

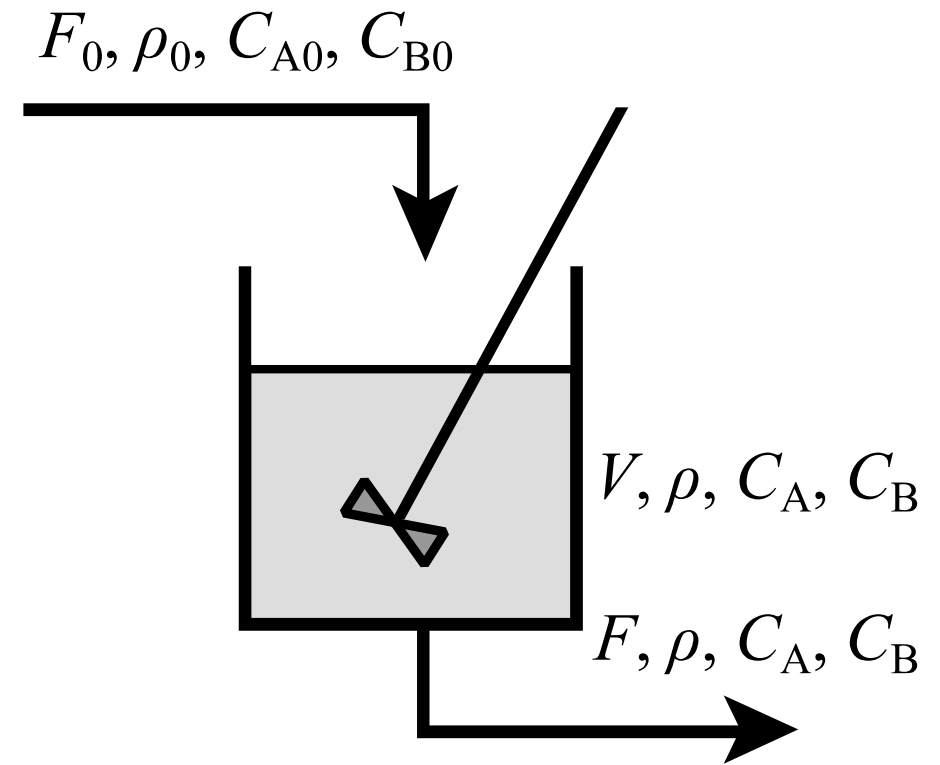
Fundamentos Parte II

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Balances de componentes en un sistema con parámetros concentrados

Balance de componente

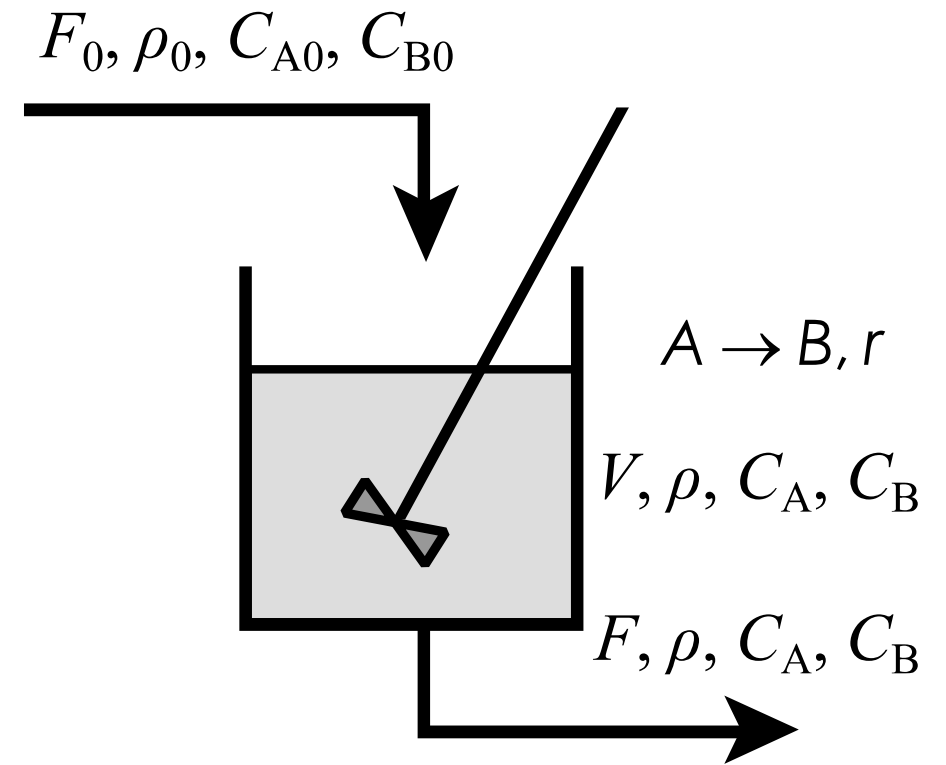
- {vel. de acumulación del comp.} =
{velocidad de entrada del comp.}
+{velocidad de generación del comp.}
-{velocidad de salida del comp.}
- [materia]/[tiempo]: mol/h
- NC o NC-1 y balance de materia global



Balance de componente

- {vel. de acum.} $= \frac{d(V C_A)}{dt}$
- {vel. de entrada} $= F_0 C_{A0}$
- {vel. de gener.} $= V r_A = -V r$
- {vel. de salida} $= F C_A$

$$\frac{d(V C_A)}{dt} = F_0 C_{A0} - V r - F C_A = 0$$



$$\frac{d(V C_j)}{dt} = \sum_{\forall i \in E} F_i C_{i,j} + V \sum_{\forall k \in R} \alpha_{j,k} r_k - C_j \sum_{\forall i \in S} F_i$$

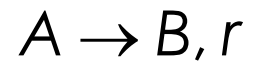
Dependencia lineal

Dependencia lineal

$$\begin{matrix} f(x) = 0 \\ g(x) = 0 \end{matrix} \quad \longrightarrow \quad h(x) = af(x) + bg(x)$$

$$h(x) = \sum_{i=1}^n w_i f_i(x)$$

Dependencia lineal del balance de materia



$$PM_A C_A + PM_B C_B = \rho$$

$$PM_A = PM_B$$

$$\begin{aligned} PM_A \left\{ \frac{d(V C_A)}{dt} = F_0 C_{A0} - V r - F C_A \right\} \\ + PM_B \left\{ \frac{d(V C_B)}{dt} = F_0 C_{B0} + V r - F C_B \right\} \end{aligned}$$

$$\frac{d(V \rho)}{dt} = F_0 \rho_0 - F \rho$$

Dependencia lineal del balance de materia

$$\sum_{\forall j \in C} PM_j \frac{d(V C_j)}{dt} = \sum_{\forall j \in C} PM_j \left(\sum_{\forall i \in E} F_i C_{i,j} + V \sum_{\forall k \in R} \alpha_{j,k} r_k - C_j \sum_{\forall i \in S} F_i \right)$$

$$\sum_{\forall j \in C} PM_j C_{i,j} = \rho_i$$

$$\sum_{\forall j \in C} \alpha_{j,k} PM_j = 0$$

$$\frac{d(V \rho)}{dt} = \sum_{\forall i \in E} F_i \rho_i - \rho \sum_{\forall i \in S} F_i$$



$$-3PM_A + 2PM_B + PM_C = 0$$

Variación de C

Variación de la propiedad intensiva

$$\frac{d(V C_A)}{dt} = F_0 C_{A0} - V r - F C_A$$

$$\frac{d(V \rho)}{dt} = F_0 \rho_0 - F \rho$$

$$\rho_0 = \rho$$

$$\frac{d\rho}{dt} = 0$$

$$V \frac{dC_A}{dt} + C_A \frac{dV}{dt} = F_0 C_{A0} - V r - F C_A$$

$$-\frac{C_A}{\rho} \left\{ V \frac{d\rho}{dt} + \rho \frac{dV}{dt} = F_0 \rho_0 - F \rho \right\}$$

$$V \frac{dC_A}{dt} - V \frac{C_A}{\rho} \frac{d\rho}{dt} = F_0 \left(C_{A0} - C_A \frac{\rho_0}{\rho} \right) - V r$$

$$V \frac{dC_A}{dt} = F_0 (C_{A0} - C_A) - V r$$

Análisis dinámico cualitativo

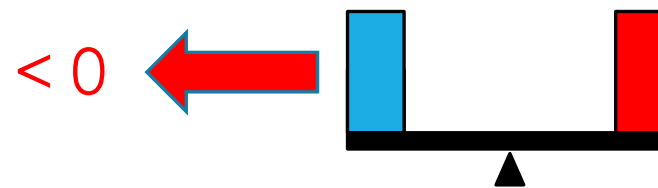
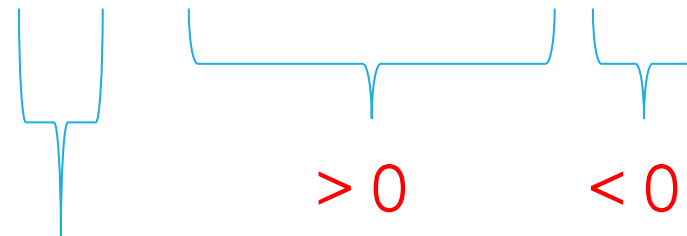
- Estado estacionario:

- $dC_A/dt = 0$

- Disminuye F_0 :

- Disminuye $C_A(-)$.

$$V \frac{dC_A}{dt} = F_0 (C_{A0} - C_A) - Vr = 0$$



Análisis dinámico cualitativo

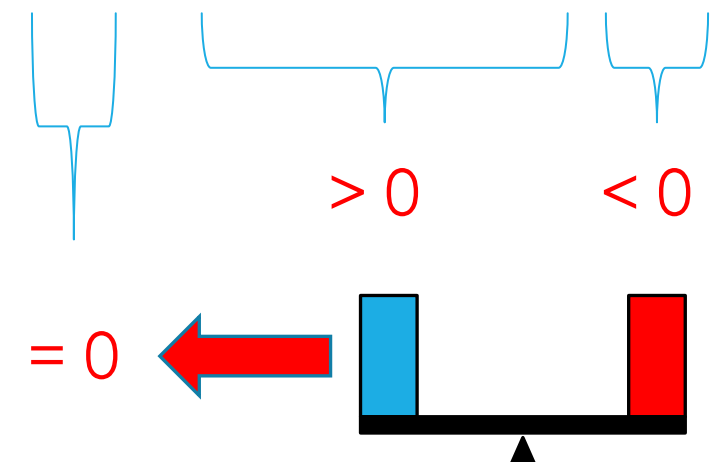
- Estado estacionario:
 - $dC_A/dt = 0$
- Propagación rápida en AEs.
- Aumenta x , dado $F_0 = kx$:
 - Aumenta $C_A(+)$.

$$V \frac{dC_A}{dt} = F_0 (C_{A0} - C_A) - Vr = 0$$

The diagram shows a seesaw with a fulcrum in the center. On the left side, there is a tall blue bar. To its left, a red arrow points left towards the bar, with a red > 0 next to it. On the right side, there is a shorter red bar. To its right, a red < 0 is written. Above the equation, blue curly braces group the terms: one brace under $V \frac{dC_A}{dt}$, one under $F_0 (C_{A0} - C_A)$, and one under $- Vr$. Below the first brace is a red > 0 . Below the second brace is a red > 0 . Below the third brace is a red < 0 .

Análisis dinámico cualitativo

- Estado estacionario:
 - $dC_A/dt = 0$
- Propagación lenta en ODEs y PDEs.
- Disminuye F , dado $\frac{dV}{dt} = F_0 - F$:
 - No cambia $C_A(0)$.

$$V \frac{dC_A}{dt} = F_0 (C_{A0} - C_A) - Vr = 0$$


The diagram illustrates a balance scale with a blue block on the left and a red block on the right. A red arrow points from the equation $= 0$ to the blue block. Above the equation, blue brackets group the terms: $V \frac{dC_A}{dt}$ is grouped with $F_0 (C_{A0} - C_A)$ and labeled > 0 , and $- Vr$ is grouped and labeled < 0 .

Variable de estado

Variable de estado n_A

$$\frac{d(V C_A)}{dt} = F_0 C_{A0} - V r - F C_A$$



$$\frac{dn_A}{dt} = F_0 C_{A0} - V r - F C_A$$

$$C_A = \frac{n_A}{V}$$

Variable de estado C_A

$$V \frac{dC_A}{dt} = F_0 (C_{A0} - C_A) - V r$$

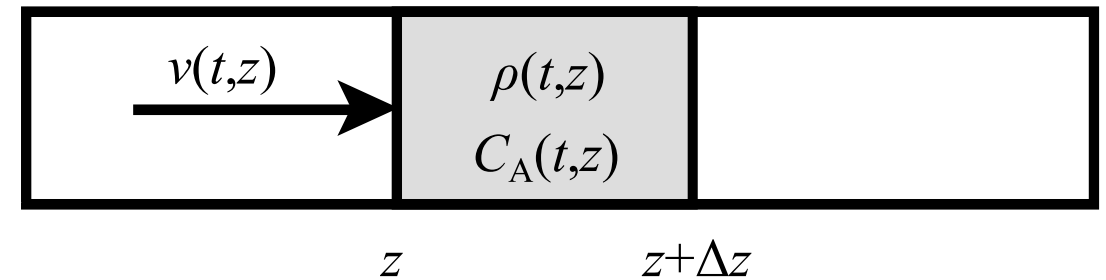
Balances de componentes en un sistema con parámetros distribuidos

Balance por componente

- {vel. de acum.} $= \frac{\partial(A \Delta z C_A)}{\partial t}$
- {vel. de entrada} $= v A C_A|_z$
- {vel. de gener.} $= r_A A \Delta z = -r A \Delta z$
- {vel. de salida} $= v A C_A|_{z+\Delta z}$

$$\frac{\partial(A \Delta z C_A)}{\partial t} = v A C_A|_z - r A \Delta z - v A C_A|_{z+\Delta z}$$

$$\Delta z \frac{\partial C_A}{\partial t} = v C_A|_z - r \Delta z - v C_A|_{z+\Delta z}$$



$$\frac{\partial C_A}{\partial t} = - \frac{v C_A|_{z+\Delta z} - v C_A|_z}{\Delta z} - r$$

$$\cancel{\frac{\partial C_A}{\partial t}} = - \frac{\partial(v C_A)}{\partial z} - r = 0$$

Variación de la propiedad intensiva

$$\frac{\partial C_A}{\partial t} = -\frac{\partial(v C_A)}{\partial z} - r$$

$$\frac{\partial \rho}{\partial t} = -\frac{\partial(v \rho)}{\partial z}$$

$$\frac{\partial \rho}{\partial z} = 0$$

$$\frac{\partial \rho}{\partial t} = 0$$

$$\frac{\partial C_A}{\partial t} = -v \frac{\partial C_A}{\partial z} - C_A \frac{\partial v}{\partial z} - r$$

$$-\frac{C_A}{\rho} \left\{ \frac{\partial \rho}{\partial t} = -v \frac{\partial \rho}{\partial z} - \rho \frac{\partial v}{\partial z} \right\}$$

$$\frac{\partial C_A}{\partial t} - \frac{C_A}{\rho} \frac{\partial \rho}{\partial t} = -v \frac{\partial C_A}{\partial z} - r + v \frac{C_A}{\rho} \frac{\partial \rho}{\partial z}$$

$$\frac{\partial C_A}{\partial t} = -v \frac{\partial C_A}{\partial z} - r$$

Medidas de concentración

Medidas de concentración

- Densidad de la solución [masa]/[volumen]: $\rho = \sum_{j=1}^{NC} \rho_j$
- Concentración de masa del componente j : $\rho_j = C_j PM_j$
- Fracción másica de j : $w_j = \frac{\rho_j}{\rho}$

Medidas de concentración

- Densidad molar [mol]/[volumen]: $C = \sum_{j=1}^{NC} C_j$
- Concentración molar de j : $C_j = \frac{\rho_j}{PM_j}$
- Fracción molar de j : $x_j = \frac{C_j}{C}$
- Peso molecular medio: $PM = \frac{\rho}{C}$

Relaciones útiles

$$1. \sum_{j=1}^{NC} x_j = 1$$

$$2. \sum_{j=1}^{NC} w_j = 1$$

$$3. \sum_{j=1}^{NC} x_j PM_j = PM$$

$$4. \sum_{j=1}^{NC} \frac{w_j}{PM_j} = \frac{1}{PM}$$

$$5. x_j = PM \frac{w_j}{PM_j}$$

$$6. w_j = \frac{x_j PM_j}{PM}$$

Balance en estado estacionario de A

- F : flujo volumétrico (m^3/h)
- C : concentración molar (mol/m^3)
- N : flujo molar (mol/h)
- y : fracción molar
- M : flujo másico (kg/h)
- w : fracción másica

$$F_E C_{E,A} - F_V C_{V,A} - F_L C_{L,A} = 0$$

$$F_E C_{E,A} - N_V y_{V,A} - \frac{M_L w_{L,A}}{PM_A} = 0$$

