6.5 Predictive Feedforward Control

Introduction

In the previous section, cascade control systems were discussed. In these systems, the disturbance was noticed by the secondary sensor and controller, and brought under control before it could adversely affect the primary variable.

For cascade control to be a suitable option, the variable which is creating the disturbance (the secondary variable) *must be controllable.*

For example, in the reheat furnace of the previous discussion, the changes in fuel flow were causing process upsets. In this example, fuel flow could be controlled. In other words, it can be sensed by the secondary transmitter, and controlled in an on-going fashion by the secondary controller which manipulates the final control element.

It is the disturbed variable's ability to be measured, compared to a remote setpoint, and continuously corrected by a final control element which makes it suited for cascade control.

When to use feedforward control

In some applications, a disturbance takes place which cannot be controlled (although it can be measured). An example of such an application could be the disturbance in the feed rate of product through a heat-exchanger.

In this case, cascade control could not be used. However, a system called *feedforward* can anticipate and compensate for the disturbance, although control of the disturbance is not possible.

The simple loop and the cascade loop are both types of "feedback" control. There are several inherent limitations to feedback control, which the feedforward system improves upon:

- All feedback control systems obtain control by measuring the error and supplying a restoring output. The system *depends* on an error to generate a corrective signal. Without the error, the controller output is stable. When the error becomes evident, the controller must slowly integrate for correction. With a steady state error, gain and derivative cease to offer a contributing factor to the output.
- All feedback control systems obtain the correct output by trial and error. The system will never know the correct output necessary to solve the problem. The basic operation of the system is shown in Figure 6-5.

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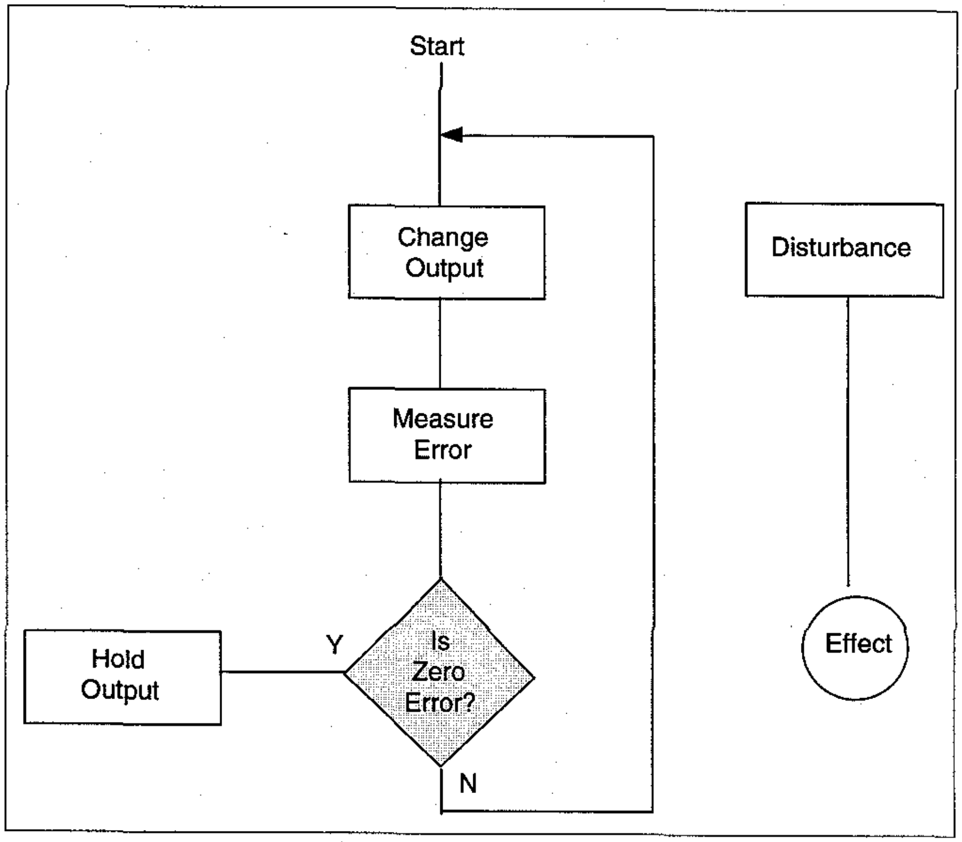
When to use feedforward control, continued

Figure 6-5 Trial and Error System



The simple flow diagram shown in this figure assumes that the controller output is changing in the correct direction.

Some degree of oscillation is common in any trial and error attempt at control.

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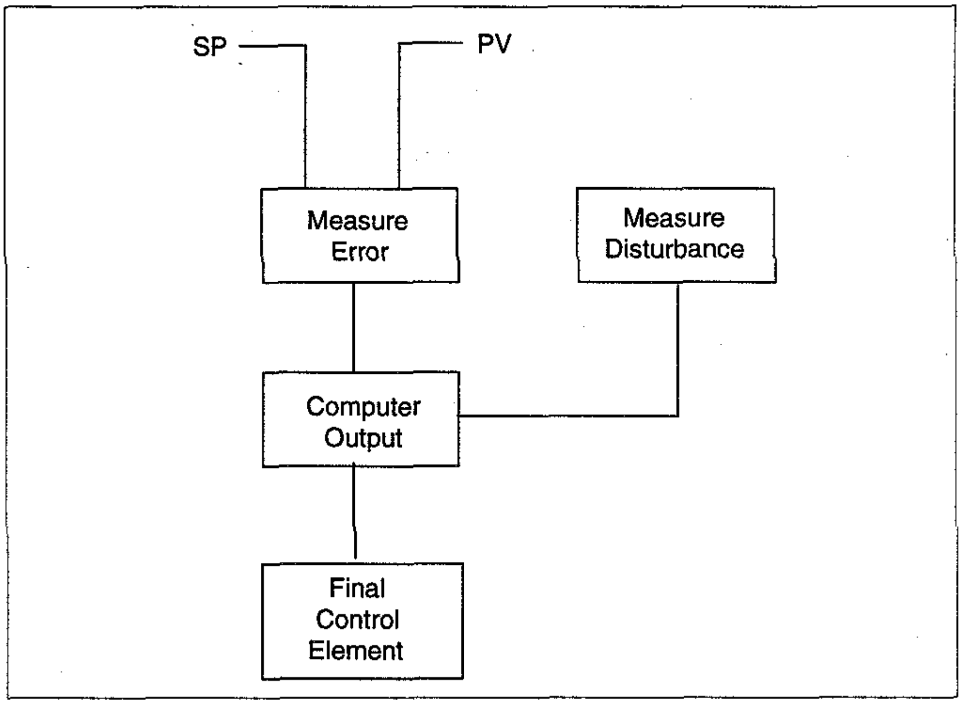
An approach to feedback problems

To find methods of solving some of the problems existing with feedback control systems, one would begin by considering a different approach. The approach would be to measure the principle factors that affect the process, and calculate the correct output to meet current conditions.

If a disturbance should occur, information will be fed to the final control device before the system senses that a problem has arrived. A flow diagram depicting this concept might appear as shown in Figure 6-6.

Figure 6-6 Feedforward Block Diagram



Note that in Figure 6-6, the system has no "return" of information. The correct output value is computed by changes in the setpoint, process variable, or fluctuations of external system disturbances.

The process of feeding this information forward to compute the correct output value is known as FEEDFORWARD. The essential feature which distinguishes this system from feedback control loops is the forward flow of information. The feedforward scheme can produce tremendous improvements in control because in practice, it continuously balances the material or energy requirements of the process against the current demands of the load.

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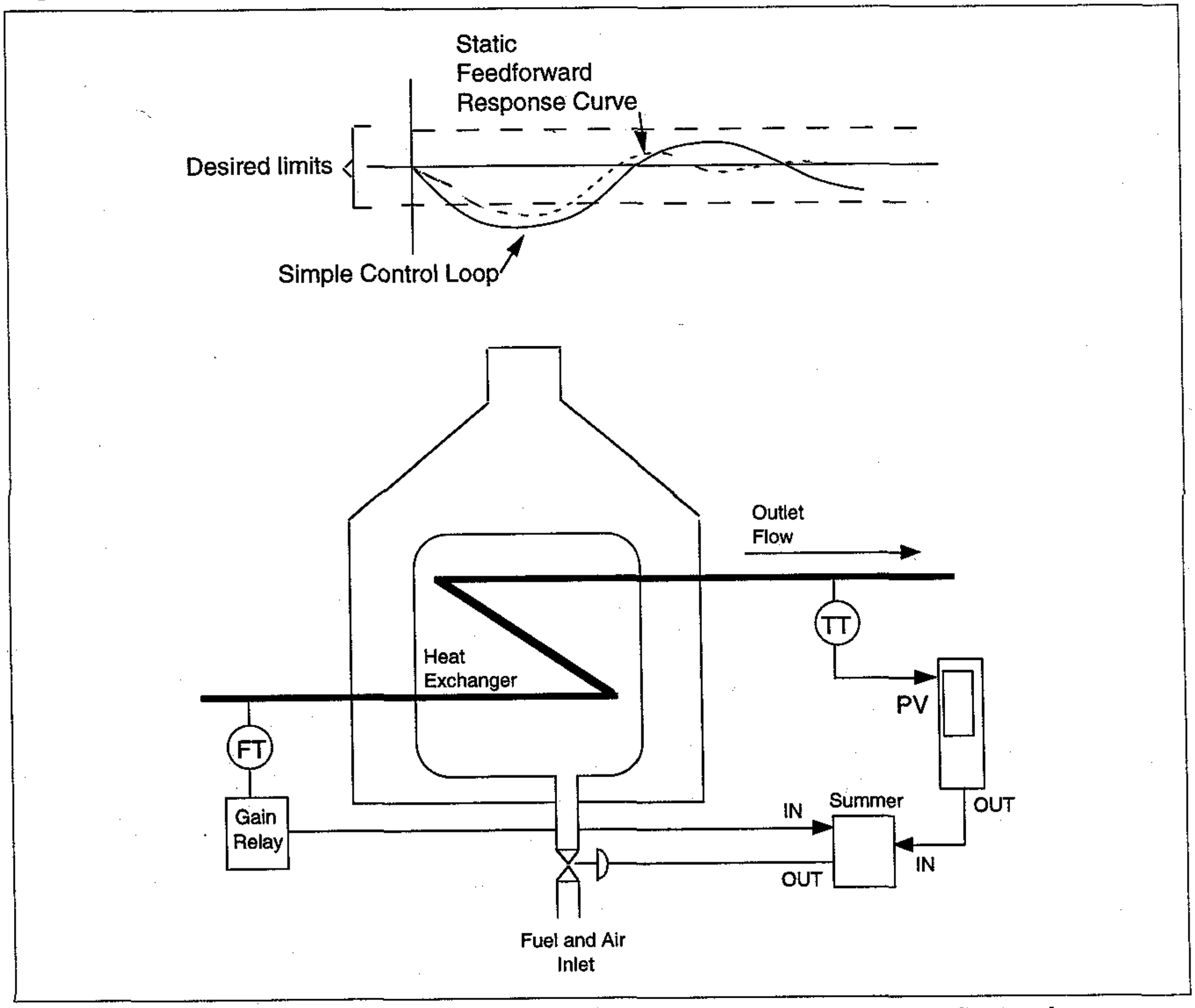
A simple feedforward control system

Figure 6-7 depicts a simple feedforward control system. The loop is of the continuous form, wherein liquid is fed through a heat exchanger and is heated to a desired value. The controller output feeds the final control element through a summation auxiliary. The auxiliary is an analog adder that sums the values of its inputs.

Figure 6-7 A Static Feedforward System



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A simple feedforward control system, continued

The feedforward transmitter measures inlet flow to the heat exchanger, and its output is multiplied by the setting on the adjustable gain relay. The resulting feedforward signal becomes the second input to the summer.

If the influent feed rate should increase, the flow transmitter instantly feeds an increase signal to the summer. The magnitude of this signal will depend on the degree of feed flow increase and the gain set on the relay. The feedforward signal will increase the output from the summer and produce an immediate change in valve position. The increased fuel inlet can now prevent large deviations of the feed temperature from occurring.

Static systems

Feedforward strategies that compute corrective output values in a manner independent of time are known as *static* systems. The computed output was instantaneous and is designed to anticipate current demand changes. Figure 6-7 is an example of a static system.