$$\begin{cases} \dot{C_A}(t) &= \frac{q_0}{V}\cdot(C_{Af}-C_A(t)) - k_0\cdot\exp\left(-\frac{E}{R\cdot T(t)}\right)\cdot C_A(t) \\ \dot{T}(t) &= \frac{q_0}{V}\cdot(T_f-T(t)) + \frac{(-\Delta H_r)\cdot k_0}{\rho\cdot C_p}\cdot\exp\left(-\frac{E}{R\cdot T(t)}\right)\cdot C_A(t) + \frac{UA}{V\cdot\rho\cdot C_p}\cdot(T_c(t)-T(t)) \\ \dot{T_c}(t) &= \frac{T_r(t)-T_c(t)}{\tau_c} \end{cases} \tag{1}$$

$$\overline{x} = \begin{cases} \overline{C}_A &= 0.5054 \\ \overline{T} &= 315.5491 \\ \overline{T}_c &= 308 \end{cases} \tag{2}$$

$$0 = \frac{\overline{T}_r - \overline{T}_c}{\tau_c} = \frac{\overline{T}_r - 308}{\tau_c} \tag{3}$$

$\overline{u} = \overline{T}_r = 308$

$$\begin{cases} \delta\dot{x}(t) &\simeq f_x(\overline{x},\overline{u})\delta x(t) + f_u(\overline{x},\overline{u})\delta u(t) \\ \delta y(t) &\simeq g_x(\overline{x},\overline{u})\delta x(t) + g_u(\overline{x},\overline{u})\delta u(t) \end{cases} \tag{4}$$

$$f_x(\overline{x},\overline{u}) = A = \begin{bmatrix} \frac{\delta f_1}{\delta x_1} & \frac{\delta f_1}{\delta x_2} & \frac{\delta f_1}{\delta x_3} \\ \frac{\delta f_2}{\delta x_1} & \frac{\delta f_2}{\delta x_2} & \frac{\delta f_2}{\delta x_3} \\ \frac{\delta f_3}{\delta x_1} & \frac{\delta f_3}{\delta x_2} & \frac{\delta f_3}{\delta x_3} \end{bmatrix}_{\substack{x=\overline{x} \\ u=\overline{u}}} \tag{5}$$

$$f_u(\overline{x},\overline{u}) = B = \begin{bmatrix} \frac{\delta f_1}{\delta u} \\ \frac{\delta f_2}{\delta u} \\ \frac{\delta f_3}{\delta u} \end{bmatrix}_{\substack{x=\overline{x} \\ u=\overline{u}}} \tag{6}$$

$$g_x(\overline{x},\overline{u}) = C = \begin{bmatrix} \frac{\delta g}{\delta x_1} & \frac{\delta g}{\delta x_2} & \frac{\delta g}{\delta x_3} \end{bmatrix}_{\substack{x=\overline{x} \\ u=\overline{u}}} \tag{7}$$

$$g_u(\overline{x},\overline{u}) = D = \left.\frac{\delta g}{\delta u}\right|_{\substack{x=\overline{x} \\ u=\overline{u}}}$$

$$\begin{cases} \dot{C_A}(t) &= \frac{q_0}{V}\cdot(C_{Af}-C_A(t)) - k_0\cdot\exp\left(-\frac{E}{R\cdot T(t)}\right)\cdot C_A(t) \\ \dot{T}(t) &= \frac{q_0}{V}\cdot(T_f-T(t)) + \frac{(-\Delta H_r)\cdot k_0}{\rho\cdot C_p}\cdot\exp\left(-\frac{E}{R\cdot T(t)}\right)\cdot C_A(t) + \frac{UA}{V\cdot\rho\cdot C_p}\cdot(T_c(t)-T(t)) \\ \dot{T_c}(t) &= \frac{T_r(t)-T_c(t)}{\tau_c} \\ y(t) &= C_A(t) \end{cases} \tag{8}$$

$$A = \begin{bmatrix} -k_0\cdot\exp\left(\frac{-E}{R\cdot\overline{T}}\right) - \frac{q_0}{V} & -\frac{\overline{C}_A\cdot E\cdot k_0}{R}\exp\left(\frac{-E}{R\cdot\overline{T}}\right)\cdot\frac{1}{\overline{T}^2} & 0 \\ \frac{-\Delta H_r\cdot k_0}{\rho C_p}\cdot\exp\left(\frac{-E}{R\cdot\overline{T}}\right) & -\frac{q_0}{V} + \left(\frac{\overline{C}_A\cdot(-\Delta H_r)\cdot k_0}{\rho\cdot C_p}\exp\left(-\frac{E}{R\cdot\overline{T}}\right)\cdot\frac{E}{R\cdot\overline{T}^2}\right) - \frac{UA}{V\cdot\rho\cdot C_p} & \frac{UA}{V\cdot\rho\cdot C_p} \\ 0 & 0 & -\frac{1}{\tau_c} \end{bmatrix} \tag{9}$$

$$B = \begin{bmatrix} 0 \\ 0 \\ \frac{1}{\tau_c} \end{bmatrix}$$
$$C = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix}$$
$$D = 0$$

$$\begin{aligned} \min_{\mathbf{u}} \quad & J(x(k), u(.)) = \sum_{j=0}^{N-1} \|x(j)\|_Q^2 + \|u(j)|_R^2 + \|x(N)\|_S^2 \\ \text{s.t.} \quad & x(0) = x(k) \\ & x(j+1) = Ax(j) + Bu(j) \\ & x(j) \in \mathcal{X}, u(j) \in \mathcal{U} \\ & x(N) \in \mathbb{X}_f \end{aligned} \qquad \text{con } Q = Q' \geq 0, S = S' \geq 0, R = R' > 0. \tag{10}$$

dove $x = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} C_A \\ T \\ T_c \end{bmatrix}$, e $u = T_r$

$$\begin{gathered} x \in \mathcal{X} \text{ dato da:} \\ 0.38 - \overline{C}_A < x_1 < 0.95 - \overline{C}_A \\ -0.1254[mol/l] < x_1 < 0.446[mol/l] \end{gathered} \tag{11}$$

$$\begin{gathered} u \in \mathcal{U} \text{ dato da:} \\ 280 - \overline{T}_r < u < 310 - \overline{T}_r \\ -28[K] < u < 2[K] \end{gathered} \tag{12}$$