RESILIENT CONTROLS

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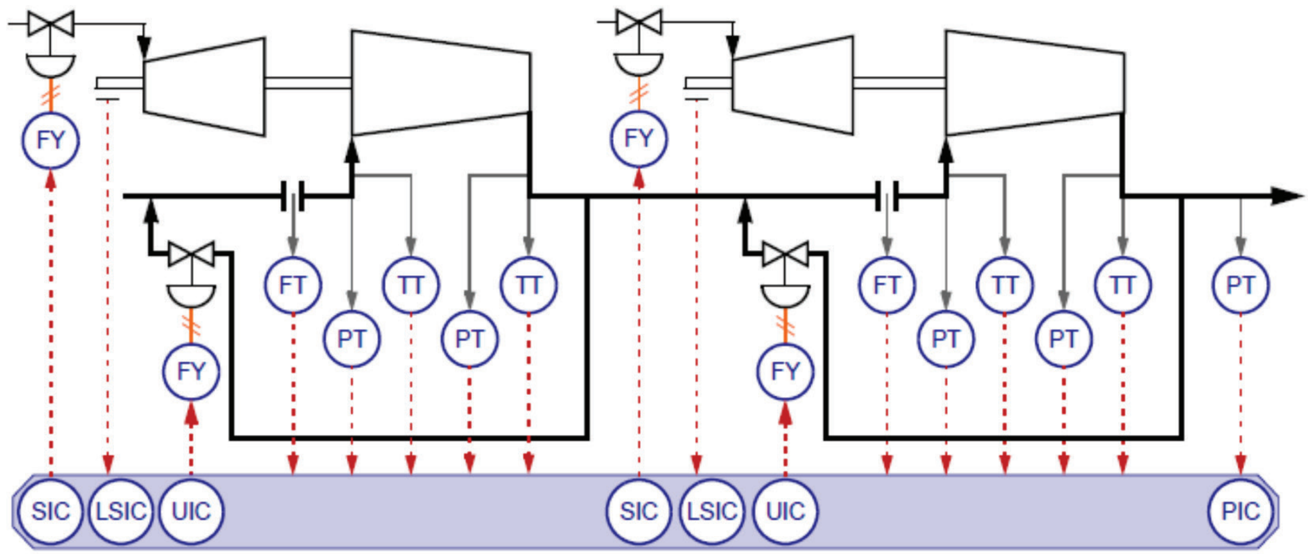

Figure 1. Performance Control Of Series Compressors — Discharge Pressure Control Example

OVERVIEW

A comprehensive control system is necessary to maintain and sustain running plants. Control philosophy applications include anti-surge control, performance control, load-sharing/load-balancing, expander control (process recovery train), quench control, variable-speed coupler control for fixed-speed motors, speed control for steam turbines, and gas turbine fuel control. These applications consist of many features that make them more resilient to process upsets. Figure 1 shows a discharge pressure control for series compressors.

AUTOMATIC SEQUENCING

The controller typically sequences startups and shutdowns for the compressor and its driver. For example, the anti-surge controller can select an appropriate operating state and hold its anti-surge valve in a position that minimizes the risk of surge. On the other hand, the steam turbine startup sequence ramps the steam control valve open until the turbine speed reaches the minimum control speed, then switches to proportional-integral-derivative (PID) control and ramps the local speed set point up to the selected target speed. For generator control applications, the turbine is started with the generator offline (generator breaker open). Before a turbine-driven generator can be brought online, it must be accelerated to its synchronous speed.

ANTI-SURGE DERIVATIVE ACTION

Anti-surge control derivative response varies with the rate the compressor's operating point is approaching the surge limit line (SLL). Therefore, the derivative response repositions the surge control line (SCL) to the right, in proportion to the rate of change of upset. By temporarily increasing the safety margin when the danger of surge is high, this feature allows a small safety margin for maximum efficiency during normal operation.

RECYCLE TRIP DERIVATIVE ACTION

Open-loop response is the fastest way to get the anti-surge valve open. At the same time, open-loop control lacks the accuracy needed to precisely position the anti-surge valve. Open-loop corrections of a fixed magnitude are often either too big or too small for any specific disturbance. The rate of change of the position of the compressor operating point is an excellent predictor of the strength of the disturbance. This derivative calculation adjusted the magnitude of the open-loop response.

PROACTIVE RECYCLE TRIP DERIVATIVE ACTION

The normal recycle trip (RT) response (having a derivative action or not) is typically triggered when the operation point crosses the recycle trip line (RTL). RT proactive response can be initiated based on the derivative of the proximity to surge.

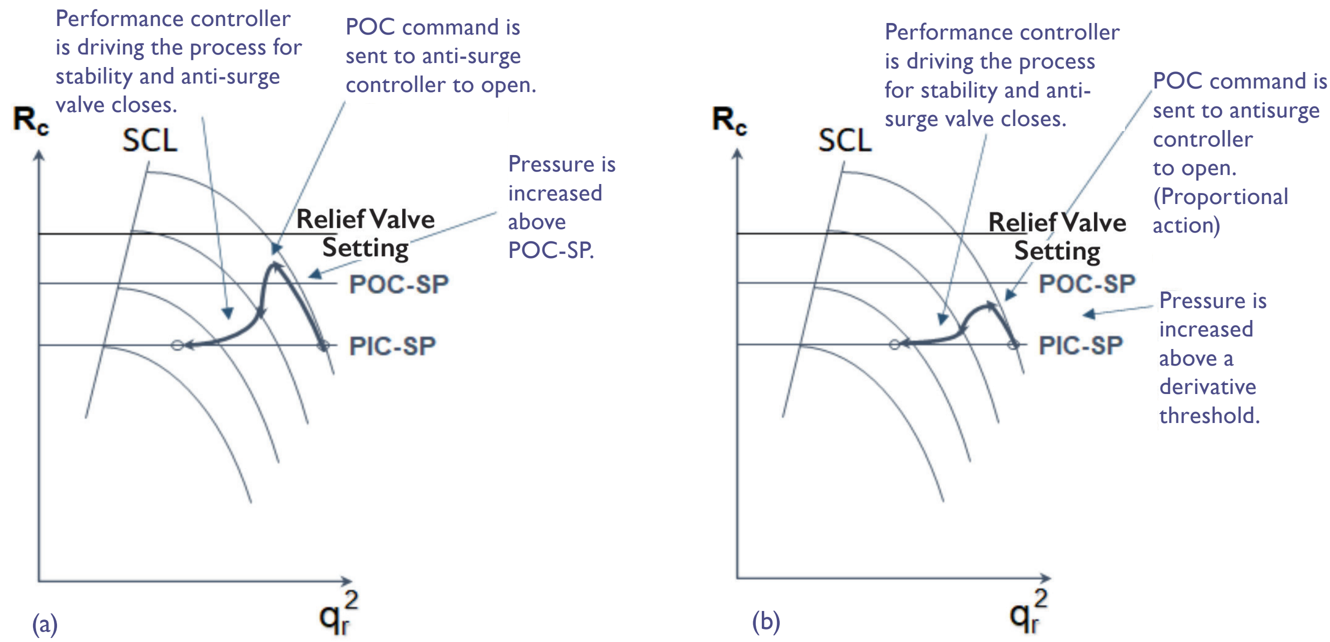

Figure 2. (a) Normal Or Relative Performance Override Control And (b) Filtered Performance Override Control (R_c is compression ratio, SP is set point, PIC is performance indicating controller, and q_r is reduced flow)

With this response, the anti-surge valve will step open by a configured amount when the rate of change for proximity-to-surge variable is greater than a configured value for a specified amount of time (very high disturbance). If the normal RT step response and the proactive RT response are triggered simultaneously, the controller will select the larger response and add it to the anti-surge valve output.

LOOP DECOUPLING

Loop decoupling is used to fine-tune the process and avoid oscillations. A decoupling control algorithm reduces and eliminates the interactions between the loops, which is also called feedforward control. For instance, anti-surge controllers need to communicate in real time to coordinate their control actions. Based on process disturbances encountered, the output of one anti-surge controller can be sent to the other controllers to proactively act on the disturbance. The result is smoother process control and quicker stabilization of the process without prolonged oscillation. Controller decoupling is enabled, tested, and tuned as required during system commissioning.

LIMIT LOOPS CONTROL

Each anti-surge or performance controller provides up to three limiting control loops to protect the compressor and maintain process conditions within safe or acceptable limits. Each limit loop can be tuned and configured independently. Suction and discharge pressures are commonly used limit loops. These limit loops prevent the trip, keeping pressure below the set point of pressure relief valves and, in some cases, can prevent process upsets. The set point (limit threshold) for each limiting control loop can be selected from a serial or analog source and can be clamped between maximum and minimum values. These limiting loops can also be configured to function while the controller is in manual mode.

PERFORMANCE OVERRIDE CONTROL

The performance override control (POC) function is set up in the performance controller. To illustrate POC functionality further, assuming a process requiring discharge pressure (Pd) control, it is unsafe to drop speed quickly to control the quickly rising discharge pressure. The process might need a faster response to prevent the compressor trip on high Pd. In this case, activation of "normal" POC opens the anti-surge valve even when the compressor is operating to the right side of the SCL, until Pd goes below the POC set point. At this point, the speed/performance can control the process variable, and the anti-surge valve closes. Activating this feature in the master performance controller, using header pressure as the POC variable, where several compressors are operating in network, is very effective. It is more effective than using only one anti-surge valve to quickly open and bring back the header process variable to normal values. A fixed or relative POC set point can be configured.

The performance controller can also be configured to look for rapid changes in the selected POC process variable that quickly opens the anti-surge valve (filtered POC). The performance controller can calculate a filtered POC proportional response for a single variable, while the anti-surge controller can calculate filtered POC proportional responses for up to two variables. A higher selector is used to select the highest proportional response to send to the anti-surge controller output. This achieves faster response during upsets and faster settling time, and proactively operates anti-surge valves, minimizing the chance of surge and upset. Figure 2 illustrates both normal POC and filtered POC concepts.

CASCADE TRIP AVOIDANCE — UNLOAD FEATURE

The unload sequence within the anti-surge controller defines a relative or absolute step opening maintained for a given amount of time. This function may be used for any purpose, but it is typically used in response to the premature shutdown of an adjacent compressor/process, causing significant flow and/or pressure changes of the current compressor. For example, in the event of a gas injection compressor trip, the unload discrete input functionality in the anti-surge controller can step open the anti-surge valve of the low-pressure (LP) compressors at a preconfigured amount and time to lower the interstage header pressure and avoid a trip. In many cases, activation of this feature has prevented tripping of the whole compressor station operating multiple compressors in series and parallel arrangements.

FALLBACK STRATEGIES

When analog input signals for calculating the compressor's proximity to surge are lost because of transmitter failures, the controller can continue to provide some level of control through several fallback strategies. Fallback settings can be determined during the engineering phase or commissioning activities. Final selection of applicable fallback control strategies should be set up in consultation with the end user.

VALVE EXERCISER

Valve exerciser is a test performed to verify associated valve responses to a given command. It does not rely on the (4-20mA) position feedback signals to monitor its valve response. Instead, its algorithm looks for process variables to detect valve movement. All configured signals must be stable before a test can be performed. For a signal to be considered stable, any changes in that signal must have remained within an associated threshold for a given amount of time. In an anti-surge controller, flow, proximity to surge, and valve position are monitored. A valve fails the test if all the process signals remain within their threshold levels during the entire evaluation time.

TRANSMITTER FREEZE DETECTION

Freeze detection is used primarily to check if the respected signal freezes. Each time the signal meets or exceeds a specified threshold, a countdown timer is restarted. The size of the threshold increases in direct proportion to the magnitude of the respected signal, increasing linearly as the input increases.

DRIFT DETECTOR

The drift detector compares the process stability with the transmitter's stability. For process stability within the anti-surge controller, the drift detector function can monitor up to three process variables. On the other hand, if a channel exceeds the threshold, an error is generated and the transmitter is flagged as failed. The drift detector function applies only when there are two redundant transmitter signals for an analog input, whether because only two transmitters exist or because only two out of three redundant transmitter signals remain.

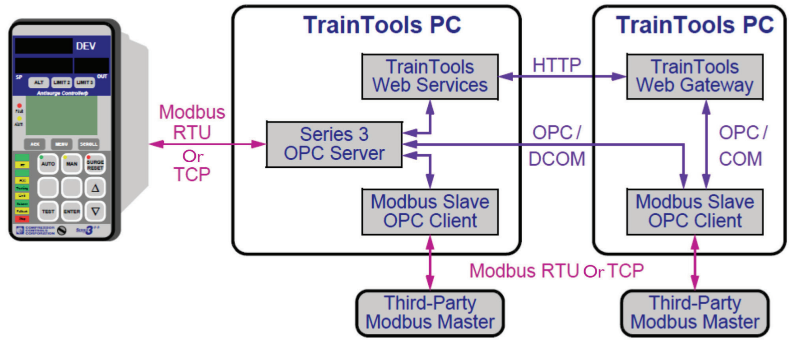

Figure 3. Modbus Communication Via Open Platform Communications And Web Services

FLEXIBLE COMMUNICATION WITH EXTERNAL SYSTEMS

Controllers can be configured to communicate with many other systems like distributed control systems (DCS) and emergency shutdown (ESD) systems. For DCS communication, Modbus protocol is mainly used. Both Modbus remote terminal unit (RTU) and Modbus transmission control protocol (TCP) are supported in new controller platforms. On the other hand, the open platform communications (OPC) server allows OPC data access (DA) clients to access human machine interface (HMI) variables, and OPC alarm and event (AE) clients to access alarm and event messages from controllers.

Modbus OPC gateways are also supported. The main purpose of protocol gateway programs is to allow control devices and HMI programs that do not support the same protocols to communicate with each other. Two types currently exist: the Modbus Master OPC Server, which allows OPC DA client programs to access data from controllers that only support Modbus, and the Modbus OPC Slave client, which allows Modbus masters to access data from the servers for devices that do not support Modbus, or to access variables that are not in a controller's Modbus data set but are available via its OPC server. These two programs can communicate with remote clients and servers using TrainTools web services. Figure 3 shows Modbus communication via OPC and web services.

SUMMARY

In many control systems, customized solutions can be developed. Many of these customized solutions can be accomplished by simple online configuration changes because most of the described control features are prebuilt and just need to be enabled or disabled. The ease of communication with other systems makes it even more flexible. Using such features, we can achieve more resilient and optimized controls.

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