PULP&PAPER

Feature: Process Automation

Caraustar's Sprague, Conn., recycled paperboard mill replaces a millwide DCS with a digital automation system, achieving automated startups and better runnability and worker productivity

Sprague Achieves Higher Automation Levels By Replacing DCS with Digital Architecture

by ARDIE HARRISON and CHRISTIAN DUNLAP

There is a big difference between having a millwide distributed control system (DCS) and achieving true automation, and Caraustar Industries Inc. has demonstrated that point during the past two years at its Sprague, Conn., paperboard mill. With minimal outside help, mill personnel gradually replaced a DCS with digital plant architecture and a digital automation system. Results include "one-button" startups and shutdowns, tighter quality control, and a significant increase in human resource productivity.

Caraustar Industries is the largest recycled paperboard producer in the U.S. The company's mill at rural Versailles village in the town of Sprague turns post-consumer-recycled materials into 12-ft-wide reels of high-quality, clay-coated paperboard in calipers from 10-point to 28-point (0.010-in. to 0.028 in. thick). With a capacity of more than 525 tpd, the mill primarily serves the folding carton market.

MILL HISTORY AND PROCESSES. Federal Paper Board Co. built the Sprague mill in 1962 on a 500-acre site that had been developed for three mills at the beginning of the 20th century. Federal merged with International Paper Co. in 1996, and Caraustar acquired the mill in 1999.

At first, this was a state-of-the-art mill with a capacity of 230 tpd. Much of the equipment remains the same, but the speed of the Beloit paper machine has more than doubled through the years by a number of improvements in processes and controls. The original pneumatic controls (mostly Bailey for the powerhouse and Foxboro for all else) were replaced in 1989 and 1990 by a Honeywell TDC 3000 DCS that encompassed the entire mill.

Figure 1 summarizes the major components of the stock preparation area and the paper machine. The Fourdrinier table in the paper machine has five headboxes, each followed by an Inverform unit. The resulting five layers are the top liner and back liner (both of highest-grade material) and three filler layers. There are four pairs of nip rolls in the press and 85 steam-heated drums in the dryer, plus three more dryer drums that follow starch application at the first of three calender stacks. The top liner is coated in two stages, first by a Jagenberg Vari-Bar coater followed by a hot-air dryer, and next by an air knife followed by an infrared dryer and four hot-air dryers. Machine control involves a Metso (formerly Neles and Valmet) computer system that was installed in 2001. It employs multivariable paper scanners located after the press, the main dryer, and the last calender stack.

Stock preparation consists of three separate continuous processes—one for the top liner, another for the back liner, and a third for the filler layers. Filler stock prep begins with two continuous hydrapulpers that receive bales of recycled material, with one of the pulpers usually being held in reserve. The top and back liner processes, in turn, share three batch pulpers that are rotated in service.

The powerhouse centers on a gas-fired boiler producing 180,000 lb/hour of 900-psi superheated steam and a turbine generator producing 11 MVA that supplies most of the mill's power. The turbine provides 125-psi extracted steam for the paper machine dryers and 15-psi steam for space heating and water heating. The water treatment system recycles about 400 gpm (575,000 gal/day), discharging only about 50,000 gal/day.

ELIMINATING FILLER DISPERSION UNITS. A major revamp project in the filler stock preparation system provided an opportu-

Senior process engineer Ardie Harrison at an engineering station for the mill's new digital automation system located in his office. Such stations exist throughout the mill and on the mill floor.

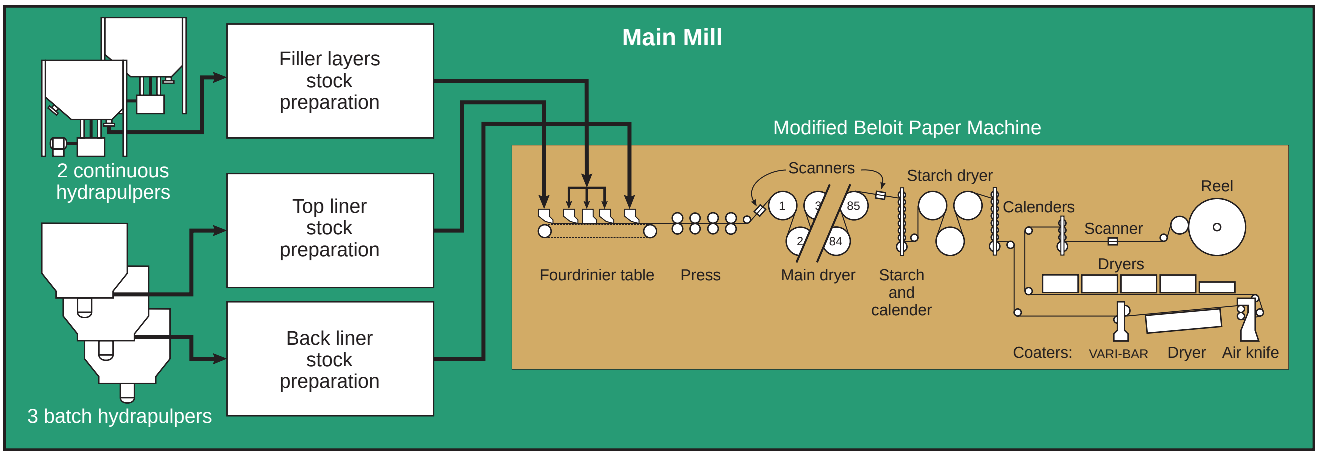


FIGURE 1. *Simplified flow diagram for major components of the Sprague mill's stock preparation area and paper machine*

nity for beginning to modernize the Sprague mill's controls. All three stock prep lines involved purification by centrifugal cleaners and various screening units, followed by concentration in drum thickeners, brushing of fibers in disk refiners to achieve desired freeness (drain speed), and blending for desired consistency.

However, to handle the relatively coarse grade of feedstock for the filler layers, cleaning and screening in that stock prep line was augmented by a dispersion system that was popular in the 1960s. There were two petroleum dispersion units and one asphalt dispersion unit operating in parallel. Each involved a steam-heated screw press followed by a high-pressure steam jet to break down stickies and undesirable materials.

The dispersers were very expensive to operate and maintain, and the presses were subject to frequent plugging, causing a speed reduction of 40% at the paper machine when one went down. In addition, the associated control techniques were difficult for operators to learn. By the late 1990s, advances in technology had made the dispersers obsolete.

In 1999, Caraustar decided to proceed with a project conceived earlier—changing the filler cleaning and screening process to one that did not use dispersers. A number of new cleaners and screens would be added. Much of the existing equipment would remain in service—including various tanks and chests—although with completely different piping configurations and control schemes. Numerous minor improvements would be made throughout the filler line, such as changing the pulper extraction plates to reduce the hole diameters. The net result would be an entirely new and different stock prep process. Mill personnel developed overall system concepts and requirements, then requested proposals from several vendors. The system selected was one of four alternatives offered by Kadant Black Clawson.

OPENING THE DOOR TO NEW CONTROLS. In planning this project, it was decided to implement the new digital automation system without a substantial shutdown. The new cleaning and screening units would be installed in vacant spaces among the operating equipment, along with associated piping and instrumentation (transmitters and control valves). Then, during intervals when the paper machine was halted for maintenance, mill personnel would make a few new connections in existing piping. Shutoff valves would be included to allow switching over to the new flow pattern when that became possible for various network sections. After the new configuration was operating, dispersers and other equipment no longer in use would be disconnected as opportunities permitted.

Incorporating the new stock prep system into the existing DCS would be relatively expensive and troublesome. It would require adding a substantial number of input and output modules to accommodate the new instruments and setting up entirely new control schemes for the filler stock prep area—all without disturbing the existing instruments and programming. After the changeover, the DCS would be left with a lot of unused input/output (I/O) and control capacity.

The old DCS worked well enough, but it provided nothing more than process monitoring, manual remote control, and centralized execution of independent control loops throughout the mill. For the powerhouse and water treatment system, this seemed satisfactory. However, for stock prep and the paper machine, operators were constantly adjusting PID setpoints, changing control valve positions, turning pumps on and off, and switching on-off valves. Maintaining quality and speed at the machine while avoiding paper breaks and other shutdowns was seldom fully achieved.

The mill needed full automation of all three stock prep lines, allowing one-button startups and shutdowns. Also needed was full integration of stock prep controls with the Metso paper machine scanners and controls to improve automation. Instead of stretching the old DCS to new extremes of performance, it was decided to apply PlantWeb digital plant architecture from Emerson Process Management, implemented with a DeltaV digital automation system. All instruments added to the filler stock prep line would be put on this new network immediately. As soon as the revamp of that area's equipment was complete, the remaining instruments would be switched over from the DCS to the DeltaV—mostly on a "hot" basis, without shutdowns. Then, if everything went as expected, the new architecture would be gradually extended throughout the mill.

REPLACING A DCS ON THE FLY. Orders for the new filler stock prep equipment and digital automation system were placed during the fourth quarter of 1999. Ardie Harrison, senior process engineer for Caraustar Sprague Paperboard, attended a one-week school with the automation system supplier in January 2000. Deliveries of processing and control equipment occurred in January and February and installation began immediately.

Harrison and other Sprague engineers performed nearly all of the configuration for the new digital automation system. Most of the control system installation and commissioning was performed by Sprague personnel, supplemented as necessary by local trade labor. Everything went as planned, except that the schedule was accelerated by three weeks, requiring some control engineering manpower from the Emerson representative organization, New England Controls. The revamped filler stock prep process was in full operation under control of the new automation system by the middle of April.

Since then, the DeltaV network has been extended throughout the main building—including the other two stock prep lines and the paper machine. Automated startup and shutdown sequences have been implemented for all three stock prep lines. As of May 2002, the new system had reached everywhere but the powerhouse, coater kitchen, and some outlying water treatment controls. Results as of May 2002 are summarized in Figure 2.

There are eight DeltaV field servers located in four existing control equipment rooms connected by a standard Ethernet local area network (LAN) in a modified star configuration using TCP/IP Internet protocol. Each field server consists of several compact, field-hardened modules mounted together on rails—controller, power supply, input modules, and output modules. Much less cabinet-rack real estate is required than for the legacy DCS. Operator stations are PCs running Windows NT located in the stock prep control room, a control booth for the machine tender at the wet end, and a factory-hardened enclosure for the backtender at the dry end. In addition, there are PC stations in the engineering office, production office, and E&I shop. Another PC in the engineering office manages process history.

Referring again to Figure 2, two more PCs in the paper scanner rack room provide easily configured OPC communication (OPC means OLE—object linking and embedding—for process control) with the Metso scanner-based paper machine control system. The DeltaV digital automation system handles lower control loops in the paper machine—such as headbox flow, dryer heat, and line shaft speed—under the supervision of the machine control computer. Other variables, such as stock consistency, are furnished to the scanner system via OPC to aid in its machine control functions.

A more familiar method is used for the much simpler task of integrating a computer-based compressor controller into the PlantWeb architecture. DeltaV I/O modules are available for nearly any sort of communication. In this case, a serial data module was added to one of the I/O racks in the motor control center at the wet end, using Modbus protocol.

Since remnants of the DCS will soon be eliminated, there is no need to set up complex communications between it and the new network. As an expedient, one discrete and five analog signals needed at the powerhouse are passed to the DCS by direct connection of field input and output cables.

NOT YOUR FATHER'S DCS. DeltaV and similar digital automation systems are sometimes called "hybrid" because they seem to resemble programmable logic controller (PLC) networks as well as a DCS. Superficial similarities to PLCs include compact, modular controllers in field locations; suitability for sophisticated discrete control and continuous algorithms; and human interface at PCs rather than special consoles. Also, terms such as "mini-DCS" are sometimes erroneously associated with these systems because they can be applied on a small scale.

However, when DeltaV implements PlantWeb architecture, results can be more advanced than a conventional DCS or PLC network, and it can be scaled up to any size. The generic name for this automation concept is "open field-based architecture." There are three chief points of distinction:

1. *The architecture is based largely on the latest generation of field instruments rather than entirely on the controllers or servers through which instruments are connected*. These are "intelligent" instruments that operate as computers and communicate on digital field networks such as Foundation fieldbus and HART. Smart transmitters and digital valve controllers (DVCs) can monitor their own condition, report multiple variables, and essentially calibrate and commission themselves. They can also execute continuous and discrete control algorithms independently.

2. *The controllers or servers that communicate with the field instruments can themselves be mounted in the field*—that is, out among the instruments they serve, not necessarily clustered together in special equipment rooms as happened to be convenient at the Sprague mill. Thus, open field-based

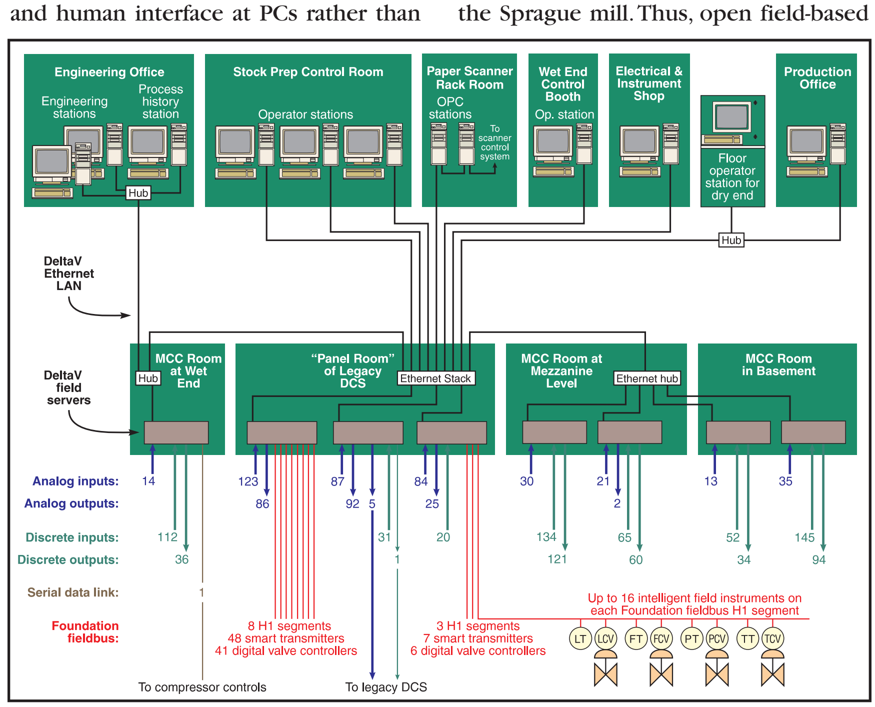
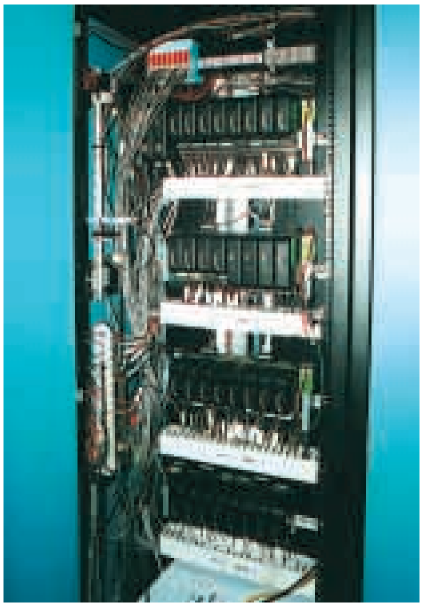


FIGURE 2. *Simplified block diagram of the mill's digital automation system network. In two years, the digital plant architecture has replaced the legacy DCS everywhere but the powerhouse.*



One of the new field servers now located in the panel room of the legacy DCS

architecture actually approaches the original DCS ideal of geographical distribution much more closely than "distributed" control systems usually do.

3. *Implementation is largely open rather than completely proprietary*. Many of the platforms, operating systems, and communication methods are industry-standard and interoperable—including personal computers, Microsoft Windows NT, Ethernet, TCP/IP protocol, Foundation fieldbus, HART, OPC, and so forth. So, users are not limited to a single vendor or its licensees as much as before. Benefits beyond proprietary hardware and software include lower prices, ready availability, broad familiarity of use, and ongoing improvements independent of a single source.

The mill's DeltaV installation is a special case in that it stepped directly into the shoes of a functioning DCS by taking over nearly all the existing conventional field instruments. However, whenever possible, new instrumentation is intelligent, mostly on Foundation fieldbus.

As of May 2002, there were 56 smart transmitters and 47 DVCs on 11 Foundation fieldbus "H1" segments. Each H1 segment is a single twisted-pair cable that provides communication and power to as many as 16 instruments. Included are Rosemount pressure transmitters and magnetic flowmeters and Fisher valves with Fieldvue digital valve controllers. The automation package at Sprague includes Emerson's AMS asset management software that works with intelligent field instruments to enable remote instrument configuration, calibration, diagnostics, and preventive maintenance. PlantWeb architecture is being realized more fully as the system grows and as conventional instruments are replaced with intelligent ones.

ONE-BUTTON STARTUPS/SHUTDOWNS. As soon as the new digital automation system came on line in the filler stock prep area, one of the most obvious benefits was the familiar, efficient Windows environment for the operators and engineers. After very little practice, everyone involved was dealing with the controls much faster and more comfortably than before. Operators found the new system provided more information and was easier to use. They soon wanted more processes moved over to the new architecture from the legacy DCS.

Another more startling result was soon apparent: Nearly all control loops in filler stock prep were operating in fully automatic mode rather than manual. Instead of constantly tinkering with the controls to hold each process on an even keel, operators could keep their hands off for extended periods—up to an hour or more—if there was no major upset. For the first time, they were able to sit back and think about better ways to manage the process rather than fighting it. All this was due to the ease with which control algorithms are developed and implemented with the new digital automation system (for instance, cascade control of thickeners), combined with important process improvements, such as elimination of the dispersers and recirculation of stock from the machine chests during machine shutdowns.

Now, flows, pressures, consistencies, and so forth are maintained in the face of load changes without transmitting upsets to the paper machine. With more tightly controlled stock consistency in all three stock prep lines, the speed variability of the paper machine has been reduced by about 75%, resulting in higher speed capability, lower operating cost, and improved product quality. The machine's "up" time in terms of fewer sheet breaks has increased about 40%.

However, the most spectacular results to date have been implementation of "one-button" (fully automated) startups and shutdowns for each of the three stock preparation lines—first the filler, later the top liner, and finally the back liner. These sequences were developed and programmed by Harrison based on querying the operators and observing their actions and the results. As a result, startup times for these processes have been reduced from six hours to 30 minutes or even less. During a sudden shutdown, unless there is a mechanical failure, the floor stays incredibly dry.

Overall, this level of automation technology has made Sprague a smarter, more productive and cost-effective mill. It can now make twice as many tons of paperboard per day per operator, in addition to improvements in quality and reductions in steam and power costs. The DeltaV digital automation system and PlantWeb digital plant architecture have provided an infrastructure on which to build future improvements in performance. ■

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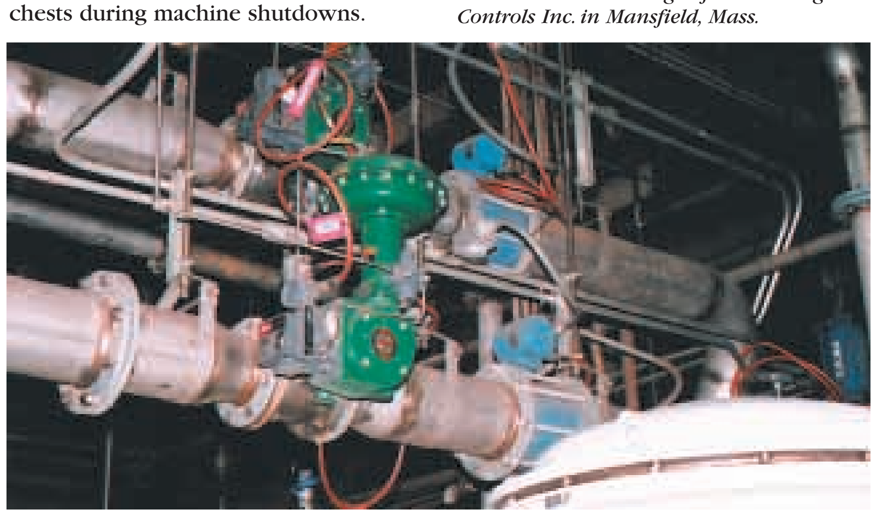

Valves with digital valve controllers and intelligent magnetic flowmeters connected via Foundation fieldbus