TECH TIP #9
METERED FUEL/AIR RATIO CONTROL PLUS O$_2$ TRIM
by David Farthing
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Today's economic and environmental demands dictate that we get the greatest practical efficiencies from our plant. To do this, we must have a basic understanding of what those efficiencies are and how to implement them.

NEW TECHNOLOGY IMPROVES OVERALL COMBUSTION EFFICIENCY AND BURNER STABILITY WHEN LOADS AND DEMANDS ARE VARIABLE.

Advanced automatic systems for combustion control are excellent methods for improving systems and process automation success. New technology available today helps improve overall combustion efficiency and burner stability when load 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 system applied to single-burner packaged boiler.

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 a direct or jackshaft 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.
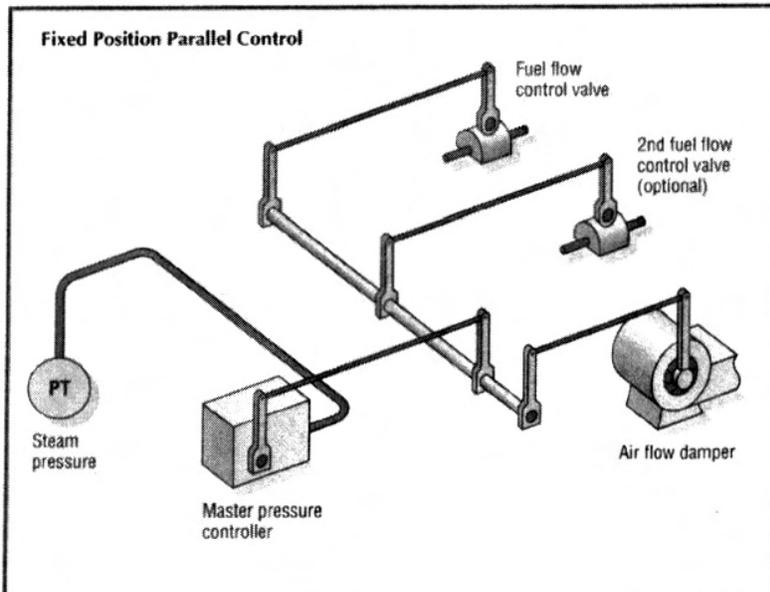
Parallel Positioning Control Systems. These systems function similarly to FPC systems, except that fuel and air end-devices are separated and driven by individual positioners. Modern electronic parallel positioning control (PPC) incorporates end-device positioning signals to ensure accurate placement of fuel and air positioners for specific firing rates. These signals make PPC system 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.

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.

Cross-limited Parallel Metered Control Systems. This strategy improves on MPPC

Figure 1. Fixed position parallel jackshaft combustion system with fuel/air ratio established through fixed mechanical linkages.

7

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.

Selecting a Strategy

The economic balance between fuel cost, safely, boiler load, and control system cost will eventually determine which of these systems best suits your process.
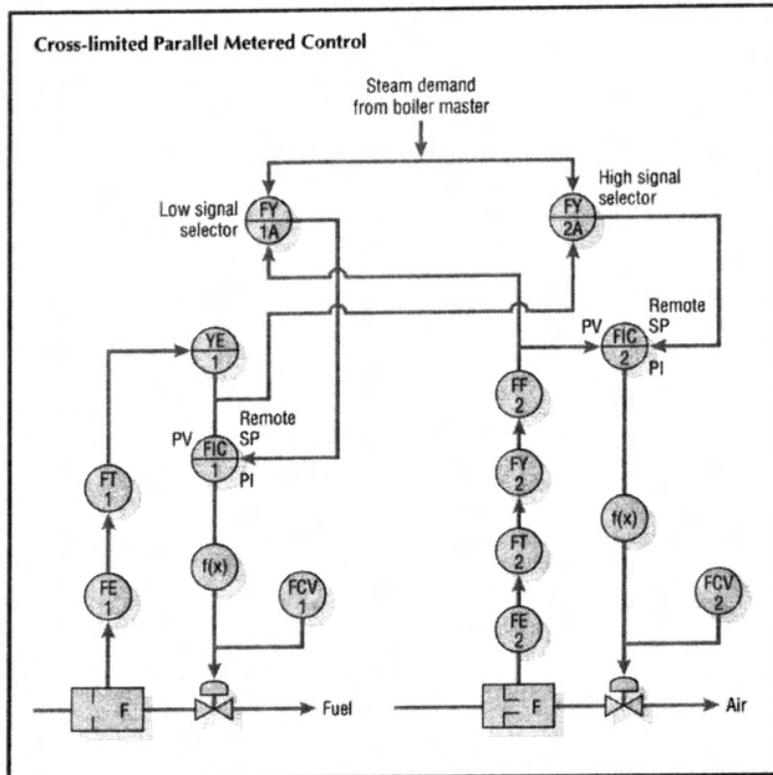

Figure 2. Cross limiting, or lead-lag fuel/air ratio control, is the most dynamic of all combustion control strategies.

Combustion Efficiency Calculations (using TechStuff)

Boiler Type & Data	Boiler #1 - 600 BHP
Fuel (Gas =1, Oil =2)	1
Rated Boiler Hp	600
Name Plate Efficiency	80.00%
Current O2 % as found	6.00%
Current Co2 % as found	
Air Diluted CO ppm as found	23.00
CO in Flue Gas ppm Corrected	32.26
Approximate Fuel Loss out stack	0.01%
Normal Firing Rate NFR (0-100)	70%
Recommended O2% @ NFR	3.25%
Average Hours/Day Run Time	14
Average Days/Month Run Time	22
Fuel Cost/Dk-Therm from billings	$ 8.00
Average Combustion Air Temp	80
Stack Temp at Firing Rate	550
Net Flue Gas Temp Rise	470
Net Efficiency Loss to Wasted Fuel as Co	0.0323%
As Found Combustion Efficiency	77.3%
New Calculated Combustion Efficiency	79.1%
New Stack Temp	539
New Net Flue Gas Temp Rise	459
Net Combustion Efficiency Gain	2.32%
Current Cost to Operate Per Month	$ 44,821.11
New Cost to Operate Per Month	$ 43,782.88
Current Fuel Dollars Wasted as Excess CO	$ 40.34
Savings Per Month	$ 1,078.57
Savings Per Year	$ 12,942.89

Performance Data	
28%	Present Excess Air Mass.
15%	New Excess Air Mass.
$10.04	OLD Fuel Cost per 1,000 Lb/Steam.
$9.81	NEW Fuel Cost Per 1,000 Lb/Steam.
2.41%	Percent Fuel Cost Savings.

Calculated savings on a sample 600 HP steam boiler comparing manual Jack-Shaft Control to Cross Limited Control with O₂ trim.

7