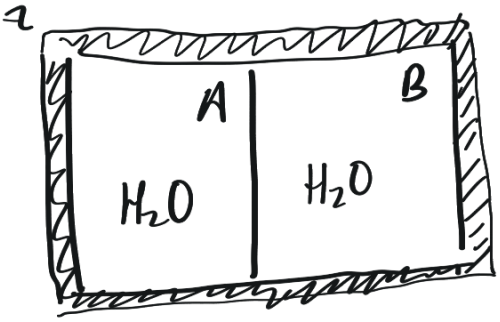
Esercitazione 5- Sistemi Chiusi

Esercitazione 4) Esercizio 4)

4.



Hp. Sistema Isolato

Liquido Incomprimibile

Da memorizzare

$$c^A = c^B = 4186 \ \frac{J}{kg\,K}$$

$M^A = M^B = 1\,kg$

$T_1^A = 353,15\,K$

$T_2^B = 293,15\,kg$

Stato finale 2 di equilibrio

? T_2^A ? T_2^B ? S_{IRR}

$E = A \cup B$

$\Delta U \overset{PR\ ADD.}{=} \Delta U^A + \Delta U^B = \cancel{Q}^{\,0\ adiabatico} - \cancel{L}^{\,0} = 0$ ← proprietà additiva

$\Delta S_U \overset{PR\ ADD.}{=} \Delta S^A + \Delta S^B = \cancel{\delta}^{\,0} + S_{IRR}$

$\Delta U^A \overset{L.I.}{=} M^A c (T_2^A - T_1^A)$

$\Delta U^B \overset{L.I.}{=} M^A c (T_2^B - T_1^B)$

(2) $T_2^A = T_2^B = T_2$

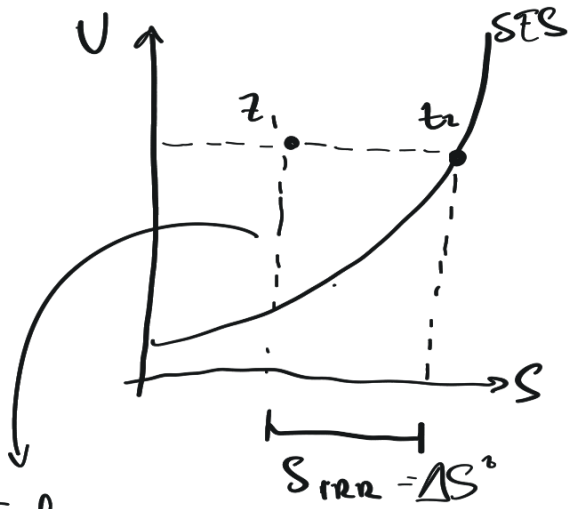
$\Delta U^A + \Delta U^B = 0$

$M_A (T_2 - T_1^A) + M_C (T_2 - T_1^B)$

$T_2 = \frac{T_1^A + T_1^B}{2} = 323,15\,K$

$$\Delta S^3 = S_{irr} = \Delta S^A + \Delta S^B \overset{L.T}{=} Mc\left(\ln\frac{T_2}{T_1^A} + \ln\frac{T_2}{T_1^B}\right) =$$

$$= 36,23\ J/K \rightarrow \text{possibile irreversibile}$$



SISTEMA 3

Se fosse così sarebbe un processo meccanico reversibile

Per trovare processo reversibile

$$\begin{cases} (U_2 - U_1)^3 = Q^{3\leftarrow} - L^{\leftrightarrow} \\ (S_2 - S_1)^3 = S^{3\leftarrow} + \cancel{S_{IRR}} \end{cases} \rightarrow \text{processo reversibile}$$

$$\Delta U = 0$$

$$\Delta S = 36,23\ \frac{J}{K}$$

Dati qualsiasi punti 1 e 2 in un sistema TD esiste un processo reversibile e posso fare quello che voglio

Serbatoi

$$\Delta U = T\Delta S$$

Gli scambi con serbatoi occorrono anche con ΔT infinitesimo

$$ds^{\leftarrow} = \frac{dQ^{\leftarrow}}{T}$$

$T_0 = 293{,}15\,K$

$$\boxed{S^{\leftarrow} = \frac{Q_0^{\leftarrow}}{T_0}}$$

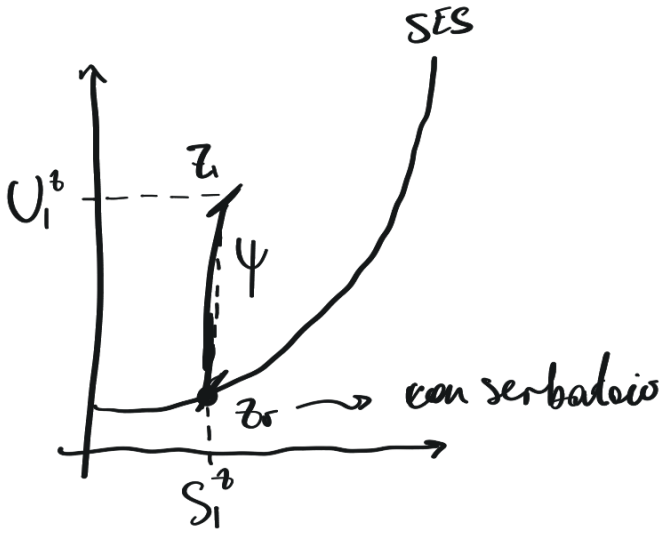
La entalpia scambiata è la Q scambiata con il serbatoio diviso per la T del serbatoio

$$\begin{cases} Q_0^{\leftarrow} - L^{\rightarrow} = 0 \rightarrow Q_0^{\leftarrow} = L^{\rightarrow} \\ \Delta S^2 = S^{\leftarrow} = \dfrac{Q_0^{\leftarrow}}{T_0} \rightarrow \dfrac{Q_0^{\leftarrow}}{293{,}15} = 36{,}25\ \dfrac{J}{K} \end{cases}$$

$$Q^{\leftarrow} = 10633\,J \rightarrow L^{\rightarrow} = 10623\,J$$

↓

ha senso perché ΔS era > 0 quindi stavamo perdendo calore



$\psi \rightarrow L^{\rightarrow}$

$$\psi_{10}^a = \left(L_{b1\rightarrow 0}\right)_{PMR}$$

↳ Processo Meccanico Reversibile

$Q^{\leftarrow} = 0 \ \wedge \ S^{\rightarrow} = 0$

$$\begin{cases} (U_0 - U_1)^A + (U_0 - U_1)^B = \cancel{Q_{10}^{\to 0}} - L_{10} \\ (S_0 - S_1)^A + (S_0 - S_1)^B = \cancel{S_{10}^{\to 0}} + S_{IRR} \end{cases}$$

$S_{IRR} \to 0$ processo meccanico reversibile

$$\begin{cases} \Psi_{10}^2 = L_{10\,max}^{\to b} = M_c \left(T_1^A + T_1^B - 2\overline{T_0} \right) = 11{,}69\,kJ \\ M_c \ln \dfrac{T_0^2}{T_1^A T_1^B} = 0 \to T_0 = \sqrt{T_1^A T_1^B} = 321{,}6\,K \end{cases}$$

Esercitazione 6 → servono tabelle dell'acqua

⑤ $M = 0{,}6\,kg$ H_2O

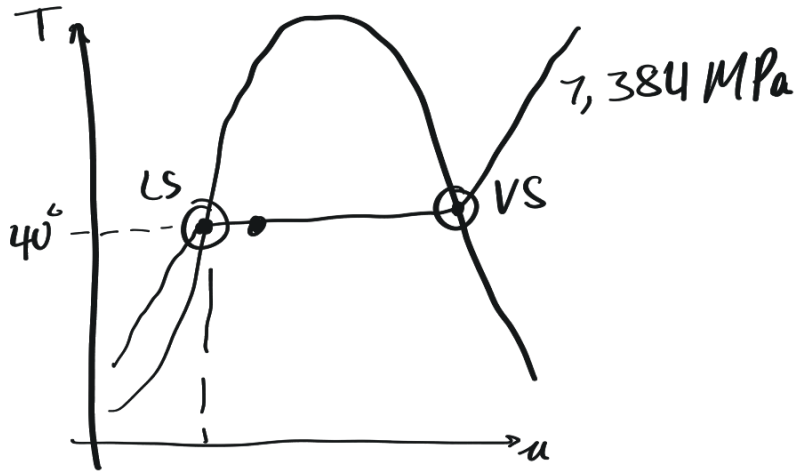
$T = 40°C = 313{,}15\,K$

$U = 320\,kJ$

?V

Bifase/Miscela → Tabelle a singola entrata

Vapore Sovrariscaldato → Tabelle a doppia entrata



$$u = \frac{U}{M} = \frac{320\ kJ}{0,6} = 533\ \frac{kJ}{kg}$$

$u_l = 167,53\ \frac{kJ}{kg}$

$u_g = u_v = 2429,4\ \frac{kJ}{kg}$

$u_l < u < u_g \Rightarrow$ siamo in stato bifase a $T = 110°C$

$$\text{Titolo } X = \frac{u - u_l}{\underbrace{u_v - u_l}_{u_{lg}}} = \frac{533,3 - 167,56}{2430,1 - 167,56} = 0,1524$$

↓ % di vapore

↳ già in tabella

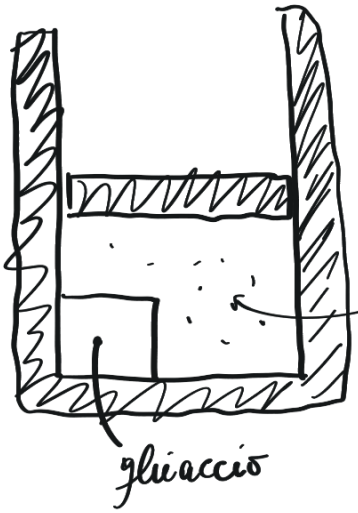
? V $\quad V = M \cdot v^* = M\left[(1-X)v_l + X v_v\right] = 1,785\ m^3$

$v_l = \cancel{1001,8}\ \cancel{1,0018}\ 0,0010018\ \frac{m^3}{kg}$

$v_g = 19,523\ \frac{m^3}{kg}$

↳ perché dovevamo dividere per 10000 non moltiplicare, sui degli numeri non sono moltiplicati

3)



$P = 2\,MPa$

$M_{V_1} = 7\,kg \quad M_{S_1} = 3\,kg$

$T_{V_1} = 623{,}15\,K$

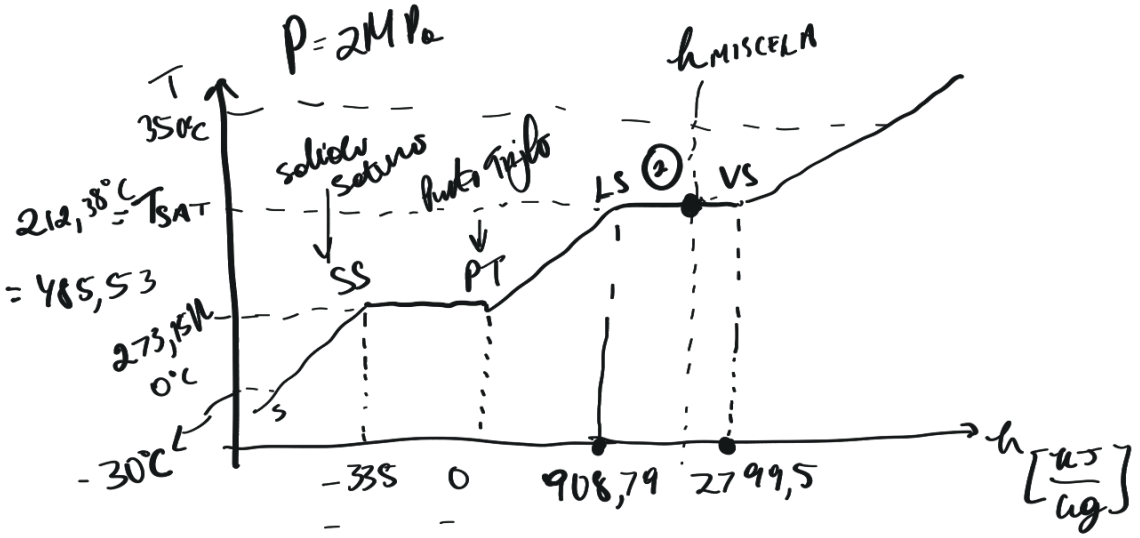
$T_{S_1} = 243{,}15\,K$

CONDIZIONI STATO FINALE $\quad ?\,M_{S_2} \quad ?\,M_{l_2} \quad ?\,M_{V_2}$

$?$ TITOLO

MISCELAZIONE ADIABATICA DI VAPORE + GHIACCIO

$$\Delta H = 0 \Rightarrow H_1 = H_2$$



$$M_{TOT} \cdot h_{TOT\,2} = M_{V1} \cdot h_{V1} + M_{S1} \cdot h_{S1}$$

$h_{TOT\,2}$: ? $\quad h_{V1}$: ? $\quad h_{S1}$: ?

$M_{TOT} = 10\,kg$

h_{V1} ← da tabelle vapore surriscaldato

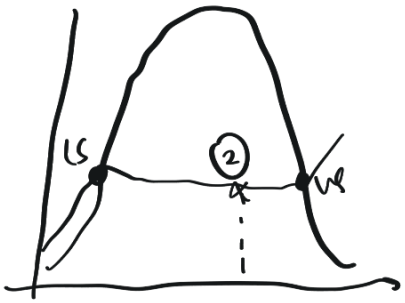
$h_{V1} = 3137 \frac{kJ}{kg}$

$$h_{s1} = -335 + c_s(\Delta T) = -335 \frac{kJ}{kg} + 2{,}0934 \frac{kJ}{kg \cdot K} \cdot (-30\,K)$$

$$= -397{,}8 \frac{kJ}{kg}$$

$$h_{TOT2} = \frac{M_{v1} h_{v1} + M_{s1} \cdot h_{s1}}{M_{TOT}} = 2076{,}56 \frac{kJ}{kg}$$

$h_{LS} < h_{TOT2} < h_{VS} \Rightarrow$ Bifase



$$h_{TOT_2} = (1-X) h_{LS} + X h_{VS}$$

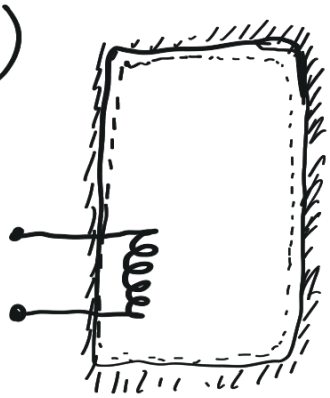
$$X = \frac{h_{TOT2} - h_{LS}}{h_{VS} - h_{LS}} = 0{,}62$$

$$M_{V2} = X \, M_{TOT} = 6{,}2\,kg$$

$$M_{L2} = (1-X) \cdot M_{TOT} = 3{,}8\,kg$$

6 e 7)

6)



$V = 0{,}06\,m^3$? P_2

$M = 0{,}3\,kg$ H_2O ? T_2 2è stato finale

$T = 333{,}15\,kg$

$\dot{L} = 1\,kW$

$t = 15' = 900s$

Adiabatico L non Q ← considerando resistenza come parte di sistema adiabatico

$$U_2 - U_1 = \cancel{Q}^{\leftarrow} - L^{\rightarrow} \qquad L^{\rightarrow} = -L^{\leftarrow}_{el} = \int_0^t \text{Watt} = \dot{L} \cdot t$$

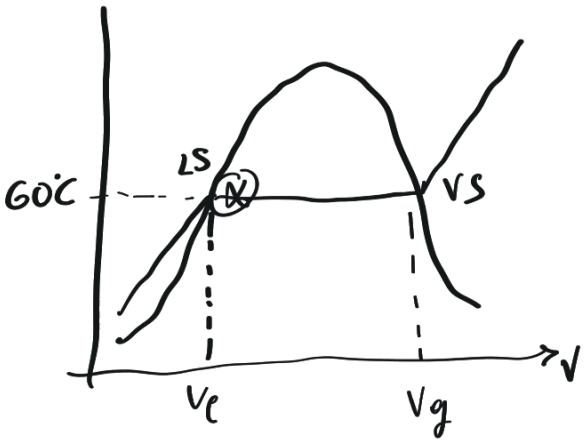
↳ 0 adiabatico

$$= 900\,kJ$$

$$\Delta U = U_2 - U_1 = L^{\leftarrow}_{el} = 900\,MJ$$

↑

Verifichiamo le fasi



$$V = v \cdot M \Rightarrow v = 0{,}2\ \frac{m^3}{kg} \qquad V_1 = 0{,}2$$

$$V_l = 0{,}001072\ \frac{m^3}{kg} \qquad V_l < V_1 < V_g \Rightarrow \text{BIFASE}$$

$$V_g = 7{,}671\ \frac{m^3}{kg}$$

$$U_1 = M u_1 = M(u_{l1} + X_1 u_{lg}) = 92{,}58$$

percentuale · differenza tra u_l e u_g

$$U_2 = U_1 + L^{\leftarrow}_{el} = 992{,}58\,kJ$$

$u_2 = \frac{U_2}{M} = 3308{,}6 \ \frac{kJ}{kg}$

sappiamo V perché non varia

A 180° → $v_g \simeq 0{,}2$ (V_2)

↳ $u_g = 2583{,}7 \ \frac{kJ}{kg} < (u_2)$

Non possiamo avere tutte e due nelle miscele

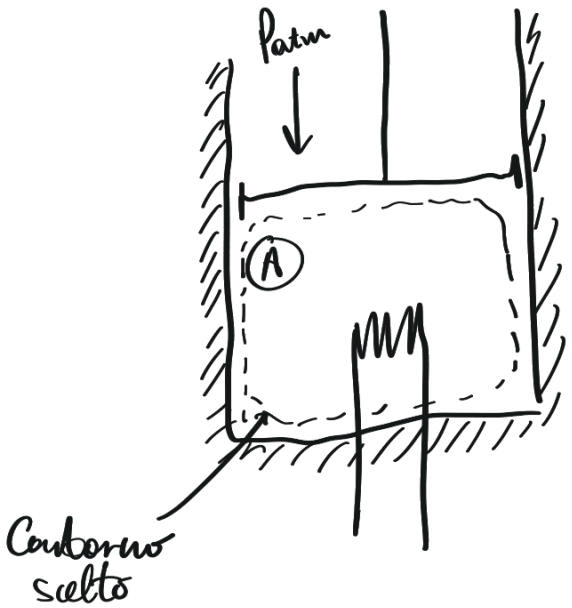
↳ dato che questo è preso dalle miscele

Nel tabelle di VS cerchiamo P_2 e T_2 che soddisfano

V_2 e u_2 → $P_2 = 2 MPa$ ←

$T_2 = 600°C$ ←

Esercizio 7



H_2O

$V_1 = 0{,}02 \ m^3$

$T_1 = 10°C$

$P_1 = P_{ATM} = 101325 \ Pa = P_2 = P$

$x_2 = 0{,}1$? h_2, v_2, s_2

↳ Titolo Finale

↳ Titolo ⇔ Bifore

? L_{el}° ← ? Me_2

$\Delta U_A = U_{2A} - U_{1A} = L^{\circlearrowright} = -L_{el}$ ←

$h_l = 419,04 \quad h_g = 2676,1$

$h_2 = X h_g + (1-X) h_l = 0,1 \cdot 2676,1 \frac{kJ}{kg} + 0,9 \cdot 419,04 \frac{kJ}{kg} =$

$= 644,7 \frac{kJ}{kg}$

$v_2 = 0,168 \frac{m^3}{kg} \qquad s_2 = 1,9 \frac{kJ}{kgK}$

$(U_2 - U_1)^A = \overleftarrow{Q} - \overrightarrow{L} = \overleftarrow{Q}^{0} - \overrightarrow{L_{el}} - \overrightarrow{L_{esp}}$

↳ Adiabatico

$\overrightarrow{L_{esp}} = \int_1^2 P\,dV \overset{\text{ISOBARO}}{=} P(V_2 - V_1) =$

$U_2 - U_1 = \overleftarrow{L_{el}} - (PV_2 - PV_1)$

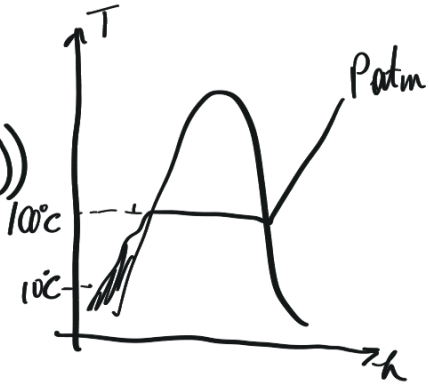
$\overleftarrow{L_{el}} - (U_2 - PV_2) - (U_1 - PV_1) = H_2 - H_1$

$\overleftarrow{L_{el}} = M_{tot}(h_2^* - h_1^*)$ ← Come detto tempo fa si potrebbero tagliare le *

$M = \rho \cdot V = \frac{V}{v} = \frac{0,002\ m^3}{0,001\ m^3/kg} = 2kg$

$h_1^{@}(P, T) = h_{ls}^{@}(10°C) + v_{es}(P - P_{sat}^{@}(10°C))$

Patm 10°C



$= 41990 \left[\frac{J}{kg}\right] + 0,01 \frac{m^3}{kg} \cdot (101325\ Pa - 1236\ Pa) = 42,090 \frac{J}{kg}$

$\overleftarrow{L_{el}} = M(h_2 - h_1) = 1202\ kJ$

$$M_{ez} = (1 - X_n) M = 0{,}9 \cdot 2\,kg = 1{,}8\,kg$$

Fine sistemi chiusi