CPN321 T3
Solving equations

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Mixing system

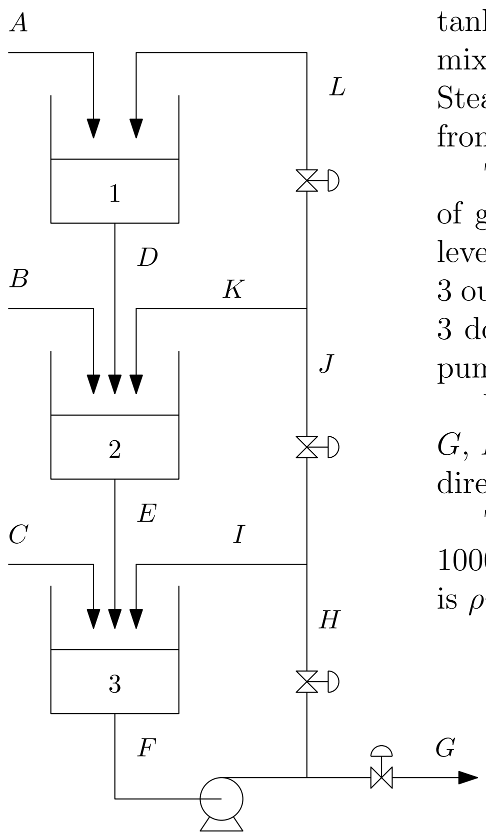

Figure 1: Mixing system

Figure 1 shows a set of well-mixed mixing tanks. All the streams contain a binary mixture of substance X and substance Y. Steams A, B and C are fed into the system from an upstream process.

Tanks 1 and 2 are drained by the force of gravity (assume flow is proportional to level), while the pump attached to the tank 3 output is sized such that the level in tank 3 does not affect the flowrate through the pump.

You may assume that the valves in lines G, H, J and L can manipulate those flows directly.

The density of substance X is $\rho_X = 1000\,\mathrm{kg/m^3}$ and the density of substance Y is $\rho_Y = 800\,\mathrm{kg/m^3}$.

1 Model

Develop a full dynamic model of this system and write your equations in a table showing clearly which symbols you have chosen as inputs, outputs, and parameters.

2 Steady state

Find the steady state flow rates and compositions of all the streams given that

- Stream A is $1\,\mathrm{m}^3/\mathrm{h}$ of substance X
- Streams B and C are both $1\,\mathrm{m}^3/\mathrm{h}$ of substance Y.
- $H = G$, $H = 2J$, $J = 2L$.

Do this in three ways:

1. Solve the mass balances by hand like in CIR
2. Write all the simultaneous equations down and use Sympy to solve them
3. Formulate the problem as a set of linear equations and solve using matrix algebra.

3 Design

Assuming all three tanks are of constant cross-sectional area of $3\,\mathrm{m}^2$, find out what the proportionality constants should be for tank 1 and 2 so that the steady state levels will be $1\,\mathrm{m}$.

4 Dynamic simulation

Now that you have all the parameters in your system, simulate the response of the system to a sudden increase in flow rate of A from $1\,\mathrm{m}^3/\mathrm{h}$ to $1.5\,\mathrm{m}^3/\mathrm{h}$ at time 0. You should start your simulation at steady state.

Assume that the level in tank 3 is also $1\,\mathrm{m}$ at the initial conditions. Note that the steady state relationships between H, G, J and L will not hold over the whole simulation. Simply set them to their steady state values.

Plot the composition of stream G as well as the compositions and levels in all three tanks.

Try to do the simulation in Python first, then try to do the same simulation in Modelica.