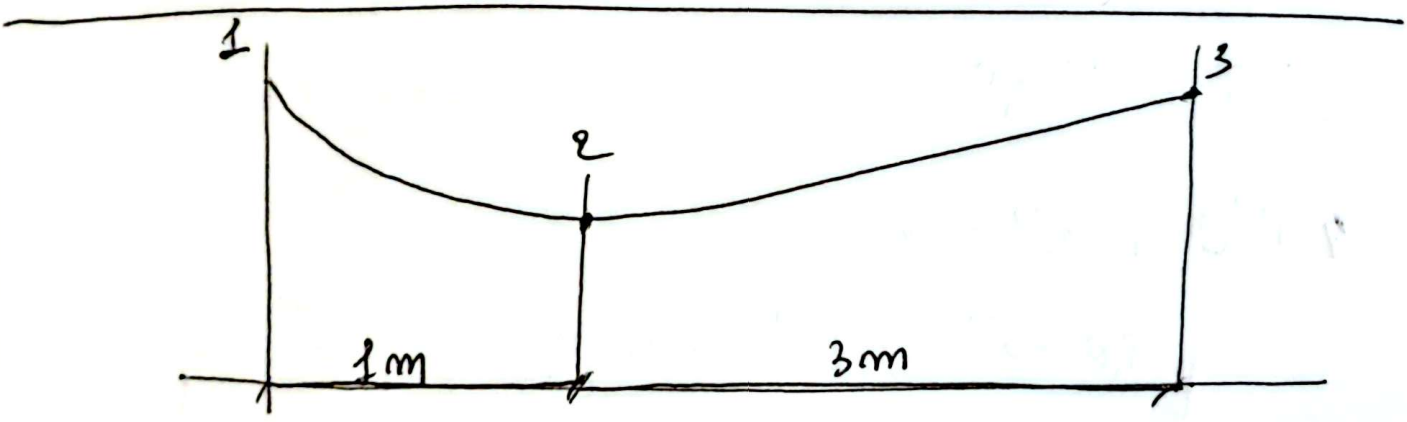
$$ec = \sqrt{\rho_{10} \cdot \left(\frac{p}{p_{10}}\right)^{\frac{2}{\gamma}} \cdot \frac{2k}{k-1} \cdot \frac{p_1^0}{\rho_1^0} \cdot \left[1 - \left(\frac{p}{p_{10}}\right)^{\frac{\gamma-1}{\gamma}}\right]}$$

$$ec^2 = \sqrt{\frac{2k}{k-1} \cdot p_1^0 \cdot \rho_1^0 \cdot \left[\left(\frac{p}{p_1^0}\right)^{\frac{2}{\gamma}} - \left(\frac{p}{p_{10}}\right)^{\frac{1+\gamma}{\gamma}}\right]}$$ ✓

$$A = \frac{\dot{m}}{ec}$$

- $ec(\text{SEZIONE}) = \dfrac{\dot{m}}{A(\text{SEZIONE})}$
  - ↳ VARIA LUNGO L'ASSE

$p = p(x)$



$p_3 = 0{,}07$ atm

$p_1^0 = 0{,}90$ atm

$T_1^0 = 300$ K

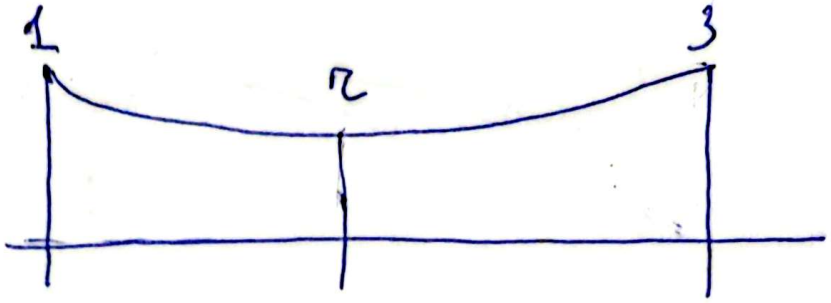
$\rho^0 = 1{,}0591 \frac{kg}{m^3}$

p_2

T_2

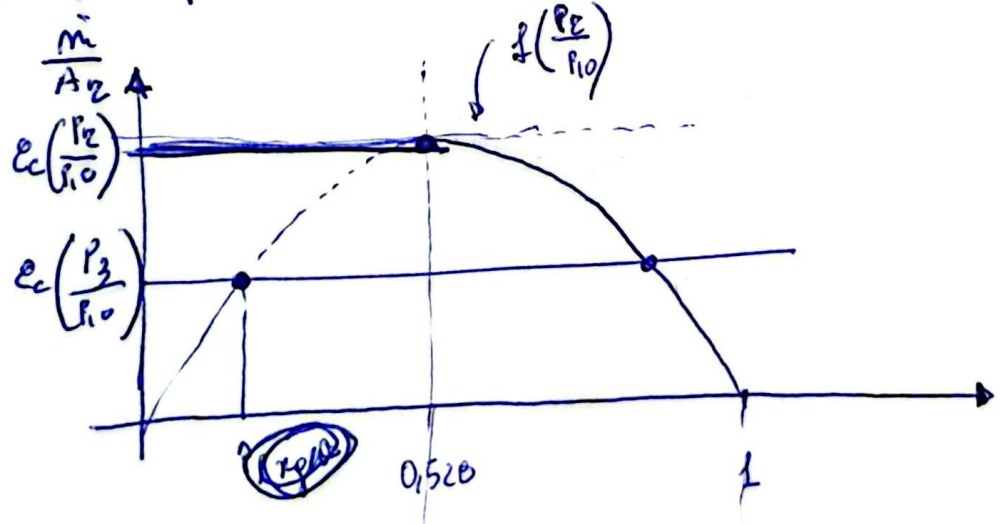
c_2

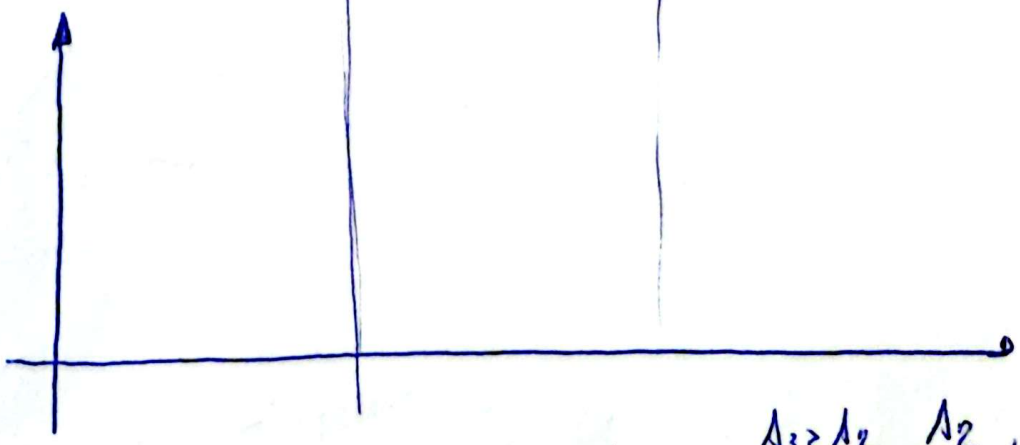
$M_{c_2} = 1$



$$\varrho_c\left(\frac{p_3}{p_{10}}\right) = \sqrt{\frac{2\kappa}{\kappa-1} \cdot p_{10}\,\varrho_{10}\left[\left(\frac{p_3}{p_{10}}\right)^{\frac{2}{\kappa}} - \left(\frac{p_3}{p_{10}}\right)^{\frac{\kappa+1}{\kappa}}\right]} = \frac{\dot{m}}{A_3}$$

$$\varrho_c\left(\frac{p_2}{p_{10}}\right) = \sqrt{\frac{2\kappa}{\kappa-1} \cdot p_{10}\,\varrho_{10}\left[\left(\frac{p_2}{p_{10}}\right)^{\frac{2}{\kappa}} - \left(\frac{p_2}{p_{10}}\right)^{\frac{\kappa+1}{\kappa}}\right]} = \frac{\dot{m}}{A_2}$$





$A_2 \cdot (\varrho_c)_2 = A_3 \cdot \varrho_{c3}$ $\quad \varrho_{c3} = (\varrho_c)_2 \cdot \frac{A_2}{A_3}$ $\quad A_3 > A_2 \quad \frac{A_2}{A_3} < 1$ $\quad \varrho_{c3} < (\varrho_c)_2$

$A_K =$

$R_K = 7{,}3383$ cm || ~~0,550|01~~ $P_K = 0{,}07$

$P_V = 109{,}5535$ $P_{voll} = 0{,}8551$ ct