Chemical Processing

Real-Time Sensor Validation Makes FMC Plant Smarter

FMC Corp. is using the Falconeer III Process Monitoring Suite (see sidebar) to monitor sensors and process operations at its Active Oxidants Division plant in Tonawanda, N.Y. The plant produces ammonium, potassium and sodium persulfates for applications including catalysts, organic synthesis and oil recovery. The company first installed the system in 2001, and upgraded to Version 3 last year. So far, the software has allowed the company to identify faulty instrumentation and troubleshoot processes more effectively, reducing downtime, according to Process and Special Projects Technologist Charles Lymburner.

To improve plant efficiency and product consistency, FMC had installed a Honeywell TDC 3000 distributed control system (DCS) at the facility, Lymburner explains. If total computer control could be achieved, the company reasoned, production costs would come down and product consistency would improve. Operators could start up processes using their normal operating procedures, but turn them over to the computer once the operation had reached its "normal or steady state" mode, allowing the process to run on virtual "auto pilot."

Online validation of data would be essential to ensuring that instruments didn't lie. "We all know that instruments fail and they never send e-mails before they do," Lymburner says. Using the Falconeer system, a method was developed to validate this critical information, using multiple data inputs with material and energy balances and automatically generated secondary logic equations to detect any faulty instruments.

FMC has applied Falconeer III to a complex electrolytic process with recycling streams, a generalized schematic for which is shown in Fig. 1. The main unit operations in the plant are electrolytic cells and a crystallizer. In addition, a series of feed and mixing tanks are used to maintain the correct chemistry, while the Honeywell TDC 3000 DCS runs the circuit.

FMC wanted to optimize use of the data collected by its process-control system. The company was most interested in improving its safety systems, optimizing certain under-performing unit operations, improving process on-stream time and reliability by 1%, a gain of about $100,000 when the plant was run at full capacity.

In addition, the company wanted to reduce raw material consumption and pare staffing, by eliminating one operator per shift, or four operators for the plant, saving $300,000. Finally, the company hoped to capture existing process knowledge in a organized and usable manner (see sidebar p.21).

FMC had evaluated a number of multivariate fault detection and control applications, Lymburner notes. Falconeer's seemed to be a more fundamental approach with easily

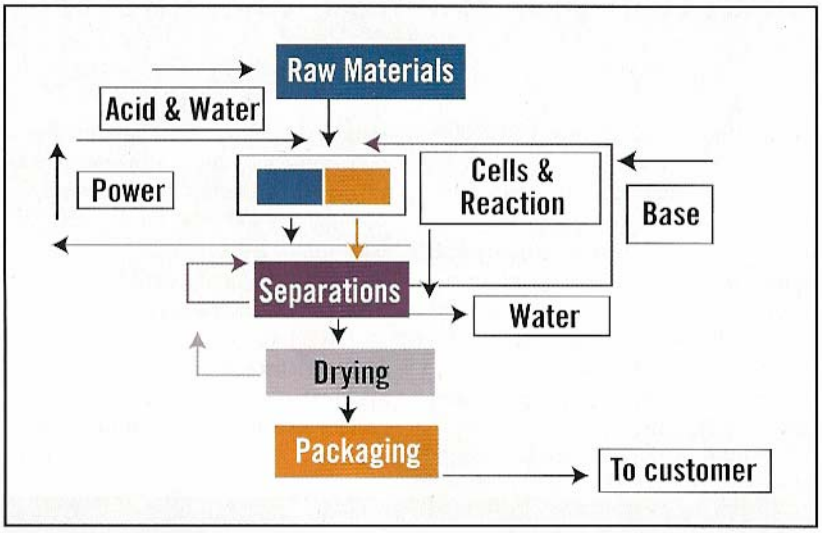
System Overview

The Falconeer III Process Monitoring Suite program is a control software tool designed to help process operators and engineers by monitoring current process operations, explains Doug Lenz, president of Williamsville, N.Y.-based, Falconeer Technologies. "It helps them use the critical data and information from their existing process control systems, whether old or new, rather than being overwhelmed by this information, so they can spend more time acting on the identified opportunities instead of trying to understand what the data are telling them," he says. The system continuously analyzes specific sensor measurements and process conditions and gives advisory alerts when processing problems occur. These alerts go beyond typical DCS alarms because they incorporate engineering models and advanced statistical calculations, allowing users to determine whether monitored sensor measurements are correct or whether other process faults are occurring.

The Falconeer III Process Monitoring Suite consists of several software modules with display screens. These include:

- A State ID software module that determines whether the process is operating within standard conditions. This determination begins once the process has started up and continues until shutdown, running continuously and adjusting its analysis to current process operations.
- The Sensor Validation and Predictive Fault Analysis (SV&PFA) software module monitors current process sensor measurements to determine if they are either valid or incorrect. It also determines if certain processing faults (leaks, pump failures, controller malfunctions, etc.) are occurring or not. It does this by evaluating engineering models that describe normal process operations. Briefly, when the process system is operating normally (i.e., fault-free), the engineering models describing normal process operation should all close. A failure to close indicates that something is going wrong in the process system. By detecting patterns, it is possible to infer the underlying fault(s) in the process that could cause such behavior. These results are then given as alerts to the users. If not found to be faulty, the sensor measurements are considered validated (i.e., trustworthy). Besides determining single-fault alerts, the SV&PFA module also determines many plausible pairs of fault hypotheses, i.e., multiple faults.
- The Virtual Statistical Process Control (VSPC) software module augments the SV&PFA module, providing an independent but complementary analysis of sensor measurements. The module uses Exponentially Weighted Moving Averages (EWMAs) to determine in real-time, rather than after the fact, whether individual process sensors and process conditions are in control, are going out of control, or are definitely out of control. "The EWMA calculation is our preferred method because of its ability to not only monitor current process operations but to forecast where the process is headed," Lenz says.

Figure 1



The process that FMC is optimizing, using a Honeywell DCS and Falconeer sensor validation software, is outlined here.

Source: Falconeer LLC

Figure 2

This screenshot depicts what an operator would see on a typical alarm page.

Source: Falconeer LLC

programmable and understandable equations and logic, he says.

Sophisticated surveillance

The Falconeer III installation incorporated about 100 sensor measurement inputs, 40 unmeasured process condition inputs (such as leaks, solution compositions, assumed flows, etc.), 24 material and energy balance primary or independent models and three performance equation models.

The program automatically generated and compiled nearly loo additional secondary or dependent engineering models, about 250 potential determinable fault hypotheses and around 60,000 single- and multiple-fault diagnostic rules.

Falconeer III uses fuzzy logic and certainty-factor calculations to ensure confidence in its conclusions, the software maker's president Doug Lenz says, with an algorithm that anticipates all possible levels of diagnostic resolution between faults.

Configuration of the software required developing engineering models and evaluating them with sufficient process data to determine their normal variances and offsets. This effort paid off, yielding the following initial dividends:

- Several process sensors routinely used to control the process were found to be in error;
- A higher-than-expected unmeasured flow was discovered in one unit operation;
- Some of the model residuals provided supporting evidence for expected, but unmeasured, process phenomena such as fines destruction and crystallizer boiling point elevation.

As the system was tested and validated, the following upsets and disturbances were identified:

- The system's VSPC module detected Coriolis meter density and flow components failure 12 to 18 hours prior to TDC alarms and detection by the SV&PFA module. The meter's temperature component was unaffected and remained validated.
- Falconeer's SV&PFA module traced a crystallizer vacuum leak to a condenser unit.
- The SV&PFA module correctly diagnosed crystallizer overflow pump failure, twice, over a six-month period, and also pinpointed catholyte pump flow failure.
- The unit's VSPC module detected four controlled variables operating in manual control.

During 14 months of implementation and testing at FMC, the software detected causes for roughly half the process' unscheduled downtime, enabling savings in the hundreds of thousands of dollars. If the system could predict just 15 to 20% of the causes with enough time for the operators, engineers or maintenance workers to take corrective action, then it would pay for itself in one to two years, the company says.

Falconeer III took six months to implement, Lymburner says, and training needs were minimal for process-Control engineers. Users can be trained in one or two hours," he says. CP

Capturing Expert Knowledge

Increasing automation can reduce manpower requirements. However, it can also result in an unquantifiable loss of process knowledge and experience. Falconeer III is designed to minimize this loss, allowing users to capture and document process knowledge in a customized user guide and readily retrievable Access database.

Since the beginning of development and implementation of Falconeer III at FMC's plant, the facility reduced its process and production-support staff by about 50%, due, in part, to advanced automation and cost-cutting. However, FMC was able to capture in the system the combined knowledge of operators as well as process, manufacturing, control and maintenance engineers. As a result, the company says, its plant remains well controlled and more productive, and has captured expert process knowledge and information that would otherwise have been lost.