Politecnico di Milano - Polo Territoriale di LECCO

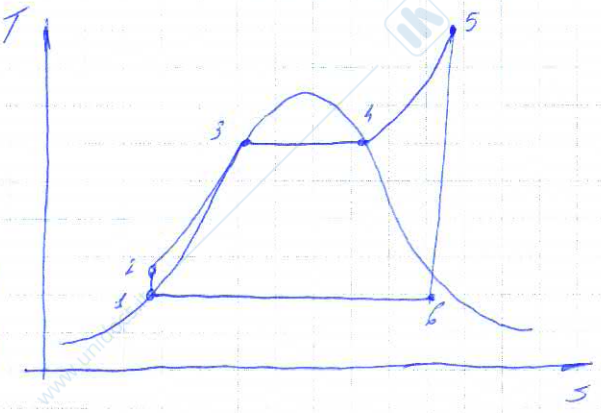
| COGNOME | NOME | FIRMA |
|---|---|---|
| ESAME DI: FISICA TECNICA | | N. MATRICOLA |
| CORSO DI LAUREA | | DATA 19-07-2011 |

1) 5/5

$T_{min} = 60°C$

$T_{max} = 500°C$

$P_{max} = 150\ bar = 15.000\ kPa$




| | P [kPa] | T [°C] | h [kJ/kg] | s [kJ/kgK] | x |
|---|---|---|---|---|---|
| 1 | 19,940 | 60 | 251,13 | 0,8312 | 0 |
| 2 | 15000 | ≃ 60 | 266,53 | 0,8312 | <0 |
| 3 | 15000 | 342,24 | 1610,5 | 3,6848 | 0 |
| 4 | 15000 | 342,24 | 2610,5 | 5,3098 | 1 |
| 5 | 15000 | 500 | 3308,6 | 6,3443 | >1 |
| 6 | 19,940 | 60 | 2088 | 6,3443 | 0,78 |

- Punto 2

$T_2 \simeq T_1 \Rightarrow 60°C$ · da tabella $v_{19,940} = 0,001017$

$h_2 = h_1 + v(\Delta P_{12}) = 251,13 + 0,001017(15000 - 19,940) = 266,53$ kJ/kg

- Punto 3/4 vedi tab $p = 15\ MPa$
- Punto 5 vedi tab $p = 15\ MPa$ $T = 500°C$
- Punto 6

$T = 60°C$

| | h | s |
|---|---|---|
| x = 0 | 251,13 | 0,8312 |
| x = 1 | 2609,6 | 7,9096 |

$\frac{s_6 - s_0}{s_1 - s_0} = \frac{6,3443 - 0,8312}{7,9096 - 0,8312} = 0,77886$

$h_6 = 0,77886(2609,6 - 251,13) + 251,13 = 2088$

$x_6 = 0,7786(1 - 0) + 0) = 0,78$

- Rendimento

$\eta = \frac{|h_5 - h_6| - |h_2 - h_1|}{|h_5 - h_2|} = \frac{|3308,6 - 2088| - |266,53 - 251,13|}{|3308,6 - 266,53|} = 0,396$

2) 5/5

$T_1 = 14,5°C$ $\varphi = 1$ $m_1 = m_2$

$T_2 = 30°C$ $\varphi = 0,7$

Da tabella $p_{vs1} = 1,46635\ kPa$ $p_{vs2} = 4,246\ kPa$

$$x_1 = \frac{0,1622\ \varphi p_{vs}}{101325 - \varphi p_{vs}} = \frac{0,1622 \cdot 1 \cdot 1466,35}{101325 - 1466,35} = 0,0091$$

$$x_2 = \frac{0,1622 \cdot 0,7 \cdot 4246}{101325 - 4246} = 0,0190$$

$$x_m = \frac{m x_1 + m x_2}{m+m} = \frac{x_1 + x_2}{2} = \frac{0,0091 + 0,0190}{2} = 0,01405$$

$$T_m = \frac{m T_1 + m T_2}{m+m} = \frac{T_1 + T_2}{2} = \frac{14,5 + 30}{2} = 21,25$$

Leggo su grafico

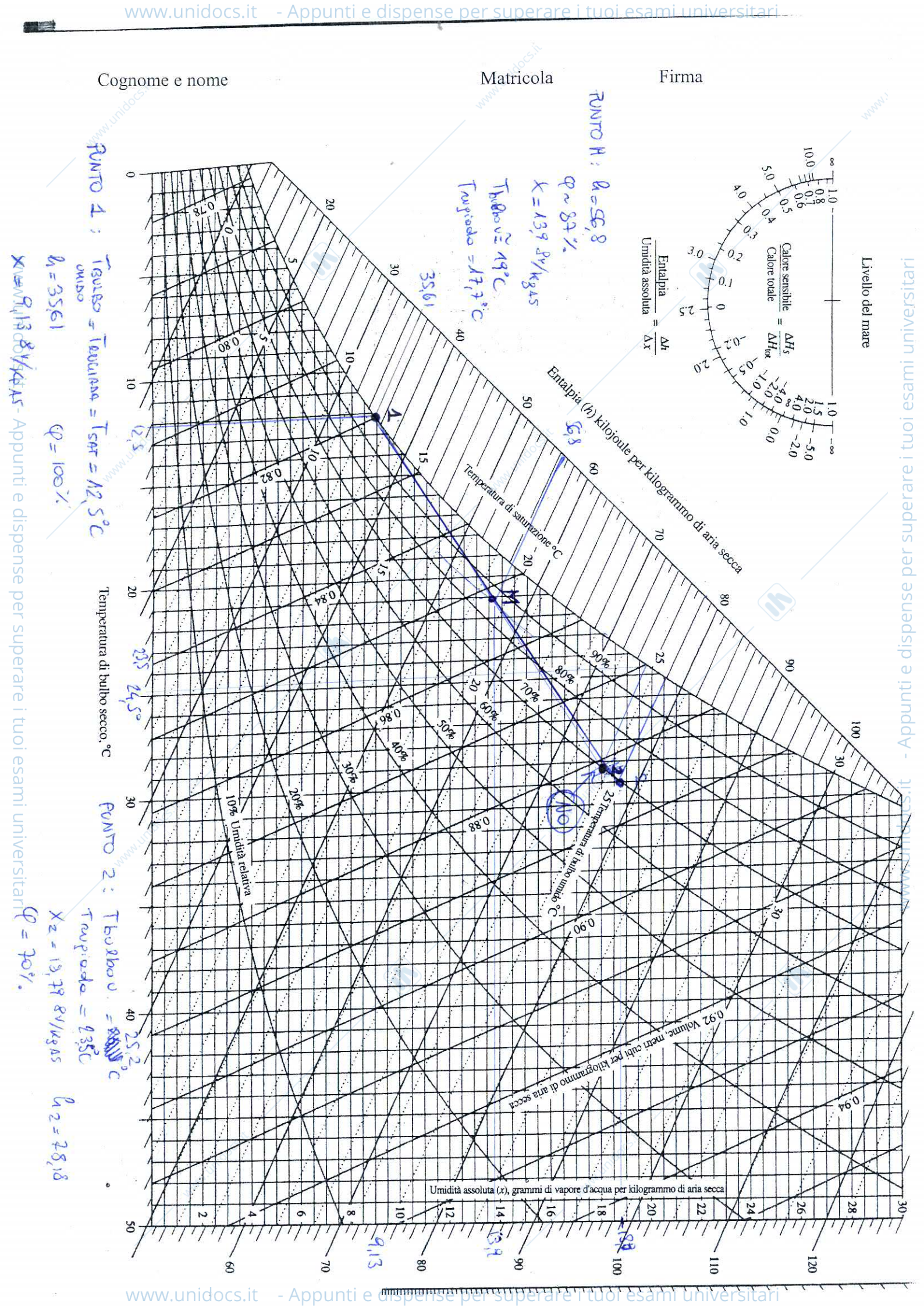
Umidità assoluta $= 14\ g/kg_{as}$

$$p_{VAP} = \frac{x \cdot 101325}{0,1622 + x} = \frac{0,01405 \cdot 101325}{0,1622 + 0,01405} = 2238\ Pa$$

$p_{VAP} = \varphi p_{SAT}$ $p_{SAT\ 21,5°C} = 2588\ Pa$

$$\varphi = \frac{p_{vap}}{p_{SAT}} = \frac{2238}{2588} = 0,865$$

Cognome e nome Matricola Firma




PUNTO 1: $T_{BULBO} = T_{BAGNATA} = T_{SAT} = 12,5°C$ UMIDO
$h_1 = 35,61$
$\varphi = 100\%$
$x = 9,13$ gV/kgAS

PUNTO H: $h = 56,8$
$\varphi \sim 82\%$
$x = 13,9$ gV/kgAS
$T_{bulbo} \sim 19°C$
$T_{rugiada} = 17,7°C$

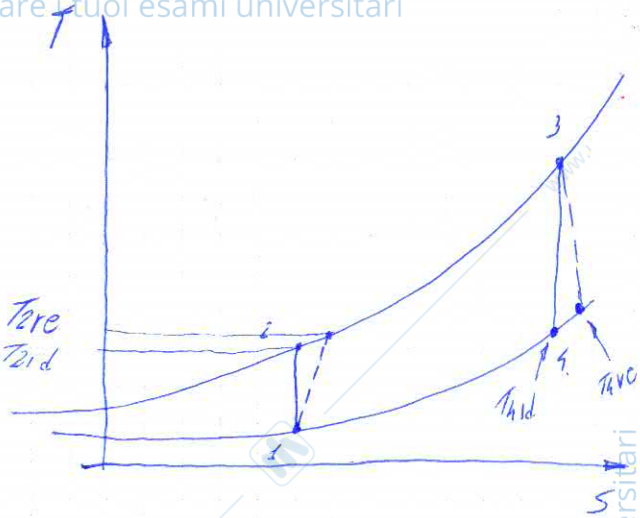
PUNTO 2: $T_{bulbo} = 25,2°C$
$T_{rugiada} = 9,3°C$
$x_2 = 18,78$ gV/kgAS
$h_2 = 28,18$
$\varphi = 70\%$

3) $T_1 = 30°C = 303\ K$ $\quad \eta_{comp} = \eta_{turb} = 0,9$

4/4 $P_1 = 1\ bar$ $\quad T_{max} = 1200°C = 1473\ K$

$\beta = 14$

| | $T_{id}$ | $P$ kPa |
|---|---|---|
| 1 | 303 | 100 |
| 2 | 644 | 1400 |
| 3 | 1473 | 1400 |
| 4 | 693 | 100 |




- Punto 2

$$\frac{T_2}{T_1} = (\beta)^{\frac{\gamma-1}{\gamma}} \qquad \gamma = \frac{c_p}{c_v} = \frac{1,005}{0,718} = 1,4$$

$$T_{2id} = (\beta)^{\frac{\gamma-1}{\gamma}} T_1 = (14)^{\frac{1,4-1}{1,4}} \cdot 303 = 644\ K$$

$T_{2re}$: $\quad \Delta T_{re} = \frac{\Delta T_{12id}}{\eta_c} = \frac{644 - 303}{0,9} = 378,89\ K$

$$T_{2re} = T_1 + \Delta T_{re} = 303 + 378,89 = 681,9\ K$$

~~$\beta =$~~ $\frac{P_2}{P_1} \Rightarrow P_2 = \beta \cdot P_1 = 14 \cdot 100 = 1400\ kPa$

- Punto 3 $\quad P_3 = P_2$

- Punto 4

$$\frac{T_3}{T_4} = \left(\frac{P_3}{P_4}\right)^{\frac{\gamma-1}{\gamma}} \Rightarrow T_4 = \frac{T_3}{(P_3/P_4)^{\frac{\gamma-1}{\gamma}}} = \frac{1473}{(14)^{\frac{1,4-1}{1,4}}} = 693,0\ K$$

$\Delta T_{4re}$: $\quad \Delta T_{re} = \Delta T_{34}\, \eta_{turb} = (1473 - 693)\, 0,9 = 702\ K$

$$T_{4re} = T_3 - \Delta T_{34re} = 1473 - 702 = 771\ K$$

- Rendimenti

$$\eta_1 = \frac{\Delta T_{34re} - \Delta T_{12re}}{\Delta T_{23re}} = \frac{702 - 378,89}{1473 - 681,9} = 0,408 \qquad \eta_c = 1 - \frac{T_1}{T_3} = 1 - \left(\frac{303}{1473}\right) = 0,79$$

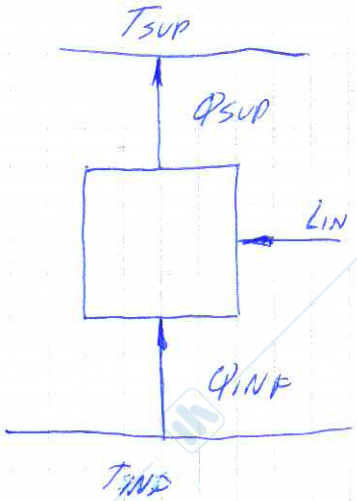
$$\eta_2 = \frac{\eta_1}{\eta_c} = \frac{0,408}{0,79} = 0,516$$

4)

$L_{IN} = 700\,W$ $\quad COP_{re} = 0{,}6\,COP_{id}$

$T_{LOC} = 22°C$ $\quad \Delta T_{ev} = 12°C$

$T_{est} = 10°C$ $\quad \Delta T_{cond} = 25°C$




$T_{SUP} = T_{LOC} + \Delta T_{cond} = 22 + 25 = 47°C = 320K$

$T_{INF} = T_{EST} - \Delta T_{EV} = 10 - 12 = -2°C = 271K$

$$COP_{id} = \frac{T_{SUP}}{T_{SUP} - T_{INF}} = \frac{320}{320-271} = 6{,}53$$

$COP_{re} = 0{,}6\,COP_{id} = 3{,}92$

$\Phi_{SUP} = L_{IN} \cdot COP_{RE} = 700 \cdot 3{,}92 = 2744\,W$

$\Phi_{INF} = \Phi_{SUP} - L_{IN} = 2744 - 700 = 2044\,W$

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5) 4/4

$\varnothing_1 = 18\,mm \rightarrow A = 254{,}47\,mm^2 = 2{,}5447 \cdot 10^{-4}\,m^2$

$T_1 = 20°C = 293\,K \qquad T_2 = -12°C = 261\,K$

$P_1 = 3\,bar\,rel$

$w_1 = 30\,m/s \qquad w_2 = 320\,m/s$

- Hp: $P_{amb} = 1\,bar \rightarrow P_1 = 4\,bar \qquad R = 0{,}2870\ \frac{kJ/kg\,K}{} \rightarrow$ tabelle $\qquad c_p = 1{,}005\ kJ/kg\,K$

- $\dot{m}_1 = \rho_1 w_1 A_1 = 4{,}76\ kg/m^3 \cdot 30\ \frac{m}{s} \cdot 2{,}5447 \cdot 10^{-4}\,m^2 = 0{,}0363\ kg/s$

$\rho_1 = \frac{P_1}{R T_1} = \frac{400\,000}{287 \cdot 293} = 4{,}76\ kg/m^3$

- $\rho_1 A_1 w_1 = \rho_2 A_2 w_2$

$\rho_2 = \frac{\rho_1 w_1 A_1}{w_2 A_2} = \frac{4{,}76 \cdot 30}{320} = 0{,}44625\ kg/m^3$

- $P_2 = \rho_2 R T_2 = 0{,}44625 \cdot 287 \cdot 261 = 33427\ P_2 \Rightarrow 0{,}33\ Bar$

- $\dot{m}_2 = \rho_2 w_2 A_2 = 0{,}44625 \cdot 320 \cdot 2{,}5447 \cdot 10^{-4} = 0{,}0363\ kg/s$

- $\Delta S = \dot{m}\left(c_p \ln \frac{T_2}{T_1} - R \ln \frac{P_2}{P_1}\right) = 0{,}0363\left(1005 \ln \frac{261}{293} - 287 \ln \frac{33427}{400000}\right) = 2{,}64\ W/K$

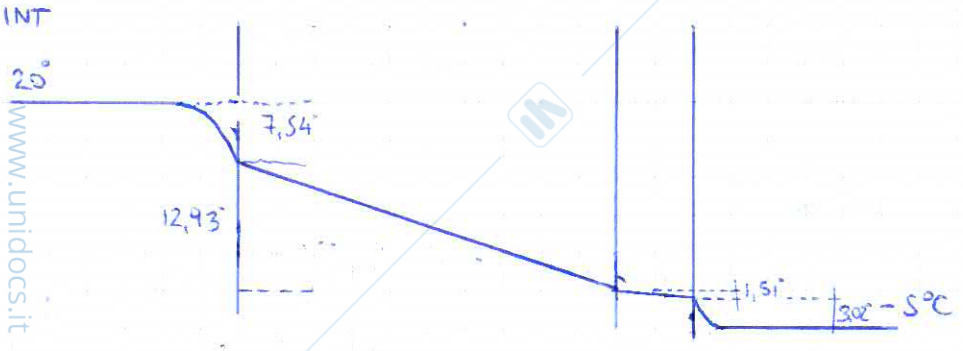
⑥ $A = 8 \times 3 = 24\ m^2$ $\quad T_i = 25°C$ $\quad T_{est} = -5°C$ $\quad \Delta T = 25°C$

4/4 $s = 0{,}2\ m$, $\lambda = 0{,}7\ W/mK$ } MATTONI

$s = 0{,}04\ m$, $\lambda = 1{,}2\ W/mK$ } RIVEST.

$h_{est} = 15\ W/m^2K$

$h_{INT} = 6\ W/m^2K$




$$R_{conv\ i} = \frac{1}{h_i A} = \frac{1}{6 \cdot 24} = 0{,}00694\ K/W$$

$$R_{MATTONI} = \frac{s_M}{\lambda_M A} = \frac{0{,}2}{0{,}7 \cdot 24} = 0{,}0119\ K/W$$

$$R_{\text{~~ISOLANTE~~ RIVESTIM.}} = \frac{s_R}{\lambda_R A} = \frac{0{,}04}{1{,}2 \cdot 24} = 0{,}001{,}39\ K/W$$

$$R_{conv\ est} = \frac{1}{h_e A} = \frac{1}{15 \cdot 24} = 0{,}00278\ K/W$$

$R_{TOT} = 0{,}02301\ K/W$

$$\dot{Q} = \Delta T / \Sigma R_i = 25\ K / 0{,}02301\ K/W = 1086{,}5\ W$$

$\Delta T_1 = \dot{Q} R_{conv\ i} = 7{,}54031\ K$

$\Delta T_2 = \dot{Q} R_{MAT} = 12{,}93\ K$

$\Delta T_3 = \dot{Q} R_{RIV} = 1{,}51\ K$

$\Delta T_4 = \dot{Q} R_{conv\ est} = 3{,}02\ K$

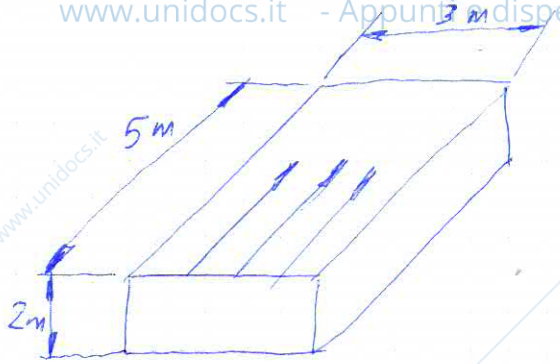
$T_{sup\ int} = 12{,}46°C$

$T_{MAT-RIV} = -0{,}47°C$

$T_{sup\ est} = -1{,}98°C$

7)

4/6




$\rho_g = 2750\ kg/m^3$

$\lambda_g = 3\ W/m.K$

$c_{p_g} = 0{,}8\ KJ/kgK$

$T_i = 50°C$

$W = 30\ km/h = 8{,}3\ m/s$

$T_W = 20°C$

- $T_{film} = \frac{T_i + T_\infty}{2} = \frac{50+20}{2} = 35°C = 308K$

$\rho_{film} = 0{,}8\,(1{,}143 - 1{,}177) + 1{,}177 = 1{,}1498\ kg/m^3$

$\mu_p = 0{,}8\,(1{,}90\cdot10^{-5} - 1{,}85\cdot10^{-5}) + 1{,}85\cdot10^{-5} = 1{,}89\cdot10^{-5}\ kg/ms$

$\lambda_p = 0{,}8\,(0{,}0268 - 0{,}0261) + 0{,}0261 = 0{,}02666\ W/m°C$

$Pr = 0{,}8\,(0{,}711 - 0{,}712) + 0{,}712 = 0{,}7112$

- $Re = \frac{\rho W L}{\mu} = \frac{1{,}1498 \cdot 8{,}3 \cdot 5}{1{,}89\cdot10^{-5}} = 2\,524\,693$

$Re > 500\,000$

$Nu = (0{,}037\ Re^{4/5} - 871)\,Pr^{1/3} = (0{,}037 \cdot 2524693^{4/5} - 871)\ 0{,}7112^{1/3} = 3594{,}05$

- $h = \frac{Nu\,\lambda_p}{L} = \frac{3594{,}05 \cdot 0{,}02666}{5} = 19{,}16\ W/m^2K$

- $Bi = \frac{h L_c}{\lambda_g} = \frac{19{,}16 \cdot \frac{5\times3\times2}{5\times3}}{3} = 12{,}77 \simeq 13$

- $Bi > 0{,}1$ $\quad \alpha = 2{,}322\cdot10^{-5}$ → tabella → $\lambda_1 = 1{,}44906$ $\quad A_1 = 1{,}26437$

$\vartheta_{(x,t)} = \frac{T_{(x,t)} - T_\infty}{T_i - T_\infty} = A_1 e^{-\lambda_1^2 \tau} \cos\left(\frac{\lambda_1 x}{L}\right)$

$\tau = \frac{\alpha t}{L^2} = \frac{2{,}322\cdot10^{-5} \cdot 3600}{5^2} = 3{,}34\cdot10^{-3} < 0.2$