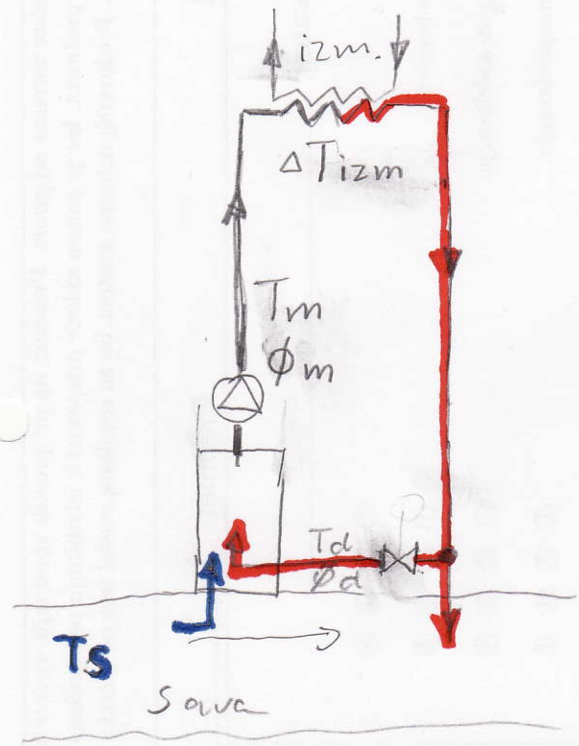
Primer 4:

Tehnika: NEK - ESWIS. Problem:

prenizka temperatura vode T_m pozimi



s - Savska voda

d - deicing voda

ϕ ... volumski tok $\frac{dV}{dt}$

m ... mešanica s in d

predpostavimo:

specif. gostota: $\rho \neq \rho(T)$

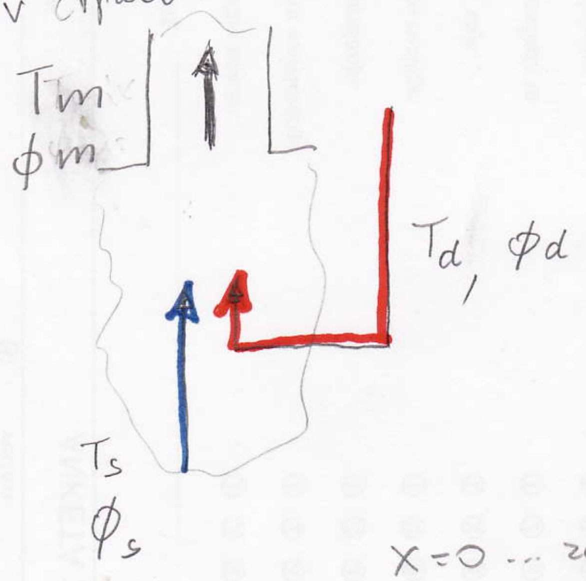
spec. topl. kapac.: $c \neq c(T)$

zanemarimo toplotne izgube skozi tla, stene, zrak

masni tok $\frac{dm}{dt} = \dot{m}$

$\dot{m}_m = \dot{m}_s + \dot{m}_d$

$\rho \cdot \phi_m = \rho \cdot \phi_s + \phi_d \cdot \rho$



definiramo razmerje: $X = \frac{\phi_d}{\phi_m}$

$X =$ konst.

reguliramo z odpiranjem in pripiranjem ventilov

$X=0$ ... zaprt ventil

$X=1$ ... vsa topla voda se vrača v črpališče - voda zavre

Fizika

Pred mešanjem : $\boxed{\begin{matrix} c_s \\ m_s \\ T_s \end{matrix}}$ $\quad$ $\boxed{m_d, T_d, c_d}$

Po mešanju : $\boxed{\begin{matrix} m_s + m_d \\ T_m \end{matrix}}$

$c_s = c_d$

$T_s < T_m$

$T_d > T_m$

Torej je savska voda prejela toliko toplote, kot jo je deicing voda oddala.

splošno Q (toplota) $= m \cdot c \cdot \Delta T$ $\qquad \dot{m}$ masni tok

toplotni tok $\frac{dQ}{dt} = \dot{Q} = \frac{dm}{dt} \cdot c \cdot \Delta T = \rho \Phi \cdot c \cdot \Delta T$

spec. gost., volum. tok

Topl. tok pri segrevanju savske vode $=$ Topl. tok pri ohlajanju deicing vode

$$\dot{m}_s \cdot c_s (T_m - T_s) = \dot{m}_d \cdot c_d \cdot (T_d - T_m)$$

$$\dot{m}_s T_m - \dot{m}_s T_s = \dot{m}_d T_d - \dot{m}_d T_m$$

$$T_m \underbrace{(\dot{m}_s + \dot{m}_d)}_{\dot{m}_m = \rho \Phi_m} = \underbrace{\dot{m}_d}_{= \rho \cdot \Phi_d} T_d + \underbrace{\dot{m}_s}_{= \rho (\Phi_m - \Phi_d)} T_s$$

$$T_m = \frac{\Phi_d}{\Phi_m} T_d + \frac{\Phi_m - \Phi_d}{\Phi_m} T_s$$

$$\boxed{T_m = x T_d + (1 - x) T_s}$$

mešalna enačba

Vpeljemo oznake

začetno stanje : indeks $\emptyset$

nadaljevanje indeks 1

2

⋮

$$T_{m1} = x\,T_{d0} + (1-x)\,T_s$$

T_{m1} se v izmenjevalniku segreje za ΔT (konst)

in se vrne v sistem kot $T_{d1} = T_{m1} + \Delta T_{izm}$

$$T_{m2} = x \cdot T_{d1} + (1-x)\,T_s \;,\quad T_{d2} = T_{m2} + \Delta T$$

$$T_{d2} = x\big[\underbrace{x\,T_{d0} + (1-x)\,T_s + \Delta T}_{T_{d1}}\big] + (1-x)\,T_s + \Delta T$$

$$T_{d2} = T_{d0}\,x^2 + \big[(1-x)\,T_s + \Delta T\big](x+1)$$

⋮

$$T_{d_n} = T_{d0}\,x^n + \big[(1-x)\,T_s + \Delta T\big]\left(x^{n-1} + x^{n-2} + \dots + x^2 + x + 1\right)$$

Voda zaokroži v sistemu v cca. 1 do 1,5 min, zato je število izmenjav veliko, torej $n \to \infty$

$$\boxed{T_{d_n} = T_{d0}\,x^n + \big[(1-x)\,T_s + \Delta T\big]\left(\frac{x^n - 1}{x - 1}\right)}$$

vsota n členov geom. zaporedja.

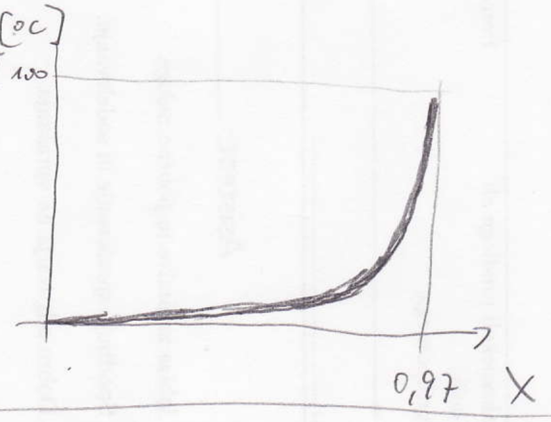
Ker $x < 1$; $\lim\limits_{n\to\infty} x^n = 0$; $\lim\limits_{n\to\infty} \frac{x^n - 1}{x - 1} = -\frac{1}{x-1}$

Dobimo:

$$T_{d\infty} = 0 + \left[(1-x)T_s + \Delta T\right]\left(\frac{1}{1-x}\right)$$

$$\boxed{T_{d\infty} = T_s + \frac{\Delta T}{1-x}}$$

$$\boxed{T_{mi\infty} = T_{d\infty} - \Delta T}$$



Številčni primer: $T_s = 0{,}1\,°C$ – Sava pozimi

$\Delta T = 3\,°C$ – segrejl izmenj.

$\phi_m = 2880\ m^3/h$ – črpalka

a) $\phi_d = 450\ m^3/h$

$x = \frac{450}{2880} = 0{,}15625$

$T_{d\infty} = 3{,}65\,°C$

$T_{m\infty} = 0{,}655\,°C$

b) $\phi_d = 680\ m^3/h$

$x = \frac{680}{2880} = 0{,}2361$

$T_{d\infty} = 4{,}03\,°C$

$T_{m\infty} = 1{,}03\,°C$

c) $\phi_d = 2800\ m^3/h$

$x = 0{,}972$

$T_{d\infty} = 108{,}1\,°C$ (nerealno)

d) hlajenje (gretje) kabine v avtu