Face to Face

Predictive Maintenance

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Predictive Maintenance 101

Using the technology sets a plant ahead of the curve

Given today’s competitive business environment and thin margins, plants simply can’t afford to wait for critical equipment to fail before making repairs. Nor can they rely on time-based preventive maintenance to minimize downtime. While less costly than breakdown maintenance, repairing or replacing components, just because the clock or counter says to do the work, is not cost-effective.

The gold standard for effective maintenance is a predictive approach that guides decisions about production assets. It monitors each asset’s condition to determine its fitness for continued operation and initiates repairs only when the machine itself starts crying for help.

Predictive maintenance uses non-invasive techniques to monitor the pulse of a manufacturing plant. It checks, for example, the usability of greases and oils. It keeps track of vibration. It correlates abnormal temperatures with mechanical problems.

Lube analysis

Oil or grease between mechanical components minimizes heat-producing friction and cools the parts. Such lubricants consist of a base stock fortified with a variety of additives that stabilize the lubricant’s physical and chemical properties to maintain its high performance. However, any lubricant will succumb to the rigors of extended use and its protective properties will degrade over time.

Oil analysis alerts a plant that such degradation is occurring. The technique involves subjecting a lubricant sample to laboratory testing that reveals, among other things, how well it can neutralize acids and resist oxidation that breaks the lube into small, ineffective molecules.

Wear particle analysis

Should oil analysis reveal that a sample is contaminated with microscopic bits of metal or other wear debris, further testing will uncover the contamination’s source. Because metals have characteristic fracture patterns, a trained lab technician armed with a microscope can identify the metallurgical contaminant, helping to identify the rotating component being damaged by insufficient lubrication. Further instrument-based testing can reveal more details, should that be necessary.

Vibration analysis

Many pieces of plant hardware feature rotating elements. Examples include compressors, fans, turbines, gearboxes and pumps with their motors, bearings, rotors, fan wheels, impellers and seals. Depending on its speed and degree of imbalance, a rotating element can generate a vibration that shakes the machine, its foundation and, perhaps, the building structure itself.

Recording vibration signals provides view of the bearing’s time-domain vibratory signature. Digital processing converts data points to a frequency-domain signal, which reveals the source and magnitude of the various superposed vibrations. Thus, vibration analysis distinguishes the shaking that originates with a faulty bearing from that of an out-of-balance rotor.

Temperature trending

Temperature and energy are linked closely in accordance with principles of basic science. Temperature trending measures that part of an object’s energy that manifests itself as temperature, which is useful for locating potential production problems. For example, it identifies cooler-than-normal clogged steam traps and overheated hardware elsewhere in the plant.

Heat produced by friction will also raise an object’s temperature. The temperature of constantly rubbing mechanical components, such as bearings, gears and mechanical seals, will rise if effective measures to minimize friction aren’t taken.

As effective as these predictive technologies may be, they are even stronger when used as part of a formal testing regimen. ▲
If a plant doesn’t already use predictive maintenance, instituting a full-featured program will minimize surprises and downtime. Initial efforts will probably uncover a surprising number of small, hidden, subtle problems that nobody realized existed. Resources will be needed to address these issues, and, at first, the existing maintenance budget may appear inadequate for the task.

However, companies that persevere and get past this initial maintenance bubble soon discover that predictive maintenance can quickly stabilize the rate at which new problems appear, allowing maintenance to be more easily managed. Once this stabilization occurs, the predictive maintenance program starts to recoup its initial costs. As the maintenance department gains more thorough knowledge of the condition of its productive assets, the rate at which new problems appear declines even further, and the program starts paying richly deserved dividends.

Typically, plant’s that have developed effective predictive maintenance programs discover that monitored assets rarely cause unplanned downtime. This new development allows the maintenance departments to address “back-burner” issues that can improve the overall condition of the operating assets even more. Smooth operation also improves the maintenance technician’s morale.

Making it happen

The Flowserve Flow Solutions Division makes it easy for maintenance departments to achieve their desired performance levels. Flowserve brings a full-featured predictive and proactive maintenance program inside the plant gates and applies its benefits to any pumps, compressors, fans, valves, gearboxes or other equipment deemed critical to operational excellence as well as to the entire mechanical sealing system.

Not only does Flowserve collect and analyze data about equipment condition, it typically provides the plant’s maintenance department with complete, comprehensive reports within three business days of testing. The reports, each delivered by e-mail, identify any critical problems, recommend corrective actions, track recommendation status and provide a summary report for maintenance departments to use as a basis for reducing the overall cost of asset ownership.

Flowserve’s Flowstar.net Equipment Management Software enables plant personnel to manage and update equipment data in real time via the Internet. The data available include detailed cause of failure and maintenance recommendations for specific equipment, which can be sorted and filtered to provide insight into ways to improve plant performance. The software also lets users calculate such equipment reliability parameters as suction specific speed. It facilitates sharing resources and knowledge to
maximize efficiency and minimize the plant maintenance burden.

The details
The Flowserve Condition Data Point Monitoring program can be applied stepwise to conform to the plant’s exact needs. This approach allows users to have access to exactly the level of technology that’s appropriate for their purpose.

For example, Flowserve’s Vibration Collection and Analysis module monitors how a piece of hardware responds to external forces. This technology identifies bearing problems, cavitation and recirculation, misalignment, resonance and imbalance. Flowserve technicians use a hand-held device to gather vibration data from designated equipment. Off-site analysts look for vibration signatures that exceed preset alarm limits and make recommendations for reducing or eliminating the causes.

Flowserve’s Critical Temperature Trending and Analysis module is designed to seek out abnormal operating conditions at predetermined locations throughout the plant. Flowserve technicians, equipped with handheld data collectors, track temperatures at bearings on motors and pumps, at process equipment and on mechanical seal hardware, including seal flush, quench and heat exchanger reservoirs. Collected data are downloaded to the asset management software and analyzed for non-conformities or notable changes in operating conditions.

With its Trigger Point Monitoring module, Flowserve identifies specific conditions that have been proven to lead to premature component failure. Like a mechanic inspecting your automobile, the Flowserve technician goes through the plant, examining pumps and documenting such items as critical pressures, process and seal fluid flow rates, reservoir levels and pump speed. Again, the collected data are downloaded to the asset management software and analyzed for non-conformities or notable changes in operating conditions.

The Lube Oil Analysis module allows Flowserve to gain insight into abnormal lubrication and machine conditions that may exist at a plant. Lubricant samples are subjected to a battery of tests, including spectroscopic analysis, wear particle counts, Fourier transform infrared spectroscopy, viscosity measurements, the Karl Fischer water test and, if the particle count is out-of-spec, analytical ferrography.

The Condition Data Point Monitoring program can be integrated easily with Flowserve’s Alliance Partner program and is a natural progression for maintenance departments that are striving to move from reactive maintenance to proactive maintenance. Plants that use both programs report excellent long-term results that can be duplicated in any plant.
Lucite International’s newest manufacturing plant in Nederland, Texas, makes methyl methacrylate monomer, the raw material that makes possible the rigid, colored and transparent acrylic sheets for which the company is so famous. Any unplanned downtime on any of the three lines would cripple the plant’s production schedule. That’s why Lucite is a firm believer in the benefits of an effective predictive maintenance program. And why Lucite relies on Flowserve to provide a key part of that predictive program.

Although the Lucite plant is rich in rotating equipment, with 250 pumps, nine refrigerant compressors, seven fans and two turbines, it operates with a lean workforce, less than 100 people working 12-hour shifts, according to Dickie Hughes, who has worked in the plant’s maintenance group for the past 12 years. The plant’s maintenance group is proportionately smaller. Lucite uses a computerized maintenance management system, primarily for generating work orders.

Hughes is responsible for the plant’s vibration monitoring and oil analysis programs. Meanwhile, Jeff Brooks, the plant’s mechanical engineer, wears many hats as he oversees the technical issues that arise at the facility.

**Historical perspective**

Lucite had been operating its own in-house vibration monitoring program for many years. That system worked well until two or three years ago, when the plant’s in-house training program couldn’t compensate for a shortage of skilled vibration technicians. As a result, the plant’s production schedule started slipping behind schedule, untenable for a facility that produces a key raw material. “At one time, we had been gathering vibration data on everything,” said Hughes, “but we had to scale that back to just the critical items because of time and manpower constraints.”

**A known entity**

After evaluating alternatives, Lucite adopted...
the Flowserve CDPM program. "We were impressed with the program and the use of Entek," Brooks said. "We're familiar with their capabilities. We liked the fact that Level 3 analysts review our vibration data. Our relationship with Flowserve was another attraction to join forces on this predictive maintenance tool." Analysts certified at Level 3 identify incipient vibration problems using sophisticated analytical tools including high-frequency envelope signal, deflection shape and waveform analyses. "We look at the analyst's report and write work orders, if we have to," added Hughes.

While Lucite uses the Flowserve CDPM program's vibration analysis module, the company operates its own oil analysis program, collecting samples and sending them to a laboratory in Houston.

Beyond the skilled analysts and up-to-date laboratories and test equipment, an important factor in an effective predictive maintenance program is deciding where to apply the technology. "Our critical machine list is based on risk to safety, the environment and the business," said Brooks. "We're monitoring six fans and six refrigerant compressors, two turbines. The rest are pumps. In all, we're monitoring 63 machines, with 10 data points on each."

Since it began early this year, Lucite's CDPM program has proved its value, says Brooks. So far, the plant has only had to pull only one pump from service and replace one gearbox based on reports of high vibration levels. The plant still-mounts its pumps to minimize pipe stress and uses laser alignment when connecting pumps and their drivers.

The cycle
"Lucite would be considered a world-class maintenance operation," boasted Dusty Young, Flowserve's senior sales engineer serving the Lucite plant. "During a start-up in 1992, once the plant was up to operating conditions, it was making on-spec product within 24 hours." Flowserve's CDPM program augments that maintenance expertise.

Once a month, a Flowserve technician visits the plant and collects data from its 600-plus monitoring points in about 12 hours, spread over two days. Then comes the customer interaction that gives the plant a headsup on potential problems. "The technician who takes the readings then discusses anomalies with us before he leaves," said Hughes. Within a week, the test results are available. "That's when we go to the Entek Web site and enter our password," added Hughes. Reports retrieved there complete another predictive maintenance cycle. "The reports are very detailed," said Brooks. The recommendations in the reports must be on target and reflect reality. "We get very few recommendations. Most say to continue monitoring," Hughes said, bearing witness to the company's effective maintenance program.

How the plant responds to the recommendations and integrates them into its daily operations is important. Once the technician's comments are confirmed, Hughes initiates a work order. Once it's scheduled, the maintenance department fixes the problem with a minimum delay between problem discovery and repair.

Implementation
Ramping up Flowserve's CDPM program at the Lucite plant was not that difficult. Lucite prepared a critical machine list based on an internal audit, which was then delivered to Flowserve for a quote. After awarding the contract, Lucite provided details about the machinery to be monitored, which Flowserve used to develop the Entek database for the site. Lucite learned some important lessons from the program. For instance, Brooks said, Lucite found that industry-standard vibration alarm limits are set too high for its system. "We lowered the limits to reveal problems earlier," he said.

Close collaboration between Lucite and Flowserve has rendered virtually meaningless such standard maintenance metrics as mean-time-between-failures, downtime hours and mean-time-between-repairs. There haven't been enough maintenance problems at the plant so far to develop these calculations.
According to U.S. Department of Energy statistics, pumping systems can account for as much as 50 percent of the energy consumed in industrial plant operations. It’s obvious that any improvements and savings in these applications can decrease costs and make a positive impact on the environment. Concurrently, mechanical failures from metal-to-metal contact are another source of reliability problems that lead to more costs.

To that end, the Flow Solutions Division of Flowserve Corp. has become the exclusive after-market distributor of Greene, Tweed’s WR® line of engineered pump wear materials and solutions. These wear materials provide Flowserve with additional tools to increase pump efficiencies, while at the same time improving pump reliability, thereby reducing total life-cycle cost.

The WR family of composites exceeds the value of metallic, carbon-graphite and rubber wear components by offering the following benefits:

- Low friction that minimizes the chances for galling and seizing, allowing for tighter wear component running clearances and higher pump efficiencies.
- Intermittent dry run.
- Strength exceeding that of steel.
- Dimensional stability and low thermal expansion.
- Resistance to chemicals, impact, thermal shocks and hydrolysis.

WR525 composites are an ideal replacement for metals and alloys used in impeller wear rings, case wear rings and bushings in large, multistage pumps. Unlike most composites, this material can be used for high speed rotating components. Temperature limitations for WR525 meet the requirements of API 610, 9th edition (-20 °F to 450 °F), and WR525 provides a pressure limit of 500 psi (2,000 psi, if suitably supported).

WR300, a unique, carbon-fiber reinforced material, delivers performance and reliability beyond the reach of metallic wear materials. The composite is used for bushings, bearings and case wear rings in most centrifugal pumps handling poorly lubricating, low-specific gravity media. The material’s anti-gall and anti-seize properties limit cavitation and bearing failure damage. Temperature limitations on the WR300 composite also meet the requirements of API 610 (-20 °F to 275 °F). WR300 has a pressure limit of 300 psi.

AR® 1, with its nearly universal chemical resistance and superior abrasion resistance, is the bearing material of choice for river water and sump pumps. The AR1 material has a temperature limit of 105 °F and, unlike bronze or rubber, it offers dry-running capability. Wear rings and bushings can be manufactured with tight clearances to reduce internal pump recirculation and stabilize the rotor. Depending on the service, this alone can pay for the upgrade. Low-friction WR prevents shaft seizure during pump startup, thus reducing warranty repairs. These characteristics, plus numerous other benefits, make Greene, Tweed’s WR family of materials the clear choice for pump wear components.

Flowserve adds Greene, Tweed’s WR® to its toolkit

If you specify API 610 pumps, here’s something you should know about wear components