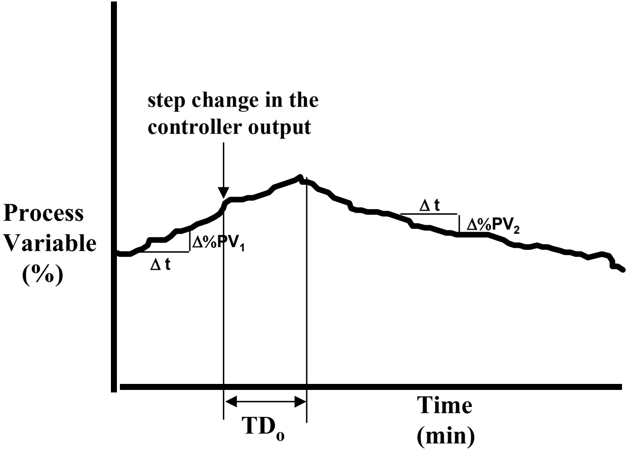
forward, and add rate if there is no inverse response or interaction.

2.4 The Shortcut Open-loop Method

The shortcut method is ideally suited for very slow responses such as column temperature where there is a good control valve and positioner and you need to get a quick estimate of the controller tuning settings. This method looks at the change in ramp rate of the %PV as shown in Figure 10 for about two to three dead times. It doesn't require the loop to be at steady state. However, if there is an upset that causes the ramp rate to change, the results will be inaccurate. In general, you should repeat this test in both directions and use the most conservative settings. Also, if the bump in controller output is much larger than the dead band, the shortcut method doesn't include the dead time from valve dead band. If the changes in controller output per scan approach the control valve dead band in size, you should add the additional dead time from the valve dead band to the observed dead time.

Figure 10 – Change in Ramp Rate for Non-Steady State



The shortcut method is also effective for pH loops because it can keep the test near the operating point on the titration curve. The use of a closed-loop method can get confusing for pH particularly if the oscillations develop into a limit cycle after being bounced back and forth between the flat ends of the titration curve. The period of such a limit cycle is extremely long and variable, and it will occur for a large range of controller gains.

A list of steps for the “Shortcut Method” are as follows:

1. Adjust the measurement filter to keep the controller output fluctuations caused by noise within the valve dead band.

2. Note the magnitude of output change for each reaction to typical upsets. With the controller in manual near set point, make a step change in the controller output ($\Delta\%CO$) of about the same magnitude as the output change you noted, but larger than twice the valve dead band.

3. Note the observed dead time and the change in ramp rates. If the process was lined out before the test, then the starting ramp rate is zero ($\Delta\%PV_1 / \Delta t = 0$).

4. Divide the change in ramp rate by the change in valve position to get the pseudo integrator gain (K_i). Then compute the dead time from the dead band.

5. Use the following equations. For a master or supervisory loop, omit τ_{dv}.

$$K_i = \frac{\left|(\Delta\%PV_2 / \Delta t) - (\Delta\%PV_1 / \Delta t)\right|}{|\Delta\%CO|}$$

$$K_c = \frac{K_x}{K_i \bullet \tau_{do}}$$

$$\tau_{dv} = \frac{DB}{K_x \bullet \Delta\%AVP} \bullet \tau_{do}$$

$$\Delta\%AVP = |\Delta\%CO| - \frac{DB}{2}$$

$$T_i = c_i \bullet (\tau_{d_v} + \tau_{do})$$

$$T_d = c_d \bullet (\tau_{d_v} + \tau_{do})$$

Where:

$\Delta\%AVP$ = change in actual valve position (%)
$\Delta\%CO$ = change in the controller output (%)
DB = dead band from valve hysteresis (%)
K_c = controller gain (dimensionless)
c_d = rate time coefficient (1.0 for back-mixed and 0.0 for plug flow volumes)
c_i = reset time coefficient (4.0 for back-mixed and 0.5 for plug flow volumes)
K_x = gain factor (1.0 for Ziegler-Nichols, 0.5 for IMC, and 0.25 for Lambda)
K_o = open-loop gain (dimensionless)
K_i = pseudo integrator open-loop gain (1/sec)
$\Delta\%PV$ = change in process variable (%)
Δt = change in time (sec)
τ = largest loop time constant (sec)
τ_{do} = dead time seen in open-loop test (sec)
τ_{dv} = dead time from control valve dead band (sec)
T_d = derivative (rate) time setting (seconds)
T_i = integral (reset) time setting (seconds/repeat)

Rule 15 **– Use the shortcut method when you want a quick estimate for a very slow or nonlinear loop, provided that the valve dead band is 0.25 percent or less and the step size keeps you near the operating point.** Make sure there are no load upsets during the test and that you measure the new rate of change of the PV for at least two dead times. You should repeat the test for both directions and use the most conservative tuning.

2.5 Simplified Lambda Tuning

If the loop is dead-time dominant, Lambda tuning is the best method. It also helps to minimize interactions and suppress oscillations. Lambda tuning is an open-loop method that is particularly effective for relatively fast loops, such as in pipelines, desuperheaters, static mixers, exchangers, conveyors, spin lines, and sheet (web) lines, or wherever there is plug flow. It provides a closed-loop time constant that approximates the open-loop time constant. Figure 11 shows the step change in controller output and the open-loop response of the process variable. The user simply needs to note these changes and the time required to reach 98 percent of the final response (T_{98}). This simplified form of the equation for Lambda