Organic control for a living process

HERMANN HARTENSTEIN AND THOMAS STEHLIK

Graphical software and powerful PLCs simplify process control design and millwide control into a single, uniform system you can adapt on demand.

No matter what grades you are making, the essential features of process control include the following:

- Tighter quality control
- Flexibility
- Troubleshooting ease
- Trends tracking
- Excellent cost/performance ratio.

To gain those features, many mills have installed sophisticated DCS and QCS systems since the 1960s, along with a myriad of instruments and software tools.

In homes and offices, the information highway has opened the way for sophisticated processing with easy-to-use software and less hardware. Likewise, a quiet revolution of graphical software and intelligent PLCs is bringing advanced control to operators and engineering and maintenance personnel while replacing multiple, complex, sometimes incompatible proprietary systems at paper mills. The modular PLC-based approach with common software also means a reduction in initial investment, as well as considerably lower costs for operation and modification.

What we will call "organic process control" (because it starts to become living control the moment you begin to design it and is easily adaptable to existing conditions or needs) is an approach for the entire paper mill to match or even exceed current expectations based upon three fundamental ingredients:

- Intuitive, universal graphical software
- Logic and control loops on a single information highway
- Standardized software and hardware.

Getting started

To achieve organic process control, you must make a technological leap of faith and accept the integration of logic control and continuous control into a single system. The traditional separation between the DCS (distributed control system) performing continuous control and the traditional not-too-bright PLC (programmable logic controller) confined to logic must be abandoned.

Next, you must accept the idea of open architecture and eliminate "black boxes," which many of us have grown accustomed to with the traditional DCS.

Finally, you must decide if you benefit by giving operators, engineers, and maintenance people system access anywhere in the mill. The introduction of a moving window of the process from anywhere you choose to place a man-machine interface in the mill will allow for on-the-spot process adjustments or permanent changes by any authorized person (see **Fig. 1**).

Some papermakers around the world have already embraced these concepts. Several minimills have also opted to try this innovative form of PLC-based control system. The system has also proven itself at one 700-tons/day newsprint facility and is theoretically powerful enough to handle any pulp and paper mill, whatever the size.

Smarter PLCs, no gateways

What follows is a description of the new organic control approach, with graphical software and standardized hardware across all mill functions.

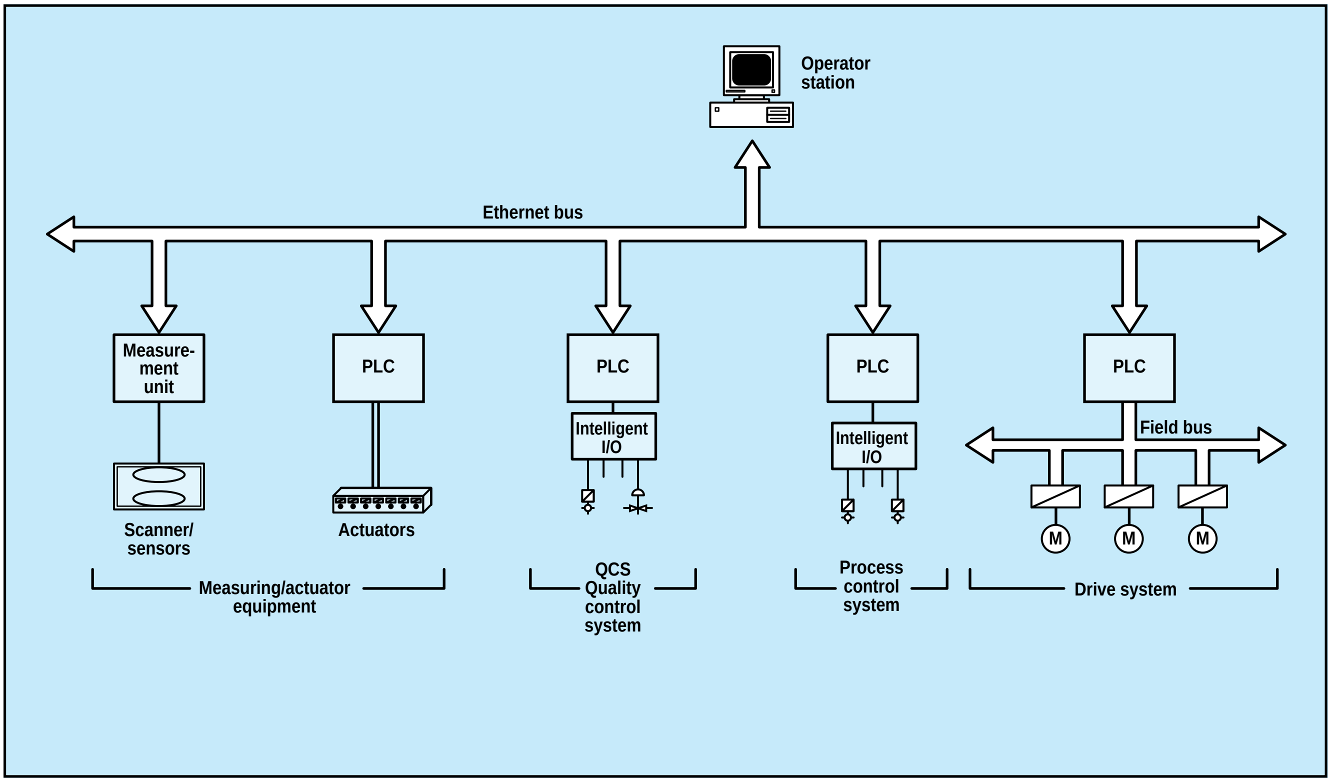
PLCs have traditionally been used as binary control devices for open-loop control applications. More recently, the functional scope of PLCs has increased to include closed-loop applications.

More-intelligent PLCs actually change the entire scheme of process control in a pulp and paper mill from centralization to decentralization, allowing complete mill visualization of any function to be generated on demand from any location in the mill.

Information isn't cabled into a central unit. It resides where it originates. But thanks to the Ethernet communications highway, the center control room is wherever you happen to be in the mill, choosing to access the information you need.

Processors slotted directly onto PLCs connect each station to provide intelligence and offer sophisticated task control capabilities (**Fig. 2**).

1. Organic process control configuration



Because of the intelligent processors associated with each PLC, binary signal processing and loop processing are combined, where binary logic commands can be processed in 0.1 microsecond and PID loop commands in 1 microsecond. Complete loops can be processed within about 100 milliseconds. With slower analog tracking of pressure and temperature levels for example, there's no need for millisecond readings, so the logic is designed to look at these measures every 2 or 4 seconds.

A graphical CAD-based programming technique is used to configure the intelligent PLC that can be done offline on any DOS-based PC or online on the PLC-based control system.

The configuring engineer has 250 standard modules to draw from to configure binary and loop controls. Function blocks, selected from the software library, are placed on the PC screen and connected by using a mouse. Any function group can be declared a macro, copied, and documented as a printout. Macros range from simple motor and valve controls to complex technological packages and even MD/CD profile controls.

Once the function has been configured, the binary and loop controls can be tested and simulated offline. PC inputs can be defined and functions tested using on-screen oscillogram functions.

Connectivity

The PLC concept can be used for all drive control and automation tasks in the mill. The PLCs are connected through a 10-Mbaud Ethernet bus conforming to IEEE 802.3 standards. That forms the lifeline throughout the mill. Fiber optics can be used as the link for enhanced noise immunity. The standardized bus allows one manufacturer's device to interface with another manufacturer's device, providing true open architecture.

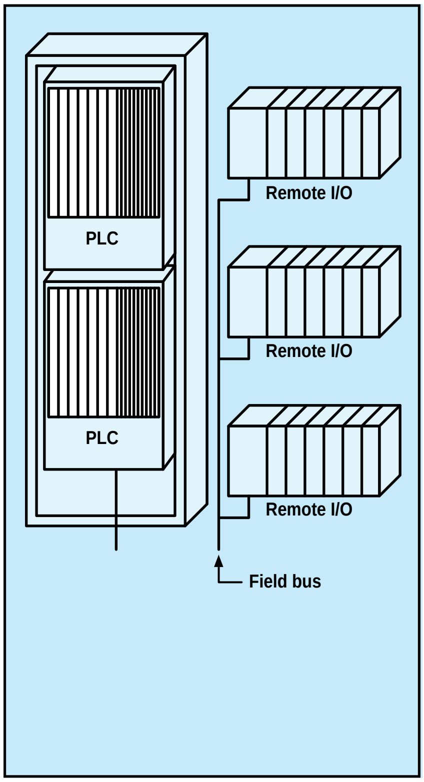
The fiber optic Ethernet bus can even be installed as a ring. If the fiber optic communications link is damaged or lost at one point of the ring, the system still works. You will get an alarm to get your attention to fix the damage. A standardized field bus is used to connect peripheral devices to the PLCs. This includes ac and dc converters for sectional drives or transmitters, sensors, and actuators for process automation functions.

Sectional drives

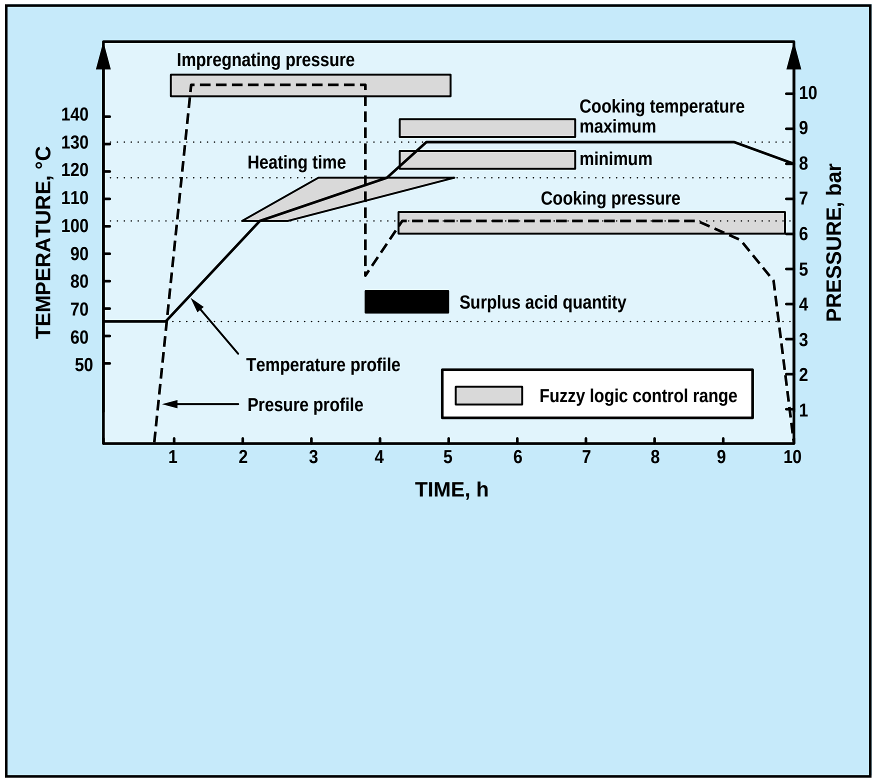
The PLC can handle well over 100 coordinated drive sections. It controls the master reference and grade changes and communicates with the drive converters through the field bus. Depending on the drive configuration, technology processors might be included to handle functions such as ramps, interlocking, tension control, and more. The converters, which can be either ac or dc or a combination of both, have their own digital speed and current control loops and sophisticated diagnostic functions that can be accessed through the field bus.

The process is broken down into a series of islands or cells that are assigned to PLCs, which handle both fast binary processing (interlocks, sequential controls) and loop controls

2. PLC graphic and intelligent processor



3. Fuzzy logic as applied to pulp cooking



(level, temperature, flow) with one common configuring technique.

The CAD-based configuring techniques used for process control are identical to those used for the sectional and stand-alone drives. This is the same type of bus used for the drive application, transferring data to and from the actual process or field. Intelligent, remote I/O are distributed throughout the process, providing significant savings for cabling, and also allowing fast startup and troubleshooting.

When it comes to quality control systems, machine-direction (MD) and cross-direction (CD) controls are also implemented using the same PLC concept that simultaneously provides a hardware platform for future concepts involving fuzzy logic.

By logging and categorizing actual process experiences of mill personnel, fuzzy logic can be designed into the organic process control system to build on human brainpower to meet targeted goals. These include gains like higher yield and strength and reduced energy requirements (**Fig. 3**). This applies to a variety of applications ranging from digesters or mapping identification on a CD basis-weight profile for paper machines.

Troubleshooting and diagnostics

Often, unscheduled downtime is caused by faulty sensors or actuators in the process, such as a defective limit switch. A diagnostic system integrated into each PLC tells the operator why an expected response has not occurred after a specific action, for instance why a motor is not running after being switched on. A display is automatically generated that shows the cause together with date, time, and symbolic designators or tags in the PLC program (**Fig. 4**).

The actual diagnosis is executed using a PC connected to the cell PLCs through the Ethernet bus. This PC contains the diagnostic system program. When a fault condition occurs, the user program is analyzed backwards until the cause or causes are found.

Full graphics display is used to indicate all of the pertinent data to either eliminate or reduce unscheduled downtime to the minimum.

Trends and phantoms

Trends, which traditionally have been made with an oscilloscope, can be accomplished with the software by configuring a trend picture. To define scaling, for example, you choose how large you want the trend to appear on the screen, then choose the time base, such as 10 minutes, or over 1 minute, and save it. You can track the same trend over and over again.

You can build hundreds of trend pictures. You can scroll forward or backward in the history of the trend. The only limit is the memory in the PC. You can also trigger the trend running, to check unexpected events.

Devices from the same system family are used for process visualization and a similar software system is used to configure graphic displays—from motor currents and paper machine operating status to process displays for all areas of the mill.

Minimill application

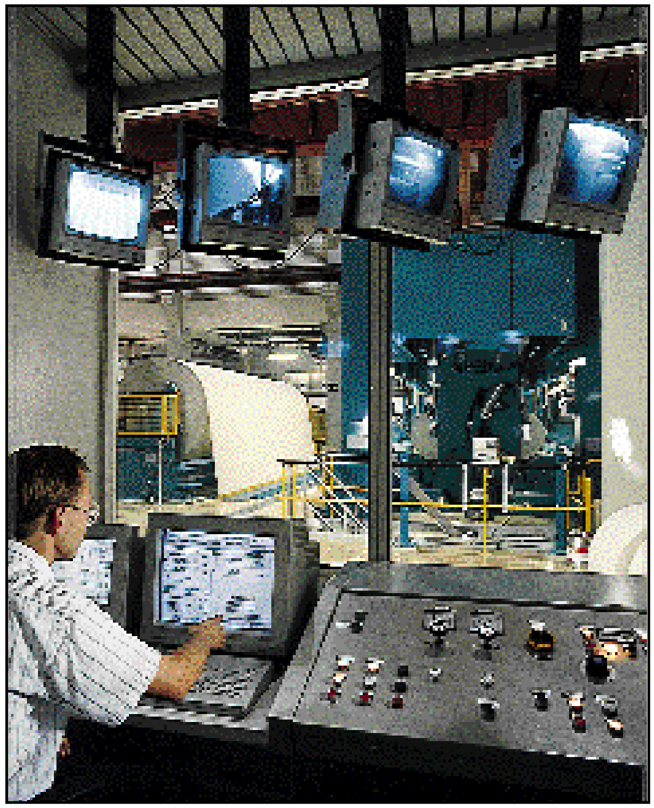
In actual use at a linerboard minimill, the PLC-based process control system tracks key parameters throughout the papermaking process, including QCS and drives control, using the single Ethernet highway. There are no gateways. With one hardware and one software platform and fewer than 10 PCB modules, the system generates valuable process data in each area of production.

Delivered by one project manager, the system requires less training, a smaller staff, less maintenance, and fewer spare parts. The configuring software links directly with the PLCs, which in turn receive sensory information from the process and send commands to the paper machine's ac drives. The drives' speed and torque are coordinated by the PLCs.

Paper tension at every point in the process is carefully monitored. The DCS automatically adjusts the speed and torque of each drive as necessary. The winder uses the same ac drives as the paper machine for its main drive and brake generator.

To minimize wiring and facilitate future expansion and modification, the system is designed to meet field bus specifications. It has distributed I/Os for its PLCs throughout the process. Intelligent terminal remote modules communicate over twisted pair cable to the main PLCs.

4. PLC in the mill



Newsprint mill application

Process control and drive automation, based upon the uniform software/hardware structure already described, have also been applied to a deinking facility with a 700-tons/day production capacity.

The power station, waste paper preparation system, water treatment, paper machine, quality control, drives, reel cutters, and the salvage winder all function under the system.

Closed-loop control and advanced applications such as trends and troubleshooting are handled by 21 smart PLCs. Signal acquisition and preconditioning draw upon intelligent terminals, which means lower cabling costs and easier startup.

Operators work from a central control room and terminals strategically located throughout the mill. Diagnostics and archiving are possible from any location in the mill.

A special feature has been added to memorize and recall any of 3000 trends for six months. All long-term trends can be accessed by any process control monitor. TJ

Hartenstein is manager, pulp and paper, Siemens Energy & Automation, Atlanta, GA. Stehlik is applications engineering specialist, Erlangen, Germany.