TD1 : Two-phase flow in a vertical evaporator

1) $G\, h_{LV} \dfrac{dx}{dz} = \dfrac{4 q_p}{D}$ $\qquad \dfrac{dx}{dz} = \dfrac{4 q_p}{D G h_{LV}} \Rightarrow x = \dfrac{4 q_p}{D G h_{LV}} z$

2) At $z = h = 1\,m$ $\qquad x = 4.28 \cdot 10^{-4}$

$j_L = \dfrac{G(1-x)}{\rho_L}$ $\qquad j_V = \dfrac{G x}{\rho_V}$ $\qquad G = 637\ kg/m^2/s$

$j_L = 0{,}675\ m/s$ $\qquad j_V = 0{,}243\ m/s$

Regime close to the transition bubbly / slug flow

3) Homogenous model

$$\frac{d}{dz}\left(\frac{G^2}{\rho_m}\right) = -\frac{dP}{dz} + \frac{4\tau_p}{D} - \rho_m g \qquad \text{with } \rho_m = \rho_L(1-R_G) + \rho_V R_G \simeq \rho_L(1-R_G)$$

$$\frac{4\tau_p}{D} = -\frac{2}{D} f_{pm} \frac{G^2}{\rho_m} \qquad \text{with } f_{pm} = 0.005$$

b) $$\frac{dP}{dz} = -\frac{d}{dz}\left(\frac{G^2}{\rho_m}\right) - \frac{2}{D} f_{pm} \frac{G^2}{\rho_m} - \rho_m g$$

c) $$R_G = \frac{x\frac{\rho_L}{\rho_V}}{1 - x\left(1 - \frac{\rho_L}{\rho_V}\right)} \Rightarrow 1 - R_G = \frac{1 - x\left(1-\frac{\rho_L}{\rho_V}\right) - x\frac{\rho_L}{\rho_V}}{1 + x\frac{\rho_L}{\rho_V}}$$

$$1 - R_G \simeq \frac{1-x}{1+x\frac{\rho_L}{\rho_V}} \simeq \frac{1}{1+x\frac{\rho_L}{\rho_V}} \qquad \frac{1}{1-R_G} = 1 + x\frac{\rho_L}{\rho_V} \quad \text{with } x \ll 1$$

$$\frac{1}{1-R_G} = 1 + \frac{4 q_p}{D G h_{LV}} \frac{\rho_L}{\rho_V} x = 1 + K z \qquad R_G = 0{,}146\ (z = h)$$

$$\Delta P = P(h) - P(0) = \left[-\frac{G^2}{\rho_m}\right]_{z=0}^{z=h} - \frac{2}{D} f_{pm} \frac{G^2}{\rho_L} \int_0^h (1+Kz)\,dz - \int_0^h \frac{\rho_L g}{1+Kz}\,dz$$

$$\Delta P = P(h) - P(0) = -\frac{G^2}{\rho_L} K h - \frac{2}{D} f_{pm} \frac{G^2}{\rho_L}\left[h + K\frac{h^2}{2}\right] - \frac{\rho_L g}{K} \ln(1+Kh)$$

$K = 0{,}361$ $\qquad -155\ Pa$ $\qquad -253\ Pa$ $\qquad -7898\ Pa$

$\Delta P = 8306\ Pa$