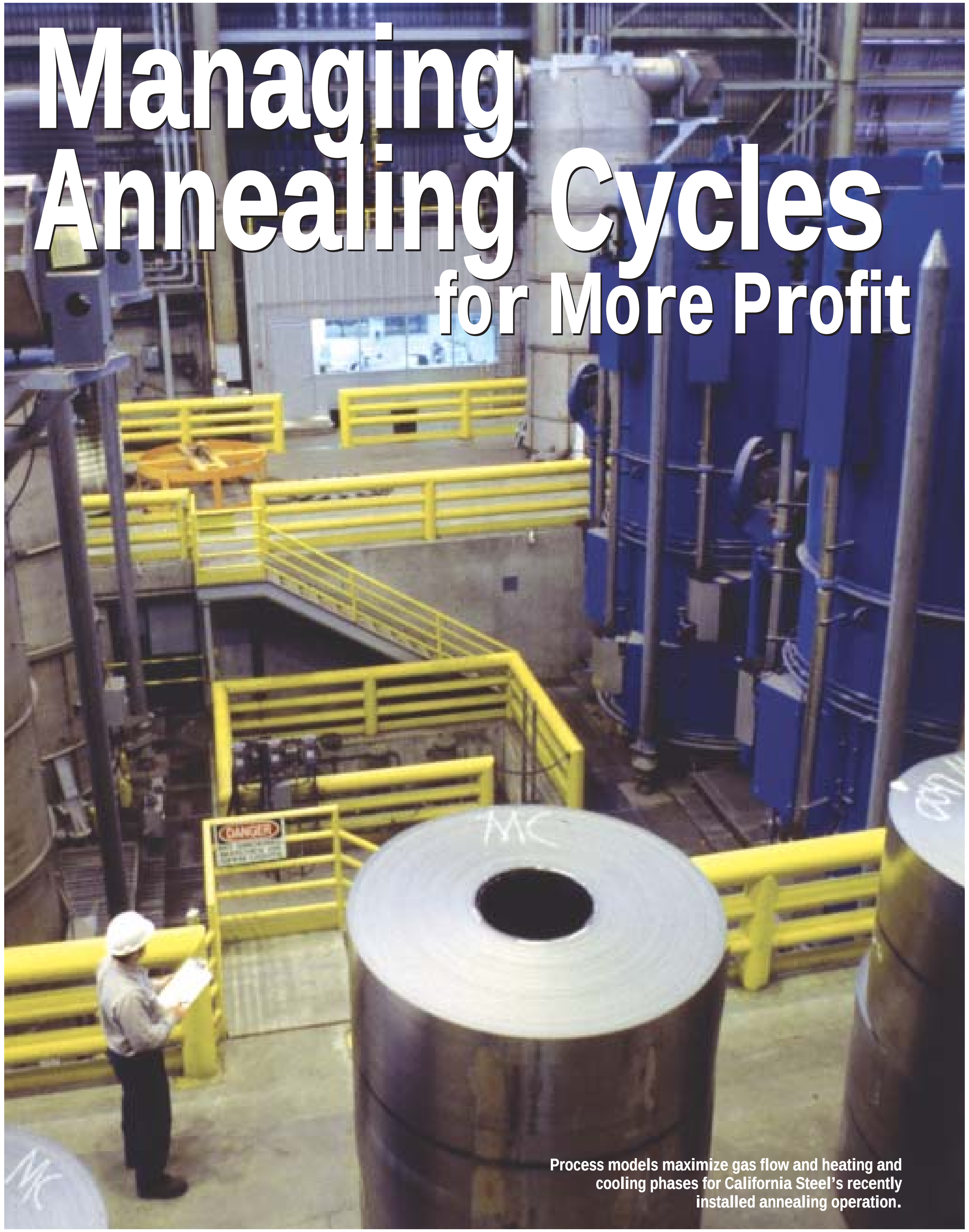
Managing Annealing Cycles for More Profit



Process models maximize gas flow and heating and cooling phases for California Steel's recently installed annealing operation.

A suite of process control modules can be used in a single-stack or multi-stack shop, using any atmospheric gas, to anneal sheet, wire, and nonferrous products. The modules are ideal for new starts, or can be retrofitted easily into an existing configuration.

BY WALLACE D. HUSKONEN, contributing editor

In October, when California Steel Industries reported the best quarterly results in the company's 20-year history, the announcement was noted with considerable satisfaction at Entec Inc., a software company specializing in control systems for annealing steel.

That's because when the Fontana, CA-based steel processor decided in 1998 to replace its annealing facilities, it assigned the turnkey project to Rad-Con Inc. At that time, Entec was working closely with Rad-Con and supplied the process-management system for the entire annealing operation. Since then, Rad-Con has purchased Entec and incorporated it as an operating division.

The CSI project was a two-phase effort. The first phase involved installing eight new bases in a coil-storage area near a strip-cleaning line. These were installed in such a way that CSI was able to use its existing furnaces in two separate shops, so that no production capacity was lost. The new equipment then replaced the 310,000-tons/year capacity of the existing furnaces, which were removed, and 12 more bases installed in the second phase. When the installation was complete, CSI had new annealing capacity totaling 360,000 tons/year for producing commercial- and drawing-quality steels.

Process management

Michael McDonald, Rad-Con vice president and general manager of the Entec division, recalls, "We were adapting our systems to existing furnaces, sort of an after-market 'add on.' With the CSI job, our system was included with the installation. It was something of a change."

Over the years, Entec has developed proprietary models to maximize the effectiveness of gas flows and heating and cooling phases, as well as monitor coil conditions like cleanliness. Its foundation is a relational database accessible from the operators' PC through Entec's Computerized Annealing Process System (CAPS).

The models take into account the coils' hot and cold spots during annealing to modify cycle parameters as needed to achieve the desired result in the most efficient way. As McDonald points out, "The models are more analytical than empirical, so they adapt very effectively to the circumstances."

The CSI installation also featured an inventory-management function that determines how to mix and arrange the coils in a charge, based on information from the plant data network. Thus, certain coils can be rushed or delayed, based on delivery needs. The annealing operation can combine or recompose charges based on order fulfillment demands, and mix or separate coils according to compatibility for an annealing cycle.

A suite of programs

Annealing shops need dependable and timely control of all aspects of the process. According to McDonald, CAPS Suite includes an array of modules and models that can be integrated to control the various elements of the process into one seamless package. They include inventory management, alarm recognition, process trending, base operation, data archiving, and reporting.

CAPS is specifically designed for the needs and requirements of the annealing operation. It can be used in a single stack or multi-stack shop, using any atmospheric gas, for sheet, wire, and nonferrous products. CAPS can be adopted as part of a new shop start-up or it can be retrofitted easily into an existing configuration.

Above all, CAPS is a supervisory control system for the anneal shop. Its Shop Overview screen displays the current shop activity, including critical information like status, control temperature, and event time for each base.

Data is entered into screens using pull down menus and check boxes. Temperature tables and graphs for current and completed runs are viewed in CAPS to monitor the process efficiently and effectively. And, the operator is notified of alarm conditions that require attention.

CAPS with optional H.60.SC integrates Level 1 HMI functions for equipment control and operation to provide one seamless Level 1+2 package. This approach streamlines communications and provides a single user interface for all shop operations.

Connecting CAPS to the plant-wide Inventory Management System allows the operator to view and edit coils available to anneal. Scheduling information, such as priority, ship week, or anneal late-start date, can be downloaded for use in building loads. This information can be used manually or by the Stacking Model option.

CAPS allows designated operators, or metallurgists, to enter cycles, or recipes, into the system. Multiple steps with different temperatures, gas-flow rates, ramp rates, and hold times can be entered for each cycle. The operator chooses the cycle to run for each load, dependent upon the coils in the load. Level 1 communication provides automatic download of setpoints to the PLC or controller at the beginning and during the cycle.

Stacking and heating

Determining the "best" coils to be annealed in a particular load is a com-

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plex and time-consuming task for annealing operators. Entec's Stacking Model simplifies load-building by allowing customers to specify multiple stacking criteria, which are incorporated into the load-building decision algorithm. Typical criteria include maximum coil overhang, allowable cycle mixing, and specific equipment or practices for particular products. Also, operators can subdivide the inventory depending upon the current shop conditions.

The Stacking Model uses an optimization routine to minimize the heating time difference between coils in the load. It also maximizes stacking height, and expedites the most critical coils without violating the shop rules. Stack weights are balanced for multi-stack bases to minimize burner trimming.

The use of the Stacking and Heating Models together make it possible to mix coils of different cycles within one charge. The Stacking Model arranges the coils into the proper positions, and the heating model calculates the charge setpoints and time to meet the requirements of each coil.

The Heating Model uses annealing-process thermodynamics to determine each coil's interior temperatures. Radiation, conduction, convection, and other components of the process are all modeled for the specific equipment and product in the shop. The hot-spot and cold-spot temperatures of each coil are used to make control decisions.

Because every coil of every charge is analyzed, a closer estimate of the required annealing time is provided. When the model determines that the last coil has met the required annealing temperature, the furnace is automatically shut off. This use of the predicted interior temperature produces shorter cycles over traditional soak-type recipes. Shorter cycles mean less furnace fuel is burned—typically the largest utility cost in a batch anneal shop. Less electricity and less atmosphere gas is used as well. And, the additional productivity can offset any perceived need for additional annealing equipment.

The Cooling Model uses a similar approach to determine when the annealing base can be unpacked. Unpacking the annealing base as soon as the cooling phase has been completed can greatly increase shop throughput while having no negative impact on quality.

The CAPS package's stacking model uses an optimization routine to minimize heating differences between coils during the annealing cycle.

Cleanliness and sticker breaking

The Cleanliness Model uses the hot-spot and cold-spot data that are dynamically calculated by the Heating model to control processing of each run. The gas stream setpoint is controlled to maintain a hot-spot temperature below the "cracking" temperature of the rolling oil used in cold reduction. The base is held at the hot-spot temperature until the cold spot for that step is reached, indicating that all the oil has been properly volatilized. Most shops use a given practice across their entire facility, regardless of coil weight, coil gauge, load size, or other factors. This practice works, but does not optimize the process.

Sticker breaks are characterized by localized welding of two strip surfaces within a strip coil, leaving a crescent shaped surface defect. The breaks may be caused by a number of factors, such as strip profile, winding tension, surface roughness, or annealing practices. The Sticker Break model uses the thermodynamic model engine to provide a profile of temperature gradients during the cycle. This thermodynamic information is necessary to determine the best control strategy. Typical parameters, such as base fan speed, cooler fan speed, bypass cooling rate, and spray water initiation, are controlled in order to maintain an acceptable temperature gradient. Although all of the causes are not related to annealing, modified operation of the annealing equipment can reduce the occurrence of breaks from other factors.

Shop optimization

Entec's Shop Optimization Model uses a Global Planning module and a Shop Planning module to maximize throughput. This provides a complete system for optimizing throughput and operating costs in the annealing shop.

The Global Planning module maximizes throughput by providing a comprehensive equipment utilization strategy for the shop using a constraint-management methodology. The optimization routine considers upstream "supplier" capabilities, downstream "customer" requirements, shop information, and data from the Budgeting Application. Output from the Global Planning module includes information on the constraint resource, equipment utilization, and loading strategy for the Shop Planning module.

The Shop Planning module uses the information provided by the Global Planning module to make operating decisions. This module schedules specific charges and equipment for the shop. Charges are built out into the future and coil load and unload times are estimated for the inventory. The optimization routine maximizes throughput by exploiting the constraint resource of the anneal shop, as identified by the Global Planning module. For example, if a shop constraint is the furnace, then the optimization routine will manage all other resources to prevent any furnace delays.

Other modules offered include the Lab Management module, for collecting metallographic and mechanical property data during sample preparation and testing; and a Reports module that adds many reports to the existing list of CAPS reports.

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CSI REPORTS RECORD QUARTER

In mid-October, California Steel Industries reported its best quarterly results ever, with net income of $46.1 million on sales of $388.6 million. Quarterly shipments of 557,980 net tons are second only to the 566,630 tons shipped in the first quarter of 2004.

Located in Fontana, CA, CSI is the leading producer of flat-rolled steel products in the western United States (i.e., the 11 states west of Rockies) based on tonnage billed, with a range of products that includes hot-rolled, cold-rolled, electric-resistant-weld pipe, and galvanized coil and sheet. CSI processes steel slab purchased from suppliers around the world, including Brazil, Australia, Japan, Mexico, South Africa, China, Europe, as well as the U.S. It employs about 1,000.

By October, year-to-date sales were $910.2 million, on shipments of 1,654,571 tons, for a year-to-date net income of $74.2 million. Shipments were 18% higher than in the comparable period in 2003, with net sales running 59% higher. Net income also rose significantly.

"As with the first half of this year, we continue to be pleased with our results," commented president and CEO Masakazu Kurushima, who admitted that favorable market conditions had much to do with the record results. CSI realized average sales price increases of 29% compared to second quarter 2004, and of 86% compared to third quarter 2003, indicative of the steel market conditions. CSI also benefited from higher levels of sales for ERW pipe products.

But, Kurushima also credited operating efficiencies and an outstanding team of employees for achieving the best quarterly results ever.

CSI sits on 450 acres, with approximately 115 acres under roof, about 50 miles east of Los Angeles.

The plant includes an 86-in. hot-strip mill, hot-rolled strip finishing facilities (build-up, shear, and slitter lines), a 62-in. continuous pickling line, a five-stand cold-reduction mill, two hot-dip galvanizing lines, cold-rolling equipment of annealing and tempering mills, and an electric-resistance-welded pipe mill.

In 1993, the company began a capital expenditure program of some $250 million to modernize and add operations. Investments included a new walking-beam reheat furnace in the hot-strip mill, a complete modernization of the five-stand cold-reduction mill, and construction of the No. 2 continuous galvanizing line and 62-in. continuous pickle line. Later, CSI completely upgraded its annealing capability by installing the 100% hydrogen anneal shop.