White Paper

Increased Plant Availability Through Proper Anti-Surge Valve Selection

EMERSON™

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You need high reliability and precise control in your most critical compressor applications—you can't afford to handle performance failures caused by surge.

Surge is characterized by fast flow reversals through a compressor and is created by a large-scale breakdown of flow patterns within the compressor. Surge typically happens at low flow rates, often when the downstream demand decreases. When the flow decreases below a certain minimum point, the patterns become unstable and the fluid moves back through the compressor from the high to the low pressure side. This causes undesired stress on equipment, especially to the plant's most critical and expensive piece of equipment—its compressor.

Figure 1. Damage to compressor stator (left) and rotor (right) from surge

Because surge is a fast, high-energy phenomenon, it can create excessive, dynamic loads on the internal components of the compressor, such as thrust bearings, seals, and blades, as well as pipeline issues caused by unwanted vibrations.

The cost of replacing the compressor seals alone could range from $20,000 to $50,000 USD. Over time, surge can increase the risk of fatigue failures that could cause damage to the entire compressor and associated piping, leading to unscheduled plant shutdown.

Also, when multiple compressors are connected in a series or in parallel, surge in one can trigger a chain reaction, causing major shutdown and possible plant accidents.

Managing Surge with Controllers

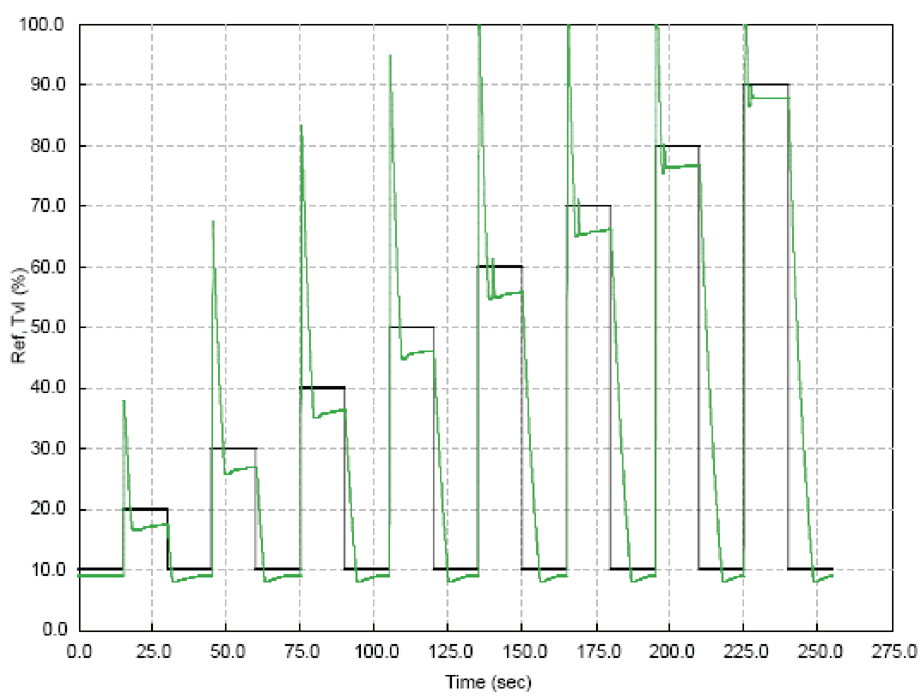
To help protect the compressor, a compressor controller is used alongside flow control devices to minimize the effects of surge. The goal of any compressor controller is to operate turbomachinery within a safe operating envelope. Aside from surge, compressor controllers must handle a number of physical limiting challenges, including choke, power, process, and rotational speed. The task of operating a compressor becomes particularly complex on multi-stage compressors or when multiple compressors are operated in parallel.

Valve Specification via Stroking Speed

While many compressors today are controlled by sophisticated and integrated control systems, the majority of anti-surge valves are still specified by stroking speed only. Valves do not perform to their potential when they are configured with only stroking speed in mind. When the valves don't work as needed, the performance of the entire anti-surge system suffers.

Systems that are designed only for stroking speed end up with a lack of robustness in the control servomechanism (servo) loop. The system will likely be unstable when operated outside of open-loop requirements. This can cause excessive overshoot and instability when the valve responds to a set point change. Figure 2 shows the performance of an NPS 18 (DN 450) anti-surge valve designed for fast stroking speed when subjected to a series of step tests. As the step size becomes larger, the valve "hunts" for position, a tell-tale sign of a poorly performing anti-surge valve.

Figure 2. Performance of anti-surge valve designed only for stroking speed



Stable valve performance is critical in compressor applications; an unstable servo loop requires the valve to be run in manual control, making startup and shutdown difficult. This also leads to reduced compressor throughput and efficiency, because the system must be de-tuned due to the valve's poor performance.

Valve Specification via Loop Performance

When selecting a valve, consider both open- and closed-loop performance. Aim to achieve adequate protection of the compressor and accurate throttling control to maximize compressor output and efficiency. Setting up the system for fast-acting, precise closed-loop control ensures that the compressor anti-surge system can perform at its peak potential and allow for higher system gains.

Adding digital valve controllers to anti-surge valves can help meet the challenging requirements of anti-surge applications, where speed and accuracy are important. Those instances include:

- Speed requirements of typically less than 2 seconds
- Overshoot criteria is in the 5% or less range
- Online tuning/diagnostics are required
- Valves must respond to small step changes without overshoot or undershoot

The addition of a digital valve controller and associated technological recommendations creates an optimized anti-surge valve package with both open- and closed-loop performance in mind. The open-loop response is tied directly to stroking speed, while the closed-loop response is related to the actual control function of the anti-surge controller. Better control yields improved system gains, which allows for faster action and tighter process control. The improved controllability allows the compressor to operate more efficiently, while increasing throughput.

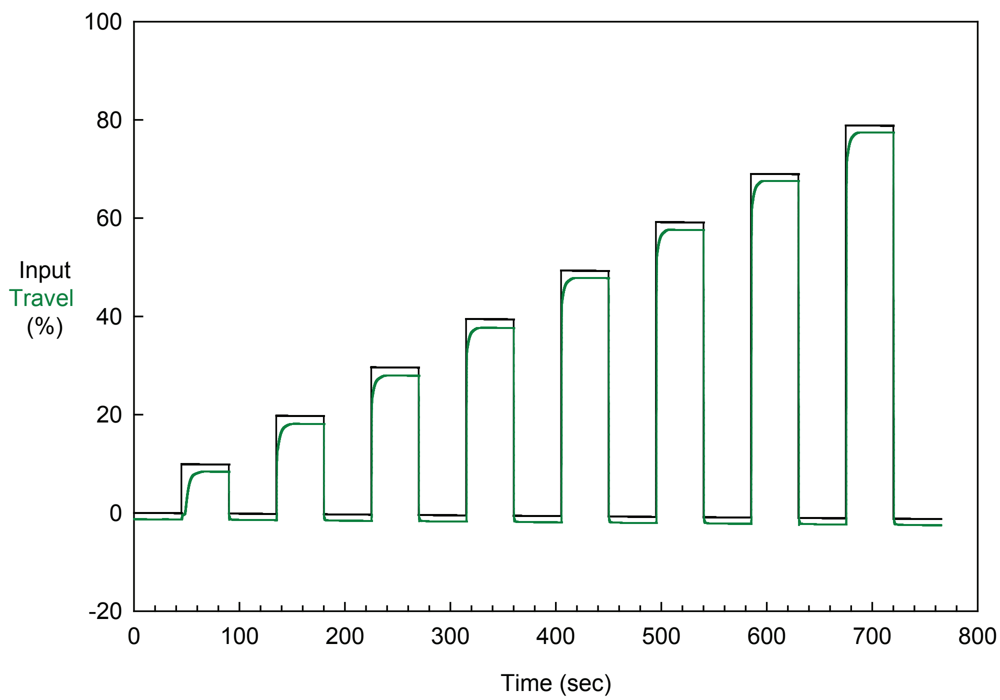
Figure 3. An anti-surge assembly features the valve, actuator, digital valve controller, and associated instruments.

Figure 4 shows the performance of an NPS 18 (DN 450) anti-surge valve designed with the enhancements of optimized anti-surge control.

Stable performance throughout the entire valve travel ensures that the valve will respond quickly and accurately to any changes initiated by the anti-surge controller. The symmetric performance in the opening and closing directions can improve tuning and controllability.

In addition, optimized digital valve controllers provide online tuning and live feedback so that adjustments can be performed quicker and from a remote location. All components can be tuned together and non-intrusive diagnostics can be gathered online including performance, triggered, and on-seat diagnostics. This allows the user to quickly identify any potential issues without shutting down the process and to actively pre-plan for any necessary improvements or upgrades during the next scheduled shutdown. The optimized digital valve controller also allows for partial stroke testing to ensure movement of the valve at the desired stroking speed during a demand, as these valves operate infrequently.

Figure 4. Performance of the optimized anti-surge valve



Conclusion

Anti-surge valves can be found in nearly any production or process facility, but are most suited for challenging performance needs of the olefin and LNG industries. Olefin and LNG facilities commonly integrate capacity and anti-surge control into the anti-surge controller since these two systems can fight one another if left independent. This integration requires excellent performance from the anti-surge valve in order to operate efficiently.

With the advent of digital technology, compressor controllers are now expected to provide more than just anti-surge control. They must be designed to handle physical limitations of the compressor, as well as maximize its throughput and efficiency. Specific control and tuning algorithms in the digital valve controller allow a user to tune the valve from the control room and adjust the gains and damping functions immediately.

When faced with anti-surge valve applications, use a digital valve controller with anti-surge-specific control algorithms built in. With the proper valve, actuator and accessories, you can increase compressor throughput, reliability, and efficiency as well as plant uptime. For newer units, this means that a smaller compressor could be used with an optimized anti-surge valve compared to one that uses a valve selected by traditional means.

Sources

Wilson, J, and A Sheldon. "Matching Antisurge Valve Performance with Integrated Turbomachinery Control Systems." *Hydrocarbon Processing*, Aug. 2006, pp. 55–58.

Additional Resources

Brochure: Compressor Control: Maximizing Safety and Efficiency

Blog Post: Effective Compressor Anti-Surge Control

Video: Optimized Anti-Surge Control Simulator

Webpage: Improve Uptime with Better Insight into Compressor Health

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