Combustion Control Strategies for Single and Dual Element Power Burners

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Today's economic and environmental demands dictate that we get the greatest practical efficiencies from our plants. To do this we must have a basic understanding of what those efficiencies are and how to implement them.

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Advanced automatic systems for combustion control are excellent methods for improving systems and process automation efficiency. New technology available today helps improve overall combustion efficiency and burner stability when loads and demands are variable. The most sophisticated systems can eliminate the need for operator input during load changes while maintaining safe and reliable fuel/air ratios.

This discussion describes several systems, from the simplest to the most elegant, and focuses on the features, benefits and applications of several systems applied to single-burner packaged boilers.

A Look at Combustion Strategies

Here are some control strategies to consider for improving burner efficiency. The right strategy depends on boiler loads, demands — and economics.

**Fixed Position Parallel Controls.** The simplest form of combustion control for power burners is the fixed position parallel control (FPC) (Figure 1)—also known as direct or jack-shaft control. This strategy incorporates a single positioning motor, which drives both the fuel and air positioning devices via an interconnected single mechanical link, the jack-shaft.

The simplicity of the FPC control strategy makes it a very economical choice for small burners with modest firing rate changes. However, because fuel and air are fixed, the fuel/air ratio is also fixed. The burner cannot compensate for environmental changes, such as combustion air temperature or fuel pressure. Additionally, the FPC strategy lacks feedback to the control element, which can cause fuel to cross over the airflow and cause a fuel-rich furnace or other burner efficiency losses.

To help prevent a fuel-rich furnace, FPC systems are set to allow 4% to 8% excess oxygen to the furnace. In practice, the excess oxygen is normally set at 6% to 7%, allowing for seasonal air temperature changes.

**Parallel Positioning Control Systems.** These systems function similarly to FPC systems, except that fuel and air end devices are separated and driven by individual positioners. Modern electronic parallel positioning controls (PPC) incorporate end-device positioning signals to ensure accurate placement of fuel and air positioners for specific firing rates. These signals make PPC systems much improved over FPC systems.

The new systems are gaining acceptance over FPC systems because they offer an economical means to improve overall combustion efficiency. PPC systems are suitable for 100 to 900 boiler horsepower (Bhp) boilers that operate with relatively stable loads. Larger systems are also becoming more prevalent.

PPC systems can hold excess oxygen levels to within 3% to 4% in many applications, but because they lack true process variable feedback in the fuel/air systems, they should be used cautiously in applications with extremely fast load swings. Like FPC systems, PPC systems cannot compensate for changes in fuel or combustion air characteristics.

**Series Metered Control Systems.** Boilers larger than 750 Bhp commonly incorporate series metered control (SMC) systems, where load changes are neither large nor frequent. In this application, both fuel and air are metered. The boiler master controller regulates combustion airflow with a set point. The airflow controller cascades the airflow signal to the fuel controller as its remote set point. A ratio algorithm signal sent to the fuel controller adjusts the fuel/air ratio.

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This ratio algorithm has an inherent lag because the air controller directs the fuel controller's function. This lag provides a desirable lean furnace on demand rise. However, on a fast falling demand, the lag between the air and fuel controllers can cause a fuel-rich furnace.

Because of the lag on a falling demand, the SMC is only adequate for near steady-state conditions. Excess oxygen levels are usually set at 5% to 8%; however, by using an oxygen trim system, levels can be adjusted to 3% to 4% during steady-state operation.

Metered Parallel Positioning Control Systems. Boilers operating at 1,000 Bhp or higher may incorporate metered parallel positioning control (MPPC) systems. These operate the fuel and air control loops in parallel from a single setpoint generated by the boiler master controller. A combustion air set point ratio establishes the fuel/air proportions.

This fuel/air customization feature means excess oxygen in the exhaust gases may be reduced to 3% to 4%. To maintain an air-rich furnace on transition, MPPC systems are normally set with additional excess air to compensate for fuel flow during setpoint excursions. In practice, the excess air is set at 4.5% to 5% to compensate for barometric changes in air density. During steady-state operation, this can be adjusted to 2.5% to 3% using an oxygen trim system.

Like the series system, the traditional MPPC system lacks feedback to the opposing flow controllers, which can result in combustion imbalance on large or very fast load swings. These systems require near identical response from both the air and fuel control loops to prevent fuel or air-rich mixtures in the furnace. This limits the MPPC system to boilers with modest demand swings.

Cross-limited Parallel Metered Control systems. This strategy improves on MPPC by interlocking fuel/air ratio control to prevent a fuel-rich furnace. The cross-limited control (CLC), or lead-lag control (Figure 2), is dynamic and easily adjusts to different response times of the fuel and air end devices. This flexibility allows its use in systems with sudden and large load swings and provides precise combustion control at steady-state operation.

CLC systems easily maintain excess oxygen levels at 3% to 4% in gas burners and 2.5% to 3% in #2 oil systems. Additionally, the cross-limiting feature prevents fuel from overshooting airflow.

Because of its capability for close tolerance control, CLC systems are suited for all sizes of boilers that can support the systems installation cost. Additionally, the CLC system can be readily adapted to oxygen trim control and is suitable for most low-NOx burner applications.

Figure 2. Cross limiting, or lead-lag fuel/air ratio control, is the most dynamic of all combustion control strategies.

Selecting a Strategy

The economic balance between fuel cost, safety, boiler load, and control system cost will eventually determine which of these systems best suits your process. However, in practice, the use of parallel positioning systems on boilers up to 900 hp is usually the most economical. Cross-limited systems are typically used in critical load applications of 1,000 hp and higher.

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