August 2014

Industrial Heating®

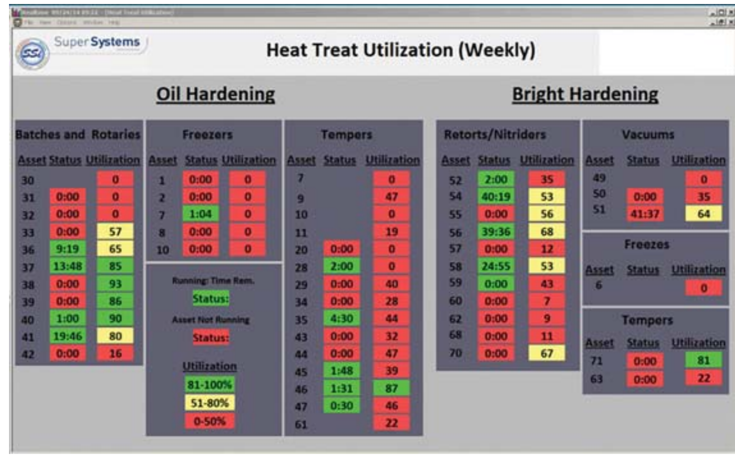
THE INTERNATIONAL JOURNAL OF THERMAL TECHNOLOGY

AUTOMATED CONTROL OF HEAT-TREATING PROCESSES: Technology, Data Acquisition, Maintenance and Productivity Gains

SSi Atmosphere Vacuum Gas Nitriding Sensors
SuperSystems

by Jim Oakes, Jeremy R. Merritt –
Super Systems, Inc.; Cincinnati, Ohio

Automated Control of Heat-Treating Processes: Technology, Data Acquisition, Maintenance and Productivity Gains



Jim Oakes, Jeremy R. Merritt – Super Systems, Inc.; Cincinnati, Ohio

Heat-treating processes are unmistakably diverse. Furnaces are built and tuned for carburizing, carbonitriding, ferritic nitrocarburizing (FNC), annealing, tempering, nitriding and vacuum heat treating (among other processes).

These processes require different types of gas generation; soak and quench times; and atmosphere and temperature control. Yet, despite different requirements, control of these processes can be divided into two general categories: traditional and automated.

Traditional control has been used for many decades. Its success depends on manufacturing experience, trial and error, a lot of paper and a certain amount of vigilance from people operating the equipment. A typical example of traditional control would be as follows. A furnace operator sets up a load manually, charges the load into the furnace, and manually sets temperature and atmosphere parameters. As process values approach setpoints, the operator checks his watch and periodically writes values on a clipboard, all the while hopeful that no deviations take place during the run. If deviations take place, the load may need to be scrapped or reworked. The operator learns "what worked" and what did not. For logging of data, a printer records data on paper.

Automated control differs from traditional control mainly in that automated control replaces manual control and monitoring, with computers and software designed specifically to control heat-treating processes. Instead of requiring an equipment operator to set up and charge a load manually, load-entry software can control the timing of a charge and electronically record all of the load parameters set up by the operator. Output is set and changed by a process controller, such as a loop controller designed specifically for heat-treating processes, or a programmable logic controller (PLC). The load-entry system automatically runs a pre-programmed recipe based on the part or parts in the load (Fig. 1). If the controller detects a process deviation or a condition likely to result in one, it can make adjustments or generate a process alarm if operator intervention is needed. Information is delivered through mobile devices to operators, supervisors or even maintenance based on an escalation and profile of the alarm and recipient. Data logging is electronic, and logged data points can be accessed at any point in the future.

There are benefits and drawbacks to both traditional control and automated control. Table 1 illustrates both.

This article will discuss specific aspects of our experience with automated control of heat-treating processes – technology shifts, data acquisition and maintenance – and how automation can be used to improve productivity at the plant level.

Table 1. Benefits and drawbacks of traditional and automated control

	TRADITIONAL	AUTOMATED
BENEFITS	• Lower up-front cost • Initial training is easier • Benefits of "manufacturing wisdom" of experienced line operators	• Significantly reduced need for operator intervention • Greater control precision • Ability to customize recipes and alarms • Ability to automate maintenance alerts • Significant cost savings possible over time due to reduced scrap and reduced rework • Reduced possibility of operator error • Opportunity to replace obsolete older equipment for which replacement parts may not be available or that may not be in compliance with industry requirements
DRAWBACKS	• Reduced ability to respond to possible deviation conditions quickly • Higher amount of scrap and rework Much higher possibility of operator error • Limits on alarm complexity	• Higher up-front cost • Reduced ability to apply "manufacturing wisdom" that comes with operator experience on the line • Additional knowledge/training requirements for operation

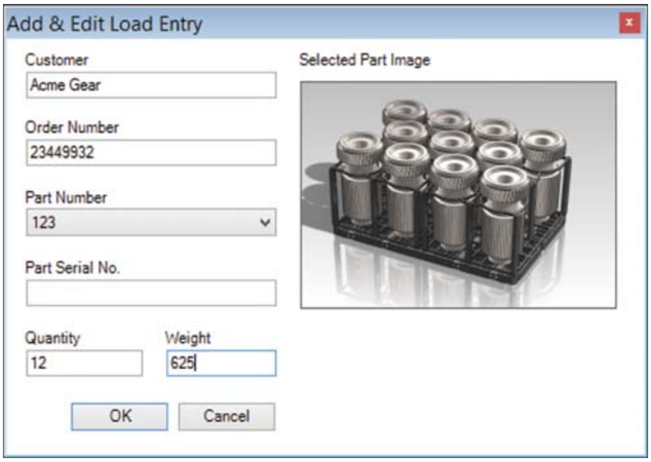


Fig. 1. Load Entry software allows a user to enter load parameters – such as order number, part information, quantity, and weight – before running a load in a furnace. This information is stored as a load record which is used for historical lookup.

Fig. 2. An operator uses a customized human-machine interface (HMI) designed to control furnace functions as part of a plant supervisory control and data acquisition (SCADA) system.

Technology and Productivity Gains

Technology has played a major role in nearly all aspects of achieving higher quality and greater efficiency in heat-treating processes. These and other factors help drive customer demands for higher quality and faster delivery. The challenge for many heat treaters is meeting such demands while justifying the cost of implementing the technology that makes it possible. Many heat treaters use *incremental improvements* to existing technology to yield positive results. In this context, incremental improvements are steps to automation. The first step may be automated recipe controls retrofitted into an existing control cabinet. A typical next step would be a plant-wide Supervisory Control and Data Acquisition (SCADA) system providing widely enhanced visibility to what is happening on the shop floor.

Today's technology is more reliable than ever before. This reliability extends to the parts of a sensor used to monitor atmosphere or temperature and to the computer system that drives an operation to be paperless. Industry standards such as AMS and CQI-9 specify procedures to help drive quality and consistency, but these often lead heat treaters to purchase new equipment or add steps to existing processes in order to achieve compliance. For example, CQI-9, a document that shows a heat-treater's commitment to quality and greater productivity, requires management review of process data and two-hour checks on processes where deviation alarms are not implemented. Many of today's controls support deviation alarms for control parameters, making it relatively easy to "check that box." Heat treaters can approach this with traditional controls, but the opportunities to reduce the amount of scrapped loads and rework often prompts management to re-evaluate that position and implement automated control.

Better technology allows for greater trust in the heat-treating process. In addition, it gives the heat treater the opportunity to free up resources for different tasks.

"Once we were able to show the operators the capacities of the automation, they were able to concentrate on the aspects of the processing that computers can't perform like racking, furnace cycle coordination and employee communication," explained Peter Hushek, fourth-generation heat treater and owner of Phoenix Heat Treating.

Phoenix Heat Treating uses control and SCADA technology, enabling operators to manage tasks more efficiently by providing alerts to cycle progress (Fig. 2). Using a monitoring and alert solution allows for plant-wide paging so that information is delivered quickly to the people who "need to know."

"The furnaces now talk back to us and create a functional communication link with the entire operation. When combined with our wireless system, the operators are in touch with the operation regardless of their location," Hushek added. "From process modeling to process control and on to communication, our controls and SCADA package have given us the command, control and communication we feel we need to maintain cost-effective processing without losing any aspect of quality control."

Data Acquisition

Data acquisition, the logging of process-related data for later analysis, has been around for a very long time. Historically, it existed with paper chart recorders and has evolved into electronic, computerized formats providing information to all areas of the business. It is almost impossible to read an article related to data acquisition (or to information technology in general) and not see the term *big data*. This term implies the fact that we are gathering more information than ever before. The challenge, naturally, becomes putting that information to good use.

"Putting data to work" is sometimes the most challenging aspect of process control. We see many customers extending data acquisition to provide valuable feedback to operators. One example of this would be furnace utilization reporting. The goal of this extension is to provide productivity information in real time.

"We have studied our operations by using data retrieved from our furnace controllers and data-acquisition package," said Tom Valenti of Specialty Steel Treating in Fraser, Mich. "With this data, we determined what realistic utilization should be for each piece of equipment and now provide real-time feedback to the entire shop floor. It helps us manage our staffing and keep minimal downtime between changeovers."

Specialty Steel Treating uses recipe-based controllers with data acquisition to streamline their operation across four facilities (Fig. 3).

What makes data "usable" is specific to each operation, and each operation is different. Business drivers in heat treating tend to be initiated from quality control, where electronic information requirements provide proof of traceability or of meeting industry requirements such as CQI-9 and AMS 2750. We find that quality is the biggest driver for investments in data-acquisition technology, but the benefits should not stop there. Every part of the business – operations, quality, sales and maintenance – can benefit from a data-acquisition strategy. Information can be gathered from all areas of a business and evaluated holistically to make better decisions on current operations.

Hushek (of Phoenix Heat Treating) talked about the benefits of one automated solution with data acquisition. "Our system has allowed us furnace processing accountability through desktop monitoring throughout our 24-hour cycle. The control capabilities have given the operators command over the process, which means a good operator can run more furnaces with less labor, greater focus and reduced anxiety about the process repeatability."

A recipe-based controller follows a mapped out, simulated process to ensure proper case requirements, which reduces time during the cycle, generates alarms in the case of deviations and provides complete traceability of the process.

Benefits to Maintenance

Preventive-maintenance programs are common to all heat-treating operations, and all of them are well-intentioned. In our experience, a large percentage of maintenance is *reactive*. When maintenance is reactive, unplanned downtime takes place with a significant impact on production planning as well as the possible load impact of rework or scrap parts. Preventive maintenance is planned, with planned activities and planned downtime that allow the maintenance department to work around production schedules. Data-acquisition and control technology both provide additional parameters (for example, the operating time of an element, pump or burner or the number of times a door has been opened and closed) useful for ensuring that maintenance is less reactive and more preventive.

By using existing inputs and outputs on controllers and PLCs, operators can set specific timers and counters, which are extremely useful when determining when certain maintenance tasks should be planned or considered. With an established baseline, quick evaluation of real-time versus historical information can identify problem situations. Taken a step further, notification software can be used to automate e-mails and text messages to key personnel.

Conclusion

While traditional control methods continue to be used and can be effective when employed, they lack the precision and customizability of automated methods. By utilizing specialized process controllers and software, automated control systems help enhance productivity through real-time monitoring and control, leading to reduced waste and freeing up operators for other tasks.

Automated systems also form the basis for electronic data acquisition, which improves process traceability and makes it much easier to analyze data in making decisions for improving processes. Preventive-maintenance programs often grow from automated methods, reducing unplanned downtime. Instrumentation upgrades associated with automation bring many additional benefits, including:

- Increased focus on operation-specific features such as carburizing, vacuum heat treating and nitriding
- Recipe control and management, leading to fewer entry points and operator requirements
- Potential for greater operating ranges due to the ability to manage multiple parameters at the same time

Clearly, processes improve as technology improves. And while the initial cost of control upgrades may be seen as significant, these upgrades will pay for themselves many times over, and customer satisfaction will grow. **IH**

Fig. 3. A nitriding/ferritic nitrocarburizing (FNC) panel with specialized control equipment

For more information: Contact Jim Oakes, Vice President of Business Development for Super Systems, Inc., 7205 Edington Dr., Cincinnati, Ohio 45249; tel: 513-772-0060; fax: 513-772-9466; e-mail: joakes@supersystems.com; web: www.supersystems.com