

Exercise 0.1 Feedforward control of a general process

Given the process

$$\dot{y} = ay + bu + cv \quad (0.1)$$

where y is process output variable, u is control variable, v is disturbance, and a , b and c are parameters. The setpoint of y is y_{SP} .

Derive the feedforward control variable, u_f . Identify the feedforward from the setpoint and the feedforward from the disturbance.

Solution 0.1

First we substitute y_{SP} for y in the process model, which gives

$$\dot{y}_{SP} = ay_{SP} + bu + cv \quad (0.2)$$

Then we solve the resulting model for the control variable to obtain the feedforward control variable u_f :

$$u_f = \frac{\overbrace{\dot{y}_{SP} - ay_{SP}}^{u_{f_{SP}}}}{b} + \frac{\overbrace{-cv}^{u_{f_d}}}{b} \quad (0.3)$$

where $u_{f_{SP}}$ is the feedforward from the setpoint and u_{f_d} is the feedforward from the disturbance.

Exercise 0.2 Ratio and cascade control

Figure 1 shows a tank with two inlet flows. The liquid level of the tank is to be

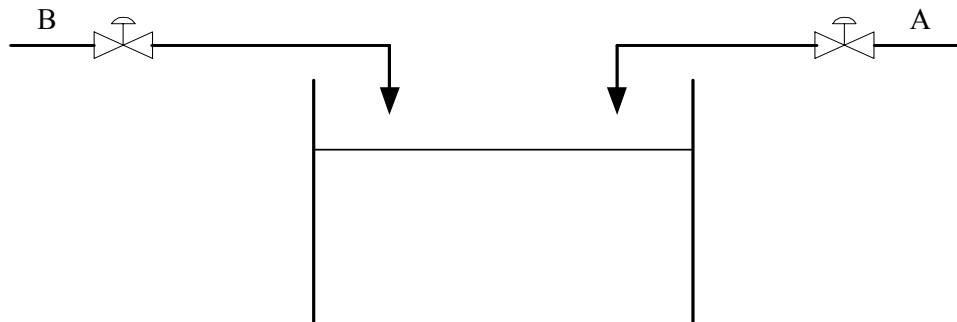


Figure 1: Exercise 0.2: Liquid tank

controlled by manipulating (controlling) flow A. The ratio between these flow A and B is specified as

$$\frac{F_A}{F_B} = k \quad (0.4)$$

where k is a given ratio. Assume that it is necessary to have local flow control loops around each valve.

Draw a Process & Instrumentation diagram of a control system for this process.

Solution 0.2

See Figure 2.

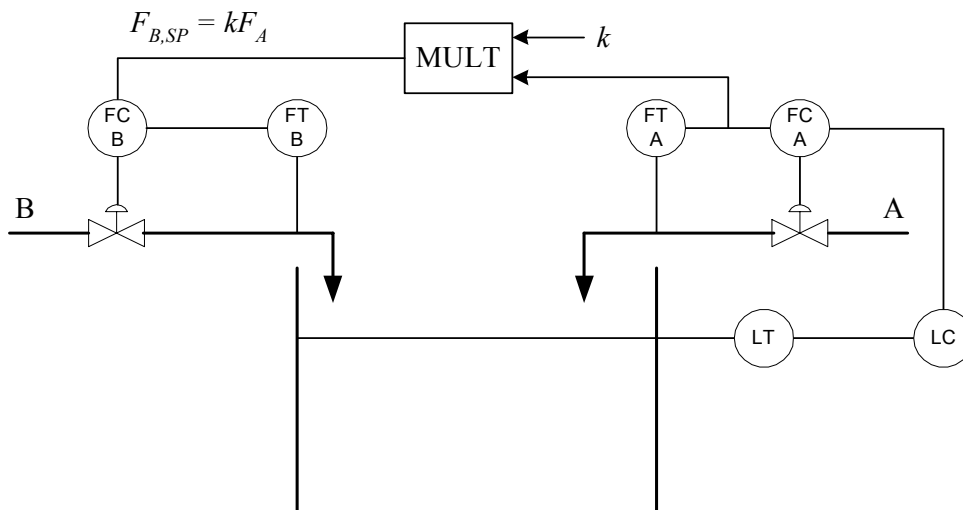


Figure 2: Solution 0.2: Liquid tank with control system

Exercise 0.3 Control of an evaporator

Figure 3 shows an evaporator where the product is created by evaporating the feed. (As an example, an evaporator is used to remove water from the half-finished fertilizer in a fertilizer factory.) Suggest a control structure for the evaporator according to the following requirements: The feed is a “wild stream”, i.e. it shall not be controlled (in this exercise). The mass balances of the liquid and the vapour

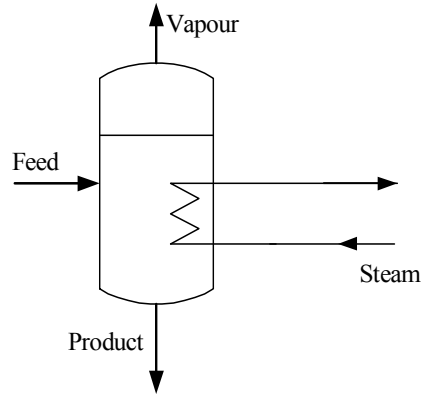


Figure 3: Exercise 0.3: Evaporator

must be maintained. The product quality or composition is strongly influenced by the steam supply (flow).

Solution 0.3

The control structure is shown in Figure 4.

Exercise 0.4 Control of distillation column

Figure 5 shows an incomplete P&I (Process & Instrumentation) diagram of a controlled distillation column. Make the diagram complete by entering letter codes in the instrumentation symbols. (It is assumed that you have some knowledge about distillation columns.)

Solution 0.4

See Figure 6.

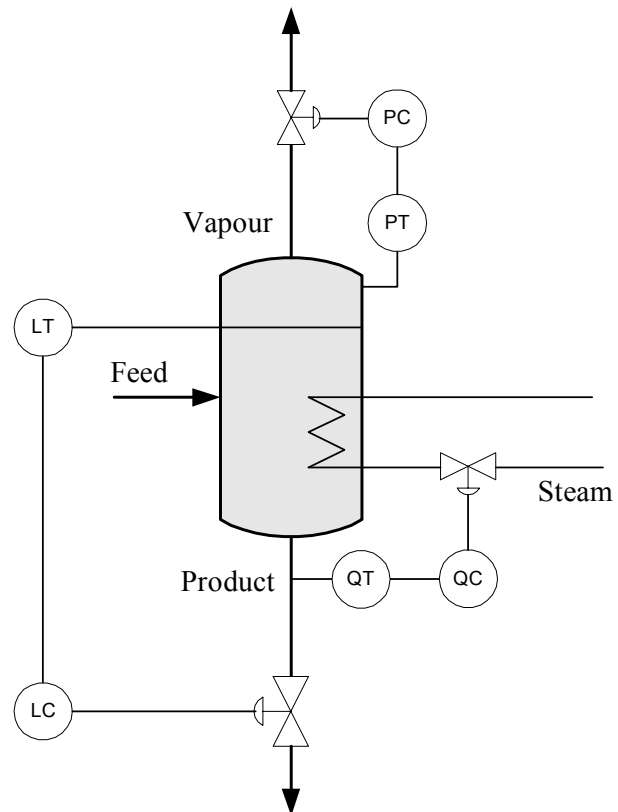


Figure 4: Solution 0.3: Control structure of an evaporator

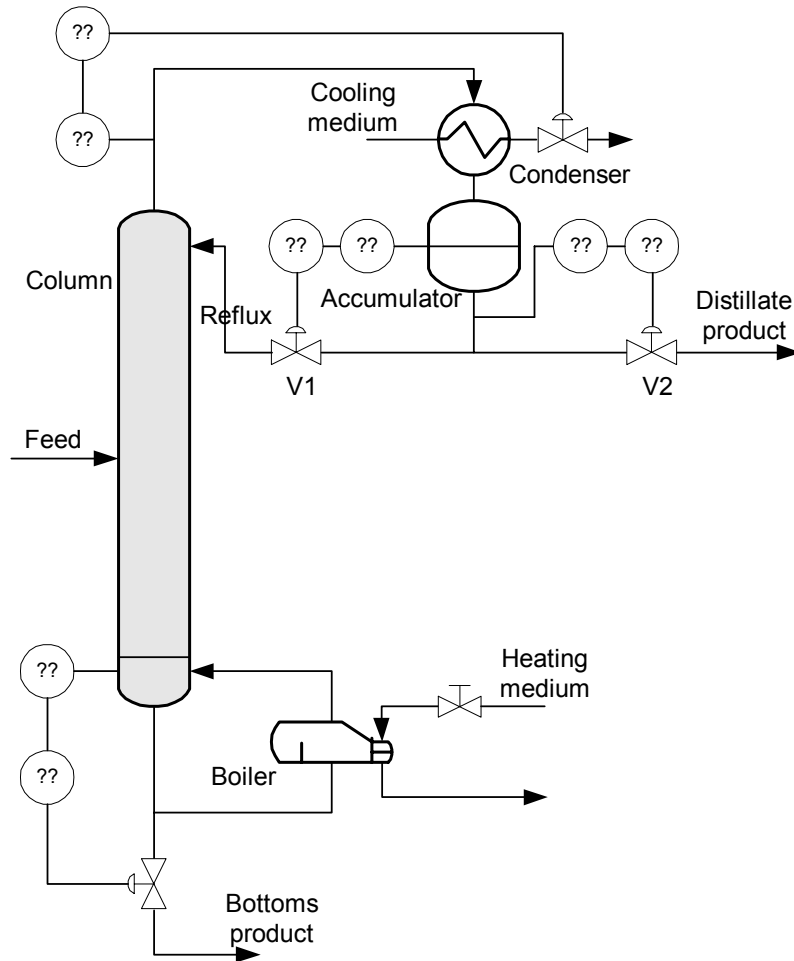


Figure 5: Exercise 0.4: Distillation column

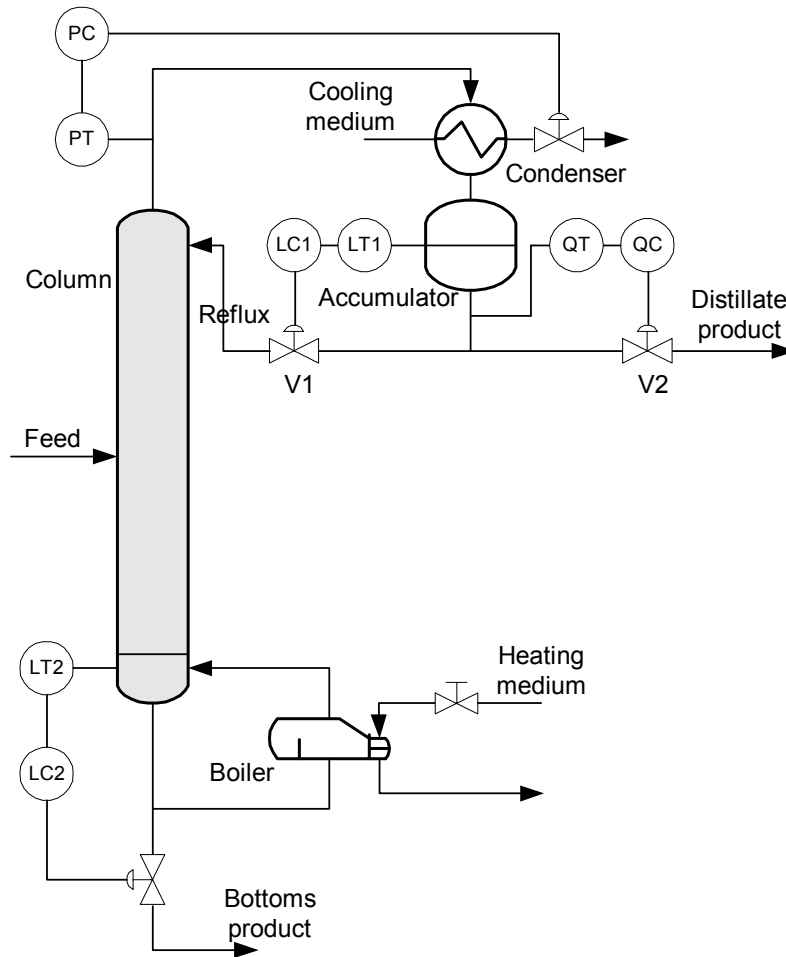


Figure 6: Solution 0.4: Control of a distillation column