

○ Izračunaj toplotne izgube izolirane stene hiše ( $m^2$  steno), če je znotraj stena iz zidakov in obložena z izolacijo iz penastega betona. Znotraj je  $T_1$  v hiši vzdržujem  $20^\circ C$ , zunanja pa je  $-10^\circ C$ .

$$A = 1 m^2$$

$$L = 0,2 m$$

$$\lambda_1 = 0,2 W/mK$$

$$L_2 = 0,1 m$$

$$\lambda_2 = 0,05 W/mK$$

$$T_1 = 20^\circ C$$

$$T_2 = -10^\circ C$$

$$k_n = 5 W/m^2K$$

$$k_z = 20 W/m^2K$$

$$\dot{Q} = ?$$

$$\dot{Q} = U \cdot A \cdot \Delta T$$

$$\frac{1}{U} = \frac{1}{k_n} + \frac{L_1}{\lambda_1} + \frac{L_2}{\lambda_2} + \frac{1}{k_z}$$

$$\frac{1}{U} = \frac{1}{5} + \frac{0,2}{0,2} + \frac{0,1}{0,05} + \frac{1}{20}$$

$$\frac{1}{U} = 3,25$$

$$U = 0,308 W/m^2K$$

$$\dot{Q} = U \cdot A \cdot \Delta T = 0,308 \cdot 1 m^2 \cdot 30 K = \underline{9,24 W}$$

b) Temperaturni profil:  $\dot{Q} = k_n \cdot A \cdot (T_m - T_2)$

$$(T_m - T_2) = \frac{\dot{Q}}{k_n \cdot A} = \frac{9,24 W}{5 W/m^2K \cdot 1 m^2} = 1,848 K$$

$$T_0 = -20 - 1,848 = 18,152^\circ C$$

$$\dot{Q} = \lambda_1 \cdot A \cdot (T_0 - T_1) \rightarrow T_0 - T_1 = \frac{\dot{Q} \cdot L_1}{\lambda_1 \cdot A} = \frac{9,24 W \cdot 0,2 m}{0,2 W/mK \cdot 1 m^2} = 8,912 K$$

$$T_1 = T_0 - 8,912 = 8,912^\circ C$$

$$\dot{Q} = \lambda_2 \cdot A \cdot (T_1 - T_2) \rightarrow T_1 - T_2 = \frac{\dot{Q} \cdot L_2}{\lambda_2 \cdot A} = \frac{9,24 W \cdot 0,1 m}{0,05 W/mK \cdot 1 m^2} = 18,48 K$$

$$T_2 = T_1 - 18,48 = -9,568^\circ C$$

July	August / August	September / September	October / October	November / November	December / December
1 2 3 4 5 6 7	1 2 3 4	1	1 2 3 4 5 6	1 2 3	1
8 9 10 11 12 13 14	5 6 7 8 9 10 11	2 3 4 5 6 7 8	7 8 9 10 11 12 13	4 5 6 7 8 9 10	2 3 4 5 6 7 8
15 16 17 18 19 20 21	12 13 14 15 16 17 18	9 10 11 12 13 14 15	14 15 16 17 18 19 20	11 12 13 14 15 16 17	9 10 11 12 13 14 15
22 23 24 25 26 27 28	19 20 21 22 23 24 25	16 17 18 19 20 21 22	21 22 23 24 25 26 27	18 19 20 21 22 23 24	16 17 18 19 20 21 22
29 30 31	26 27 28 29 30 31	23 24 25 26 27 28 29	28 29 30 31	25 26 27 28 29 30	23 24 25 26 27 28 29
		30			30 31

Izračunaj debelino izolacije, da izgube zmanjšamo za polovico.

$$\dot{Q} = 9,24 \text{ W}$$

$$L_2 = ?$$

$$\dot{Q}' = \frac{\dot{Q}}{2}$$

$$\dot{Q}' = U' \cdot A (T_M - T_Z)$$

$$\downarrow U' = \frac{\dot{Q}}{2} = 0,154 \text{ W/m}^2\text{K}$$

$$\frac{1}{U'} = \frac{1}{k_m} + \frac{L_1}{\lambda_1} + \frac{L_2}{\lambda_2} + \frac{1}{k_2}$$

$$L_2 = \left( \frac{1}{U'} - \frac{1}{k_m} - \frac{L_1}{\lambda_1} - \frac{1}{k_2} \right) \lambda_2 = \left( \frac{1}{0,154} - \frac{1}{5} - \frac{0,2}{0,2} - \frac{1}{20} \right) \cdot 0,05 = 0,262 \text{ m}$$

2) Cev notranjega premera 4 cm in zunanjega 5 cm je izolirana s 5 cm debelino olojnim izolacije. Izračunaj toplotne izgube, če je  $T$  tekočine v cevi  $100^\circ\text{C}$ ,  $T$  zraka pa  $20^\circ\text{C}$ . Koliko zmanjša  $T$  na površini izolacije? Oceni toplotne izgube.

$$D_0 = 4 \text{ cm } r_0 = 0,02 \text{ m}$$

$$D_1 = 5 \text{ cm } k = 0,025 \text{ m}$$

$$D_2 = 5 \text{ cm } (\Delta r)_2 = 0,075 \text{ m}$$

$$T_M = 100^\circ\text{C}$$

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

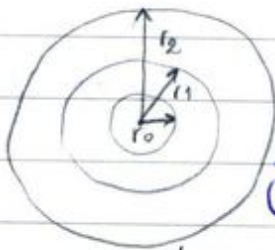
$$k_m = 1000 \text{ W/m}^2\text{K}$$

$$k_2 = 2,5 \text{ W/m}^2\text{K (izolirana cev)}$$

$$k_2 = 5 \text{ W/m}^2\text{K (neizolirana cev)}$$

$$\lambda = 60 \text{ W/m}^2$$

$$\lambda_2 = 0,05 \text{ W/m}^2$$



izolirana cev:

$$\dot{Q} = U_2 \cdot A_2 (T_M - T_Z)$$

$$\frac{1}{U_2} = \frac{r_2}{r_0} \frac{1}{k_m} + \frac{r_2 \cdot \ln\left(\frac{r_1}{r_0}\right)}{\lambda} + \frac{r_2 \cdot \ln\left(\frac{r_2}{r_1}\right)}{\lambda_2} + \frac{1}{k_2}$$

$$\frac{1}{U_2} = \frac{0,075}{0,02} \cdot \frac{1}{1000} + \frac{0,075 \cdot \ln\left(\frac{0,025}{0,02}\right)}{60} + \frac{0,075 \cdot \ln\left(\frac{0,075}{0,025}\right)}{0,05}$$

$$= 2,0519$$

$$U_2 = 0,487 \text{ W/m}^2\text{K}$$

$$\dot{Q} = U_2 \cdot A_2 (T_M - T_Z) = 0,487 \text{ W/m}^2\text{K} \cdot 2\pi \cdot 0,075 \text{ m} \cdot (100^\circ\text{C} - 20^\circ\text{C}) = 18,36 \text{ W/m}$$

Januar / January	Februar / February	Marec / March	April / April	Maj / May	Junij / June
P/M T/T S/W Č/T P/F S/S N/S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	P/M T/T S/W Č/T P/F S/S N/S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28	P/M T/T S/W Č/T P/F S/S N/S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	P/M T/T S/W Č/T P/F S/S N/S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	P/M T/T S/W Č/T P/F S/S N/S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	P/M T/T S/W Č/T P/F S/S N/S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

temperatura ma stemi ovojnice

$$\dot{Q} = h_2 \cdot 2\pi r_2 \cdot l \cdot (T_x - T_2) = U_2 \cdot A_2 \cdot (T_m - T_2)$$

$$\frac{U_2 \cdot A_2 \cdot (T_m - T_2)}{h_2 \cdot 2\pi r_2 \cdot l} = \frac{18,36 \text{ W/m}}{2,5 \text{ W/m}^2\text{K} \cdot 2\pi \cdot 0,075 \text{ m} \cdot 1 \text{ m}} = 15,58 \text{ K}$$

$$T_2 = 15,58 \text{ K} + 20 = 35,58 \text{ K}$$

$$T_2 = 15,58 \text{ K} + 20 = 35,58 \text{ K}$$

vezdirana cev  $\frac{1}{U_2} = \frac{r_1}{r_0} \cdot \frac{1}{h_m} + \frac{r_1}{\lambda_1} \cdot \ln\left(\frac{r_1}{r_0}\right) + \frac{1}{h_2}$

$$\frac{1}{U_2} = \frac{0,025 \text{ m}}{0,02 \text{ m}} \cdot \frac{1 \text{ m}^2\text{K}}{1000 \text{ W}} + \frac{0,025 \text{ m}^2}{60 \text{ W}} \cdot \ln\left(\frac{0,025 \text{ m}}{0,02 \text{ m}}\right) + \frac{1 \text{ m}^2\text{K}}{5 \text{ W}} = 0,2013$$

$$U_2 = 4,97 \text{ W/m}^2\text{K}$$

$$\dot{Q} = U_2 \cdot A_2 \cdot (T_m - T_2) = 4,97 \text{ W/m}^2\text{K} \cdot 0,025 \text{ m} \cdot 2\pi \cdot 80 \text{ K} = 62,45 \text{ W/m}$$

⊕ V toplotnem menjalniku naj se ohladi  $1,2 \text{ m}^3/\text{h}$  organskega topila od  $122^\circ\text{C}$  na  $49^\circ\text{C}$ . Wa razpolago je hladilna voda pri  $21^\circ\text{C}$ . V ~~kolikini~~  $4,8 \text{ m}^3/\text{h}$ . Menjalnik toplote je sestavljen iz motrajnih tankostenskih bakrenih cevi dolzine  $3,6 \text{ m}$ , motrajnega premera  $0,019 \text{ m}$  ter iz zunanjih izoliranih cevi premera  $0,038 \text{ m}$ . Koliko cevi je potrebnih pri tocnosti protitokom maximu obratovanja? koef. prestopa je  $700 \text{ W/m}^2\text{K}$ .

$\dot{Q}_{HT} = 1,2 \text{ m}^3/\text{h}$   $c_{pH} = 4200 \text{ J/kgK}$  vode  
 $T_{T1} = 122^\circ\text{C}$   $\rho = 1000 \text{ kg/m}^3$

tankostenske cevi:  $\frac{1}{U} = \frac{1}{h_m} + \frac{1}{h_2}$

$T_{T2} = 49^\circ\text{C}$   
 $T_{K2} = 21^\circ\text{C}$

$\dot{Q} = \phi_{mT} \cdot c_{pT} \cdot (T_{T1} - T_{T2})$  bilanca  
 $\dot{Q} = \phi_{mH} \cdot c_{pH} \cdot (T_{H1} - T_{H2})$   
 $\dot{Q} = U \cdot A \cdot (\Delta T)_{eu}$

$\phi_w = 4,8 \text{ m}^3/\text{h}$   
 $l_1 = 3,6 \text{ m}$   
 $d_m = 0,019 \text{ m}$   
 $d_z = 0,038 \text{ m}$

Protitok:  $T_{H1} - T_{H2} = \frac{\phi_{mT} \cdot c_{pT} \cdot (T_{T1} - T_{T2})}{\phi_{mH} \cdot c_{pH}}$

$$= \frac{1,2 \text{ m}^3/\text{h} \cdot 2300 \text{ J/kgK} \cdot 870 \text{ kg/m}^3 \cdot (122 - 49) \text{ K}}{4,8 \text{ m}^3/\text{h} \cdot 4200 \text{ J/kgK} \cdot 1000 \text{ kg/m}^3} = 8,69 \text{ K}$$

$U = 700 \text{ W/m}^2\text{K}$   
 $c_{pT} = 2300 \text{ J/kgK}$   
 $\rho = 870 \text{ kg/m}^3$

August														September / September							Oktober / October							November / November							December / December						
PM	T	SW	CT	PF	S/S	N/S	PM	T	SW	CT	PF	S/S	N/S	PM	T	SW	CT	PF	S/S	N/S	PM	T	SW	CT	PF	S/S	N/S	PM	T	SW	CT	PF	S/S	N/S							
1	4	5	6	7	8	9	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7							
10	11	12	13	14	15	16	8	9	10	11	12	13	14	8	9	10	11	12	13	14	8	9	10	11	12	13	14	8	9	10	11	12	13	14							
17	18	19	20	21	22	23	15	16	17	18	19	20	21	15	16	17	18	19	20	21	15	16	17	18	19	20	21	15	16	17	18	19	20	21							
24	25	26	27	28	29	30	22	23	24	25	26	27	28	22	23	24	25	26	27	28	22	23	24	25	26	27	28	22	23	24	25	26	27	28							
31							29	30	31					29	30	31					29	30	31					29	30	31											

$$T_{H1} = 8,69 + T_{H2} = 8,69 + 21 = 29,69^{\circ}\text{C}$$

$$(\Delta T)_{em} = \frac{(T_{T1} - T_{H1}) - (T_{T2} - T_{H2})}{\ln\left(\frac{T_{T1} - T_{H1}}{T_{T2} - T_{H2}}\right)} = \frac{(122 - 29,69) - (49 - 21)}{\ln\left(\frac{122 - 29,69}{49 - 21}\right)} = 53,91^{\circ}\text{C}$$

$$\Delta T_{ar} = \frac{(122 - 29,69) + (49 - 21)}{2} = 60,16^{\circ}\text{C}$$

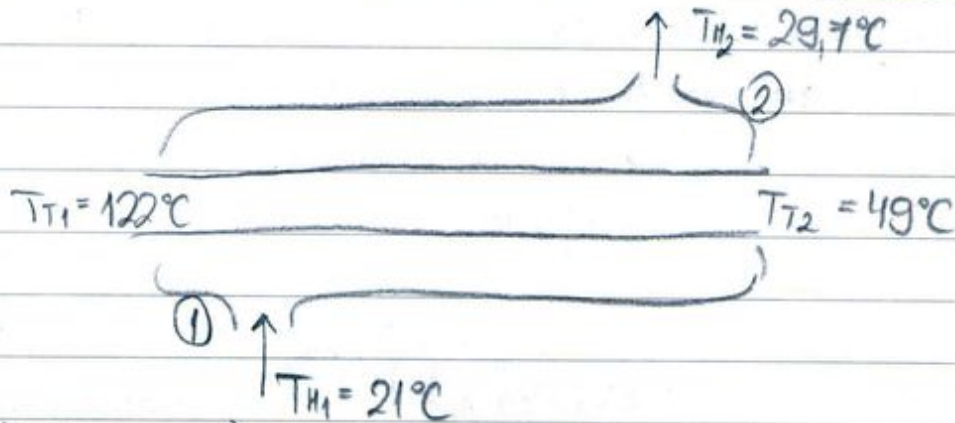
$$U \cdot A (\Delta T)_{em} = \phi_{mH} \cdot c_{pH} (T_{H1} - T_{H2})$$

$$A = \frac{\phi_{mH} \cdot c_{pH} (T_{H1} - T_{H2})}{U \cdot (\Delta T)} = \frac{4,8 \text{ m}^3/\text{h} \cdot 4200 \text{ J/kgK} \cdot 1000 \text{ kg/m}^3 \cdot (29,69 - 21)}{3600 \text{ s} \cdot 700 \text{ W/m}^2\text{K} \cdot 53,91} = 1,29 \text{ m}^2$$

$$A = n \cdot \pi \cdot D_m \cdot l_1 \quad n = \frac{A}{\pi \cdot D_m \cdot l_1} = \frac{1,29 \text{ m}^2}{\pi \cdot 0,019 \text{ m} \cdot 3,6 \text{ m}} = 6 \text{ cevi}$$

SOTOK:

drugacem potencijal



$$(\Delta T)_{em} = \frac{(122 - 21) - (49 - 29,7)}{\ln\left(\frac{122 - 21}{49 - 29,7}\right)} = 49,37^{\circ}\text{C}$$

$$U \cdot A (\Delta T)_{em} = \phi_{mH} \cdot c_{pH} (T_{H2} - T_{H1})$$

$$A = \frac{\phi_{mH} \cdot c_{pH} (T_{H2} - T_{H1})}{U (\Delta T)_{em}} = \frac{4,8 \text{ m}^3 \cdot 4200 \text{ J/kgK} \cdot 1000 \text{ kg/m}^3 \cdot (29,7 - 21)}{3600 \text{ s} \cdot 700 \text{ W/m}^2\text{K} \cdot 49,37 \text{ K}} = 1,41 \text{ m}^2$$

Januar / January							Februar / February							Marec / March							April / April							Maj / May							Junij / June													
P/M	T/T	S/W	Č/T	P/F	S/S	N/S	P/M	T/T	S/W	Č/T	P/F	S/S	N/S	P/M	T/T	S/W	Č/T	P/F	S/S	N/S	P/M	T/T	S/W	Č/T	P/F	S/S	N/S	P/M	T/T	S/W	Č/T	P/F	S/S	N/S	P/M	T/T	S/W	Č/T	P/F	S/S	N/S							
1	2	3	4	5	6		1	2	3					1	2	3					1	2	3	4	5	6	7	1	2	3	4	5			1	2	3	4	5			1	2	3	4	5	6	7
7	8	9	10	11	12	13	4	5	6	7	8	9	10	4	5	6	7	8	9	10	8	9	10	11	12	13	14	6	7	8	9	10	11	12	3	4	5	6	7	8	9	7	8	9	10	11	12	13
14	15	16	17	18	19	20	11	12	13	14	15	16	17	11	12	13	14	15	16	17	15	16	17	18	19	20	21	13	14	15	16	17	18	19	10	11	12	13	14	15	16	14	15	16	17	18	19	20
21	22	23	24	25	26	27	18	19	20	21	22	23	24	18	19	20	21	22	23	24	22	23	24	25	26	27	28	20	21	22	23	24	25	26	17	18	19	20	21	22	23	17	18	19	20	21	22	23
28	29	30	31				25	26	27	28				25	26	27	28	29	30	31	29	30						27	28	29	30	31			24	25	26	27	28	29	30	24	25	26	27	28	29	30

$$A = m \cdot \pi \cdot D_m \cdot l \rightarrow m = \frac{A}{\pi \cdot D_m \cdot l} = \frac{1,41 \text{ m}^2}{\pi \cdot 0,019 \text{ m} \cdot 3,6 \text{ m}} = 6,56 \text{ m}$$

7 cevi

1) Voda grejemo v dvocevni toplotni menjalniku (protitok) od temperature  $T = 20^\circ\text{C}$  na  $100^\circ\text{C}$  s tokom kondenzata pri  $120^\circ\text{C}$ . Masni tok vode je  $1800 \text{ kg/h}$ . Masni tok kondenzata:  $16000 \text{ kg/h}$ . Prevalnost cevi:  $100 \text{ W/mk}$ . Izracunaj koeficient prestopa na strani s hladno vodo.

Snovne lastnosti: tabela!

$T_1 = 20^\circ\text{C}$

$T_{ar} = \frac{20 + 100}{2} = 60 \rightarrow 333,15 \text{ K} \rightarrow 335 \text{ K}$

$T_2 = 100^\circ\text{C}$

$T_3 = 120^\circ\text{C}$

$\dot{m}_1 = 1800 \text{ kg/h}$

$\dot{m}_2 = 16000 \text{ kg/h}$

$\alpha_{11} = 100 \text{ W/mk}$

$d = 0,025 \text{ m}$  (notr. premer notrajuje cevi)

$d_e = 0,028 \text{ m}$  (sum. premer notrajuje cevi)

$\delta = 0,038 \text{ m}$

$\alpha_{12} = 6000 \text{ W/m}^2\text{k}$

$$Re = \frac{\rho \cdot v \cdot d}{\eta} = \frac{4 \cdot \dot{m}}{\pi \cdot d \cdot \eta} = \frac{4 \cdot 1800 \text{ kg/h}}{\pi \cdot 0,025 \text{ m} \cdot 453 \cdot 10^{-6} \text{ kg/m}\cdot\text{s}} = 5,621 \cdot 10^4$$

$\rho = (1,018 \cdot 10^{-3})^{-1} =$ $C_p = 4,186 \cdot 10^3 \text{ J/kg}\cdot\text{K}$ $\eta = 453 \cdot 10^{-6} \text{ kg/m}\cdot\text{s}$ $\lambda = 0,655 \text{ W/m}\cdot\text{K}$ $Pr = 2,88$	TABELA!
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D.B (Dittus-Boelterjeva korelacija)  $Nu = \frac{k \cdot D}{\lambda}$  (Nusseltova št.)

$$\lambda = 0,023 \cdot Re^{0,8} \cdot Pr^m \quad (m = 0,3 \text{ ohlajanje})$$

$$0,023 \cdot Re^{0,8} \cdot Pr^{0,4} = 0,023 \cdot (5,621 \cdot 10^4)^{0,8} \cdot 2,88^{0,4} = \quad (m = 0,4 \text{ segrevanje})$$

$Nu = 221,48$

$$h_{12} = \frac{Nu \cdot \lambda}{D} = \frac{221,48 \cdot 0,655 \text{ W/m}\cdot\text{K}}{0,025 \text{ m}} = 5802,8 \text{ W/m}^2\text{k}$$

July / July	August / August	September / September	October / October	November / November	December / December
1 2 3 4 5 6 7	1 2 3 4	1	1 2 3 4 5 6	1 2 3	1
8 9 10 11 12 13 14	5 6 7 8 9 10 11	2 3 4 5 6 7 8	7 8 9 10 11 12 13	4 5 6 7 8 9 10	2 3 4 5 6 7 8
15 16 17 18 19 20 21	12 13 14 15 16 17 18	9 10 11 12 13 14 15	14 15 16 17 18 19 20	11 12 13 14 15 16 17	9 10 11 12 13 14 15
22 23 24 25 26 27 28	19 20 21 22 23 24 25	16 17 18 19 20 21 22	21 22 23 24 25 26 27	18 19 20 21 22 23 24	16 17 18 19 20 21 22
29 30 31	26 27 28 29 30 31	23 24 25 26 27 28 29	28 29 30 31	25 26 27 28 29 30	23 24 25 26 27 28 29
		30			30 31

$$U_2 = ? \quad \frac{1}{U_2} = \frac{1}{h_H} \left( \frac{r_2}{r_1} \right) + \frac{r_2 \cdot \rho_m \left( \frac{r_2}{r_1} \right)}{\lambda_{\text{cevi}}} + \frac{1}{h_T} \quad \begin{matrix} r_1 = 0,0125 \text{ m} \\ r_2 = 0,014 \text{ m} \end{matrix}$$

$$\frac{1}{U_2} = \frac{1}{5802,8} \left( \frac{0,014 \text{ m}}{0,0125 \text{ m}} \right) + \frac{0,014 \text{ m} \cdot \rho_m \left( \frac{0,014}{0,0125} \right)}{100} + \frac{1}{6000} = 3,76 \cdot 10^{-4}$$

$$U_2 = 2662,8 \text{ W/m}^2\text{K}$$

Veljima monjaluka (A!)

$$\dot{Q} = A \cdot U \cdot (\Delta T)_{\text{em}} = \Phi_{\text{mH}} \cdot c_{pH} (T_{H2} - T_{H1})$$

Ni korelacij  $\Rightarrow c_{pH} = c_{pT}$   $T_{H1} = 20^\circ\text{C}$   $T_{H2} = 100^\circ\text{C}$   $T_{T2} = 120^\circ\text{C}$

$$\Phi_{\text{mT}} = c_{pT} (T_{T2} - T_{T1}) = \Phi_{\text{mH}} \cdot c_{pH} (T_{H2} - T_{H1}) \quad \textcircled{1} \quad \downarrow T_{T1} = ? (30^\circ\text{C}) \quad \textcircled{2}$$

$$T_{T2} - T_{T1} = \frac{\Phi_{\text{mH}} \cdot c_{pH} (T_{H2} - T_{H1})}{\Phi_{\text{mT}} \cdot c_{pT}} = \frac{1800 \text{ kg} \cdot (100 - 20) \cdot 3600 \text{ s}}{3600 \text{ s} \cdot 1600 \text{ kg}} = 90^\circ\text{C}$$

$$T_{T1} = T_{T2} - 90 = 120^\circ\text{C} - 90^\circ\text{C} = 30^\circ\text{C}$$

$$(\Delta T)_{\text{em}} = \frac{(T_{T1} - T_{H1}) - (T_{T2} - T_{H2})}{\ln \left( \frac{T_{T1} - T_{H1}}{T_{T2} - T_{H2}} \right)} = \frac{(30 - 20) - (120 - 100)}{\ln \left( \frac{10}{20} \right)} = 14,4^\circ\text{C}$$

$$A = \pi \cdot D_2 \cdot l_2 \Rightarrow l = \frac{A}{\pi \cdot D_2} = \frac{4,38 \text{ m}^2}{\pi \cdot 0,028 \text{ m}} = 49,8 \text{ m}$$

$$A = \frac{\Phi_{\text{mH}} \cdot c_{pH} (T_{H2} - T_{H1})}{U \cdot (\Delta T)_{\text{em}}} = \frac{1800 \cdot 4200 (100 - 20)}{2662,8 \cdot 14,4 \cdot 3600} = 4,38 \text{ m}^2$$

Januar / January							Februar / February							Marec / March							April / April							Maj / May							Junij / June													
P/M	T/T	S/W	Č/T	P/F	S/S	N/S	P/M	T/T	S/W	Č/T	P/F	S/S	N/S	P/M	T/T	S/W	Č/T	P/F	S/S	N/S	P/M	T/T	S/W	Č/T	P/F	S/S	N/S	P/M	T/T	S/W	Č/T	P/F	S/S	N/S	P/M	T/T	S/W	Č/T	P/F	S/S	N/S							
1	2	3	4	5	6					1	2	3					1	2	3		1	2	3	4	5	6	7				1	2	3	4	5							1	2	3	4	5	6	7
7	8	9	10	11	12	13	4	5	6	7	8	9	10	4	5	6	7	8	9	10	8	9	10	11	12	13	14	6	7	8	9	10	11	12	3	4	5	6	7	8	9	10	11	12	13	14	15	16
14	15	16	17	18	19	20	11	12	13	14	15	16	17	11	12	13	14	15	16	17	15	16	17	18	19	20	21	13	14	15	16	17	18	19	10	11	12	13	14	15	16	17	18	19	20	21	22	23
21	22	23	24	25	26	27	18	19	20	21	22	23	24	18	19	20	21	22	23	24	22	23	24	25	26	27	28	20	21	22	23	24	25	26	17	18	19	20	21	22	23	24	25	26	27	28	29	30
28	29	30	31				25	26	27	28				25	26	27	28	29	30	31	29	30						27	28	29	30	31			24	25	26	27	28	29	30							

5) Vodovodna voda je v ravnotežju z zrakom. Izračunaj koncentracijo kisika v vodi  $C_A^*$  [mol/l, g/l] pri  $T = 25^\circ\text{C}$ , He konstanta je  $4,44 \cdot 10^4$  bar.

$C_A^*$  [mol/l, g/l]  
 $T = 25^\circ\text{C}$

- raztopljena skupina

ravnotežna delež

$$p_A = H_e \cdot X_A^*$$

$H_e(25^\circ\text{C}) = 4,44 \cdot 10^4$  bar  
 $P = 1,013$  bar

$$p_A = y_A \cdot P_T$$

21% v zraku

$$p_A = 0,21 \cdot 1,013 \text{ bar} = 0,213 \text{ bar}$$

$$X_A^* (\text{ravnotežna}) = \frac{p_A}{H_e} = \frac{0,213 \text{ bar}}{4,44 \cdot 10^4 \text{ bar}} = 4,79 \cdot 10^{-6} \text{ - delež kisika v vodi}$$

$$X_A = \frac{m_A \cdot V}{m_A + m_B \cdot V} \Rightarrow X_A = \frac{C_A}{C_B}$$

↓  $C_A = X_A \cdot C_B$

skoraj sama voda,  $m_A(\text{O}_2) = 0$

$C_B$  ... kmolska konc. vode,  $S = 1 \text{ kg/l}$

$$C_B = \frac{1000 \text{ g/mol}}{18 \text{ g}} = 55,56 \text{ mol/l} \rightarrow \text{voda v 1 l vode}$$

$$C_A^* = X_A^* \cdot C_B = 4,79 \cdot 10^{-6} \cdot 55,6 \text{ mol/l} = 2,66 \cdot 10^{-4} \text{ mol/l}$$

$$C_A^* (\text{g/l}) = C_A^* (\text{mol/l}) \cdot M_A(\text{O}_2) = 2,66 \cdot 10^{-4} \text{ mol/l} \cdot 32 \text{ g/mol} = 8,52 \cdot 10^{-3} \text{ g/l}$$

za 21% kisika

June / July	August / August	September / September	Oktober / October	November / November	December / December
P/M T/T SW Č/T P/F S/S N/S	P/M T/T SW Č/T P/F S/S N/S	P/M T/T SW Č/T P/F S/S N/S	P/M T/T SW Č/T P/F S/S N/S	P/M T/T SW Č/T P/F S/S N/S	P/M T/T SW Č/T P/F S/S N/S
1 2 3 4 5 6 7	1 2 3 4	1	1 2 3 4 5 6	1 2 3	1
8 9 10 11 12 13 14	5 6 7 8 9 10 11	2 3 4 5 6 7 8	7 8 9 10 11 12 13	4 5 6 7 8 9 10	2 3 4 5 6 7 8
15 16 17 18 19 20 21	12 13 14 15 16 17 18	9 10 11 12 13 14 15	14 15 16 17 18 19 20	11 12 13 14 15 16 17	9 10 11 12 13 14 15
22 23 24 25 26 27 28	19 20 21 22 23 24 25	16 17 18 19 20 21 22	21 22 23 24 25 26 27	18 19 20 21 22 23 24	16 17 18 19 20 21 22
	26 27 28 29 30 31	23 24 25 26 27 28 29	28 29 30 31	25 26 27 28 29 30	23 24 25 26 27 28 29
		30			30 31





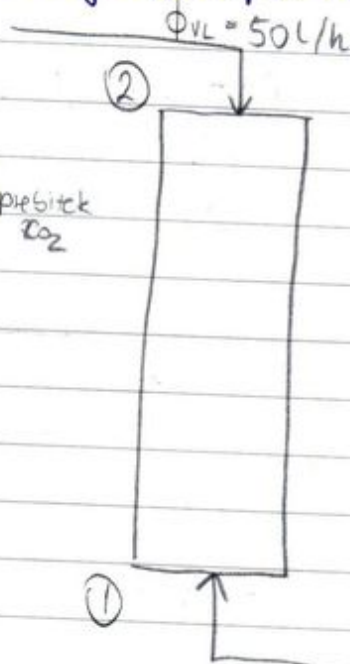
# SNOVNI MENJALNIK

PETROL

☺ Po notranji strani vertikalne smeri premera 5cm, dolžine 1m, teče v protiteku voda, tok plina pa je mešanica CO<sub>2</sub> in zraka v razmerju 1:3. Totalni tlak = 1,2 bar. Pretok plinske mešanice = 10000 l/h. Pretok vode, ki popolnoma omči steno cevi, je 50 l/h. Vstopna konc. plinske komponente v vodi je 0,1 g/l, izstopna pa 60% ravnotežne.

2) Doloci koeficient snovnega prestopa k<sub>L</sub> (He = 1220 bar)

- d = 5cm
- l = 1m
- tok plina: CO<sub>2</sub>:zrak = 1:3 <sup>25%</sup> prebitok CO<sub>2</sub>
- P = 1,2 bar
- Φ<sub>g</sub> = 10000 l/h
- Φ<sub>v</sub> = 50 l/h
- c<sub>1</sub> = 0,1 g/l
- c<sub>2</sub> = 0,6 · c<sub>1</sub>
- He = 1220 bar



Y<sub>A2</sub> = Y<sub>A1</sub> = 0,25 <sup>paracu prebitka</sup>  
 C<sub>A2</sub> = 0,1 g/l ⇒ 0,0023 mol/l  
 C<sub>A1</sub>\* = 0,0136 mol/l

C<sub>A1</sub>\* = 0,0136 mol/l  
 C<sub>A1</sub> = C<sub>A1</sub>\* · 0,6

Y<sub>A1</sub> <sup>(dele?)</sup> = 0,25 (25%)  
 Φ<sub>vG</sub> = 10000 l/h

c<sub>A</sub> = He · X<sub>A</sub>\*

→ y<sub>A</sub> = He · X<sub>A</sub>\* (do kavi se mora tekočina masiti)

$$c_A^* = \frac{P \cdot y_A}{He} = \frac{1,2 \text{ bar} \cdot 0,25}{1220 \text{ bar}} = 2,46 \cdot 10^{-4}$$

→ dčema raztopima: C<sub>A1</sub>\* = X<sub>A1</sub>\* · 55,5 mol/l vode <sup>(log)</sup>

$$C_{A1}^* = 2,46 \cdot 10^{-4} \cdot 55,5 = 1,36 \cdot 10^{-2} \text{ mol/l}$$

$$c_1 = \left( \frac{\text{mol}}{\text{l}} \right) = \frac{C_{A2} \text{ (g/l)}}{M_A \text{ (g/mol)}} = \frac{0,1 \text{ g/l}}{44 \text{ g/mol}} = 0,0023 \text{ mol/l}$$

molna koncentracija

July / July	August / August	September / September	Oktober / October	November / November	December / December
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

Potenciali:  $(C_{A1}^* - C_{A1}) = 0,4 \cdot C_{A1}^*$   
 $(0,0136 - 0,0023)$

Toplotni menjalnik:  $U \cdot A \cdot (\Delta T)_{em} = \phi_{mH} \cdot C_{pH} (T_{H2} - T_{H1})$

Snovni menjalnik:  $K_L \cdot A \cdot (\Delta C_A)_{em} = \phi_{VL} (C_{A11} - C_{A12})$

$$(\Delta C_A)_{em} = \frac{(C_{A12}^* - C_{A12}) - (C_{A11}^* - C_{A11})}{\ln \left( \frac{C_{A12}^* - C_{A12}}{C_{A11}^* - C_{A11}} \right)}$$

$$= \frac{(0,0136 - 0,0023) - (0,0136 - 0,6 \cdot 0,0136)}{\ln \left( \frac{0,0136 - 0,0023}{0,0136 - 0,6 \cdot 0,0136} \right)} = \frac{0,00586}{0,73102} = 8,02 \cdot 10^{-3}$$

$$K_L = \frac{\phi_{VL} (C_{A11} - C_{A12})}{A \cdot (\Delta C_A)_{em}} = \frac{50 (0,6 \cdot 0,0136 - 0,0023)}{0,05 \cdot 1 \cdot \pi \cdot 8,02 \cdot 10^{-3}} = 232,6 \text{ ??}$$

$(5,5 \cdot 10^{-5} \text{ ?})$

8) 100 molov vodne raztopine metanola diferencialno destiliramo. T vrelišča na začetku je 75,3°C, proces prekinemo, ko T vrelišča naraste na 84,4°C. Kolikšen je utežni delež metanola v destilatu? Koliko g destilata dobimo? Razm. podatke aproksimiraj s funkcijo  $y = c \cdot x$ .

$m_0 = 100 \text{ mol}$

$T_{vr}(\text{zač.}) = 75,3^\circ\text{C}$  } tabela!  $X_0 = 0,4 \rightarrow y = 0,729$

$T_{vr}(\text{kou.}) = 84,4^\circ\text{C}$  }  $X = 0,15 \rightarrow y = 0,517$

$y = c \cdot x$

$X_D(\text{ut}) = ? \quad m_D = ?$

$X_D \approx 0,615$

Januar / January							Februar / February							Marec / March							April / April							Maj / May							Junij / June													
P/M	T/T	SW	Č/T	P/F	S/S	N/S	P/M	T/T	SW	Č/T	P/F	S/S	N/S	P/M	T/T	SW	Č/T	P/F	S/S	N/S	P/M	T/T	SW	Č/T	P/F	S/S	N/S	P/M	T/T	SW	Č/T	P/F	S/S	N/S	P/M	T/T	SW	Č/T	P/F	S/S	N/S							
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28	29	30	31				25	26	27	28				25	26	27	28	29	30	31	29	30						27	28	29	30	31			24	25	26	27	28	29	30							

$$c = \frac{y}{x}$$

PETROL

$$y = c \cdot x \quad (x_0 = 0,4, x = 0,15)$$

x	y	c
0,4	0,729	1,8225
0,3	0,665	2,217
0,2	0,579	2,895
0,15	0,517	3,447

$$\ln \frac{m}{m_0} = \int_{x_0}^x \frac{dx}{y-x}$$

$$m_0 = m + m_D \rightarrow m_D$$

$$m_0 \cdot x_0 = m \cdot x + m_D \cdot x_D \rightarrow x_D$$

$$\bar{c} = 2,59 = 2,6$$

$$\ln \frac{m}{m_0} = \int_{x_0}^x \frac{dx}{2,6x-x} = \frac{1}{1,6} \int_{x_0}^x \frac{dx}{x} =$$

$$= \frac{1}{1,6} \cdot \ln \frac{x}{x_0} \rightarrow \ln \frac{m}{m_0} = \frac{1}{1,6} \cdot \ln \frac{0,15}{0,4} = 0,613$$

$$m = m_0 \cdot e^{-0,613} = 100 \cdot e^{-0,613} = 54,2 \text{ mol}$$

$$m_D = m_0 - m = 100 - 54,2 = 54,8 \text{ mol}$$

$$x_D = \frac{100 \cdot 0,4 - 54,2 \cdot 0,15}{45,2} = 0,695 \text{ mol (molski delez)}$$

$$x_D(\text{wt}) = \frac{0,695 \cdot 32}{0,695 \cdot 32 + (1-0,695) \cdot 18} = 0,802$$

metanol      voda

= ?

$$m_D = m_D \cdot \bar{M}_D; \bar{M} = 0,695 \cdot 32 + (1-0,695) \cdot 18 = 27,73 \text{ g/mol}$$

$$m_D = m_D \cdot \bar{M} = 45,8 \cdot 27,73 = \underline{1270 \text{ g}}$$

Julij / July

August / August

September / September

Oktober / October

November / November

December / December

P/M T/T SW Č/T P/F S/S N/S

P/M T/T SW Č/T P/F S/S N/S

P/M T/T SW Č/T P/F S/S N/S

P/M T/T SW Č/T P/F S/S N/S

P/M T/T SW Č/T P/F S/S N/S

P/M T/T SW Č/T P/F S/S N/S

1 4 5 6 7

1 2 3 4

1

1 2 3 4 5 6

1 2 3

1

8 11 12 13 14

5 6 7 8 9 10 11

2 3 4 5 6 7 8

7 8 9 10 11 12 13

4 5 6 7 8 9 10

2 3 4 5 6 7 8

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12 13 14 15 16 17 18

9 10 11 12 13 14 15

14 15 16 17 18 19 20

11 12 13 14 15 16 17

9 10 11 12 13 14 15

22 25 26 27 28

19 20 21 22 23 24 25

16 17 18 19 20 21 22

21 22 23 24 25 26 27

18 19 20 21 22 23 24

16 17 18 19 20 21 22

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25 26 27 28 29 30

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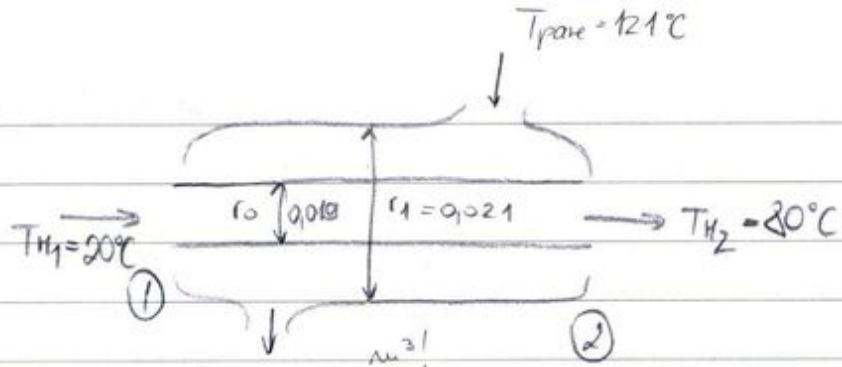
30 31

30 31

KALOKVIJ

①

$h_h = 2900 \text{ W/m}^2\text{K}$   
 $h_z = 20000 \text{ W/m}^2\text{K}$   
 $T_{pora} = 120^\circ\text{C}$



$\phi_s = 600 \text{ l/h} = 0,6 \text{ m}^3/\text{h} \cdot 3600\text{s} = 1,67 \cdot 10^{-4}$

$\dot{Q} = \phi_v \cdot \rho \cdot c_p \cdot \Delta T = 0,167 \cdot 4200 \cdot 60 = 116,9 \text{ W/m}^2\text{K}$

$\phi_m = \phi_v \cdot \rho = 1,67 \cdot 10^{-4} \cdot 1000 = 0,167$

$\lambda_{stene} = 60 \text{ W/mK}$

$\dot{Q} = U_2 \cdot A_2 \cdot (\Delta T)_{em} = \phi_v \cdot \rho \cdot c_p (T_{H2} - T_M)$

$\frac{1}{U} = \frac{r_1}{r_0} \cdot \frac{1}{h_h} + \frac{r_1 \cdot \rho_m \left(\frac{r_1}{r_0}\right)}{\lambda} + \frac{1}{h_z}$

$\dot{Q} = \phi_m \cdot c_p (T_{H2} - T_{H1}) = 0,167 \cdot 4200 \cdot 60 = 116,9$

$\frac{1}{U} = \frac{0,021}{0,019} \cdot \frac{1}{2900} + \frac{0,021 \cdot \rho_m \left(\frac{0,021}{0,019}\right)}{60} + \frac{1}{20000} =$

$= 3,81 \cdot 10^{-5} + 3,5 \cdot 10^{-5} + 5 \cdot 10^{-5} = 4,66 \cdot 10^{-4}$

$U = 2145,9 \text{ W/m}^2\text{K}$

$(\Delta T)_{em} = \frac{(T_{H1} - T_{H1}) - (T_{H2} - T_{H2})}{\rho_m \left(\frac{T_{H1} - T_{H1}}{T_{H2} - T_{H2}}\right)} = \frac{(120 - 20) - (120 - 80)}{\rho_m \frac{100}{40}} = \frac{60}{\rho_m \frac{100}{40}} = 65,48^\circ\text{C}$

$T_{H1} = T_{H2} = 120^\circ\text{C}$

$T_{H1} = 20 \quad T_{H2} = 80$

Januar / January					Februar / February					Marec / March					April / April					Maj / May					Junij / June																																								
P/M	T/T	SW	Č/T	P/F	S/S	N/S	P/M	T/T	SW	Č/T	P/F	S/S	N/S	P/M	T/T	SW	Č/T	P/F	S/S	N/S	P/M	T/T	SW	Č/T	P/F	S/S	N/S	P/M	T/T	SW	Č/T	P/F	S/S	N/S																															
	1	2	3	4	5	6				1	2	3					1	2	3				1	2	3	4	5	6	7						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
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	28	29	30	31	25	26	27	28	25	26	27	28	29	30	31	29	30	27	28	29	30	31	24	25	26	27	28	29	30	31																																			

$$\dot{Q} = U_g \cdot A \cdot (\Delta T)_{lm} \rightarrow A = \frac{Q}{U(\Delta T)_{lm}} = \frac{116,9}{2145,9 \cdot 65,48} = 8,32 \cdot 10^{-4}$$

$$A = \pi \cdot D \cdot l \quad l = \frac{A}{\pi \cdot D} = \frac{8,32 \cdot 10^{-4}}{\pi \cdot 0,021} = 0,0126 \quad ???$$

$$t_{ar} = \frac{20+80}{2} = 50^\circ C \rightarrow 323 \rightarrow 325^\circ C$$

- $\rho = 987,2 \text{ kg/m}^3$
- $C_p = 4,182 \cdot 10^3 \text{ J/kgK}$
- $\eta = 528 \cdot 10^{-6} \text{ kg/lms}$
- $\lambda = 0,645 \text{ W/mK}$

$$Re = \frac{v \cdot D \cdot \rho}{\eta} = \frac{4 \cdot \phi m}{\pi \cdot D \cdot \eta} = \frac{4 \cdot 0,167}{\pi \cdot 0,019 \cdot 528 \cdot 10^{-6}} = 2,12 \cdot 10^4$$

$$Pr = 3,42$$

$$Nu = \frac{h_H \cdot D}{\lambda}$$

$$Nu = 0,023 \cdot Re^{0,8} \cdot Pr^{0,4} = 0,023 (2,12 \cdot 10^4)^{0,8} \cdot 3,42^{0,4} = 108,74$$

$$h_H = \frac{Nu \lambda}{D} = \frac{108,74 \cdot 0,645}{0,019} = 3691,6 \text{ W/m}^2\text{K}$$

$$t = 20^\circ C$$

$$a) p_A = y_A \cdot p_T = 0,21 \cdot 1,013 \text{ bar} = 0,213 \text{ bar}$$

$$p = 1,013 \text{ bar}$$

$$l = 50L$$

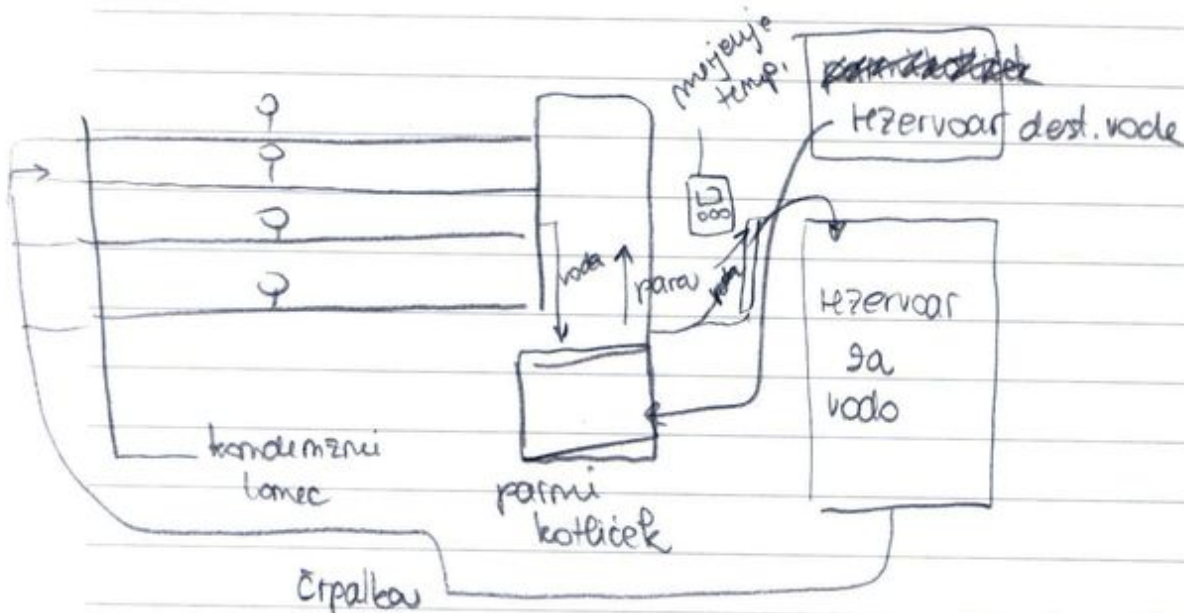
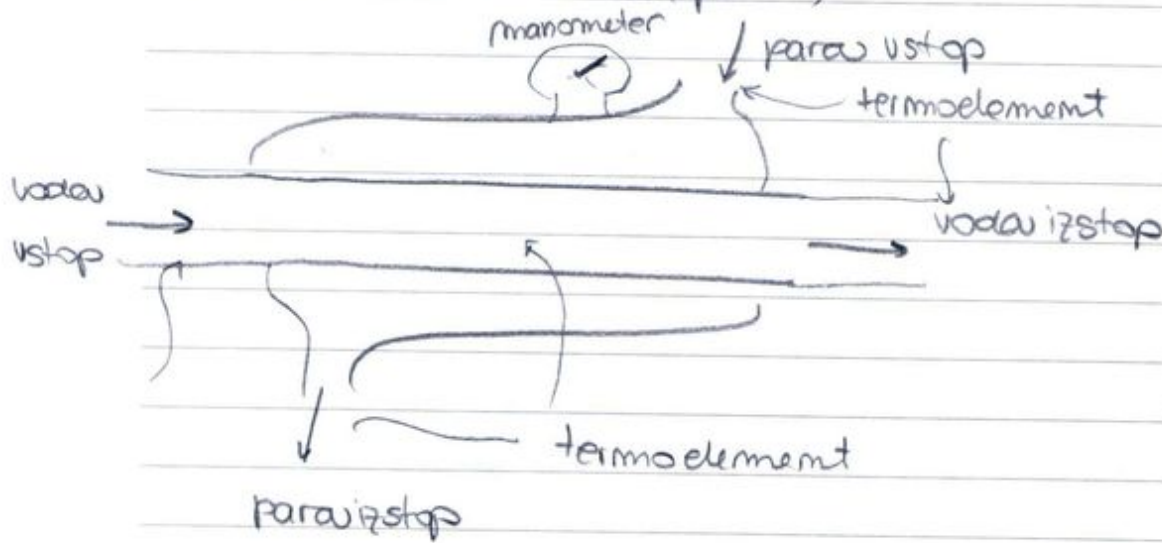
$$X_A^* = \frac{p_A}{p} = \frac{0,213 \text{ bar}}{1,01 \cdot 10^4 \text{ bar}} = 5,31 \cdot 10^{-6} \text{ deleš bisika v vodi}$$

$$p_e(20) = 4,01 \cdot 10^4 \text{ bar}$$

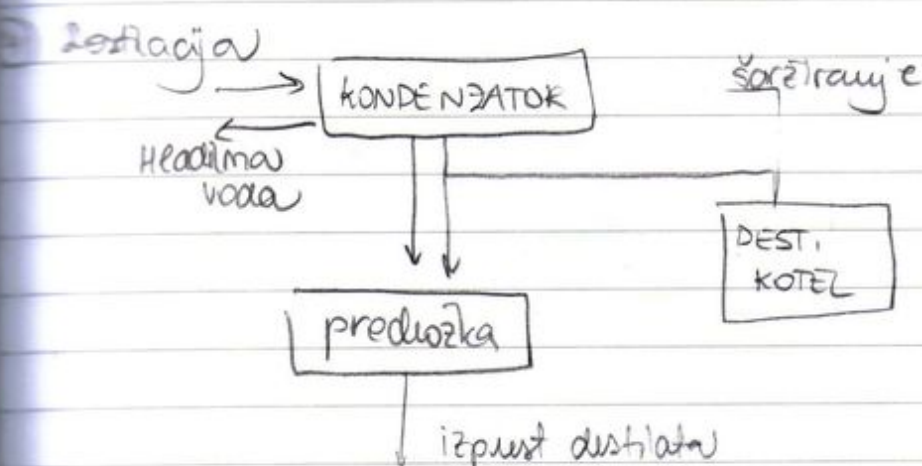
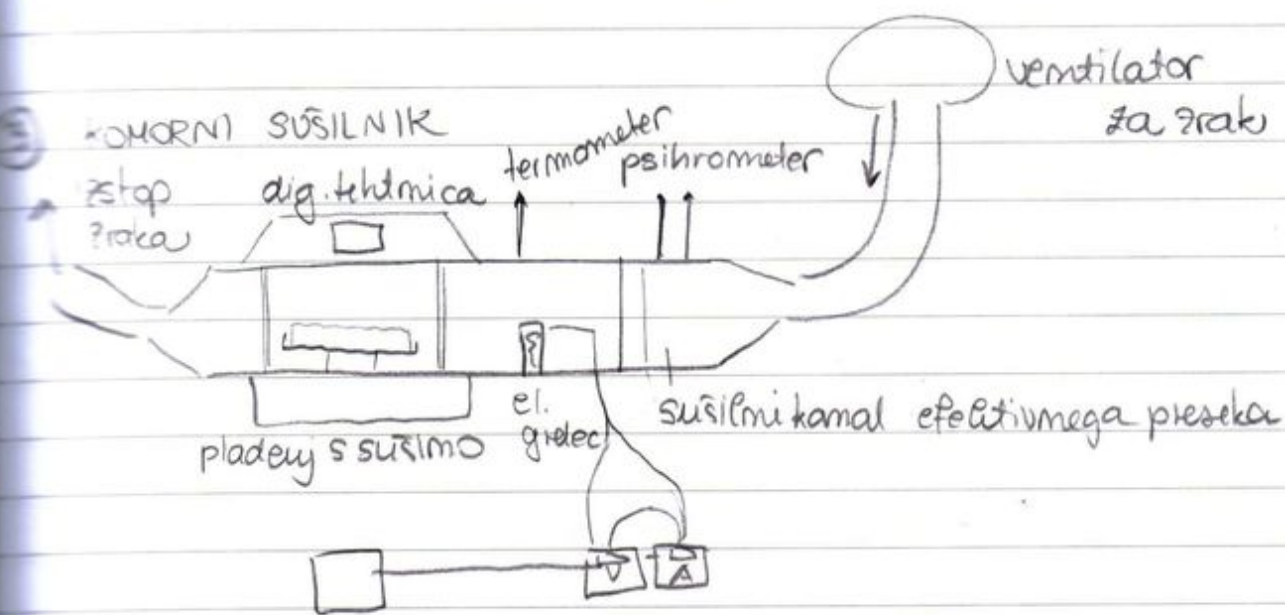
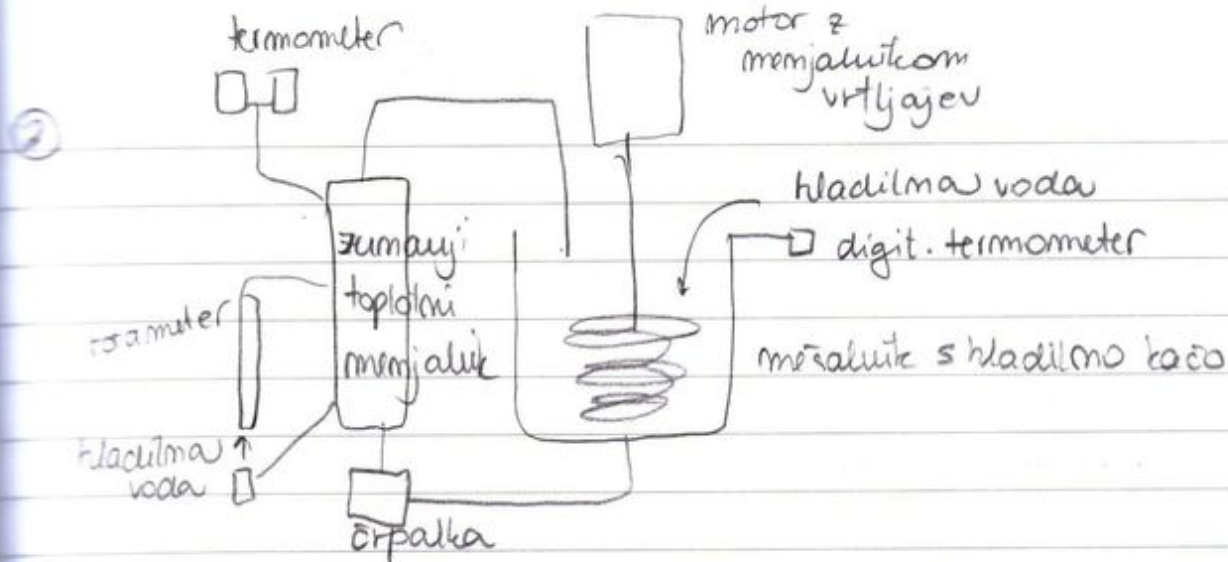
July	August / August	September / September	October / October	November / November	December / December
1 2 3 4 5 6 7	1 2 3 4	1	1 2 3 4 5 6	1 2 3	1
8 9 10 11 12 13 14	5 6 7 8 9 10 11	2 3 4 5 6 7 8	7 8 9 10 11 12 13	4 5 6 7 8 9 10	2 3 4 5 6 7 8
15 16 17 18 19 20 21	12 13 14 15 16 17 18	9 10 11 12 13 14 15	14 15 16 17 18 19 20	11 12 13 14 15 16 17	9 10 11 12 13 14 15
22 23 24 25 26 27 28	19 20 21 22 23 24 25	16 17 18 19 20 21 22	21 22 23 24 25 26 27	18 19 20 21 22 23 24	16 17 18 19 20 21 22
29 30 31	26 27 28 29 30 31	23 24 25 26 27 28 29 30	28 29 30 31	25 26 27 28 29 30	23 24 25 26 27 28 29 30 31

DVOCEVNI TOPLLOTNI MENJALNIK

- 4 izobitami dvocevni menjalnik (termoelementi za merjenje vstopne in izstopne T toplega in hladnega medija ter stene)
- digitalni milivolt meter
- vir ciste vode s cirkulacijo
- vir čistega zraka
- vir nizkotlačne pare (parni kotlice)
- rotametri vode in zraka (pretok)

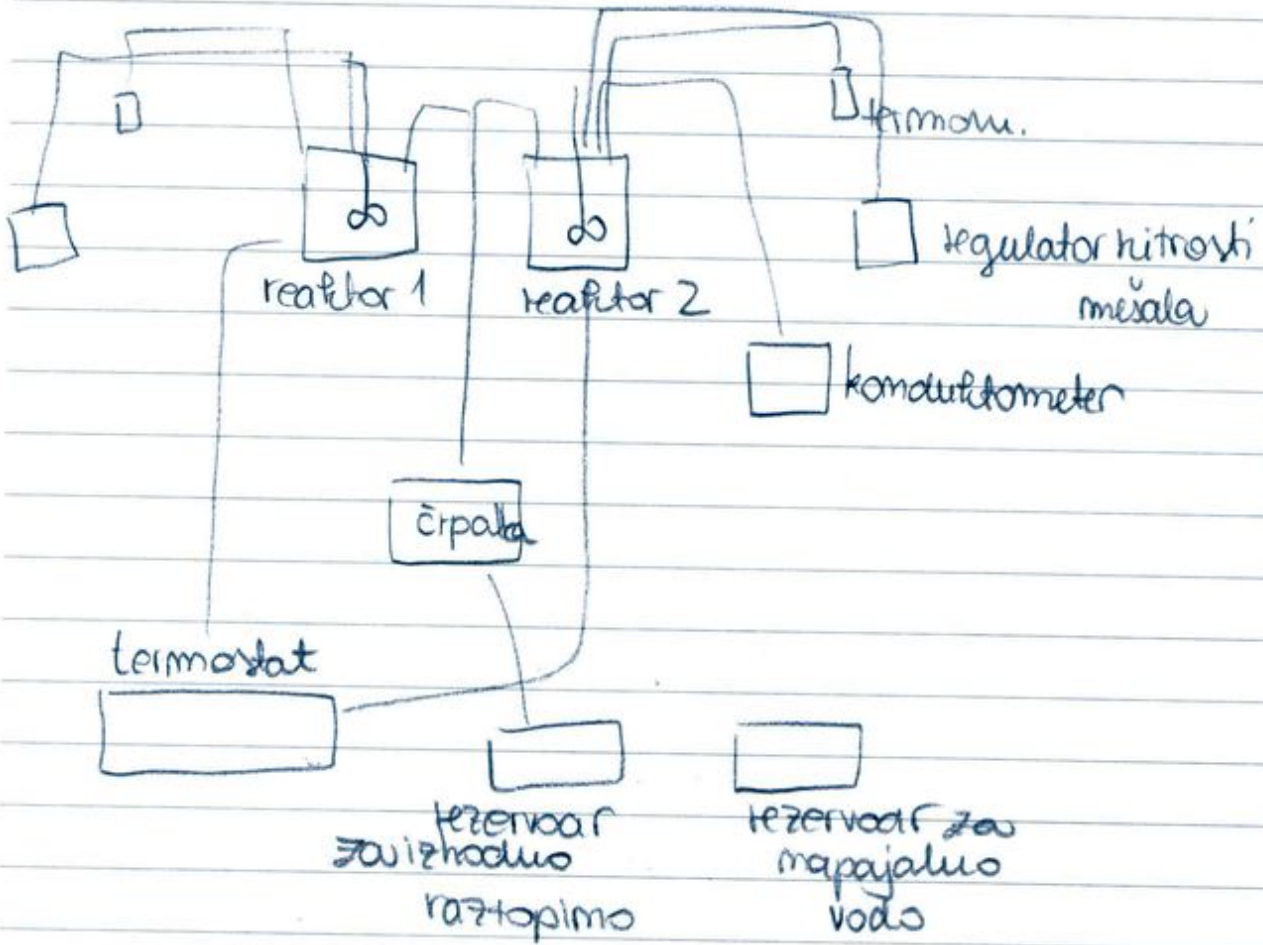


Januar / January							Februar / February							Marec / March							April / April							Maj / May							Junij / June						
P/M	T/T	S/W	Č/T	P/F	S/S	N/S	P/M	T/T	S/W	Č/T	P/F	S/S	N/S	P/M	T/T	S/W	Č/T	P/F	S/S	N/S	P/M	T/T	S/W	Č/T	P/F	S/S	N/S	P/M	T/T	S/W	Č/T	P/F	S/S	N/S	P/M	T/T	S/W	Č/T	P/F	S/S	N/S
1	2	3	4	5	6		1	2	3					1	2	3					1	2	3	4	5	6	7	1	2	3	4	5			1	2	3	4	5	6	7
7	8	9	10	11	12	13	4	5	6	7	8	9	10	4	5	6	7	8	9	10	8	9	10	11	12	13	14	6	7	8	9	10	11	12	3	4	5	6	7	8	
14	15	16	17	18	19	20	11	12	13	14	15	16	17	11	12	13	14	15	16	17	15	16	17	18	19	20	21	13	14	15	16	17	18	19	10	11	12	13	14	15	16
21	22	23	24	25	26	27	18	19	20	21	22	23	24	18	19	20	21	22	23	24	22	23	24	25	26	27	28	20	21	22	23	24	25	26	17	18	19	20	21	22	23
28	29	30	31				25	26	27	28				25	26	27	28	29	30	31	29	30						27	28	29	30	31			24	25	26	27	28	29	30



July	August / August	September / September	October / October	November / November	December / December
1 2 3 4 5 6 7	1 2 3 4	1	1 2 3 4 5 6	1 2 3	1
8 9 10 11 12 13 14	5 6 7 8 9 10 11	2 3 4 5 6 7 8	7 8 9 10 11 12 13	4 5 6 7 8 9 10	2 3 4 5 6 7 8
15 16 17 18 19 20 21	12 13 14 15 16 17 18	9 10 11 12 13 14 15	14 15 16 17 18 19 20	11 12 13 14 15 16 17	9 10 11 12 13 14 15
22 23 24 25 26 27 28	19 20 21 22 23 24 25	16 17 18 19 20 21 22	21 22 23 24 25 26 27	18 19 20 21 22 23 24	16 17 18 19 20 21 22
29 30 31	26 27 28 29 30 31	23 24 25 26 27 28 29	28 29 30 31	25 26 27 28 29 30	23 24 25 26 27 28 29
		30			30 31

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Januar / January							Februar / February							Marec / March							April / April							Maj / May							Junij / June						
P/M	T/T	SW	Č/T	P/F	S/S	N/S	P/M	T/T	SW	Č/T	P/F	S/S	N/S	P/M	T/T	SW	Č/T	P/F	S/S	N/S	P/M	T/T	SW	Č/T	P/F	S/S	N/S	P/M	T/T	SW	Č/T	P/F	S/S	N/S	P/M	T/T	SW	Č/T	P/F	S/S	N/S
1	2	3	4	5	6		1	2	3					1	2	3					1	2	3	4	5	6	7	1	2	3	4	5			1	2	3	4	5	6	7
7	8	9	10	11	12	13	4	5	6	7	8	9	10	4	5	6	7	8	9	10	8	9	10	11	12	13	14	6	7	8	9	10	11	12	3	4	5	6	7	8	
14	15	16	17	18	19	20	11	12	13	14	15	16	17	11	12	13	14	15	16	17	15	16	17	18	19	20	21	13	14	15	16	17	18	19	10	11	12	13	14	15	16
21	22	23	24	25	26	27	18	19	20	21	22	23	24	18	19	20	21	22	23	24	22	23	24	25	26	27	28	20	21	22	23	24	25	26	17	18	19	20	21	22	23
28	29	30	31				25	26	27	28				25	26	27	28	29	30	31	29	30						27	28	29	30	31			24	25	26	27	28	29	30