minerals

Supplementary Materials

Tank Network Model Development and Implementation

The tank network model was developed by performing a mass balance around a tank, and extending that to all the tanks in the network. The symbols used in the model development correspond to those in Figure S1.

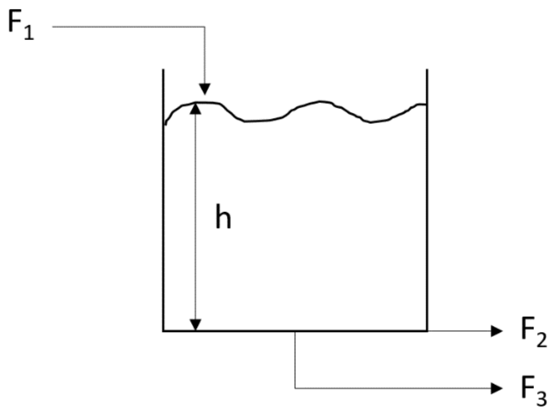

Figure S1. Diagram with symbols corresponding to one-tank model development.

$$\frac{dm}{dt} = \rho(F_1 - F_2 - F_3) \tag{S1}$$

Assume the fluid is incompressible, so the density is constant.

$$\frac{dV}{dt} = F_1 - F_2 - F_3 \tag{S2}$$

$$\frac{d(Ah)}{dt} = F_1 - F_2 - F_3 \tag{S3}$$

Since the cross-sectional area A remains constant:

$$\frac{dh}{dt} = \frac{F_1 - F_2 - F_3}{A} \tag{S4}$$

Divide by the maximum height possible in the tank H_{max} to obtain the tank height as a fraction of its total:

$$\frac{d\left(\frac{h}{H_{max}}\right)}{dt} = \frac{F_1 - F_2 - F_3}{AH_{max}} \tag{S5}$$

$$\frac{dh_{frac}}{dt} = \frac{F_1 - F_2 - F_3}{V_{max}} \tag{S6}$$

Since F_2 is the MV, it is calculated using the PI controller equation in the Laplace domain.

$$F_2 = K_c\left[1 + \frac{1}{s\tau_I}\right] \tag{S7}$$

F_3 is the underflow, which is proportional to the squareroot of the tank level:

$$F_3 = k\sqrt{h_{frac}} \tag{S8}$$

Equations S6, S7, and S8 were implemented in Simulink, as shown in Figure S2, and the tanks were connected into a tank network as described in the process description in the article.

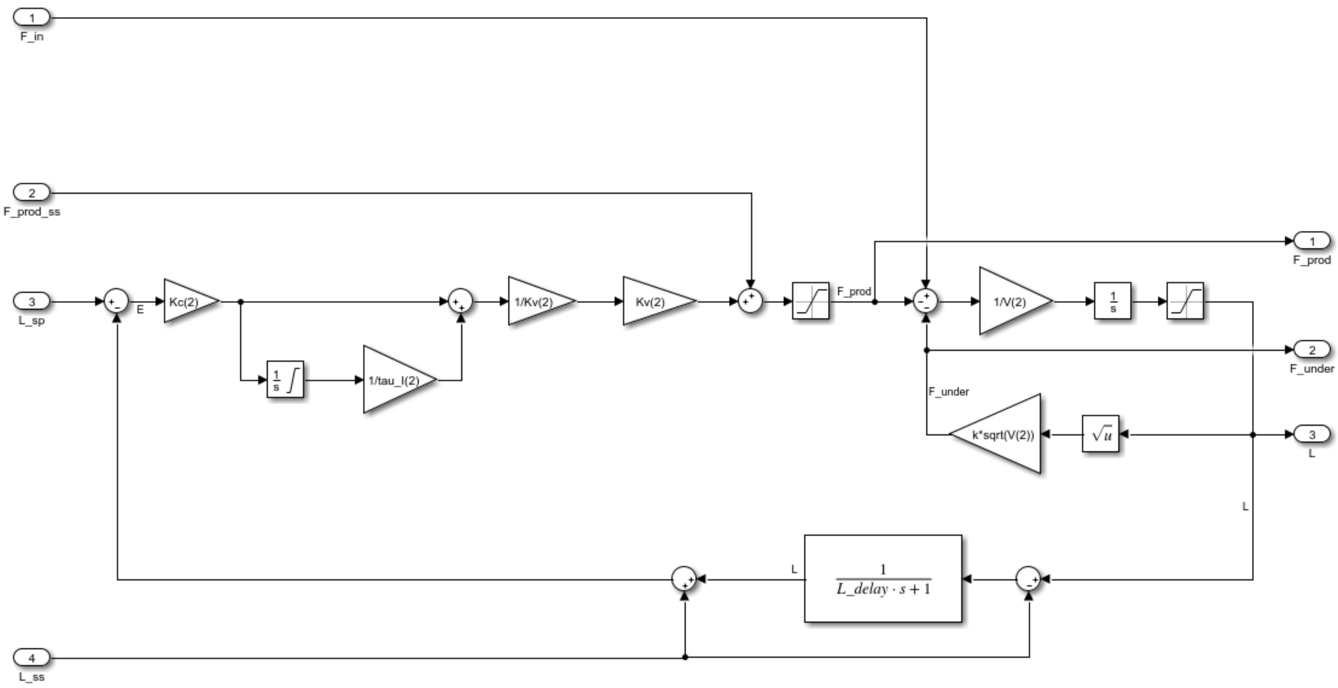

Figure S2. Simulink implementation of the one-tank model.

The exogenous disturbances fed to each plant section were modelled as random walks by integrating a series of random numbers multiplied by a gain, as shown in Figure S3.

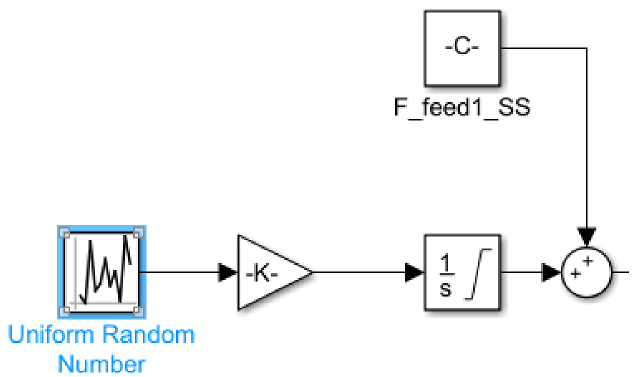

Figure S3. Random walk implementation in Simulink.