FLUID CONDITIONING MODULE

AUTOMATED TEST STAND FOR PERSONAL COOLING SYSTEMS

Client

Aspen Systems, Inc., Thermal Division, Marlboro, MA (http://www.aspensystems.com/)

Problem Scope

Aspen Thermal develops micro-climate conditions systems designed to protect people in harsh exposures. These miniature cooling systems are used in hazmat suits and fighter pilot vests–where water is circulated to keep the body's core temperature within safe limits during exposure to extreme thermal conditions.

Aspen Thermal required an automated test stand for their Personal Cooling System Fluid Conditioning Module (FCM) that would demonstrate the actual performance of each FCM at the rated load over a range of operating conditions. Their miniature cooling system, based on a vapor compression cycle and a miniature rotary compressor, contains a small but powerful brushless DC motor that allows variable operation of the compressor to meet the load demand. The miniature refrigeration unit is utilized to chill a heat transfer liquid (usually water), which is then circulated to a tube-lined garment worn by the user. A custom digital control system maintains the circulating liquid temperature at the user-specified set point by varying the speed of the compressor.

Viewpoint's Solution

Viewpoint built a custom software application using National Instruments LabVIEW and its own toolkits to perform automated sequencing, control, measurement, analysis, and reporting.

Technical Highlights

- National Instruments FieldPoint Distributed I/O Hardware, including:
  - FP-1601 Ethernet Network Interface
  - FP-RTD-122 8-Channel RTD Temperature Module
  - FP-AI-110 8-Channel Analog Input Module
  - FP-PWM-520 8-Channel Pulse (PWM) Output Module
  - FP-RLY-420 8-Channel SPST Relay Module
- National Instruments LabVIEW Software
- National Instruments PID Toolkit Software
- Viewpoint Systems dBaser Database Toolkit Software
- Viewpoint Systems Circular Buffer Toolkit Software
- Viewpoint Systems ActiveX Excel Engine Toolkit Software
  - Model-View-Controller Software Architecture

Description

A Fluid Conditioning Module must maintain the desired water out temperature–at multiple setpoints–regardless of the ambient temperature and/or the actual cooling load. The FCM Test Stand is designed to gather cooling performance, at the rated load, over a range of operating conditions.

A thermal test enclosure provides the stable, repeatable ambient temperature environment for the FCM. A Liquid Circulating Loop (LCL) provides the variable cooling load for the test stand. Software PID control loops maintain the enclosure temperature at the desired ambient setpoint by controlling the PWM and maintaining actual heat load at the desired setpoint.

The test software starts the LCL pump and heater, energizes the FCM condenser fan, turns on the FCM, and starts the PID controllers. A setpoint sequencer begins the test sequence, waits for each setpoint to stabilize, and gathers the test results. At the end of the sequence, the test software shuts down the PID controllers, the FCM, the LCL, and prints the final test report.

Software Architecture

The software solution was developed and implemented by Viewpoint Systems using National Instruments' LabVIEW Graphical Development Environment. A layered Model-View-Controller (MVC) architecture framework was tailored to Aspen's specific test stand requirements.

The MVC framework allows a separation of application components into three groups:

Model – The data and logic representing the FCM, the LCL, and the enclosure.

View – Renders the user interface with data from the model.

Controller – Defines application behavior, maps user actions to model updates.

The Setpoint Auto Sequencer is driven by a simple tab-delimited text file. Setpoint profiles can be quickly created/edited and deployed to support changing test requirements or experimental testing. The Viewpoint Systems dBaser Database toolkit software is utilized to read all test stand configuration data from an Microsoft Excel worksheet, directly into native LabVIEW data types. This file contains all the specific information while allowing for a high degree of application flexibility– without touching the LabVIEW code.

A complete snapshot of all test results are date/time stamped and written to a spreadsheet results file using the dBaser toolkit. The dBaser toolkit is used in conjunction with the Viewpoint Systems ActiveX Excel Engine Toolkit Software to write to and print a formatted test report. The final hardcopy test report with a graph is shipped with each completed FCM.

When the client decided to switch from thermocouples to RTD sensors, the conversion was quickly implemented by changing the sensors, swapping FieldPoint hardware devices, and reconfiguring the device and channel model parameters in the Excel worksheet. No LabVIEW code changes were required.

Results

Aspen is now able to automatically test a completed FCM under all desired operating conditions to ensure compliance with performance specifications. The MVC architecture provides the necessary performance, safety, and flexibility required for demanding test applications. Most modifications can be easily made in the Excel worksheet without rewriting the software.