

# What Can Your Combustion System Do For You?

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In today's competitive market environment, heat treaters must focus on higher productivity, lower costs, increased product quality, and reduced environmental impact. Therefore, increasing throughput while simultaneously reducing per-unit fuel consumption and pollutant emissions are the keys to current and future success in the industry. Meeting the challenges to achieve these objectives will in large part be tied to improving the combustion system through the use of:

- Air/fuel ratio control
- Preventative maintenance
- Pulse firing
- Preheated air
- Recuperative systems

## Air/Fuel Ratio Control

While improvements, upgrades, and replacements of furnace systems, controls, and burners will help achieve the above objectives, an area that cannot be overlooked is simple air/fuel ratio control.

Hauck, a product brand  
of the Elster Group



Advancements in burner designs, recuperative systems, and pulse-fired control algorithms are just a few of the technological improvements available to the heat treating/thermal processing industries to reduce energy costs.

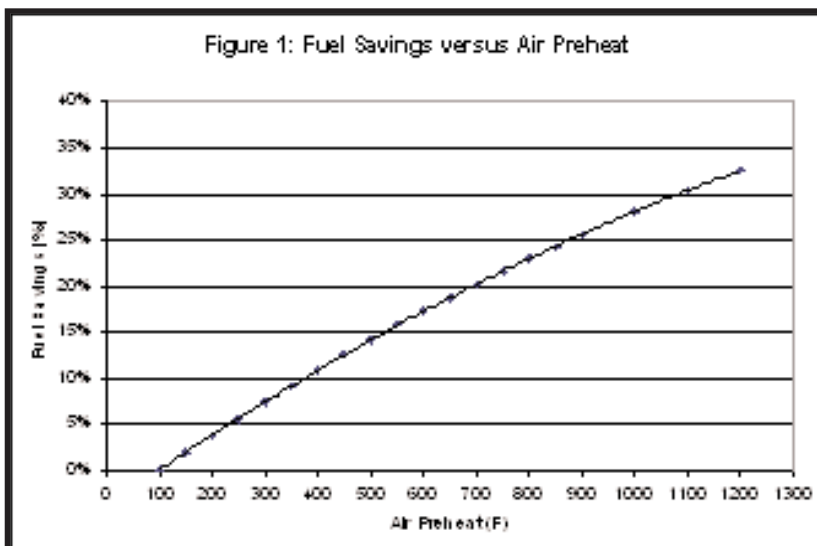


Fig. 1 - Fuel savings versus air preheat temperature at a furnace temperature of 1900°F (1040°C)

Assuming a cold air combustion system with 1900°F (1040°C) furnace exhaust temperature, simply tuning the burners to operate with 10% excess air will result in a 15% fuel savings. Few companies would argue over saving 15% in what is often the highest cost of production.

### Preventative Maintenance

The best maintenance practices, such as repairing worn or damaged refractory or insulation, checking door seals, and ensuring positive furnace pressure via exhaust damper operation, will go a long way toward increasing overall furnace efficiency. Maintaining proper air/fuel ratio of the combustion system and eliminating air infiltration into the furnace not only will maximize fuel efficiency, but also will typically lower NOx emissions. A few hours spent on combustion system tuning and maintenance every six months can result in significant, ongoing energy savings.

### Pulse Firing

Many heat treating operations have used pulse-fired combustion control systems resulting in reduced fuel consumption, excellent temperature uniformity (product quality) and, in many cases, lower emissions. Pulse firing uses multiple high-velocity burners that fire high-off or high-low to control temperature input. Burners are at or near their maximum firing rates when 'on'. Therefore, they yield the highest possible convective heat transfer, which continuously moves the products of combustion (POC) through the entire furnace resulting in excellent temperature uniformity, and therefore, the best product quality. Furthermore, this frequency-firing method will reduce fuel consumption because the burners are only firing at their most efficient high fire rating, which maximizes the energy

reaching the product. Pulse firing will actually reduce pollutant emissions like NOx because typical high velocity burners actually produce higher concentrations of NOx at lower firing rates (with turn-down).

### Preheated Air

While heat treating processes are implemented in differing furnace designs with a variety of control methodologies and atmospheres, the principles behind reducing per-unit cost via improved combustion system efficiency (otherwise known as available heat) are similar. Preheating the combustion air is a well-known, effective technique to reduce fuel consumption. As carbon dioxide (CO<sub>2</sub>) emissions come under more strict government regulations, additional benefits of preheating the combustion air include reduced CO<sub>2</sub> emissions as well as increased productivity via the increased furnace throughput. Figure 1 shows a graph of fuel savings versus air preheat temperature of 1900°F.

How does preheated air save fuel?

- Preheating the combustion air reduces the heat required for products of combustion to reach exhaust gas temperature, resulting in less fuel required to do the same work
  - Flame temperature is increased
  - More heat is available to heat the load or do useful work.

### Recuperative Systems

Air preheating techniques include the use of plug-in recuperators (Fig. 2) or single-ended radiant tube burners for indirect firing, and central recuperators or regenerators for direct fired furnaces.

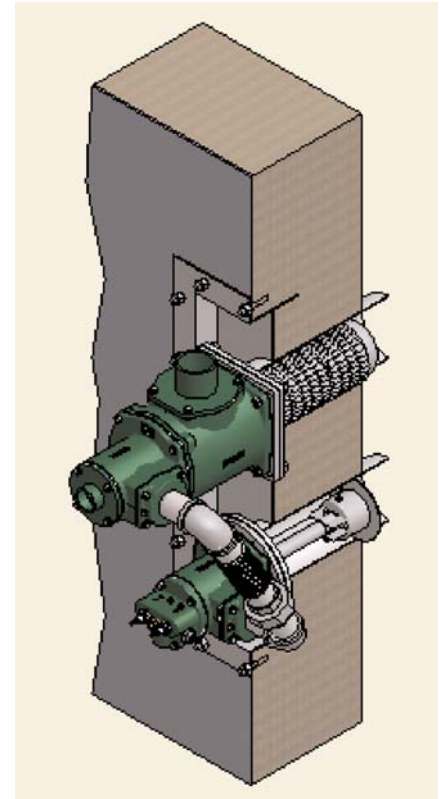


Fig. 2 - Radiant tube burner and plug-in recuperator

Recent technology advancements in direct-firing applications include a recuperator direct coupled or integrated into the burner design such that the flue products from the furnace are educted or drawn around the recuperator to preheat the combustion air to the burner (Fig. 3). Such designs are being widely implemented not only for their efficiency but for their simplicity of field piping and burner setup.

Burners equipped with built-in recuperators can be installed, set up, controlled, and maintained more easily than burners fed from a central recuperator because the air up to the point of burner connection is still ambient. This eliminates the need, expense, and maintenance of hot air piping.

Self-recuperative burners such as the Ecomax (Fig. 3) are typically pulse fired high-off. High-off pulse firing results in the benefits that were previously discussed with the added fuel efficiency of operating with hot air.

Efficiencies of self-recuperative burners tend to be higher than indirect (plug-in or central recuperators) as heat losses are less than systems incorporating additional piping and hot air-control components. Added benefits to the heat treating operation include better temperature uniformity of parts with potentially fewer rejects. In terms of fuel savings, a direct fired self-recuperative burner with 1100°F (595°C) air preheat in a 1900°F (1040°C) furnace would save approximately 32% on the fuel bill versus an ambient air fired burner.

The fuel savings benefits of preheating combustion air via a recuperative system are obvious. However, one potential downside is higher NOx emissions which, with conventional burners, typically increase with air temperature. Fortunately, there are several technological advancements in burner design in recent years to alleviate this problem. One approach in direct-fired burners is extreme delayed mixing of the fuel and air streams, termed Invisiflame® by Hauck. Compared with conventional nozzle mix style burners, the Invisiflame® process stages the mixing of fuel and air such that flame temperatures are dramatically reduced, even when using preheated combustion air. Figure 4 shows such a burner. A corresponding Fluent® computational fluid dynamic (CFD) illustration of the temperature field in the burner flame region is shown in Figure 5.

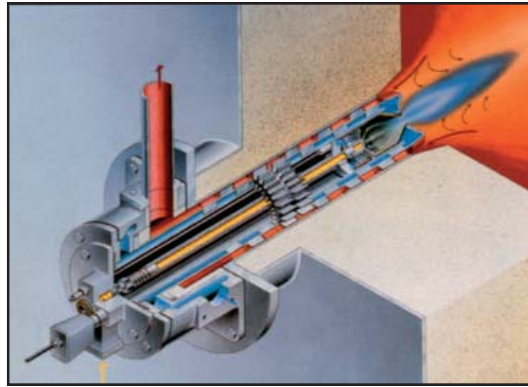


Fig. 3 - Ecomax direct-fired self-recuperative burner

It demonstrates that despite 900°F (480°C) preheated air, the peak flame temperature is only about 3000°F (1650°C), resulting in very low NOx emissions levels.

**Conclusion**

Advancements in burner designs, recuperative systems, and pulse fired control algorithms are just a few of the technological improvements available to the heat treating/thermal processing industries. These advancements, when combined with good operating and maintenance practices, can lead to substantial cost savings, increased productivity, improved product quality with fewer rejects and reduced downtime.



Fig. 4 - TriOx ultra low NOx staged air burner

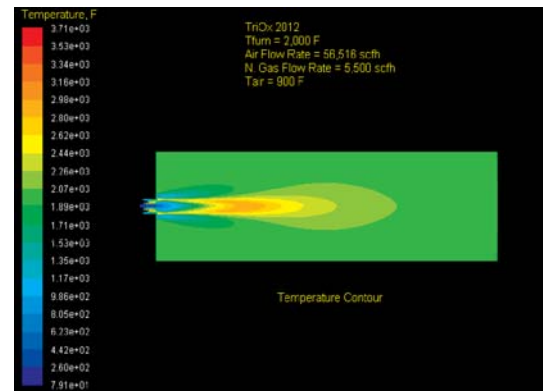


Fig. 5 - Fluent® CFD temperature field of TriOx burner with preheat

As with any industry, there is no one burner, one control method, or one system that will act as a magic wand for increased productivity, improved product quality and reduced fuel costs. There are advantages and limitations for all system types. In the final analysis, the question remains: What change, upgrade or improvement will be the best choice to achieve your goals?

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