Tutorial 7
Selecting Controlled and Manipulating Variables

Before designing process control, we must know the control objectives!

7.1 Designing a feedback control system involves the selection of controlled and manipulated variables, and sensors for measuring the controlled variables. In addition, we have to know the possible disturbances occurring in the process in order to design a control system with good dynamic performance.

In this exercise, you are going to select the variables to be controlled for the CSTR in Figure 7.1 to satisfy the seven control objectives. The seven control objectives were introduced in Chapter 2 and are listed in Table 7.1. Complete Table 7.1 by filling in the selected controlled and manipulated variables, sensor principle (e.g., orifice meter) for the measurements and the possible disturbances occurring in the CSTR. You may add valves and sensors to the figure, if necessary.

Hint: Review the discussion on control objectives for the flash separator presented in Chapter 2.

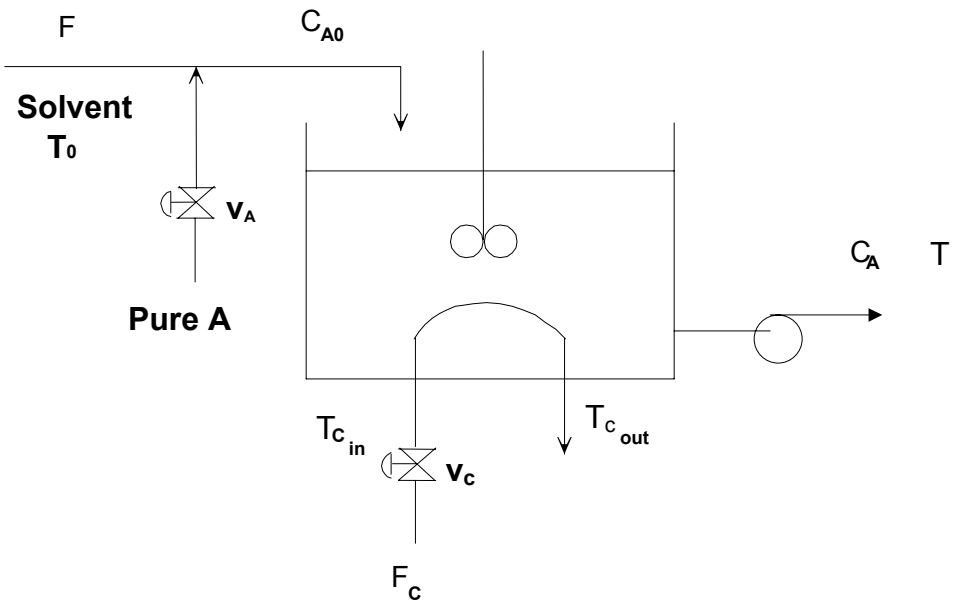

Figure 7.1 CSTR with heat exchange for the reaction system A → B → C.

Table 6.1 Control objectives for the non-isothermal CSTR.

Control Objective	Controlled Variable	Sensor Principle	Manipulated Variable	Disturbances that would affect the controlled variable
Safety				
Environmental Protection				
Equipment Protection				
Smooth Plant Operation and Production Rate				
Product Quality				
Profit Optimization				
Monitoring and Diagnosis				

7.2 Discuss whether each of the following control designs satisfies the specified control objective.

a. Control the flow in a pipe.

b. Control the flow in a pipe.

c. Control the pressure in an enclosed vessel.

d. Control the pressure in an enclosed vessel.

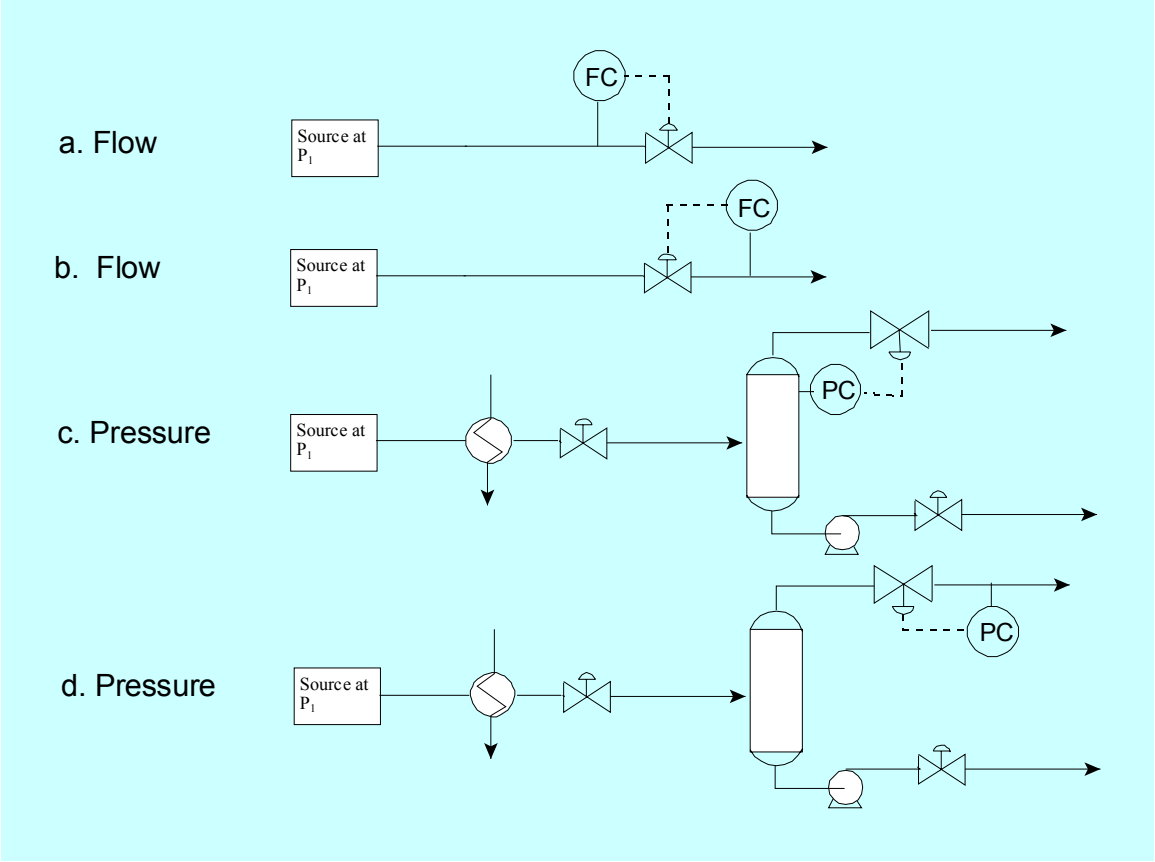

Figure 7.2

7.3 Possibility of feedback control.

Engineers must be able to quickly determine whether feedback control is possible. For many "straightforward" process systems, we can make this determination using qualitative analysis of the process behavior. If we do not have sufficient insight, we can develop mathematical models and perform identification experiments.

In this exercise, we will build our ability to use the modelling principles developed in prior lessons to predict the behavior of process systems. Here, we will apply qualitative reasoning to determine whether feedback control is possible for some proposed designs. Feedback is possible if a causal relationship exist between the manipulated and controlled variables. Later, we will consider other factors to find the best variables, but now we will concentrate on the possibility of control.

In addition, engineers must actually do it in the real world. Thus we require sensors and final elements (valves). The designs provide proposals for the equipment associated with each design; we will evaluate these as well.

Prior to Chapter 8, we do not know what calculation is required to implement feedback control. Therefore, we will look for the causal relationship. We recall that the symbol for a controller is a circle or "bubble" with letters inside, such as "TC" for temperature controller.

Scenario: You are working as an engineer and a colleague has asked you to evaluate some designs that she has prepared. She says that she does not have as much experience as you have in control and would appreciate your assistance.

For each of the designs, determine whether feedback control is possible and evaluate the instrumentation recommendations.

The proposed designs are presented in Figure 7.3.

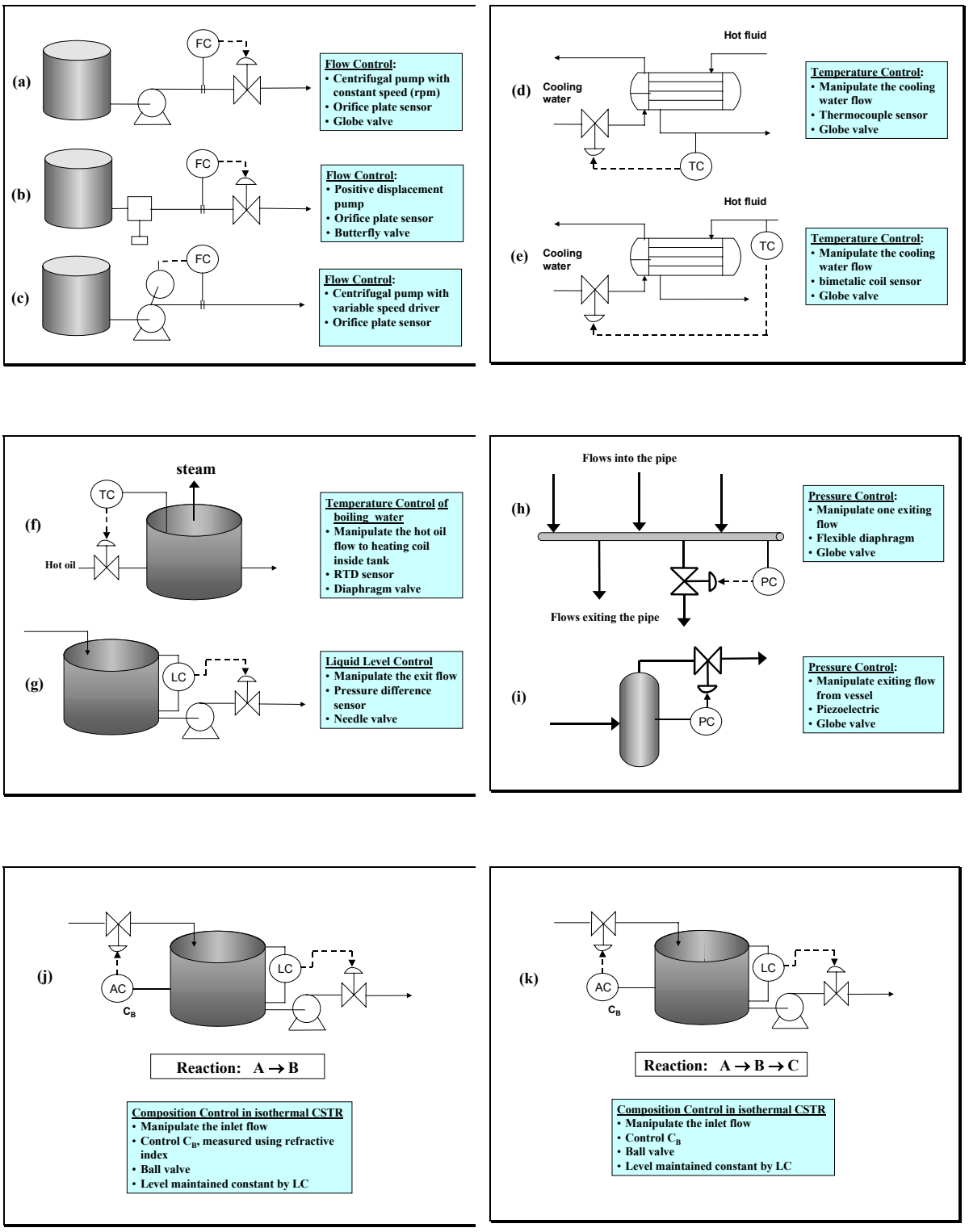

Table 7.3 **Proposed Control Designs with instrumentation recommendations.**
Caution: Some designs might not be possible!