DATA SCIENCE AUTOMATION

Emissions monitoring

PACE Article

Emissions monitoring

The second finalist in the Control category at National Instruments' Virtual Instrumentation Paper Contest 2007: developing a reliable mercury emissions sampling system to provide the control, calibration and maintenance features required by stringent regulations for coal-fired power plants.

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The Solution:

To create a flexible, real-time software architecture deployed to a National Instruments Compact FieldPoint Programmable Automation Controller (PAC) with a wireless communications interface to a PDA. The PDA provides all status displays and operator interactions. The system saves data to the CompactFlash drive and broadcasts data over an RS-485 serial connection to a data logger.

In order to comply with clean air regulations, mercury emissions from coal-fired power plants must be continuously monitored. The proportional measurement technique requires sampling rates to be continually adjusted to remain in proportion with stack flow. In addition, all calibration, maintenance, and leak-checking modes must be automated. The system uses a PAC that operates remotely, controlling the sample collection for as much as a week. The only computer connection is an RS-485 output line to a data logger. Therefore, all control and programming of the PAC, as well as all user feedback, is through a wireless connection to a PDA running the National Instruments LabVIEW PDA Module.

Sampling mode

The full system controls two sampling paths consisting of sampling pumps, leak-check valves, and proportional control valves operated through the pulse-width modulation NI Compact FieldPoint. Immediately after connecting to the Compact FieldPoint bank, we were able to test and troubleshoot all the hardware modules in the system, allowing several design issues to be addressed early in the process before the LabVIEW programming became too specific.

Data is collected at one-second intervals, with each collection of data broadcast over a serial connection to a remote system. The data is averaged hourly. Hourly averages are saved to non-volatile memory and used to adjust set points for flow and temperature control. All data is compared with a series of alarm set points that raise system flags or stop sampling during the alarm. The system needs to have the ability to enter and return from a suspended function during an alarm. The integrated RS-485 connection on the cFP-2120 allows industrial serial communication, and the expanded memory of the CompactFlash slot enables long-tem data storage for the system.

Running simultaneously with the data collection, broadcasting, and analysis functions are the control loops. A set of heaters is controlled by PID loops to maintain the sampling ports at constant temperatures. Also, in order to maintain the sampling flow at a constant ratio to changing stack flow rate, each flow path is controlled by its own PID controller. Each of these loops references user-defined set points in conjunction with measured values to maintain flow and temperature at required values.

PDA connection

The remote location of the system, and lack of network connection meant that the device would run 'headless,' or with no computer connection. The deployed executable communicates with a rugged PDA through a shared variable library with the cFP-2120 as the shared variable server. The variables are network published and an 802.11 wireless Ethernet bridge connects the cFP-2120 Ethernet port to the wireless capability of the PDA. Both system commands and changes of program state are communicated through the PDA, which can also display and change system settings. Other than beginning the automated sampling mode described above, the PDA is used to operate several user-interactive modes.

Calibration

This mode checks all the built-in sensors of the system. The calibrations range in complexity from a simple comparison to a standard in the case of thermocouple calibration, to an intricate, controlled-flow check of the dry gas meters. All calibration data is stored locally on the PAC in a LabVIEW configuration file format, as a .CAL file. The most recent calibration values are retrieved from these files in order to convert and scale raw values read from the Compact FieldPoint module in each sampling run.

Leak check

This is another automated check of the system used before each sampling run to verify the integrity of the sample path. The values are checked before and after each test and the user can interact with the device to accept or repeat tests as necessary.

Maintenance

During maintenance mode, the user has full control of the system. This mode can turn all pumps and valves on and off, and read the current state or level of all the Compact FieldPoint channels. In this mode, the user-defined functional set points can be entered, read, or updated., and the cFP-2120 system time is automatically synchronised with the PDA to prevent divergence of timestamp values.

Data transfer

The 2 GB memory of the CompactFlash means several years of data can accumulate on the system. For diagnostic procedures and record keeping, a transfer mechanism is set up to collect data files from the PAC to send to the PDA. The PDA connects to the Compact FieldPoint which then populates a list with all the existing .DAT or .CAL files, any of which can be selected and copied through TCP/IP protocol to local PDA memory. The system prevents currently used and incomplete data files from being transferred in the middle of a sampling run.

The success of the project was due to the processing and automation power of the cFP-2120, as well as the ease of use derived from integrating the PDA control system. This streamlined the interface for the user while allowing the automated processes to take care of most of the sampling functions. Performance was enhanced through the cFP-2120 incorporation of Ethernet and serial communication. The CompactFlash expandable memory saved time by avoiding the need for additional hardware integration and troubleshooting.

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