White Paper

Improving Process Quality with Cascade Control

Cascade Control is a temperature control method which has two elements, the primary (end product) and the secondary (used to control the primary). In these applications the secondary variable is measured and controlled in addition to the primary element to achieve better control.

This whitepaper looks at why we need cascade control, provides some examples of temperature control applications which use cascade control and discusses how the process can be stabilized and product quality improved.

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What is Cascade Control?

Cascade Control is a temperature control method which has two elements, the primary (end product) and the secondary (used to control the primary). In these applications the secondary variable is measured and controlled in addition to the primary element to achieve better control. For example monitoring and controlling the flow of steam into a system to achieve stable temperature control of the primary object that is being heated.

Why Do We Need Cascade Control?

Applications with a delicate matter are inherently difficult for a single instrument to control without affecting product quality.

Disturbances can lead to large overshoots and slow system recovery times can be problematic due to thermal lag. The solution is to cascade two or more controllers (each with its own input) in series to form a single regulating device.

Temperature Control Application Example – Dairy Pasteurization

In dairy pasteurization the water used to indirectly heat milk reaches temperature quickly but the milk itself heats more slowly and, crucially, must not be allowed to overheat. In conventional single loop control with a sensor only monitoring and directly controlling milk temperature the water temperature would continue to rise until the milk reached its setpoint – a satisfactory outcome until you consider what happens next. While single loop control achieves setpoint efficiently and at speed, problems due to thermal lag will result. The temperature of the water will be higher than the milk so it will continue to heat, resulting in temperature overshoot and seriously compromizing the product quality of the milk.

The answer is to use dual loop, cascade control–. One loop measures the temperature of milk and another the water. A cascade control system uses measurement recorded by the rising temperature of the milk to slowly decrease the heat of the water, allowing the milk to continue heating at a pace that will not result in overshoot.

Process Stability

Once cascade control is implemented, disturbances from rapid changes of the secondary controller will not affect the primary controller, offering an excellent solution for applications with a delicate end product.

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Application Example – Heat Exchangers for Industrial Building Heaters

Another example of how cascade control can overcome temperature overshoot is in heat exchangers for industrial building heaters. Typically in this application, one would see a product setpoint temperature programmed on a master controller that is then compared to the product temperature.

A maximum input value restricts the jacket temperature. At start-up the master loop compares the product temperature to its setpoint and gives maximum output. This sets the maximum setpoint on the slave, which is compared to the jacket temperature that is giving maximum heater output. As the jacket temperature rises, the slave's heater output falls. The product temperature also rises at a rate dependant on the transfer lag between the jacket and product. This causes the master's output to decrease, reducing the 'jacket' setpoint on the slave, effectively reducing the output to the heater. This continues until the system becomes balanced.

Cascade control can be implemented in a single multi-loop controller where master power is given to the slave directly, or two discrete instruments can be wired together, in which case the master power is wired to the auxiliary input of the slave controller as a remote setpoint input, scaled to suit any expected temperature. The slave loop's natural response time should ideally be at least five times faster than the master.

How To Set-up and Tune Cascade Control in Controllers

The first consideration is that there must be a clear relationship between the measured variables of the primary and secondary loops. The secondary loop must have influence over the primary loop. Any major disturbance to the system should act in the primary loop.

When configuring an application for cascade control it is essential that the secondary loop is tuned first. If the primary loop is tuned first then the setpoint for the secondary loop will be constantly changing and the autotune function will be constantly recalculating and unable to tune. Instead, a fixed setpoint should be entered on the secondary loop so that other parameters can be tuned. Once complete, the primary loop can be tuned and the secondary loop setpoint can then become dependent upon the primary loop.

Summary

Where two or more capacities cannot be adequately controlled by a single instrument, the combination of two or more in cascade offers a simple but highly effective solution to process temperature control. Cascade control can seriously improve product quality as well as boosting energy efficiency in a wide range of applications.

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