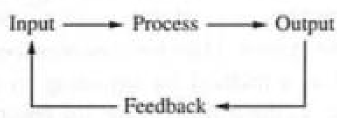
Feedback Control

PART III

To this point we have studied the dynamic responses of various systems and learned important relationships between process equipment and operating conditions and dynamic responses. In this part, we make a major change in perspective: we change from understanding the behavior of the system to *altering its behavior* to achieve safe and profitable process performance. This new perspective is shown schematically in Figure III.1 for a physical example given in Figure III.2. In discussing control, we will use the terms *input* and *output* in a specific manner, with input variables influencing the output variables as follows:



Here we see a difference in terminology between modelling and feedback control. In feedback control the input is the cause and the output is the effect, and there is no requirement that the input or output variables be associated with a stream passing through the boundary defining the system. For example, the input can be a flow and the output can be the liquid level in the system.

There is a cause/effect relationship in the process that cannot be directly inverted. In the process industries we usually desire to maintain selected output variables, such as pressure, temperature, or composition, at specified values. Therefore,

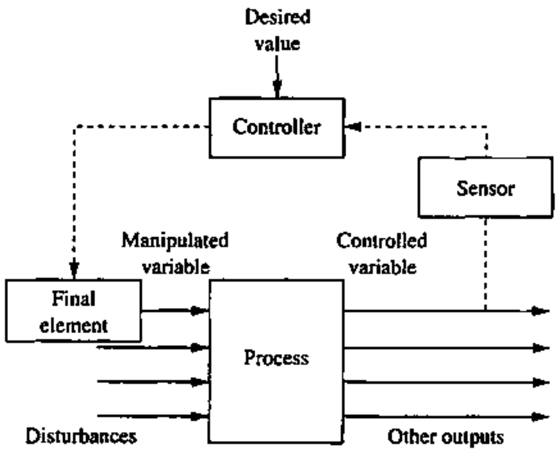


FIGURE III.1

Schematic of feedback system.

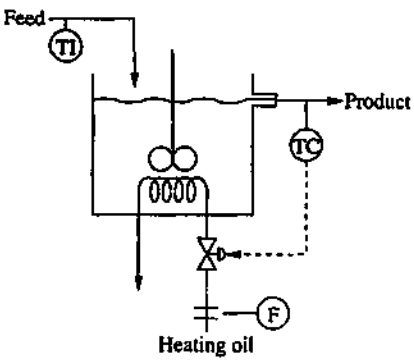


FIGURE III.2

Process example of feedback.

feedback is applied to achieve the desired output by adjusting an input. This explains why the feedback control algorithm is sometimes described as the inverse of the process relationship.

First, the engineer selects the measured outlet variable whose behavior is specified; it is called the *controlled variable* and typically has a substantial effect on the process performance. In the example, the temperature of the stream leaving the stirred tank is the controlled variable. Many other output variables exist, such as the outlet flow rate and the exit heating oil temperature. Next, the variables that have been referred to as process inputs are divided into two categories: manipulated and disturbance variables. A *manipulated variable* is selected by the engineer for adjustment in a control strategy to achieve the desired performance in the controlled variable. In the physical example, the valve position in the heating oil pipe is the manipulated variable, since opening the valve increases the flow of heating oil and results in greater heat transfer to the fluid in the tank. All other input variables that influence the controlled variable are termed *disturbances*. Examples of disturbances are the inlet flow rate and inlet temperature.

To achieve the desired behavior of the output variable, an additional component must be added to the system. Here we consider feedback control, which was introduced in Chapter 1 as a method for adjusting an input variable based on a measured output variable. In the simplest case, the feedback system could involve a person who observes a thermometer reading and adjusts the heating valve by hand. Alternatively, feedback control can be automated by providing a computing device with an algorithm for adjusting the valve based on measured temperature values. To automate the feedback, the sensor must be designed to communicate with the computing device, and the final element must respond to the command from the computing device.

Among the most important decisions made by the engineer are the selection of controlled and manipulated variables and the algorithm and parameters in the calculation. In this part, the greatest emphasis is placed on understanding the feedback principles through the analysis of particular feedback control algoms. The selection of measured controlled variables and manipulated variables is introduced here and expanded in later chapters. While this part emphasizes the control algorithm, one must never lose sight of the fact that the process is part of the control *system!* Since chemical engineers are responsible for designing the process equipment and determining operating conditions to achieve good process performance, the material in this part provides qualitative and quantitative methods for evaluating the likely dynamic performance of process designs under feedback control.