Carburization Furnace Control System

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Category
Manufacturing

Products Used
LabVIEW Version 7.0
LabVIEW Data logging And Supervisory Control Version 7.0
LabVIEW Measurement & Automation Explorer Version 3.0
LabVIEW Advanced PID Control Toolset
1 FieldPoint FP-2000 Ethernet Controller
1 FieldPoint TC-120 8-Channel Thermocouple Module
1 FieldPoint AI-100 8-Channel Analog Input Module
2 FieldPoint FP-AO-V5 Dual Channel Analog Output Modules
1 FieldPoint FP-AO-C420 Dual Channel Analog Output Module
1 FieldPoint FP-DI-301 Digital Input Module
1 FieldPoint FP-DO-400 8 Channel Digital Output Module
1 FieldPoint FP-DO-401 8 Channel Digital Output Module
9 Iconic Solenoid Valves
4 Brooks Mass Flow Controllers
2 Watlow single-phase SCR Power Controllers
1 Wika Pressure Transducer
2 Esector Pressure Switches
10 Omega Thermocouples
2 KOBALT Flow Switches

The Challenge
A leading material development start-up company pioneered a new carburization process and required an automated control system for unmanned operation of their furnace. The control system was required to monitor the process variables, control furnace temperature, log process variables (PVs) at a user specified rate and both annunciate and record alarms with the time of occurrence.

The Solution

Data Science Automation (DSA) developed a PC based automation solution using FieldPoint Ethernet Controllers and LabVIEW Data Logging and Supervisory Control (DSC) System. Signals from flow and pressure switches, pressure transducers, thermocouples, mass flow controllers and solenoid valves were terminated in a control panel. Native LabVIEW DSC functionality was used for user management, alarm handling, report generation, data logging and monitoring the sensors.

Abstract

Rather than use a PLC to implement the control system for their new carburization furnace, a start-up company required the flexibility provided by LabVIEW and the Data Logging and Supervisory Control Toolkit. The system allowed for unmanned 24/7 operation and remote web based control. Key features of the system allowed postponing of alarm notification until after a PV remained in the alarm state for a user configurable period of time or went in and out of alarm state a user configurable number of times.

The Design Requirements

The purpose of the control system was to control retort and gas pre-heater temperatures within +/- 1.0 Deg C and also be capable of running the heat / soak processes from a recipe file. The design requirements were:.

- System should take care of the fact that a typical heat run may run for several days unmanned without interruption. High reliability of system components and implementation of safety interlocks for protecting the retort were of utmost importance to protect the retort and costly product material inside the retort.
- Accept heat / soak process inputs from a recipe file; Operator shall be capable of changing recipe parameters during the system operation, if required.
- A user interface showing the status of all solenoid valves, process variables and alarms.
- Perform PID closed loop control for temperature with a scan rate of less than a second.
- Log all process variables at a user configured rate and generate a text report at the end of a heat run.
- Log alarms with time stamps to a text report at the end of a heat run.
- Each alarm shall be configurable with configurable timers to avoid reporting spurious alarms. In addition, the control system shall report alarms if the frequency of their occurrence exceeds a configurable limit even if they are spurious and intermittent.
- Perform safe shut down process in the event of “abort” alarms.
- Provide both manual and automatic operation of the reactor through user interface controls.
- The control system shall be provided with appropriate security features for allowing / disallowing personnel from making changes to operating parameters.

The Implementation

DSA developed a concise user interface (Figure 1) showing status of all process variables and alarms. When a measured process variable (PV) went out of range continuously for a pre-configured time or when the PV goes out of limits intermittently more than the allowed frequency limits, an alarm was generated. Out of range limits were configurable and time delays prevented alarms for temporary disruptions.

Alarms were classified in three categories. Level-1 alarms were self clearing alarms that were automatically acknowledged the the PV left the alarm range; Level-2 alarms required operator acknowledgement; Level-3 alarms were “abort” alarms that initiated a safe shut down process. On the user interface, alarms were shown next to the PV display and an audible alarm sounded on occurrence of any alarms. Operator controls were provided to place the system in automatic or manual mode of operation. Also, when the system is in run mode, the operator has the ability to place the system into a “Hold” or “Abort” state. .

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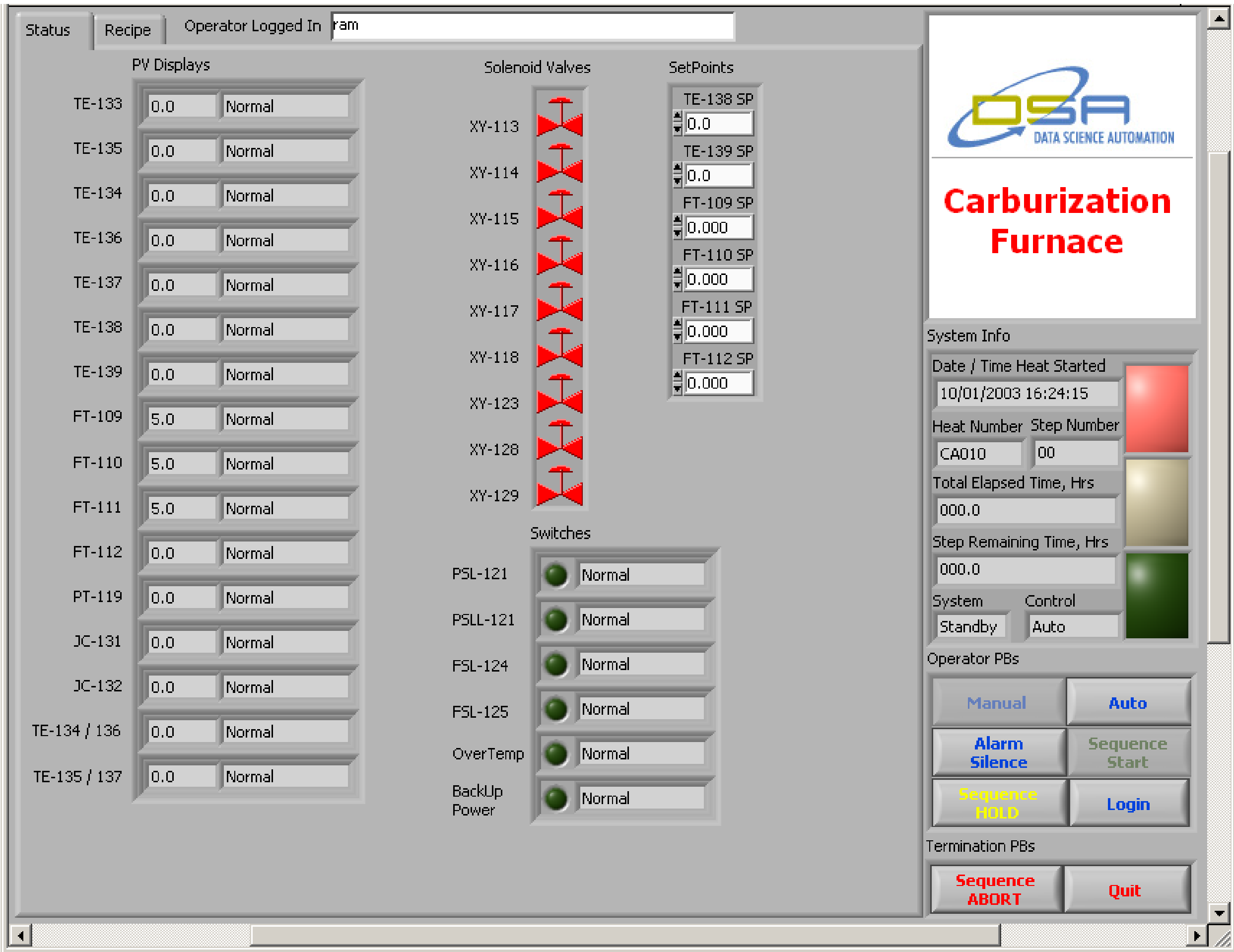

Figure 1. User Interface-Status Page

The control system accepted inputs from a recipe file and populates the user interface controls with the set points when a heat run is initiated by the operator. Shift supervisors have the ability to change these parameters while the system is in “run” mode. The control system also ramps the temperature set points at a specified ramp rate. LabVIEW executes the PID algorithm once a second and the power controllers vary the power level to the reactor based on the controlled variable output from the PID control algorithm. For reactor safety, inlet and outlet temperatures of the furnace were monitored. If their value goes out of the set limits, a safe shut down process is initiated (Level 3 Alarm criterion). The control system generated the flow set points at a pre-configured ramp rate. Signals from FieldPoint modules were wired to the mass flow controllers for modulating flow control valves. Figure 2 shows the recipe page of the user interface with typical heat run parameter values.

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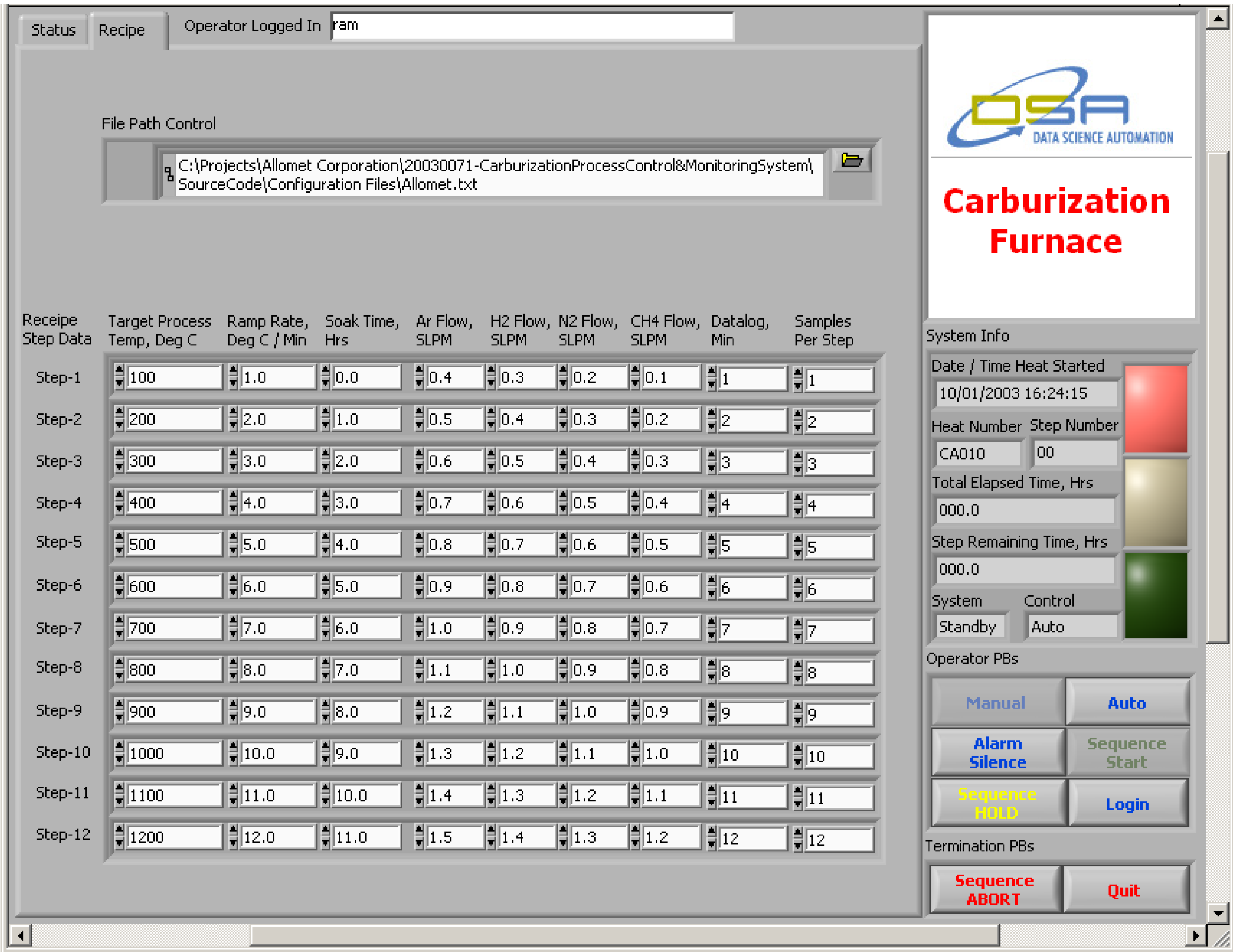

Figure 2. User Interface - Recipe Page

The control system also controlled two other sub processes: air delivery and cooling water delivery.. The air delivery system ensured adequate air pressure for actuating the flow control and on/off solenoid valves. The cooling water system monitored and controlled the water flow around the retort flanges and removed heat from exhaust gases.

Pressure and temperature inside the reactor were monitored continuously and the reactor was shut down whenever those PV values exceeded high-high limits. The system monitored process variables for warning pressure and temperature limits. A special "reverse" flow sub-process was initiated to determine whether a heat run might be continued without aborting the process unnecessarily. If the "reverse" flow sub-process actions do not yield acceptable results then a shut down process is initiated protecting the reactor and the valuable product material.

The Reward

This effort produced a fully integrated and automated control system that reliably controlled the system and accurately acquired, reported and recorded data. It enabled unmanned operation of the reactor 24/7. The native functionality of LabVIEW DSC in combination with FieldPoint modules allowed DSA to implement all design requirements in a reliable, user friendly control system that was flexible enough to accommodate future enhancements.