

Adapting Single-Loop Control Systems for Nonlinear Processes

CHAPTER

16

16.1 ■ INTRODUCTION

Linear control theory provides methods for the analysis and design of many successful control strategies. Control systems based on these linear methods are generally successful in the process industries because (1) the control system maintains the process in a small range of operating variables, (2) many processes are not highly nonlinear, and (3) most control algorithms and designs are not sensitive to reasonable ($\pm 20\%$) model errors due to nonlinearities. These three conditions are satisfied for many processes, but they are not satisfied by all; therefore, the control of nonlinear processes must be addressed.

It is possible that the response of a nonlinear system could give better performance than a linear system and, therefore, a nonlinear control calculation might be better than any linear algorithm. However, there is no recognized, *general* nonlinear control theory that has been widely applied in the process industries. (An example of a nonlinear algorithm applied to level control is given in Chapter 18.) Therefore, the goal of the approaches in this chapter is to attain the performance achieved with a well-tuned linear controller. To reach this goal, the control methods in this chapter attempt to achieve a system that has a linear closed-loop relationship. If an element in the control loop is nonlinear, the approach applied here is to introduce a *compensating nonlinearity*, so that the overall closed-loop system behaves approximately linearly. This compensating nonlinearity may be introduced in the control algorithm or in physical equipment, such as a sensor or final element.

The next section begins the analysis by introducing a method for determining when nonlinearities significantly affect a control system. This analysis is extended