Integración IV

Modelado individual de equipos en estado dinámico (V)

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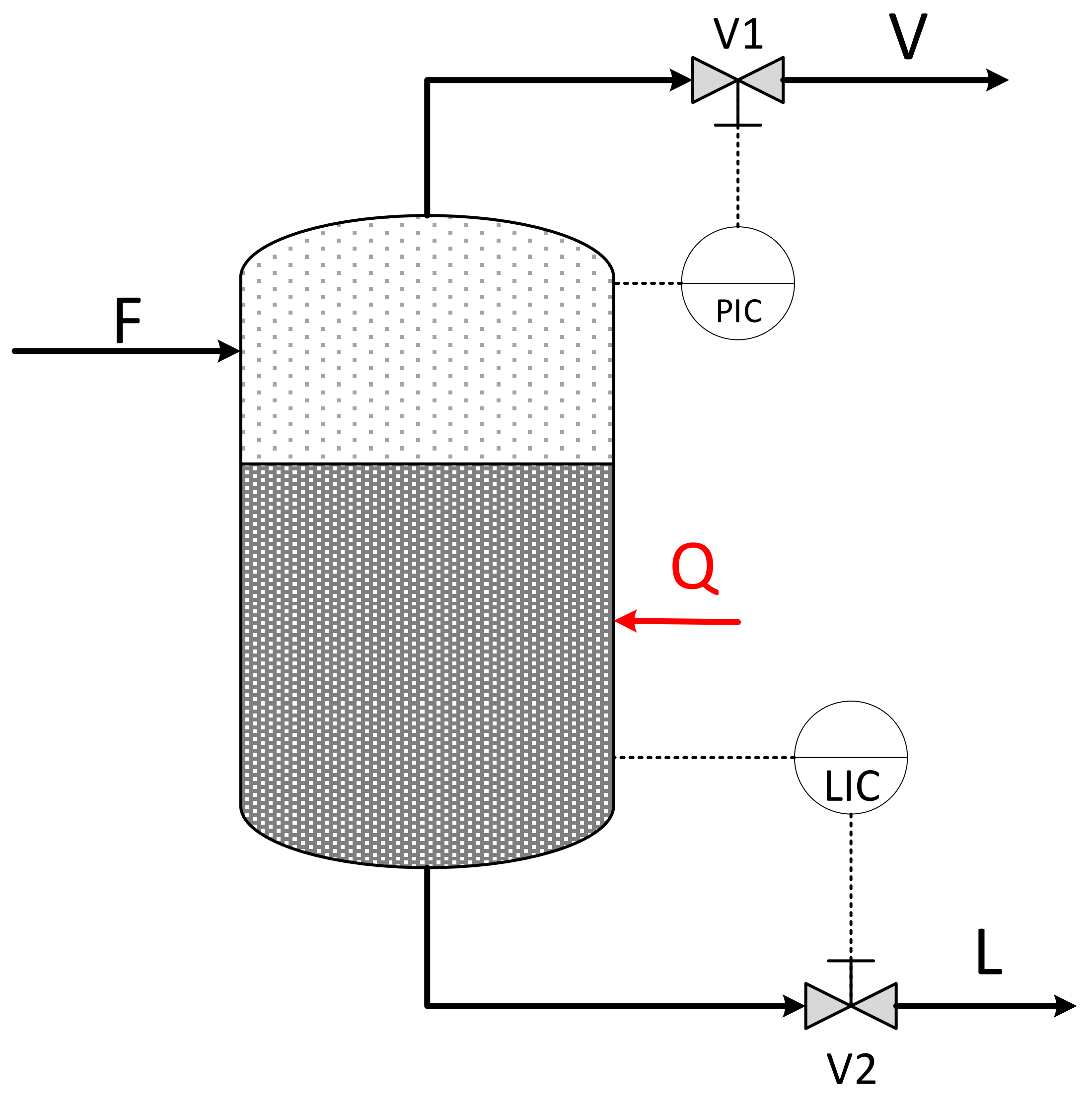
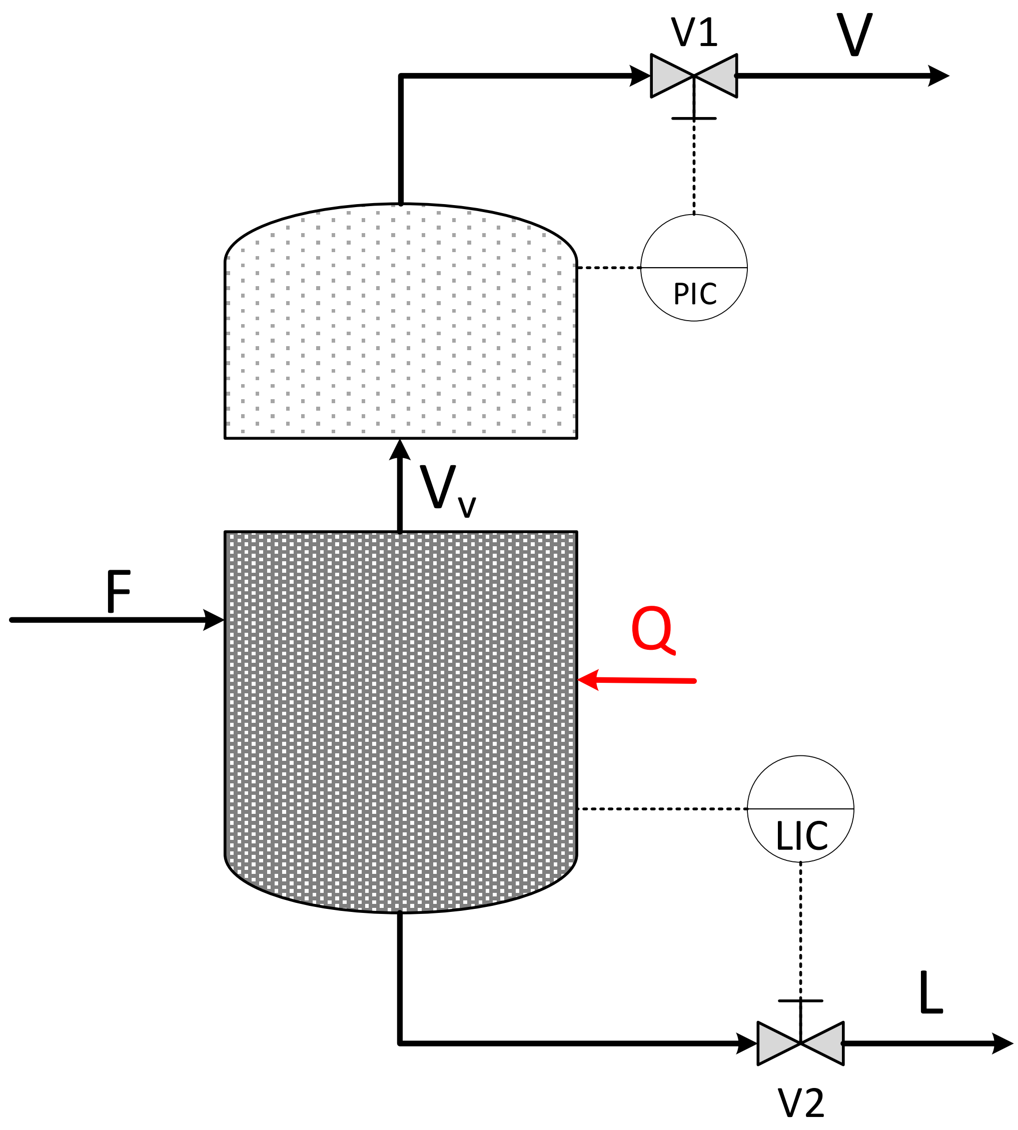
Evaporador Flash



Evaporador Flash - Hipótesis

- No se producen reacciones químicas.
- Opera en equilibrio térmico
- Hold up de vapor **NO** despreciable.
- Las presiones de descargas son conocidas y constantes.
- Líquido con mezcla perfecta.

Evaporador FLash



Evaporador Flash - Modelo

- Balance de materia total en el líquido:

$$\frac{dM_l}{dt} = F - V_s - L$$

$$\frac{d\,\rho_L A_{FL} h_l}{dt} = F - V_s - L$$

$$\rho_L A_{FL}\frac{dh_l}{dt} = F - V_s - L$$

$$\rho_L = f\left(T_L, x\right)$$

Evaporador Flash - Modelo

- Balance por componentes:

$$\frac{dM_l x_i}{dt} = Fz_i - V_s y_{s,i} - Lx_i \qquad \forall i$$

$$\frac{dM_l x_i}{dt} = Fz_i - V_s K_i x_i - Lx_i \qquad \forall i$$

$$\frac{d\rho_L A_{FL} h_l x_i}{dt} = Fz_i - V_s K_i x_i - Lx_i \qquad \forall i$$

$$\rho_L A_{FL} \frac{dh_l x_i}{dt} = Fz_i - V_s K_i x_i - Lx_i \qquad \forall i$$

$$\rho_L A_{FL} h_l \frac{dx_i}{dt} + \rho_L A_{FL} x_i \frac{dh_l}{dt} = Fz_i - V_s K_i x_i - Lx_i \qquad \forall i$$

$$K_i = f\left(T_L, P_{eq}\right) \qquad P_{eq} = \sum_i x_i P_i^{vap}\left(T_L\right)$$

Presión de burbuja

Evaporador Flash - Modelo

- Balance de energía:

$$\frac{dM_l H_L}{dt} = FH_F - V_s H_{Vs} - LH_L + Q$$

$$\rho_L A_{FL} \frac{dh_l H_L}{dt} = FH_F - V_s H_{Vs} - LH_L$$

$$\rho_L A_{FL} h_l \frac{dH_L}{dt} + \rho_L A_{FL} H_L \frac{dh_l}{dt} = FH_F - V_s H_{Vs} - LH_L$$

$$H_L = f\left(T_L, x\right)$$

$$H_{Vs} = f\left(T_L, Kx\right)$$

Evaporador Flash - Modelo

- Balance de materia total en el vapor:

$$\frac{dM_v}{dt} = V_s - V$$

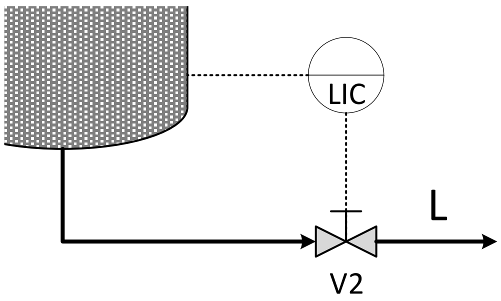
- Masa evaporada:

$$W_s = K_{evap}\left(P_{eq} - P_G\right)$$

- Moles evaporados:

$$V_s = K_{evap}\left(P_{eq} - P_G\right) \Big/ \sum_i K_i x_i MW_i$$

Evaporador Flash - Modelo



$$\varepsilon_L = h_l - h_{sp}$$ Control directo

$$A_P^L = K_P^L \varepsilon_L \qquad \frac{dA_I^L}{dt} = K_I^L \varepsilon_L \quad A_D^L = K_D^L \frac{dh_l}{dt}$$

$$AC^L = A_P^L + A_I^L + A_D^L + A_0^L$$

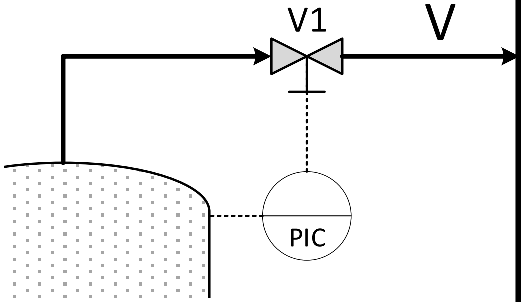
$$x_{V2} = \max\left(0, \min\left(1, AC^L\right)\right)$$

$$\Delta P_{V2} = P_G + \rho_L g h_l - P_L$$

$$L = \rho_L \beta^{x_{V2}-1} K_{V2} \sqrt{\frac{\Delta P_{V2}}{G_{V2}}}$$

Evaporador Flash - Modelo

$$\varepsilon_{PR} = P_G - P_{sp}$$ Control directo



$$A_P^{PR} = K_P^{PR}\,\varepsilon_{PR} \qquad \frac{dA_I^{PR}}{dt} = K_I^{PR}\varepsilon_{PR} \qquad A_D^{PR} = K_D^{PR}\frac{dP_G}{dt}$$

$$AC^{PR} = A_P^{PR} + A_I^{PR} + A_D^{PR} + A_0^{PR}$$

$$x_{V1} = \max\left(0, \min\left(1, AC^{PR}\right)\right)$$

$$\Delta P_{V1} = P_G - P_V \qquad P_G = \frac{M_v R T_L}{A_{FL}\left(h_T - h_l\right)}$$

$$V = \rho_V \beta^{x_{V2}-1} K_{V1}\sqrt{\frac{\Delta P_{V1}}{G_{V1}}} \qquad \rho_V = \frac{P_G}{RT_L}$$

Evaporador Flash - Modelo

$$\rho_L A_{FL} \frac{dh_l}{dt} = F - V_s - L$$

$$\rho_L A_{FL} h_l \frac{dx_i}{dt} + \rho_L A_{FL} x_i \frac{dh_l}{dt} = F z_i - V_s K_i x_i - L x_i \qquad \forall i$$

$$\rho_L A_{FL} h_l \frac{dH_L}{dt} + \rho_L A_{FL} H_L \frac{dh_l}{dt} = F H_F - V_s H_{Vs} - L H_L$$

$$\frac{dM_v}{dt} = V_s - V$$

$$\frac{dA_I^L}{dt} = K_I^L \varepsilon_L$$

$$\frac{dA_I^{PR}}{dt} = K_I^{PR} \varepsilon_{PR}$$

Evaporador Flash - Modelo

$$\rho_L A_{FL} \frac{dh_l}{dt} = F - V_s - L$$

$$\frac{dh_l}{dt} = f_1\left(\frac{dh_l}{dt}\right)$$

$$\rho_L A_{FL} h_l \frac{dx_i}{dt} + \rho_L A_{FL} x_i \frac{dh_l}{dt} = F z_i - V_s K_i x_i - L x_i \qquad \forall i$$

$$\frac{dx_i}{dt} = f_2\left(\frac{dh_l}{dt}\right) \qquad \forall i$$

Evaporador Flash - Modelo

$$\rho_L A_{FL} h_l \frac{dH_L}{dt} + \rho_L A_{FL} H_L \frac{dh_l}{dt} = FH_F - V_s H_{Vs} - LH_L$$

$$\frac{dH_L}{dt} = f_3\left(\frac{dh_l}{dt}\right)$$

$$\frac{dM_v}{dt} = V_s - V$$

$$\frac{dM_v}{dt} = f_4\left(\frac{dP_G}{dt}\right)$$

Evaporador Flash - Resolución

$$h_l^{(0)} \quad x_i^{(0)} \quad H_L^{(0)} \quad M_v^{(0)} \quad A_I^{L(0)} \quad A_I^{PR(0)}$$

$$H_L = f\left(T_L, x\right) \rightarrow T_L^{(0)}$$

$$\rho_L = f\left(T_L, x\right) \rightarrow \rho_L^{(0)}$$

$$P_{eq} = \sum_i x_i P_i^{vap}\left(T_L\right) \rightarrow P_{eq}^{(0)}$$

$$K_i = \frac{P_i^{vap}}{P_{eq}} \rightarrow K_i^{(0)}$$

$$H_{Vs} = f\left(T_L, Kx\right) \rightarrow H_{Vs}^{(0)}$$

Evaporador Flash - Resolución

$$P_G = \frac{M_v R T_L}{A_{FL}\left(h_T - h_l\right)} \rightarrow P_G^{(0)}$$

$$V_s = K_{evap}\left(P_{eq} - P_G\right) \Big/ \sum_i K_i x_i MW_i \rightarrow V_s^{(0)}$$

$$\left.\begin{aligned} \varepsilon_L &= h_l - h_{sp} \\ A_P^L &= K_P^L\, \varepsilon_L \\ \varepsilon_{PR} &= P_G - P_{sp} \\ A_P^{PR} &= K_P^{PR}\, \varepsilon_{PR} \end{aligned}\right\} \rightarrow \varepsilon_L^{(0)}, A_P^{L(0)}, \varepsilon_{PR}^{(0)}, A_P^{PR(0)}$$

$$\left(\frac{dA_I^{PR}}{dt}\right)^{(0)} = K_I^{PR} \varepsilon_{PR}^{(0)} \qquad \left(\frac{dA_I^{L}}{dt}\right)^{(0)} = K_I^{L} \varepsilon_{L}^{(0)}$$

Evaporador Flash - Resolución

proponemos: $\left(\dfrac{dh_l}{dt}\right)^*$

$$\left.\begin{aligned}
A_D^L &= K_D^L \left(\frac{dh_l}{dt}\right)^* \\
AC^L &= A_P^L + A_I^L + A_D^L + A_0^L \\
x_{V2} &= \max\left(0, \min\left(1, AC^L\right)\right) \\
\Delta P_{V2} &= P_G + \rho_L g h_l - P_L \\
L &= \rho_L \beta^{x_{V2}-1} K_{V2} \sqrt{\frac{\Delta P_{V2}}{G_{V2}}}
\end{aligned}\right\} \rightarrow L^{(0)}$$

Evaporador Flash - Resolución

proponemos: $\left(\dfrac{dP_G}{dt}\right)^*$

$$\left.\begin{aligned}
&A_D^{PR} = K_D^{PR}\frac{dP_G}{dt}\\
&AC^{PR} = A_P^{PR} + A_I^{PR} + A_D^{PR} + A_0^{PR}\\
&x_{V1} = \max\left(0, \min\left(1, AC^{PR}\right)\right)\\
&\Delta P_{V1} = P_G - P_V\\
&\rho_V = \frac{P_G}{RT_L}\\
&V = \rho_V \beta^{x_{V2}-1} K_{V1}\sqrt{\frac{\Delta P_{V1}}{G_{V1}}}
\end{aligned}\right\} \rightarrow V^{(0)}$$

Evaporador Flash - Resolución

$$\left(\frac{dh_l}{dt}\right)^{(0)} = f_1\left(\left(\frac{dh_l}{dt}\right)^{*}\right)$$

Para comparar

$$\left(\frac{dx_i}{dt}\right)^{(0)} = f_2\left(\left(\frac{dh_l}{dt}\right)^{*}\right) \qquad \forall i$$

$$\left(\frac{dH_L}{dt}\right)^{(0)} = f_3\left(\left(\frac{dh_l}{dt}\right)^{*}\right)$$

$$\left(\frac{dM_v}{dt}\right)^{(0)} = f_4\left(\left(\frac{dP_G}{dt}\right)^{*}\right)$$

Verificación del salto temporal

$$x_i^{(1)} = x_i^{(0)} + \Delta t \left(\frac{dx_i}{dt} \right)^{(0)} \qquad \forall i$$

$$H_L^{(1)} = H_L^{(0)} + \Delta t \left(\frac{dH_L}{dt} \right)^{(0)}$$

$$M_v^{(1)} = M_v^{(0)} + \Delta t \left(\frac{dM_v}{dt} \right)^{(0)}$$

$$h_l^{(1)} = h_l^{(0)} + \Delta t \left(\frac{dh_l}{dt} \right)^{(0)}$$

$$H_L^{(1)} = f\left(T_L^{(1)}, x^{(1)} \right) \rightarrow T_L^{(1)}$$

$$P_G^{(1)} = \frac{M_v^{(1)} R T_L^{(1)}}{A_{FL}\left(h_T - h_l^{(1)} \right)}$$

$$\left(\frac{dP_G}{dt} \right)^{(0)} = \frac{P_G^{(1)} - P_G^{(0)}}{\Delta t}$$

Para comparar

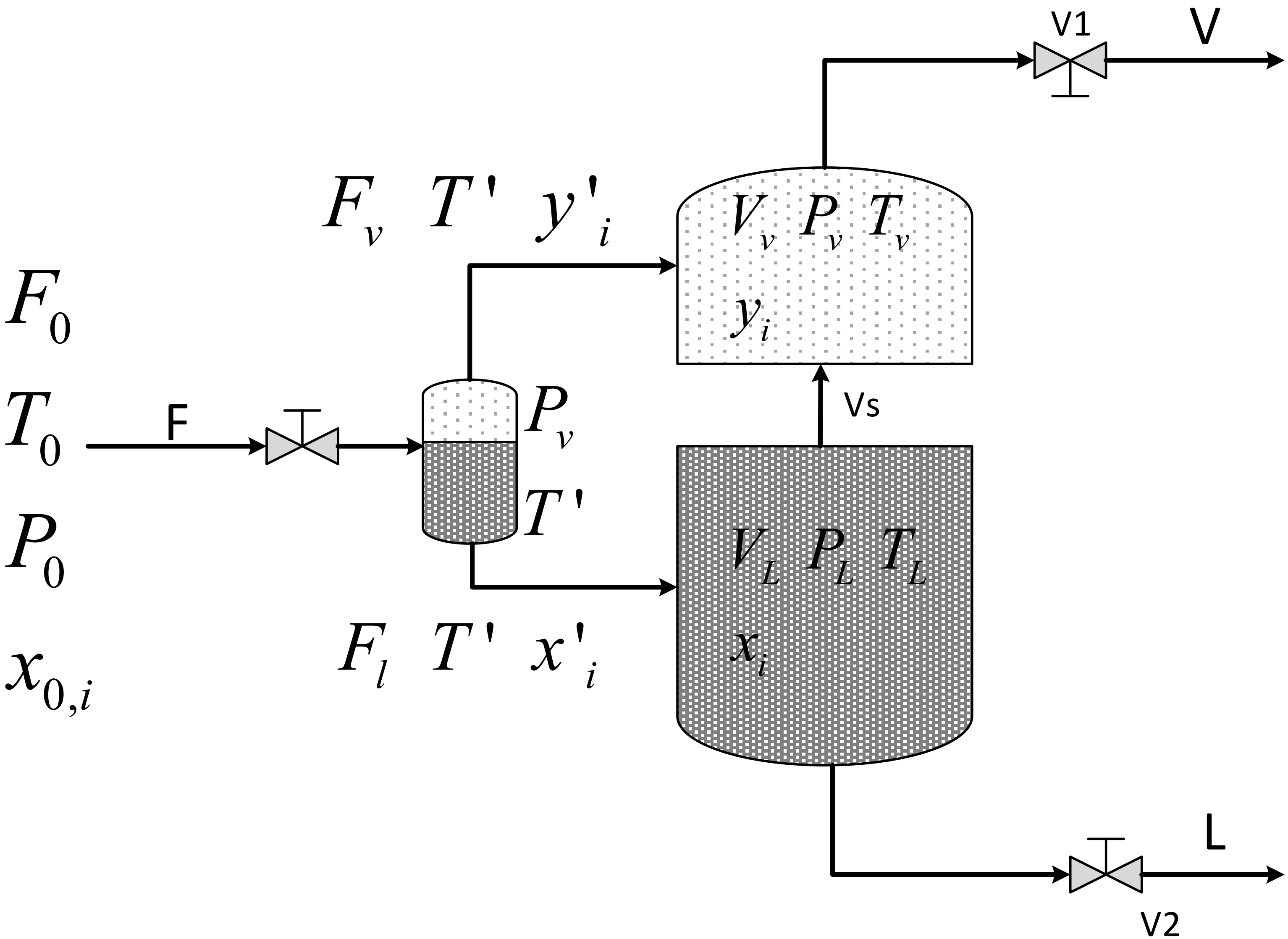
Verificación del salto temporal

$$G_1 = \left| \left(\frac{dh_l}{dt} \right)^* - \left(\frac{dh_l}{dt} \right)^{(0)} \right|$$

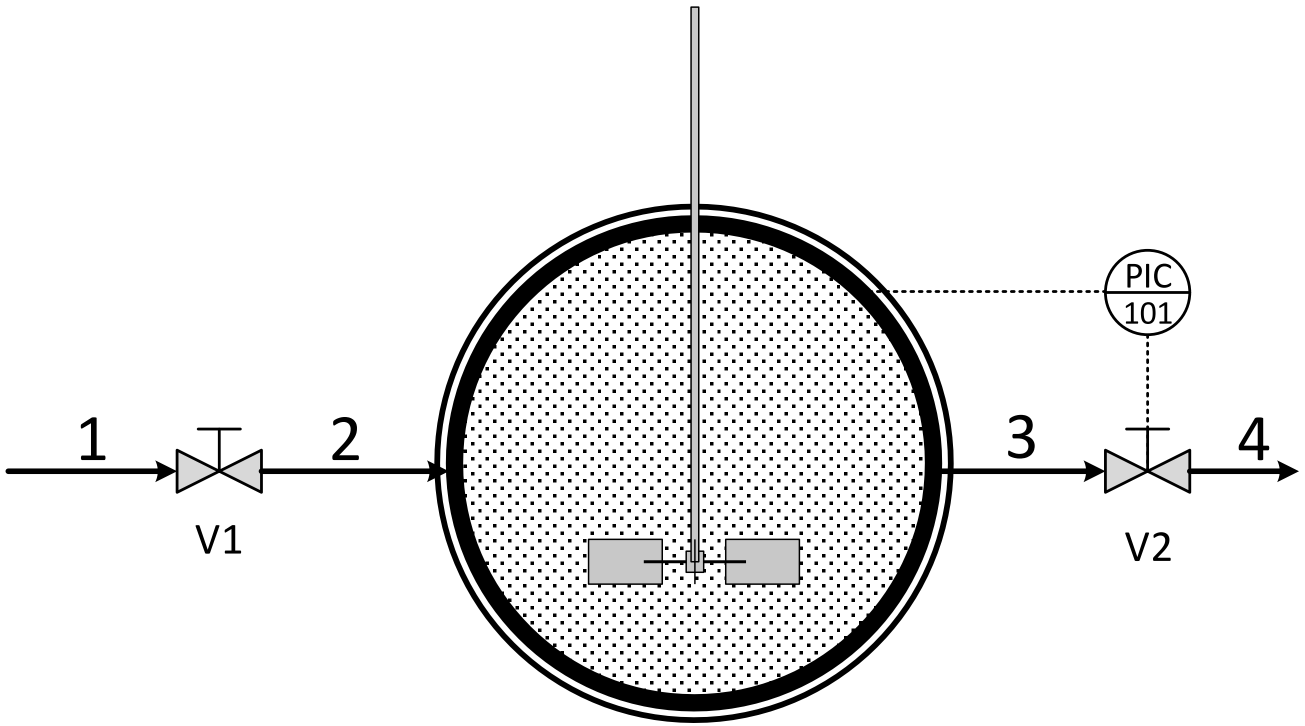
$$G_2 = \left| \left(\frac{dP_G}{dt} \right)^* - \left(\frac{dP_G}{dt} \right)^{(0)} \right|$$

Chequeamos convergencia y recalculamos o pasamos al siguiente tiempo…

Flash II



Reactor adiabático en fase gaseosa con control de presión



Reactor adiabático en fase gaseosa con control de presión

Hipótesis

- Volumen y set point de presión conocidos.
- Con reacción química en fase gaseosa cuya cinética es:

$$A \leftrightarrow 3B$$

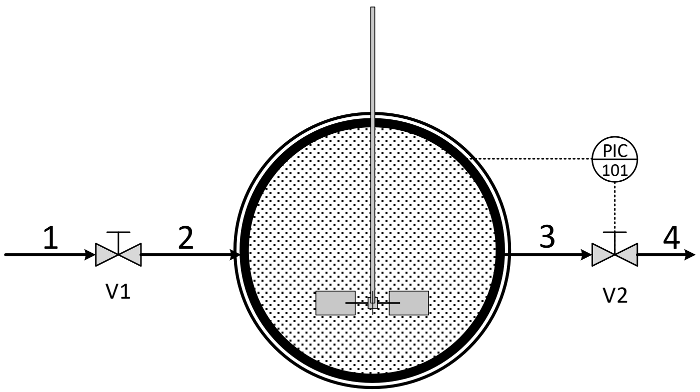
$$r_D = k_D p_A \qquad r_A = -k_D p_A + k_I {p_B}^3$$

$$r_I = k_I {p_B}^3 \qquad r_B = 3k_D p_A - 3k_I {p_B}^3$$

- Reacción exotérmica: (ΔHR<0)
- Adiabático.
- Válvulas de igual porcentaje.
- Válvula de alimentación (V1) abierta al 50%

Reactor adiabático en fase gaseosa con control de presión

$$\frac{dM_A}{dt} = m_2 y_{A,2} + r_A V_R - m_3 y_{A,3}$$



$$M = \frac{P_R V_R}{ZRT_3} \xrightarrow{IG} M = \frac{P_R V_R}{RT_3}$$

$$M_A = \frac{p_A V_R}{RT_3}$$

$$\frac{d\,\frac{p_A V_R}{RT_3}}{dt} = m_2 y_{A,2} + r_A V_R - m_3 y_{A,3}$$

$$\frac{V_R}{RT_3}\frac{dp_A}{dt} - \frac{p_A V_R}{RT_3^{\,2}}\frac{dT_3}{dt} = m_2 y_{A,2} + r_A V_R - m_3 y_{A,3}$$

Reactor adiabático en fase gaseosa con control de presión

$$\frac{V_R}{RT_3}\frac{dp_A}{dt}-\frac{p_A V_R}{RT_3^{\,2}}\frac{dT_3}{dt}=m_2 y_{A,2}+r_A V_R-m_3 y_{A,3}$$

$$\frac{V_R}{RT_3}\frac{dp_B}{dt}-\frac{p_B V_R}{RT_3^{\,2}}\frac{dT_3}{dt}=m_2 y_{B,2}+r_B V_R-m_3 y_{B,3}$$

$$r_A=-k_D p_A+k_I p_B^{\,3}$$

$$r_B=3k_D p_A-3k_I p_B^{\,3}$$

$$k_D=f\left(T_3\right)$$

$$k_I=f\left(T_3\right)$$

Reactor adiabático en fase gaseosa con control de presión

$$\frac{dM}{dt} = m_2 + \sum_{i=A}^{B} r_i V_R - m_3$$

$$\frac{dM}{dt} = m_2 - 2r_A V_R - m_3 \rightarrow M = \frac{P_R V_R}{R T_3}$$

$$\frac{V_R}{R}\frac{d\left(P_R / T_3\right)}{dt} = m_2 - 2r_A V_R - m_3$$

$$\frac{V_R}{RT_3}\frac{dP_R}{dt} - \frac{P_R V_R}{RT_3^2}\frac{dT_3}{dt} = m_2 - 2r_A V_R - m_3$$

$$p_A + p_B = P_R$$

$$\frac{dp_A}{dt} + \frac{dp_B}{dt} = \frac{dP_R}{dt}$$

$$p_A = y_{A,3} P_R$$

$$p_B = y_{B,3} P_R$$

Reactor adiabático en fase gaseosa con control de presión

$$\frac{dMH_3}{dt} = m_2 H_2 + \left(-r_A\right)\left(-\Delta H_{RD}\right)V_R - m_3 H_3$$

$$M\frac{dH_3}{dt} + H_3\frac{dM}{dt} = m_2 H_2 + \left(-r_A\right)\left(-\Delta H_{RD}\right)V_R - m_3 H_3$$

$$\frac{P_R V_R}{RT_3}\frac{dH_3}{dt} + H_3\frac{V_R}{RT_3}\frac{dP_R}{dt} - H_3\frac{P_R V_R}{RT_3{}^2}\frac{dT_3}{dt} = m_2 H_2 + \left(-r_A\right)\left(-\Delta H_{RD}\right)V_R - m_3 H_3$$

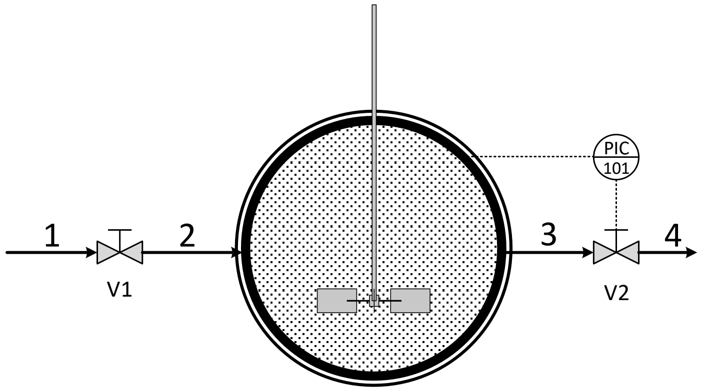
$$H_3 = f\left(T_3, y_3\right)$$

$$H_2 = f\left(T_2, y_2\right)$$

$$\Delta H_{RD} = f\left(T_3\right)$$

Reactor adiabático en fase gaseosa con control de presión

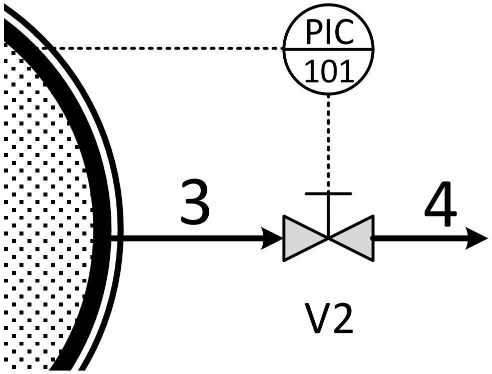
$$m_2 = \rho_1 \alpha^{x_{V1}-1} K_{V1} \sqrt{\frac{\Delta P_{V1}}{G_{V1}}}$$



$$\Delta P_{V1} = P_1 - P_R$$

Reactor adiabático en fase gaseosa con control de presión

$$\varepsilon_{PR} = P_R - P_{sp}$$ Control directo



$$A_P^{PR} = K_P^{PR}\,\varepsilon_{PR} \qquad \frac{dA_I^{PR}}{dt} = K_I^{PR}\varepsilon_{PR} \qquad A_D^{PR} = K_D^{PR}\frac{dP_R}{dt}$$

$$AC^{PR} = A_P^{PR} + A_I^{PR} + A_D^{PR} + A_0^{PR}$$

$$x_{V2} = \max\left(0, \min\left(1, AC^{PR}\right)\right)$$

$$\Delta P_{V2} = P_R - P_4$$

$$m_3 = \rho_3 \beta^{x_{V2}-1} K_{V2}\sqrt{\frac{\Delta P_{V2}}{G_{V2}}} \qquad \rho_3 = \frac{P_R}{RT_3}$$

Resumen

$$\frac{V_R}{RT_3}\frac{dp_A}{dt}-\frac{p_A V_R}{RT_3^{\,2}}\frac{dT_3}{dt}=m_2 y_{A,2}+r_A V_R-m_3 y_{A,3}$$

$$\frac{V_R}{RT_3}\frac{dp_B}{dt}-\frac{p_B V_R}{RT_3^{\,2}}\frac{dT_3}{dt}=m_2 y_{B,2}+r_B V_R-m_3 y_{B,3}$$

$$\frac{dP_R}{dt}=\frac{dp_A}{dt}+\frac{dp_B}{dt}$$

$$\frac{P_R V_R}{RT_3}\frac{dH_3}{dt}+H_3\frac{V_R}{RT_3}\frac{dP_R}{dt}-H_3\frac{P_R V_R}{RT_3^{\,2}}\frac{dT_3}{dt}=m_2 H_2+\left(-r_A\right)\left(-\Delta H_{RD}\right)V_R-m_3 H_3$$

$$\frac{dA_I^{PR}}{dt}=K_I^{PR}\varepsilon_{PR}$$

Resumen

$$\frac{V_R}{RT_3}\frac{dp_A}{dt}-\frac{p_A V_R}{RT_3^{\,2}}\frac{dT_3}{dt}=m_2 y_{A,2}+r_A V_R-m_3 y_{A,3}$$

$$\frac{V_R}{RT_3}\frac{dp_B}{dt}-\frac{p_B V_R}{RT_3^{\,2}}\frac{dT_3}{dt}=m_2 y_{B,2}+r_B V_R-m_3 y_{B,3}$$

$$\frac{P_R V_R}{RT_3}\frac{dH_3}{dt}+\frac{H_3 V_R}{RT_3}\frac{dp_A}{dt}+\frac{H_3 V_R}{RT_3}\frac{dp_B}{dt}-H_3\frac{P_R V_R}{RT_3^{\,2}}\frac{dT_3}{dt}=\dots$$

$$m_2 H_2+\left(-r_A\right)\left(-\Delta H_{RD}\right)V_R-m_3 H_3$$

$$\frac{dA_I^{PR}}{dt}=K_I^{PR}\varepsilon_{PR}$$

Resumen

$$\frac{V_R}{RT_3}\frac{dp_A}{dt}-\frac{p_A V_R}{RT_3{}^2}\frac{dT_3}{dt}=m_2 y_{A,2}+r_A V_R-m_3 y_{A,3}$$

$$\frac{dp_A}{dt}=f_1\left(\frac{dT_3}{dt},\frac{dp_A}{dt},\frac{dp_B}{dt}\right)$$

$$\frac{V_R}{RT_3}\frac{dp_B}{dt}-\frac{p_B V_R}{RT_3{}^2}\frac{dT_3}{dt}=m_2 y_{B,2}+r_B V_R-m_3 y_{B,3}$$

$$\frac{dp_B}{dt}=f_2\left(\frac{dT_3}{dt},\frac{dp_A}{dt},\frac{dp_B}{dt}\right)$$

Resumen

$$\frac{P_R V_R}{R T_3}\frac{dH_3}{dt}+\frac{H_3 V_R}{R T_3}\frac{dp_A}{dt}+\frac{H_3 V_R}{R T_3}\frac{dp_B}{dt}-H_3\frac{P_R V_R}{R {T_3}^2}\frac{dT_3}{dt}=\ldots$$

$$m_2 H_2 - r_A\left(-\Delta H_{RD}\right)V_R - m_3 H_3$$

$$\frac{dH_3}{dt}=f_3\left(\frac{dp_A}{dt},\frac{dp_B}{dt},\frac{dT_3}{dt}\right)$$

$$\frac{dA_I^{PR}}{dt}=K_I^{PR}\varepsilon_{PR}$$

$$\frac{dA_I^{PR}}{dt}=f_4\left(\quad\right)$$

Tiempo $i = 0$

$$p_A^{(0)} \quad p_B^{(0)} \quad H_3^{(0)} \quad A_I^{PR(0)}$$

$$p_A + p_B = P_R \rightarrow P_R^{(0)}$$

$$\left.\begin{array}{l} p_A = y_A P_R \\ p_B = y_B P_R \end{array}\right\} \rightarrow y_{A,3}^{(0)} \quad y_{B,3}^{(0)}$$

$$H_3 = f\left(T_3, y_3\right) \rightarrow T_3^{(0)}$$

$$\left.\begin{array}{l} \Delta P_{V1} = P_1 - P_R \\ m_2 = \rho_1 \alpha^{x_{V1}-1} K_{V1} \sqrt{\Delta P_{V1} / G_{V1}} \end{array}\right\} \rightarrow m_2^{(0)}$$

Tiempo i = 0

$$\left.\begin{aligned} k_D &= f\left(T_3\right) \\ k_I &= f\left(T_3\right) \\ r_A &= -k_D p_A + k_I p_B^{\,3} \\ r_B &= 3k_D p_A - 3k_I p_B^{\,3} \end{aligned}\right\} \rightarrow r_A^{(0)} \;\; r_B^{(0)}$$

$$\Delta H_{RD} = f\left(T_3\right) \rightarrow \Delta H_{RD}^{(0)}$$

Tiempo $i = 0$ (*)

$$\left.\begin{aligned} \varepsilon_{PR} &= P_R - P_{sp} \\ A_P^{PR} &= K_P^{PR}\,\varepsilon_{PR} \\ \Delta P_{V2} &= P_R - P_4 \end{aligned}\right\} \varepsilon_{PR}{}^{(0)} \quad A_P^{PR(0)} \quad \Delta P_{V2}{}^{(0)}$$

$$\left(\frac{dA_I^{PR}}{dt}\right)^{(0)} = K_I^{PR}\varepsilon_{PR}{}^{(0)}$$

proponemos: $\left(\frac{dp_A}{dt}\right)^{*}$ y $\left(\frac{dp_B}{dt}\right)^{*}$ Luego los debo chequear

$$A_D^{PR} = K_D^{PR}\left(\frac{dP}{dt}\right)^{*} = K_D^{PR}\left(\left(\frac{dp_A}{dt}\right)^{*} + \left(\frac{dp_B}{dt}\right)^{*}\right) \rightarrow A_D^{PR(0)}$$

Tiempo i = 0

$$\left.\begin{aligned}
AC^{PR} &= A_P^{PR} + A_I^{PR} + A_D^{PR} + A_0^{PR} \\
x_{V2} &= \max\left(0, \min\left(1, AC^{PR}\right)\right) \\
\Delta P_{V2} &= P_R - P_4 \\
\rho_3 &= \frac{P_R}{RT_3} \\
m_3 &= \rho_3 \beta^{x_{V2}-1} K_{V2} \sqrt{\frac{\Delta P_{V2}}{G_{V2}}}
\end{aligned}\right\} \rightarrow m_3^{(0)}$$

Tiempo i = 0

proponemos: $\left(\frac{dT_3}{dt}\right)^*$ Luego lo debo chequear

$$\left(\frac{dp_A}{dt}\right)^{(0)} = f_1\left(\left(\frac{dT_3}{dt}\right)^*, \left(\frac{dp_A}{dt}\right)^*, \left(\frac{dp_B}{dt}\right)^*\right)$$

$$\left(\frac{dp_B}{dt}\right)^{(0)} = f_2\left(\left(\frac{dT_3}{dt}\right)^*, \left(\frac{dp_A}{dt}\right)^*, \left(\frac{dp_B}{dt}\right)^*\right)$$

Para comparar con los propuestos

$$\left(\frac{dH_3}{dt}\right)^{(0)} = f_3\left(\left(\frac{dp_A}{dt}\right)^{(0)}, \left(\frac{dp_B}{dt}\right)^{(0)}, \left(\frac{dT_3}{dt}\right)^{(0)}\right)$$

Estimación de (dT/dt)

$$H_3^{(1)} = H_3^{(0)} + \Delta t \left(\frac{dH_3}{dt} \right)^{(0)}$$

$$p_A^{(1)} = p_A^{(0)} + \Delta t \left(\frac{dp_A}{dt} \right)^{(0)}$$

$$p_B^{(1)} = p_B^{(0)} + \Delta t \left(\frac{dp_B}{dt} \right)^{(0)}$$

$$y_{A,3}^{(1)} = \frac{p_A^{(1)}}{p_A^{(1)} + p_B^{(1)}}$$

$$y_{B,3}^{(1)} = \frac{p_B^{(1)}}{p_A^{(1)} + p_B^{(1)}}$$

$$H_3^{(1)} = f\left(T_3^{(1)}, y_3^{(1)} \right) \rightarrow T_3^{(1)}$$

Para comparar con el propuesto

$$T_3^{(1)} = T_3^{(0)} + \Delta t \left(\frac{dT_3}{dt} \right)^{(0)} \rightarrow \left(\frac{dT_3}{dt} \right)^{(0)} = \frac{T_3^{(1)} - T_3^{(0)}}{\Delta t}$$

Verificación del salto temporal

$$G_1 = \left| \left(\frac{dp_A}{dt} \right)^* - \left(\frac{dp_A}{dt} \right)^{(0)} \right|$$

$$G_2 = \left| \left(\frac{dp_B}{dt} \right)^* - \left(\frac{dp_B}{dt} \right)^{(0)} \right|$$

$$G_3 = \left| \left(\frac{dT_3}{dt} \right)^* - \left(\frac{dT_{F1}}{dt} \right)^{(0)} \right|$$

Verificación del salto temporal

$$\left(G_1 \wedge G_2 \wedge G_3\right) \leq tol\,? \rightarrow No:$$

$$\left(\frac{dp_A}{dt}\right)^{*} = \left(\frac{dp_A}{dt}\right)^{(0)}$$

$$\left(\frac{dp_B}{dt}\right)^{*} = \left(\frac{dp_B}{dt}\right)^{(0)}$$

Y repetimos desde **(*)**.....

$$\left(\frac{dT_3}{dt}\right)^{*} = \left(\frac{dT_3}{dt}\right)^{(0)}$$

Variables temporales

$$\left(G_1 \wedge G_2 \wedge G_3\right) \leq tol\,? \rightarrow Si:$$

$${H_3}^{(1)} = {H_3}^{(0)} + \Delta t \left(\frac{dH_3}{dt}\right)^{(0)}$$

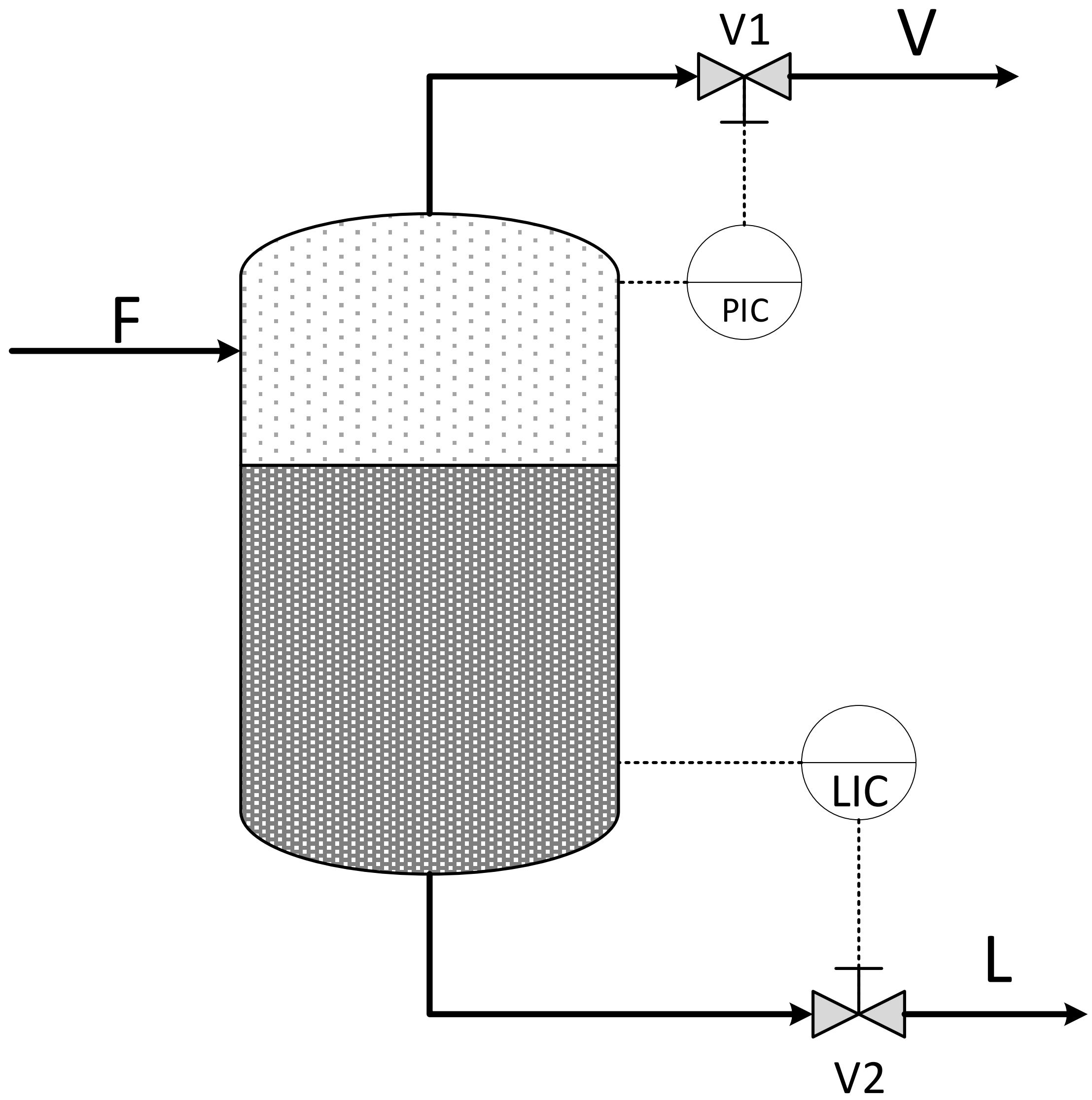
$${p_A}^{(1)} = {p_A}^{(0)} + \Delta t \left(\frac{dp_A}{dt}\right)^{(0)}$$

$${p_B}^{(1)} = {p_B}^{(0)} + \Delta t \left(\frac{dp_B}{dt}\right)^{(0)}$$

$$A_I^{PR(1)} = A_I^{PR(0)} + \Delta t \left(\frac{dA_I^{PR}}{dt}\right)^{(0)}$$

Y repetimos desde el comienzo…

Separador de Liquido y Gas

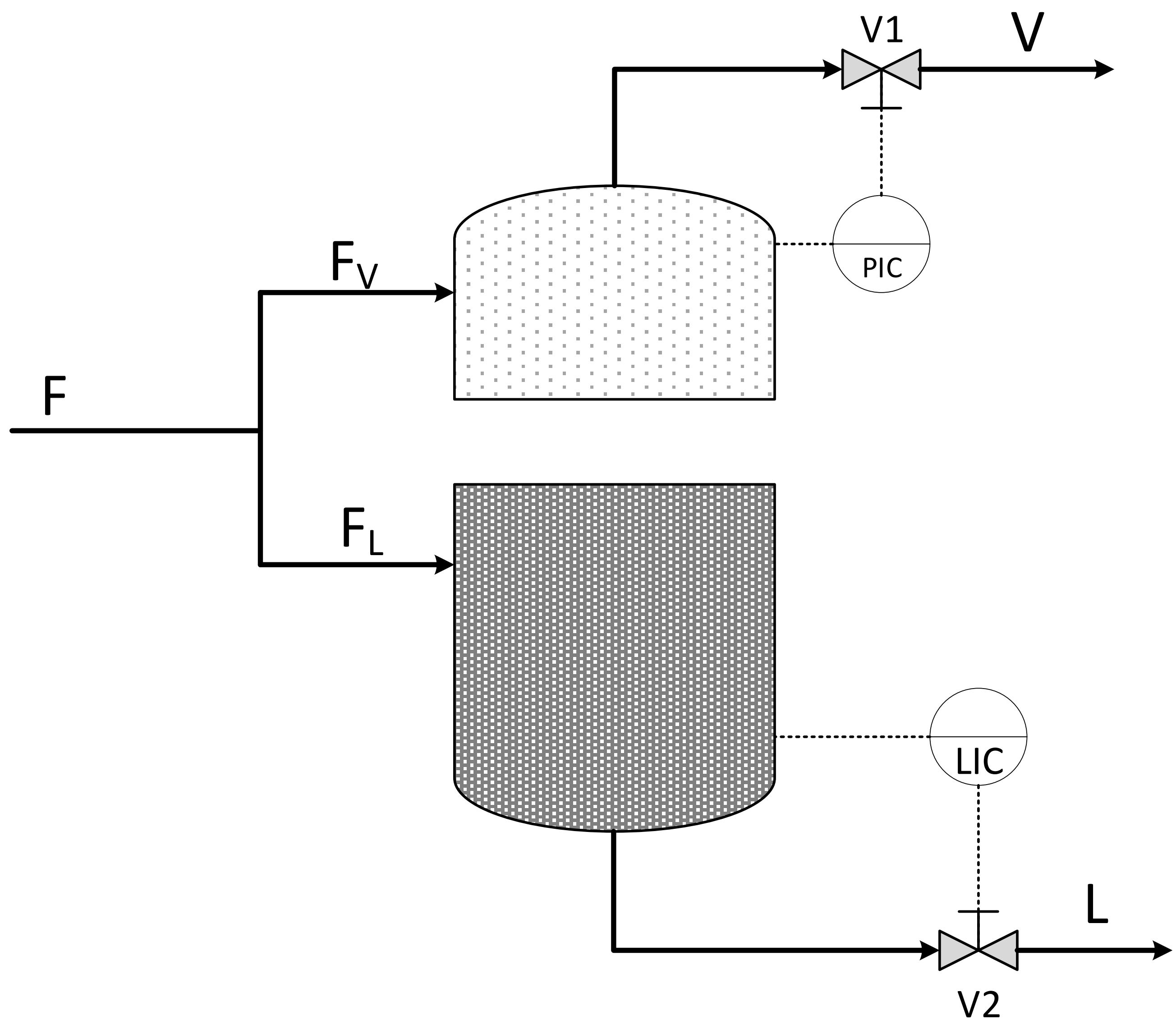


Separador de Liquido y gas

Hipótesis

- No se producen reacciones químicas.
- Opera en equilibrio térmico
- Hold up de gas **NO** despreciable.
- Las presiones de descargas son conocidas y constantes.
- Líquido con mezcla perfecta.
- Gases incondensables.
- Proceso isotérmico.
- F corriente perfectamente conocida de líquidos y gases

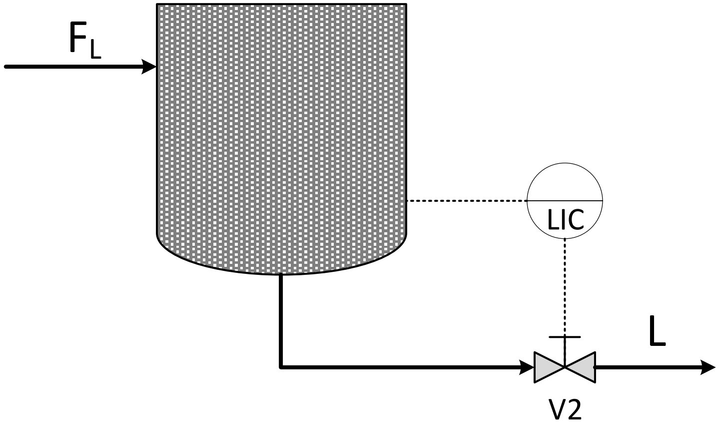
Separador de Liquido y gas



Separador de Liquido y Gas

- Balance de materia total en el líquido:

$$\frac{dM_l}{dt} = F_L - L$$

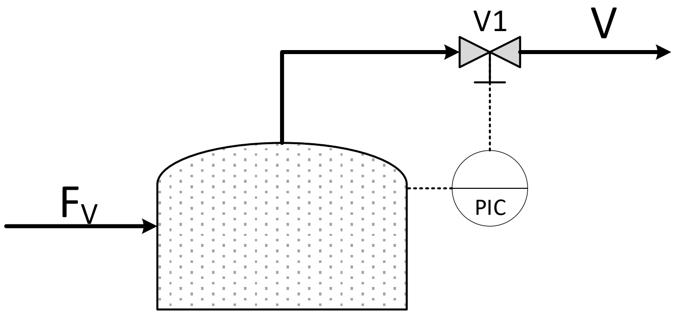


$$\frac{d\rho_L A_T h_l}{dt} = F_L - L$$

$$\rho_L A_T \frac{dh_l}{dt} = F_L - L$$

Separador de Liquido y Gas

- Balance de materia total en el vapor:



$$\frac{dM_v}{dt} = F_V - V$$

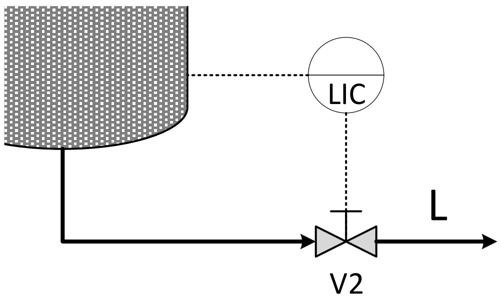
$$M_v = \frac{P_G A_T \left(h_T - h_l\right)}{RT}$$

$$\frac{A_T}{RT}\frac{dP_G \left(h_T - h_l\right)}{dt} = F_V - V$$

$$\frac{A_T}{RT}\left(h_T - h_l\right)\frac{dP_G}{dt} - \frac{A_T}{RT}P_G\frac{dh_l}{dt} = F_V - V$$

Separador de Liquido y Gas

$$\varepsilon_L = h_l - h_{sp}$$ Control directo



$$A_P^L = K_P^L \varepsilon_L \qquad \frac{dA_I^L}{dt} = K_I^L \varepsilon_L \quad A_D^L = K_D^L \frac{dh_l}{dt}$$

$$AC^L = A_P^L + A_I^L + A_D^L + A_0^L$$

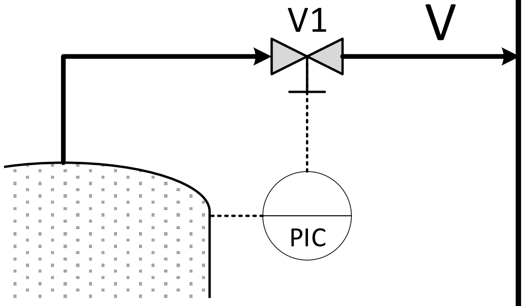
$$x_{V2} = \max\left(0, \min\left(1, AC^L\right)\right)$$

$$\Delta P_{V2} = P_G + \rho_L g h_l - P_L$$

$$L = \rho_L \beta^{x_{V2}-1} K_{V2} \sqrt{\frac{\Delta P_{V2}}{G_{V2}}}$$

Separador de Liquido y Gas

$$\varepsilon_{PR} = P_G - P_{sp}$$ Control directo



$$A_P^{PR} = K_P^{PR}\,\varepsilon_{PR} \qquad \frac{dA_I^{PR}}{dt} = K_I^{PR}\varepsilon_{PR} \qquad A_D^{PR} = K_D^{PR}\frac{dP_G}{dt}$$

$$AC^{PR} = A_P^{PR} + A_I^{PR} + A_D^{PR} + A_0^{PR}$$

$$x_{V1} = \max\left(0, \min\left(1, AC^{PR}\right)\right)$$

$$\Delta P_{V1} = P_G - P_V$$

$$V = \rho_V \beta^{x_{V2}-1} K_{V1}\sqrt{\frac{\Delta P_{V1}}{G_{V1}}} \qquad \rho_V = \frac{P_G}{RT}$$

Separador de Liquido y Gas - Resumen

$$\rho_L A_T \frac{dh_l}{dt} = F_L - L$$

$$\frac{A_T}{RT}\left(h_T - h_l\right)\frac{dP_G}{dt} - \frac{A_T}{RT} P_G \frac{dh_l}{dt} = F_V - V$$

$$\frac{dA_I^L}{dt} = K_I^L \varepsilon_L$$

$$\frac{dA_I^{PR}}{dt} = K_I^{PR} \varepsilon_{PR}$$

Separador de Liquido y Gas - Resumen

$$\rho_L A_T \frac{dh_l}{dt} = F_L - L \quad \rightarrow \frac{dh_l}{dt} = f_1\left(\frac{dh_l}{dt}\right)$$

$$\frac{A_T}{RT}\left(h_T - h_l\right)\frac{dP_G}{dt} - \frac{A_T}{RT}P_G\frac{dh_l}{dt} = F_V - V \rightarrow \frac{dP_G}{dt} = f_2\left(\frac{dh_l}{dt}, \frac{dP_G}{dt}\right)$$

$$\frac{dA_I^{PR}}{dt} = K_I^{PR}\varepsilon_{PR} \quad \rightarrow \frac{dA_I^{PR}}{dt} = f_3(\quad)$$

$$\frac{dA_I^{L}}{dt} = K_I^{L}\varepsilon_{L} \quad \rightarrow \frac{dA_I^{L}}{dt} = f_4(\quad)$$

Tiempo i = 0

$$h_l^{(0)} \quad P_G^{(0)} \quad A_I^{PR(0)} \quad A_I^{L(0)}$$

$$\left.\begin{aligned} &\varepsilon_L = h_l - h_{sp} \\ &A_P^L = K_P^L\,\varepsilon_L \\ &\Delta P_{V2} = P_G + \rho_L g h_l - P_L \end{aligned}\right\} \varepsilon_L^{(0)} \; A_P^{L(0)} \; \Delta P_{V2}^{(0)}$$

$$\left(\frac{dh_l}{dt}\right)^* \rightarrow A_D^L = K_D^L \left(\frac{dh_l}{dt}\right)^* \rightarrow A_D^{L(0)}$$

Luego lo debo chequear

$$\left.\begin{aligned} &AC^L = A_P^L + A_I^L + A_D^L + A_0^L \\ &x_{V2} = \max\left(0, \min\left(1, AC^L\right)\right) \end{aligned}\right\} x_{V2}^{(0)}$$

$$L = \rho_L \beta^{x_{V2}-1} K_{V2} \sqrt{\frac{\Delta P_{V2}}{G_{V2}}} \rightarrow L^{(0)}$$

Tiempo i = 0

$$\left.\begin{array}{l} \varepsilon_{PR} = P_G - P_{sp} \\ A_P^{PR} = K_P^{PR}\,\varepsilon_{PR} \\ \Delta P_{V1} = P_G - P_V \end{array}\right\} \varepsilon_{PR}{}^{(0)}\; A_P^{PR(0)}\; \Delta P_{V1}{}^{(0)}$$

$$\left(\frac{dP_G}{dt}\right)^{*} \rightarrow A_D^{PR} = K_D^{PR}\frac{dP_G}{dt} \rightarrow A_D^{PR(0)}$$

Luego lo debo chequear

$$\left.\begin{array}{l} AC^{PR} = A_P^{PR} + A_I^{PR} + A_D^{PR} + A_0^{PR} \\ x_{V1} = \max\left(0, \min\left(1, AC^{PR}\right)\right) \end{array}\right\} x_{V1}{}^{(0)}$$

$$\rho_V = \frac{P_G}{RT} \rightarrow \rho_V{}^{(0)}$$

$$V = \rho_V \beta^{x_{V2}-1} K_{V1}\sqrt{\frac{\Delta P_{V1}}{G_{V1}}} \rightarrow V^{(0)}$$

Tiempo i = 0

$$\left(\frac{dh_l}{dt}\right)^{(0)} = f_1\left(\left(\frac{dh_l}{dt}\right)^*\right)$$

$$\left(\frac{dP_G}{dt}\right)^{(0)} = f_2\left(\left(\frac{dh_l}{dt}\right)^*, \left(\frac{dP_G}{dt}\right)^*\right)$$

$$G_1 = \left|\left(\frac{dh_l}{dt}\right)^* - \left(\frac{dh_l}{dt}\right)^{(0)}\right|$$

$$G_2 = \left|\left(\frac{dP_G}{dt}\right)^* - \left(\frac{dP_G}{dt}\right)^{(0)}\right|$$

$$¿\left(G_1 \wedge G_2\right) \leq tol\,?$$

No, reemplazamos y repetimos

Tiempo i = 0

$$\left(\frac{dh_l}{dt}\right)^{(0)} = f_1\left(\left(\frac{dh_l}{dt}\right)^*\right)$$

$$\left(\frac{dP_G}{dt}\right)^{(0)} = f_2\left(\left(\frac{dh_l}{dt}\right)^*, \left(\frac{dP_G}{dt}\right)^*\right)$$

$$G_1 = \left|\left(\frac{dh_l}{dt}\right)^* - \left(\frac{dh_l}{dt}\right)^{(0)}\right|$$

$$G_2 = \left|\left(\frac{dP_G}{dt}\right)^* - \left(\frac{dP_G}{dt}\right)^{(0)}\right|$$

$$¿\left(G_1 \wedge G_2\right) \leq tol\,?$$

Si, calculamos todos los diferenciales a tiempo cero y aplicamos Euler.