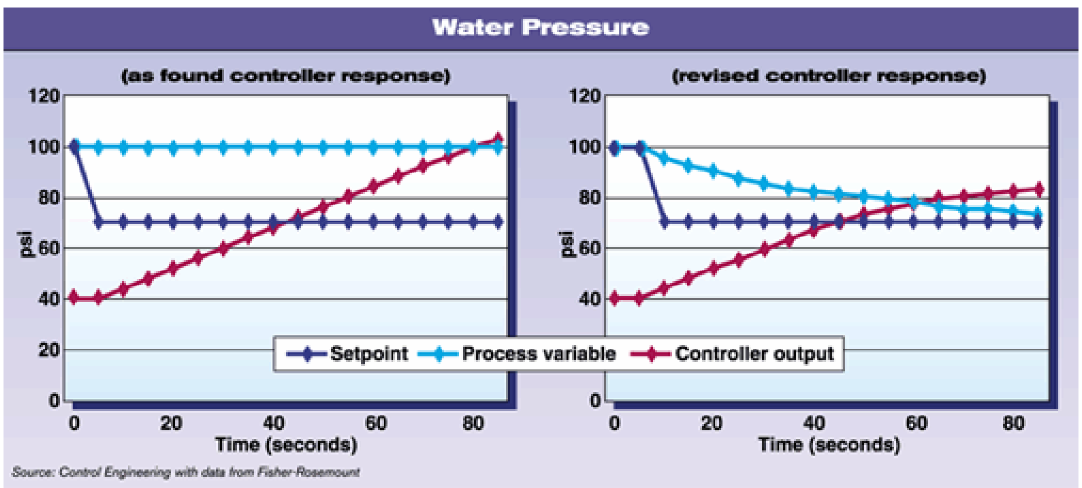
Open-Loop Response Testing Improves Process

John Egnew, Fisher-Rosemount Educational Services -- 5/1/1999

Three-quarters of all process control loops are operating below peak efficiency, according to one industry survey. Among conditions that can reduce process efficiency are improper control valve selection, sizing, or calibration; instability or oscillation above and below a setpoint; slow response to changing conditions; or a combination of these factors. Approximately half of all loop problems relate to control valve performance, and the others are largely due to poorly tuned controllers.

Many production engineers, and even process control engineers, don't realize there is a way to evaluate the operation of individual control loops right from the control room. The open-loop response test, which is part of a three-step evaluation procedure, enables plant or refinery personnel to define the process by determining the process time constant, process gain, and process deadtime. Using these values, new controller settings can be calculated and applied. Resulting improvements in loop performance lead to better overall control of the process and enhanced productivity.



One of Vulcan Chemical's 4-in. butterfly valves indicated an 8% deadband. The large deadband produced impractical controller tuning settings; however, applygin high gain forced output signal changes sufficient to drive the valve through the deadband fast enough to reduce overall setting time. Maintenance and addition of a positioner are planned for thie valve.

On-line loop evaluation

Even experienced engineers are frequently surprised to learn that a simple test of an operating control loop, performed from a distributed control system (DCS) console, can reveal much about the process.

Selected processes in the plant can be evaluated, and the loop controllers can be tuned using values calculated from the test results. Techniques applied to 'live' process control minimize the possibility of upsetting plant operations.

It is possible for users to tune controllers to minimize or eliminate process variable overshoot and produce predictable process variable settling times.

When computer simulations are used, field equipment performs flawlessly, but real-life loops can have sticking or improperly positioned valves that confound even the best-tuned controller. Working on live plant loops builds user confidence because class room teachings can be applied during hands-on sessions.

Using a DCS operator interface, a three-step process can verify, test, and tune a control loop.

Step one involves checking the valve or final control device, including the positioner and other accessories, to be sure it's performing reasonably well. A valve deadband check can determine if it's performing adequately. If the valve does not react properly, conducting maintenance work must be evaluated, especially on valves that can significantly impact plant operations. Less significant valves can be tested and tuned, even if the valve is not operating properly, realizing that loop performance will not be optimized.

Step two is an open-loop response test that determines process time constant, process gain, and process deadtime. These values are used to calculate new gain and reset settings for the controller connected to that valve or final control device. Prior to conducting the test, signal filtering values and sample rate settings are assessed to ensure accurate test results.

Step three uses the data collected during step two to calculate new loop tuning values.

This three-step procedure is straightforward, but results improve when steps two and three are repeated. Following the second series of tests, it becomes apparent how loop tuning affects stability and settling time.

A frequently asked question is, 'What about autotuning?' Many autotuning offerings are available to simplify tuning, but these algorithms do not always achieve optimum results. The three-step method makes attainment of performance goals more predictable and reliable. Relying totally on autotuning, especially on loops that continually wander away from setpoint, is not recommended.

On-site experience

Production engineers at the Vulcan Chemical Co. (Wichita, Kan.) tested and tuned three operational loops, with results shown in the table, Open-loop Response Test.

Documented results were achieved at operating conditions and valve positions existing at the time of testing. Other conditions and/or valve positions might produce different results, therefore a series of open-loop tests is recommended to obtain optimum performance across the expected operating range.

According to Rod Graf, production engineer and operational excellence supervisor at Vulcan's chlor-alkali plant, 'We're implementing an Operational Excellence program designed to improve production efficiency in this plant and our other plants in Port Edward, Wisconsin, and Geismar, Louisiana. Obviously, control system stability is very important to the overall operational excellence of our plants.'

For Vulcan, production efficiency means operating 'closer to the edge' and requires optimizing each control loop. When too much variation or big swings occur in a process, a sizeable cushion must be provided for products to meet specifications. When overshoot is eliminated and variations are reduced, it helps each facility achieve its performance targets.

'We need to be able to stabilize these loops to optimize our processes,' says Mr. Graf. 'Sometimes, we become complacent with existing conditions. Changes to the test loops gave us all a better understanding of how the control system works and how we can influence the process. Now, when we begin the stabilization phase of our Operational Excellence program, we'll know what to look for and how to correct loop performance problems that may exist. This technique definitely has a practical value for us, and it's given us more confidence in our abilities to make a difference.'

Individual loop stability allows optimization of the control system and has a positive impact on the overall process. Eliminating problems within individual loops helps improve production efficiency, and that's what makes open loop testing so valuable.

However, the real payoffs come when changes have a positive impact on overall operations. It's a good idea to select a measurable standard for documenting benefits of open-loop testing and closed-loop controller tuning. The standard can be different from plant-to-plant and depends on operational objectives. It could be increased throughput, reduced downtime, higher quality, greater financial savings, or any economic or performance factor. By establishing meaningful criteria, making measurements before and after loop changes are made, and comparing results you can fully realize the benefits of on-line loop evaluation.

Fisher-Rosemount Educational Services (Marshalltown, Ia.) conducts the 'Process Control III' course on site, on live plant loops in hands-on sessions to 'prove' these process improvements are possible. Vulcan engineers attended a three-day course

Open Loop Response Test

	As found controller settings		**Revised controller settings**			
Process description	**Gain**	**Reset (repeats/min)**	**Gain**	**Reset (repeats/min)**	**As found settling time (minutes)**	**Revised settling time (minutes)**
Temperature differential	0.75	0.3	2.5	0.8	10-15	5
Water pressure	0.5	1.0	1.5	1.0	10	4
Water flow	0.7	1.3	0.2	8.3	3-4	1

3-Step Loop Tuning

Step 1: Check the valve or final control device, including the positioner and other accessories.

Step 2: Open-loop response test determines process time constant, process gain, and process deadtime.

Step 3: Calculate new loop tuning values.

Repeat as necessary.