Advanced boiler automation integrated with paper mill legacy DCS

Use of PlantWeb® with FOUNDATION™ Fieldbus Speeds Retrofit

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The cogeneration plant at the Blandin Paper Company mill in Grand Rapids, Minnesota, was recently upgraded to provide a more reliable source of steam to assure that headers serving the mill would be rock-solid. The project involved decommissioning two 65-year old natural gas-fired boilers, installing two new gas-fired package boilers automated with the latest field-based process automation, and then tightly integrating the new automation with an 11-year old DCS . The DCS runs the mill's paper machines plus the cogeneration facility's plant master and two retained wood-fired boilers.

The upgrade allows better coordination between the four boilers plus two steam turbine generators and three headers supplying steam to the mill at 400, 150, and 50 psi for drives, thermo-compressors, dryers, and building heat. Benefits from the upgrade: more stable header pressures, reduced fuel costs through more efficient boiler loading, and faster response to mill steam loads multi-sourced from the boilers and from downstream pressure reducing valves (PRVs), turbine extractions, and turbine exhaust.

Blandin Paper, a subsidiary of UPM-Kymmene, Helsinki, has a pressurized groundwood mill and four paper machines and is a major manufacturer of the light weight coated paper used by publications such as national news magazines. Its largest paper machine boasts a 311-inch trim width and 4900 fpm speed using an off-machine coater.

Automated with latest technology

The mill's free-standing cogeneration plant, which houses the boilers and turbines, was owned by the paper company until 2000, at which point it was sold to Minnesota Power and became the Rapids Energy Center. The sale contract stipulated that the two aging gas boilers be decommissioned and that the two new automated boilers be installed within a powerhouse building expansion. The new boilers were to more closely supplement the two existing wood-fired traveling-grate boilers. Significantly, the upgrade had to be completed within 10 months.

Minnesota Power's Engineering Department was allowed three months to design the expansion and to specify and purchase

On the left is the dual-screen DeltaV PC operator workstation for the new gas boilers, manned here by Mac Bonham, Station I&L; on the right is the existing PROVOX DCS operator console manned by Ray Nellis, Cogeneration Plant Operator.

equipment. Controls development was allotted only 6 to 8 weeks, which led to Minnesota Power retaining systems integrator Novaspect Inc., Minneapolis, to assist. PlantWeb digital plant architecture with FOUNDATION fieldbus technology from Emerson Process Management provided needed design and installation speed and simplicity.

PlantWeb's DeltaV™ digital automation system consists of:

- A single, modular, DIN rail-mounted controller in an un-airconditioned field cabinet adjacent to one boiler
- PC operator, application, and engineering workstations in the powerhouse control room,
- An Ethernet network tying the controller and workstations together,
- FOUNDATION fieldbus technology for networking of field instrumentation,
- Intelligent motor protection relays, and
- Graphical configuration of boiler control logic.

Fieldbus instruments include Fisher® valves with Fisher FIELDVUE® digital valve controllers, Rosemount® pressure and temperature transmitters, Micro Motion® Coriolis flowmeters, and several non-Emerson devices. The PlantWeb architecture was seamlessly integrated into an existing Emerson PROVOX® DCS running the paper mill, turbines, and wood boilers.

The powerhouse operator has a DeltaV dual-screen PC workstation for monitoring and running the gas boilers. He can also monitor

DeltaV controller in a field cabinet adjacent to one of two new packaged gas boilers.

and run these boilers from the DCS console. For convenience, the existing DCS console is most often used.

Variety of steam sources

The four boilers produce approximately 200,000 pph each of super-heated steam; the high pressure (HP) wood-fired boilers at 1250 psi and 900°F, the new low pressure (LP) gas-fired boilers at 400 psi and 670°F. Total mill and cogeneration plant steam demand can be as high as 500,000 pph.

The HP boilers feed a 17 MW non-condensing turbine-generator. They also serve a turbine bypass PRV that supplies 400 psi steam to both a 16 MW LP condensing turbine-generator and the 400 psi mill header. That header is additionally served by extraction steam from the HP turbine.

The two new water-tube boilers directly feed the LP turbine and the 400 psi mill header. The 150 and 50 psi headers are served by combinations of extraction steam, additional turbine bypass PRVs, and HP turbine exhaust.

The mill is king

A plant-master control algorithm, which resides in the DCS and takes into account operating priorities and economics, was enhanced to govern which on-line steam sources would be the most cost efficient for particular combinations of mill and turbine loads and fuel costs. In general, some of the factors considered by the algorithm's strategy are the following:

• To maximize paper output (the site's most valuable economic activity), the mill has first priority on steam. Turbine generator outputs are sacrificed if necessary to support surges in mill header demands. Under normal conditions, however, both turbines operate at their maximum outputs to minimize purchased power costs and maximize available extraction and exhaust steam. The generators, whose only customer is the mill, provide at full output 80% of the mill's electrical needs. The shortfall is purchased from the Minnesota Power grid.

• The HP wood boilers are the base steam source and are loaded to the maximum. The HP turbine's 1250>400 psi bypass PRV is normally closed, with headers maintained by turbine extraction and exhaust alone. Extraction is more efficient than a PRV.

• Because wood and bark waste trucked from local sawmills is the least expensive energy source, it is the primary HP boiler fuel. Coal supplements these boilers if wood alone cannot maintain steam pressure. The HP boilers have been running a 90% wood / 10% coal mixture, with about 1000 tons of waste wood consumed per day.

• The new LP gas boilers contribute steam only if the wood boilers cannot meet mill and turbine loads or if a wood boiler is off line. The algorithm states that if either a wood boiler, the HP turbine, or the 1250>400 psi PRV becomes hi limited, a gas boiler will be brought on line as a peaking unit in swing service to meet steam demand.

Should natural gas become less expensive than coal, supplementing the wood boilers with coal will cease, steam from these boilers will be portioned to assure maximum HP turbine output, and the gas boilers will pick up unmet 400 psi header and LP turbine loads. With recent high gas prices, the gas boilers were largely unused last summer, although one was occasionally maintained at minimum steam flow for quick response should a wood boiler fail. During the winter, one gas boiler was needed to help meet building heating loads.

Efficient communications between control systems

To maintain solid header pressures, the new boiler automation must communicate quickly and transparently with the plant master in the DCS. Communications are accomplished using a PROVOX Application Server (PAS), a combination PC hardware/software solution for automatically configuring data flow in both directions and for enabling DCS screens to operate DeltaV control modules. The PAS resides on the new automation's Ethernet network and taps into the DCS's data highway.

The PAS has prolonged the life of Rapids Energy Center's legacy DCS by permitting the DCS to be quickly and cost-effectively expanded by adding the fully scalable, field-based automation. The server-to-server PAS solution is faster to develop, less engineering intensive, and more capable than serial links, hard wiring, or an OPC bridge. Hundreds of points, including error messages and tuning parameters (the later handled appropriately to the system they are viewed on) were configured in minutes. Because the PAS does not support commands, several hardwired analog I/O-to-I/O circuits were necessary for gas boiler raise and lower commands.

At some time in the future, Minnesota Power expects to switch the plant master and HP boiler control to the new automation, leaving the legacy DCS for mill control only and splitting the ownership of the two control systems at a more natural point.

Same as company-wide historian

A further advantage of the new automation is its built-in OSI PI historian. PI is Minnesota Power's standard generation historian

Bonham at an instrumentation stand for Rosemount fieldbus transmitters adjacent to one of the package boilers.

Exterior, Rapids Energy Center cogeneration plant. Steam at 400, 150, and 50 psi is piped underground (directly below pipe bridge in the foreground) to the UPM Blandin paper mill unseen to the right.

for assisting dispatchers and power marketers. The historian used by the DCS in the Blandin mill -- and formerly used in the cogeneration plant -- is paper industry oriented and not feasible for integration into Minnesota Power's corporate system.

The new automation's PI historian captures data from the gas boilers, as well as relevant data captured by the DCS. In fact, much of the data from the DCS passing through the PAS is intended for the new historian. All cogeneration plant historical data will soon be uploaded to a Minnesota Power central PI server.

Fieldbus speeds installation

On the backplane of the gas boilers' modular controller are dual-redundant CPU and power supply cards, three FOUNDATION fieldbus cards having two H1 segments each, six 4-20 mA analog I/O cards, and a serial communications card. The burner management system is separately hardwired.

A total of 56 bus-powered fieldbus instruments are distributed over the six H1 fieldbus segments. One fieldbus card is dedicated to each boiler, while the third card is common to both. All PID and operating logic takes place in the controller; none is distributed to field devices. Fieldbus instrumentation was chosen over conven-

tional analog versions primarily to save time -- although overall costs later proved to be lower. Less wiring and conduit was necessary, and commissioning and calibration proved to be about twice as fast. An ongoing benefit to operators is the large amount of device status and health information available.

The controller's analog cards service several instruments not available in fieldbus plus inputs from an O_2/SO_2/NOX continuous emissions monitor, the commands from the DCS, and several on-off devices that were later fitted with positioners. The latter include flue gas recirculation dampers that now permit percent-open settings to be established from the control room, and startup vent valves whose flows can now be adjusted to protect the super-heaters.

Boiler configuration graphical

Systems integrator, Novaspect, used an in-house developed boiler control package plus the boiler manufacturer's P&IDs to quickly and graphically configure the new gas units. The package consists of standard and derived function blocks in the IEC 61131.3 Function Block Diagram language that are assembled to manage combustion, fuel-air ratio, excess air trim, three-element drum level, feedwater pumps, steam pressure, FD fans, etc. The boilers have no ID fans, and only the condensate pumps are common between the gas and wood-fired units.

Minnesota Power plans to add a simple, automatic, feed-forward notification system that will tell the cogeneration plant operator when a surge in steam demand is expected. The operator will then be able to temporarily overstoke the boilers and raise turbine back-pressures to make more steam available for the mill headers. Notification will be by an alarm triggered by vacuum being applied to a paper machine press, an indication that a sheet is about to be pulled across the press and that demand for steam by the dryer will soon soar. If two paper machines at the same time signal that press vacuums are being pulled, the operator could call the mill and ask that one machine be delayed for 20 minutes or so. Presently, notification by the mill of impending steam loads is by phone and too often forgotten by mill operators.

Switchgear relays go electronic

With typical boiler control systems, open/close commands to relays operating 2400-volt switchgear powering large motors are transmitted over hard-wired connections. For the new boilers, Minnesota Power elected to employ intelligent electronic relays communicating with the DeltaV controller via a high speed, full-duplex, RS-485 serial link using the open Modbus data representation in a multi-drop configuration. The only hardwiring is for emergency trip pushbuttons on the face of the switchgear. The relay installation consists of six motor protection relays (for three BFPs, two FD fans, and one spare) and one overcurrent relay for the switchgear feed.

By going digital, wiring costs were drastically cut and operating information from current transducers and nearly 30 other points plus some 25 alarms are transmitted to the operator, giving a very good picture of the status and health of these vital motors and their power source.