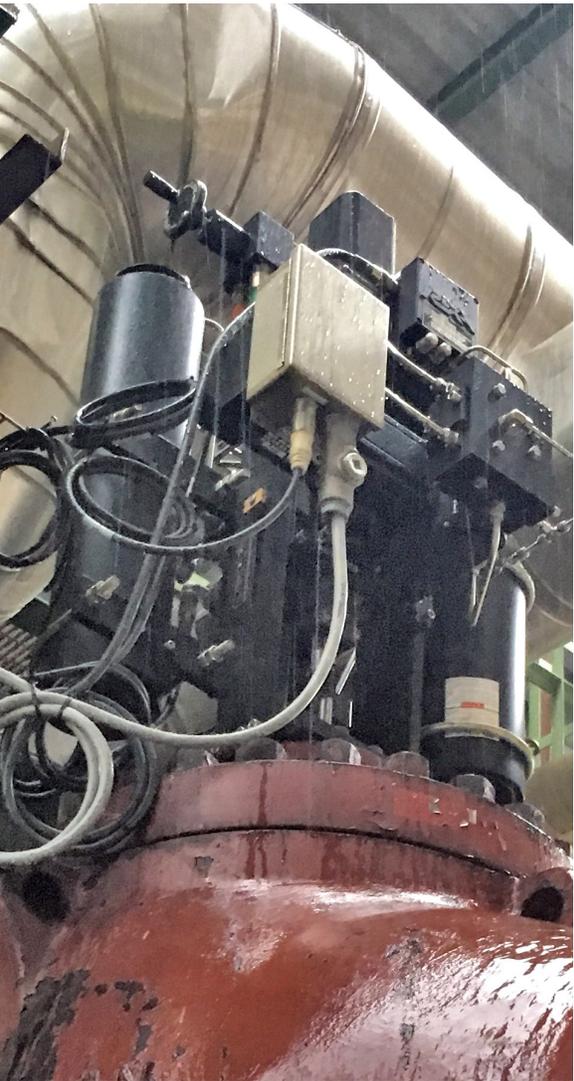


ROTATING EQUIPMENT



COMPRESSOR ANTISURGE



BACKGROUND: Axial and centrifugal compressors are expensive, critical pieces of equipment that can be found at the heart of many industrial processes and across a multitude of industry segments. Implementing the correct, high performance compressor control strategy has direct impact upon the control of the process and the profitability of the plant. It is important to have control that is both responsive and stable to improve yield and ensure compressor availability is maximized. One of the main applications to ensure maximizing availability and throughput is Antisurge Control.

Compressor surge events occur as a result of process dynamics and are common during start-up and shutdown sequences, as well as when the compressor is operated at a reduced rate of throughput. The surge phenomenon is created when a flow reversal through the compressor occurs due to the compressor's inability to overcome the energy (pressure) stored in the discharge volume. An Antisurge Valve (ASV) is utilized to protect the compressor by safely recycling gas from the discharge side to the suction side in order to keep the compressor operating point safely away from the surge limit.

KEY TO SUCCESS: The antisurge valve requires an actuator capable of immediate response to signal change (minimal deadtime), rapid stroking speed, and precise modulating control. In a surge scenario, the ASV is designed to rapidly open in order to protect the compressor, typically under 2 seconds, and occasionally as fast as 500msec. This action moves the operating point away from the surge limit line and allows the compressor to resume normal operation. Precision control, with minimal deadtime for steps of all sizes, is critical to keep the compressor out of surge in the first place, but equally as important in stabilizing this extremely fast process. Valve hysteresis and overshoot can create and accelerate process upset conditions.

ELECTRAULIC™ ACTUATION

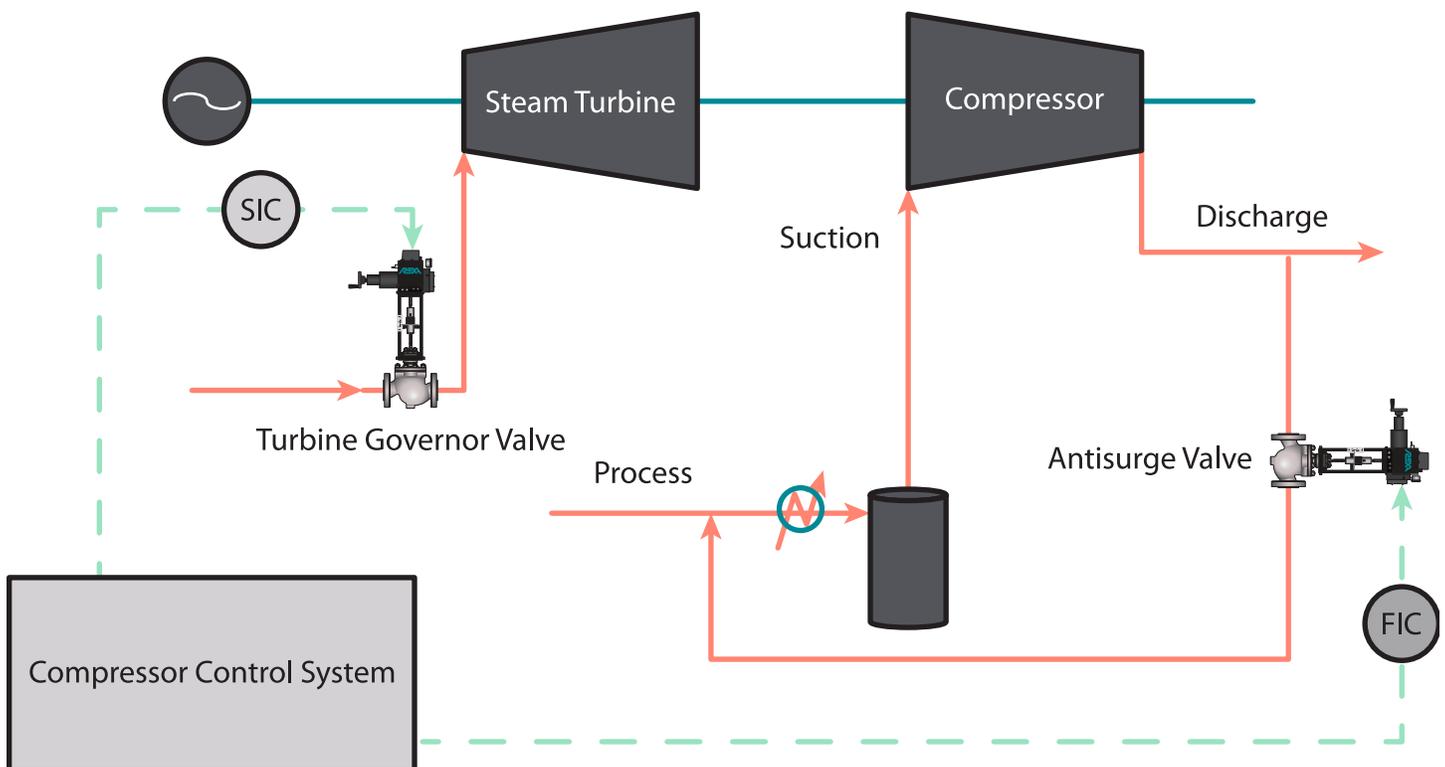
PROBLEM: All suppliers of Antisurge Control Valves also offer actuation packages as part of the valve assembly. Most of these companies are driven to offer their brand of pneumatic positioner (smart or traditional) to support their own company growth strategy. These companies have gone through great effort to engineer the specifications for the application to meet the best “optimized” performance that can be achieved from pneumatic actuation. What is constant across all pneumatic actuation, in fact all closed loop systems that use compressible gas as a medium, is the effect of Boyle’s law. Boyle’s Law explains the inverse relationship of pressure and volume with respect to a fixed amount of gas, like a pneumatic actuator. This relationship states that $P_1V_1 = P_2V_2$. This principle explains the effect of jump and overshoot (hysteresis) inherent to all pneumatic actuation.

Every time a pneumatically-operated valve is required to move it needs to overcome the force of static friction (P1)(area) to initiate movement. Once it overcomes static friction the dynamic friction force is greatly reduced (P2)(area). Plugging into a Boyle’s Law formula, the drastic reduction in pressure requires a drastic increase in volume to equalize the equation. That increase in volume is directly translated to overshoot in a pneumatic system. The goal of a smart positioner, regardless

of the manufacturer, is to limit the amount of jump/overshoot as pneumatic response can be predicted. The trade off with “controlling” this effect is in greatly slowing the response, which is artificially adding deadtime into the loop. On small step changes (less than 0.5%) the impact can be many seconds, in some cases greater than 10 seconds. In this application, where the impact on compressor efficiency and throughput can be so easily affected by process disturbances, pneumatic actuation on compressor control is costing end users millions of dollars in lost revenue.

SOLUTION: In modern compressor control theory, a Surge Control Line (SCL) is developed to protect the compressor, so a required safety margin is necessary to prevent approaching the Surge Limit Line (SLL). See the graph below. The Surge Limit is the minimal flow point before the compressor becomes highly unstable. Crossing above the SLL causes the compressor to enter a surge condition. The SCL is typically established at around a 10% flow margin of safety to the right of the SLL, but is really dependent upon both the process dynamics of the system surrounding the compressor, and system’s response at different loads (ASV speed of response). The performance of critical valves, like the ASV, is a significant determining factor on loop performance. Some

Compressor Train Example

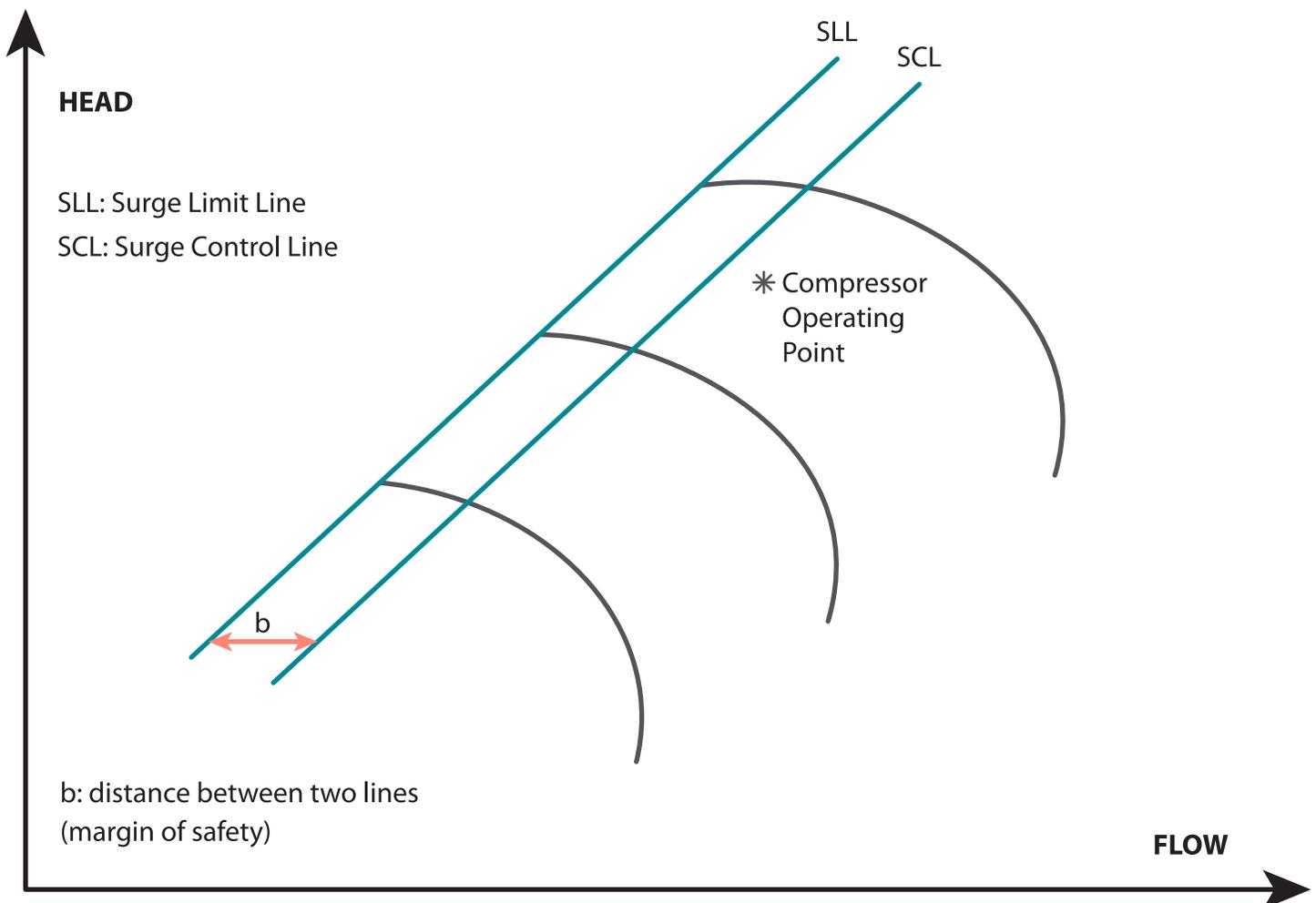


processes require a larger margin of safety between the SCL and SLL to prevent the compressor from going into frequent surge cycles. As the required margin of safety increases, the envelope of the compressor map decreases in size resulting in lower operational efficiency of the compressor. A less efficient compressor is not desirable, but is better than a compressor that is frequently in surge.

There are two critical requirements of an ASV that the Antisurge Control application needs to meet to ensure the compressor control is optimized. The first requirement is to open the ASV in a stable and precise manner. The compressor controller uses suction pressure, discharge pressure, flow, and temperature inputs while utilizing PID control (close loop response) to cope with typical process changes. The ASV receives the command from the controller and begins to open before the unit reaches a surge condition. Minimal deadtime, precise control, and minimal overshoot from the ASV are critical to loop performance, particularly on small operating point changes. The second requirement of the ASV is to be able to open rapidly when a rapid surge approach does occur due to a major process upset.

To meet the critical requirements of Compressor Control, REXA Actuators, based on the company's proprietary Electraulic® Technology, are the perfect choice. The self-contained REXA Actuators combine the simplicity of electric operation, the power of hydraulics, the reliability of solid state electronics, and the flexibility of user-configured control.

Electraulic™ Technology is comprised of two primary subassemblies: a mechanical subassembly and an electrical subassembly. The principle behind its technology is a unique hydraulic circuitry called the flow match valve system (FMV). The actuator incorporates a bi-directional gear pump coupled to either a stepper or a servo motor that provides a highly-efficient method of pumping hydraulic fluid from one side of a double-acting cylinder to the other. The discrete operation of the motor and pump creates action only when a position change is required. Once the required position is reached, the motor shuts off and the FMV system hydraulically locks the actuator in place. Minimal power is required to maintain actuator position. The motor and pump sit idle until a new command signal is received.



REXA Actuators can easily exceed the requirements for 500msec full stroke trip, moving the operating point away from the surge line and back into control. REXA Actuators are also capable of much tighter control than pneumatic actuation. REXA Actuation can precisely position down to 0.05% of stroke, and are not impacted by process load because hydraulics are non-compressible. REXA Actuators have minimal deadtime (approximately 50-70msec), regardless of the step change size.



RESULT

The result is improved performance of the entire compressor train. With REXA Actuation, the plant is now able to get better return out of their compressor control system. Tighter actuation technology allows for a large reduction, and in some cases, elimination of surge events. Elimination of surge events means less time in recycle, therefore increased throughput for the process or fewer process interruptions due to plant upsets or compressor trips. Reduced dead time and more precise control allow for improvements in the compressors performance control. Valves are no longer subject to overshoot and hysteresis, allowing the compressor map to be expanded and higher compression ratios to be achieved. Higher compression ratios and compressor speeds directly lead to an increase in production. In an average sized refinery, ammonia plant, ethylene plant, or the like, even a modest increase in production can bring millions to the bottom line. Please contact REXA to discuss how we can help your plant performance.

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