Control performance supervision enhances revamp

Upgraded ethylene cracker achieves targeted production rates in record time

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BOREALIS OPERATES A FACILITY IN PORVOO, FINland, that produces ethylene, propylene, butadiene, acetone, phenol and polyethylene. The complex, which employs almost 900 people, is integrated with a refinery upstream. In the spring of 2007, Borealis upgraded an ethylene cracker there. To get a solid return on the millions of euros invested in the project, it was essential to meet the target production rates each week once the ethylene unit came online. The company realized that improved control performance was crucial to achieving that goal. With almost 1,000 control loops in the ethylene cracker and only a few control engineers, Borealis needed to focus efforts on the most important areas.

Project scope

The revamp was designed to increase annual capacity from 330,000 tons to 380,000 tons. The project included equipment upgrades to a gas compressor, hydrogen purification unit and several distillation columns. Regulatory and Advanced Process Controls (APC) were updated to handle the modified process. For the advanced controls to deliver the best results, all regulatory controls must properly function.

Without any dedicated tools or techniques for control loop monitoring, Borealis relied heavily on instrument maintenance and control engineers to detect problems. This reactive approach meant that only the most obvious and visible problems were addressed. Equipment repairs were based on age of service rather than objective measures of condition. Without the tools for continuous monitoring, problems often progressed to the point of failure before being reported and corrected.

To prepare the controls for successful startup, the company adopted three major strategies:

1. operator training with a simulator;
2. revision of APC; and
3. improvement of regulatory controls.

Operator training — Ethylene crackers average five years between turnarounds, so operators don't develop much experience with startup and shutdown situations. To fill that experience gap, Borealis installed an operator training simulator.

The simulator trains operators to handle:

- startup;
- shutdown;

• normal operation; and
• abnormal and emergency situations.

Advanced controls — With the changing process, Borealis needed to revise the APC. They were extended to include the new process equipment; models also were updated to reflect the performance of the new system.

To ensure that APC could deliver the most value, Borealis focused particularly on stabilizing and improving the underlying regulatory controls. Even small levels of cycling or instability may cause the APC to back away from optimal operation.

Regulatory control improvements — Borealis recognized that issues such as control valve mechanical problems, poor controller tuning and instrument failures were undermining regulatory control and directly affecting the performance of the plant.

To address these issues, we installed PlantTriage performance supervision software from ExperTune. This software connects to the control system via OPC and then identifies and prioritizes opportunities to improve regulatory control.

The software allowed us to see, for the first time, the performance of all the important control loops in our plant. Within a few days of software installation, we had uncovered a host of control system opportunities.

Dashboard insights

The Borealis team used plant performance dashboards (Figure 1) to determine the most important issues. Through these dashboards plant personnel could quickly identify the issues, drill down to root causes and then take appropriate actions.

One of the most useful tools was the "Biggest Payback Loops" list, which singles out the 10 most important opportunities in the plant ranked by technical and economic criteria. Using this list, control engineers could allocate their time to deliver the greatest value. Drilling down on each loop in the Biggest Payback list shows specific details and the likely root cause of poor performance.

"When plants first start with performance monitoring, it is quite common to find some 'low hanging fruit.'"

For instance loop FC-16026 was diagnosed as having extremely high valve travel — which causes high process variability, increased valve wear-and-tear and valve mechanical problems. Simply adding a small filter to the instrument signal can address the issue. Process stability improves almost immediately. "In most plants, valve travel may be reduced by a factor of 50% or more through the application of a filter and some appropriate tuning," notes John Gerry, president and founder of ExperTune.

"When plants first start with performance monitoring, it is quite common to find some 'low hanging fruit.' These are problems that have been overlooked because most plants do not monitor some of the most important key performance indicators," Gerry adds.

Borealis found "low hanging fruit" in the form of underperforming control valves, lack of instrument filters and some controller tuning opportunities.

Uncovering valve issues

The performance supervision system automatically identifies a variety of mechanical control valve issues. These include:

• oversized valves;
• undersized valves; and
• valves with stiction and hysteresis.

The standard reports prioritize valve repair issues according to both technical and economic factors. This information helps the team to plan and schedule the appropriate maintenance and to focus on issues to investigate in more detail. In some cases overcoming valve problems requires only minor adjustments, such as recalibration of positioners or adjustments to valve air pressure.

>> Plant performance dashboard

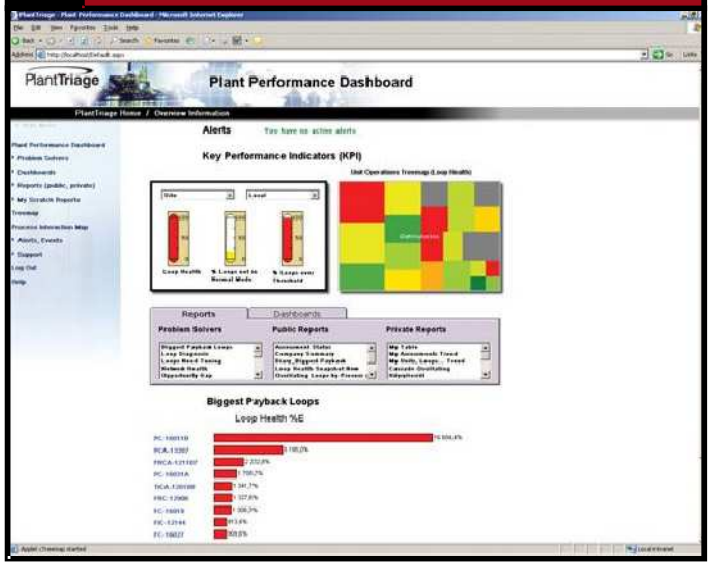

Figure 1. The dashboard provides an overall view and, with drilling down, highlights major opportunities for improvement.

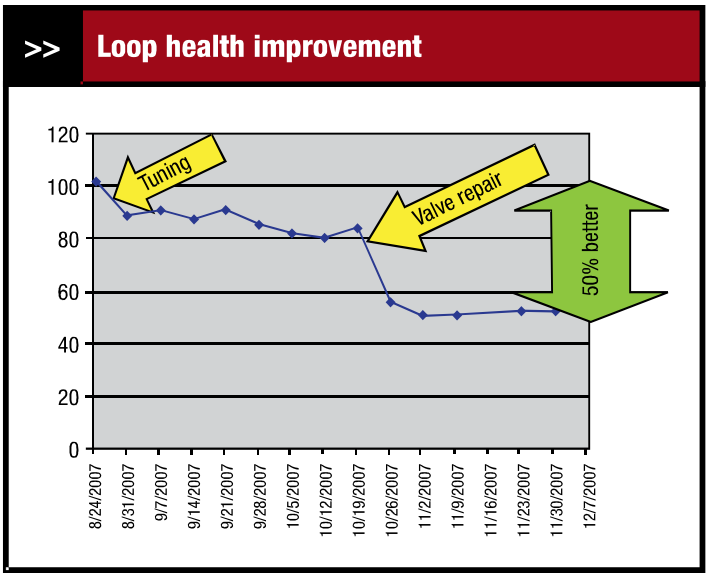

Figure 2. Tuning and valve repair significantly enhanced furnace temperature control.

The payout from resolving these issues can be dramatic. At Porvoo, the PlantTriage software detected problems with the feed and dilution steam control valves on the cracking furnace. So, the maintenance schedule for these valves was accelerated. The furnace operation stabilized, reducing energy consumption. Figure 2, which charts a composite metric called Loop Health that is used to measure the overall effectiveness of the control loop, shows the impact of tuning and valve repair for the furnace temperature control. With better control, variability reduction resulted in better quality and capacity utilization.

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The undersized valves report identifies process constraints or bottlenecks. In some cases the constraint may be removed with relatively minor equipment changes.

Oversized valves amplify mechanical, tuning and control design issues. Replacing valves or swapping out the valve trim greatly reduces these effects and brings the process back into control.

Other improvements

Process stability depends heavily on the performance of individual control loops. In the ethylene facility, tem-

perature controls have been notoriously difficult. Previous manual attempts at improving controller performance left us with controls that worked but were less than optimal. Using the integrated tuning and loop optimization tools within PlantTriage allowed us to push controller performance closer to optimal. The results were immediately apparent (Figure 3).

The robust controller tuning approach eliminated loop cycling and interactions, adding a great deal of stability to the process. This, in turn, allowed APC to be used to the fullest, actively pushing the entire process toward optimum performance.

We also focused on the control valve, because it's the most likely point of failure in a control loop. Using valve travel diagnostics, we've been able to identify control valves with the highest level of wear. The root cause usually is related to tuning or inadequate instrument signal filters — and so can be addressed quite easily. Appropriate filtering and tuning can dramatically reduce valve travel.

Figure 3. Effective tuning provided close-to-optimal control of process variable.

We're now using the performance supervision tools to identify and eliminate bottlenecks, further increasing production.

Standard measurements and thresholds — e.g., for valve stiction, valve hysteresis and instrument noise band — will guide future maintenance action for valves and instrumentation. Setting an accurate metric and a definite threshold helps in two ways, by:

1. drawing attention to valves and instruments as they *start* to deteriorate; and
2. reducing unnecessary maintenance. Hardware that performs within the thresholds receives low priority from the maintenance team.

Impressive results

The startup was the quickest in our plant's history. Borealis achieved production at the new nameplate capacity within 20 days after startup, with all product on-spec. The plant now is exceeding design output.

It's impossible to separately measure the return on investment from the operator training, advanced controls and performance supervision. However, the net effect was to reduce the start-up curve by several days. These investments also have paid for themselves in the ability to run the plant closer to bottlenecks. With the increased capacity, Porvoo is pushing the process further and simultaneously hitting several new bottlenecks. These tools enable Borealis to drive closer to new production limits while at the same time adding stability and safety.

"This was a fantastic start-up. The tools and techniques used at Porvoo are state-of-the-art, and helped us to deliver a high rate of return to our business," says Hannu Luoto, Plant Manager at Porvoo.

Maintaining good control performance and equipment reliability are key goals for the future. But Borealis also is continuing to find opportunities to improve. We're now using the performance supervision tools to identify and eliminate bottlenecks, further increasing production. With most of the obvious constraints eliminated, we're applying some of the more advanced tools to find and remove oscillations, improving efficiency even more and pushing production rates higher. As we integrate performance supervision into our daily routine, we expect to continue to uncover more opportunities not just to sustain but to continually improve plant performance.

Borealis also is looking at the possibilities of applying these tools and techniques at plants around the world. **CP**

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