FTV 1 26.06.2011

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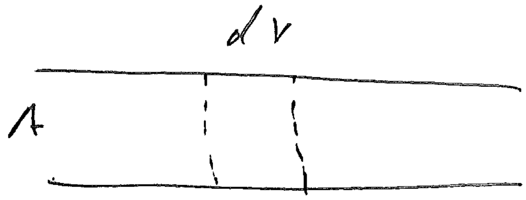

a) Balans : $0 = \phi_V \, c_{B_2}\Big|_x - \phi_V \, c_{B_2}\Big|_{x+dx} + k_r \cdot c_{B0}^2 \cdot A \cdot dx$

$$\phi_V \frac{dc_{B_2}}{dx} = k_r \cdot c_{B0}^2 \cdot A$$

$$dc_{B_2} = \frac{k_r \cdot c_{B0}^2 \cdot A}{\phi_V} \, dx$$

$$c_{B_2} = \frac{k_r \, c_{B0}^2 \cdot A}{\phi_V} \, x + C$$

$$c_{B_2}\Big|_{x=0} = 0 \Rightarrow C = 0$$

$$c_{B_2} = \frac{k_r \, c_{B0}^2 \cdot A}{\phi_V} \, x = \frac{k_r \cdot c_{B0}^2 \cdot A \cdot L}{\phi_V}$$

b) Balans :

$$0 = \phi_V \, c_B\Big|_x - \phi_V \, c_B\Big|_{x+dx} - 2k_r \, c_B^2 \cdot A \cdot dx$$

$$\phi_V \frac{dc_B}{dx} = -2k_r \, c_B^2 \cdot A \, dx$$

$$\frac{dc_B}{c_B^2} = -\frac{2k_r \cdot A}{\phi_V} \, dx$$

$$\frac{1}{C_B} = \frac{2k_r A x}{\phi_V} + C$$

$$C_B\Big|_{x=0} = C_{B0} \Rightarrow C = \frac{1}{C_{B0}}$$

$$\frac{1}{C_B} = \frac{1}{C_{B0}} + \frac{2k_r A \cdot x}{\phi_V}$$

$$C_B = \frac{\phi_V \, C_{B0}}{\phi_V + 2k_r A x \cdot C_{B0}}$$

$$C_B(L) = \frac{\phi_V \cdot C_{B0}}{\phi_V + 2k_r \cdot A \cdot L \cdot C_{B0}}$$

c). $\frac{1}{C_B} \approx \frac{1}{C_{B0}}$ als $\frac{1}{C_{B0}} >> \frac{2k_r A \cdot L}{\phi_V}$

of $\frac{\phi_V}{2k_r A \cdot L \cdot C_{B0}} >> 1$

N 2

a). Massabalans:

$$\rho v \cdot A_1 = \rho v_2 A_2$$

$$v_2 = v \cdot \frac{A_1}{A_2} = v \frac{D^2}{4D^2} = \frac{v}{4};$$

b) Bernoulli vergelijking:

$$\frac{p}{\rho} + \frac{v^2}{2} = \frac{p_2}{\rho} + \frac{v_2^2}{2} + g y_0$$

$$\frac{p_2}{\rho} = \frac{p}{\rho} + \frac{v^2}{2} - \frac{v_2^2}{2} - g y_0$$

$$p_2 = p + \rho \left(\frac{v^2}{2} - \frac{v^2}{2 \cdot 16} - g y_0 \right);$$

$$p_2 = p + \frac{\rho}{2} \left(\frac{15}{16} v^2 - 2 g y_0 \right)$$

c) ~~Krachtenbalans~~: Impulsbalans in x-richting

$$0 = \phi_v \rho v_{x,in} - \phi_v \rho v_{x,uit} + \sum F_x$$

$$0 = -\phi_v \cdot \rho v_2 - p_2 A_2 + F_{W \to F, x}$$

Volgens de 3e wet van Newton, $F_{W \to F, x} = -F_{F \to W, x}$

$$F_{F \to W, x} = -\phi_v \rho v_2 - p_2 A_2$$

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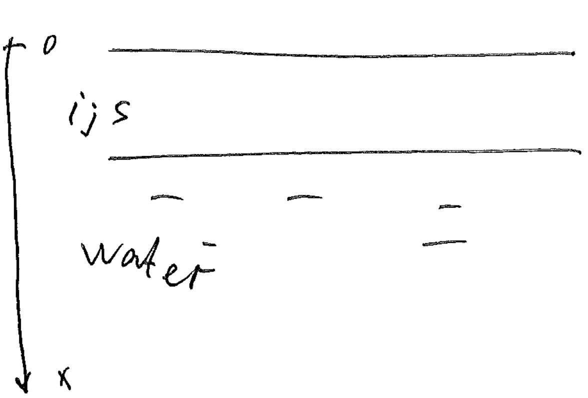
$$-F_{F\to w,x} = v\,\frac{\pi D^2}{4}\,\rho\,\frac{v}{4} + \pi D^2 \cdot p + \frac{\pi D^2}{2}\,\rho\left(\frac{15}{16}v^2 - 2gy_0\right)$$

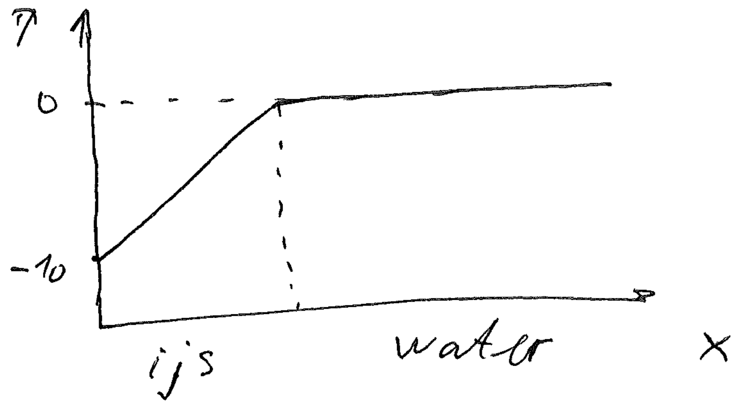
$$-F_{F_1\to w,x} = \frac{\pi D^2}{16}\,\rho v^2 + \frac{15\pi D^2}{32}\,\rho v^2 + \pi D^2 \cdot p - \pi D^2 \rho g y_0$$

$$-F_{F_1\to w,x} = \frac{17\pi D^2}{32}\,\rho v^2 + \pi D^2 \cdot p - \pi D^2 \rho g y_0$$

$$F_{F\to w,x} = -\left(\frac{17}{32}\rho v^2 + p - \rho g y_0\right)\cdot \pi D^2$$

№3





a). De energiebalans voor vrijgekomen stollings-warmte:

$$\phi_q \cdot dt = \Delta H_s \cdot \rho \cdot dx \cdot A$$

$$\phi_q = \lambda\,\frac{dT}{dx}\cdot A = \lambda\,\frac{\Delta T}{x}\,A$$

$$\lambda \frac{\Delta T}{x} dt = \Delta H_s \rho \, dx$$

$$\lambda \Delta T \, dt = \Delta H_s \rho \cdot x \, dx$$

$$\lambda \Delta T \, t = \Delta H_s \rho \cdot \frac{x^2}{2} + C$$

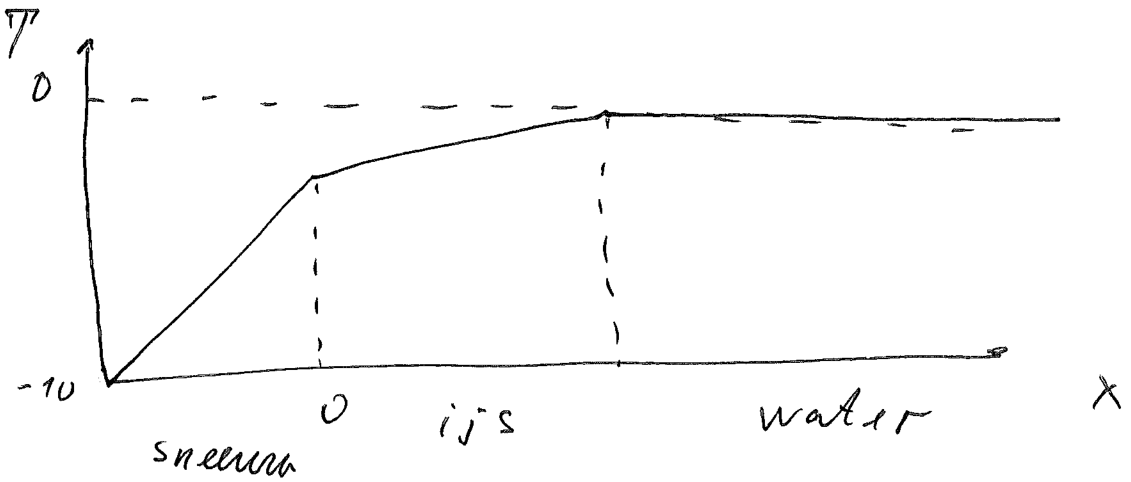
$$x\Big|_{t=0} = 0 \Rightarrow C = 0$$

$$t = \frac{\Delta H_s \, \rho}{\lambda \, \Delta T} \, \frac{x^2}{2}$$

$$t = \frac{335{,}2 \cdot 10^3 \cdot 800}{2{,}3 \cdot 10} \cdot \frac{10^{-2}}{2} = 5{,}8 \cdot 10^4 \, s \approx 16 \text{ uren}$$

b) Warmtestroom : $\phi_q = U \cdot \Delta T \cdot A$;

$$\frac{1}{U} = \frac{1}{h_{sneeuw}} + \frac{1}{h_{ijs}} = \frac{l_s}{\lambda_s} + \frac{x}{\lambda_{ijs}}$$



$$\phi_q = \frac{\Delta T \cdot A}{\left(\frac{l_s}{\lambda_s} + \frac{x}{\lambda_{ijs}} \right)}$$

$$dt = \frac{\Delta H_s \cdot \rho}{\Delta T} \left(\frac{l_s}{\lambda_s} + \frac{x_{ijs}}{\lambda_{ijs}} \right) dx$$

$$t = \frac{\Delta H_s \cdot \rho}{\Delta T} \cdot \left(\frac{l_s}{\lambda_s} x + \frac{x^2}{2 \lambda_{ijs}} \right) + C$$

$$x \Big|_{t=0} = 0 \quad \Rightarrow \quad C = 0$$

$$t = \frac{335{,}2 \cdot 10^3 \cdot 800}{10} \left(\frac{0{,}1 \cdot 0{,}1}{0{,}3} + \frac{0{,}1 \cdot 0{,}1}{2 \cdot 2{,}3} \right) =$$

$$= 9{,}5 \cdot 10^6\,s \approx 264 \text{ uren}$$

c) Wij berekenen de penetratiediepte voor de tijd 1 uur:

$$L_p = \sqrt{\pi \alpha t} \quad , \qquad \alpha = \frac{\lambda_{ijs}}{\rho_{ijs} \cdot c_{p,ijs}}$$

$$L = \sqrt{3{,}14 \cdot \frac{2{,}3 \cdot 3600}{2{,}11 \cdot 10^3 \cdot 800}} \approx 0{,}12\,m \,;$$

Omdat de ijslaag de dikte van 50 cm heeft, de temperatuur profiel niet verandert in een uur bij $x = 50$ cm. Dus de snelheid van het groeien van het ijs verandert niet.

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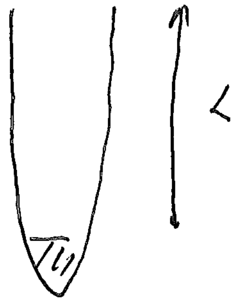

a) Massa balans:

$$\frac{dM}{dt} = -\phi_m'' \cdot A$$

$$\rho \frac{dV}{dt} = -\phi_m'' \cdot A$$

ϕ_M'' is constant $\Rightarrow$ $\rho V_0 = \phi_M'' \cdot A\, t$

$$t = \frac{\rho V_0}{\phi_m'' A}$$

a). Wederzijdse diffusie:

$$\phi_M'' = -D \cdot \frac{dc}{dx} = \text{const}$$

$c = c^* - c^* \frac{x}{L}$, waarin c^* de concentratie van alcohol damp is

$$\phi_M'' = D \frac{c^*}{L};$$

$$p^* = \frac{c^*}{M} RT \Rightarrow c^* = \frac{p^* \cdot M}{RT}$$

$$t = \frac{\rho V_0 L R T}{D A p^* \cdot M}$$

$$t = \frac{0.8 \cdot \cancel{1} \cdot 10^{-5} \cdot 0{,}2 \cdot 8{,}314 \cdot 293}{5 \cdot 10^{-5} \cdot 3.14 \cdot 10^{-4} \cdot 5{,}95 \cdot 10^{3} \cdot 46 \cdot 10^{-3}} \approx 907\,s$$

b) Eenzijdige diffusie:

$$\phi'' = -D \frac{c}{c - c_A} \frac{dc_A}{dx}$$

Het wordt wederzijds als $c > c_A$ of

$$c^* < c \quad \text{of} \quad \frac{c^*}{c} << 1$$

$$C = \frac{p \cdot M_{lucht}}{RT}$$

$$C^* = \frac{p^* \cdot M_{alc}}{RT}$$

$$\cancel{p \cdot M_{lucht} >> p^* \cdot M_{alc}}$$

$$\frac{c^*}{c} = \frac{p^* \cdot M_{alc}}{p \cdot M_{lucht}} = \frac{5{,}95 \cdot 10^3 \cdot 46}{10^5 \cdot 29} \approx 0.1 < 1 \Rightarrow$$

De benadering is correct

c) De verdampingstijd is evenredig met $1/\phi''_{MA}$

$$\phi''_{MA} = D \frac{c^*}{L} \quad (\text{wederzijds})$$

$$\phi''_{MA} = \frac{DC}{L} \ln \frac{c}{c - c^*} \quad (\text{eenzijdig})$$

of $\phi''_{MA,W} = -D \frac{dc_A}{dx}$

$$\phi''_{MA,E} = -D \frac{c}{c - c_A^*} \frac{dc_A}{dx}, \quad \frac{c}{c - c_A^*} < 1$$

$\phi''_{MA,E} > \phi''_{MA,W} \Rightarrow$ verdampingstijd is korter bij eenzijdige diffusie