Emerson

By Bryant Benter*, and Asaël Hervet-Binois**

*Bryant Benter is the product marketing manager of Combustion, Americas, at Emerson. In his role, he serves customers in a variety of applications, including burners, boilers, furnaces and ovens. Bryant has been with Emerson for five years. https://www.emerson.com/en-us/automation/fluid-control-pneumatics/combustion-products

** Asaël Hervet-Binois is product marketing manager of Combustion, EMEA, at Emerson. He serves different customers and applications in the field of heat treatment, including petrochemical furnaces; process boilers; thermal oxidizers; industrial and commercial burners; and metal, ceramic and glass furnaces. https://www.emerson.com/en-gb/automation/solenoids-pneumatics/asco/combustion-solutions

Improving industrial sustainability

... With Advanced Furnace Fuel Train Technology

Combustion furnaces are widely used across major industrial and commercial applications to perform functions ranging from heating spaces such as commercial buildings and warehouses to powering boilers, ovens, thermal oxidizers and power generation equipment used in industrial applications.

These furnaces, which use a range of fuels, including natural gas, coke oven gas, fuel oil, biogas and biodiesel, are ubiquitous in the modern world. Through their combustion processes, they generate greenhouse gas emissions including carbon monoxide (CO), carbon dioxide (CO_2) and nitrous oxide (NOx). Therefore, a key goal for clean air and climate change programs, including regulatory efforts, is to find new and more reliable ways to control, minimise and ultimately reduce these emissions.

One way to reach this goal is to make combustion as efficient as possible while supporting the development and use of environmentally friendly fuel sources such as biodiesel, biogas and hydrogen.

There is a range of furnace fuel train technologies that can be implemented to provide more flexible, fuel-efficient combustion processes, such as pulse firing. In addition, integrating the latest digital sensors and edge computing systems can provide a platform to customise combustion control and move toward a fully metered air/fuel ratio control strategy that can reduce greenhouse gas emissions while optimising heating performance.

Bryant Benter

Asaël Hervet-Binois

Figure 4. Left: To improve sustainability in combustion processes, PACs like Emerson's PACSystems RX3i CPL410 Controller, configured as powerful and flexible edge controllers, can support more sophisticated pulse firing processes, as well as collect, analyze and transmit data to higher-level management and analytical systems. (Image courtesy of Emerson)

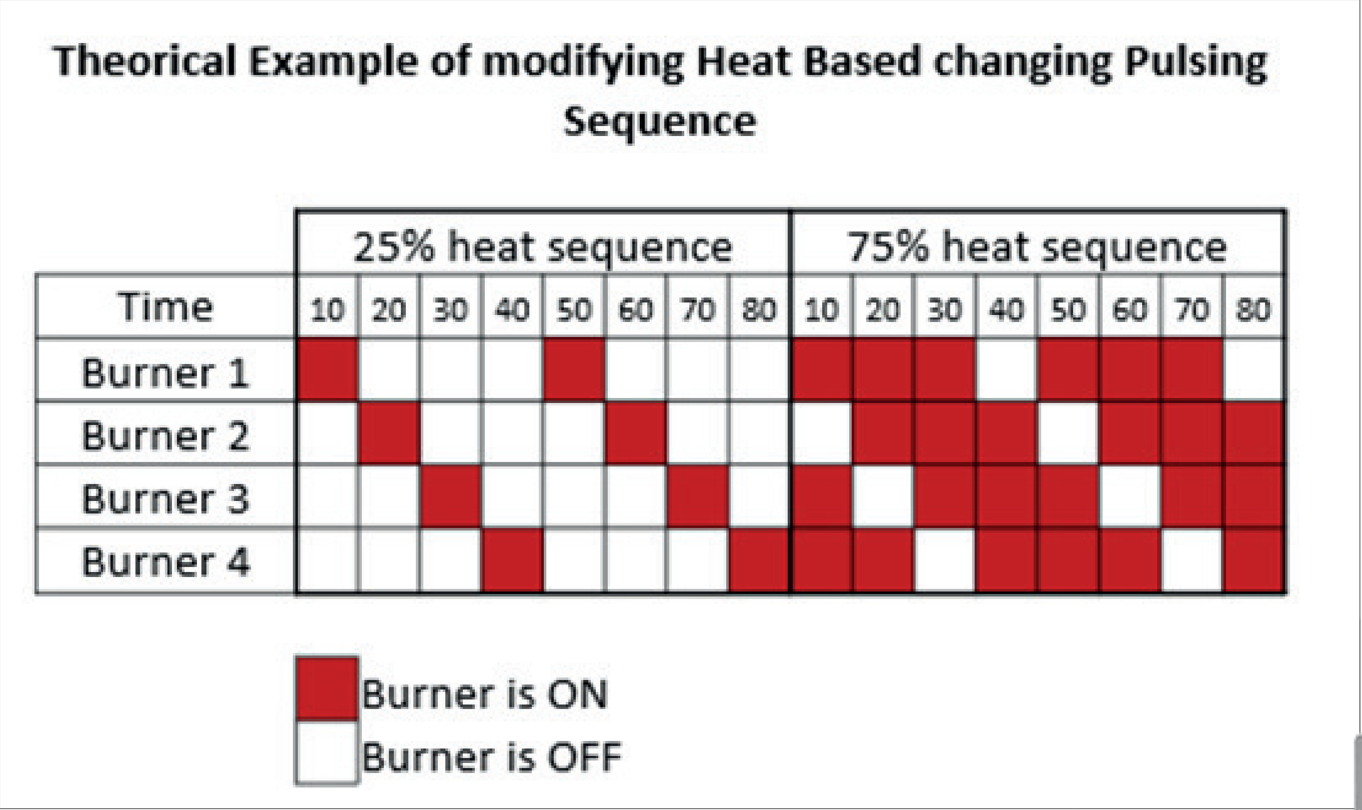

Figure 1. Example of pulse firing process illustrates how burner cycle times are managed depending on heat demand. (Image courtesy of Emerson)

Combustion efficiency and matching load to demand

The amount of greenhouse gases produced in combustion processes is directly related to the efficiency of that combustion. The goal in combustion efficiency is to control, as tightly as possible, the air/fuel ratio, which can help minimise greenhouse gas emissions: Too much fuel and too little air results in excess carbon, while the reverse can result in excess ni

Another method for achieving more sustainable combustion is to better match the heat load in furnaces to the actual demand of the system. Frequent start-ups and shutdowns of burner systems lead to unnecessary fuel waste and excessive emissions. By installing valve systems with higher turndown ratios and flow factors, it is possible to significantly reduce on/off cycles and increase fuel efficiency.

Implementing these combustion efficiency approaches not only makes good environmental sense and helps control costs, but it can also help facilities comply with increasing regulatory requirements. There are local laws and regulations in multiple countries that define maximum nitrous oxide levels in parts per million, depending on equipment type and size. Taking steps to optimise the air/fuel ratio can provide one strategy to help facilities comply.

Figure 2. Designed for high cycling applications such as pulse firing, Emerson's ASCOTM Series 290D pneumatic angle seat valves feature best-in-class lifetime and fast response time that minimizes energy use and emissions. (Image courtesy of Emerson)

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Figure 3. Emerson's ASCOTM Series 158/159 are engineered to support higher flow rates and performance longevity. These safety shut-off valves can replace pneumatic operation with electrical actuation, which can improve energy efficiency. (Image courtesy of Emerson)

Pulse firing offers significant potential for combustion efficiency

Pulse firing can provide a smarter and more sophisticated way to improve heat distribution in heating equipment. This approach is particularly suited to industrial multi-burner furnaces and oven applications.

To be effective, multiple burners are placed strategically on the equipment based on the anticipated heat demands. Rather than have all burners operate at the same time and same flow rate to reach the desired heat levels, burners "pulse" intermittently in a highly controlled fashion, either by firing on and off or ranging between low and high fire sequences.

Temperature modulation can be done by modifying the pulse firing sequence and fine-tuning pulsing parameters such as coordinating multiple burners and each burner's duty cycle (how long ON versus how long OFF).

There are multiple approaches that can be taken, mainly governed by the heat demand of a given furnace or oven system. **Figure 1** shows a fixed cycle time with a duty cycle for each burner that increases the ON time and decreases the OFF time as the system moves from 25% demand to 75% demand.

This is a much more fuel-efficient method of meeting heat demand, aligning both fuel consumption and emissions levels with actual need. However, to accomplish pulse firing, or burning, it's important to properly select key components, such as safety shut-off valves, sensors and controllers, to achieve the precise control that will yield more sustainable combustion.

For high-intensity applications such as pulse firing, the latest pneumatic piston safety shut-off valves feature very fast response times – less than one second opening and closing – that can help reduce energy consumption and decrease emissions. These valves have been tested to several million cycles and have a proven longer lifetime. Given that some valves in pulse-firing applications may cycle 500,000 per year, this level of reliability makes a big difference. (**Figure 2**)

As in a pulse firing configuration, there is much more frequent modulation of these sequences, as well as a need to support higher flow rates. The latest pneumatic piston valves provide high flow and can handle a range of fuels and other media at pressures up to 25 bar (360 pounds per square inch), including coke oven gas, oxygen, hydrogen, ammonia, oil, nitrogen, steam and hot water. Compared to conventional pneumatic ball valves, these valves consume less air, have a lower actuator volume and a smaller footprint.

In addition to these pneumatic piston valves, there are motorised safety shut-off valves available that can either stop the flow of fuel or provide high/low/off control to provide a range of flow rates. This new generation of safety shut-off valves has been engineered to provide optimised curvature, volumes and capacities that support higher flow rates. Higher flow rates allow for a higher turndown ratio, so burners in a pulse firing configuration can operate with greater flexibility, generate greater heat output — reducing the number of burner shutdowns and restarts — and, ultimately, help reach targeted goals of fuel consumption and emissions reduction.

Valves that support a more variable high/low/off functionality can be useful if the furnace fuel train has no modulation. It allows an operator to set an intermediate position between 15% and 100% of the normal valve stroke; with this feature, the ability to implement more fuel-efficient pulse firing sequences is possible. (**Figure 3**)

One other energy-savings aspect of this latest generation of valves is their use of electronic actuation in place of pneumatic actuation. Pneumatic circuits, while generally reliable, can contribute to significant energy losses due to air leakages in pneumatic lines.

In addition, compressed air must be supplied to these systems, typically through a centralised compressor that may need to run constantly. With electric valve actuation, this additional energy is no longer required. To fully optimise the sustainability of a furnace, this may provide an incremental way to reduce power consumption across the system.

Figure 5. Real-time, actionable data is key to more sustainable combustion processes. Emerson's advanced sensors enhance measurement of key parameters for combustion efficiency and emissions.
(Image courtesy of Emerson)

Digital sensors and controllers can improve air/fuel ratios

As with many other industrial systems, many furnaces and ovens are seeking to integrate Internet of Things (IoT) technology to improve their ability to capture and track key fuel and air train data points and support more sophisticated burner processes, such as fully metered air/fuel ratio control.

Improving sustainability by improving air/fuel ratio control can be more effectively accomplished through use of the latest generation of sensors and programmable automation controllers (PACs). Real-time, actionable data is key: The more a furnace operator knows about air and fuel flow variations, the more effective they can be in implementing the most fuel-efficient, emissions-reducing combustion process. (**Figure 4**)

There is now a range of robust, highly accurate sensors that can be integrated into significant points in the fuel train to capture key parameters for combustion efficiency and emissions, such as fuel pressure and flow rates and oxygen and oxides in the flue gas. This can include data about flow and pressure rates into the burner/combustion systems as well as the measurement of emissions. (**Figure 5**)

With this data, fuel train PACs can be configured to customise combustion control and implement a fully metered air/fuel ratio control strategy. This kind of control enables a furnace designer to more easily configure and continuously improve a combustion process. These PACs can also be configured to support edge computing capabilities, supplying data to higher-level, cloud-based systems for more complex process analysis.

Solutions to enhance combustion sustainability

There is no single quick fix for the challenges of climate change and energy efficiency. What is possible is following more intelligent approaches to the design and function of combustion systems that generate heat.

Technology is now available that equips furnace builders and operators with safety shut-off valves, sensors, PACs and other systems that increase the control of air/fuel ratios much more precisely. This control can enable more efficient fuel use and reduction in greenhouse gas emissions without impacting the ability to satisfy the heating requirements of these ovens and furnaces. ■