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Optimize cracked-gas compressors with smart-automation technology

Machine health monitors can provide critical information to avoid unit and plant-wide shutdowns

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The cracked-gas compressor (CGC) is the single most critical piece of equipment in an ethylene plant (Fig. 1). This asset can cost as much as $50 million and operates 24/7 under demanding conditions. Because it has no backup, ethylene producers know that if their CGC trips—whether the trip is caused by excess vibration, a surge, an instrument malfunction or other problems—their entire ethylene process may be halted for up to a week.

Compressor operation must be fine-tuned to maximize performance and reduce spurious trips that result in downtime and unnecessary maintenance. By increasing operating efficiency, boosting unit availability and production, and reducing maintenance costs, producers can increase their ethylene plant's throughput to meet market demands. But several challenges lie between the producer and attaining those goals.

Challenges. Results of an olefin-compressor reliability survey presented at the 2008 Ethylene Producers' Conference highlight several of these issues.[1] Producers named instrument problems as the major cause for compressor trips. The ethylene production process itself is inherently tough on such devices. Probes become dirty and are subjected to extreme temperatures. This can result in measurement inaccuracies (i.e., drift) in temperature, flow and pressure signals from the process—all vital information used to calculate the proximity to the compressor's surge line and its safe, optimal operating capacity.

When instruments drift—even by as little as 1%—operators cannot accurately assess actual compressor flow. Drifting instruments result in a reading that deviates from reality. If the reading is too low, then it could activate the antisurge system, leading to production loss. If the reading is too high, then the operation could be closer to the surge line than operators believe and the compressor can start to surge. This is likely to lead to compressor damage—and potentially extended downtime. Without confidence in instrument readings, operators afraid of causing a surge will run their compressors farther away from the surge line. Such actions prevent optimal operation and cause unnecessary energy consumption.

Fouling issues. The 108 ethylene plants polled in the survey, which are responsible for 62% of the world's production, named compressor fouling as the second most frequent cause for compressor failure. The inevitable compressor blade fouling by the cracked-gas process leads to a blade imbalance that causes excess vibration and compressor trip.

Blade fouling also causes energy efficiency losses as great as 1%. For turbo-machinery, that can use up to 70 megawatts of power and translates into annual losses of $300,000. This is a controllable loss, but the decision to wash fouled blades to gain energy efficiency or to stop vibration must be an informed one or operators risk poorly timed maintenance that unnecessarily reduces throughput.

Mechanical problems. Surveyed producers also identified mechanical problems as causing the longest tripped compressor downtime. Operators need reliable, predictive diagnostics about machinery health to detect shaft misalignment and cracks, cou-

FIG. 1 The cracked-gas compressor is an ethylene plant's most critical asset. (Photo courtesy of Elliott Co.)

pling failure and bearing oil instability so they can act quickly to avoid a compressor trip or, worse, a catastrophic failure (Fig. 2).

If the compressor trips, operators have a 10- to 30-minute window during which they must assess the trip's cause and determine whether it's safe to restart the machine. After that, the rest of the plant will move too far from its normal operating conditions and the process will be saturated. A compressor shutdown has a domino effect on the rest of the plant that can necessitate product flaring and even a full plant shutdown for up to a week.

Spurious trips can be problematic, but a compressor surge must be avoided at all costs. Operators must rely on the compressor's antisurge valve reaction time, which utilizes a dedicated control system, to both optimize process operations and react quickly and accurately to prevent surge. In case of an emergency, the antisurge valve may have to travel up to 20 in. within 0.75 seconds. Unless it is very tightly controlled, such a large stroke in a short time could cause the valve to overshoot.

Because this important turbomachinery rotates at very high speed, the situation degenerates rapidly when things start to go wrong. The control room needs an API 670-compliant machinery health-protection system to ensure a safe compressor train shut down to protect assets and personnel, and to minimize flaring.

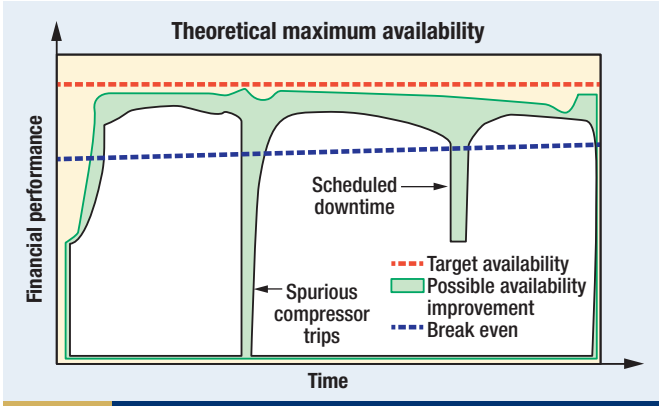

FIG. 2 Increase compressor uptime by avoiding spurious trips and extending the time between scheduled downtime.

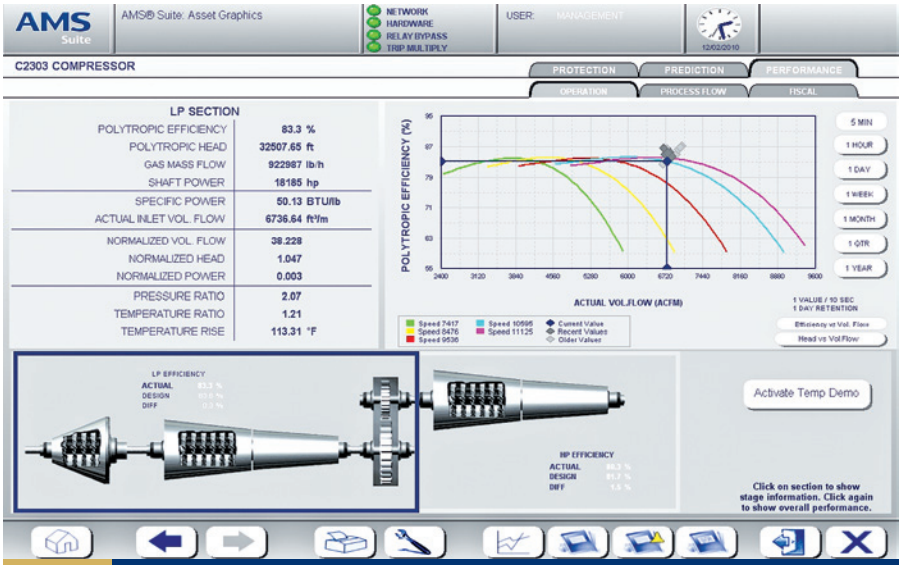

FIG. 3 The intuitive graphics allow the operator to easily check rotating-equipment efficiency by viewing current process and alarm data along with diagnostic data and any predictions of impending problems.

Solutions. Contemporary automation technology lets ethylene producers meet these multiple challenges head-on. Plant operators can safely maximize throughput, gain energy efficiencies and reap maintenance cost savings by using a combined automation strategy that includes a smart digital machinery health- and asset-management system; a robust, high-performance antisurge valve; and reliable, accurate instruments.

Machinery health monitoring and asset management. Producers can benefit by using a machinery health- and asset-management system that integrates protection capabilities with predictive diagnostics and performance monitoring to improve compressor availability, protect this valuable asset, tighten energy efficiency, reduce maintenance costs, improve throughput and decrease environmental costs. The field-based diagnostics provided by these systems give operators the ability to recognize faults many months in advance and to prevent excess vibration, mechanical breakdowns and compressor trips. Whether it's a shaft misalignment, a cracked shaft, a coupling failure, bearing wipe, oil instability, excess imbalance or blade fouling, operators and maintenance staff have the information that they can use to take corrective actions. This reduces maintenance and improves throughput, and if a trip can be avoided because of early machinery health information, it provides real machinery health protection—safeguarding the plant's bottom line.

If a trip does occur, the monitor delivers a rapid transient analysis of all vibration waveforms collected before, during and after the event. Its ability to analyze and replay the event assists with diagnosing the mechanical problems that led to the trip. Operators can quickly determine whether the machine suffered a severe mechanical problem and can assess whether it can be restarted before other plant areas are adversely affected. These monitors prevent false machine trips by monitoring sensor health and networking with intelligent field instrumentation tuned to automatically recognize bad cables and sensors, adjust trip logic and notify operators so action can be taken.

Critical information in realtime. In addition, the technology helps plants avoid catastrophic failure by continuously measuring critical information about machinery operation, including relative and absolute vibration, thrust position, case and differential expansion, shaft eccentricity, temperature and speed. By applying these measurements, the system conforms to API 670 machinery-protection standards for compressor trains and allows for safe shut down when unsafe operating modes occur. Critical assets and personnel are protected, flaring is minimized, and insurance requirements are met.

The performance-advisor feature of this automation technology allows for lower operational cost through improved process control and energy use. Operators can view key performance indicators—such as compressor efficiency, blade fouling, head generation, power consumption and operating costs—to easily see if the compressor train is running within its optimal operating window. They can even drill down to

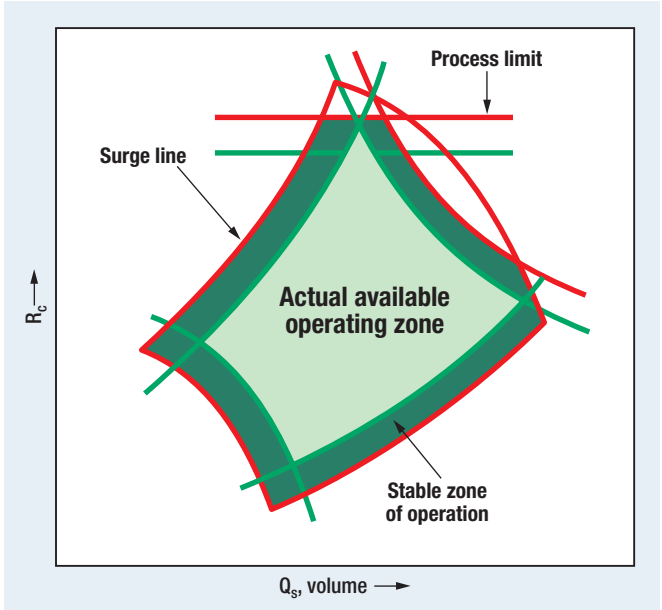

FIG. 4 Operate confidently close to the compressor's surge line with real-time process and asset data delivered through smart field devices.

check performance of specific compressor sections and compare actual to design (expected) efficiency. In addition, automation partners experienced with this tool can tune the performance advisor system to accommodate seasonal or operational variations that affect the process.

Contemporary machinery health- and asset-management technology can be easily integrated into an existing control system. Because it provides native systems with intuitive graphical interfaces presented in a format that ethylene-plant operators recognize, they can make fast, accurate decisions. For example, when operators perform an online water wash in response to compressor fouling, they receive real-time feedback about performance increases as well as machinery health monitoring data alerting them to blade cracking that can commonly occur during this sensitive process. The machinery health- and asset-management data covering the 4Ps of machinery monitoring—protection, prediction, performance and integration with process—is made available directly from the plant's existing control system through user-friendly screens, and without the need for extra engineering (Fig. 3).

Antisurge valves. Because of the critical role that the antisurge valve plays in preventing surge, it is the most vital valve on the ethylene plant's important asset. The best control valves today have been engineered to be accurate and reliable and to respond quickly. These smart valves also have built-in features that protect the critical asset and ensure that it performs accurately under the most demanding conditions. Optimized antisurge valves:

- Have an air-cushioned actuator that tightly controls deceleration to protect valve and actuator components
- Are specially designed to reduce noise by up to 40 dBA, and to protect the compressor and piping system from damaging vibration
- Have fine control and rapid, accurate stroke response to prevent surge
- Deliver diagnostic information that uncovers problems such as dirty instrument air, actuator and tubing leaks, insufficient air supply, I/P integrity and worn-out instrument elastomers—all without the need to move the in-service valve
- Capture additional diagnostic data—while the valve is moving—to determine potential valve blockage, plug binding, broken or loose linkages, poor calibration or valve friction issues.

These multiple features deliver confidence to operators who know they can rely on the valve to perform, when needed, as they operate as close to the surge line as possible. The larger the CGC, the greater the operational costs savings.

And because downtime equals lost production, it's important to note that these valves can be easily commissioned and tuned remotely within minutes and they require only half the usual actuation accessories compared to most traditional systems. When there are problems with the valve, the performance diagnostics will help operators quickly diagnose the root cause (Fig. 4).

Intelligent, accurate instruments. Smart digital instruments can assist ethylene producers by delivering accurate, integrated pressure, temperature and flow data—critical data for efficient and safe operation close to the surge line. Intelligent devices bring reliability, repeatability and stability to this process.

Calculating your position relative to the compressor's surge line is only as reliable as the data it's calculated with. Precise flow calculations are possible with data delivered from a number of robust, smart instruments that offer advanced diagnostic capability, rapid operating speed and hot backup.

- Smart flowmeters—Using the latest-generation innovative flowmeters on your compressor makes a big difference. Devices with a very high-speed update rate of 22 times per second are now available. They provide rapid insight into surge-line proximity. In addition, statistical process monitoring and advanced diagnostics allow for rapid identification of flow reversal, alerting the process operator to problems with the antisurge control system.
- Integrated flowmeter with a conditioning orifice plate—For installations with insufficient space for piping, flow-conditioning orifice plates are available. This device requires a much shorter pipe length for accurate measurement than a conventional orifice plate (2x pipe diameter upstream and downstream). Enhanced control is also enabled through the flow correction provided by this device. It measures differential pressure, temperature and operating pressure to arrive at the volumetric flow.
- Temperature transmitters with hot backup—The redundant temperature measurements taken by this device automatically detect instrument drift or failure. Its inherent hot-backup feature allows operators to switch control or monitoring to the healthy sensor without need to shut down the process to replace the device. **HP**

LITERATURE CITED

[1] Shah, R., "Olefins compressors' reliability performance survey results," 2008 Ethylene Producers' Conference.

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