Proper Commissioning of a Parallel-Positioning System

White Paper

One of the main benefits of a parallel-positioning system is that precise control of the fuel-air ratio can be ensured at any firing rate. These systems are sold on the benefits of the lower operating costs and the ability to meet strict emissions standards, but the actual results from installing such a system really depends upon the quality of commissioning.

Methods of process control

The firing rate of a burner falls under the category of process control. With any process, there is always a process value as well as a setpoint. The process value is another way to refer to the actual output of the process, while the setpoint is the desired value to reach.

One of the most basic methods of process control is known as proportional control. With proportional control, the output is at the maximum at a certain level below the setpoint, and it is reduced linearly toward no output as the process value gets closer to the setpoint. At setpoint, there is no output at all. The main issue with proportional control is that in theory, you can never reach the setpoint — you can only get infinitely closer.

To deal with this limitation, two additional components were added to the proportional component to create PID control. PID stands for proportional, integral and derivative. These three components are added together to create an output that can be tuned to control a setpoint and can dynamically react to any situation to maintain that setpoint. Most parallel-positioning systems are going to be controlled using PID control.

Ability to maintain setpoint

Burners that use on/off or staging control to maintain a setpoint will have an issue with frequent overshooting of the setpoint. This is a necessity because tight control of the setpoint is not possible due to the fixed burner outputs, and to shut off at the setpoint would lead to high cycling (and wear) on the equipment. The key to acceptable performance with these systems is to balance an acceptable amount of cycling with an acceptable amount of setpoint overshoot.

Burners that have proportional control or PID control have an advantage in that they can modulate their output to react to the setpoint. This will allow cycling to be greatly reduced or eliminated, while also offering much better control of the setpoint at the same time. Even with a linkage burner, this type of control has the potential to save a lot of money in operational costs over an on/off or staging burner.

Parallel-positioning control offers an additional benefit that modulating linkage burners do not. With a linkage burner, only the low– and high-fire positions can be accurately set with regards to gas input. Any point in between will follow the curve of the linkage, which will is definitely not going to be linear. Sometimes a linkage burner will allow some curve characterization, but this does not approach the level of linearity that the parallel positioning servos can provide. The gas input of any point entered during commissioning can be assured to be accurate, and any point in between will be linear to the two closest points. The more points entered during commissioning, the more accurate this curve will be.

Effectiveness of PID control

Successfully using PID control requires that the output requested is accurately deployed into the process. The PID control will receive feedback in the form of the process value and is expecting a certain amount of response. When the output is linear and accurately reflecting the command of the PID control, the process can be tuned to run smoothly in most cases. If the output is not linear, it is likely that the PID control will never run well, regardless of the tuning. This is because the output requested will manifest as unknown and unreliable amounts in the process. A PID control simply cannot be tuned to run with an output that is not linear – this is a basic expectation of a PID control. With ever increasing requirements Fireye is often requested to assist in upgrading flame scanners to meeting ever changing new standards and also provide increasing flame scanner features and functionality.

Commissioning a parallel-positioning system properly

In order to properly commission a parallel-positioning system to work well with a PID control, it is necessary to accurately measure the fuel flow at both low- and high-fire and to calculate the required fuel flows at all intermediate tuning points. This is a simple linear calculation. If the low-fire fuel flow is 5000 SCFH and the high-fire fuel flow is 20000 SCFH, mid-fire would be 12500 SCFH. While commissioning each point, the fuel servos are trimmed to match these fuel flow numbers, and the air-influenced servos (air damper and VSD) are trimmed to provide the desired combustion numbers.

For gas fuels, if a fuel flow meter is not available to measure all combustion curve points, isolating the burner as the only appliance and then clocking the incoming gas meter is another way that fuel flow can be measured. Clocking the meter at low- and high-fire will be necessary to verify the flow at those points, while also measuring the burner head pressures as a reference. Using Bernoulli's principle of flow and pressure, the approximate burner head pressure at each combustion curve point can be calculated. During commissioning, the fuel servos are then trimmed to the calculated burner head pressure measurements instead of to fuel flow at the intermediate points.

Note that this method will not be as accurate as using a fuel flow meter but it is better than not attempting to make any measurement of fuel flow with regards to creating a linear combustion curve.

For gas fuels, a spreadsheet (NXF4000-PPC4000 Commissioning Worksheet for Gas Fuels) is provided to assist with calculating the servo positions at each step of commissioning. Measured or calculated fuel flow is entered, as well as burner head pressure measurements. Targets positions for the servos at ten combustion points from low- to high-fire are provided. The fuel servo positions should then be trimmed to match the fuel flow or burner head pressure for that point, and the air-influenced servo positions should be trimmed to meet desired combustion numbers.

Effects of turndown on PID control of a burner

Each burner is going to have a maximum turndown. This is expressed as a ratio, and indicates how much lower that the low-fire is compared to the high-fire output. If a burner has a high turndown ratio, there will be less burner cycling since the output can be reduced further when the process value is too high, instead of shutting the burner off.
PID control is expecting that the output of a process can be reduced to zero at any point in time. The controls do not take into account that a burner output cannot be reduced below the low-fire point without the burner shutting off. Shutting a burner off is generally to be avoided since it can be a significant amount of time for a burner to transition from standby mode into normal operation due to the purge times as well as flame establishing periods.
Upon periods of low demand, this is where a burner will cycle. If the burner is running at the lowest output and the process value is still rising, the burner will eventually overshoot enough to shut down. At this point the burner is going to operate exactly as an on/off or staged burner would, and the same balance of overshooting the setpoint and cycling must be found.

Conclusion

While PID control may not be the perfect solution due to turndown limitations, it works quite well in most burner applications when the burner is commissioned properly.
It is when commissioning is done with no reference to the gas input that problems can develop and the PID control itself is usually blamed for this. If the commissioning is not done well in the first place, there is no amount of PID control tuning that will ever make the burner run well. Even if it can be made to run reasonably well, it will be a less efficient process overall and will cost more to operate in the long run. The best way to address this is to use a fuel flow meter as a commissioning tool, or to permanently install on for each burner. For gas fuels, in-line fuel flow meters often only need a single tapping and a straight run of piping to install, and this tapping can be specified during installation. Upon commissioning, simply isolate the gas line, remove the plug and install the meter. Remove and re-plug the tapping upon completion. Using a fuel flow meter can also save a lot of time during commissioning by making the process more structured and repeatable.

The ability to control the process will only be as good as the efforts made during commissioning. Remember that for most endeavors, what you get out of something depends upon what you put in.

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