

AD353-104

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Procidia™ Control Solutions

Combustion Management Solutions

O₂ Trim Control

INTRODUCTION

This paper is the fourth in a series that discusses Combustion Management Solutions. This installment discusses O₂ Trim Control.

The benefit of O₂ trim control is:

- ◇ Maximizes boiler operation by improving control of the air/fuel ratio

BACKGROUND

Oxygen (O₂) trim is one of several flue gas analysis trim control methods. Flue gas analysis trim control is used to optimize air/fuel ratio and control stack emissions.

Theoretically, if air and fuel are thoroughly mixed in chemically equivalent (stoichiometric) proportions, the combustion products will be carbon dioxide and water vapor. In a dynamic process, like a burner, the mixing and reaction time is short. Pockets of combustion mixture may not have enough oxygen to completely burn or there may not be enough time for these pockets to mix with the remaining oxygen before the combustion gases cool. The result is incomplete combustion and formation of carbon monoxide.

Carbon monoxide (CO) is an intermediate product in the combustion (oxidation) process and it contains significant thermal energy. Other combustion by-products are formed but a high CO concentration in the flue gases means wasted energy and increased fuel costs. Increasing the

air/fuel ratio will reduce the formation of carbon monoxide. Depending on the fuel and burner, 2-4% excess oxygen significantly reduces carbon monoxide concentration in flue gases.

Another factor that affects carbon monoxide formation is furnace temperature. At higher temperatures, the combustion process is more efficient. Since boilers run hotter at higher loads, less excess oxygen is required to maintain CO concentration below air emission limits. Depending on fuel and burner, excess oxygen can be reduced to 1-1/2% at full load. However, high furnace temperatures increase formation of nitrous oxide (NO_x), which is another regulated air emissions contaminant.

O₂ trim control is used to control the air/fuel ratio. Ideally, carbon monoxide should also be monitored because the amount present is a measure of burner performance. Theoretically, controlling excess O₂ indirectly controls CO emissions, but a high CO concentration with plenty of excess O₂ means the burner needs tuning.

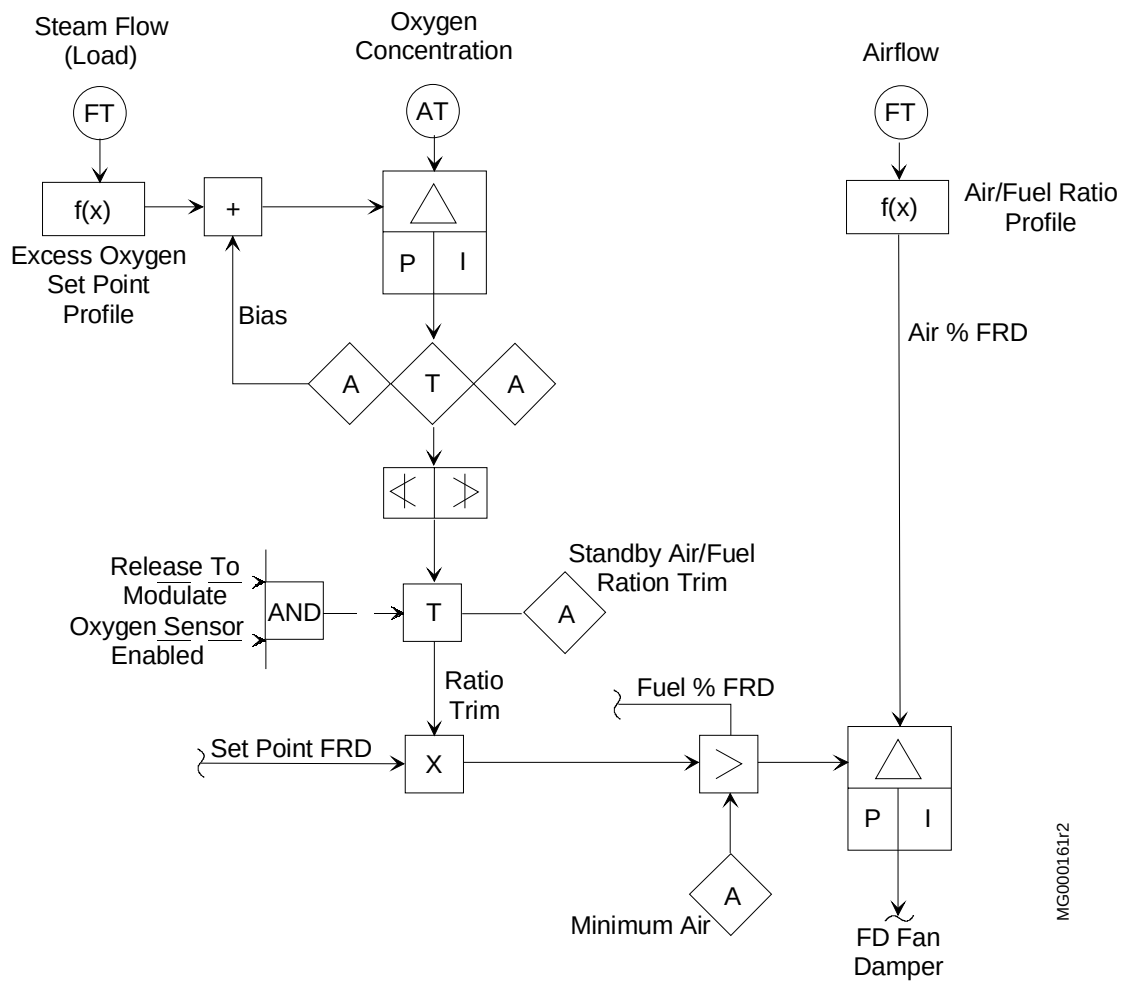
MEASUREMENT

There are numerous gas analyzers available that employ a variety of detection methods. Flue gas oxygen analyzers are designed to detect lower concentrations of oxygen. An in situ oxygen analyzer is most commonly used in these applications.

CONTROL

O₂ trim is used to automatically adjust the air/fuel ratio in the combustion airflow control loop (see AD353-103, Full-Metered, Cross-Limited Control). The SAMA¹ diagram below illustrates how the excess oxygen control loop integrates with the combustion airflow control loop. The excess oxygen setpoint is determined by the boiler load. The load signal can be either steam flow or FRD (Firing Rate Demand) from the firing rate control loop.

During commissioning, the excess oxygen required to maintain CO below emissions limits is determined at various loads. The data is used to configure the characterizer function block and define the excess oxygen setpoint profile. For example, the profile may go from 4% at low fire to 1-1/2% at full load. A bias is available to the operator to manually increase the excess oxygen setpoint by a fixed amount. This provides manual compensation for controlling CO emissions.



O₂ Trim Control

¹ SAMA – Scientific Apparatus Makers Association

Since the flue gas sensor is located in the stack, there is a significant delay between a change in airflow and the corresponding response change in the flue gas. To compensate for the lag, a large integral time constant is used in the PID tuning parameters. A Smith Predictor or other such dead-time compensation algorithm can also be used. The PID control function block uses proportion and integral action control.

The controlled variable is the air/fuel ratio trim. The ratio trim range is critical because any large deviation from the air/fuel ratio can result in a dangerous combustion mixture. Limit the trim to approximately a 10% change, or 0.9 to 1.1. In the Model 353 controller, the controlled variable range is specified in the PID function block parameters. This safeguard is represented in the SAMA diagram as a high/low limit function block to stress its importance. The auto/manual switch permits the operator to manually set the air/fuel ratio trim. In configuring the Model 353 controller, configure the A/M function block range pointer to the PID range output to incorporate the control variable range.

The operator should disable the excess oxygen control loop during start-up. While in standby, the air/fuel ratio trim is set at 1.0. When the controller is released to modulate, the control loop should remain in manual mode. The operator then enables the O₂ trim control loop once the boiler has come on-line.

Oxygen sensors need to be regularly calibrated. During calibration, the O₂ trim loop is set to standby mode and the air/fuel ratio trim is set at 1.0. Use an external input signal to place the loop in standby.

APPLICATION SUPPORT

The next publication in this series is AD353-105, Boiler Drum Level (Feedwater) Control. User manuals for controllers and transmitters, addresses of Siemens sales representatives, and more application data sheets can be found at www.usa.siemens.com/ia. To reach the process controller page, click **Process Instrumentation** and then **Process Controllers and Recorders**. To select the type of assistance desired, click **Support** (in the right-hand column).

The control concepts in this publication can be developed into a controller configuration using the Siemens i|config™ Graphical Configuration Utility.

Combustion management configurations can be created and run in the following Siemens controllers:

- Model 353 Process Automation Controller
 - Model 353R Rack Mount Process Automation Controller*
 - i|pac Internet Control System*
 - Model 352*Plus* Single-Loop Digital Controller*
- * Discontinued model

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