Application of Personal Computer as a Self-Tuning PID Controller

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Abstract

Controlling the process by PID controller is widely used in industry by applying Ziegler-Nichols method in analyzing parameter of the controller. However, in fact, it is still necessary to tune parameter in order to obtain the best process response. This paper presents a Self-Tuning PID controller utilizes the personal computer to synthesize and analyze controller parameter as well as tune for appropriate parameter by using Dahlin method and Extrapolation. Experimental results using a Self-Tuning PID controller to control water level and temperature, it is found that the controller being developed is able to control the process very effectively and provides a good response similar to the controller used in the industry.

1. Introduction

Today technologies have created principle and theory of new control that can be used to control complicated process effectively, but the PID control system remains its popularity as the PID controller contains simple structure, including maintenance and parameter adjustment being so simple [1]. However, in order to tune various values suitable for the best response of the process it takes time and may cause a mistake if user lacks skill and sufficient experience. To solve this problem, there are many developed methods of PID controller that can analyze and tune parameter suitable for the process automatically, but it is still expensive and is designed for this particular assignment. This paper presents an idea of using personal computer as PID controller, which can analyze and tune appropriate parameter for the process automatically by showing a graph of response and important parameter of the process on the monitor. Thus, it is very easy to use and a good response of the process can be shown.

2. Principle and Theory

A. PID Controller

PID controller has a fundamental equation [2]

$$V_o(t) = K_p\left[e(t)+\frac{1}{T_i}\int e(t)dt+T_d\frac{de(t)}{dt}\right] \qquad (1)$$

and $\quad e(t) = sp(t) - pv(t) \qquad (2)$

when $V_o(t)$ = controller output
$e(t)$ = error
$sp(t)$ = set point
$pv(t)$ = process output
K_p = controller gain
T_i = integral time (sec.)
T_d = derivative time (sec.)

The Discrete Differential Equation of the above Eq. is

$$V_o = V_{o_{n-1}} + K_p[(e_n - e_{n-1}) + \frac{\Delta T}{T_i}e_n + \frac{T_d}{\Delta T}(e_n - 2e_{n-1} + e_{n-2})] \qquad (3)$$

when ΔT = the sampling period
$V_{o_{n-1}}$ = controller output at the *n*th sampling instant
$e(n)$ = error at the *n*th sampling instant

B. Process Characteristics Analysis

Transfer function of the process used for characteristic analysis will be in form of a process called First-Order Lag Plus Dead Time (FOPDT), that is,

$$G(s) = \frac{Ke^{-t_o s}}{\tau s+1} \qquad (4)$$

when τ = process time constant

The testing of the process characteristic can be done by unit step input signal [$m(t)$] into the process. The response obtained in regardless of disturbance signal is S-shaped as shown in Fig. 1. This method can use to test with second or higher-order process with Damping Ratio equal to or higher than 1.

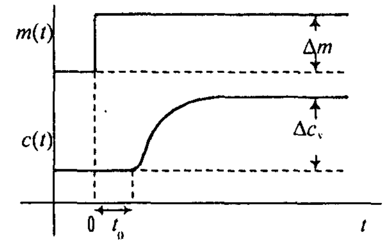

Fig. 1. Process reaction curve or open-loop step response.

With the step change of $m(t)$, the output response of the FOPDT process is

$$\Delta c(t) = K\Delta m \; u(t-t_0)[1-e^{-(t-t_0)/\tau}] \qquad (5)$$

At the steady-state,

$$\Delta c_s = \lim_{t\to\infty} \Delta c(t) = K\Delta m \qquad (6)$$

The steady-state gain of the process can be obtained from Eq. (6) as

$$K = \frac{\Delta c_s}{\Delta m} \qquad (7)$$

Dead time of the process (t_0) is derived from checking time from the beginning until there is a response of the process about 3%,