APPLICATION NOTE

YS1700 Boiler Control Overview

OVERVIEW

Automated control of industrial boilers is an excellent application for YS1700 microprocessor-based loop controllers. These instruments can be programmed to perform the operations of plant master, boiler master, fuel and air control with oxygen trim and drum level/feedwater control. Each of these control applications are discussed in this application note.

The YS1700 is a reliable and cost effective means of upgrading boiler controls and increasing boiler efficiency while lowering operating costs by implementing advanced control strategies. Although the functions of each controller discussed here differ, the YS1700 hardware platform is identical for each application.

Key features of the YS1700 include:
- **Dual PID loop capability**
- **Built-in "Hard Manual" backup station**
- **Two CPU design for reliability**
- **LOOP, TREND & ALARM operator displays**
- **Integral 24VDC transmitter power supply**
- **Advanced self-tuning**
- **RS485, Ethernet & peer-to-peer communications options**
- **Expanded I/O option (total of 8 AI, 4 AO and 14 DI/DO**

PLANT MASTER

Most industrial boilers operate on a header system. Steam is delivered to a header pipe by one or more boilers and is transferred from the header to the various process users. Pressure in the header is used as an indicator of the steam demand. A pressure transmitter is connected to the header and this signal is the process variable input to a YS1700 programmed as "Plant Master". This is a P+I controller that compares the pressure with an operator selected set point and computes a firing rate demand signal (output) to the combustion controls: {boilermaster(s) and the fuel/air controllers}.

BOILERMASTER

This controller accepts the firing rate demand signal from the Plant Master controller as the process variable. The output of boiler master provides the firing rate demand signal and operator applied bias to the fuel and air controllers for that specific boiler. This bias station allows the operator to select higher firing rates and therefore higher steam production from the more efficient boilers in a multiple unit configuration.

Additionally, discrete outputs from the fuel and air controllers provide mode status to the boilermaster controller. If the fuel or air controller is in MANUAL, the YS1700 programming logic can alert the boiler operator that the firing rate demand signal cannot be used in the combustion controllers.

A "Flame On" permissive from the burner management equipment alerts the boilermaster controller that the boiler can accept a firing rate demand signal and is not in a low fire, purge or off condition.

COMBUSTION CONTROLS

The firing rate demand signal from the boilermaster controller(s) is used in the combustion control: fuel, air and flue gas percent oxygen. The YS1700 controller can be programmed to perform all these functions. In this text, the combustion control discussions will be limited to a single fuel with a parallel metered cross limited control
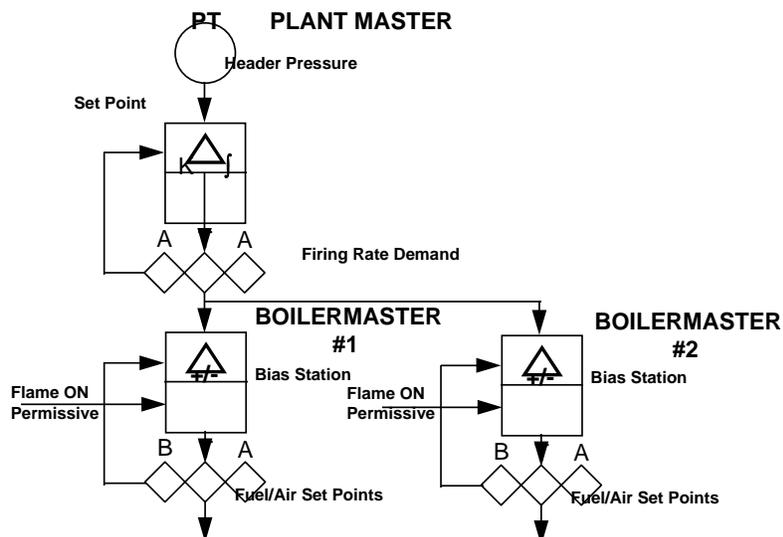
configuration. The YS1700 controller can be programmed to select multiple fuels (e.g., oil or gas) or control a ratio of two combustibles.

The SAMA logic diagram below shows the interaction of the fuel and air controllers. The fuel and air flows are measured and compared to the firing rate demand signal. Low and high signal selectors are incorporated in the YS1700 programs to insure safe operation. The low selector in the fuel controller compares the firing rate demand signal and the air flow measurement and selects the lower signal as the set point. Inversely, the air controller compares the fuel flow measurement and firing rate demand signal selecting the higher as the air flow set point. Therefore, the fuel flow will not exceed the air flow. Function generators are applied to the outputs for characterization to the final control elements. A low limiter is configured into the air flow controller to prevent the air flow set point from being reduced less than 25% of full

range. This minimum setting is required by NFPA code and insures safe operation during transmitter outage.

Discrete inputs and outputs are used for tracking the auto/manual status of the air controller. The fuel controller is forced to MANUAL if the air controller is placed in MANUAL. The fuel cannot be placed into the automatic mode until the air controller is returned to AUTO. This action is required to insure a safe and proper air/fuel ratio.

An auto/manual station can be used to generate a fuel/air ratio. For better combustion control and boiler efficiency, a flue gas percent oxygen analyzer and YS1700 controller can be incorporated into the air flow control strategy. The firing rate demand signal is modified by a function generator to calculate a load index. An operator applied bias can be applied to the index and this is the set point to the oxygen trim controller. The P+I output is

adjusted for gain and bias (y=mx+b) and applied to the air flow measurement signal. High and low output limiters are used in the event of analyzer outage.

The YS1700 can be programmed to operate as a dual loop P+I+D controller. Therefore, the combustion air and percent oxygen controls can reside in one instrument. The YS170 can display the measured variables (air & percent oxygen) on two different screens. Operator interface is simple and easy-to-read.

FEEDWATER CONTROL

The boiler feedwater controller is used to maintain the water in the steam drum at a desired set point. The intent is to replace each pound of steam taken from the steam drum with a pound of makeup water. A high drum level may allow water droplets to be carried over into the steam header and damage process equipment. A low level can cause damage to exposed tube surfaces.

A phenomenon exhibited in the steam drum is swelling and shrinkage. This is caused by the bubbles in the boiler tubes and the drum expanding and contracting. As the demand for steam is increased, the header pressure decreases and the master pressure controller increases the firing rate of the boiler(s). The associated decrease in drum pressure and higher firing rate causes the water bubbles to expand and the drum level increases. Conversely as the steam demand decreases, the header pressure increases and firing
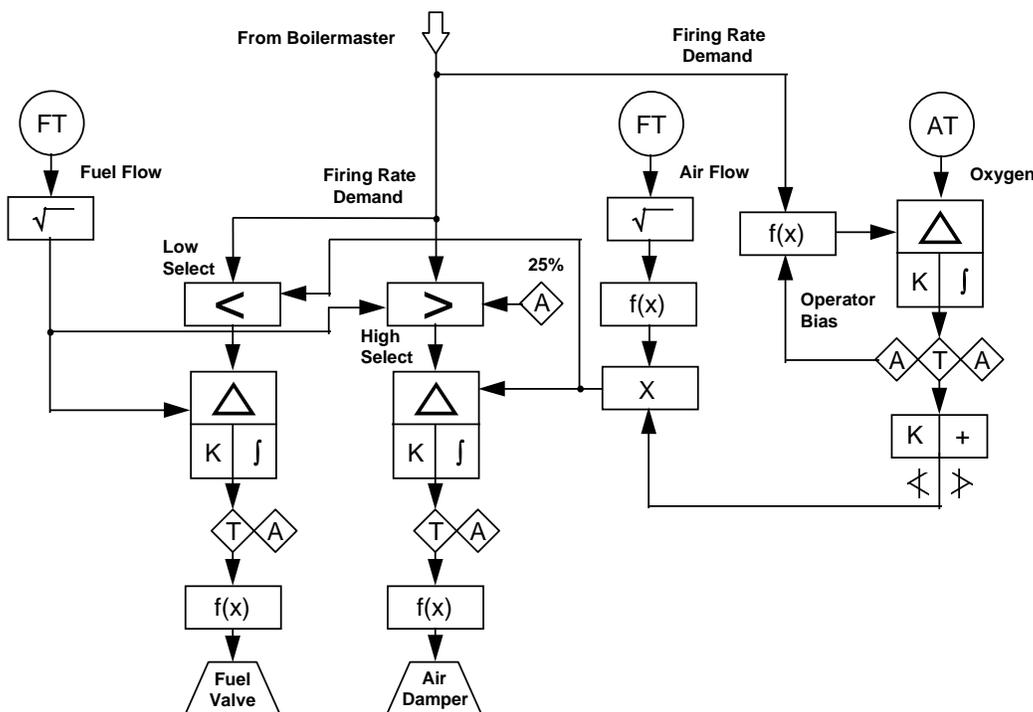
rate declines, causing collapsing bubbles and a lowering of the steam drum level. This action creates an opposite reaction in the feedwater controller. More feedwater is needed for higher steam flow, but as the level swells, the feedwater controller reduces the output to the valve. Using a drum level pressure transmitter and compensating for the change in drum pressure, the feedwater controller is not adversely affected. The drawing at the right shows a drum pressure measurement being applied through a function generator to the level input.

There are three types of boiler feedwater control configurations that are commonly supplied: *single element* (drum level only), *two element* (level & steam flow) and *three element* (level, steam & feedwater).

Single element control is commonly used in small boilers that are based loaded, i.e., little variation in steam demand. Changes in load are not incorporated into the control strategy.

Two element control uses a steam flow measurement as a feedforward element to change position in the feedwater valve. Changes in steam demand are sensed and adjustments to the valve are made. Varying feedwater pressure can change the flow rate and drum level. Fluctuating pressure is common in multi-boiler feedwater systems.

The SAMA diagram below shows a three element drum level control with pressure compensated

drum level. The YS1700 controller is programmed in a cascade configuration, where the output of the drum level controller is linked to the remote set point of the feedwater flow controller. The steam flow measurement is applied to the output of the level controller to adjust the remote set point to the feedwater control proportional to varying steam demands. The secondary control is the faster reacting feedwater flow controller. Three element control is common on large boilers with varying load demands. This can be programmed into one YS1700, as a single station cascade controller with feedforward element and pressure compensated drum level.

PEER-TO-PEER COMMUNICATION

YS1700 controllers can be optionally provided with peer-to-peer communications. This feature permits data from one controller to be sent to another digitally over a

single pair of twisted wires. Any controller parameter can be shared. Up to sixteen (16) controllers can be linked on this data network with custom configuration.

SCADA/HMI

Many boiler locations combine the control power and reliability of panel mounted controllers by linking their YS1700 controllers with popular SCADA/HMI software packages. Running such software in a personal computer provides advanced trending, alarming, operator graphics and other features while maintaining the boiler control functions in the YS1700's. Such a system provides features and functions similar to a Distributed Control System without the high price tag!

When using the RS485 communication option, sixteen (16) YS1700's can be linked to each communication port of the SCADA/HMI computer. The peer-to-peer option allows sixteen (16) controllers to "talk" with each other as the SCADA/HMI host computer accesses the network. The peer-to-peer option runs approximately eight times faster than the RS485 option (78,000bps vs 9600bps). Custom applications with up to 63 YS1700 controllers linked to a single PC communications port are possible when using the YS-Net peer-to-peer/PC network. Either YS1700 digital communication card discussed here can be provided at the initial purchase of the controllers or easily retrofitted in the field.
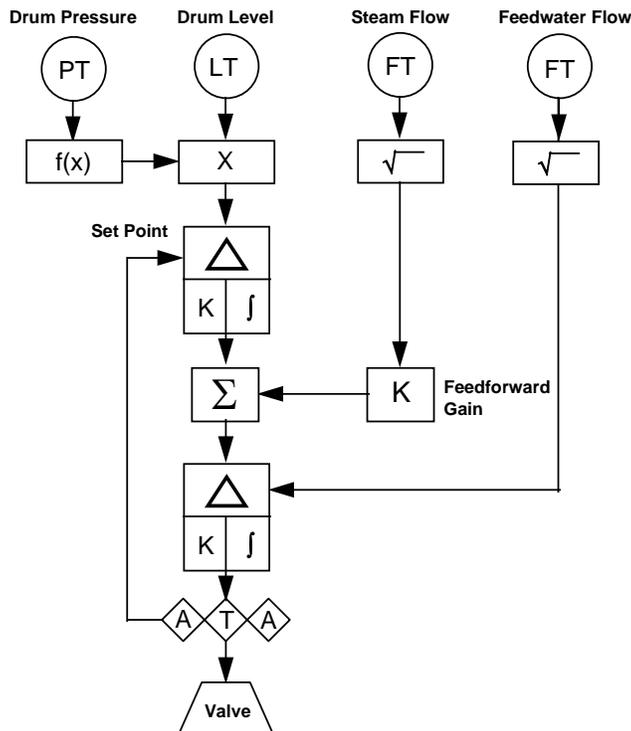
APPLICATION NOTE

SUMMARY

Using YS1700 loop controllers is an answer to upgrading aging or cumbersome boiler controls. Increased boiler efficiency and reduced operating costs can be realized. The programmability allows them to be used in a variety of applications. Discussions here have been limited to the most common boiler control applications. However, the YS1700 can be used for deaerator control, steam drum b treatment and a variety of auxiliary control applications in the industrial boiler domain.lowdown, condensate return, water treatment and a variety of auxiliary control applications in the industrial boiler domain.

Related Technotes

CP-A-04 - RS485 Communications/ Graphical User Interface Packages

CP-A-08 - YS170 Peer-to-Peer Communications

CP-A-11 - Boiler Feedwater Control

CP-A-12 - Boiler Combustion Control

YS1700 - Boiler Control Solution

Pressure Flow   Level Temperature

High Resolution Color LCD Display

Independent Dual Loop Capability

Maximum Versatility

LOOP Display

TREND Display

Pull Down Configuration Menus

YS1700 Dual Loop Programmmable Controller