Simulation of a Blending Tank with Proportional Control

File: `Ch08_BlendingTankControl.m`

A blending tank accepts a flow from from a plant at mass flow rate w_1. The mass fraction of A is x_1. A stream of pure A (x_2 = 1) is blended with the plant stream in a well-mixed tank. The tank is designed to maintain constant volume. The task is to design a control system to maintain the effluent concentration at a desired setpoint x_{SP}.

Contents

Process Diagram

```
        From Plant                                Pure A
          w1,x1 ------              ---|X|-- w2,x2
                      |           |
                      v           v
                   ----------------
                  |                 |
                  |   Volume = V    |
                  |                 |-----> w3,x3
                   ----------------
```

Parameter Values

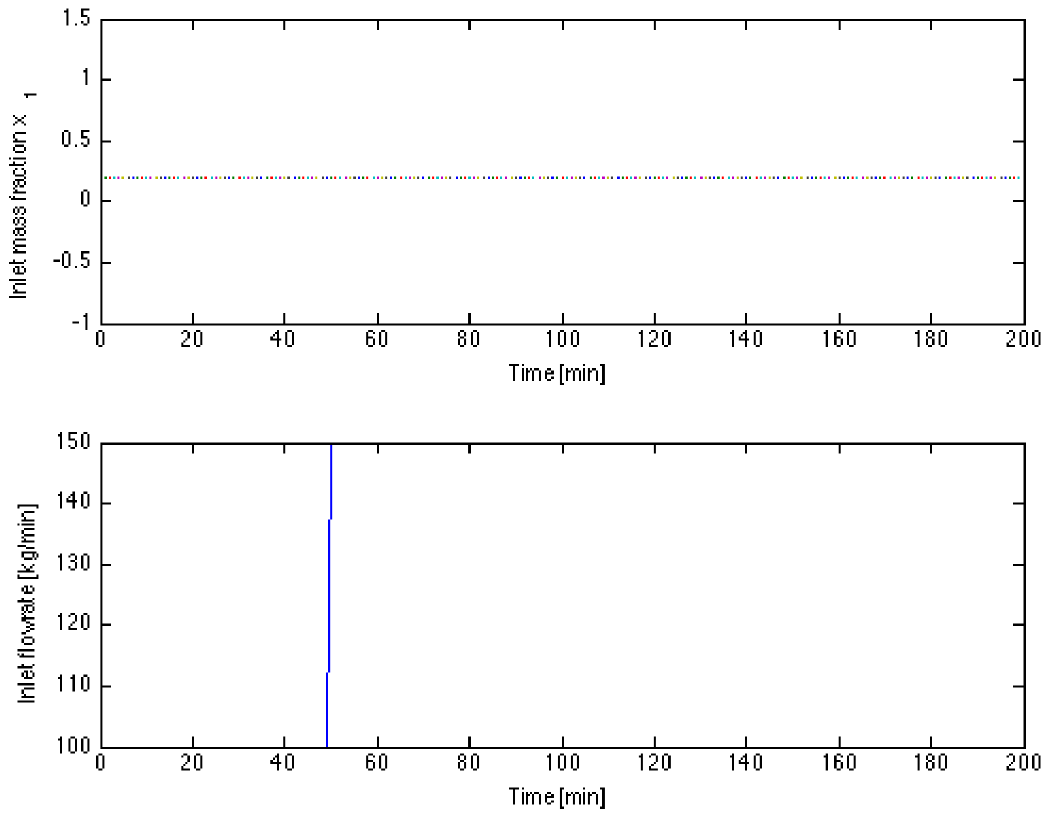
```
rho = 1.00;   % kg/liter, assume constant
V   = 4000;   % liters
```

Disturbance Variables (DV)

The disturbances are functions of time. Here we specify a constant value for x_1, and a flowrate w_1 with a step change at $t = 50$.

```
x1 = @(t) 0.2;  % Mass fraction
w1 = @(t) 100 + (t >= 50).*50;  % kg/min

t = 0:200;
subplot(2,1,1);
plot(t,x1(t));
xlabel('Time [min]');
ylabel('Inlet mass fraction x_1');
```

```
subplot(2,1,2);
plot(t,w1(t));
xlabel('Time [min]');
ylabel('Inlet flowrate [kg/min]');
```



Manipulated Variable (MV)

w2(t) is the flowrate of the manipulated flow. For the first simulation we'll assume a constant flowrate.

```
w2 = @(t) 50;    % kg/hour
```

Blending Tank Model

For a simple problem like this one, we'll use an anonymous function to model the tank dynamics.

```
f  = @(t,x) (w1(t)*(x1(t)-x) + w2(t)*(1-x))/rho/V;
```

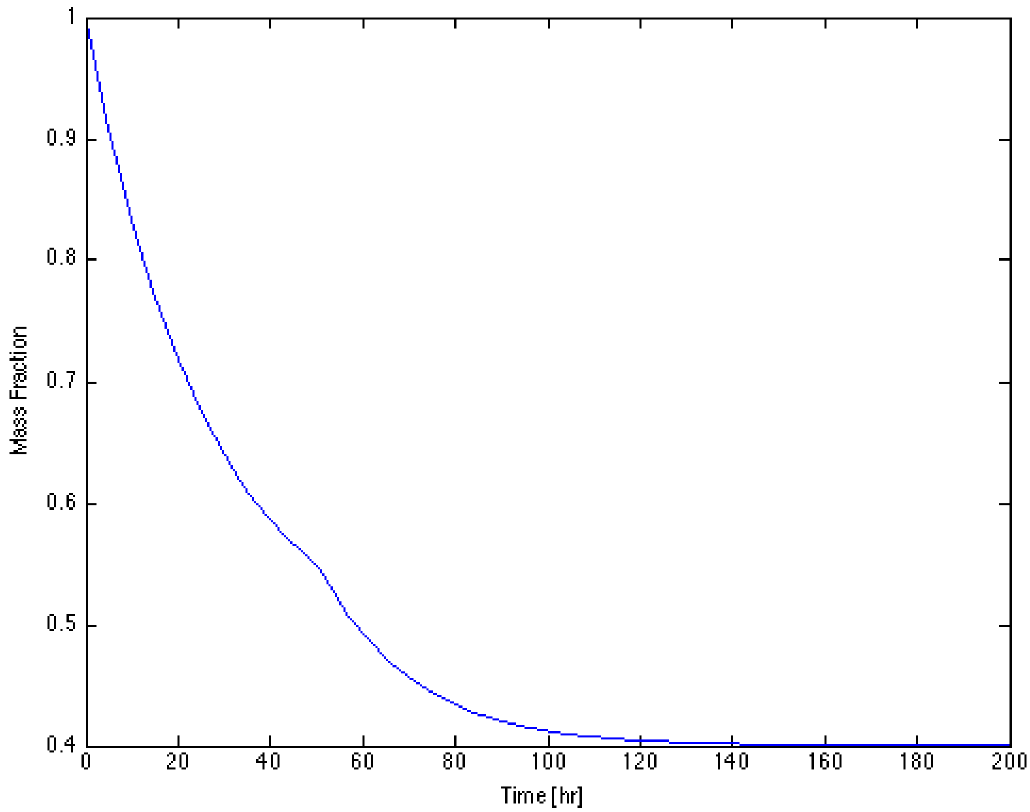
Integrate differential equation and plot results

We integrate the model from t = 0 to t = 200 with an initial condition x(0) = 1.

```
[t,x] = ode45(f,[0,200],1);
clg;
plot(t,x);
```

```
xlabel('Time [hr]');
ylabel('Mass Fraction');
```

```
Warning: This function is obsolete and may be removed in future versions. Use
Clf instead
```



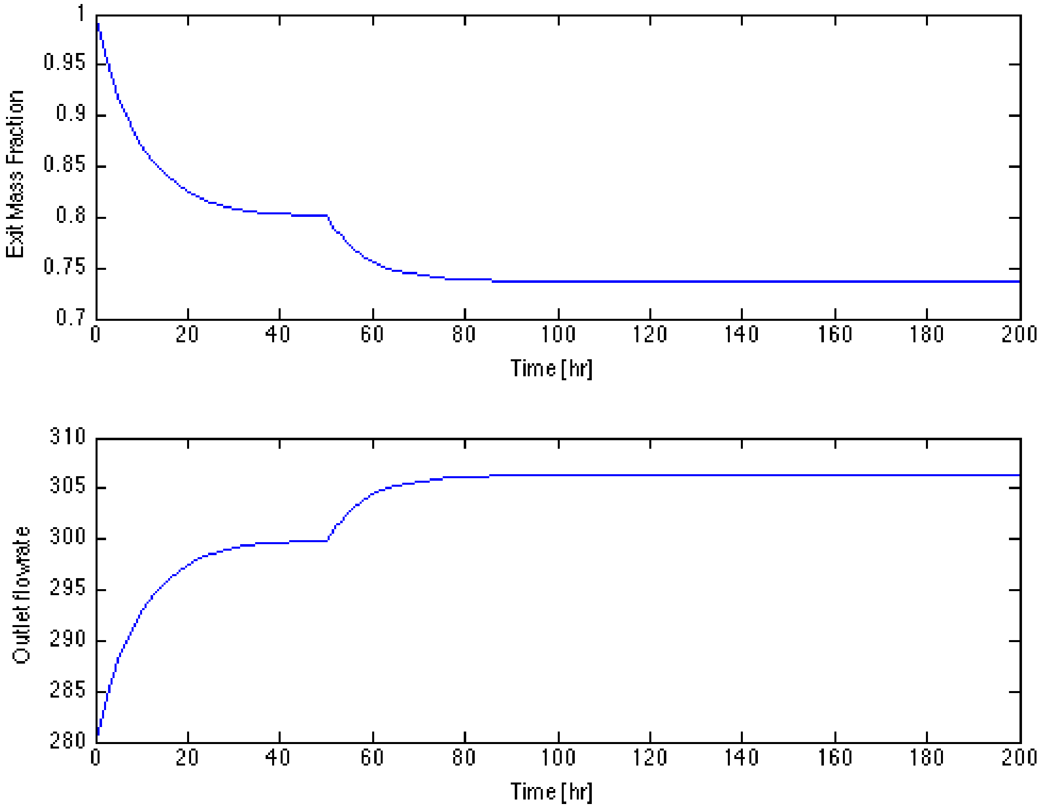
Feedback Control

Next we install a feedback controller using proportional control.

```
Kp = 100;
xSP = 0.8;

w2offset = w1(0)*(xSP-x1(0))/(1-xSP)
w2 = @(t,x) w2offset + Kp*(xSP - x);

f  = @(t,x) (w1(t)*(x1(t)-x) + w2(t,x)*(1-x))/rho/V;

[t,x] = ode45(f,[0,200],1);
subplot(2,1,1);
plot(t,x);
xlabel('Time [hr]');
ylabel('Exit Mass Fraction');

subplot(2,1,2);
plot(t,w2(t,x));
xlabel('Time [hr]');
```

```
ylabel('Outlet flowrate');
```

```
w2offset =

   300.0000
```



Exercises

1. Change the control constant from Kp = 100 to Kp = 10000. Is the result realistic? Adjust the control rule so that you're getting realistic values of the outlet flow.
2. Implement a feedforward controller.

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