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A river of tumbling tomatoes

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For 100 days and nights each summer, over 5 billion tomatoes arrive at the crest of Morning Star's man-made "Niagara Falls of Tomatoes," only four hours later destined to become flash-cooled tomato paste.

DCS? PLCs?
Which Platform to Choose?

In the past, Morning Star had relied on single loop controllers, buttons, selector switches and chart recorders to control their plants and record vital information. Identifying problems and trends, however, was difficult based on limited information from new charts. And making the necessary changes to the process would prove difficult without major rewiring. Based on their previous experience, the Morning Star team developed a process goal chart.

Process Control Goals:

- Strict quality control
- Flexibility
- High availability
- Troubleshooting ease
- Data tracking and archiving
- Excellent cost/performance ratio

After a thorough search through control options, the team realized that they needed the capabilities of a DCS system for process design, database management and information storage, but also the flexibility and ease of troubleshooting offered by a standard PLC. These two competing themes led Morning Star to choose a hybrid system.

The SIMATIC PCS (Process Control System) is a UNIX X-Windows-based graphical application that utilizes a real-time relational database management system. This system is shared by an object-oriented graphical programming language (like a DCS programming environment) used to program the PLCs and generate the database that is used by the control system. Thus, Morning Star achieved the design goal they set for themselves: DCS-like capabilities without DCS expense, and the flexibility and simplicity that comes with Siemens PLCs.

The Process Flow

The process, where evaporation is the heart and the control room the brain, begins and ends in a straightforward way. First, trucks arrive at the top of the 40-foot man-made hill, where a mechanical "tarantula" moves into position to load bins with water. Every 4.5 minutes a hatch door is opened, allowing tomatoes to flow into the stream just prior to the waterfall, where they then flow through four phases of washing and cleaning. Gravity eliminates the need for pumps and motors. Next, mechanical fingers and electronic sensors spot and eject unwanted tomatoes and debris.

A flow gate interrupts tomato flow. The gate is controlled by a mass flow PID loop that utilizes feed forward averaging obtained over the Ethernet network from the rest of the plant to determine actual tomato need. In the past, a single loop controller with no feed forward network controlled this gate based on the level of a single tank. This calculation method would sometimes result in

too many tomatoes (and overflowing juice) or too few tomatoes (and less efficiency) in the system.

The tomatoes continue forward for chopping and immersion into a hot break process, where they are pre-cooked at 211-212º F, and then "finished," where pure "juice" moves to twin three-stage evaporation units, and rejected pomace (skins) is processed to become animal feed. Depending on the formula, the finish ranges from fine, coarse or crushed to pure juice (no seeds).

The three-stage evaporators reduce the water content by 33 percent and then advance the juice to a finishing evaporator where the juice loses its remaining excess water and becomes tomato paste. The paste is then pumped through a sterilizer system into a hot hold tank, then flash-cooled for packaging.

From a central control room, one operator per shift runs and monitors the process. Five multi-windowing operator stations communicating over an Ethernet network provide for maximum viewing of plant operation. From receiving, hot breaks, finishing, evaporation, flash cooling to boiler control, any station is capable of displaying all information. Seven additional SIMATIC HMI (COROS) OP-25 and OP-35 operator interface stations in the plant operation are connected via RS-422 and allow for redundant control of each area if the PCS system fails.

The Hybrid
Process Control System

- 2 SIMATIC PCS operator Stations, 3 X-Terminals
- 7 remote operator panels
- 6 PLCs, 11 remote PLCs
- 117 Motors, MCC Centers with both Run and Overload trip feedback
- 79 Valves with Open/Close Feedback or Position Feedback for Control Valves
- 133 PID Loops
- 280 Analog Sensors Used in PID Loops and/or Analog Alarms
- 379 Discrete I/O Including Motors, Valves and Associated Feedback
- 11 VFDS connected via PROFIBUS I/O

PROFIBUS

In addition to the Ethernet network, the plant was wired with a PROFIBUS field-level network. This RS-485 token ring network is used to communicate to a whole array of smart family devices. In this particular installation, the 11 variable frequency drives (VFDs) used in the plant would be placed several hundred feet away from the PLCs that were controlling them. Over PROFIBUS, not only can the drive be controlled, but faults can be monitored as well. So an increase in motor control and a decrease in wiring costs made using the network a great alternative to the traditional wiring method.

Higher Level Control

In past Morning Star installations, most process adjustments were made to the system and the overall effect might take several hours to identify. But thanks to the conversion of real-time data into straightforward graphical information at the PCS operator stations, the process can be modified or adjusted in a timely manner, critical to maintaining color, sugar content and texture, to meet exacting specifications of Morning Star customers. Critical to the efficient operation of the plant is the ability of operators to bypass certain areas of the process that were down or needed cleaning. Twenty-one different modes of evaporator control head the list for options in process flow. Five modes for tomato juice feed flow control, and many sub-modes for practically every PID loop are designed in, too. Each of these modes allows the PID loops to use several different process variables or different control device outputs (like level valves or VFDs) for controlling the process given the selected mode.

In many of the modes, the PID loops will control vastly different devices that require loading in different tuning parameters on the fly. For instance, every tank in an evaporator can use temperature or pressure to control the steam valve. Without loading in different PID parameters, optimum control for each would be impossible. Using ladder logic to achieve all these modes would present a very complex challenge. With the APT (application productivity tool) software approach chosen by Morning Star, it's as simple as redirecting the PID object to control another object such as the valve or motor using built-in math instruction to load the tuning parameter stored as an array into the PID project.

Moving Fast After Rain Delay

The record California rains of '95 delayed plant construction until April, leaving only three months for complete construction, testing and start-up. This meant little or no test time for system integration. The systems integration team was a combination of Process Controls Engineering, Ripon, CA, RPM Engineering, Inc., located in Baton Rouge, LA, and Fred Band & Associates of Sacramento, CA. According to Don Lum, RPM Engineering, "This is where the power of an object-oriented software pays off. Debugging a ladder program of this size and complexity would have meant a considerable delay in start-up, even potential loss of part of the production season."

The Tomato Information Highway

The Morning Star communications network converts raw data into graphical troubleshooting, trending and historical models to optimize the making of paste. Connecting intelligent PLCs via Ethernet and PROFIBUS, operators, engineering and maintenance are able to enhance quality in real time and modify the system by simple changes in programming. Besides the reduction in initial capital investment, less time and fewer special skills are required for lower cost of operation and modification.

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