VAC AERO INTERNATIONAL INC.

HC900 vacuum Furnace Controller

Challenges of vacuum processing

Temperature control in a vacuum heat treating environment can be difficult because of the changing heat transfer characteristics of the furnace as it moves from conduction and convection to radiation. The rapid heating rate of a vacuum furnace demands precise control, including setpoint program control with soak guarantee inputs.

Overshoot of temperature set points is usually not tolerated for metal treating applications.

Setpoint program control is often applied to both the temperature and the vacuum, with extensive interaction between the two programs and also with the logic control.

Vacuum furnaces are often used by a variety of products by the heat treater making recipe management an important function.

Vacuum furnaces are used in the metal treating industry for applications such as heat treating, brazing, melting, thin film deposition, etc. They are used to bring materials to high temperature with a minimum of surface reaction such as oxidation. In addition, surface and internal contaminants on molten metal applications are volatized and removed. Heating is fast and efficient using radiant energy that heats only the product in the vacuum environment.

Vacuum furnaces for heat treating and brazing are typically single chamber furnaces operating batch cycles. The batch cycles vary between processes but commonly require regulation of temperature, vacuum and sequence logic. The temperature and vacuum interact extensively with the logic.

A typical heat treating cycle starts after the product is loaded into the furnace and the door is clamped shut. Some users secure the furnace and perform a leak test before proceeding. A roughing vacuum pump lowers the pressure to about 50 microns. A diffusion pump lowers the pressure to below 1 micron. Some processes require an inert gas such as argon to be fed into the furnace at a low rate, allowing the pressure to rise to about 500 microns (this process is called partial pressure (PP) heat treatment).

The pressure increases as the temperature rises and contaminants volatize. Control of the vacuum is maintained at about 500 microns in PP processes or below 10-4 TORR in high vacuum processes. If the vacuum deviates from the specific set point by more than a specific value, the temperature program is held until the condition is corrected. The temperature program goes through a series of ramps and soaks. After a high temperature soak, the furnace is bottled up and the temperature is allowed to drop. An increased flow of inert gas and circulation of cooling water in the furnace walls cools the work. The cooling lowers furnace pressure, requiring additional pressure control. During the cooling, the pressure is controlled between 0.85 Barr to 10

Barr depending on process type. A light or horn usually provides indication to the operator that the cycle is complete.

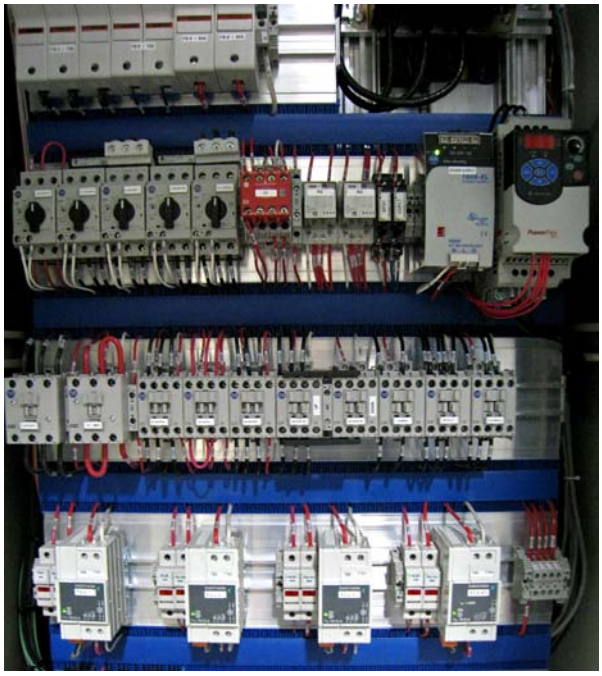
The operator brings the furnace back to atmospheric pressure manually and unloads the product.

Control implementation

During the last 40 years of vacuum furnace manufacturing different hardware platforms for controls have been used. A more recent platform based on the Honeywell HC900 hybrid controller together with Experion Vista SCADA software is reviewed in this article.

Salient features of the HC900 Experion Vista process controller

The HC900 Hybrid Controller combined with Experion Vista interface meets all of the requirements for safe and productive process operation with maximum operator convenience including:



- Program control of sequencing and variables versus time
- Proportional (PID) modulating loop control
- Logic functions for equipment and process status
- Alarm detection, annunciation, and logging
- Data acquisition and data logging
- Recipe configuration, local storage and download capability
- Easily programmable by operators in engineering units.
- Sixteen programmable events for integration with sequence control functions.
- Alarms and events may be programmed to send an e-mail message.
- Modbus/TCP protocol allows interfacing to HMI, data acquisition and OPC server software.
- Ethernet port supports direct PC connection or external Modem connection for configuration upload, download and maintenance.
- Isolated, universal analog inputs allow mix of analog input types on same card, saving I/O cost
- Auto tuning and fuzzy overshoot protection for quick start-up and proper control operation
- Storage of up to 1000 recipes for fast, error-free product selection
- Storage of up to 1000 time/temperature profiles. Each profile may be part of a recipe.
- Any HC900 can support up to 8 peer controllers for exchange of analog or digital data over Ethernet.

HC900 Vacuum Furnace

Control of temperature is executed with a powerful algorithm set that satisfies the most demanding application requirements.

Multiple tuning constants may be used to tailor the control response to the dynamic characteristics of the furnace.

Approach limits allow maximum heating rates without overshoot, reducing cycle time and optimizing efficiency.

HC900 integrates the setpoint programmer, loop and logic functions within a single device.

The Setpoint Program capability of the HC900 is used to control the temperature profiles. Up to 1000 different profiles, appropriate for a wide range of products, can be created and stored for use when these products are processed.

For example Fig.1 shows a typical heat treat cycle profile that uses load guarantee soak function (as event 7) to control critical soak temperature. The cycle profile also contains other events used to control diverse functions required by a heat treatment cycle (high and low vacuum level, partial pressure, quench, etc.).

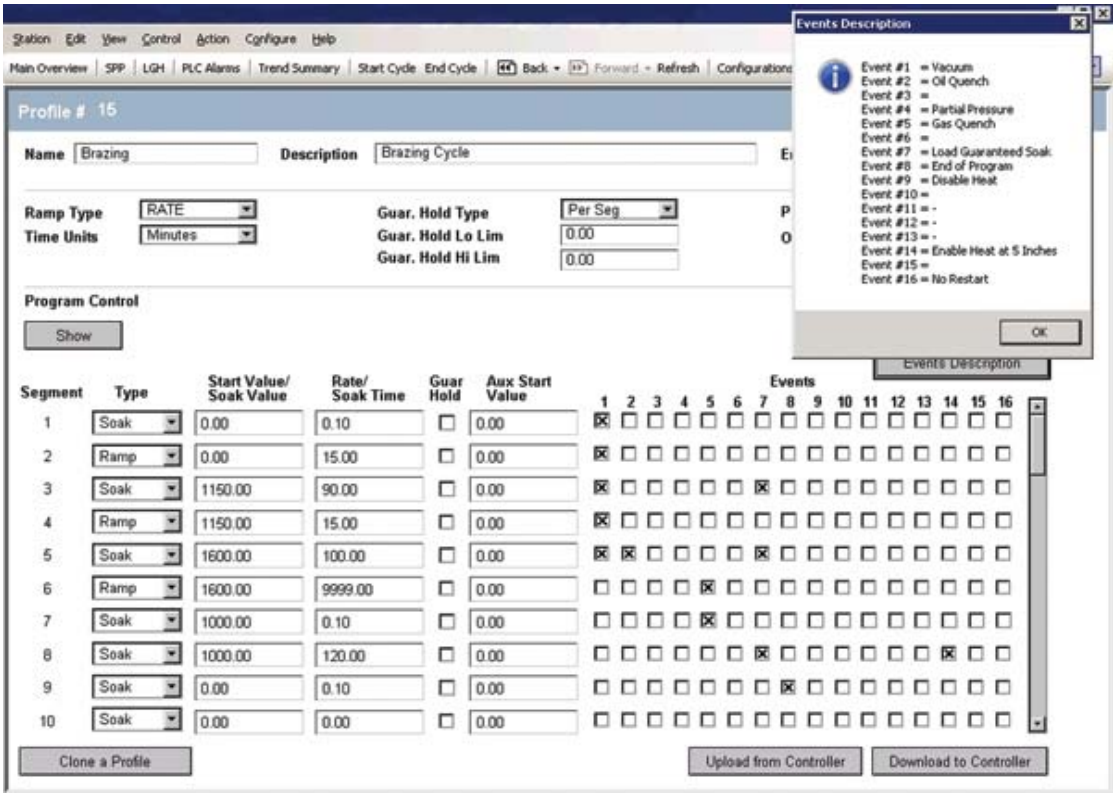


Fig1. Typical Heat treatment brazing cycle

A single configurable database integrates both the loop (proportional, modulating) functions and the logic (discrete, boolean) functions required by the process.

Familiar operator displays provide the operator with dynamic information about the status of each run as it progresses. Alarms are announced in color on dedicated displays and can be acknowledged directly from the Operator Interface.

The data acquisition and control capability of the HC900 permits ongoing process analysis to define and implement the control strategies while maintaining high production with safety and at low cost.

Implementation

The HC900 is a panel-mounted controller (Fig.2), connected to a computer based operator interface.

All field signals terminate at the controller. The controller has universal analog inputs, analog outputs and a wide variety of digital input and output types. This controller will provide all the vacuum furnace control functions.

Configuration.

The Hybrid Control Designer tool (Fig.3) provides advanced configuration techniques allowing a variety of strategies to be easily implemented. The run-mode configuration monitoring and editing capability allows these strategies to be tested and refined as process knowledge is gained.

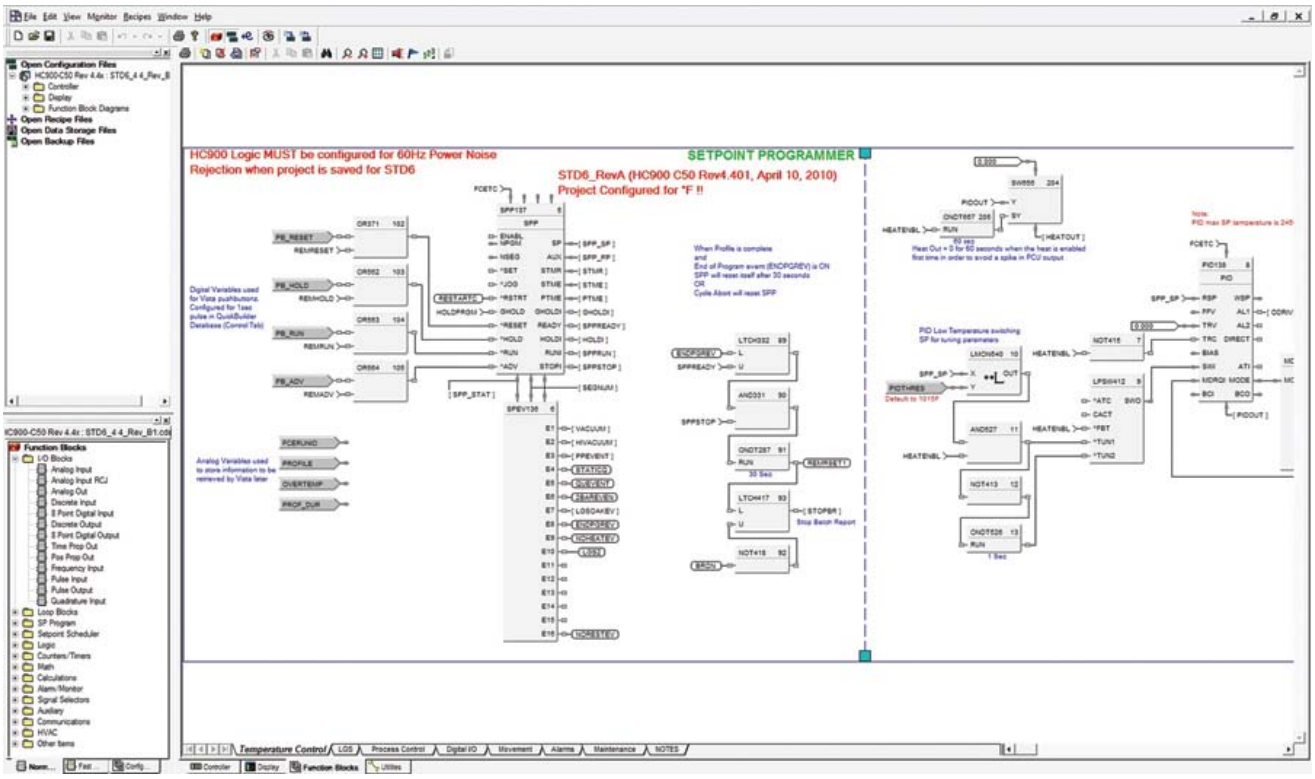


Fig.3 HC900 configuration Screen

Monitoring.

The complete operation can be monitored and controlled from the easy to use, familiar displays of the Experion Vista software. Standard system and customized displays make it easy for operators to learn and use the system (Fig.4 to 11).

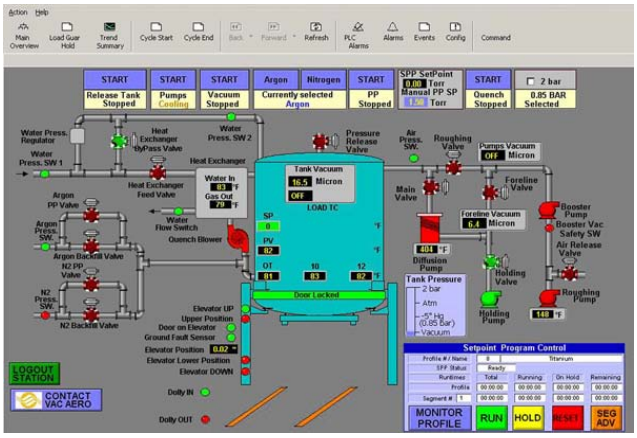


Fig 3 Operator Interface Main Overview Screen

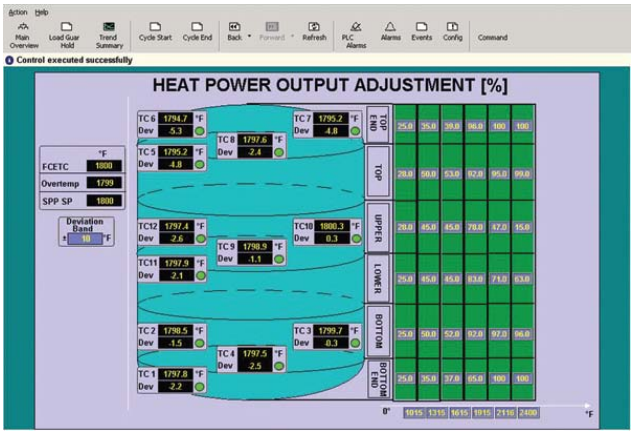


Fig.4 Heat Power Adjustment Screen

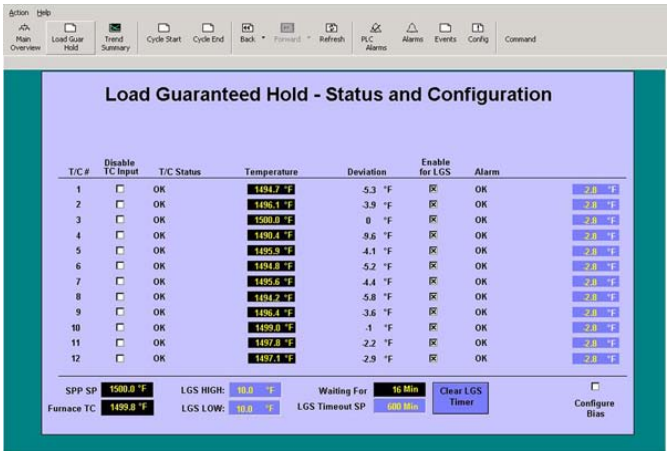


Fig.5 Load Guaranteed Hold Configuration Screen

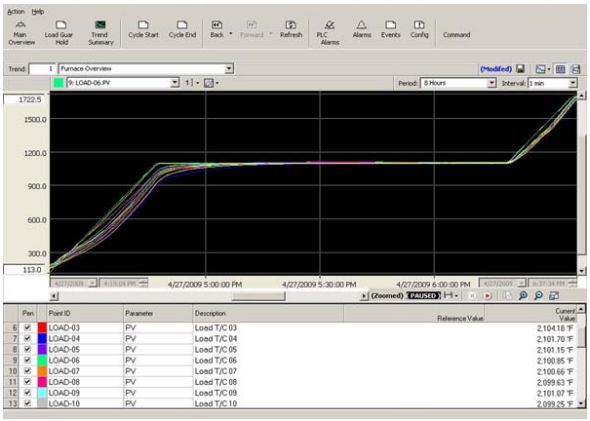


Fig.6 Trend Screen Example

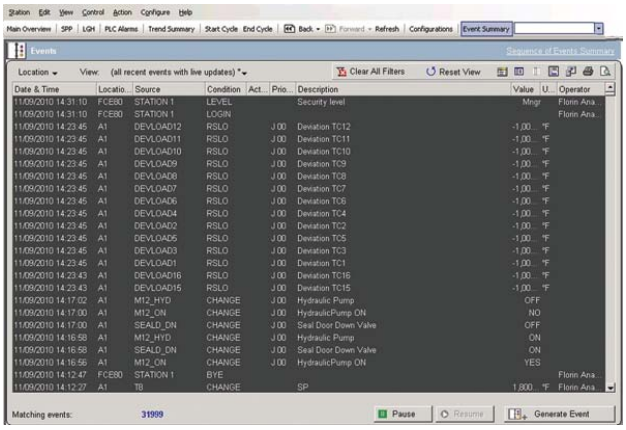


Fig.7 Event Log Screen

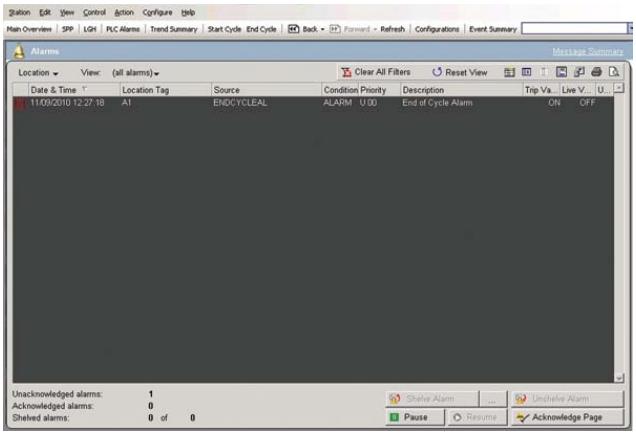


Fig.8 Alarm Screen

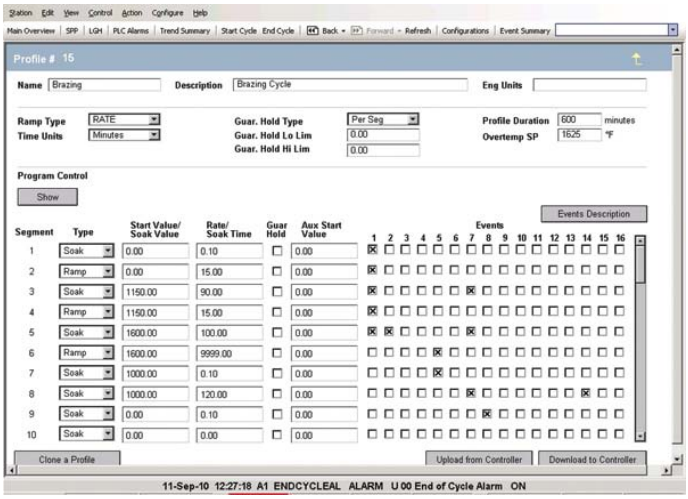


Fig.9 Profile Configuration Screen

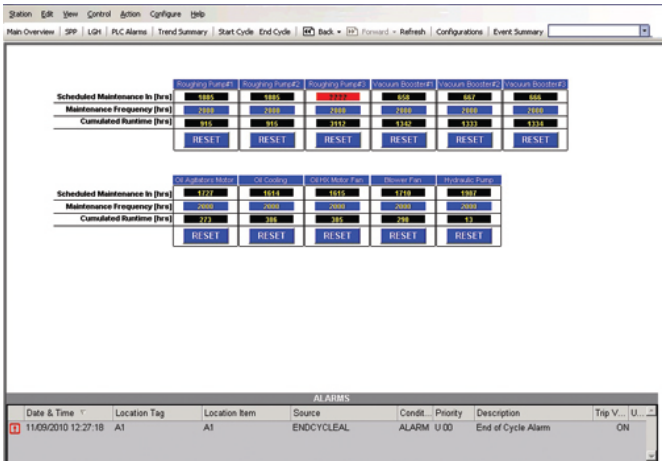


Fig.10 Maintenance Timers Screen

Data Collection and Storage.

The supervisory system provides many built-in reporting functions. Standard alarm and report functions include:

- Alarm / Event Log reports all alarms and events in a specified time period.
- Alarm Duration Log reports the time of occurrence and elapsed time before return-to-normal for specific alarms in a specified time period.
- Alarm Pager: With this option, point alarms may be sent to an alarm paging or messaging system.
- Integrated Excel Report provides the ability to launch a report built using Microsoft Excel.
- Batch Reports collect history for points and events that occurred during a process production run. Static batch data may also be added to the report such as batch number, customer name, lot size, etc.
- Bar-coded data functionality may be used to enter batch information.
- Reports may be generated periodically, or on an event-driven or demand basis. Report output may be directed to screen, printer, file, or directly to another computer for analysis or viewing electronically.
- History collection is available over a wide range of frequencies in both average and snapshot/production formats. A large amount of history can be retained on line, with automatic archiving allowing retention of and access to unlimited quantities of historical data.
- Flexible Trend Configuration allows trends to be configured. Real-time and historical data are presented together on the same trend.
- The data storage feature of the Experion Vista can be used to log process information during the cycle to an internal hard drive disk or to a plant network storage device for a permanent record.

CONCLUSION:

The HC900 control system is programmable, logic based and comprised of proven hardware components, suitably hardened for an "industrial shop" environment.

The HC900 control systems have been operating reliably through thousands of service hours. The software has been optimised to cover all normal operating and alarm conditions. The system uses Honeywell HC900 Hybrid controller to control the machine functions and furnace temperature.

The HC900 can be integrated with Honeywell Experion Vista software to provide Supervisory Control and Data Acquisition (SCADA) using a touch screen LCD for operator interface.

The system's key benefits include:

- Compatibility with plant wide SCADA and network integration.
- Process cycle validation.
- Extensive alarm and event management and reporting.
- Temperature control using advanced algorithms, auto tuning, and multiple zone digital trimming.
- Operator sign-on/sign-off security to limit operator control of individual functions.
- Enhanced maintenance and troubleshooting management.
- Extensive set of advanced algorithms for maximum process performance
- Open Ethernet connectivity via Modbus/TCP protocol that provides plant wide process access and data acquisition
- Extensive equipment diagnostic and monitoring to maximize process availability