Che 532 : Process Dynamics & control II

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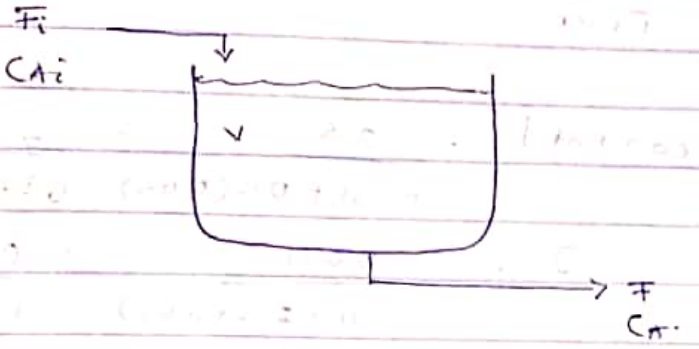
Answers



Balance Equation

Accumulation = Input − output + Gen − consumption

$$\frac{dm}{dt} = \dot{m}_{in} - \dot{m}_{out} - r_A V$$

$$\frac{d(VC_A)}{dt} = F_i C_{Ai} - F C_A - r_A V$$

constant volume, $F_i = F$

$$V\frac{dC_A}{dt} = F(C_{Ai} - C_A) - r_A V$$

divide through by V, $r_A = kC_A$.

$$\frac{dC_A}{dt} = \frac{F}{V}(C_{Ai} - C_A) - r_A$$

$$\frac{dC_A}{dt} = \frac{F}{V}(C_{Ai} - C_A) - kC_A$$

$$\frac{dC_A}{dt} = \frac{F}{V}C_{Ai} - \frac{F}{V}C_A - kC_A$$

$$\frac{dC_A}{dt} = \frac{F}{V}C_{Ai} - C_A\left[\frac{F}{V} + k\right]$$

$$\frac{dC_A}{dt} = \frac{F}{V}C_{Ai} - C_A\left[\frac{F + Vk}{V}\right]$$

$$\frac{dC_A}{dt} + C_A\left[\frac{F + Vk}{V}\right] = \frac{F}{V}C_{Ai}$$

divide through by $\frac{F+VK}{V}$

$$\frac{V}{F+VK}\frac{dC_A}{dt} + C_A = \frac{F}{F+VK} \times \frac{F}{F} C_{Ai}$$

$$\therefore \frac{V}{F+VK}\frac{dC_A}{dt} + C_A = \frac{F}{F+VK} C_{Ai}$$

let $\frac{V}{F+VK} = \tau_p$ [time constant] $= \frac{2.5}{0.091 + 2.5(0.03)} = \frac{2.5}{0.166} = 15.06$

$\frac{F}{F+VK} = K_p$ [static gain] $= \frac{0.091}{0.091 + 2.5(0.03)} = \frac{0.091}{0.166} = 0.54$

$$\tau_p \frac{dC_A}{dt} + C_A = K_p C_{Ai}$$

$$\tau_p s C_A(s) + C_A(s) = K_p C_{Ai}(s)$$

$$C_{ip}(s) = \frac{C_A(s)}{C_{Ai}(s)} = \frac{K_p}{\tau_p(s)+1}$$