

COGNOME                     

NOME                     

FIRMA                     

ESAME DI: FISICA TECNICA

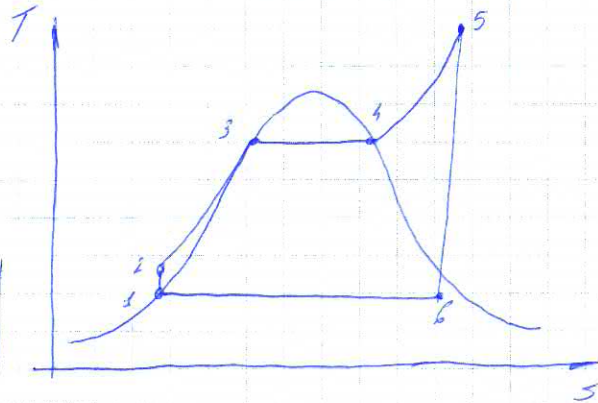
N. MATRICOLA                     

CORSO DI LAUREA

DATA 19-07-2011

1)  $T_{min} = 60^\circ C$   
 $T_{max} = 500^\circ C$   
 $P_{max} = 150 \text{ bar} = 15000 \text{ kPa}$

	$P [\text{kPa}]$	$T [^\circ C]$	$h [\text{kJ/kg}]$	$s [\text{kJ/kg}]$	$x$
1	19,940	60	251,13	0,8312	0
2	15000	$\approx 60$	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	6,13443	0,78



• Punto 2

$$T_2 \approx T_1 \Rightarrow 60^\circ C \quad \text{da tabella } v_{19,940} = 0,001017$$

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

• Punto 3/4 vedi tab  $p = 15 \text{ MPa}$

• Punto 5 vedi tab  $p = 15 \text{ MPa}$   $T = 500^\circ C$

• Punto 6

	$h$	$s$
$T = 60^\circ C$		
$x = 0$	251,13	0,8312
$x = 1$	2609,6	7,9096

$$\frac{s_6 - s_0}{s_1 - s_0} = \frac{6,13443 - 0,8312}{7,9096 - 0,8312} = 0,77886$$

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

$$x_6 = 0,77886(1 - 0) + 0 = 0,78$$

• Rendimento

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

$$2) \quad T_1 = 125^\circ\text{C} \quad \varphi = 1 \quad m_1 = m_2$$

$$s/s \quad T_2 = 30^\circ\text{C} \quad \varphi = 0,7$$

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

$$x_1 = \frac{0,1622 \cdot \varphi P_{vs}}{101325 - \varphi P_{vs}} = \frac{0,1622 \cdot 1 \cdot 1,46635}{101325 - 1,46635} = 0,0091$$

$$x_2 = \frac{0,1622 \cdot 0,7 \cdot 4,246}{101325 - 4,246} = 0,0190$$

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

$$T_m = \frac{m T_1 + m T_2}{m + m} = \frac{T_1 + T_2}{2} = \frac{125 + 30}{2} = 21,5^\circ\text{C}$$

Leggo su grafico

$$\text{Umidit  assoluta} = 14 \text{ g/kg}_{\text{as}}$$

$$P_{\text{vap}} = \frac{x \cdot 101325}{0,1622 + x} = \frac{0,01405 \cdot 101325}{0,1622 + 0,01405} = 2238 \text{ Pa}$$

$$P_{\text{vap}} = \varphi P_{\text{SAT}} \quad P_{\text{SAT } 21,5^\circ\text{C}} = 2588 \text{ Pa}$$

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



Cognome e nome

Matricola

Firma

PUNTO H:  $h = 56,8$

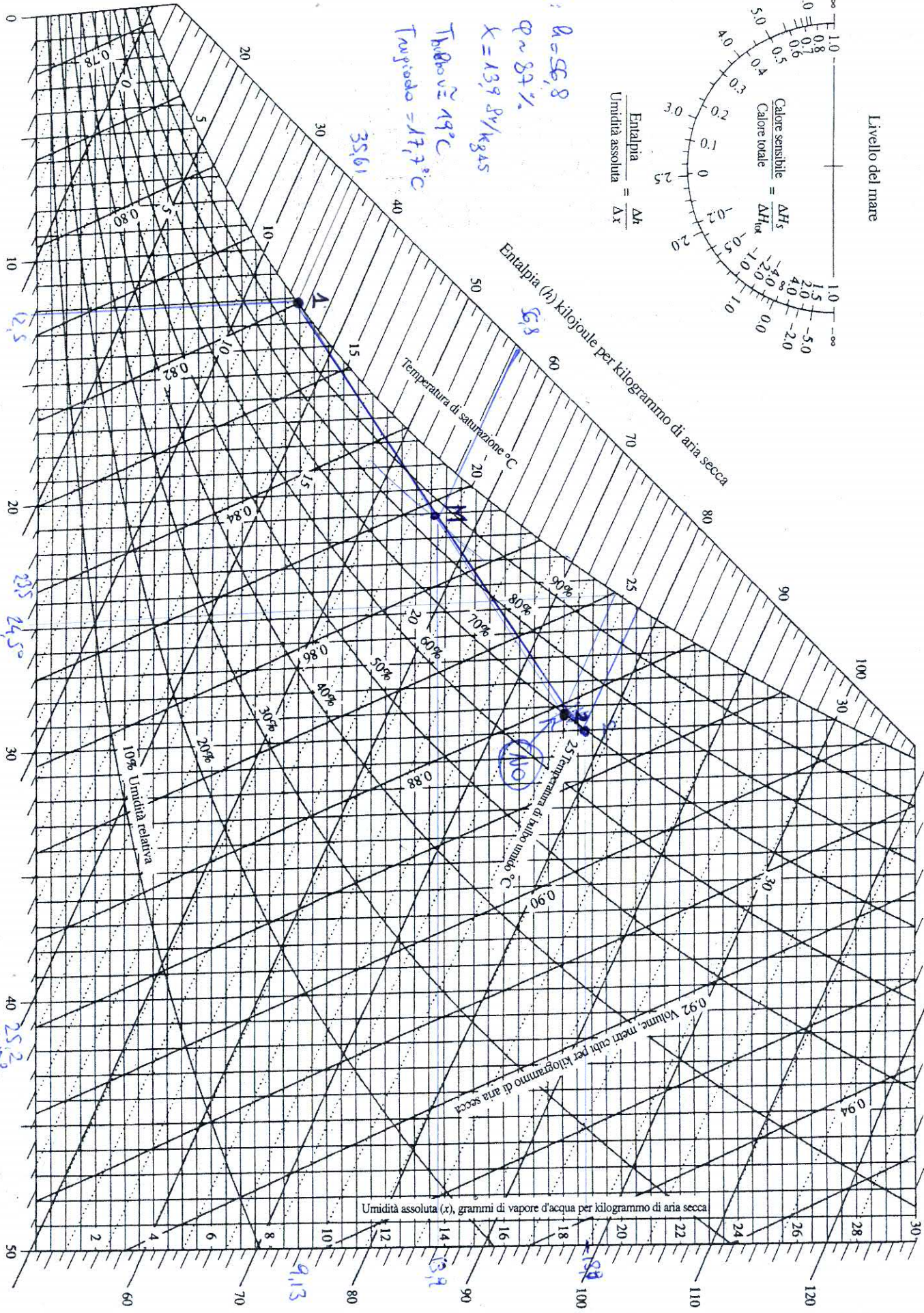
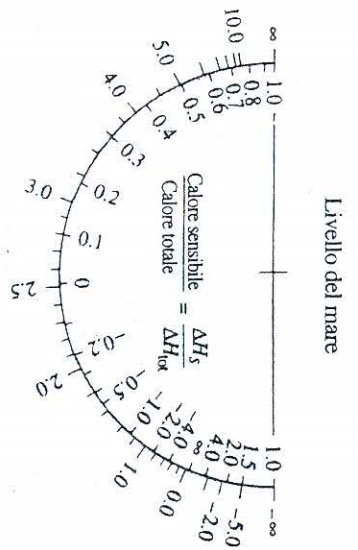
$\phi \sim 87\%$

$x = 13,98 \text{ g/kg AS}$

$T_{\text{bulbo}} \sim 19^\circ\text{C}$

$T_{\text{umido}} = 17,7^\circ\text{C}$

35,61



PUNTO A:  $T_{\text{bulbo}} = T_{\text{umido}} = T_{\text{SAT}} = 12,5^\circ\text{C}$

UMIDO

$h_1 = 35,61$

$\phi = 100\%$

Temperatura di bulbo secco, °C

PUNTO B:  $T_{\text{bulbo}} = 25,2^\circ\text{C}$

$T_{\text{umido}} = 17,7^\circ\text{C}$

$x_2 = 13,98 \text{ g/kg AS}$

$h_2 = 28,18$

$\phi = 70\%$



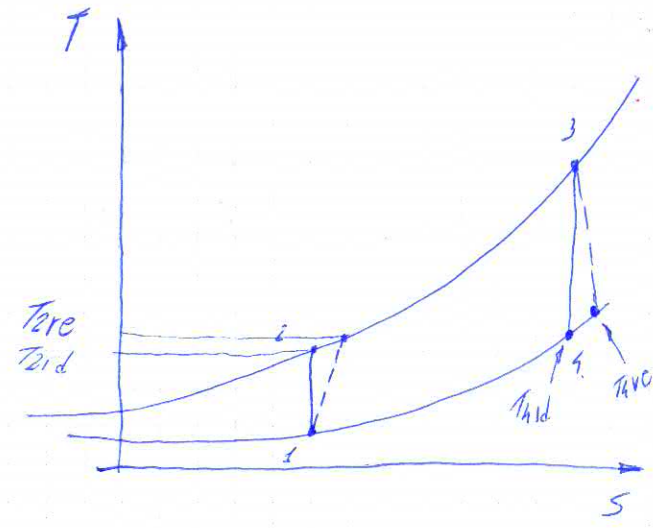
3)  $T_1 = 30^\circ\text{C} = 303\text{ K}$

4/4  $P_1 = 1\text{ bar}$

$\beta = 14$

$\eta_{comp} = \eta_{exp} = 0,9$

$T_{max} = 1200^\circ\text{C} = 1473\text{ K}$



• Ponto 2

$$\frac{T_2}{T_1} = (\beta)^{\frac{\gamma-1}{\gamma}}$$

$$\gamma = \frac{c_p}{c_v} = \frac{1,005}{0,718} = 1,4$$

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

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

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

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

• Ponto 3

$P_3 = P_2$

• Ponto 4

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

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

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

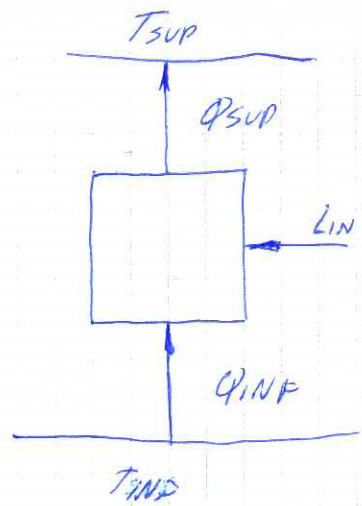
• Rendimenti

$$\eta_1 = \frac{\Delta T_{4re} - \Delta T_{2re}}{\Delta T_{3re}} = \frac{702 - 378,89}{1473 - 681,9} = 0,408$$

$$\eta_c = 1 - \frac{T_1}{T_3} = 1 - \left(\frac{303}{1473}\right) = 0,79$$

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

4)  $L_{IN} = 700 \text{ W}$   $COP_{re} = 0,6 COP_{id}$   
 $T_{loc} = 22^\circ \text{C}$   $\Delta T_{ev} = 12^\circ \text{C}$   
 $T_{est} = 10^\circ \text{C}$   $\Delta T_{cond} = 25^\circ \text{C}$



$$T_{SUP} = T_{loc} + \Delta T_{cond} = 22 + 25 = 47^\circ \text{C} = 320 \text{ K}$$

$$T_{INF} = T_{est} - \Delta T_{ev} = 10 - 12 = -2^\circ \text{C} = 271 \text{ K}$$

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

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

$$Q_{SUP} = L_{IN} \cdot COP_{re} = 700 \cdot 3,92 = 2744 \text{ W}$$

$$Q_{INF} = Q_{SUP} - L_{IN} = 2744 - 700 = 2044 \text{ W}$$

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CORSO DI LAUREA

DATA 19-07-2011

$$5) \quad \varnothing_i = 18 \text{ mm} \rightarrow A = 254,47 \text{ mm}^2 = 25447 \cdot 10^{-4} \text{ m}^2$$

$$5/4 \quad T_1 = 20^\circ\text{C} = 293 \text{ K} \quad T_2 = -12^\circ\text{C} = 261 \text{ K}$$

$$P_1 = 3 \text{ bar rel.}$$

$$W_1 = 30 \text{ m/s}$$

$$W_2 = 320 \text{ m/s}$$

$$\bullet \text{Hp: } P_{\text{amb}} = 1 \text{ bar} \rightarrow P_1 = 4 \text{ bar} \quad R = 0,2870 \frac{\text{kJ}}{\text{kgK}} \rightarrow \text{tabella} \quad C_p = 1,005 \frac{\text{kJ}}{\text{kgK}}$$

$$\bullet \dot{m}_1 = \rho_1 W_1 A_1 = 4,76 \frac{\text{kg}}{\text{m}^3} \cdot 30 \frac{\text{m}}{\text{s}} \cdot 25447 \cdot 10^{-4} \text{ m}^2 = 0,0363 \text{ kg/s}$$

$$\rho_1 = \frac{P_1}{R T_1} = \frac{400000}{287 \cdot 293} = 4,76 \frac{\text{kg}}{\text{m}^3}$$

$$\bullet \rho_1 A_1 W_1 = \rho_2 A_2 W_2$$

$$\rho_2 = \frac{\rho_1 W_1 A_1}{W_2 A_2} = \frac{4,76 \cdot 30}{320} = 0,44625 \frac{\text{kg}}{\text{m}^3}$$

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

$$\bullet \dot{m}_2 = \rho_2 W_2 A_2 = 0,44625 \cdot 320 \cdot 25447 \cdot 10^{-4} = 0,0363 \text{ kg/s}$$

$$\bullet \Delta S = \dot{m} \left( C_p \ln \frac{T_2}{T_1} - R \ln \frac{P_2}{P_1} \right) = 0,0363 \left( 1,005 \ln \frac{261}{293} - 287 \ln \frac{33427}{400000} \right) = 2,64 \frac{\text{W}}{\text{K}}$$



⑥  $A = 8 \times 3 = 24 \text{ m}^2$

$T_i = 25^\circ\text{C}$

$T_{\text{est}} = -5^\circ\text{C}$

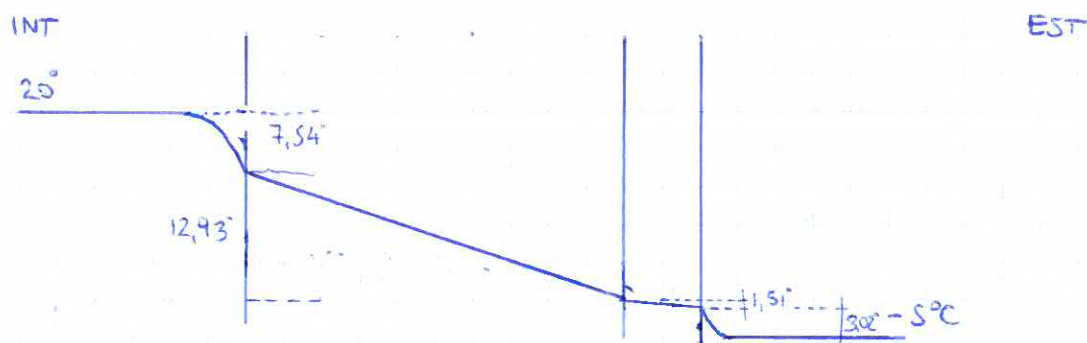
$\Delta T = 25^\circ\text{C}$

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

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

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

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



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

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

$R_{\text{ISOLANTE RIVESTIM.}} = \frac{s_R}{\lambda_R A} = \frac{0,04}{1,2 \cdot 24} = 0,00139 \text{ K/W}$

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

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

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

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

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

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

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

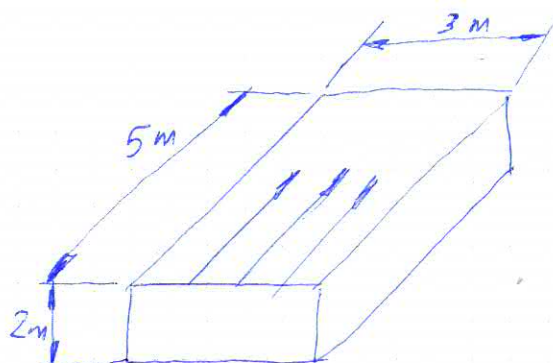
$T_{\text{sup int}} = 12,46^\circ\text{C}$

$T_{\text{MAT-RIV}} = -0,47^\circ\text{C}$

$T_{\text{sup est}} = -1,98^\circ\text{C}$

7)

4/6



$$\rho_g = 2750 \text{ kg/m}^3$$

$$\lambda_g = 3 \text{ W/m}\cdot\text{K}$$

$$c_{p,g} = 0,8 \text{ kJ/kg}\cdot\text{K}$$

$$T_i = 50^\circ\text{C}$$

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

$$T_w = 20^\circ\text{C}$$

$$T_{film} = \frac{T_i + T_\infty}{2} = \frac{50 + 20}{2} = 35^\circ\text{C} = 308 \text{ K}$$

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

$$\mu_p = 0,8 (1,90 \cdot 10^{-5} - 1,85 \cdot 10^{-5}) + 1,85 \cdot 10^{-5} = 1,89 \cdot 10^{-5} \text{ kg/ms}$$

$$\lambda_p = 0,8 (0,0268 - 0,0261) + 0,0261 = 0,02666 \text{ W/m}\cdot\text{K}$$

$$\nu_r = 0,8 (0,711 - 0,712) + 0,712 = 0,7112$$

$$Re = \frac{\rho W L}{\mu} = \frac{1,1498 \cdot 8,3 \cdot 5}{1,89 \cdot 10^{-5}} = 2524693$$

$$Re > 500000$$

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

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

$$Bi = \frac{h L_c}{\lambda_g} = \frac{19,16 \cdot \frac{5 \times 3 \times 2}{5 \times 3}}{3} = 12,77 \approx 13$$

$$Bi > 0,1 \quad \alpha = 2,1322 \cdot 10^{-5} \text{ -- tabell 2 -- } \lambda_1 = 1,44906 \quad A_1 = 1,26637$$

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

$$\tau = \frac{\alpha t}{L^2} = \frac{2,1322 \cdot 10^{-5} \cdot 3600}{5^2} = 3,34 \cdot 10^{-3} < 0,2$$