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Energy Conservation Benefits With Process Control

By Jim Oakes
Super Systems Inc., Cincinnati, Ohio

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Jim Oakes – Super Systems Inc., Cincinnati, Ohio

Energy conservation is the exercise of optimizing the quantity of energy used. In today's economic environment, with strict regulations and competition for resources, industrial users of energy are challenged with trying to minimize their energy footprint.

As global demand for natural resources sharply increases, costs are escalating. According to U.S. government statistics from the Energy Information Administration (EIA), in late 2006, average spot prices for natural gas were $6-8 per MMBtu. In the first quarter of 2008, natural gas prices had increased to $9-10 per MMBtu. Many experts and commodity traders expect the price to reach $14-16 per MMBtu in the near future. Spot price was $13.00 on July 3, 2008.

Energy conservation can be looked at in many different forms. Well-thought-out plans by large-scale manufacturing operations, which incorporate the latest techniques in fabricating components and building finished goods, yield better use of resources. Heat treating, in general, delivers stronger, lighter, more durable products. A heat-treated part requires less overall energy to transform the part than to reproduce it.

Currently, the metal-treating industry is challenged with delivering the highest quality parts in a competitive environment while costs are rising. Energy conservation is the most economical solution to the increase in energy costs. Many companies are experimenting with alternative processes to traditional heat treating, but the largest majority of heat treaters are looking at the current operation trying to find ways to optimize the existing practice. Today's technology provides heat treaters with opportunities to be more efficient through the use of sensors, process control and access to information.

Combustion

Heat treating requires the use of extreme temperatures to alter the structure of a part or raw material to meet a desired metallurgical result. Although heating is not the only method used for heat treating, it is by far the largest. Many of the "extreme temperatures" are achieved by combustion systems using natural gas or electricity.

During a typical combustion reaction, air and fuel are supplied to a burner with just enough air to ensure complete combustion. Supplying too much air to a burner lowers the efficiency because the excess air absorbs heat. A chemical analysis of the flue gas will indicate the air-fuel ratio in a closed-loop system. Process controls, along with 0_2-sensor technology, allow for in-situ monitoring of oxygen on the burners. Taking into consideration the multiple variables involved in this process such as high fire, 0_2 and sensor temperature, the percentage of excess oxygen can be measured and the burners adjusted using trim control in real-time.

The ability to control excess air has a significant effect on the efficiency of the burners. "At a temperature of 1750°F, with Eclipse sealed burners and Bayonet recuperators – at 3% excess oxygen – your burners operate at 65% efficiency," said Bill Hopson, an applications engineer from Eclipse. "Each 2% increase in excess-oxygen measured decreases your efficiency 3-5%."

The obvious benefit of properly adjusted burners is more efficient heating. The more effective the heat-up time, the more efficiently loads are completed. Shorter heat-up time leads to more loads, yielding greater utilization of the equipment and a less wasteful use of resources. Many heat treaters have a procedure in place to manually monitor burners using portable handheld devices. Alternative solutions to the manual monitoring of burners include in-situ oxygen monitoring with real-time process-control technology for alarming and trim control for burners reaching an "out-of-balance" condition. The use of this technology provides a real-time approach to efficiency and resource utilization, resulting in a cost-competitive operation.

Endothermic Generators

Generated endothermic atmosphere is used in many heat-treating applications.

Fig. 1 Cost of endothermic-gas burn-off with natural gas prices at $10 a MMBtu/Decatherm

Endothermic Gas Burn Off	Annual Cost	Carbon Emissions
500 CFH	$14,441	79 Metric Tones
1000 CFH	$28,881	158 Metric Tones
1500 CFH	$43,322	237 Metric Tones

The consistency of the gas produced and availability of natural gas – along with low maintenance – make the generator a popular source of atmosphere for hardening, stress relieving and carburizing processes. The traditional endothermic generator produces a fixed amount of endothermic gas, which means a fixed amount of natural gas being used by the furnaces and any excess gas being burned off. With high gas prices, even small "burn-off" flames can have a large cost. This waste also adds to carbon emissions. A significant way to reduce endothermic-gas production costs and carbon emissions is to eliminate the waste created by this burn-off.

Historically, with a typical generator mixer or carburetor setup there are limits to the generator's turndown capability. The generator does not easily compensate for changes in furnace demand. The inflexibility of the controls is why a generator with a carburetor will typically be set up to run at a constant output. The result is that any gas not being used by the furnace is burned off or wasted. As the furnace demand changes (furnaces are brought on and off line), the typical generator with a carburetor does not compensate for these demand changes. Years ago when natural gas prices were $2-$3 per MMBtu, this waste was not considered a major issue. In today's high-cost energy climate, however, this burn-off may be at a considerable expense.

Microprocessor-based solutions are on the forefront of energy savings for endothermic-gas generators. The "fuel-injector"-based system replaces the existing carburetor setup with an "on-demand" injection system. "The EndoInjector is a patented fuel-injection system that automatically compensates for changes in demand to only make as much endothermic gas as the furnaces require," explained Eric Jossart, vice president of Atmosphere Engineering. Using this state-of-the-art process-control technology and sensors, it measures the back pressure from the furnace and controls the necessary flow with the precise mixture of natural gas and air to meet the desired endothermic-gas composition. "The system is designed to maintain a constant output pressure, and any sudden decease or increase in back pressure will automatically be adjusted for by the EndoInjector," Jossart said.

A small incremental change to existing capital equipment has significant impact to the bottom line. Because of the wide use of endothermic generators, the use of demand-based equipment plays a significant role in the heat treater's ability to remain competitive and be energy conscious.

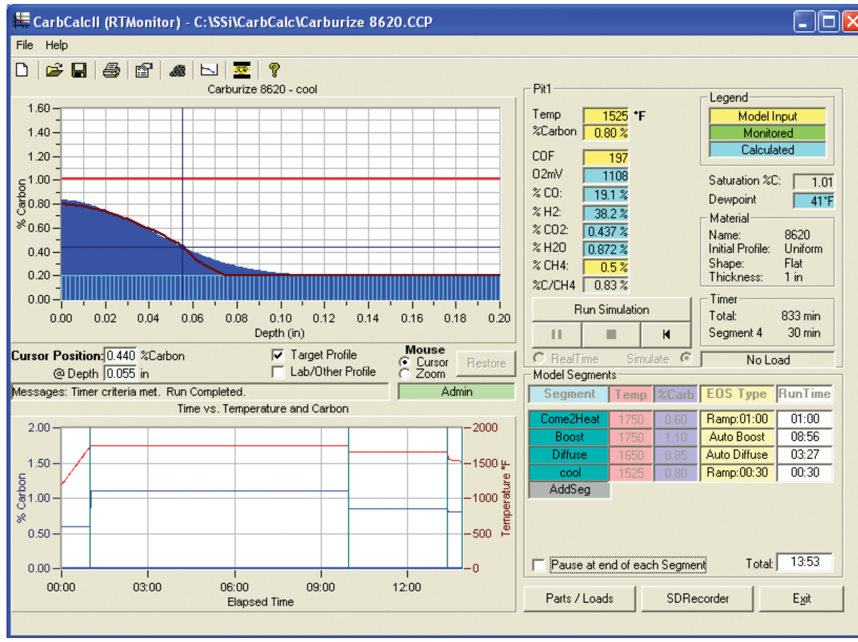

Fig. 2. Carbon-profile modeling programs provide a predictive approach to minimizing the time in a furnace.

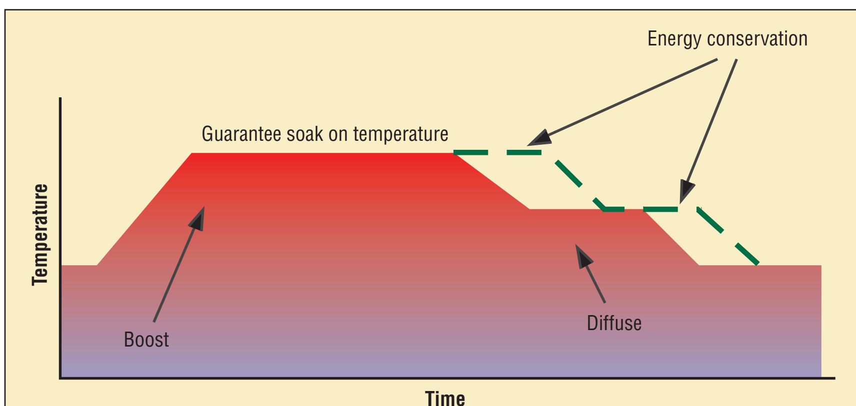

Fig. 3. Control technology helps to reduce cycle time, resulting in energy and atmosphere savings.

Programmable Controls

Process control in the heat-treating industry uses standard techniques to run the process for a predetermined time after the furnace has a specified temperature, giving the parts an opportunity to achieve thermal equilibrium. Multiple variables are used to determine a number of the inputs utilized to provide precise control. More precise controls with more variables on which to make decisions are readily available today. The technology and techniques used in heat treating not only provide quality results, but they enable operations to be more energy conservative.

Software applications such as carbon-profile modeling programs (Fig. 2) provide a predictive approach to minimizing the time in a furnace. This is accomplished by using simulation to determine the most optimal process to meet the desired metallurgical results. "We have used the Carb-CALCII simulation program to reduce many of our processes," said Marcio Torres Boragini of Maxitrate in Sao Paul. "We have saved over two hours on some of our cycles by modifying the temperatures and carbon potential at different segments on our carburizing cycles."

Simulation software is now being used to evaluate processes in real time. Controlling the process based on actual values of temperature and carbon is being used to evaluate the diffusion of the carbon. This information is then used for precise timing of the boost and diffuse segment in the program, and only the time for each step to achieve the desired metallurgical results is needed.

Today's available control technology provides information that can be used to make informed decisions. Many companies look at information such as the percent output of the controller to determine when temperature equilibrium is reached. This approach reduces the cycle time by allowing the advancement of a program at the point where the load is considered "at heat" and not using a conservative soak-time method, which may extend the time of a cycle using more gas or electricity for heating and maintaining atmosphere (Fig. 3). Other "at-heat" requirements use additional load thermocouples so that during soak cycles the part temperature can be monitored at multiple positions in the load. This not only promotes quality but also can be used to efficiently run a process to its true cycle.

Control functions today allow for the use of different tuning parameters based on specific program segments or temperature set points. The benefit of using these functions to meet process requirements such as heat-up time or overshoot suppression generally achieves faster "at-heat" times.

Low-Pressure Nitriding

Traditional gas nitriding is performed in vertical retort furnaces at temperatures that allow parts to be altered by adding nitrogenous gas. Much of the current gas nitriding is performed using manual procedures with gas flows and periodic burette checks for atmosphere. Today, state-of-the-art sensors and process controls are available that take a labor-intensive manual process and replace it with an automated system. By using this newer technology, more precise control allows for better quality and shorter cycle times that meet the desired metallurgical results. This reduces scrap, process gas, heating time and labor hours required.

An alternative method for this process includes low-pressure gas nitriding. With operations performed in a horizontal vacuum furnace, the load is heated to the necessary temperature for nitriding. Heat-up rates are decreased due to the absence of a retort. "The overall reduction in cycle time is about 50%," said Bill Jones of Solar Atmospheres. The furnace and control system is designed for precise control with less consumption of resources required for delivering quality nitrided parts. "A secondary advantage to low-pressure gas nitriding is there is no alloy reacting with the ammonia, which results in 1/3 less ammonia flow," Jones added.

Conclusion

Energy consumption as it relates to process control is continuously improving with advancements in technology. More access to information, better controls, more precise sensors and advancements in processes all contribute to reducing the energy footprint utilized in heat treating. Heat-treating operations look at incremental payback for control, sensor and furnace technology implemented on existing and new capital equipment. Microprocessor control technology provides more efficiency through real-time measurement and adjustments based on sensor readings and demand. Significant benefit also comes from operational efficiencies. Maximizing loads with the use of tighter process control and alternative cycles delivering desired metallurgical results are allowing operations to push through more poundage with the same energy footprint. **IH**

For more information: Contact Jim Oakes, vice president business development for Super Systems Inc., 7205 Edington Drive, Cincinnati, Ohio 45249; tel: 513-772-0060; e-mail: joakes@supersystems.com

Additional related information may be found by searching for these (and other) key words/terms via BNP Media SEARCH at www.industrialheating.com: energy conservation, oxygen monitoring, endothermic generator, carbon diffusion, soak time, low-pressure nitriding