Beyond Burners

Designing the ideal combustion system requires a careful evaluation of all components to meet your firing objectives.

By Brian Hall

A chain is no stronger than its weakest link. If you're designing a combustion system, you might want to keep that adage in mind when you're evaluating components, because the system you put together will never be stronger than its weakest component.

You should start your evaluation and selection process by defining your objectives. Some of the most common objectives include:

- Greater product quality
- Temperature uniformity
- System flexibility
- Efficiency
- Dependability
- Increased productivity
- Reasonable return on investment

As you assess the overall design of the combustion system and its components, be sure that all of your objectives are fully met. Now is the time to get it right. Remember also that the operating range of the system is extremely important; the greater the control range, the more flexible the control system must be.

While burners are an essential part of any combustion system, four other equally important components comprise the entire system: the fuel train, combustion blower, flame safety system and temperature control system. Understanding the function and capabilities of each of these components can help you make the best selection for your process.

While burners are an essential part of any combustion system, the fuel train, combustion blower, flame safety system and temperature control system are equally important.

A good burner has the flexibility to light reliably with direct-spark ignition, can operate from excess air to excess-fuel, and can operate in on/off mode during frequency firing.

Fuel Train

The fuel train delivers fuel to the burner system at the pressure and volume required to operate the combustion system properly. It is important to size all of the components to suit the application. The size and rating of regulators, valves, piping and switches all vary, depending on the type of combustion system you are using and the available inlet pressure. In a frequency-fired system, you should size your components downstream of the pressure regulator for a minimum pressure drop. This will reduce variations in pressure, which will influence the flow at the burner between minimum and maximum firing rates, and will maximize the system's performance.

In a proportional, or fuel-only, control system, the pressure drop in the fuel train is less critical to system operation. Pressure drops through the components can be increased to reduce component size.

Selection of components depends on the choice of temperature control. In a frequency-fired system, select components that allow on/off cycling of each burner using direct-spark ignition.

Using new products could enhance your system, safety and reliability, so it's definitely worth your time to investigate all of your options.

Temperature Control

The temperature control system is extremely important to the operation of your overall combustion system. It is a common belief that all temperature controllers are the same and provide adequate control; however, this is absolutely not the case. Many differences exist between controllers, with some offering universal input and output capabilities, auto tuning, and extensive set-point programming.

As combustion control technology has evolved, the cost of fuel and improved product quality have played major roles in product design. In the past, the most common types of combustion control systems were fuel-only control and cross-connected ratio control. Both types used either a modulated main air valve or fuel valve as the primary control element.

In the fuel-only control system, the air is set at a constant high flow, and the fuel is modulated between low- and high-fire by the zone temperature control. The system is only on-ratio at the maximum firing rate. When operating below the high-fire position, the system is operating in an excess-air condition. The excess air increases as the fuel

Combustion Blower

The combustion blower delivers air to the burner system at the pressure and volume necessary to operate the system. It is important to size the air components for the proper pressure drop; this depends on the type of control system you select. When sizing the air butterfly valve in a proportional system, the pressure drop across the butterfly valve determines the quality of the control in the system. For example, if you size the butterfly valve with little or no pressure drop at full flow, you reduce the control range. It is conceivable that by over-sizing the butterfly valve, the total range of the valve could be 0 to 30% instead of 0 to 70%. To achieve as broad a control range as possible, size the valve for as much of a drop as your process can handle with the available pressure from the blower. As a general rule, a 4- to 6-in. pressure drop is desirable.

Flame Safety

The flame management system must be given equal consideration when you are determining the appropriate type of control system. In a frequency-fired control system, the flame safety has to be capable of on-off operation, which means that the flame control will be frequently switched on and off using the control algorithm. Additionally, in a high-low operation, some flame management systems integrate the air valve control into the flame module.

The flame safety decision is often made without researching new products and the impact those products might have on system design. Many companies choose their flame management system based on what is currently being used in their facility or by name recognition, instead of on the requirements of the complete combustion system.

A high cycle-life valve and actuator combination provides years of trouble-free service and is one of the keys to reliable frequency-firing. (Shown is the Kromschroder MK series with a dampened actuator.)

valve is driven to the low-fire setting. This system offers a very uniform temperature profile within the furnace, but it is also very inefficient. Because it's an inexpensive system to install, it often seems attractive from an initial cost standpoint; however, the end-user is burdened with paying for the inefficiency of the system for the life of the furnace.

The more efficient air/fuel ratio control began gaining acceptance in the early '70s. In this control system, the primary control element is the modulated main air butterfly valve, which is controlled by the zone temperature controller. Each zone has one temperature controller and one modulated main air butterfly valve. The gas flow is controlled with a crossconnected proportional control regulator (ratio regulator), which is pneumatically linked to the main air butterfly valve with an impulse line that senses the outlet pressure of the modulating main air butterfly valve. As the air pressure to the burner system increases or decreases, the impulse line senses the change and biases the ratio regulator so that the gas pressure follows the change in air pressure.

This type of system ensures a reasonably close air/fuel ratio throughout the complete control range of the system. In the past, it was common to find only one ratio regulator per zone of control, which greatly reduced the control of the fuel/air ratio at each burner and made it nearly impossible to maintain the same ratio at low-fire at all burners. Over the years, it has become more acceptable to install a ratio regulator at each burner, which makes it possible to accurately set the ratio at low- and high-fire at each burner.

A common complaint with the crossconnected system is a lack of temperature uniformity. This occurs because the burner velocity and air-fuel volume change at the burner as the system input is reduced, creating less recirculation, or "stirring action," within the furnace. As recirculation within the furnace is reduced, the ability to obtain temperature uniformity is reduced. To achieve temperature uniformity, the standard practice is to provide some method of excess-air control. This can be done with an impulse air bleed system.

However, by increasing the amount of excess air in the system, you increase the heating load in the furnace by forcing the burner system to work harder to maintain the temperature, which is inefficient. So, at times, the trade-off in some combustion control systems is *efficiency vs. temperature uniformity*. This is especially true when a furnace operates in higher temperature ranges.

The ideal control system would offer the highest efficiency and greatest degree of temperature uniformity. In the late '70s, a combustion control system called frequency-firing was developed in Germany. Frequency firing maximizes the available burner velocity by operating individual burners at either high- or low-fire. The time between each burner cycle is determined through the zone temperature control and a frequency-firing algorithm. This type of control is called frequency modulation.

Frequency modulation control is designed to keep burners constantly cycling from low- to high-fire in a near random firing pattern. This increases the recirculation within the furnace and enhances the temperature uniformity. The efficiency of this type of system is greater because it accurately controls the ratio at high- and low-fire positions. The primary elements in this system are individual air valves and ratio regulators at each burner. The zoning of the burners is established through the electronics of the control system, making it very easy to re-zone the furnace if necessary.

A popular frequency control system has evolved from the initial high/low firing to on/off firing. The on/off firing method cycles the burner from off to high-fire and then off again, establishing one cycle. This provides a nearly infinite on-ratio control turndown situation and reduces the need for excess air. It is extremely important to use very high cycle-life solenoid valves in this type of system. General-purpose valves require frequent replacement and increase the maintenance requirements of the system, reducing the potential payback. No matter how efficient a system, it might not be worth the investment if it increases your maintenance requirements. To keep maintenance costs to a reasonable level, be sure to select only high cycle-life valves for your frequency control system.

Burner Selection

A good burner offers a wide operating range (from excess-air to excess-fuel) and a high turndown capability, is easily direct-spark-ignited, and provides reliable and repeatable ignition. For the greatest efficiency and uniformity in a

When selecting the right burner for your application, determine the burner capacity, ratio requirement, flame shape, turndown capability and outlet velocity. All of these aspects of burner operation play a key role in the successful operation of the system. (Shown is the Kromschroder modular design BIC burner.)

frequency-fired system, it is also crucial that the burner can be operated in an on/off mode. Features such as integrated air and gas orifice meters, limiting orifice valves, and ignition and ionization electrodes can reduce the overall system cost and assist in the burner setup. Choosing a burner that can operate at all ratios with ionization flame control can also be beneficial, because it eliminates the need for expensive self-check ultraviolet (UV) cells and provides a fail-safe method of flame detection. A burner that meets or exceeds these important characteristics provides the greatest system flexibility and offers the best system performance.

When selecting the right burner for your application, determine the burner capacity, ratio requirement, flame shape, turndown capability and outlet velocity. All of these aspects of burner operation play a key role in the successful operation of the system. For example, in some applications, burner velocity might be too high and create hot spots or even erosion to the furnace lining. It might be necessary to select a burner with a lower velocity in this situation. Some burners offer several outlet diameters with different tiles, which make it simple to select the proper capacity and velocity for the application. This is normally true with burners that use silicon carbide materials for the combustion tiles, but it is rare to find this flexibility in burners that use refractory tiles. Today, it is very common to see more silicon carbide materials used for the manufacturing of combustion tiles; the low mass makes it very attractive material to use in soft wall fiber linings.

A wide variety of silicon carbide materials can be used—some are very durable and provide a great resistance to thermal shock, while others do not. Make sure the materials offered with the burner protect against thermal shock. Be sure to investigate the replacement cost for the combustion tile, regardless of the materials used, because it is common to find that the replacement costs for the tile can equal or exceed the cost of the burner. If this is the case, it may be worth investigating alternative burner suppliers.

A correctly sized fuel train provides even flow of fuel to the combustion system throughout the operating range of the system.

Ensuring Good Performance

Take the time now to set your objectives and research your options. Evaluate products that have a proven track record, but also consider new products and their potential impact on your system design. You should also be sure to match the various combustion components to your objectives. Most importantly, remember that each component of your combustion system—not just the burners—contributes to the overall performance of your furnace or oven.

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