APPLICATION NOTE

DID YOU KNOW ?
Almost all of the tuning rules that have been developed aim for a fast loop response. Even the IMC / Lambda tuning rules fall short of providing good tuning settings for a surge tank control loop.

Tuning Surge Tank Level Control Loops

Preamble

A surge tank is placed between two processing units (Figure 1) to absorb flow rate fluctuations coming from the upstream process so that the flow rate to the downstream process changes less rapidly. To do this, the tank level has to go up and down. Consequently, the level controller should not try to hold the level as close as possible to its set point. The controller should simply keep the surge tank's level between its upper and lower limits, and do this with the least possible amount of change to its output.

Although there are other methods of controlling the surge tank level, the level-averaging method is preferred by most operators and engineers. This method minimizes control valve movement during disturbances, keeps the level between its limits, and brings the level back to set point in the long term. This Application Note describes how to tune surge tank level controls using the level-averaging method.

Applicable Process Types

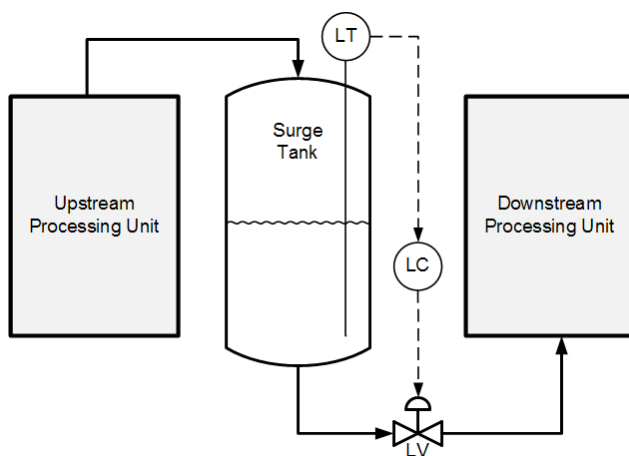The tuning method described below is intended for use with surge tank levels (Figure 1).

Figure 1
A Surge Tank Control Loop

Target Controller Algorithm

The tuning rule presented here is designed for use on a noninteractive controller algorithm with its integral time set in minutes, such as the one provided in the Dataforth MAQ®20 system.

Tuning Procedure

To tune the controller for level-averaging control, the residence time of the surge tank, the greatest expected change in flow rate, and the maximum allowable deviation from set point must be known.

Residence Time (t_{res})

The residence time is the time it will take the tank to drain from 100% level to 0% level if there is no flow into the tank and the outlet valve is 100% open. It can be calculated by dividing the volume of the vessel between 0% and 100% of its level measurement span (V) by the maximum flow rate with the outlet valve wide open (Q_{max}).

$$t_{res} = V / Q_{max}$$

The same unit of measure must be used for volume in V and Q_{max}.

Q_{max} must be expressed in volume / minute.

Change in Flow Rate (Δf_{max})

The greatest expected change in flow rate should be expressed as a percentage of maximum valve capacity. If available, historical trends of the level control valve's position can be used to find the largest change the controller output has made over a relatively short period of time.

Maximum Deviation from Set Point (ΔL_{max})

The maximum allowable deviation of level from its set point should be specified as a percentage of the full span of the level measurement.

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Tuning Equations

Once the three quantities described above are available, tuning settings can be calculated for the controller.
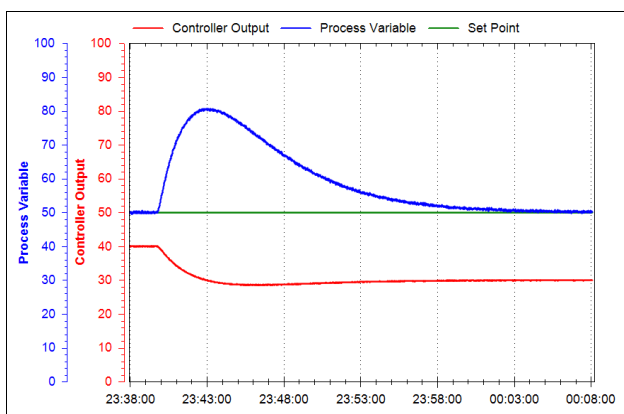
$$K_C = 0.74 \, \Delta f_{max} / \Delta L_{max}$$
$$T_I = 4 \, t_{res} / K_C$$
$$T_D = 0$$

Where:

K_C is controller gain
T_I is the integral time in minutes
T_D is the derivative time

The typical response of a surge tank tuned with the level-averaging tuning rule is shown in Figure 2.

Figure 2
A Surge Tank Control Loop Responding to Disturbance

Conclusion

While the Ziegler-Nichols and most other tuning methods for level controllers are not suitable for use on surge tanks, using the level-averaging tuning rule will keep the surge tank's level between its upper and lower limits with the least possible amount of change to the controller's output.

References

The reader is encouraged to visit Dataforth's website to learn more about PID control and the MAQ®20.