

Pulse-Firing Technology

Combustion System Retrofit at Superior Forge

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High-performance control components are essential for all pulse-fired combustion systems. Due to rising fuel costs and ever increasing concerns about product quality, there has been an increased demand for pulse-fired combustion systems in recent years to meet these challenges. In addition, improved control technologies using PLC-based control systems are being incorporated to enhance the performance and flexibility of new state-of-the-art pulse-fired combustion systems.

In mid-2005, Hauck, in conjunction with Robbins Industrial Furnace Company (formerly 'The Furnace Works'), proposed a unique pulse-fired combustion system to Superior



Fig. 1 - Car-bottom heat-treating furnace

Hauck Manufacturing Company has been providing pulse-fired combustion systems in North America for more than 20 years with many successful installations. Pulse firing was first introduced in Europe more than 30 years ago.

Forge and Steel Corporation (Superior) in Lima, Ohio. This system was to be used in a retrofit project of a car-bottom heat-treating furnace.

Furnace design was performed by Robbins of Sheffield, Ohio. The company was founded in 1994 to provide innovative solutions for industrial furnace refractory and insulation applications. Robbins also provides services including combustion system design and construction.

Superior is an ISO 9000 certified company formed in 1991. The company's primary product is forged, hardened steel rolls for hot and cold rolling of ferrous and non-ferrous materials. Other products include commercial ingots, specialty forging, heat treatment and machining. The company also maintains facilities in Pittsburgh and New Castle, PA.

This furnace project was to rebuild a furnace approximately 32 feet long x 15 feet wide x 17 feet high. The project included a new car, ceramic-fiber lining, flue modification and a new combustion system. A typical load consists of steel rolls of varying sizes with weight ranging from 60,000 - 130,000 pounds. The required heating cycle was needed to obtain the required steel metallurgy. The product cycle heats the load from ambient to 1800°F with long holds at various temperatures followed by a controlled cooling cycle. A typical heating cycle is shown in Figure 2.



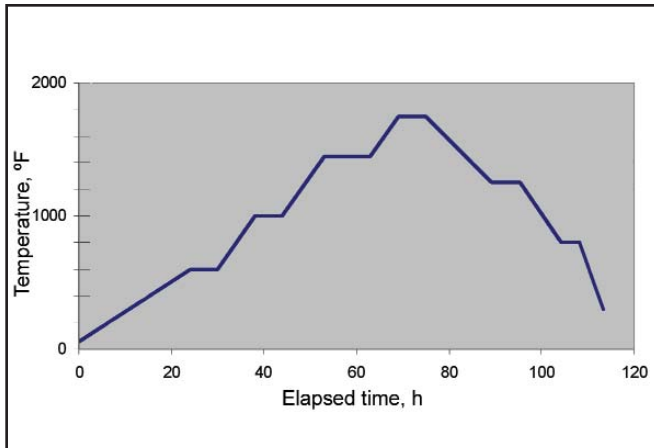


Fig 2. - Typical heating cycle

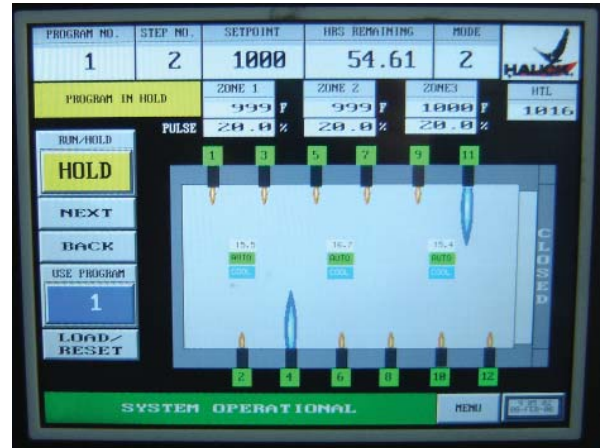


Fig 3. - Pulse-firing control screen

The Challenge

The challenge was to provide a combustion system that can meet the temperature uniformity requirements with a load that can vary dramatically in weight for both the heating and cooling sides of the thermal cycle. A standard pulse-fired combustion system did not have enough flexibility to do the job because of the large range of input requirements at different times of the cycle with long holding periods - especially at lower temperatures.

Keep in mind that the furnace construction was now ceramic fiber, and the furnace heat loss was very low. To maintain furnace temperature uniformity during a long hold cycle with very low heat input demand is difficult. The solution was to provide a pulse-fired combustion system with heat/cool control. The burners would pulse fire stoichiometrically, full excess air or air only based on temperature demand.

A minimum firing frequency is required to maintain uniformity in the furnace. Since there would be no energy coming from the burners during a low demand period, uniformity would not be achieved. If a control philosophy was not used to address this condition, furnace

temperature uniformity and product quality would be compromised. To accomplish this, a PLC-based pulse-fired control system was provided. Each zone had four thermocouple inputs. The customer could select which thermocouple to use for control or use an average of all four thermocouple inputs based on load configuration.

Hauk Pulse Control System

The system was comprised of 12 Hauk SVG 125 burners and necessary control components arranged in three zones with pulse-fire control. The SVG 125 has a rated capacity of 1,023,000 Btu/hr. The burners were arranged to fire from the top on one side of the furnace and near hearth level on the opposite side to maxi-



Fig. 4. - Hearth level SVG burner

mize the convective heat transfer of the furnace.

Pulse firing is a specialized type of cross-connected control utilizing frequency modulation rather than amplitude modulation. A Kromschroder air-solenoid valve at each burner with adjustable minimum and maximum flow settings replaces the typical modulated air valve. Low-fire gas input is set by a bypass in or around the pulse regulator.

Each burner is ignited at low fire. Each time the air solenoid is energized, the burner switches from low-fire to high-fire operation. This uses the entrainment and stirring action benefits of high-velocity burners to their best advantage. Also, because the air and fuel piping to each burner is identical, changing the pulsing sequence or even moving a burner from one zone to another is all done electronically.

Benefits of pulse firing include:

- Up to 30% fuel savings
- Enhanced convective heat transfer
- Excellent temperature uniformity
- Lower NOx emissions
- Versatility of control scheme
- Heating and cooling cycles
- Improved turndown
- High/low or on/off control

Pulse Control System Design

Because of the increased on-off cycling that is at the heart of pulse firing, high performance control valves are important to ensure repeatability and durability yet remain cost effective. The Kromschröder air-solenoid valve and pulse regulators are designed and rated for millions of cycles. Typical factory testing is for a 20 million cycle life expectancy.

Each high-velocity SVG burner is equipped with a pulsing air-solenoid valve. The burner air pressure is cross-connected to the pulsing ratio regulator. The air solenoid valve is energized during the pulse cycle for approximately six seconds. During the pulsing duration, the burner is operating at its optimum high-fire design pressure. After the pulsing duration has elapsed, the burner returns to its low-fire position. This ensures that the desired maximum effect of the high velocity burner is utilized.

The pulsing ratio regulator is designed to maintain air/fuel ratio before during and after the pulse duration. To illustrate the performance requirements of the valves, a furnace operating 16 hours a day for 300 days would require the air solenoid valve and ratio regulator to pulse more than 2,800,000 times.

The heating/cooling system incorporated with pulse-firing control enables the combustion system to

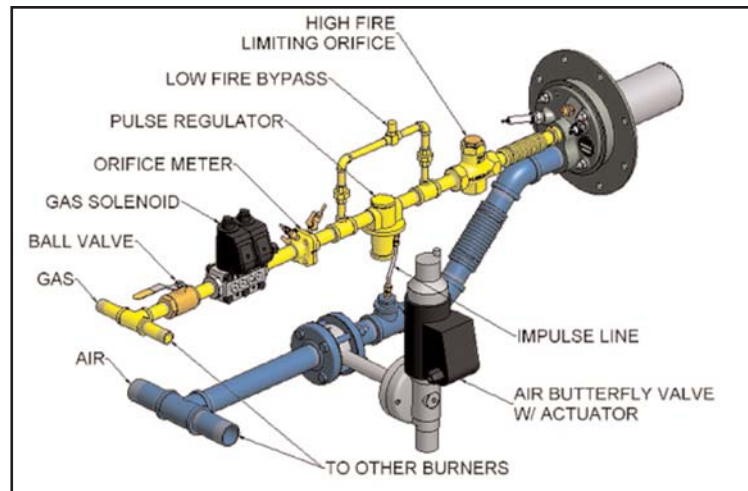


Fig. 6 - Typical pulse-firing control design

achieve excellent temperature uniformity and system turndown throughout the heating and cooling cycle.

The furnace has been in service for approximately 24 months, and Superior Forge is very satisfied with performance. Temperature surveys show that the uniformity achieved is better than the $\pm 10^\circ\text{F}$ required.

Conclusion

Hauck's high-velocity burners combined with high-performance Kromschröder control components met the challenges posed by the long heating/cooling cycles required by Superior Forge. Temperature uniformity and product-quality goals were achieved with this unique application of pulse-firing technology.

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