BURNER CONTROL BASICS

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The basics

Traditional burner control

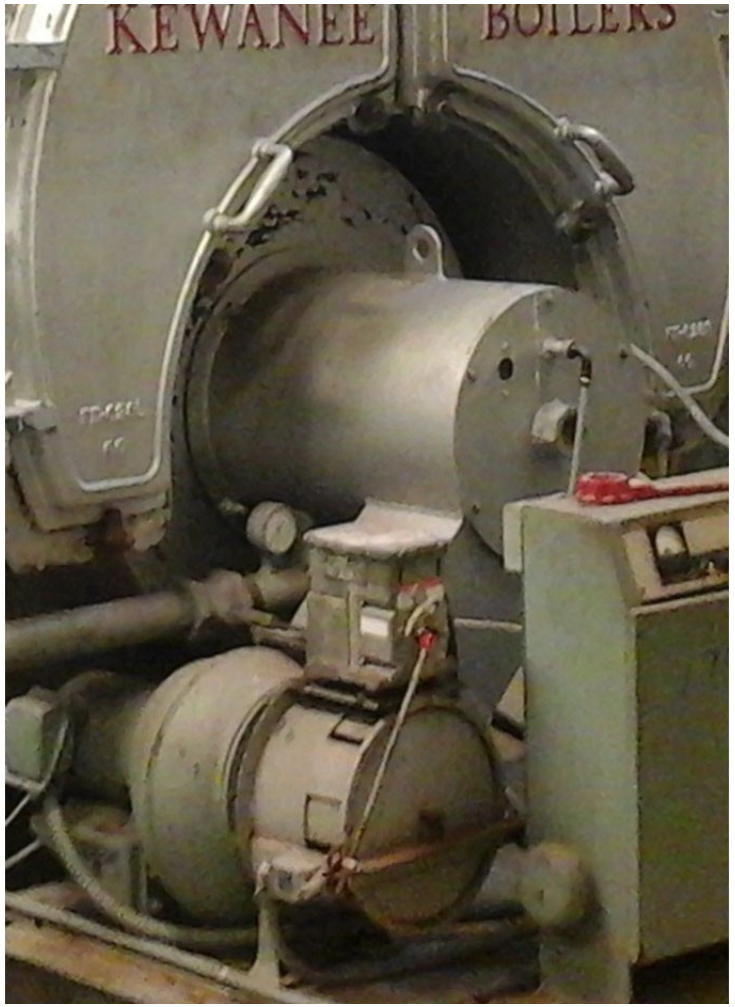
ON/OFF

This is the most basic form of burner control. When automatic burner controls became available, this was the best available control technology.

SINGLE-POINT MODULATING

Over time, modulation was possible with the advent of the proportional slide wire control and the modulating motor. This type of control is known as single-point, or linkage control. This is because only one motor can safely be controlled by the slide wire output.

The basics



Linkage burner control

Linkage burners link the air damper and fuel valves together through a common linkage. They maintain a fixed relationship through the firing range due to the mechanical connection.

The basics

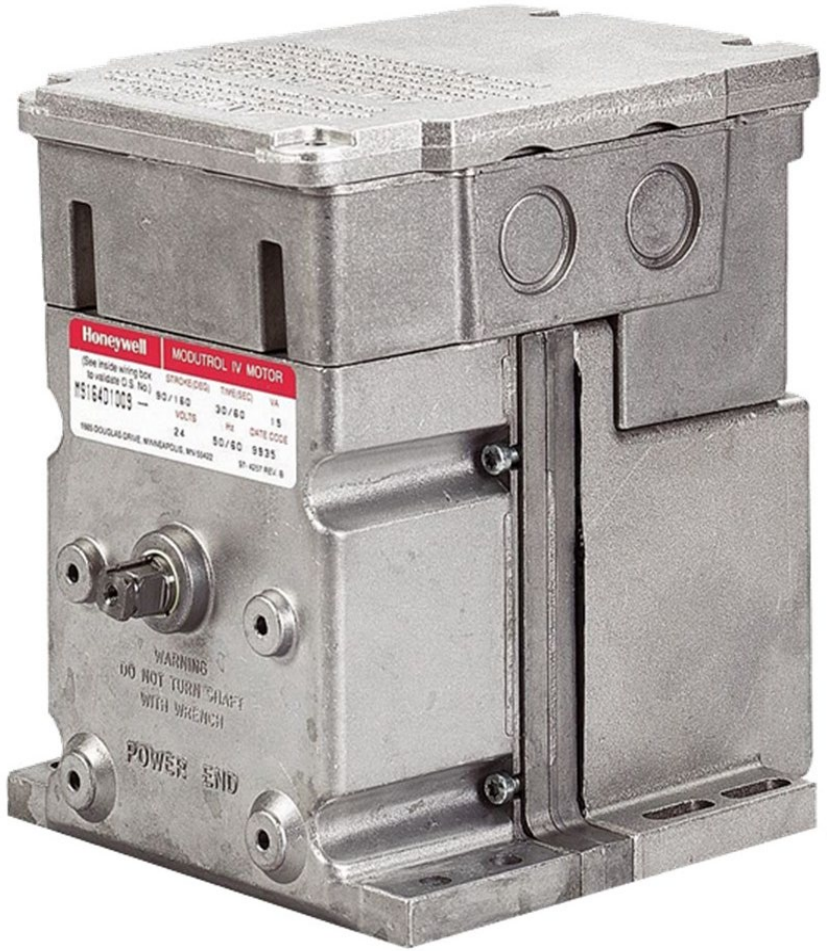
Slide wire control

For the technology of the time, slide wire control was revolutionary. It is a mechanical system that creates a proportional output of 0 to 135 ohms based upon the setpoint and actual value. This resistance output is then connected to a modulating motor.

The setpoint and the proportional gain are set using springs. These are presented to the user on a printed legend. As such, the slide wire can't control too precisely since the actual setpoint is never known.

Lastly, proportional control can't account for changing load conditions. This can make it hard to reach the setpoint during periods of high load.

The basics



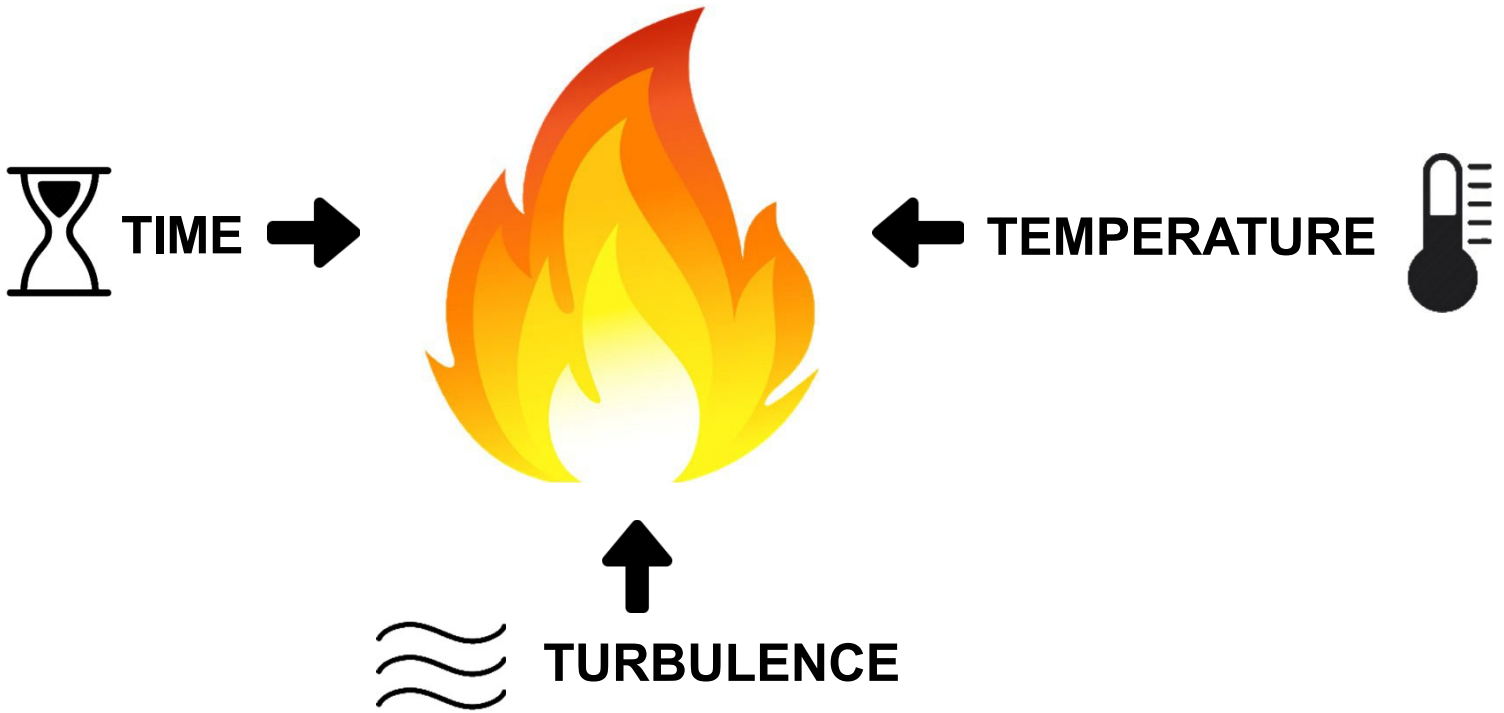
Modulating motors

The typical 0-135ohm modulating motors that are used are directly connected to the slide wire controls. The motors can be commanded to the high and low positions as needed through the flame safeguard for purge and ignition and are connected to the slide wire control through a relay when the automatic run state is reached.

- **These motors run open-loop (no feedback) and do not have fine resolution. This means that while the motor may have a span of 90 angular degrees, this may only result in 20 or fewer different steps of modulation. This is due to the inherent design of the motor and slide wire control.**

Combustion basics

Three T's of combustion



Combustion basics

Time

When a fuel is burned, sufficient time must be provided for the fuel to burn fully. If allowed to only partially burn, there will be losses as unburnt fuel. If too much time is allowed the burner may not be able to achieve the desired power output.

Combustion basics

Temperature

If the temperature is not sufficiently high fuel will take longer to ignite. This may result in a change in the power output. Low NO_X burners may take advantage of this principal to lower the flame temperature by re-introducing exhaust gas into the combustion process (FGR). This lower temperature inhibits the chemical reaction between nitrogen and oxygen.

Combustion basics

Turbulence

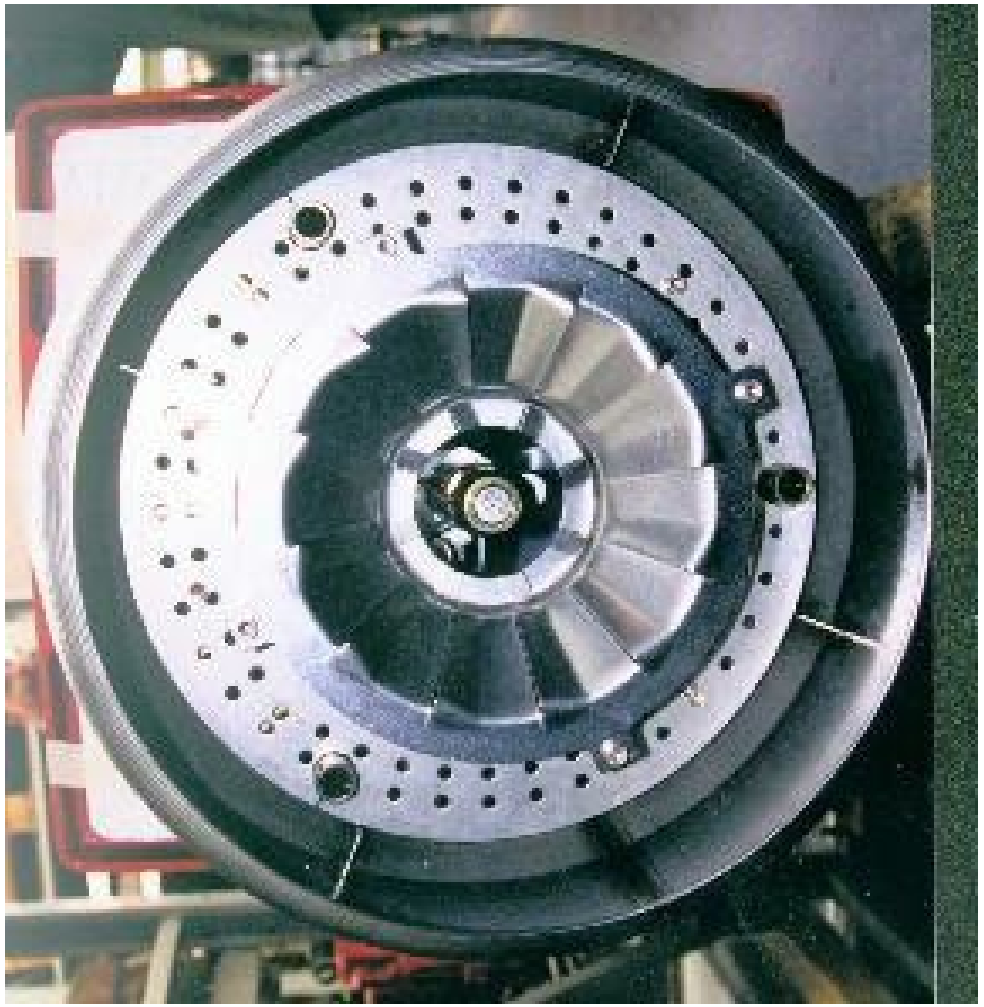
Thorough mixing of the air and fuel is necessary to achieve proper combustion. If this is not done there may be partial combustion which can result in increased emissions or reduced power output.

Burner head

Design

The burner head is designed to properly mix the fuel and air before combustion. The velocity of the mix is affected by the gap between the diffuser and where the fuel and air are introduced. A gap that is too large can affect the turbulence.

Burner head



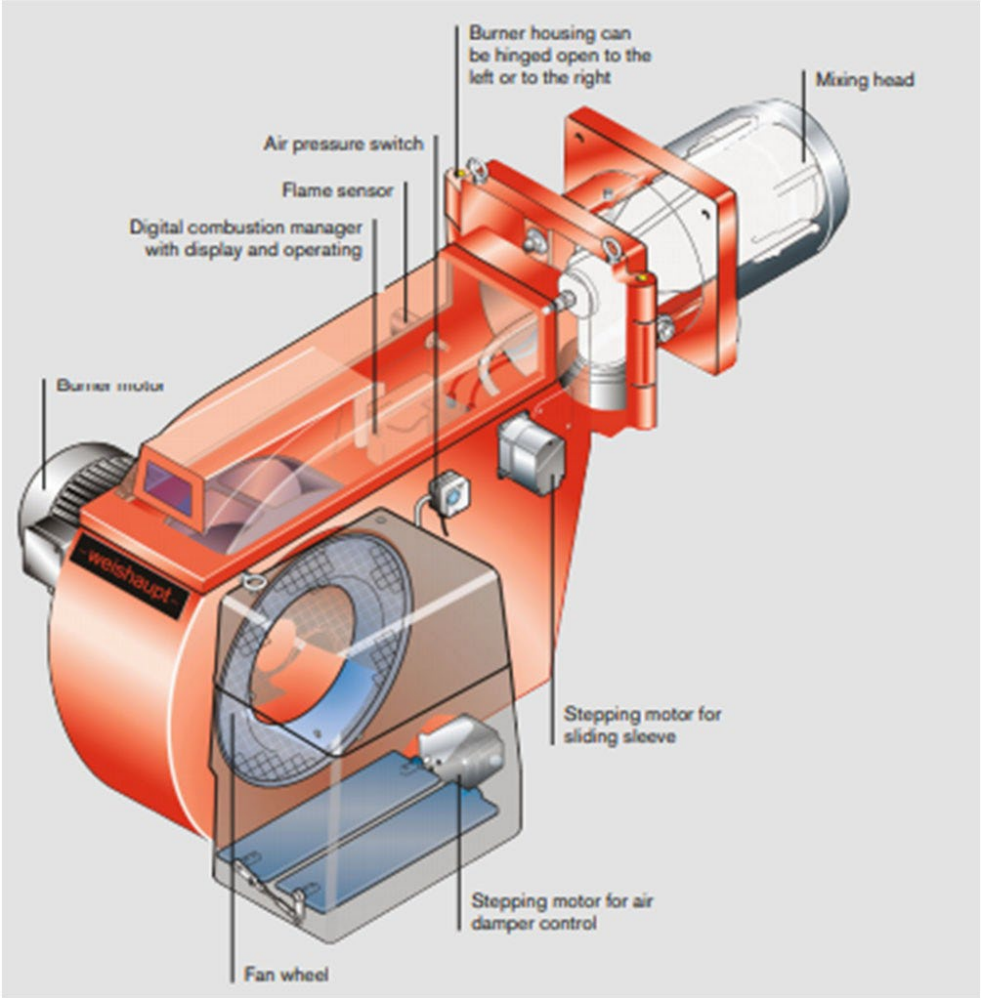
Fixed head

A fixed burner head is designed for ideal mixing at the highest firing rate. The result of this is that more excess air will be required at lower firing rates to eliminate CO. This can result in less efficiency.

Burner head

Sliding head

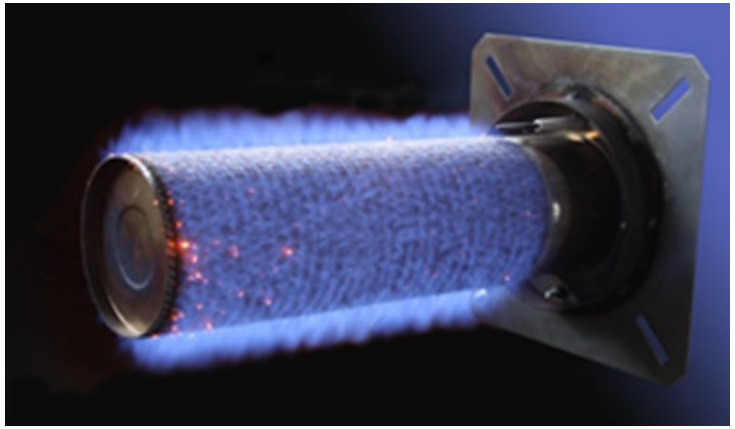
A sliding burner head is designed for ideal mixing at all firing rates. The result of this is that the burner will be able to run in the ideal combustion setting throughout the range. A burner with a sliding head adds complexity to control as the head must be adjusted in some manner during operation.



Burner head

Mesh head

A mesh burner head is designed for ideal mixing at all firing rates. The fuel/air is pre-mixed and distributed evenly through the mesh material on the surface of the burner.



Burners

Types of burners	LINKAGE	PARALLEL POSITIONING	INTEGRATED BURNER
There are three main categories of burners.	These burners use a single-point modulating motor and connect all the dampers and valves using linkages.	These burners use a microprocessor-based safety control to synchronize multiple high-precision motors, with one connected to each damper and valve. Also referred to as “Linkageless”.	These burners are built into the appliance and are an integral part of the design. These can use linkage or parallel positioning controls.

Burners

Linkage burners

Linkage burners link the air damper and fuel valves together through a common linkage. They maintain a fixed relationship through the firing range.

Linkage burners can only be set up accurately on low-fire and high-fire. Any firing rate in between is subject to the position of the linkage and may not be optimal.

This can lead to the following issues:

- Intermediate firing rates can't be fine tuned
- Hysteresis occurs from the tolerances or "slop" present in the linkage mechanisms
- The same point will have a different fuel/air ratio when modulating up than down due to different tension on the linkage

Burners

Characterized linkage burners

Linkage burners may have a mechanism in place for slight characterization of the fuel to air ratio. Using these adjustable cams can allow some characterization of the air damper throughout the firing rate to improve upon this shortcoming with linkage burners, which will improve combustion efficiency by a small amount.

Burners

Parallel positioning burners

Parallel positioning burners allow the air and the fuel to each be individually controlled by a servo at each designated firing rate. Additional servos for FGR and/or sliding head position can also be incorporated. This allows for a true characterized combustion curve through the entire firing rate.

Instead of using wrenches to adjust a linkage, commissioning is done via an operator interface. The servos used are closed loop with much more precision than the typical modulating motor, with 900 steps of resolution over 90 angular degrees. This also eliminates all the hysteresis during firing rate changes.

Different brands of controls have support for different quantities of connected servos and torques.

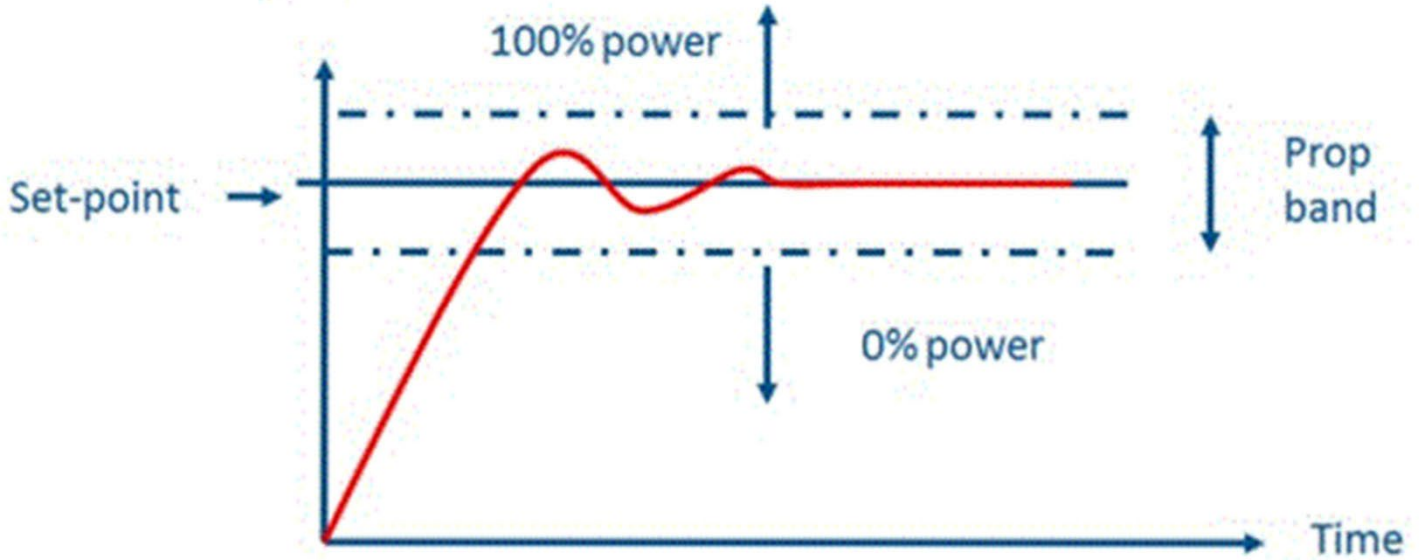
Servos can be used for:
Air
Gas
Oil
FGR
Sliding head
Secondary air
Any other damper or valve

Burners

Parallel positioning burners

BETTER LOAD CONTROL

Slide wire control is replaced by intelligent PID control. The slide wire lack of resolution and lack of available integral and derivative corrections are addressed by the PID control.



Burners

Integral burners

Some boilers have integral burners designed by the manufacturer. These burners can be linkage or parallel positioning type.

Burners

Integral burners

One way to upgrade an integral burner that uses linkage is to retrofit a parallel positioning system with a servo on each damper and valve.

Burners

Turndown

Every burner has a minimum and maximum output. The difference between these is known as the turndown and is usually expressed as a ratio. For example, if the minimum output is 100,000 BTU/hr. and the maximum is 1,000,000 BTU/hr., the turndown would be expressed as 10:1.

Standard turndown is usually in the range of 2:1 to 5:1. Higher turndown can be achieved by tightly controlling the amount of air that is allowed by sealing off any sources of tramp air and using rubber gaskets on the dampers. Both linkage and parallel positioning burners can offer high turndown.

In addition to providing superior control, turndown will also help to reduce cycling on a boiler. If the lowest available firing rate results in too much output, it will lead to cycling.

High turndown allows a boiler to be more versatile since it can operate across a larger range of conditions.

Burners

Independent ignition position

With a linkage burner, sometimes the low-fire position is dictated by where the burner can safely and/or reliably light off. If the burner has parallel positioning, the ignition position can be set differently from the low-fire position to alleviate this concern.

In some cases, the burner will not be able to achieve the desired turndown without an independent ignition position. For example, if a 5,000,000 BTU/hr. boiler can turndown 5:1, it should be able to achieve 1,000,000 BTU/hr. output at low fire. However, if it can only light off reliably with the fuel input set to achieve 2,000,000 BTU/hr. output, the maximum turndown will never occur since the ignition and low-fire position are tied together.

Upgrading burners and controls

Why do customers choose to upgrade their burners or controls?

- Reliability
- Reduced fuel costs
- Reduced electrical usage
- Longevity
- Parts availability
- Repeatability
- Emissions requirements

Upgrading burners and controls

What is the total cost of upgrading to the end user?

- Burner and/or control – The initial cost of the equipment is fixed and represents a small overall amount.
- Installation – This is also fixed and represents a small overall amount.
- Commissioning – Another fixed cost that is less than the equipment or installation.
- Integration (BMS) – Depending upon whether this is needed, it represents a small initial and recurring expense.
- Energy (fuel/electric) – This is going to be the **largest recurring expense** and it is subject to fuel costs. The costs shown above for upgrading controls and/or adding a VFD should save enough in energy costs to pay off in a short amount of time.
- Maintenance – While not as much as energy costs, maintenance will be the **second largest expense** over the lifetime of the burner. Choosing reliable equipment will reduce these costs.

Features and benefits of upgrades

Firing options

Burners can be ordered to modulate on gas, oil or both (dual-fuel). This allows them to modulate on either fuel with a switchover process. Dual-fuel burners can also run on two gaseous fuels such as natural gas and propane.

The fuel switchover process with a linkage burner can often be labor-intensive, requiring that piping is connected or that couplers are inserted. Additionally, the ignition point of the backup fuel may dictate where the ignition and low-fire point of the primary fuel can be.

With parallel positioning, the switchover can be as simple as an electrical signal or a command from the operator interface.

Parallel positioning

Upgrade or replace existing burner

One of the easiest efficiency upgrades that can be done to an existing linkage burner is to add a parallel positioning system. The whole installation and commissioning process can be done in a few days or less by qualified personnel. If a new burner is to be installed, Fireye parallel positioning controls can be requested from the burner OEM with any new burner order.

NEXUS NXF4000

NEXUS NX6100

Parallel positioning

Upgrade or replace existing burner

Fireye offers four options for parallel positioning:

1. PPC4000 – allows the existing flame safeguard to be retained which cuts down on installation time or allows for some additional flame safeguard features to be retained
2. NXF4000 – complete system with flame safeguard
3. PPC6000 – same benefits as PPC4000 but also has available add-on features such as draft control and water level control for a more complete solution.
4. NX6100 – complete system with flame safeguard with available add-on features such as draft control and water level control for a more complete solution.

Parallel positioning

Multiple profiles

Four different profiles can be programmed into a Fireye parallel positioning control to account for different scenarios. For example, a different curve for use with a VFD or with the VFD in bypass mode for both gas and oil. A separate profile can be commissioned for use in different ambient conditions as well, such as for summer and winter.

The changeover is as simple as applying a voltage to a digital input.

Before selecting a parallel positioning system, make sure that it will support enough profiles to meet the site needs.

Parallel positioning

Servo technology

The purpose of the servos is to replace the linkage connected to the fuel valves and dampers with an individual motor coupled to each for precise control.

The servos used with a parallel positioning system are accurate to 0.1 angular degree and have positive feedback (closed loop). This ensures perfect repeatability for the combustion control curve when modulating either up or down with no hysteresis. If the servo does not indicate that it is in the correct position, safety logic will lockout the control until the problem is identified and corrected. With Fireye parallel positioning controls, up to ten servos can be connected for use with the various profiles.

Servos can come in a variety of torque ranges to adapt to almost any burner need.

Parallel positioning

O_2 trim system

- Continuous adjustment of fuel-to-air ratio
- Proven sensor technology doesn't need maintenance and is self-calibrating
- O_2 can be trimmed by making metered adjustments to servos in a profile
- Keeps O_2 in ideal combustion band even with small changes in ambient environment
- Helps with emissions compliance

Parallel positioning

Variable frequency drives (VFD)

With parallel positioning controls, VFDs can be used to control the speed of the combustion air fan. This results in improved combustion and a significant reduction in electricity usage. The affinity laws that apply to fans indicate that at 80% of the maximum RPM, a fan will only use half of the power. Safety is ensured as feedback is monitored just as it is with servos.

By using multiple profiles, the VFD can be bypassed if there is a need (for service or due to a malfunction) without having to shut down the boiler – only a temporary rise in energy usage.

Parallel positioning

Sequencing multiple boilers

Fireye NXF4000 and PPC4000 controls can connect (up to) six boilers together for intelligent lead/lag control without the need for a master control panel. Thermal shock protection and standby water temperature control for steam boilers (to prevent condensation) are also provided with this feature. The NX6100 and PPC6000 offer similar functionality for up to four boilers.

Parallel positioning

Connectivity to building automation

Modernizing the burner controls will allow the building automation system to connect to the Modbus interface to get an expanded collection of data. All the operating data as well as lockout data can be collected and monitored. Depending upon the building automation or supervisory system used, alarms can be sent out automatically or the systems can be monitored remotely.

All Fireye parallel positioning controls offer Modbus connectivity. A communication gateway is also available to convert to other protocols such as BACnet and Ethernet/IP.

THANK YOU