SIEMENS

APPLICATION DATA

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Procidia™ Control Solutions
Combustion Management Solutions
Furnace (Draft) Pressure Control

INTRODUCTION

This paper is the sixth and last in a series that discusses Combustion Management Solutions and discusses furnace pressure control.

Furnace pressure control provides two significant advantages:

◊ It prevents leakage of hot combustion gases by ensuring that the furnace operates with negative pressure.
◊ It maintains a constant furnace condition to ensure safe, reliable operation of a boiler.

BACKGROUND

A boiler consists of two systems. It has a water system centered on the boiler drum and it has a combustion system centered on the furnace. The combustion system deals with the feeding of fuel and air in order to control the firing rate. This paper deals with the movement and control of combustion air into the furnace and removal of the combustion by-product gases (or flue gases). The term draft refers to the movement of combustion air and flue gases.

Furnace pressure, also known as draft pressure or simply as draft, is maintained slightly negative relative to atmospheric (room) air pressure to prevent combustion by-products from escaping into the surrounding area through furnace openings (e.g. inspection ports, doors, feeders). However, this pressure needs to be maintained as close as possible to atmospheric pressure to minimize the intake of excess air through furnace openings, referred to as tramp air. Tramp air cools the combustion gases and reduces boiler efficiency.

A furnace is classified by its draft system: natural, forced, induced or balanced.

Natural Draft
Natural draft uses the stack or chimney affect. Flue gases are hotter and less dense than surrounding air around the stack opening. As flue gases rise through the stack, a natural convection current is formed creating a pressure gradient through the stack, ducting and furnace. This causes combustion gases to be sucked into the stack and combustion air to be drawn into the furnace. Natural draft boilers are not as efficient as mechanized draft boilers. Natural draft furnaces operate below atmospheric pressure.

Forced Draft
A forced draft furnace uses a fan or blower to force combustion air through the system. Control is accomplished by regulating the fan speed or damper operation. This type of furnace is operated slightly above atmospheric pressure. Forced draft furnace must be airtight to prevent leakage of flue gases into surrounding area.

Induced Draft
An induced draft fan draws the gases through the flue ducting and the combustion air into the furnace making high stacks unnecessary. Control is accomplished by regulating the fan speed or damper operation. An induced draft furnace is operated slightly below atmospheric pressure. Induced draft is used with solid fuel burning or stokers, because the furnace is not airtight.

Balanced Draft
Furnaces equipped with both an FD (Forced Draft) and ID (Induced Draft) fans are called balanced draft systems; see Figure 1. In balanced draft systems, the forced and induced draft fans work together to move combustion air and flue gases through the furnace. The FD fan is used to regulate the combustion airflow and the ID fan is used to regulate furnace pressure. Balanced draft furnaces are typically operated slightly below atmospheric pressure.

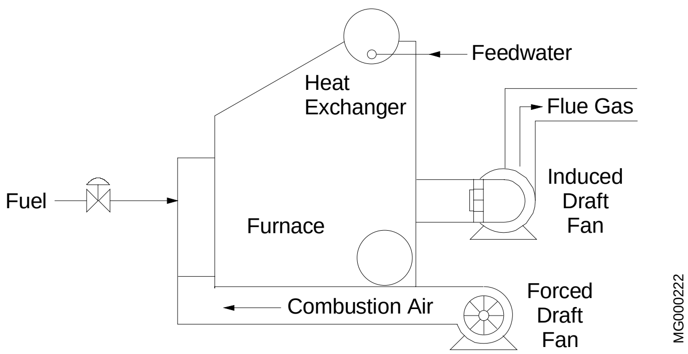

FIGURE 1 Typical Single Burner Boiler

MEASUREMENT

Furnace pressure control is typically implemented in balanced draft operations. Most often the furnace pressure is maintained just slightly below atmospheric pressure to prevent flue gas leakage to the surroundings. However, too low a pressure must also be avoided to minimize air leakage into the furnace reducing efficiency and, in the extreme case, to prevent furnace implosion.

Furnace pressure is typically measured using a differential pressure transmitter. Normal operating draft ranges are 0.25 to -1 inH_2O. Narrow spans are not practical because fast changes in flow may cause draft measurement to go outside the range limits. Also, narrow spans tend to amplify noise. Noise is the fluctuation in the real-time pressure measurements, and furnace pressure is subject to a lot of noise. Transmitters support signal damping to filter out noise and provide steadier readings. The location of the furnace pressure measurement tap is important since pressure gradients exist within the furnace.

CONTROL

Furnace (draft) pressure control is used in balanced draft furnaces in order to regulate draft pressure. Draft pressure is affected by both the FD and ID fans. The FD fan is regulated by the combustion control loop, and its sole function is to provide combustion air to satisfy the firing rate. The ID fan is regulated by the furnace pressure control loop and its function is to remove combustion gases at a controlled rate such that draft pressure remains constant. Typically, furnace pressure control uses feedforward control as illustrated in Figure 2. Since combustion airflow fluctuates with the firing rate, frequent and sometime large disturbances are introduced. A standard feedback control strategy for draft pressure control will have difficulty maintaining a steady setpoint. Feedforward control permits the control loop to respond to changes in airflow before sensing a change in draft pressure. The PID portion of the control loop makes fine adjustments to the ID fan in order to maintain setpoint. The result is tighter control of furnace pressure.

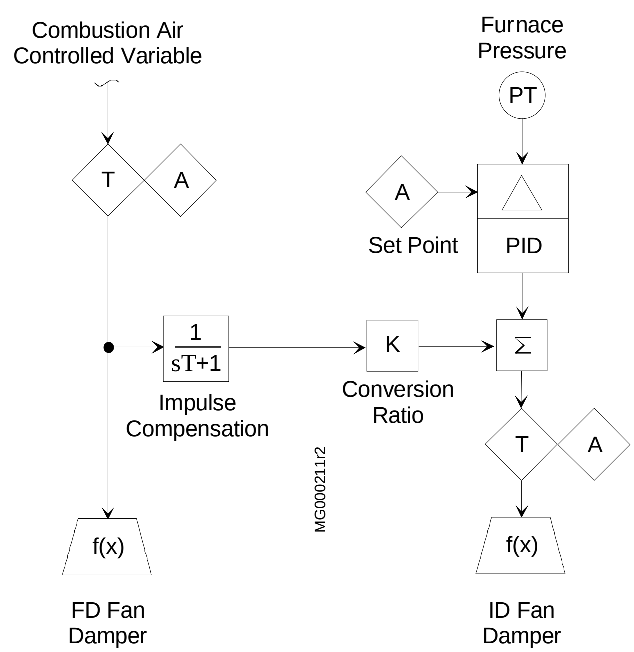

FIGURE 2 Furnace Pressure Control

Since air is compressible, any change in the draft due to the FD fan is not seen across the furnace instantaneously. Rather, there is a delayed response in draft pressure. One technique to compensate for this affect is to use feedforward impulse compensation. The simplest version is a lead-lag function block.

Another consideration with feedforward control is the coupling of a draft pressure change in the FD fan to the ID fan. The ID fan is sized much larger than the FD fan because there is a significant volume change between combustion air and flue gases. The volume change is mostly due to the temperature increase. The ratio between the FD and ID fans may not correspond to the ratio of gas volume change. In Figure 2, a proportional constant converts the FD fan flow to ID fan flow equivalent. This method assumes that the volume expansion ratio is constant and that flow rates through each fan are linear with damper position. In reality, furnace temperature changes with firing rate. Also, air flow is not linear when regulated with dampers. Fortunately, any deviations from theoretical are compensated for by the PID portion of the control algorithm.

Figure 2 is a common control strategy for a balanced draft furnace control with only one FD fan and one ID fan. Furnace draft control can be challenging when complex furnace dynamics are present. For example, stokers, solid fuel burning furnaces, have multiple dampers to control combustion airflow across the grate. Some furnaces recirculate combustion air in order to reduce NOx formation. In addition to the FD fan damper, these furnaces have internal dampers to control the recirculation rate. Furnaces with complex dynamics require more advanced control strategies. The Siemens combustion management system has the versatility and built-in functionality for a complete furnace pressure control solution.

APPLICATION SUPPORT

User manuals, addresses of Siemens sales representatives, for additional application support, and other application data sheets, can be found at www.usa.siemens.com/ia. To reach the 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 Software.

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