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Get the benefits of "linkageless" control with a faster ROI: Add O2 Trim to your jackshaft boiler

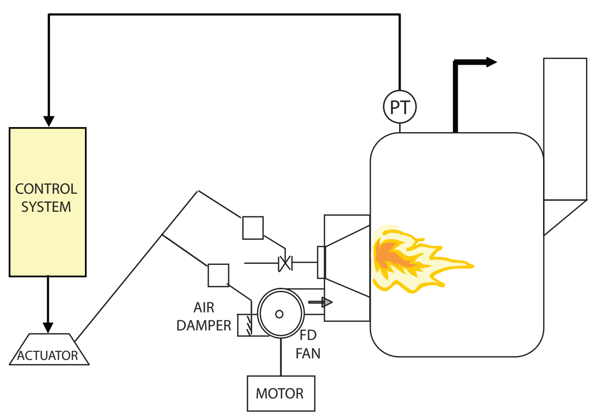
The most widely accepted method of improving package boiler control - splitting the jackshaft and adding O2 trim - can be labor intensive and may not provide the fastest ROI

Abstract

With energy prices on the rise and environmental regulations being increasingly enforced, more and more companies and institutions are looking to their steam generation plants for higher efficiencies and lower costs. For small to medium package boilers this usually involves upgrading the original control system to include oxygen trim. However the most widely accepted method of achieving this – parallel positioning or "linkageless" control – can have a daunting installed cost and very long payback period for these boilers. This white paper examines a new method of adding O2 trim to a jackshaft boiler that provides a quicker return on investment along with improved environmental control.

Introduction

Most package boilers are originally supplied with a single-point positioning combustion control system. This involves a mechanical linkage that moves a jackshaft, which in turn actuates mechanical cams that have been physically set to a pre-determined fuel/air ratio. The controller compares the pressure signal to the local setpoint and generates an output signal to the jackshaft actuator for fuel and air demand. Although this is the least expensive in terms of equipment and the easiest to operate, it is the least energy-efficient due to the safety requirement for excess air, and the most maintenance-intensive.



Since a simple pressure control system is unable to respond to changing fuel and air properties on a continuous basis, the fuel/air ratio must be re-calculated with a new combustion test at least every season, and the mechanical cams adjusted accordingly. But to do this properly requires a knowledgeable boiler technician and several hours or days of downtime on the boiler; therefore, most plants and institutions only do this once or twice per year at best. Furthermore, to ensure safe operation at all times, extra air flow – up to 50% excess air (5-7% O2) – must be included during setup to prevent a fuel-rich environment and guarantee safe combustion. This extra air reduces the combustion efficiency as it results in more fuel burned to create ht same amount of steam. Other factors such as inaccurate, low-precision actuators, changes in air properties (temperature, pressure and humidity), and wear in mechanical linkages, cams and valves because of continuous adjustment contribute to inefficient combustion.

Adding O2 Trim to a jackshaft system improves efficiency, reduces electricity consumed by the FD Fan motor, and compensates for worn linkages and cams

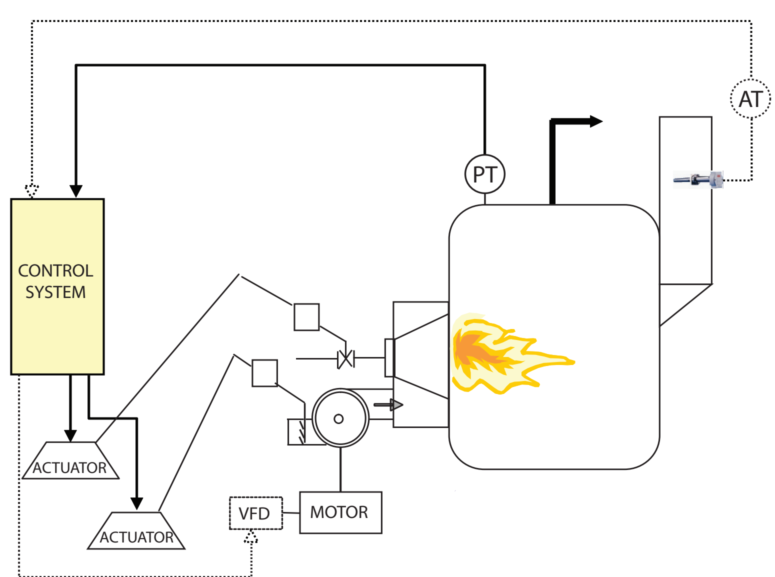
It is well-known that adding oxygen trim to these boilers improves combustion efficiency and reduces emissions. It allows the controller to compare the excess air to an internal lookup table and continually calculate the correct fuel flow and air volume. In this paper we review two methods of achieving this on a jackshaft boiler: the generally accepted parallel positioning ("linkageless") method, and that of simply adding O2 trim to the existing pressure control system. Done properly, both require the installation of an oxygen analyzer in the exhaust stack and a variable speed drive on the FD Fan motor. However the latter method provides a higher return on investment and faster payback, especially for small to medium boilers.

Method 1: Installing Parallel Positioning or "Linkageless" Control

The traditional and most widely known method requires dismantling the jackshaft and eliminating the linkages, in order to modulate the fuel and air independently. This involves a considerable amount of mechanical and electrical labor in addition to the cost of new actuators, positioners and other equipment.

Depending on the condition of the linkages, eliminating the jackshaft can mean either disassembling the linkages and mechanical bars to the air damper actuator and fuel valve cams, or physically cutting it apart if the components are too rusted or worn to take apart easily. The mechanical installer must then repair the valve heads and replace the cams with positioners, or replace the entire valve (for each fuel) with a new valve and a positioner. A new actuator and linkage is typically required for the air damper. Finally, new conduit and wiring must be run to the fuel valve positioner(s) and air damper actuator. The entire procedure can take two to three days of mechanical and electrical work. In addition, the user is reliant on the mechanical supplier to provide the correct equipment and still maintain NFPA (National Fire Protection Agefcy) requirements such as installing limit switches on the positioners and actuators and wiring them to the Burner Management System.

Linkageless or parallel positioning systems are often implemented without the O2 trim to save on the cost of equipment. However, the FD fan is then still operating at a fixed speed and the air flow is controlled only by modulating the damper. This results in wasted electricity, because the fan continues to produce a fixed amount of pressure at all boiler loads, and this pressure is lost when the air is throttled back with the damper.

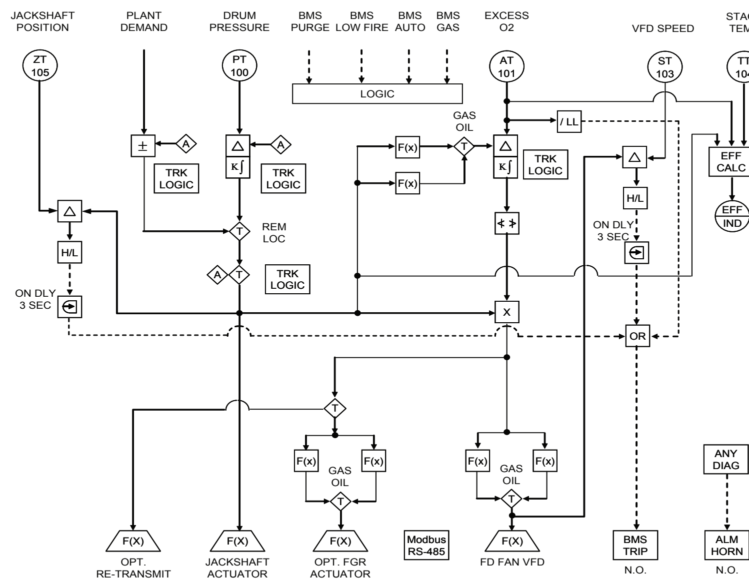


In many cases, depending on current efficiencies, payback on the project can be realized in as little as 12 months

Method 2: Adding O2 trim to the existing pressure control system

A less well-known but extremely effective method provides a faster payback and higher ROI for small to medium boilers. It involves leaving the jackshaft intact and maintaining the fuel valve cams and damper actuator linkages, while simply adding the O2 analyzer and VFD to the existing installation with a new controller. This requires only a day of electrical work and little mechanical intervention.

In this strategy, the controller adjusts the air volume to demand by regulating the speed of the fan instead of throttling back with the damper.



TrimPAK Logic Diagram

The Steam Pressure control loop receives an input signal from the steam pressure transmitter and generates an output signal for air and fuel demand. The Oxygen control loop receives the excess O2 signal from the analyzer, compares it to the remote setpoint generated by the internal combustion table in the controller and puts out a limited adjustment to the Steam Pressure controller output to ensure the correct amount of air for the current fuel demand. Separate tables and tuning constants for gas and oil are provided to eliminate the need for technician intervention when changing fuels. For safety, a feedback signal from the VFD is provided to trip the boiler if the deviation between controller output and fan speed exceeds a predetermined value, and limits are applied to the O2 Trim signal. A low-low oxygen alarm or loss of O2 signal will also trip the boiler. A jackshaft position sensor provides feedback on the fuel side and will cause the boiler to trip if the output signal deviates from the feedback signal.

Once the new controller is installed and connected, a new combustion test is performed with each fuel to set the air damper cams to new positions corresponding to the varying speed of the fan. The resulting values are entered into the controller’s combustion tables.

Changing the speed of the fan creates the correct pressure for the required air flow at all times. At higher boiler load, the damper will be wide open and the air flow will be adjusted by fan speed. At lower loads the damper is still used to throttle the air flow since the variable speed drive motor must typically maintain a minimum speed.

Adding O2 trim to a jackshaft boiler provides maximum energy savings at the lowest installed cost

Because the fan horsepower required to produce a given amount of air is a cubic relationship, a small change in fan speed produces a large change in horsepower consumption. Therefore running a motor at 70% (n2) of its maximum speed rating (n1) at full load (Hp1) using the drive results in a 66% reduction in horsepower:

$$\frac{Hp_2}{Hp_1} = \left(\frac{n_2}{n_1}\right)^3$$

$$\frac{Hp_2}{100} = \left(\frac{70}{100}\right)$$

$$Hp_2 = 34\%$$

This method has the added benefit of providing a failsafe in the event the drive malfunctions. The drive can be supplied with a bypass, giving the operator the option to run the boiler as if the system were simply a single-point positioning system without O2 trim. The plant can continue to safely produce steam, albeit with a lower efficiency, until the drive can be repaired or replaced. Likewise, an external transfer switch allows the boiler to be restarted and run without O2 trim in the event of a stack analyzer failure.

Case Study: Method 2

Four boilers at a brewery in Honduras were operating with old on-off pressure controls supplied with the boilers, modulating the jackshaft with no O2 trim. The brewery upgraded their controls to new pressure controllers with O2 Trim, installing an O2 analyzer in each stack and a VFD on the FD fna motors. Production was not affected by the changeover and the operators adapted easily to the new system. The brewery is saving more than 4% in fuel since the upgrade, is producing 11% more beer per gallon of fuel burned, and black emissions from the stacks have turned to white, to the considerable relief of the surrounding neighborhoods.

Conclusion: Higher, Faster Return on Investment with Method 2

Companies are continually seeking to improve their profitability with lowered operating costs. This can be achieved on a jackshaft boiler, avoiding the expense of a full parallel-position system. The savings in electricity consumption realized by reducing FD fan speeds to deliver exactly the right volume of air for optimum combustion are added to the acknowledged savings achieved through combustion efficiency improvements using O2 trim. The elimination of two days of mechanical and electrical installation labor as a result of leaving the jackshaft intact lowers the overall installation cost and compensates for worn linkages while ensuring the system conforms to NFPA safety standards. When properly installed, the system allows the plant to continue safely producing steam in the event of a drive or O2 sensor failure. Although it’s a non-traditional method, the economic and operational benefits can be much higher. In many cases, depending on current efficiencies, payback on the project can be as fast as 12 months.

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