1) Liquid and wall température

$$G \pi \frac{D^2}{4} C_p \frac{dT}{dz} = q_p \pi D \rightarrow T_L(z) = T_{Le} + \frac{4 q_p z}{D G C_p}$$

$$q_p = H_L (T_p - T_L(z)) \rightarrow T_p = T_L(z) + \frac{q_p}{H_L}$$

with $H_L = 570\ W/m^2/K$

2) $$z_{sat} = \frac{(T_{sat} - T_{Le}) D G C_p}{4 q} = 0.281\ m$$

$T_p = 56.92\ °C$

$$T_p - T_{sat} = 17.52 > \left[\frac{8 \sigma T_{sat} q}{\lambda \rho_v h_{LV}}\right]^{1/2} \frac{1}{P_r} = 0.153$$

The wall temperature is larger than the temperature for the onset of nucleate boiling

3) For $z > z_{sat}$ $\quad G \pi \frac{D^2}{4} h_{LV} \frac{dx}{dz} = q_p \pi D$

$$x = \frac{4 q_p}{D G h_{LV}} (z - z_{sat})$$

$z = 0.3 m$ $\quad x = 0.0058$ $\quad j_V = \frac{G x}{\rho_V} = 0.023\ m/s$

$j_L = 0.172\ m/s \rightarrow$ slug flow

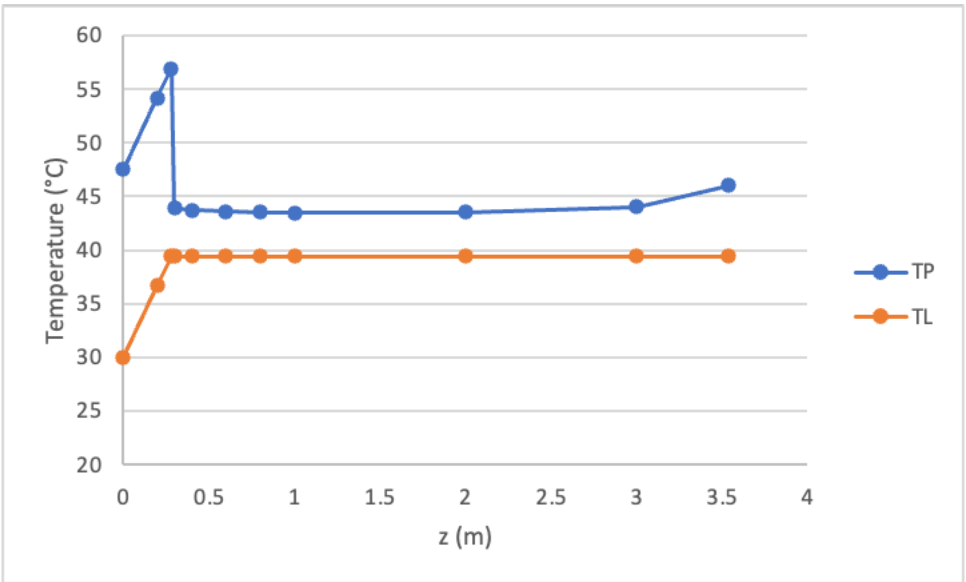
$z = 0.6 m$ $\quad x = 0.0977$ $\quad j_V = 0.392\ m/s$, $j_L = 0.152\ m/s$ $\rightarrow$ churn flow

Pure vapor $x = 1$ $\quad z = 3.55 m$

4) $T_p = T_{sat} + \frac{q}{H}$, H calculated with Gungor & Winterton correlation

$z = 0.3 m$ $\quad T_p = 43.9°C$

$z = 0.6 m$ $\quad T_p = 43.59\ °C$



5) Void fraction evaluate from the drift flux model

$$U_v = \frac{j_v}{R_G} = C_0 (j_v + j_L) + U_\infty$$

$C_0 = 1.2$ $\qquad$ $U_\infty = 0.35\sqrt{gD}$

$z = 0.3\,m$ $\qquad$ $R_G = 0.076$

$z = 0.6\,m$ $\qquad$ $R_G = 0.538$

6)
$$\underbrace{\frac{d}{dz}\left[\frac{G^2 x^2}{\rho_v R_v} + \frac{G^2(1-x)^2}{\rho_L(1-R_v)}\right]}_{\text{inertia term}} = \underbrace{-\frac{dP}{dz}}_{\text{pressure gradient}} + \underbrace{\frac{4\tau_p}{D}}_{\text{wall friction}} \underbrace{-\left(\rho_L(1-R_G)+\rho_G R_G\right)g}_{\text{hydrostatic pressure gradient}}$$

Single-phase flow $\quad z < z_{sat}$

$$-\frac{dP}{dz} + \frac{4\tau_p}{D} - \rho_L g = 0 \qquad P(z_{sat}) - P(0) = \left[\frac{2}{D} f_p \frac{G^2}{\rho_L} - \rho_L g\right] z_{sat}$$

Two-phase flow

$$P(z) - P(z_{sat}) = \frac{4\tau_p}{D}(z - z_{sat}) - \rho_L(1-R_G)\, g\,(z - z_{sat})$$
$$- \left[\frac{G^2 x^2}{\rho_v R_v} + \frac{G^2(1-x^2)}{\rho_L(1-R_v)} - \frac{G^2}{\rho_L}\right]$$