Shortcut Tuning Methods

PROFESSOR ROBERT HEIDER

Abstract

Many of the PID controller tuning methods require the user to obtain a process transfer function, sometimes called process identification. There are times or instances someone does not have the luxury of time to define the process model. This presents some ways to obtain controller tuning settings ‘on the fly’ using simple arithmetic. These tuning methods assume the process is self-regulating and the ratio of dead time to time constant is between 0.1 to 0.5 [4]. These dynamic conditions are what are generally found in chemical and other processing industries.

June 29, 2012 rev 1 March 5, 2013

1 Closed Loop Method

Perhaps the loop is controlling in the automatic mode, but does not have good performance. Wade [3] wrote of a technique for tuning PI controllers in the automatic mode. It is based on the premise that the ratio between the closed loop period and the reset time should be within the inequality:

\[ 1.5 < \frac{P}{T_I} < 2 \]  

(1)

Wade encourages the user to document each step in the interactive procedure. The user increases the gain until the loop begins to oscillate. Then the ratio between the period and the reset time is checked. The reset time is changed to be within the ratio. The gain or proportional band is then changed to obtain 1/4 decay, by the use of a chart showing how to determine the gain based on the decay ratio as shown in figure 2.

Wade method is for a PI controller. To convert a PI controller to a PID, a simple set of factors can be calculated. The units for rate and reset here are time, usually seconds or minutes.

\[ Gain_{PID} = 1.3Gain_{PI} \]  

(2)

\[ Reset_{PID} = 0.6Reset_{PID} \]  

(3)

Use the known 4 to 1 reset to rate factor, based on Ziegler-Nichols settings:
Another way to implement the Wade method is to test a P only controller, increase the gain for quarter decay, the use the following for PI gain:

\[ \text{Gain}_{PI} = 1.1 \text{Gain}_P \]  

The reset value can be calculated based on the cycling period.

2 Open Loop Method

There are many methods documented in the control literature for open loop tests. If one has the time to develop a full step test, once the transfer function is known, the techniques can be employed. If the process dead time can be determined, the rate and reset setting can be simply set based on the dead time. The rate is set to 1/2 the dead time and the reset set to 2 times the dead time. This is the classic ASME paper Ziegler Nichols method [2]. The gain can then be be adjusted to suit the degree of overshoot tolerated. Another method described by McMillan [1], does not require the process to be at a stable state, a distinct advantage if the process variable, PV is wandering or ramping. This is a manual method, so the controller should be in manual. The user then makes a step change in the output, in percentage \( \Delta IV \) noting the time when that occurred. The change should be of sufficient magnitude to cause the process variable to change direction. Note the figure 1. Note the time between the time the output changed and when the PC changes direction. That time is TD or dead time. Measure the two slopes, the PV units are in percentages. Next calculate the pseudointegrator gain, \( Ki \).

\[
K_i = \left( \frac{\Delta PV_2}{\Delta T_2} - \frac{\Delta PV_1}{\Delta T_1} \right) / \Delta IV \]

\( Ki \) should be positive, reverse the order of 1 and 2 to obtain a positive number. Note the units of this gain 1/time.

2.1 Calculate PID Settings

Once \( Ki \) and the dead time are known, the PID settings can be calculated. The reset and rate times are in the same units of the deadtime.

2.2 Gain

Gain, \( Ke \)

\[
Ke = \frac{0.5}{K_i TD}
\]
2.3 Reset Time

Reset time, $T_i$

$$T_i = 4TD$$ (8)

2.4 Rate Time

Rate time, $T_d$

$$T_d = TD$$ (9)

2.5 Remarks

Note that that the reset setting is four times the rate time. This 4 to 1 ratio is what Ziegler-Nichols has in their original ASME paper [2]. The rate setting is conservative and is set to the process deadtime rather than half the deadtime as Ziegler-Nichols reported.

Also note that to make the problem even easier, only the dead time can be determined to calculate the reset and rate times. The gain can be set to obtain the degree of robustness the user desires.

References


Figure 1: The shortcut tuning method.
Instructions: When the Flow Chart recommendation is to Change Gain or Change PB, enter the graph on the horizontal axis at the present decay ratio. Read the related factor on the vertical axis. Multiply the present Gain, or Divide the present PB by this factor.

Figure 2: Gain Adjustment