Optimal Control, exercise 1

This exercise deals with the watermixing process, which is described in a separate document. The plant will be used in several exercises. We will start by setting up simulation using available files, and implement a basic controller assuming states are all measurable.

- Download the files constants.m, simWT.m and plotdata.m. Write a script (m-file) which simulates and plots system behaviour with the input data $U = U_{sekv}$ and $U = D_{sekv}$ as defined in constants.m

- A linearized state space model of the plant may be written

$$\dot{x} = A_s x(t) + B_s u(t) + B_d d(t)$$

  with small letters denoting deviations from the operating point and

$$A_s = \begin{bmatrix} 0 & 0 & 0 \\ 0 & \frac{-(V_{10}+V_{20})}{AH_{30}} & 0 \\ 0 & \frac{1}{\tau} & -\frac{1}{\tau} \end{bmatrix} \quad B_s = \begin{bmatrix} \frac{1}{A} & \frac{1}{A} \\ \frac{T_{10}-T_{30}}{AH_{30}} & \frac{T_{20}-T_{30}}{AH_{30}} \\ 0 & 0 \end{bmatrix} \quad B_{sd} = \begin{bmatrix} -\frac{1}{A} & 0 & 0 \\ 0 & \frac{V_{10}}{AH_{30}} & \frac{V_{20}}{AH_{30}} \\ 0 & 0 & 0 \end{bmatrix}$$

  The operating point values of states and references can be chosen as in constants, and corresponding values of the two input flows can be determined from the nonlinear model equations by setting the derivatives to zero

$$\left\{ \begin{array}{lcl} 0 & = & V_{10} + V_{20} - V_{30} \\ 0 & = & \frac{(V_{10}T_{10}+V_{20}T_{20}-V_{30}T_{3mix0}}{AH_{30}} \\ 0 & = & \frac{T_{3mix0}-T_{30}}{\tau} \end{array} \right\} \Rightarrow \left\{ \begin{array}{lcl} V_{10} & = & \frac{V_{30}(T_{20}-T_{30})}{T_{20}-T_{10}} \\ V_{20} & = & \frac{V_{30}(T_{10}-T_{30})}{T_{10}-T_{20}} \end{array} \right\}$$

  These calculations are already done in the scripts oppoint.m and contmodel.m. Use Matlab to calculate the corresponding discrete time state space model assuming a zero order hold connecting discrete time control signals with the plant. Disturbances may be taken constant between sampling points as well. Sampling time is 5 seconds.

- Implement a function with discrete time model (Φ_s, Γ_s, H_s), weighting matrices (Q_1, Q_2) and time horizon N as inputs and a time varying optimal controller $L_s(k)$ as output. Calculate a controller for the plant using diagonal weighting matrices. Select matrix elements such that the performance function punishes the square of signals scaled according to following maximum values ($h_{3,max} = 0.4$; $t_{3mix,max} = 30$; $t_{3,max} = 30$; $u_{1,max} = 0.001$; $u_{2,max} = 0.0005$). Choose the time horizon $N = 150$ and simulate how this controller brings the plant from the initial state to the operating point (let the disturbance $d = 0,\ \ D = D_0$).

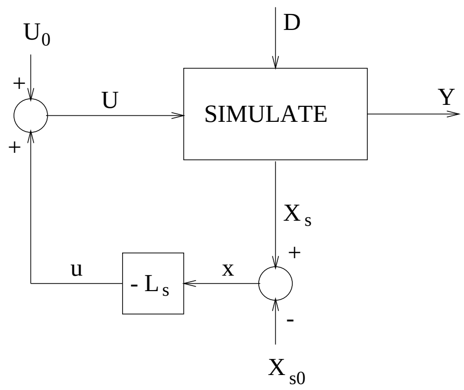

Figure 1:

- Use also the calculated controller with moving horizon and compare with the results above