

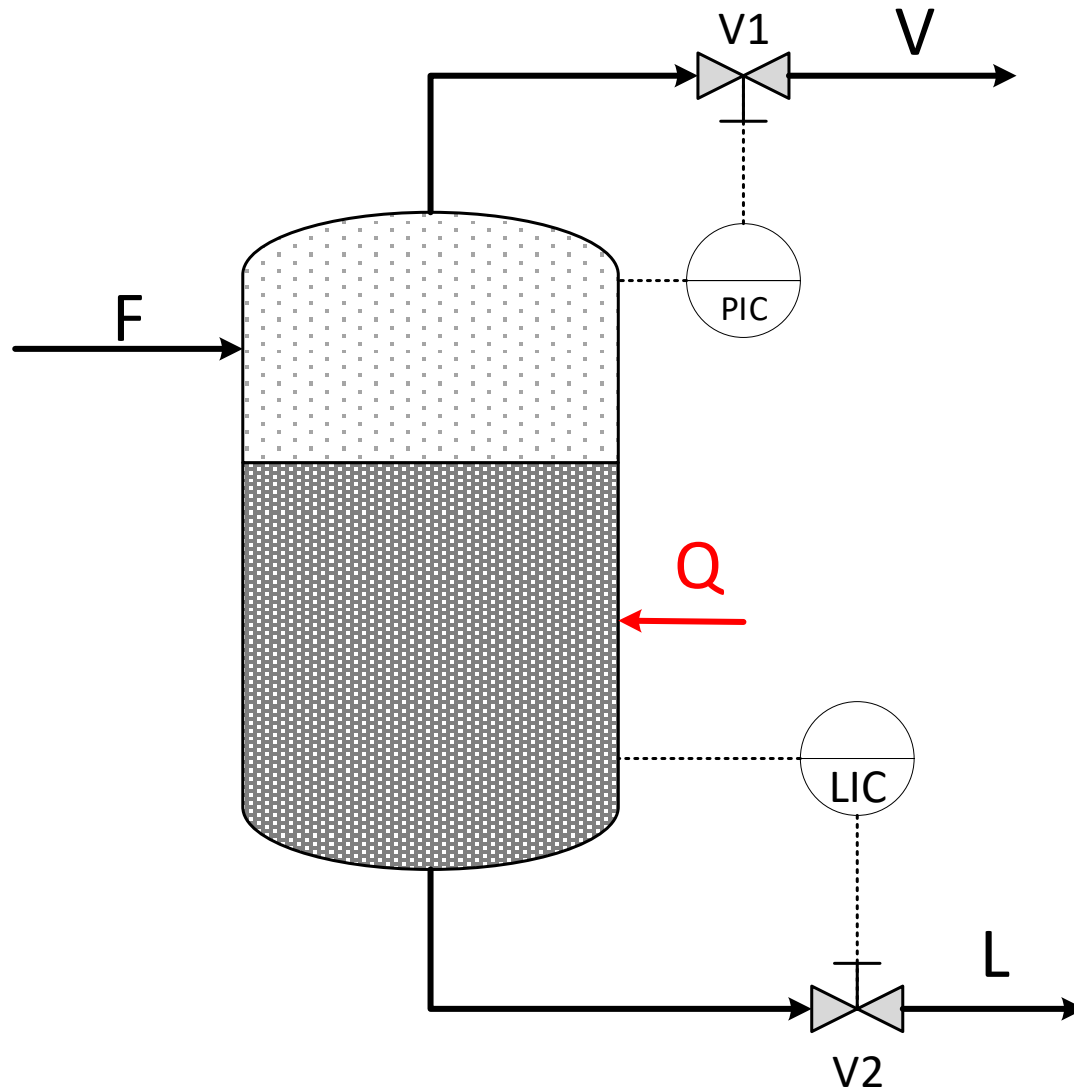
# DSOySP

## **Modelado individual de equipos en estado dinámico (V)**

2024

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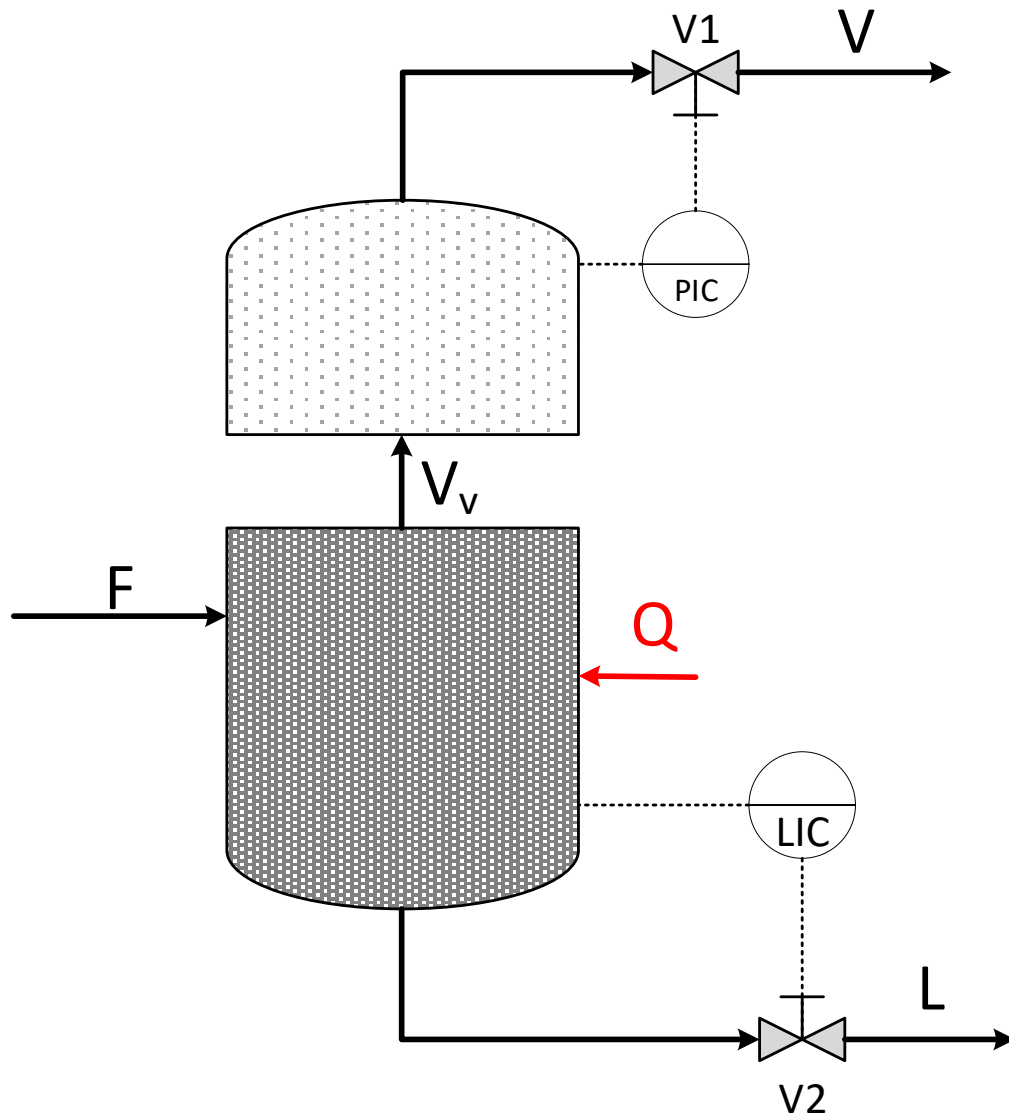
# Evaporador Flash



## 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:

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

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

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

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

# Evaporador Flash - Modelo

- Balance por componentes:

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

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

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

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

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

$$K_i = f(T_L, P_{eq}) \quad P_{eq} = \sum_i x_i P_i^{vap}(T_L) \quad \text{Presión de burbuja}$$

# Evaporador Flash - Modelo

- Balance de energía:

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

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

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

$$H_L = f(T_L, x)$$

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

# Evaporador Flash - Modelo

- Balance de materia total en el vapor:

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

- Masa evaporada:

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

- Moles evaporados:

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



# Evaporador Flash - Modelo

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

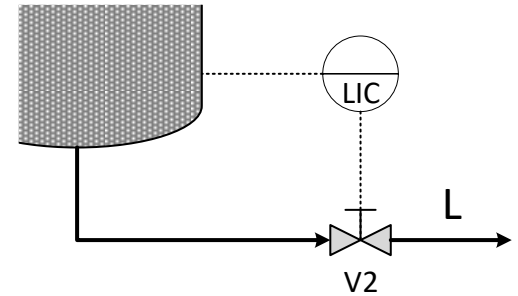
$$A_P^L = K_P^L \varepsilon_L \quad \frac{dA_I^L}{dt} = K_I^L \varepsilon_L \quad A_D^L = K_D^L \frac{dh_l}{dt}$$

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

$$x_{v_2} = \max\left(0, \min\left(1, AC^L\right)\right)$$

$$\Delta P_{V_2} = P_G + \rho_L g h_l - P_L$$

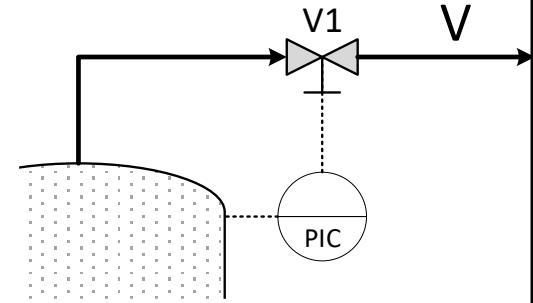
$$L = \rho_L \beta^{x_{v_2}-1} K_{V_2} \sqrt{\frac{\Delta P_{V_2}}{G_{V_2}}}$$



# Evaporador Flash - Modelo

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

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



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

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

$$\Delta P_{V1} = P_G - P_V \quad P_G = \frac{M_v RT_L}{A_{FL} (h_T - h_l)}$$

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

# Evaporador Flash - Modelo

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

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

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

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

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

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

# Evaporador Flash - Resolución

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

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

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

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

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

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

# Evaporador Flash - Resolución

$$P_G = \frac{M_v RT_L}{A_{FL} (h_T - h_l)} \rightarrow P_G^{(0)}$$

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

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

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

# Evaporador Flash - Resolución

proponemos:  $\left(\frac{dh_1}{dt}\right)^*$

$$A_D^L = K_D^L \left(\frac{dh_1}{dt}\right)^*$$

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

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

$$\Delta P_{V2} = P_G + \rho_L g h_1 - P_L$$

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

# Evaporador Flash - Resolución

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

$$A_D^{PR} = K_D^{PR} \frac{dP_G}{dt}$$

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

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

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

$$\rho_V = \frac{P_G}{RT_L}$$

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

}  $\rightarrow V^{(0)}$

# Evaporador Flash - Resolución

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

Para comparar

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

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

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



# Verificación del salto temporal

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

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

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

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

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

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

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

Para comparar

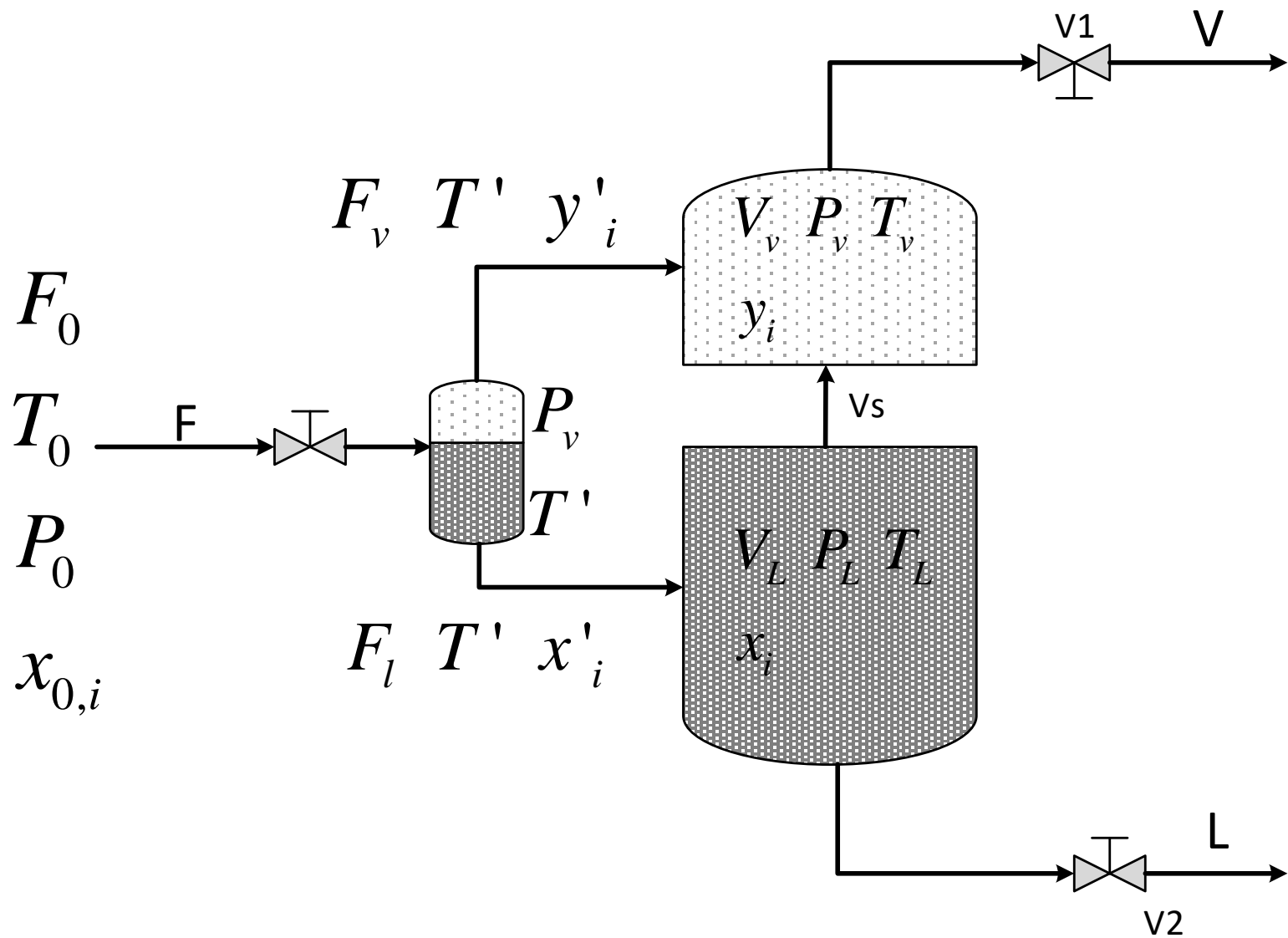
## Verificación del salto temporal

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

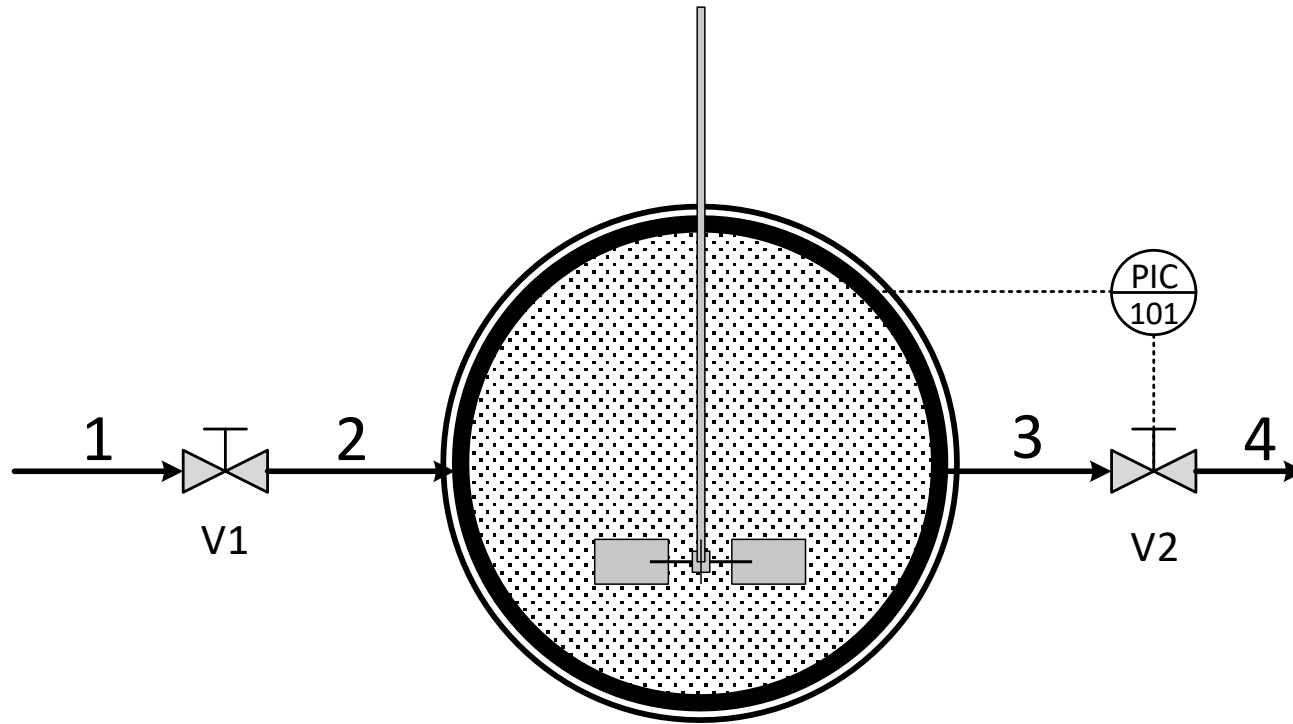
$$G_2 = \left| \left( \frac{dP_G}{dt} \right)^* - \left( \frac{dP_G}{dt} \right)^{(0)} \right|$$

Chequeamos convergencia y  
recalculamos o pasamos al  
siguiente tiempo...

# Flash II



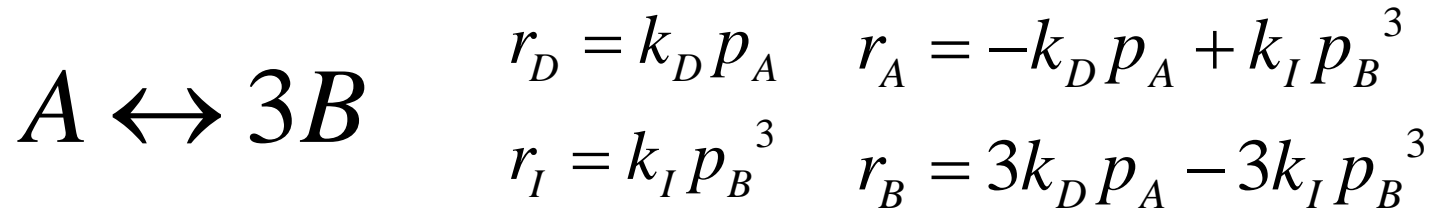
# Reactor adiabático en fase gaseosa con control de presión



# 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:



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

# Reactor adiabático en fase gaseosa con control de presión

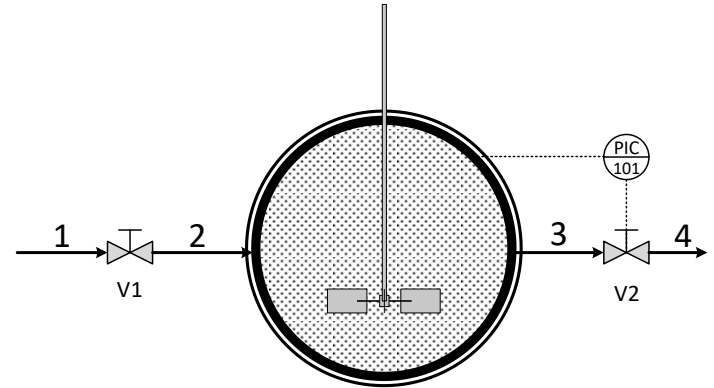
$$\frac{dM_A}{dt} = m_2 y_{A,2} + r_A V_R - m_3 y_{A,3}$$

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

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

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

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



# Reactor adiabático en fase gaseosa con control de presión

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

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

$$r_A = -k_D p_A + k_I p_B^3$$

$$r_B = 3k_D p_A - 3k_I p_B^3$$

$$k_D = f(T_3)$$

$$k_I = f(T_3)$$

# Reactor adiabático en fase gaseosa con control de presión

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

$$\frac{dM}{dt} = m_2 - 2r_A V_R - m_3 \rightarrow M = \frac{P_R V_R}{RT_3} \qquad \frac{dp_A}{dt} + \frac{dp_B}{dt} = \frac{dP_R}{dt}$$

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

$$\frac{V_R}{R} \frac{d(P_R/T_3)}{dt} = m_2 - 2r_A V_R - m_3 \qquad p_B = y_{B,3} P_R$$

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



# Reactor adiabático en fase gaseosa con control de presión

$$\frac{dMH_3}{dt} = m_2H_2 + (-r_A)(-\Delta H_{RD})V_R - m_3H_3$$

$$M \frac{dH_3}{dt} + H_3 \frac{dM}{dt} = m_2H_2 + (-r_A)(-\Delta H_{RD})V_R - m_3H_3$$

$$\frac{P_R V_R}{RT_3} \frac{dH_3}{dt} + H_3 \frac{V_R}{RT_3} \frac{dP_R}{dt} - H_3 \frac{P_R V_R}{RT_3^2} \frac{dT_3}{dt} = m_2H_2 + (-r_A)(-\Delta H_{RD})V_R - m_3H_3$$

$$H_3 = f(T_3, y_3)$$

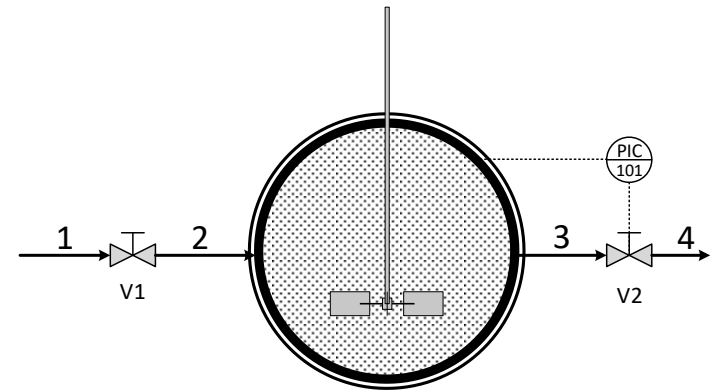
$$H_2 = f(T_2, y_2)$$

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

# 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

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

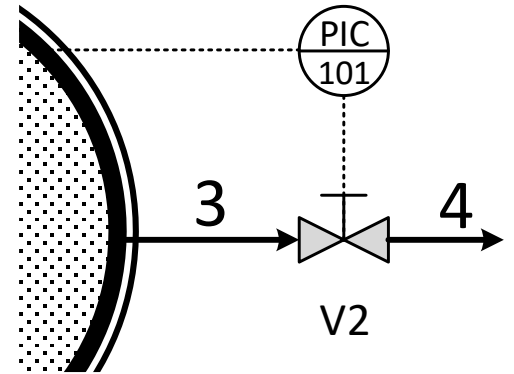
$$A_P^{PR} = K_P^{PR} \varepsilon_{PR} \quad \frac{dA_I^{PR}}{dt} = K_I^{PR} \varepsilon_{PR} \quad A_D^{PR} = K_D^{PR} \frac{dP_R}{dt}$$

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

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

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

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



# Resumen

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

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

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



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

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

# Resumen

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

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

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

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

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

# 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

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

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

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

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

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

Tiempo  $i = 0$

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

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

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

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

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



Tiempo  $i = 0$

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

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

## 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  $i = 0$

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

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

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

$$\rho_3 = \frac{P_R}{RT_3}$$

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

$\rightarrow m_3^{(0)}$

# 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 $(dT/dt)$

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

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

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

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

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

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

Para comparar con el propuesto

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

## 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

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

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

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

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

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

## Variables temporales

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

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

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

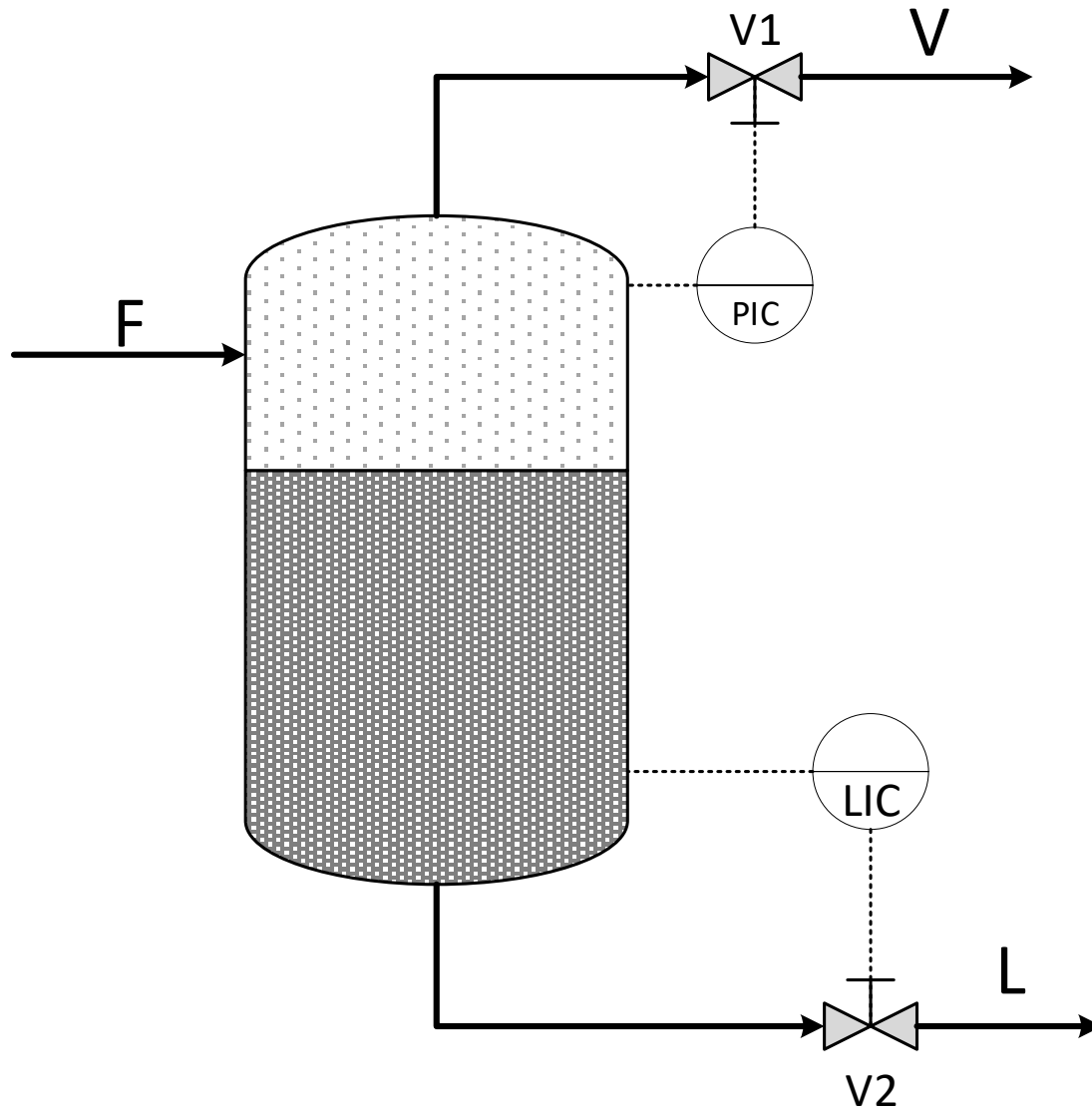
$$p_B^{(1)} = p_B^{(0)} + \Delta t \left( \frac{dp_B}{dt} \right)^{(0)}$$

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

Y repetimos desde el comienzo...



# Separador de Liquido y Gas

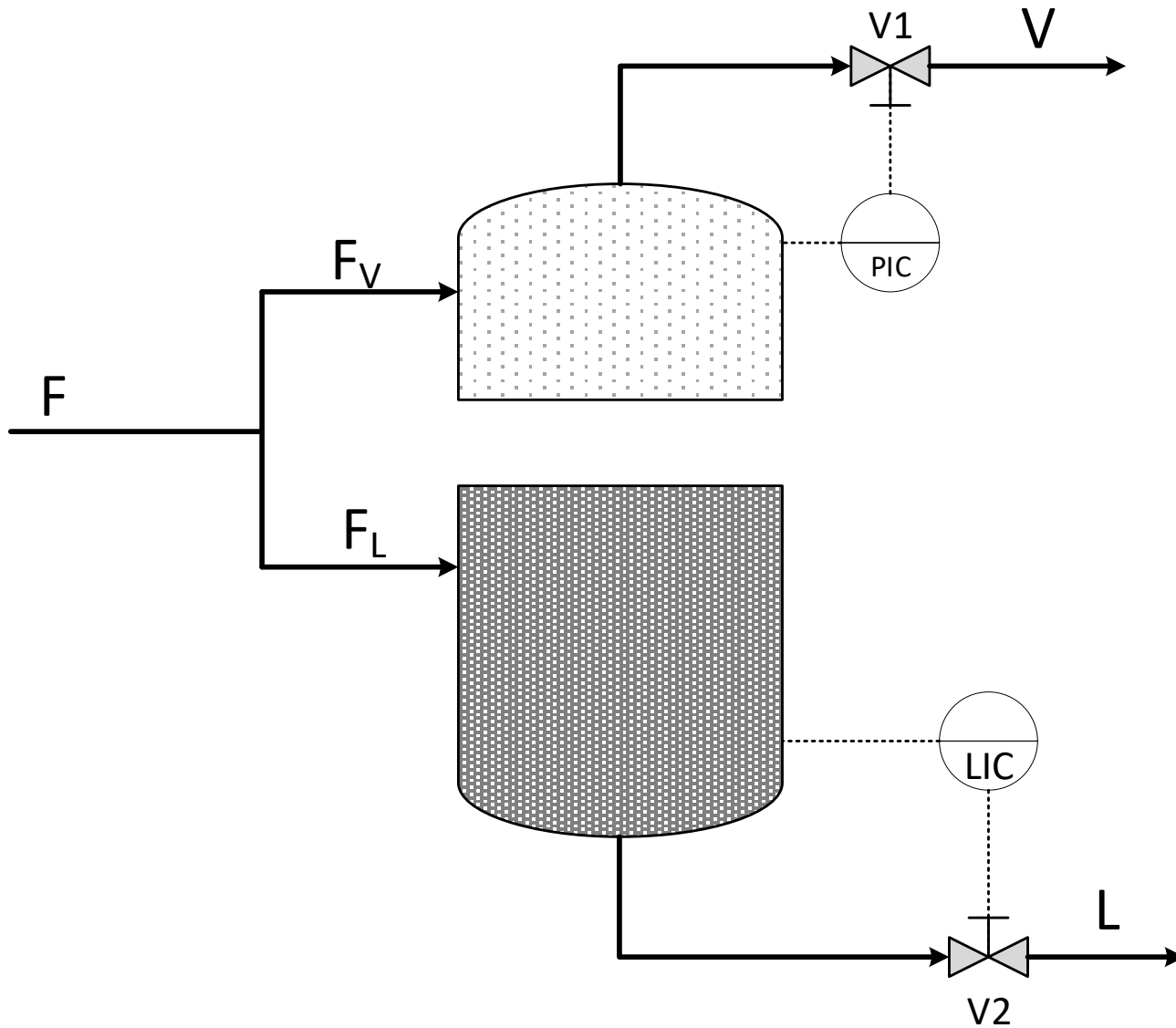


# Separador de Liquido y gas

## 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



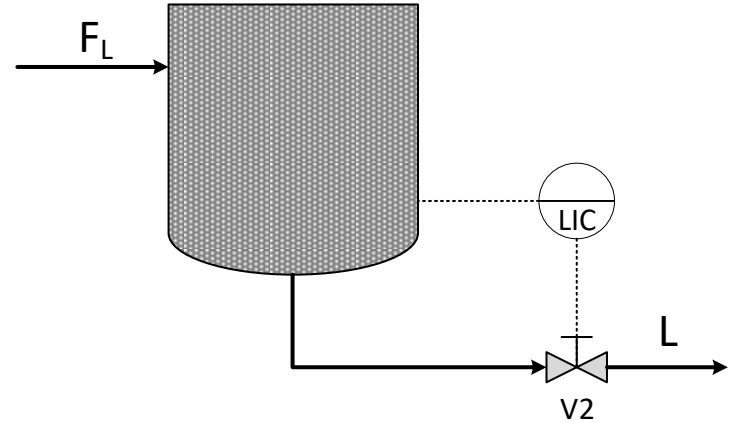
# Separador de Líquido y Gas

- 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

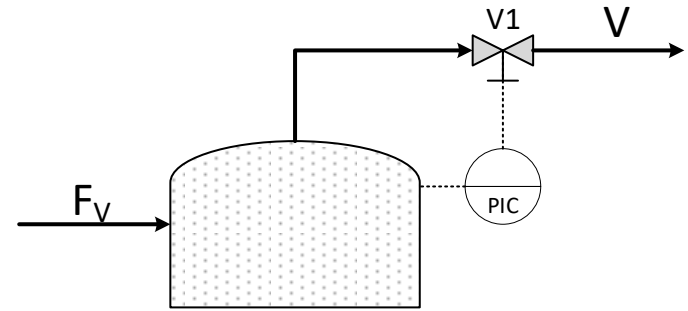
- Balance de materia total en el vapor:

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

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

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

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



# Separador de Liquido y Gas

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

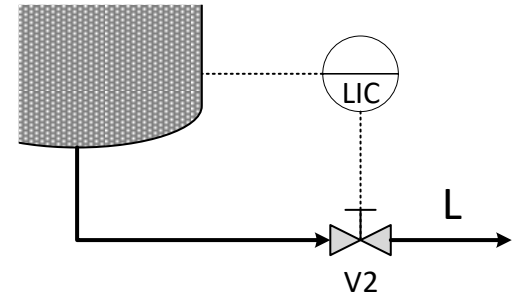
$$A_P^L = K_P^L \varepsilon_L \quad \frac{dA_I^L}{dt} = K_I^L \varepsilon_L \quad A_D^L = K_D^L \frac{dh_l}{dt}$$

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

$$x_{v_2} = \max\left(0, \min\left(1, AC^L\right)\right)$$

$$\Delta P_{V_2} = P_G + \rho_L g h_l - P_L$$

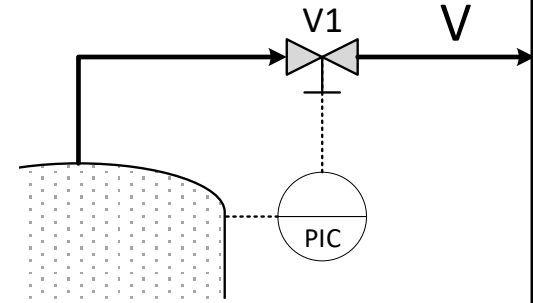
$$L = \rho_L \beta^{x_{v_2}-1} K_{V_2} \sqrt{\frac{\Delta P_{V_2}}{G_{V_2}}}$$



# Separador de Liquido y Gas

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

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



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

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

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

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

## Separador de Liquido y Gas - Resumen

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

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

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

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



## Separador de Liquido y Gas - Resumen

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

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

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

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

## Tiempo $i = 0$

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

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

Luego lo debo chequear

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

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

# Tiempo $i = 0$

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

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

Luego lo debo chequear

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

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

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

Tiempo  $i = 0$

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

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

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

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

$\text{¿}(G_1 \wedge G_2) \leq tol?$

No, reemplazamos y repetimos

## Tiempo $i = 0$

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

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

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

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

$$\text{¿} (G_1 \wedge G_2) \leq \textit{tol} \text{?}$$

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