Automated Atmosphere Furnace Technology Optimizes Results

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Automated atmosphere furnace systems have proven success in reducing labor and manufacturing costs, while allowing companies to be cost competitive in the global market.

Automation of thermal processing equipment is a key factor in meeting the increasing demands of the heat-treating industry to increase system throughput while reducing initial capital and operating costs. In the area of atmosphere furnace systems, Ipsen International's IronHorse™ technology combines improved furnace components and control systems to reduce labor and manufacturing costs. The system includes TQ-type straight through (Fig. 1) and RTQ-type in-out (Fig. 2) integral quench furnaces with precise batch charge loading and unloading, highly efficient Recon-III™ burners, forced convection atmosphere control, Supercarb™ direct-feed atmosphere system and an endless chain-transfer mechanism, which offer improved performance compared with traditional systems. The furnace systems are suitable for completely automated carburizing, neutral hardening and carbonitriding.

Optimal heating and atmosphere circulation

Single-ended radiant tubes, consisting of an inner silicon-carbide tube for long life and an outer metal alloy tube to resist possible damage from manual handling and cracking from thermal cycling, and are fired using Recon-III burners including internal recuperators, and are individually controlled by a burner control unit. The burner combustion chamber includes separate air and combustion gas inlets. A constant gas pressure is supplied to the burner, and the airflow to each burner is the same—an arrangement that ensures maintaining optimal gas-to-air ratios, resulting in precise tuning and setup capability, high efficiency ratings (Fig. 3) and low NOx emissions (Fig. 4).

Burners can be manually shut off independent of the other burners. Therefore, in the event of a burner failure, the malfunctioning burner can be turned off, diagnosed and brought back online without losing a valuable load. In the case of a more serious failure, the entire burner can be removed from the furnace and replaced without taking the furnace out of production.

Representative IronHorse system installation

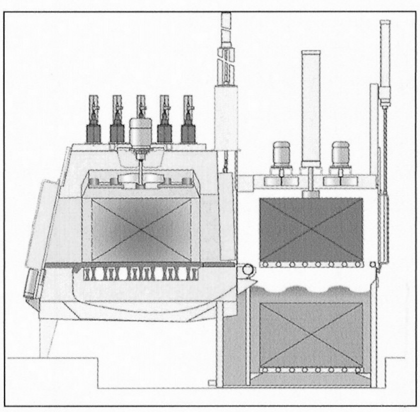

Fig 1 TQ- type straight-through integral quench furnace

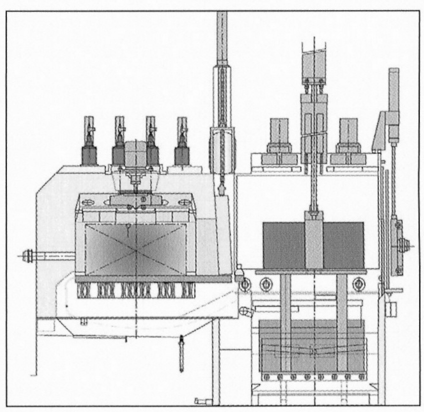

Fig 2 RTQ- type in-out integral quench furnace

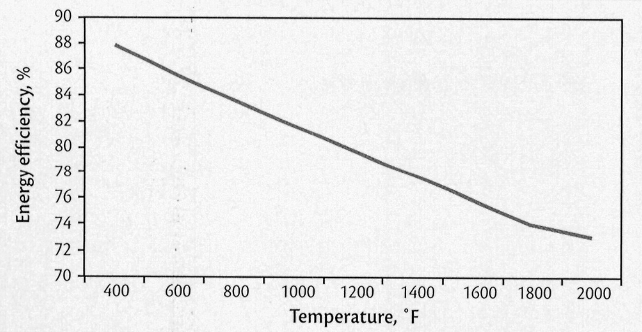

Fig 3 Burner energy efficiency vs. furnace temperature

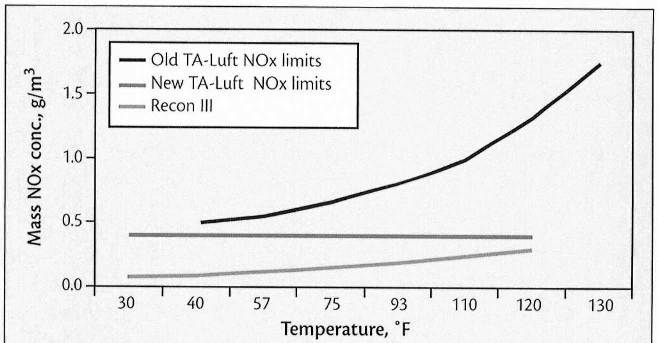

Fig 4 Mass concentration of NOx vs. preheat air temperature

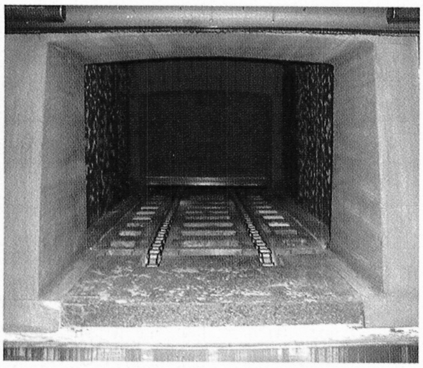

Fig 5 Full support hearth, muffle and transfer chains in heating chamber

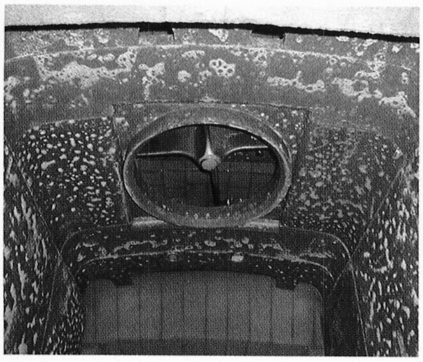

Fig 6 Circulating fan and muffle

TQ and RTQ type furnaces include a convection muffle in conjunction with a roof mounted circulation fan (Fig. 5 and Fig. 6) to uniformly circulate the atmosphere and heat through the workload from the annulus between the muffle and furnace wall where the sources reside. Unlike a system without a muffle, forced convection through the workload and chamber provides more uniform atmosphere penetration and improved temperature uniformity throughout the entire heat up and soak periods (Fig. 7), resulting in improved part-hardness uniformity.

Each chain in the endless chain transfer mechanism is equipped with one pusher dog to transfer the workload from the heating chamber to the quench tank elevator (Fig. 8). At the end of the heating cycle, the workload is pushed onto the quench chamber lower elevator position, which allows the inner door to begin closing after the load has transferred past the inner door. This offers faster "to quench" time than systems requiring the pusher dog to retract behind the inner door before it is allowed to close. The through design allows immediate reloading of the hot zone (no wait for the quench tank) enabling fast throughput.

Supercarb atmosphere system

The patented Supercarb atmosphere system provides a stable, controllable reaction gas suitable for carburizing, neutral hardening and carbonitriding (using ammonia). The atmosphere is created directly in the furnace, eliminating the need for an endothermic gas generator or a nitrogen-methanol system, and heat treatment results are equal or superior to those achieved using endothermic and nitrogen-methanol atmospheres.

A hydrocarbon gas (e.g., methane or propane) and air are directly injected into the heating chamber. The hydrocarbon gas flow rate and air flow rate are varied to control the desired carbon potential. The reaction gas com-

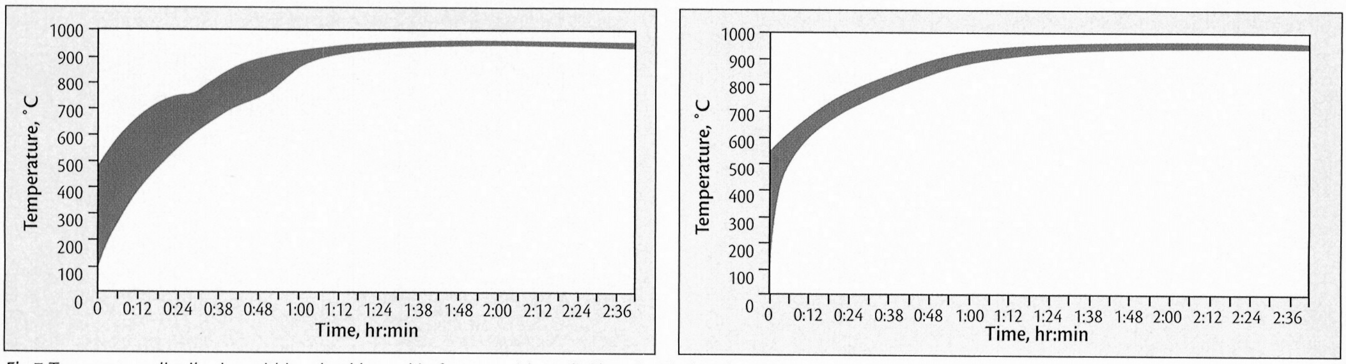

Fig 7 Temperature distribution within a load heated in furnace without (left) and with (right) muffle

Fig 8 *Transfer chains with pusher dogs in heating chamber*

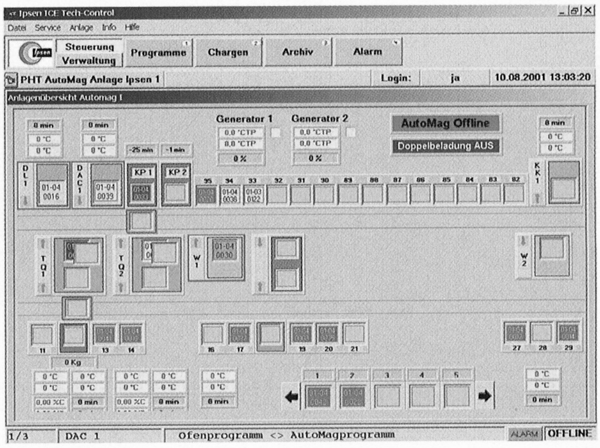

Fig 9 *AutoMag Installation Visualization screen*

prises mainly CO, H_2, N_2 and some residual CH_4.

The Supercarb atmosphere system also incorporates a CO analyzer in addition to a heating chamber oxygen probe and temperature indicator. From the measured furnace oxygen content, CO content and temperature, a computer (such as Carb-o-Prof™) calculates the carbon potential of the reacted hydrocarbon gas-air mixture.

Supercarb is suitable for a wide range of heat treating process within the temperature range of 1470 to 1830°F (800 to 1000°C) depending on the type of hydrocarbon being used and processing requirements. The maximum admissible carbon potential is dependent on soot formation at a specific temperature; values are slightly lower for methane and slightly higher for propane.

Control systems

Control systems are based on the ICTE™ (Integrated Commercial and Technical Expert) system, which enables optimizing a company's internal procedures while simultaneously rendering its own operations transparent; the software brings together all of the technological and commercial aspects of plant management. The ICTE systems incorporate three integrated or independent modules, which can be configured to suit both large and small companies, as well as commercial heat-treat shops having a wide variety of production needs and captive heat-treat shops.

An ICTE^{Com} module, best suited for the commercial heat treater, handles order processing, providing a means to estimate prices and generate formal quotations, track a job, determine job costs and handle other commercial aspects of the business. ICTE^{Tech} handles manufacturing planning such as furnace capacity optimization and load tracking, and allows program creation, modification and storage. ICTE^{Automag} can link atmosphere batch lines, vacuum furnace lines and mixed atmosphere and vacuum furnace lines, enabling reliable, unmanned operation and optimized use of furnaces with minimal delay in transporting loads.

Load specific information and parameters can be input manually or by barcode reader and stored for later retrieval, documentation or back up. A load document is automatically generated at the end of a heat treatment including all process details. The core of the AutoMag module is the Installation Visualization screen (Fig. 9) showing the

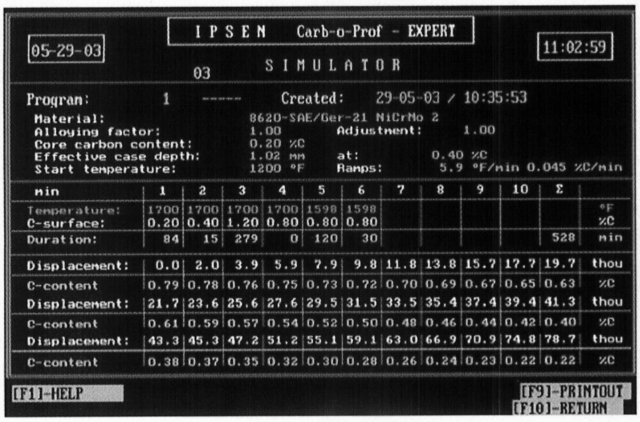

Fig 10 *Carb-o-Prof time, temperature and carbon potential-recipe development screen*

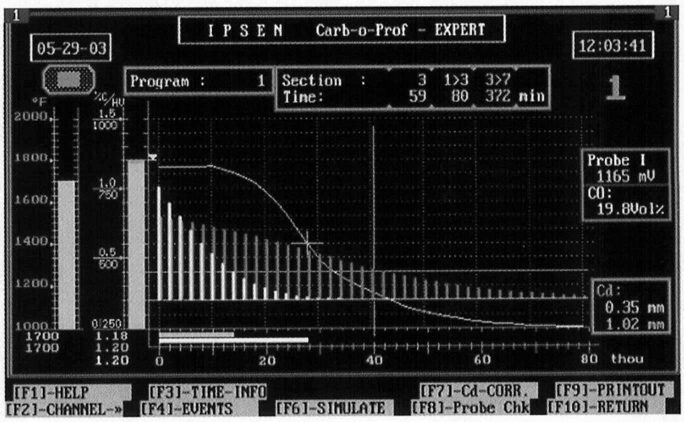

Fig 11 *Carb-o-Prof expert real-time carbon and hardness profile control*

customer-specific installation layout plus information including equipment set-points and measured values, carbon profile and temperature, specific fault-condition status of each unit, fault messages and location, etc. AutoMag tracks every movement of each load in the furnace, so it is possible to see where a charge is, where it is going to next and where it has been at all times.

Carbon diffusion control

Carbon diffusion modeling and control is conducted in real time using the Carb-o-Prof control system. Carb-o-Prof's process simulator is used to generate time, temperature and carbon potential recipes on-line by drawing from a comprehensive materials library. The Process simulator uses an interactive iterative process-simulator to demonstrate surface carbon content and carbon depth (Figure 10), while at the same time optimizing the cycle.

During actual rocessing, Carb-o-Prof continuously (1) monitors real-time process parameters, (2) calculates the process duration and the workload's real-time carbon profile (Fig. 11) from actual temperature and atmosphere values, and (3) adjusts the cycle as necessary. In addition, Carb-o-Prof helps to produce the required case depth in the shortest time by: (1) optimizing the switchover from the boost to diffuse phases, and (2) controlling the carbon level relative to the soot level at a given temperature. For example, Carb-o-Prof can be programmed to run at 10 to 15% below the soot level and controls the furnace at that level relative to the temperature. In addition, all heat treatment data are archived for later use. Lastly, it directly interfaces with AutoMag to advise of necessary load movements and routing to maximize furnace throughput.

Conclusions

IronHorse technology offers significant savings in energy costs and process time over alternative atmosphere furnace systems including 40% less energy consumption using single-ended radiant tubes with internal recuperation, 50% less natural gas requirements with in-furnace atmosphere generation compared with endothermic-gas generator, 30% reduction in atmosphere process gas consumption with small upper quench zone in type TQ furnace, reduced furnace system operator time and an increase in annual available system time (7,400 vs. 5,100 hr) when using the ICTE^{Automag} "lights out" module.

Further developments to improve the process technology include the use of primary and secondary containment of quench oil eliminating the need for pits, top cooling capability with 50% less cooling gas required, and advanced washer technology. **IH**

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