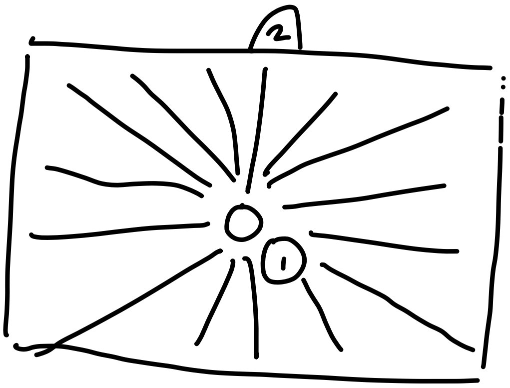
Esercitazione 12

Esercizio 1



$A_1 = 16{,}8\ mm^2 = 0{,}00168\ dm^2$

$T_2 = 300°C$

$A_2 = 40\ dm^2$

Sfera è un corpo grigio e opaco

$\Downarrow$

$\tau = 0$ non trasparente

$\varepsilon_1 = 0{,}8$

Potere emissivo monocromatico E_λ è massimo per $\lambda = 0{,}9\ \mu m$

? T_1 ? α_1

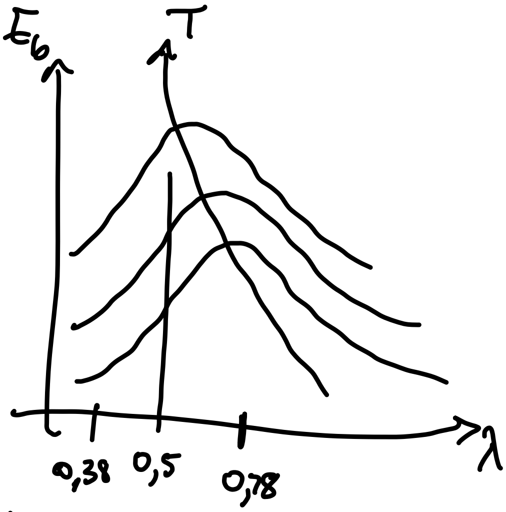
? $\dot{Q}_{12}^{\rightarrow}$? ρ_1

$$\dot{Q}_{12}^{\rightarrow} = \frac{\sigma(T_1^4 - T_2^4)}{\frac{1-\varepsilon_1}{\varepsilon_1 A_1} + \frac{1}{F_{12} A_1} + \frac{1-\varepsilon_2}{\varepsilon_2 A_2}} \cdot \frac{A_1}{A_1}$$

possiamo se è convesso e $A_1 \ll A_2$

$$\dot{Q}_{12}^{\rightarrow} = \frac{\sigma A_1 (T_1^4 - T_2^4)}{\frac{1-\varepsilon_1}{\varepsilon_1} + \underbrace{\frac{1}{F_{12}}}_{=1} + \frac{1-\varepsilon_2}{\varepsilon_2} \cdot \cancel{\frac{A_1}{A_2}}^{\approx 0}}$$

$$= \frac{\sigma A_1 (T_1^4 - T_2^4)}{\frac{F_{12}(1-\varepsilon_1)+\varepsilon_2}{F_{12}\varepsilon_1}} = \boxed{\sigma A_1 \varepsilon_1 (T_1^4 - T_2^4)}$$



Legge di Wien

$$\lambda_{max} \cdot T = 2897{,}6 \; \mu m \cdot K$$

$$T_1 = \frac{2897{,}6 \; \mu m \cdot K}{0{,}9 \; \mu m} = 3219{,}53 \, K$$

$$\sigma = 5{,}67 \cdot 10^{-8} \; \frac{W}{m^2 K^4}$$

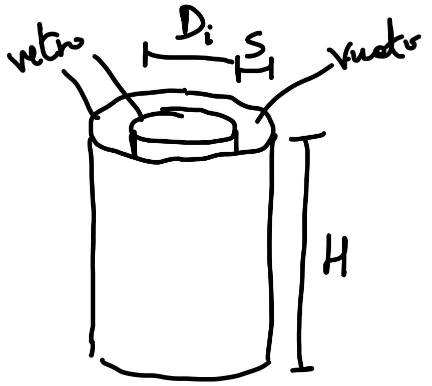
Teorema di kirchhoff per corpi grigi

$$\boxed{\varepsilon = \alpha}$$

$$\boxed{1 = \rho + \alpha + \cancel{\tau}^{\,0}}$$

$$\rho = 1 - \varepsilon = 0{,}2$$

Esercizio 2



$D_i = 0{,}07 \, m$

$H = 0{,}3$

$\rho_1 = \rho_2 = 0{,}92$

$S = 0{,}008 \; m$

$T_1 = 348{,}15 \, K$

$T_2 = 308{,}15 \, K$

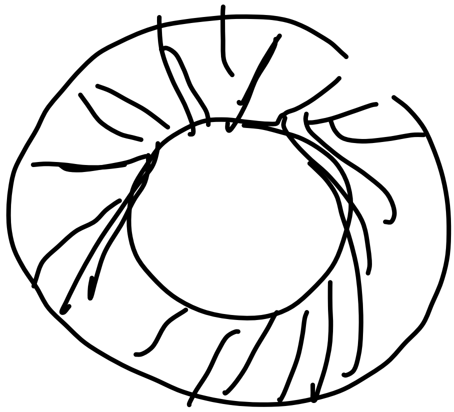
$? \; \dot{Q}_{12}$

Hp. : no dispersioni a base e tappo

superfice grigie e opache

$$\dot{Q}_{12}^{\rightarrow} = \frac{\sigma(T_1^4 - T_2^4)}{\frac{1-\varepsilon_1}{\varepsilon_1 A_1} + \frac{1}{F_{12} A_1} + \frac{1-\varepsilon_2}{\varepsilon_2 A_2}} \cdot \frac{A_1}{A_1}$$

$$\dot{Q}_{12}^{\rightarrow} = \frac{\sigma A_1 (T_1^4 - T_2^4)}{\frac{1-\varepsilon_1}{\varepsilon_1} + \frac{1}{F_{12}} + \frac{1-\varepsilon_2}{\varepsilon_2} \cdot \frac{A_1}{A_2}}$$



$$\dot{Q}_{12}^{\rightarrow} = \frac{\sigma \pi D_1 H (T_1^4 - T_2^4)}{\frac{1-\varepsilon_1+\varepsilon_1}{\varepsilon_1} + \frac{1-\varepsilon_2}{\varepsilon_2} \cdot \frac{D_1}{D_1+2s}} = 0,97\,W$$

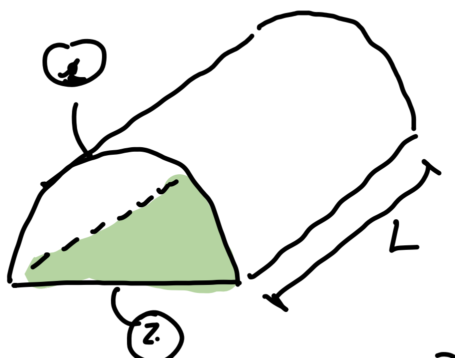
$F_{12} = 1$

$\overset{0}{\cancel{\tau_1}} + \rho_1 + \alpha_1 = 1$ → CORPO GRIGIO $\varepsilon_1 = \alpha_1 = 0,08$

$\alpha_1 = \alpha_2 = 0,08$ $\varepsilon_2 = \alpha_2 = 0,08$

già dato

<u>Esercizio3</u>



$D = 1\,m$

$L = 10\,m$

$T = 323,15\,K$

② $\boxed{\text{CORPO NERO} \Leftrightarrow \varepsilon_2 = 1}$

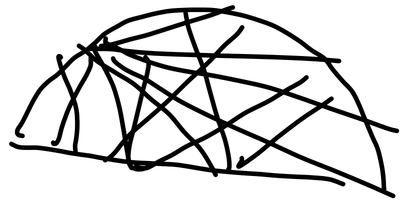
① $\varepsilon_1 = 0,8$

$T_1 = 1273,15\,K$

? $\dot m$ acqua evaporata

Hp: No dispersioni da semi-circonferenze

$F_{21} = 1 \qquad F_{12} \neq 1$



$F_{12} A_1 = F_{21} A_2$

In cavità vale $F_{21} + F_{22} = 1$

$$\dot Q_{12} = \frac{\sigma (T_1^4 - T_2^4)}{\frac{1-\varepsilon_1}{\varepsilon_1 A_1} + \underbrace{\frac{1}{F_{12} A_1}}_{F_{21} A_2} + \frac{1-\varepsilon_2}{\varepsilon_2 A_2}} \cdot \frac{A_2}{A_2} = \frac{\sigma A_2 (T_1^4 - T_2^4)}{\frac{1-\varepsilon_1}{\varepsilon_2} \cdot \frac{A_2}{A_1} - \frac{1}{\varepsilon_2}} = 1279834\,W$$

$$\frac{dE}{dt} \overset{ss}{=} -\dot m h_v + \dot Q = 0$$

$$\dot m = \frac{\dot Q}{h_v} = 0{,}533 \frac{kg}{s}$$

<u>Esercizio 4</u>

$T_s = 280°C = 553{,}15\,K$

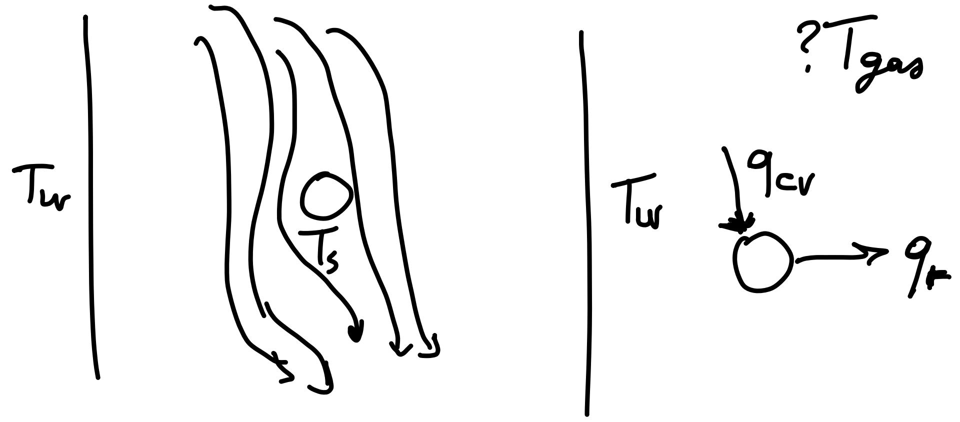
$T_w = 200°C = 473{,}15\,K$

$h = 100 \frac{W}{m^2 K}$

superficie suola e superficie scambiatore grigio

$\varepsilon = 0{,}8$

? T_{gas}



$$\frac{dE}{dt} = \overleftarrow{\dot{Q}_{cv}} - \overrightarrow{\dot{Q}_{rad}} = 0$$

$$h A_s (T_g - T_s) = \frac{\sigma (T_s^4 - T_w^4)}{\frac{1-\varepsilon_s}{\varepsilon_s A_s} + \frac{1}{F_{sw} A_s} + \frac{1-\varepsilon_w}{\varepsilon_w A_w}}$$

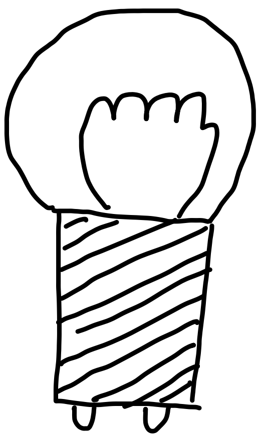
$$h A_s (T_g - T_s) = \sigma A_s \varepsilon_s (T_s^4 - T_w^4)$$

$$T_g - T_s + \underbrace{\frac{\sigma \varepsilon_s}{h} (T_s^4 - T_w^4)}_{19{,}73\ K} = 299{,}73^\circ$$

Errore di 19 K, se fossimo progettisti, saremmo licenziati

Per ridurre errore, possiamo ridurre ε_s o riscaldare le pareti più vicino a T_s

Esercizio 5



$\tau_v = 0,7$

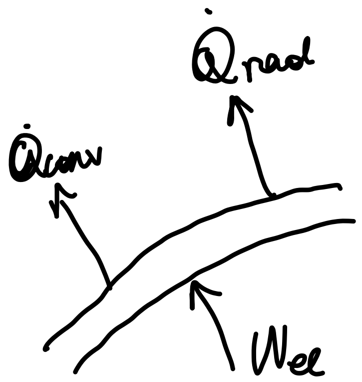
Potenza lampadina $= 100W = W_{el}$

$A_v = 0,01\ m^2$

$T_{pareti} = 293,15\ W = T_p$

$\rho = 0$

$\dot{Q}_{rad} = \dot{Q}_{conv}$? T_v



$\varepsilon_v = 1$

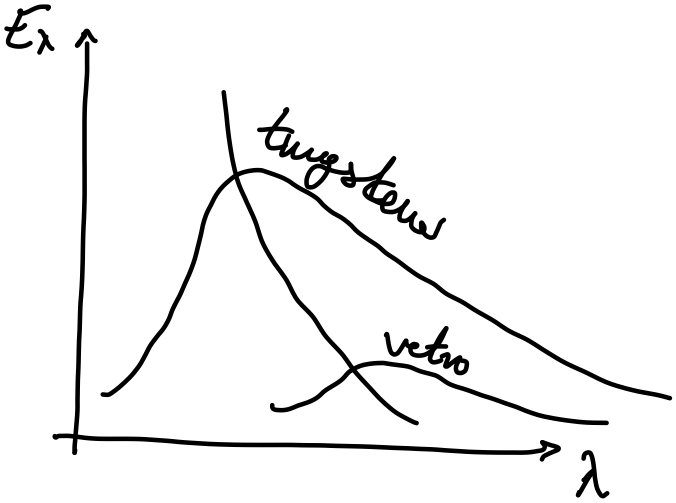
$$\begin{cases} \dfrac{dE}{dt}^{vetro} \ \dot{Q}_{in}^{\leftarrow} - \dot{Q}_{rad}^{\rightarrow} - \dot{Q}_{conv}^{\rightarrow} \\ \dot{Q}_{in}^{\leftarrow} = \dot{Q}_{rad}^{\rightarrow} + \dot{Q}_{conv} = 2\dot{Q}_{rad}^{\rightarrow} \\ \dot{Q}_{in}^{\leftarrow} = W_{el} \cdot (1-\tau) = 30W \\ \dot{Q}_{conv}^{\leftarrow} = \dot{Q}_{rad} \end{cases}$$

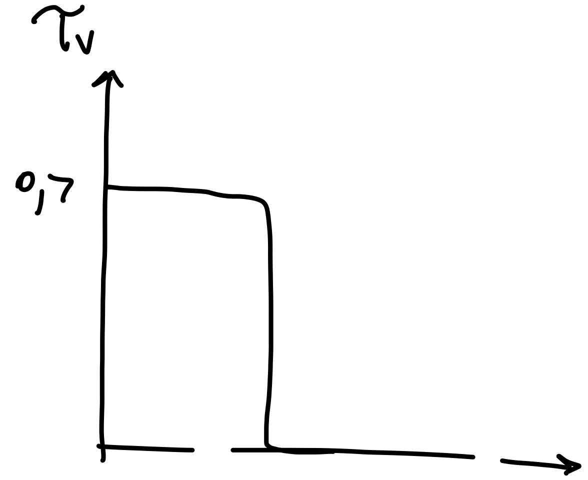
$$\dot{Q}_{rad}^{\rightarrow} = 15\ W$$

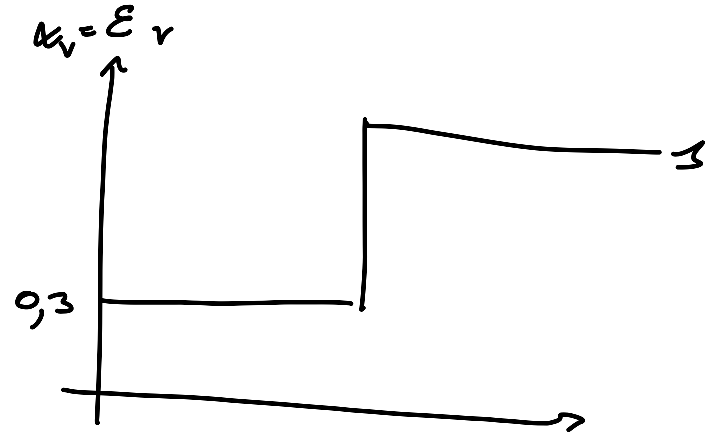
$$\dot{Q}_{rad}^{\rightarrow} = \sigma A_v \varepsilon_v (T_v^4 - T_p^4)$$

$$T_v = \left[T_p^4 + \frac{\dot{Q}_{rad}}{\sigma A_v \varepsilon_v}\right]^{1/4} = 428,9\ K = 155,75°C$$

$T_{tung} = 2700K$







Esercizio Joule-Brayton (Non per irraggiamento

$\eta_{J,B} = 0{,}27$ $\dot{m} = 12\,kg/s$

$M_m = 28{,}97\,kg/mol$ $\beta = 4{,}134 = \frac{P_2}{P_1}$

gas biatomico $T_4 \overset{\text{uscita turbina}}{=} 820\,K$

$\eta_c = 0{,}89$

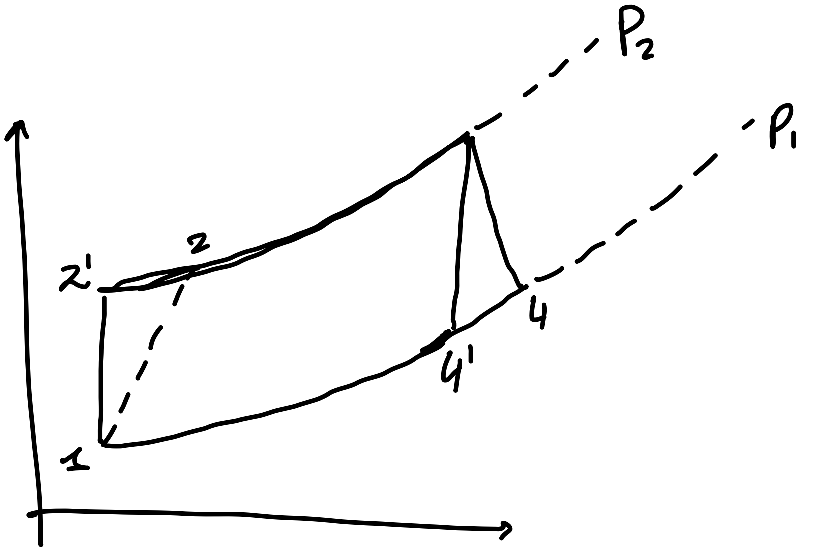
INGRESSO COMPRESSORE $T_1 = 400\,K$ $P_1 = 200\,kPa$

? $q_{in}^{\leftarrow}$? $q_{out}^{\rightarrow}$? $l_c^{\leftarrow}$? $l_T^{\rightarrow}$? $\dot{L}_u$

$? \dot{Q}^{\leftarrow}_{ng\ max}$ $\quad ? \eta_{JB\ R_{max}}$

$$c_p = \frac{7}{2}\frac{R}{M_m} = 1004,51 \ \frac{J}{kg \cdot K}$$

$$k = \frac{c_p}{c_v} = 1,4$$



$$T_{2'} = T_1 \left(\frac{P_2'}{P_1}\right)^{\frac{R}{c_p}} = T_1 \cdot \beta^{\frac{R}{c_p}} = 600,02K$$

$$\eta_c = \frac{m c_p (T_{2'} - T_1)}{m c_p (T_2 - T_1)} \qquad T_2 = T_1 + \frac{T_{2'} - T_1}{\eta_c} = 624,74K$$

$$q^{\rightarrow}_{OUT} = c_p (T_4 - T_1) = 421894,2 \ \frac{J}{kg}$$

$$\eta_{JB} = 1 - \frac{q^{\rightarrow}_{OUT}}{q^{\rightarrow}_{IN}} \rightarrow q^{\leftarrow}_{IN} = 577937,3 \ \frac{J}{kg}$$

$$\dot{q}^{\leftarrow}_{IN} = c_p (T_3 - T_2) \rightarrow T_3 = T_2 + \frac{\dot{q}^{\leftarrow}_{IN}}{c_p} = 1200,08 \ K$$

$$l_c^{\leftarrow} = c_p (T_2 - T_1) = 225753,6 \ \frac{J}{kg}$$

$$l_T^{\rightarrow} = c_p (T_3 - T_4) = 381\,794,2 \ \frac{J}{kg}$$

$$L_u^{\rightarrow} = \dot{m} \left(l_T^{\rightarrow} - l_c^{\leftarrow} \right) = 1872487 W$$

$$\dot{Q}^{\leftarrow}_{rig\,max} = \dot{m}\, c_p \big(\underbrace{T_{2R}}_{= T_4} - T_2 \big) = 2333\,687 W$$

$$\dot{q}_{in\,rig} = c_p \big(T_3 - \underbrace{T_{2R}}_{= T_4} \big) = 381794,2 \ \frac{J}{kg}$$

$$\eta_{J.B.\,rig\,max} = \frac{l^{\rightarrow}_{u\,rig}}{\dot{q}^{\leftarrow}_{in\,rig}} = \frac{l_T^{\rightarrow} - l_c^{\leftarrow}}{q^{\leftarrow}_{in,\,rig}} = 0,4087$$