CHBE 470
Fall 2022
Homework 1
Solutions

Assigned Friday, August 27, 2021
Homework due Friday, September 3 by 5:00 PM

Problem 1 - 10 points

Problem 1.1 in Marlin. Hint: the four necessary components are provided in Figure 1.4 and include the set point.

Solution: 1. A **set point** for the controlled value; 2. A **sensor** that obtains the value of the controlled variable; 3. A **controller** or **control algorithm** that uses the information from the sensor to determine the value of the manipulated variable; 4. A **final element** or **manipulated variable** that changes an input into the process.

Problem 2 - 10 points

Problem 1.2 in Marlin.

Solution: a) The controlled variable is the liquid level, and the float on the surface of the water measures the level in the tank. So there is a measured controlled variable. b) The valve is the final element, and this is an adjustable variable which determines the flowrate of fluid into the tank. c) The flowrate of fluid into the tank has a causal impact on the liquid level. Therefore, this system satisfies the criteria for a process control system.

b) a) The controlled variable is the liquid level in the tank, but it is not measured. b) The flow out is determined in part by the level of liquid in the tank, but there is not a final

element which allows for adjusting the flowrate out of the tank. c) There is a causal impact from the flowrate out of the tank on the liquid level, but the flowrate out is not an adjustable variable. This does not satisfy the criteria for a process control system.

Problem 3 - 10 points

Problem 1.6a. Perform the analysis for the continuous-flow stirred tank chemical reactor only. Provide a sketch of the sensors and final elements - see Figure 1.7 for example sketches.

Solution: The variables to be controlled are the composition, temperature, and liquid level. The sketch below shows three sensors and final elements that can be used to control these variables. The liquid level is measured using a level sensor, and the manipulated variable is the flow out of the tank. The reactor temperature is measured, and the final element is the flowrate of coolant to the reactor. An analyzer monitors the tank composition, and the final element is the flow of reactant into the tank. In addition to these sensors, there may be additional sensors for the temperature of fluid entering the tank and the pressure of the liquid in the tank for safety or monitoring purposes.

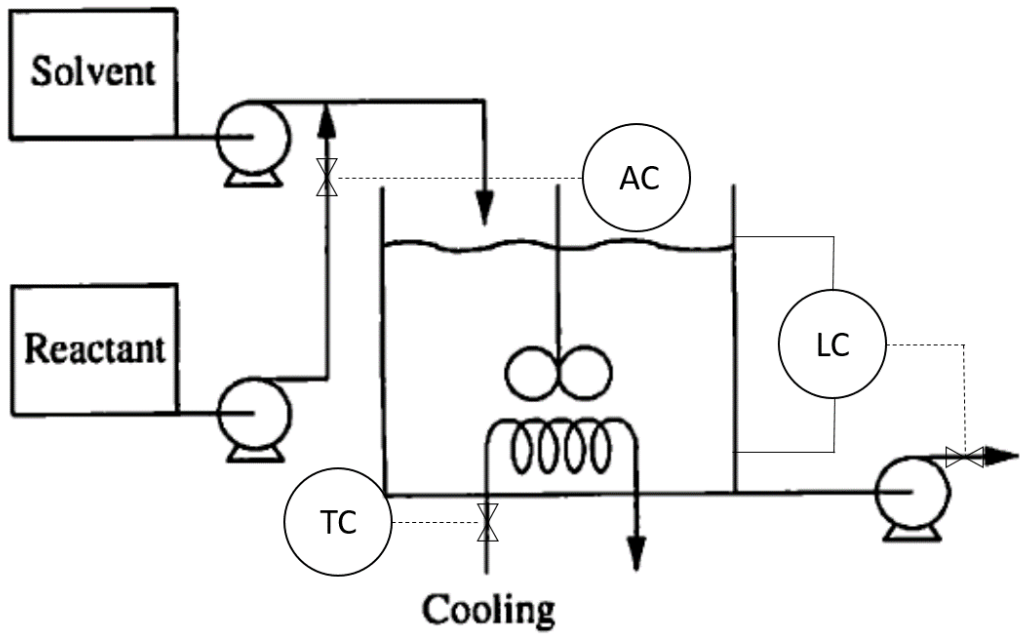

Figure 1: Schematic of sensors and final elements for controlling temperature, composition, and liquid level of the continuous-flow stirred tank reactor

Problem 4 - 10 points

Does a typical microwave oven utilize feedback control to set the cooking temperature or to determine if the food is "cooked"? If not, what technique is used? Can you think of any disadvantages to this approach, for example, in thawing and cooking foods?

Solution: Microwaves do not use feedback control. There is nothing that is actively monitoring the temperature of something in the microwave or the cooked state of foods (although it is possible to argue that the sound of popcorn popping or of your food exploding is a very crude feedback of how cooked something is). In general, microwaves do not rely on feedback control.

Cooking in a microwave is an example of feedforward control. We know based on past experience how long it takes to heat up food based on how much food we are putting in the microwave and the power of the microwave. Every time we put something in the microwave, we do a calculation in our heads to predict how long it will take for the food to cook. Or, we can rely on microwave presets, which have been calibrated based on prior measurements.