Warning

Are Nonlinearities Making Your Valves the Weakest Link?

Valves are an integral component in the majority of production processes and their performance is key to efficient production. Even so, valves are susceptible to a variety of anomalies — nonlinearities — that are regularly misdiagnosed and that undermine performance. The end result: Valves become your weakest link.
Warning

A typical production facility applies hundreds – sometimes thousands – of individual PID control loops to the real-time management of complex production processes. In order to maintain production that is both consistent and cost-effective, it’s essential that each loop performs its task correctly and compensates quickly for disturbances. That’s particularly true as either significant or persistent lapses in control loop performance can cripple output and undermine a facility’s financial viability. Ironically a large portion of disturbances that hamper performance can be linked directly to the same final control elements that are responsible for meeting out the associated controller’s calculated corrections. Valves with their predisposition to nonlinear behavior drive the bulk of oscillatory behavior, and they can undermine a facility’s ability to maintain effective and efficient control loop performance.
It’s often said that a chain is only as strong as its weakest link – a cliché that clearly applies to valves. As the most common form of final control element, valves are generally the only moving parts in regulatory control loops. They are critical to the regulation of gases, liquids, powders, slurries and other process streams. In an ideal world their operation would be precise with both actuator and positioner operating in concert with the valve, opening or closing exactly as directed by the controller. Unfortunately valves are highly susceptible to nonlinearities such as Stiction, Hysteresis and Deadband which place severe limitations on the precision with which valves operate.

Nonlinearities affecting control loop performance in general and valves in particular can be difficult to diagnose even if their impact is obvious. Excessive oscillations due to nonlinearities are often quite evident in the process data, revealing themselves clearly in the shape of sinusoidal, saw-toothed or square oscillating lines (i.e. Process Variable, Controller Output). They can also be exposed in a facility’s performance. Whether in the form of increased energy consumption and off-spec production or reduced throughput and yield, the economic impact of nonlinearities are ultimately disclosed in a facility’s financial reports. Understanding nonlinearities and knowing how to distinguish them are essential to formulating an accurate diagnosis and to restoring control loop performance.

Following are explanations and examples of common nonlinearities associated with valves and their installed characteristics. Learning to distinguish between the various types of nonlinearity is key to accurately diagnosing control loop performance issues and to correcting them for improved operation.
Stiction

Stiction – otherwise known as static friction – is a force that restricts the free movement of a valve. Stiction most often results from excessive packing around a valve’s stem thereby limiting its ability to execute small positional adjustments. As a result of Stiction a valve’s actuator must exert additional force to enact a change, ultimately causing the valve to ‘pop’ into its new position. The results are two-fold. First, sudden changes in position are often disruptive to a process. Secondly and more importantly, excessive force is required causing both the valve to overshoot its objective position and the controller to compute a compensating adjustment. Back-and-forth the valve overshoots its objective, driving process oscillation and accelerating equipment wear and tear.

Hysteresis

Hysteresis explains how the application of uniform amounts of force by a valve’s actuator can result in movements of differing size. More specifically this phenomenon explains behavioral differences in the opening versus the closing of a valve. This form of nonlinearity can be exceptionally difficult to diagnose without direct knowledge of the associated changes in stem position. What’s more, Hysteresis’ effect on control can be significant especially due to the fact that the amount of nonlinearity can vary at different ranges of the valve’s position (e.g. low when moving from 10% to 20% open vs. high when moving from 80% to 90% open) as well as under different amounts of force (e.g. opening a valve 5% vs. opening a valve 15%). A control loop regulated by such a valve will tend to oscillate as the PID controller repeatedly calculates adjustments for error in order to achieve the designated control objective.
Idle Claims About Essential Indicators

Process manufacturers are regularly investigating new ways to improve their facility’s performance, and control loop performance monitoring (CLPM) technologies offer an automated means for identifying and isolating control-related issues. Questions consistently raised by practitioners about such tools: Do the software’s indicators distinguish between common nonlinearities? Are they based on sound science, or are they offering little more than snake oil?

Definitions matter. Stiction, Hysteresis, and Deadband are unique conditions and yet CLPM tools often bundle them into a single diagnostic. Doing so simply ignores their unique nature, and it hampers the ability of production staff to apply appropriate corrective measures. Imagine being diagnosed with a common cold when you truly have the flu. Similar symptoms? Sure. Same treatment plan? No way. You’ll eventually get better, but a poor diagnosis unnecessarily extends the recovery time.

The use of CLPM tools as a complement to preventative maintenance has been shown to reduce unscheduled downtime. The identification of potentially harmful performance trends equips practitioners with advance warning, and quality diagnostics enable more rapid repair. But that is only possible if the diagnostics are accurate and actionable. If they point to a jumble of possible issues, then those diagnostics don’t speed the time to correction. More than likely idle claims about essential diagnostics will result in extended downtime and increased costs.
Control Loop Performance Monitoring
Providing Accurate and Insightful Information

Most production processes are highly dynamic and constantly changing, so much so that it’s not hard to stumble upon issues that hamper performance. The real challenge for practitioners is prioritizing limited time around their facility’s most pressing issues. To optimize their effectiveness practitioners need access to information that is both accurate and insightful. That applies equally to their facility’s PID controllers as it does to process instrumentation. If you require improved awareness of your facility’s production performance issues, look no further than PlantESP!

- Plant-Wide Control Loop Monitoring
- Timely Alerts and Detailed Reports
- Targeted KPIs and Advanced Forensic Tools
- Actionable Recommendations for Corrective Action

Contact us today to learn how PlantESP is enabling manufacturers across the process industries to accurately diagnose complex control loop performance issues and to quickly correct them for increased production and enhanced efficiency.