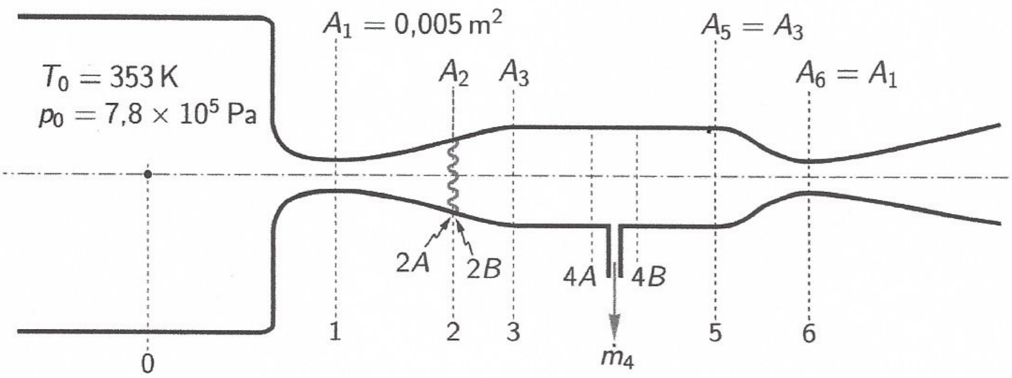
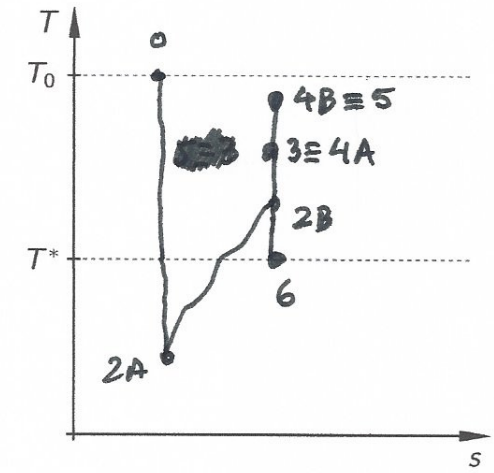


$p_{2A} = 2{,}1 \times 10^5\,\mathrm{Pa}$

$p_3 = 5{,}6 \times 10^5\,\mathrm{Pa}$



$\gamma = 1{,}2987$

$R = 518{,}27\ (J/kg\,K)$

$A_1 = A_6 = 0{,}005\ m^2$

$P_0 = 7{,}8 \times 10^5\ Pa$

$T_0 = 353\ K$

$P_3 = 5{,}6 \times 10^5\ Pa$

$P_{2A} = 2{,}1 \times 10^5\ Pa$

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a) $$\frac{P_0}{P_{2A}} = \left(1 + \frac{\gamma-1}{2} Ma_{2A}^2\right)^{\gamma/\gamma-1} \Rightarrow$$

$$1 + \frac{\gamma-1}{2} Ma_{2A}^2 = \left(\frac{P_0}{P_{2A}}\right)^{\frac{\gamma-1}{\gamma}} \Rightarrow$$

$$Ma_{2A}^2 = \sqrt{\left[\left(\frac{P_0}{P_{2A}}\right)^{\frac{\gamma-1}{\gamma}} - 1\right]\frac{2}{\gamma-1}} = 1{,}5359$$

$$Ma_{2B} = \sqrt{\frac{(\gamma-1)Ma_{2A}^2 + 2}{2\gamma Ma_{2A}^2 - (\gamma-1)}} = 0{,}6812$$

$$\frac{A_2}{A_1^*} = \frac{1}{Ma_{2A}}\left[\frac{2}{\gamma+1}\left(1 + \frac{\gamma-1}{2} Ma_{2A}^2\right)\right]^{\frac{1}{2}\frac{\gamma+1}{\gamma-1}} = 1{,}217$$

$$A_2 = \frac{A_2}{A_1^*} \cdot A_1^* = 0{,}006086\ m^2$$

b) $$\frac{A_3^*}{A_1^*} = \frac{p_{01}}{p_{03}} = \frac{Ma_{2B}}{Ma_{2A}}\left[\frac{2+(\gamma-1)Ma_{2A}^2}{2+(\gamma-1)Ma_{2B}^2}\right]^{\frac{1}{2}\frac{\gamma+1}{\gamma-1}}$$

$$= 1{,}09469$$

$$p_{03} = \frac{p_{03}}{p_{01}} \cdot p_{01} = \frac{780\,000}{1{,}09469} = 712525\,Pa$$

$$\frac{p_{03}}{p_3} = \left(1+\frac{\gamma-1}{2}Ma_3^2\right)^{\gamma/\gamma-1} \Rightarrow$$

$$Ma_3 = \sqrt{\frac{2}{\gamma-1}\left(\left(\frac{p_{03}}{p_3}\right)^{\frac{\gamma-1}{\gamma}}-1\right)} = 0{,}6176$$

$$\frac{T_0}{T_3} = 1+\frac{\gamma-1}{2}Ma_3^2 \Rightarrow T_3 = \frac{T_0}{1+\frac{\gamma-1}{2}Ma_3^2} = 333{,}97$$

$$\frac{A_3}{A_3^*} = \frac{1}{Ma_3}\left[\frac{2}{\gamma+1}\left(1+\frac{\gamma-1}{2}Ma_3^2\right)\right]^{\frac{1}{2}\frac{\gamma+1}{\gamma-1}} = 1{,}1729$$

$$A_3 = \frac{A_3}{A_3^*}\frac{A_3^*}{A_1^*}\cdot A_1^* = 0{,}00642\,m^2$$

$$A_3^* = \frac{A_3^*}{A_1^*}A_1^* = 0{,}00547\,m^2$$

c) $\dfrac{\dot{m}}{A^*}\dfrac{\sqrt{T_0}}{p_0}=\sqrt{\dfrac{\gamma}{R}\left(\dfrac{2}{\gamma+1}\right)^{\frac{\gamma+1}{\gamma-1}}} = 0,0293$

Caudal na primeira garganta

$$\dot{m}_1 = \frac{A_1^* \, p_{01}}{\sqrt{T_0}} \cdot 0,0293 = 6,082 \text{ kg/s}$$

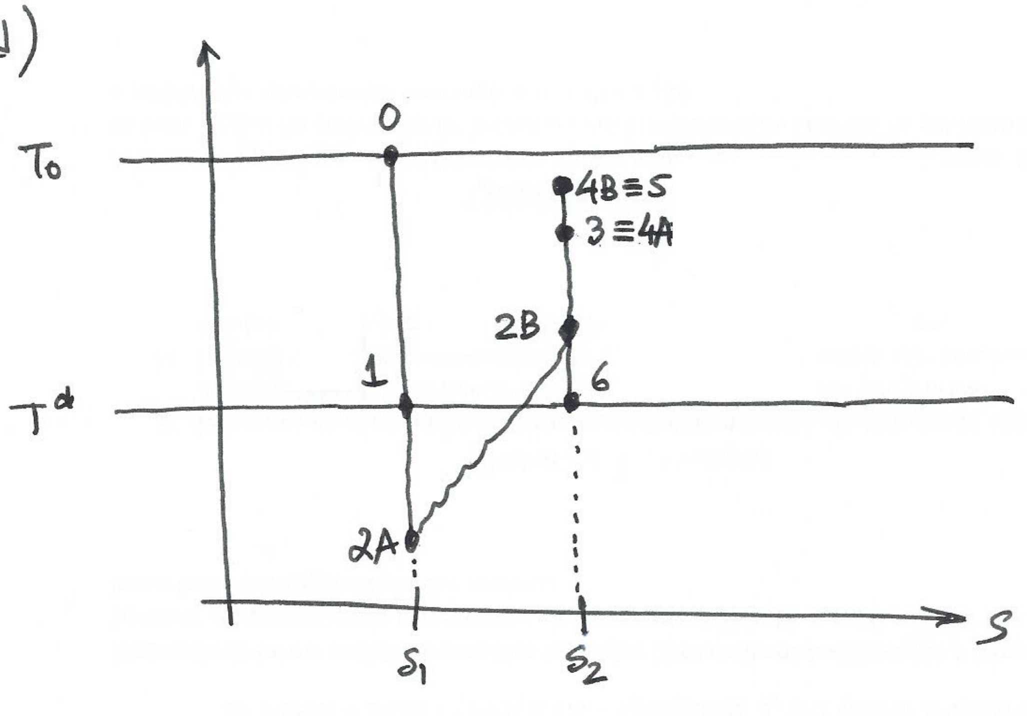
Caudal na segunda garganta (mesma área)

$$\dot{m}_6 = \frac{A_1^* \, p_{03}}{\sqrt{T_0}} \, 0,0293 = 5,556 \text{ kg/s}$$

logo

$$\dot{m}_{41} = \dot{m}_1 - \dot{m}_6 = 0,526 \text{ kg/s}$$

d)



T^* não varia na onda de choque

4A ≠ 4B → retiramos caudal ⇒ diminui o número de Mach ⇒ $Ma_{4A} > Ma_{4B}$

Alínea c) resolução alternativa

$$\frac{A_{4B}}{A_6^*} = \frac{A_3}{A_6^*} = \frac{0{,}00642}{0{,}005} = \frac{1}{Ma_{4B}}\left[\frac{2}{\gamma+1}\left(1+\frac{\gamma-1}{2}Ma_{4B}^2\right)\right]^{\frac{1}{2}\frac{\gamma+1}{\gamma-1}}$$

$$\longrightarrow Ma_{4B} = 0{,}5358$$

$$\dot{m}_{4A} = A_3 \frac{p_{03}}{\sqrt{T_0}}\sqrt{\frac{\gamma}{R}}\, Ma_{4A}\left(1+\frac{\gamma-1}{2}Ma_{4A}^2\right)^{-\frac{1}{2}\frac{\gamma+1}{\gamma-1}} =$$

$$= 6{,}0819 \text{ kg/s}$$

$M_{4A} = M_3$

$$\dot{m}_{4B} = A_3 \frac{p_{03}}{\sqrt{T_0}}\sqrt{\frac{\gamma}{R}}\, Ma_{4B}\left(1+\frac{\gamma-1}{2}Ma_{4B}^2\right)^{-\frac{1}{2}\frac{\gamma+1}{\gamma-1}} =$$

$$= 5{,}556 \text{ kg/s}$$

$$\dot{m}_4 = \dot{m}_{4A} - \dot{m}_{4B} = 0{,}526 \text{ kg/s}$$