$$\dot{m} = 0.001601$$

$$qual_{ave} = 5$$

$$2 \cdot L_{c,s} = 0.0015$$

$$k_s = \mathbf{k}\left(\text{'Stainless}_{AISI304}\text{'} , T_{r,E,Build} \right)$$

$$c_s = \mathbf{c}\left(\text{'Stainless}_{AISI304}\text{'} , T_{r,E,Build} \right) \cdot 1000$$

$$\rho_s = \mathbf{rho}\left(\text{'Stainless}_{AISI304}\text{'} , T_{r,E,Build} \right)$$

$$c_{prl} = \mathbf{Cp}\left(\text{'R717'} , T = T_{r,E,Build} , x = 0 \right)$$

$$c_{prl,g} = \mathbf{Cp}\left(\text{'R717'} , T = T_{r,E,Build} , x = 1 \right)$$

$$cp_1 = \mathbf{Cp}\left(\text{'R717'} , T = T_{r,E,Build} , x = 0 \right)$$

$$cp_w = \mathbf{Cp}\left(\text{'Water'} , T = 2 , P = P_{atm} \right)$$

$$k_w = \mathbf{k}\left(\text{'Water'} , T = 2 , P = P_{r,E} \right)$$

$$P_{atm} = 83.5$$

$$P_{r,E} = 260 + 83.5$$

$$T_{r,E,Build} = \mathbf{T}\left(\text{'R717'} , P = P_{r,E} , x = 0 \right)$$

$$P_{r.har} = 510 + 83.5$$

$$T_{r.har} = \mathbf{T}\left(\text{'R717'} , P = P_{r.har} , x = 1 \right)$$

$$T_{sat} = T_{r,E,Build}$$

$$h_{fg} = \mathbf{h}\left(\text{'R717'} , P = P_{r,E} , x = 1 \right) - \mathbf{h}\left(\text{'R717'} , P = P_{r,E} , x = 0 \right)$$

$$\sigma = \mathbf{SurfaceTension}\left(\text{'R717'} , T = T_{r,E,Build} \right)$$

$$\mu_{rl} = \mathbf{Visc}\left(\text{'R717'} , T = T_{r,E,Build} , x = 0 \right)$$

$\mu_{rl,g} = \textbf{Visc}('R717', T=T_{r,E,Build}, x=1)$

$\mu_{rl,r} = \textbf{Visc}('R717', T=T_{r,E,Build}, x=0)$

$\mu_{rl,water} = \textbf{Visc}('Water', T=2, P=P_{r,E})$

$\mu_{rl,w} = \textbf{Visc}('R717', T=T_w, x=0)$

$\rho_{rl} = \rho('R717', x=0, P=P_{r,E})$

$\rho_{rv} = \rho('R717', x=1, P=P_{r,E})$

$\rho_r = \rho('R717', x=0.333, P=P_{r,E})$

$g = 9.81$

$k = \textbf{k}('R717', x=0, P=P_{r,E})$

$k_g = \textbf{k}('R717', x=1, P=P_{r,E})$

$L = 3.5$

$$Vel = \frac{\dot{m}}{\rho_r \cdot A}$$

$$A = \pi \cdot \frac{d^2}{4}$$

$d = 0.012$

$$Gm = \frac{\dot{m}}{A}$$

F\$ = 'R717'

$H = d$

$$W = 0.035$$

$$RelRough = 0.005$$

$$T_{l.o} = 0$$

$$\text{Call } \mathbf{DuctFlow}\left(F\$,\ T_{r,E,Build} - 0.001,\ P_{r,E},\ \dot{m},\ H,\ W,\ L,\ RelRough : t,\ h_w,\ C_f,\ Nusselt,\ Re_w,\ Re_{duct} \right)$$

$$x = \frac{1}{qual_{ave}}$$

$$C_{nb} = 0.013$$

$$Cr = C_{nb}$$

$$m = 2$$

$$t_{ib} = 810$$

$$Ja = c_{prl} \cdot \left[\frac{0 - T_{sat}}{h_{fg}} \right]$$

$$L_{star} = \frac{0.0015}{L_c}$$

$$L_c = \left[\frac{\sigma}{(\rho_{rl} - \rho_{rv}) \cdot g} \right]^{0.5}$$

$$Pr = c_{prl} \cdot \frac{\mu_{rl,r}}{k} \cdot 1000$$

$$Pr_w = cp_w \cdot 1000 \cdot \frac{\mu_{rl,water}}{k_w}$$

$$\nu = \frac{Ja^2}{C_{nb}^3 \cdot Pr^m}$$

$$Nus = 0.023 \cdot Re^{0.8} \cdot Pr^{0.4}$$

$$Re = \rho_r \cdot Vel \cdot \frac{d}{\mu_{rl,r}}$$

$$h_{theory} = k \cdot \frac{\nu}{d}$$

$$h_{theory2} = k \cdot \frac{Nus}{d}$$

$$h_{paolo,lam} = 0.5 \cdot \left[k^2 \cdot \rho_r^{(4/3)} \cdot c_{prl} \cdot \frac{g^{(2/3)}}{L \cdot \mu_{rl}^{(1/3)}} \right]^{(1/3)} \cdot \left[\frac{\mu_{rl}}{\mu_{rl,w}} \right]^{(1/4)} \cdot Re^{(1/9)}$$

$$h_{paolo,turb} = 0.01 \cdot \left[k^3 \cdot \rho_r^2 \cdot \frac{g}{\mu_{rl,r}^2} \right]^{(1/3)} \cdot Re^{(1/3)} \cdot Pr^{(1/3)}$$

$$tau2 = 4 \cdot \frac{\dot{m}}{\pi \cdot d \cdot \mu_{rl,r}}$$

$$h_{paolo,turb2} = 0.01 \cdot \left[k^3 \cdot \rho_r^2 \cdot \frac{g}{\mu_{rl,r}^2} \right]^{(1/3)} \cdot \left[c_{prl} \cdot 1000 \cdot \frac{\mu_{rl,r}}{k} \right]^{(1/3)} \cdot tau2^{(1/3)}$$

Call **Flow**$_{Boiling}$ (F\$, T_{sat} , Gm , d , x , q`` , 'vertical' : t , T_{wfl})

$$y_{s,E} = 0.0015$$

$k_{s,E}$ = **k** ('Stainless$_{AISI304}$' , $T_{r,E,Build}$)

$$k_I = \mathbf{k}\ (\text{'Ice'}, -2.9)$$

$$q`` = \frac{T_{I.o} - T_{r,E,Build}}{\frac{1}{h_{2ph,Sh}} + \frac{y_{s,E}}{k_{s,E}} + \frac{y}{k_I}}$$

$$q``_{gungor} = \frac{T_{I.o} - T_{r,E,Build}}{\frac{1}{h_{2ph,G}} + \frac{y_{s,E}}{k_{s,E}} + \frac{y_g}{k_I}}$$

$$qmax = 0.12 \cdot h_{fg} \cdot 1000 \cdot (\sigma \cdot \rho_{rv}^2 \cdot (\rho_{rl} - \rho_{rv}) \cdot g)^{(1/4)}$$

$$\alpha_s = \frac{k_s}{\rho_s \cdot c_s}$$

$$Fo_s = \alpha_s \cdot \frac{t_{ib}}{(2 \cdot L_{c,s})^2}$$

$$\sigma_s \cdot \mathbf{tan}(\sigma_s) = Bi$$

$$C = 4 \cdot \left[\frac{\mathbf{sin}(\sigma_s)}{2 \cdot \sigma_s + \mathbf{sin}(2 \cdot \sigma_s)}\right]$$

$$\frac{T_w - T_{r,E,Build}}{T_{r.har} - T_{r,E,Build}} = C \cdot \mathbf{exp}(-\sigma_s^2 \cdot Fo_s)$$

$$\bar{x} = 0.5$$

$$Fo = Fo_s$$

$$Bi = h_{2ph,G} \cdot 2 \cdot \frac{L_{c,s}}{k_s}$$

$$Bi2 = h_{2ph,Sh} \cdot 2 \cdot \frac{L_{c,s}}{k_s}$$

$$Bi3 = h_b \cdot 2 \cdot \frac{L_{c,s}}{k_s}$$

$$\Theta = \mathbf{planewall}_{T,ND} (\bar{x} , Fo , Bi)$$

$$THETA2 = \mathbf{planewall}_{T,ND} (\bar{x} , Fo , Bi2)$$

$$THETA3 = \mathbf{planewall}_{T,ND} (\bar{x} , Fo , Bi3)$$

$$T_{w2} = T_{r,E,Build} + \Theta \cdot (T_{r.har} - T_{r,E,Build})$$

$$T_{w2.2} = T_{r,E,Build} + THETA2 \cdot (T_{r.har} - T_{r,E,Build})$$

$$T_{w2.3} = T_{r,E,Build} + THETA3 \cdot (T_{r.har} - T_{r,E,Build})$$

$$T_s = T_{l.o}$$

Fluid\$ = 'Water'

$$T_{w.i} = 1.5$$

$$P_{w.inlet} = P_{atm}$$

$$u_{inf} = 0.2738$$

Call **External**$_{Flow,Plate}$ (Fluid\$, $T_{w.i}$, T_s , $P_{w.inlet}$, u_{inf} , L : t , T_{wfl} , C_f , Nusselt , Re_w)

$$h_{w2} = 0.037 \cdot Re_w^{(4/5)} \cdot Pr_w^{(1/3)} \cdot \frac{k_w}{L}$$

$$h_{sf} = 335000$$

$$\rho_I = \mathbf{rho} (\text{'Ice'} , 0)$$

$$\rho_l \cdot h_{sf} \cdot y_{g`} = \frac{T_{l.o} - T_{r,E,Build}}{\frac{1}{h_{2ph,G}} + \frac{y_{s,E}}{k_{s,E}} + \frac{y_g}{k_l}} - \left[\frac{T_{w.i} - T_{l.o}}{\frac{1}{h_w}} \right]$$

$$y_g = y_{g,i} + \int_1^{810} (y_{g`}) \; d\,t$$

$$y_{g,i} = 0.00001$$

$$\rho_l \cdot h_{sf} \cdot y` = \frac{T_{l.o} - T_{r,E,Build}}{\frac{1}{h_{2ph,Sh}} + \frac{y_{s,E}}{k_{s,E}} + \frac{y}{k_l}} - \left[\frac{T_{w.i} - T_{l.o}}{\frac{1}{h_w}} \right]$$

$$y = y_i + \int_1^{810} (y`) \; d\,t$$

$$y_i = 0.00001$$

$$\rho_l \cdot h_{sf} \cdot yb` = \frac{T_{l.o} - T_{r,E,Build}}{\frac{1}{h_b} + \frac{y_{s,E}}{k_{s,E}} + \frac{yb}{k_l}} - \left[\frac{T_{w.i} - T_{l.o}}{\frac{1}{h_w}} \right]$$

$$yb = yb_i + \int_1^{810} (yb`) \; d\,t$$

$$yb_i = 0.00001$$

$$h_l = 0.023 \cdot \left[Gm \cdot (1 - x) \cdot \frac{d}{\mu_{rl}} \right]^{0.8} \cdot Pr^{0.4} \cdot \frac{k}{d}$$

$$Co = \left[\frac{1}{x} - 1\right]^{0.8} \cdot \left[\frac{\rho_{rv}}{\rho_{rl}}\right]^{0.5}$$

$$Bo = \frac{q``}{Gm \cdot h_{fg} \cdot 1000}$$

$$\alpha_{bs} = F_{shah} \cdot Bo^{0.5} \cdot \mathbf{exp}\left(2.74 \cdot Co^{-0.1}\right)$$

$$\alpha_{cb} = \frac{1.8}{Co^{0.8}}$$

$$F_{shah} = 15.43$$

$$h_{2ph,Sh} = \alpha_{cb} \cdot h_{l}$$

$$jh = \frac{h_{2ph,Sh}}{h_{l}}$$

$$Re2 = Gm \cdot (1 - x) \cdot \frac{d}{\mu_{rl}}$$

$$E_{gungor} = 1 + 24000 \cdot Bo^{1.16} + 1.37 \cdot \left[\frac{1}{X_{tt}}\right]^{0.86}$$

$$X_{tt} = \left[\frac{1 - x}{x}\right]^{0.9} \cdot \left[\frac{\rho_{rv}}{\rho_{rl}}\right]^{0.5} \cdot \left[\frac{\mu_{rl,r}}{\mu_{rl,g}}\right]^{0.1}$$

$$S_{gungor} = \frac{1}{1 + 1.15 \cdot 10^{-6} \cdot E_{gungor}^{\;2} \cdot Re2^{1.17}}$$

$$h_{pool} = 55 \cdot Pr^{0.12} \cdot \mathbf{log}^{-0.55}(Pr) \cdot Mass^{-0.5} \cdot q``^{0.67}$$

$$h_{2ph,G} = E_{gungor} \cdot h_{l} + S_{gungor} \cdot h_{pool}$$

$$Mass = 17.03$$

$$h_{hh} = \frac{h_{2ph,G} - h_{2ph,Sh}}{h_{2ph,G}}$$

$$h_{malek.colin} = k_k \cdot Gm^{aa} \cdot q``^{bb} \cdot P_{red}^{cc}$$

$$k_k = 2.46$$

$$aa = 0.017$$

$$bb = 0.515$$

$$cc = 0.25$$

$$P_{red} = \frac{P_{r,E}}{P_c} \cdot 1000$$

$$P_c = \mathbf{P}_{Crit} ('R717')$$