Wireless Data Acquisition for Machinery in Motion: Improving PET Blow Mold Bottle Production

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Category: Industrial Automation

Products Used: National Instruments LabWindows/CVI, Keeva, L.C. Wireless Data Acquisition System

The Challenge: Obtain accurate, high-resolution manufacturing data from a rotating bottle blow mold wheel. Move it into an advanced data analysis and visualization environment where it can be used to reject substandard products, optimize quality, anticipate maintenance, and support R&D. Provide an inexpensive solution that is easy to install with minimal downtime.

The Solution: Use the Keeva, L.C. Data Acquisition Unit to collect deterministic (± 5 ms), 1,000 sample/s data from sensors on the wheel bottle forming stations. Send the data via wireless Ethernet to a LabWindows/CVI workstation where it can be analyzed and displayed. Use a digital interface to reject bad bottles.

Introduction

As the Polyethylene Terephthalate (PET) bottle industry expands into new markets, the increased demand makes it important to ensure continuous high-quality production runs. New requirements in bottle size, shape, durability, and shelf life, however, make these production runs more difficult to achieve.

In the PET blow mold production cycle, a preheated test tube-shaped preform enters a chamber where a descending plunger uses high-pressure air to rapidly expand the thick plastic wall of the tube until it conforms to the mold. For continuous rapid production, several bottle-forming stations are mounted on the rim of a rotating wheel. As the wheel turns, each station moves through the steps of picking up a preform, expanding the bottle, and discharge.

The physical characteristics of the resulting bottle are critically dependent on the proper execution of the forming cycle. If malformed bottles are not rejected, they could cause an entire truckload of bottles to be refused by the customer, resulting in substantial costs. In order to monitor the forming cycle, a high-performance data acquisition system must be mounted on the wheel that can transfer detailed process measurements to an off-wheel analytical workstation.

System Hardware

As shown in Figure 1, the Keeva, L.C. Wheel Watcher system consists of two computers communicating via TCP/IP over a wireless Ethernet link. The Data Acquisition Unit (DAU) is a Pentium class embedded computer mounted on the wheel and equipped with air pressure and rod displacement sensors placed at each bottle forming station. The DAU makes high-speed deterministic readings from these sensors and assembles them into a data frame that is sent to the Data Management Unit (DMU) located off the wheel. The DMU is equipped according to the processing load of the LabWindows/CVI application and in consideration of customer preferences. For this application, a Pentium II 350MHz platform running Windows NT was used.

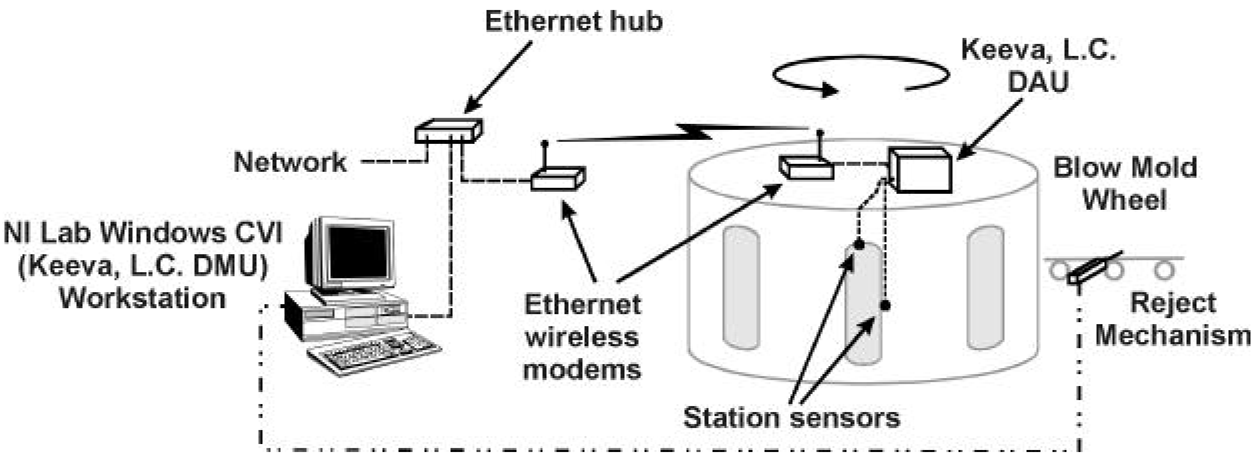

Figure 1. Keeva, L.C. Wheel Watcher System topology

System Software

For this application the DAU was configured to sample both air pressure and rod displacement for a 24-station wheel at a rate of 1 sample/sensor/ms. Since each sample yields a two-byte data value, this requires a hefty (2 x 24 x 1000 x 2) ≈ 100,000 bytes/s data transfer rate. In order to moderate the demand that this rate places on the workstation and data storage, the DAU is equipped with two features: 1) data frames are consolidated on a per-bottle basis to maximize the communication overhead-to-payload ratio, and 2) each station follows a 'sampling profile' that gathers data at various resolutions during the cycle according to downstream analytical requirements.

We picked LabWindows/CVI for developing the DMU software because of its maturity, its industry-proven reliability, and its rich graphic development environment. These characteristics served to streamline our efforts and allowed us to concentrate on the special requirements of our product and the application. The modular architecture and message-based strategy of LabWindows/CVI enabled us to develop components that are both reusable and multipurpose in nature.

Once the data reaches the DMU, the advanced multithreading and instrumentation driver features of LabWindows/CVI are used to distribute the information according to a client/server strategy in support of the visualization, quality control, and archival activities. Additional clients could include a relational database, an SPC application, or other special customer needs.

System Features

The following screen shots show some of the system features. All presentations include an area on the right side (blue) that shows current production statistics.

The 'cycle display' (Figure 2) allows the user to view six curves derived from any station, signal, or mathematical transform. The air pressure (red) and rod displacement (cyan) are displayed along with the first order derivative of air pressure (green). The first and second order derivatives of the sensor data are used to amplify variations in the signal.

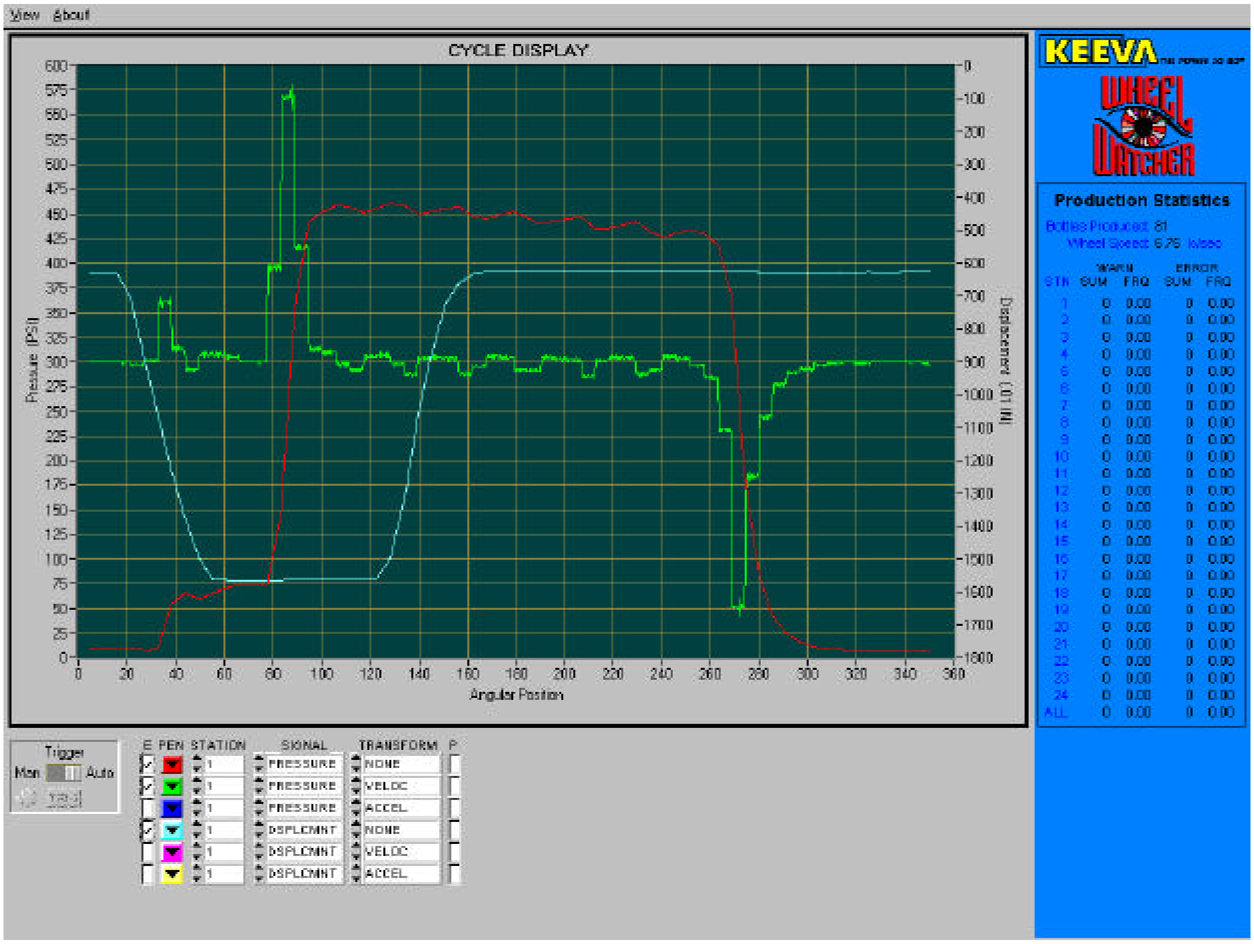

Figure 2. Cycle Display

In the Process Display (Figure 3) the user can set 'warn' (yellow) and 'error' (red) limits for each station. When the signal goes outside of a limit, a tally is kept and, if the error limit is exceeded, the product is rejected. Each limit can be given a sliding 'detection window' that specifies both a span and intensity setting when testing the signal.

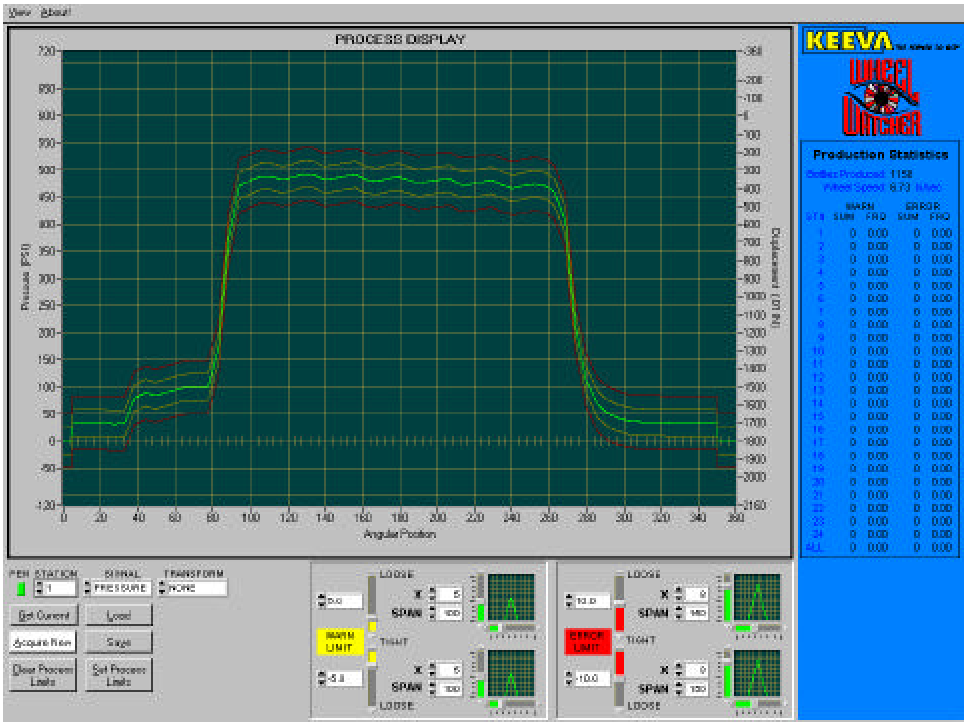

Figure 3. Process Display

The Design of Experiment Display (Figure 4) provides a setting in which the user can examine and analyze a specific signal. The LabWindows/CVI graphic cursor tools are used to provide instantaneous and interval readings of signal magnitude and angular position.

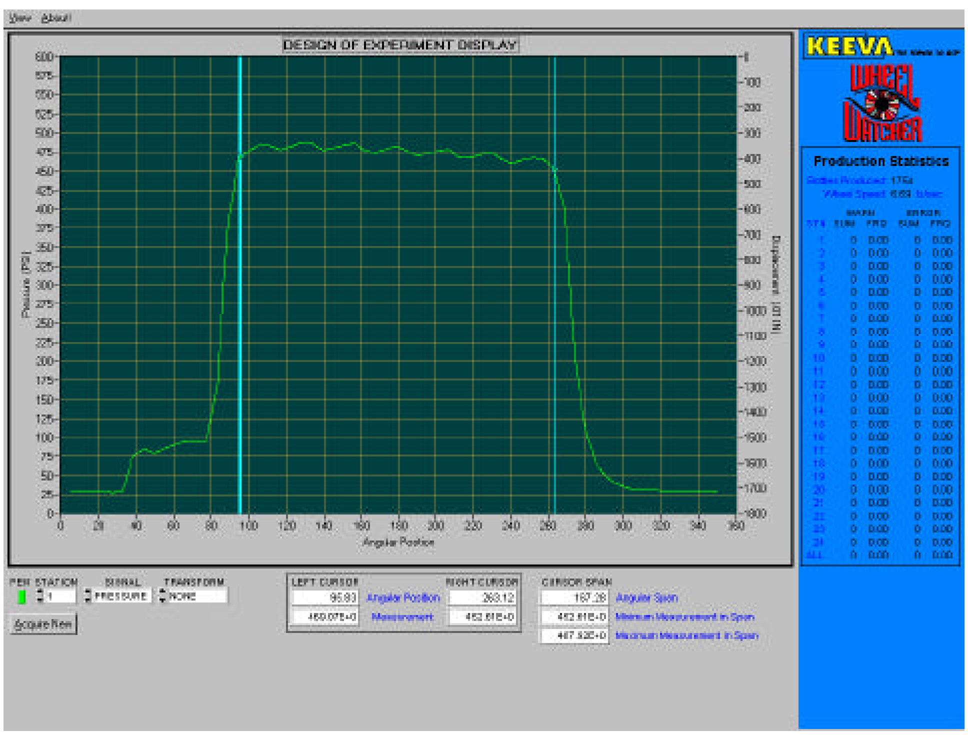

Figure 4: Design of Experiment Display

Two more displays (not shown) round out the system features. The Calibration Display simplifies calibration of sensors by allowing the system to 'learn' the maximum and minimum signal values from incoming data, which are then paired with the corresponding engineering values. The Indices Display presents mathematical coefficients that serve to characterize the quality of the forming cycle, such as the timing and impact of air delivery, the smoothness of displacement rod movement, and so forth.

The Bottom Line

The process solution in this application has three significant economic benefits:

- Dramatically lower installation costs – this system requires two days to install, compared to ten days for other solutions, yielding a 500 percent saving in downtime that can pay for the system outright
- Significant operational savings – client estimates indicate the return on investment to be about 180 days, representing a net present value of over 300 percent based on a 25 percent internal rate of return
- Capable and efficient network administration – the Ethernet network allows distributed network maintenance expected by leading edge users

The economic benefits accrued to this system are a result of employing advanced software such as LabWindows/CVI, high-speed hardware such as Pentium™ class embedded controllers and capable networking solutions such as Ethernet. Moreover, and of quantum significance, these choices allow rapid deployment of this core technology to a variety of industries.