COMBUSTION SOLUTIONS FOR MEETING GLOBAL EMISSIONS REGULATIONS

Honeywell

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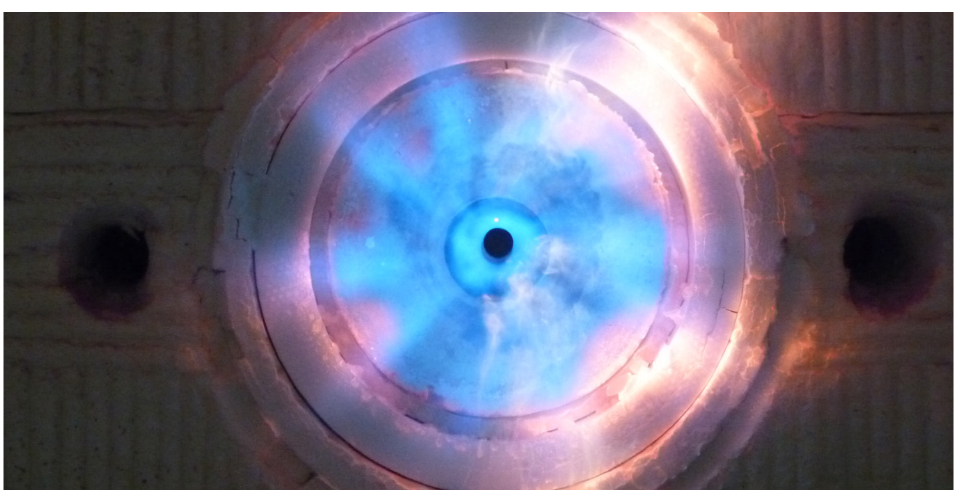
OEM furnace builders and end users who want to upgrade their heat treatment processes today face multiple operating challenges. Not only are they under pressure to optimize performance and minimize waste, but they must meet increasingly stringent NOx emissions regulations and standards in every market in which they do business. Furthermore, it can be difficult to focus on these necessities while delivering the process and product quality required for commercial success.

This white paper explores the complexities OEMs and end users face in meeting ever-changing global emissions requirements and offers practical guidance on selecting the right burner and control combination for specific industrial heating applications.

THE NOx CHALLENGE POSED BY MODERN COMBUSTION PROCESSES

It's important at the outset to understand some of the chemistry behind combustion. Because of the complexity and variables involved in the processes, it isn't possible to achieve the perfect combustion of air and natural gas, which is defined as $CH_4 + 2\,(O_2 + 3.76\ N2) \rightarrow CO_2 + 2\ H_2O + 7.52\ N_2$.



At high temperatures, nitrogen in the combustion air reacts with oxygen to form NOx — a collective term for nitric oxide (NO) and nitrogen dioxide (NO_2) — and with carbon in fuel to form carbon monoxide (CO). These combustion byproducts — carbon dioxide (CO_2), NOx and CO — are under scrutiny in combustion processes around the world.

MEETING GLOBAL EMISSIONS STANDARDS

OEM furnace manufacturers typically sell their products in multiple markets around the world. This means they must have detailed knowledge of local emissions standards. It's important to note that some standards apply nationally while others are set at a regional, state or even city level. Dealing with the sheer volume, variation and constant change in these requirements is a full-time job in itself.

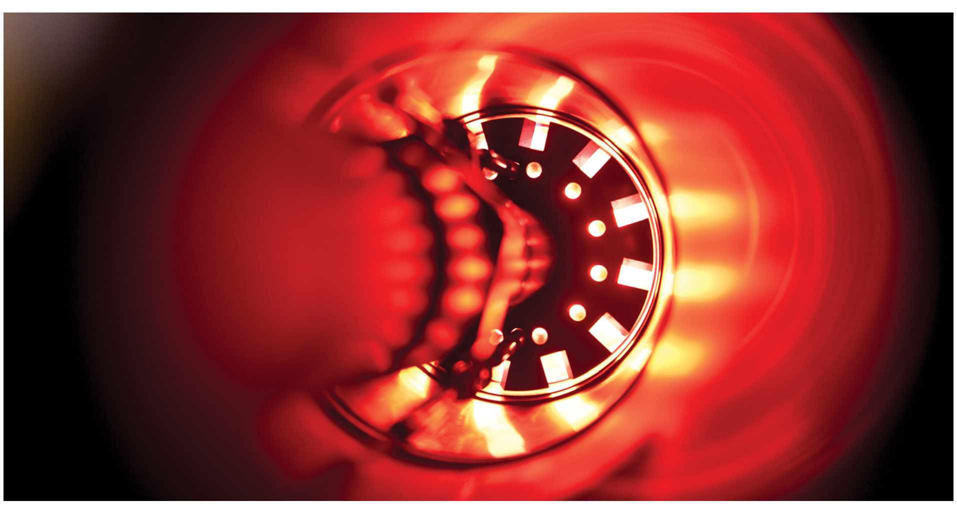
Typically, emissions standards are stated such that when process exhaust gas is measured, levels of NOx and CO may not be above a certain threshold, measured in parts per million (ppm). In low emissions, low temperature applications such as California's South Coast Air Quality Management District, NOx is required to be below 30 ppm, and CO is required to be below 200 ppm, corrected to three percent O_2. High temperature applications have more lenient requirements of 60 ppm NOx or less, corrected to three percent O_2. One concept that has been adopted in California's San Joaquin Valley is the use of Best Available Control Technologies, which emphasize technologies such as mass-flow control.

Across the world, emissions standards are tightening. In Canada, for example, Base-Level Industrial Emission Requirements (BLIERs) have been established as a minimum standard of environmental performance across major sectors and equipment types. As a result of BLIERs, NOx emissions limits in some areas have – within a short period of time – decreased by 50 percent — from 30 ppm to 15 ppm.

A recent set of European Directives also requires lower emissions over time, with the latest targets being below 100ppm NOx corrected to 3% O_2, in all applications. Meanwhile, in Germany, emissions requirements are part of the TA-Luft standard, which is used by authorities to define allowable emissions permits for manufacturing facilities.

China is moving toward lower emissions vehicles and industrial processes are starting to follow suit. In recent years, cities such as Beijing have seen tighter emissions for boiler applications – from less than 50 ppm NOx to less than 30 ppm NOx. In addition, China has started requiring the same stringent NOx levels as the European Directives and are applying it across all industries – not just to boilers.

India and other high growth regions are on a similar path and will likely adopt stricter industrial process emissions requirements in the coming years.



NOx IN THE CONTEXT OF THERMAL EQUIPMENT

In order to choose equipment to lower NOx in your process, it's helpful to understand how NOx is formed.

NOx comes from three primary sources: thermal NOx, fuel NOx and prompt NOx. Thermal NOx is triggered by heat from the combustion reaction and is relevant when attempting to reduce NOx. Fuel NOx and prompt NOx are inherent in fuel and nitrogen reaction properties, respectively, and cannot be changed significantly.

To reduce NOx, one must focus on reducing thermal NOx, which can be achieved through a combination of burner design, selection strategies and air-fuel control schemes.

CONSIDERATIONS FOR SELECTING A BURNER TO MINIMIZE NOx

Selecting the right burner design to meet your emissions targets is imperative and requires a thorough understanding of the solutions on the market today.

First, it's important to know that compared to high temperature applications, reduced NOx numbers can be achieved in low temperature, air-heating applications because the overall temperature is lower, which reduces thermal NOx. In general, regulations for ultra-low NOx numbers apply to low temperature, air-heating burners. NOx requirements are higher for high temperature burners, but as with low temperature applications, they are constantly being driven down by regulations.

One common design for lower NOx and CO in single-burner applications is a swirl burner. Swirl is achieved in a variety of ways such as nozzle- or burner-body design. No matter the design, the goal is to mix air and gas well enough to ensure complete combustion. Additionally, mixing improves combustion uniformity – which reduces peak flame temperature and results in lower NOx.

It's important to note that complete combustion reduces CO production by burning into CO_2, while uniform combustion reduces NOx production by reducing peak temperatures.

For line-style burners, a common way to achieve thorough mixing of air and fuel is through a premix design, in combination with high excess air. To premix the air and fuel, unique mixing plates are used. Like the swirl burner, the cut-outs and holes in the mixing plates cause the air and fuel to mix comprehensively, ensuring uniform combustion.

For applications that require higher temperatures, one approach to reducing NOx is via flue-gas recirculation (FGR). Some self-recuperative burners have a uniquely designed internal combustor that draws exhaust gases back into the flame to cool it, lowering thermal NOx. It should be noted that FGR will improve NOx but reduce overall efficiency.

Another method of reducing NOx in high temperature applications is staged combustion. Burners designed for staged combustion typically use internal baffles or switching valves to split the combustion air or gas into primary and secondary streams. The telltale sign of a burner designed for staged combustion is an extra set of holes or slots for the secondary stream to travel through and into the combustion chamber. The idea of staged combustion is to introduce primary air or gas into the fuel stream – as is typical in burner designs – but at sub-stoichiometric conditions. The secondary stream, required to complete combustion, is introduced away from the flame, delaying combustion and lowering peak flame temperature. This reduces the creation of NOx. The lowest level of NOx is achieved with this type of burner when operating at low excess air levels of five percent (or, one percent O_2).

Flameless combustion also is used to reduce NOx. The general principle is that once the combustion chamber reaches autoignition temperature (approximately 1400°F [750°C]), the combustion of the fuel gas shifts from within the burner to the space outside of the burner or chamber. This spreads the combustion over a larger volume instead of concentrating it at the nozzle, so the temperature is lower. The overall temperature within the chamber still is high enough to cause combustion of the fuel gas, but low enough to reduce NOx levels.

SPECIFYING A CONTROL SCHEME

Specifying the right control scheme is just as important as burner design to control emissions.

For flameless combustion, you should choose a flame safety with a high temperature bypass. When switching from flame mode to flameless, there is no longer a flame for the sensor to detect, and a standard flame safety would detect a loss of flame inside the combustor. A flame safety with a high temperature bypass will allow the burner to continue operating after switching to flameless.

Pulse firing is a technique used in multi-burner applications to lower NOx by operating the burners in two positions: either high/low or on/off. This method can reduce NOx because when the burner is at high fire, it is operating at optimum NOx performance. Unique controls are required because each burner has to be on and off for a certain amount of time, and this cycle is timed with the other burners in the system to deliver the required heat to the process.

One of the best ways to control emissions is to use a mass-flow control system, which combines control valves and flowmeters for gas and air, and a burner-management system. These components “talk” to each other in order to provide precise electronic control of the air and fuel flow to the burner. The flowmeters provide feedback to the burner management system, which adjusts the control valves accordingly. This type of system can respond to and automatically compensate for changes in combustion or process conditions such as temperature, humidity and air density – maintaining the best air-fuel ratio for optimal burner performance and NOx emissions.

ECOMAX LE
HONEYWELL’S SOLUTION

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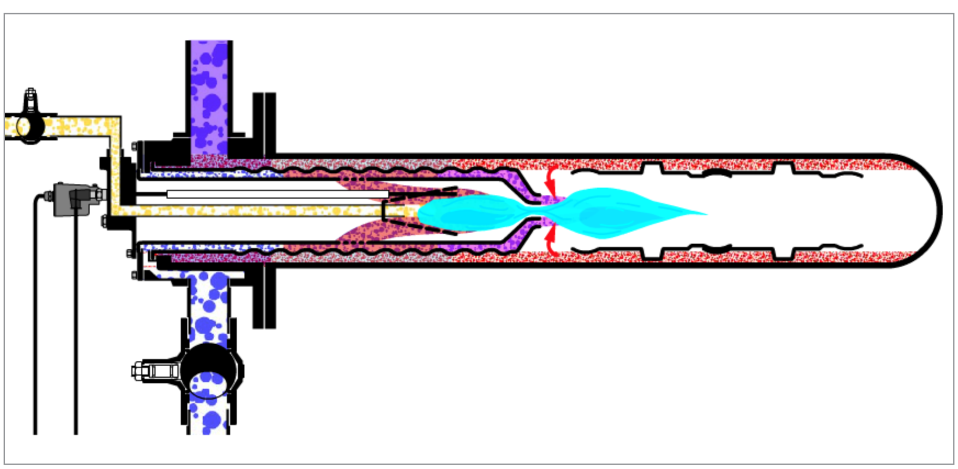
One example of an effective burner control solution is Honeywell’s ECOMAX® LE, based on the industry leading ECOMAX platform. Developed specifically for OEM furnace builders and end users who want to upgrade their heat treatment processes, ECOMAX LE offers low emissions, process efficiency and low operating costs.

The solution is a self-recuperative burner with a ceramic combustor and radiant tube. To reduce NOx emissions beyond that of a traditional self-recuperative burner, it features a patent-pending way to control the air and gas and switch from flame mode to flameless, with a switching temperature of 850°C (1560°F). The burner operates in flame mode until the switching temperature is reached, then switches to flameless mode for optimal NOx performance. In flameless mode, the flame combusts over the entire volume of the radiant tube, lowering peak flame temperature. The result? Best-in-class NOx emissions.

Incorporating Honeywell’s next generation, IIoT-ready BCU 4 burner control unit, ECOMAX LE features easy-to-use on/off control, with direct spark ignition in flame mode. In low-NOx mode, it uses temperature supervision, requiring a separate SIL rated zone control unit such as a PLC or Kromschröder FCU furnace control device.



CONCLUSION

OEM furnace builders and end users who want to upgrade their heat treatment processes must make a number of decisions when it comes to meeting tightening emissions requirements. First, they must research and select the optimal burner and control combination for their control application – specifically, one that meets the NOx requirements of the country, region or city in which it will be sold. Second, they must take these critical steps while continuing to achieve the process and product quality required for commercial success.

Given the constant changes to standards and regulations around the world and the fact that every combustion application is unique, reducing industrial emissions is a continuous process that requires strong knowledge of safe, industry-proven techniques.

For More Information

If you need advice or support in meeting global emissions requirements or would like to learn more about ECOMAX LE or other best-in-class Honeywell solutions and services, please contact your Honeywell account manager or visit honeywellprocess.com/EcomaxLE

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