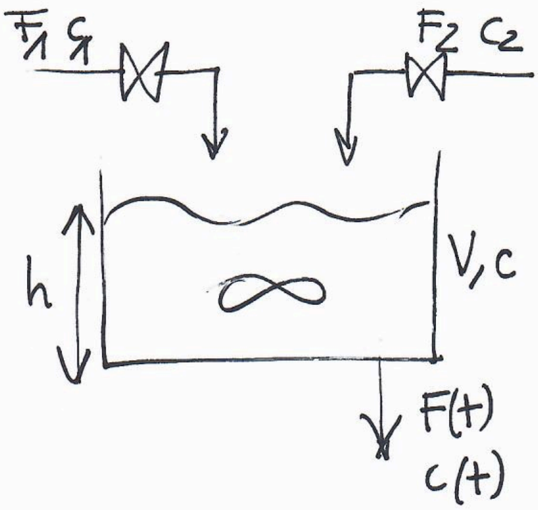
STIRRED TANK




1

$u_1(t) = F_1(t)$
$u_2(t) = F_2(t)$

$c_1, c_2$ concentrazioni costanti

$y_1(t) = F(t)$
$y_2(t) = c(t)$

$$x(t) = \begin{bmatrix} V(t) \\ c(t) \end{bmatrix} \begin{matrix} \to \text{volume} \\ \to \text{concentrazione} \end{matrix}$$

$$\dot{x}(t) = \begin{bmatrix} -0.01 & 0 \\ 0 & -0.02 \end{bmatrix} x(t) + \begin{bmatrix} 1 & 1 \\ -0.25 & 0.75 \end{bmatrix} u(t)$$

$u \in \mathbb{R}^m$
$x \in \mathbb{R}^n$
$y \in \mathbb{R}^p$

$$y(t) = \begin{bmatrix} 0.01 & 0 \\ 0 & 1 \end{bmatrix} x(t)$$

$m=2 \quad n=2 \quad p=2$

$$y_{des} = \begin{bmatrix} 0.05 \\ 1.5 \end{bmatrix} \text{ riferimento}$$

N.B. Non c'è disturbo $w(t)$

- $P = 0_{n \times d}$, $Q = 0_{p \times d}$ > matrici nulle, $w \in \mathbb{R}^d$

Processo soggetto al disturbo generalizzato

$\tilde{w} \equiv y_d$

$$\boxed{S} \to \tilde{w}(t)$$

$$S = \begin{bmatrix} s_1 & 0 \\ 0 & s_2 \end{bmatrix}$$

$s_1 = s_2 = 0 \quad r = 2$

$$\tilde{w}(0) = \begin{bmatrix} 0.05 \\ 1.5 \end{bmatrix}$$

$$\tilde{w}(t) = \begin{bmatrix} 0.05 \\ 1.5 \end{bmatrix} \quad \tilde{w} \in \mathbb{R}^r \quad r = p$$

$$\begin{cases} \dot{x} = Ax + Bu + \tilde{P}\,\tilde{w} \\ e = \tilde{C}x + \tilde{Q}\,\tilde{w} \end{cases}$$

(2)

$\tilde{w} \equiv y_d \Rightarrow \tilde{P} = 0_{m \times r}$

$\tilde{C} \triangleq -C \qquad \tilde{Q} = ?$

$e \triangleq y_d - Cx - \cancel{Qw}$
$= y_d - Cx$

$\tilde{Q} = I_p$

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Verifica $H_1, H_2$ $\qquad u = kx + (\Gamma - k\Pi)\tilde{w}$

$K = \text{place}(A, B, [\lambda_1, \dots, \lambda_n])$

$k = -K \qquad$ N.B. !!

Yalmip $\quad$ Risoluzione equazioni matriciali del teorema

$\Pi \; n \times r \qquad \Gamma \; m \times r$

$$\Pi S = A\Pi + B\Gamma + \tilde{P}$$

$$0 = \tilde{C}\Pi + \tilde{Q}$$

$$\underset{(n+m)\times r}{X} = \begin{bmatrix} \Pi \\ \Gamma \end{bmatrix} : \begin{bmatrix} I & 0 \\ 0 & 0 \end{bmatrix} \cdot \begin{bmatrix} \Pi \\ \Gamma \end{bmatrix} S = \begin{bmatrix} A & B \\ \tilde{C} & 0 \end{bmatrix} \begin{bmatrix} \Pi \\ \Gamma \end{bmatrix} + \begin{bmatrix} \tilde{P} \\ \tilde{Q} \end{bmatrix}$$

$$J \cdot X \cdot S = W X + \tilde{R}$$

Sintassi Yalmip

3

- $X = \text{sdpvar}(n+m, r, \text{'full'})$

$F = [WX + \tilde{R} - JXS == 0]$

Insieme dei vincoli

$\text{diagnostic} = \text{optimize}(F)$

$X = \text{value}(X)$

$\Pi = X(1:n, :)$

$\Gamma = X(n+1:n+m, :)$

$L \triangleq \Gamma - K\Pi$

$u = Kx + L\tilde{w}$

Rappresentazione in spazio di stato del sistema a ciclo chiuso

$\dot{x}(t) = (A + BK)x(t) + (\tilde{P} + BL)\tilde{w}(t)$

$e(t) = \tilde{C}x(t) + \tilde{Q}\tilde{w}(t)$

$y(t) = Cx(t) \qquad y(t) = Cx(t) + Q_y\tilde{w}(t)$

$0_{p \times p}$