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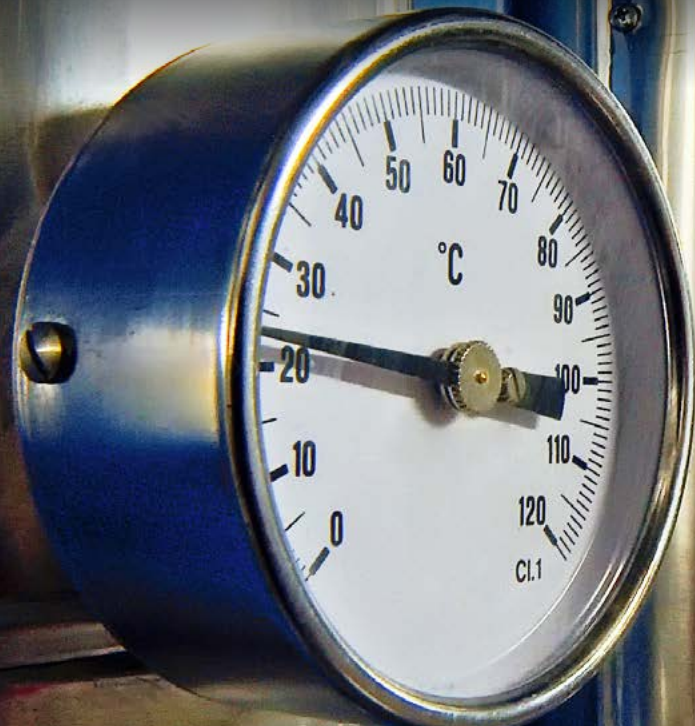
PdM

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Duke Energy has a fleetwide network of sensors for online monitoring of critical plant equipment.

photo courtesy of Duke Energy

by Sheila Kennedy, contributing editor

UNLOCK YOUR PdM POTENTIAL

Data sharing and collaboration are bringing new life to predictive maintenance while delivering greater reliability gains

Predictive maintenance is not only reshaping maintenance processes and priorities – it’s also redefining maintenance roles and how teams communicate. Human observation and interaction is more valuable than ever.

Early PdM tools were stand-alone, built to serve a specific purpose, but new technologies offer opportunities for data sharing that support more-

robust performance. They meet the need to reach beyond organizational confines for new points of view.

“One of the most common challenges to incorporating world-class best practices is being able to incorporate all parties in the solution: operators, maintenance technicians, reliability engineers, design engineers, industrial engineers, and even original equipment manufacturers

and contractors,” says Kevin Price, enterprise asset management product director at Infor (www.infor.com).

Thankfully, continuing advancements in PdM are improving information sharing, collaboration, and ultimately plants’ bottom line. By working toward this last common goal, vendors and their customers are embracing the potential of organizational change and delivering reliability gains that were not previously possible.

LEADERS IN THE FIELD

Food and beverage manufacturing and power generation are among the most heavily regulated industries. The neces-

photos courtesy of Smucker's



Smucker's currently monitors 250 assets using vibration and ultrasound.



ADVICE FROM A PdM PRO

Want to reap all of the competitive rewards that PdM can offer? Check these off your list, advises Smucker's Joe Anderson:

1. Understand the business need for PdM and quantify your business case.
2. Become great at capturing every failure that has been identified early and fixed; turn it into a cost avoidance; and share those numbers with everyone who will listen.
3. Educate everyone on the basics of each technology and why each is important to your process.
4. Have a great time bragging about the accomplishments of your people and reward people early and often.



In the first seven months of 2015 (year-to-date) the avoided costs at Duke Energy totaled \$5.85 million.

photo courtesy of Duke Energy

sities of operating within that regulatory environment are among the reasons. The J.M. Smucker Company and Duke Energy are ahead of the curve when it comes to PdM. “In every industry, there are leaders and laggards,” remarks Mary Bunzel, portfolio manager for IoT, EAM and analytics at IBM (www.ibm.com). “The leaders are already experimenting and have the support of management to explore and learn.”

The reliability team at Smucker’s has a weekly meeting with the operations team to plan out the next four weeks of scheduling; this plan gets adjusted based on the findings of the PdM technologies as well as defects identified by operators during their clean, inspect, and lubricate (CIL) rounds.

“We have begun to share our findings within the organization,” says Joe Anderson, PM and reliability leader at The J.M. Smucker Company (www.smucker.com). “Data sharing is huge when trying to justify the need for scheduled line time to fix machine defects and also to develop credibility within the organization as experts on your assets. Everyone wins when everyone understands the importance of early failure detection and defect elimination.”

“Once we were able to prove that life can be better, we made significant gains towards plant stability,” he says. “Anytime you can drive defects out of your system, you will see improvements in safety, quality, environmental sustainability, throughputs, and plant stability.”

Duke Energy’s SmartGen project for advanced condition monitoring feeds vibration, temperature, and process data into Duke’s main Monitoring & Diagnostics (M&D) Center, and oil analysis is performed by a central lab or on-site at the larger sites. “We haven’t gone with the cloud yet,” says Russell Flagg, engineering technologist and CBM program owner at Duke Energy’s Smith Energy Complex (www.duke-energy.com). “It’s a matter of security, being the largest utility in country, and our IT people are not there yet.”



photo courtesy of GTI Predictive Technology

Internet and cellular connectivity through the iPad provides instant access to cloud and internal networks.

But, he continues: “I’ll receive email notifications so I can handle issues from the plant side, and I can log in to see other plants’ data if they need help with a diagnosis. Our vibration or rotating equipment experts can also access the data from anywhere in the fleet.” Flagg adds: “We can call OEM rotating equipment engineers and send them data if we have a specific issue, and they have their own monitoring systems so they will send me a notification when something goes out of spec. I can also see and advise on oil analysis data.”

The diagnosis is quicker and probably more accurate when you bring all that experience to bear, he explains. “I embrace it all,” Flagg says. “For me, it cuts down on the time I spend monitoring acceptable running equipment.”

INNOVATIONS IN DATA SHARING

A combination of modern user interface tools and integration with “smart” assets and buildings enhances users’ ability to work with PdM programs, says Paul Lachance, president and CTO at Smartware Group (www.bigfootcmms.com).

“There has been the ability to gather this data electronically for some time, but it was slow, expensive, and difficult.”

Centralizing data makes data easier to share. At Azima DLI (www.azimadli.com), “We host data centrally and serve diagnostic results to customers over a Web-browser-accessible portal,” says company CEO Burt Hurlock. “The portal integrates the results of multiple PdM technologies so technicians and engineers have a single point of access for machine health diagnostics.”

John Neeley, product planner and program manager for Fluke Connect Assets (www.fluke.com), says Fluke is working to make it very cheap, simple, and reliable to move the data from the tools to a place where the team can share it. “During rounds, rich measurement data automatically transfers to the smartphone and to the cloud,” Neeley says. “When an alarm is triggered and the status of the asset is escalated, everybody gets a message via email or IM on their phone.”

Connectivity is one of the reasons

GTI Predictive Technology (www.gtipredictive.com) chose the Apple iPad as its PdM platform. “Internet and cellular connectivity through the iPad gives us instant access to cloud and internal networks,” notes Paul Berberian, condition monitoring specialist at GTI Predictive Technology. “The capabilities and functions that already exist in the iPad allow us to create reports in the field that include notes, photographs, highlighted measuring locations, GPS location, etc.”

M&D centers are growing in prevalence, scope, and capability. GE’s M&D center has shifted focus from monitoring only GE’s equipment to helping power plant customers manage reliability and operational excellence throughout the whole plant, says Justin Eggart, general manager of fleet management power generation services for GE Power & Water (www.gepower.com).

“Every second we’re collecting a sensor value and a time stamp on a thousand different parameters – for example, on a gas turbine,” he says. “Over time, the data starts to mean a lot. And it’s not just operational data; now you can bring in third-party data or the customer’s other instrumentation or ERP system data, and the opportunity to improve operational performance continues to grow.”

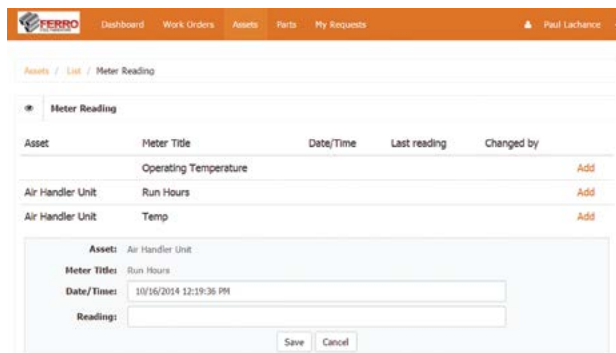
ORGANIZATIONAL IMPACTS

Collaboration among internal teams

UE Systems (www.uesystems.com) is among many suppliers seeing more collaboration between maintenance and reliability professionals and the IT team. “I think it is being driven by the increased need for continuous monitoring, increased IT infrastructure within facilities, and an increased need for machine alarm conditions to automatically generate a work order in the CMMS/EAM,” says Adrian Messer, the company’s manager of U.S. operations.

The layout of facilities can play a key role in optimizing this cross-functional collaboration. “Some of the best programs that I’ve seen are where all the technicians are co-located in one area rather than in different parts of the plant,” says Tim Dunton, director and instructor/developer at Reliability Solutions (www.reliabilitysolutions.net). “There’s a huge benefit to having the IR, lubrication, and vibration technicians interact on a daily basis, face-to-face.”

To support collaboration among field technicians, aggregating equipment data taken by various measurement tools in a single online database and dashboard makes sense. It allows all the trades to refer to one communication tool instead of multiple sources of information, notes Fluke’s Neeley. A slight overheat of a motor detected using thermography can trigger someone else to check the vibration and another person to look at the electrical supply for an imbalance, for example.



Users can either manually type asset data or pull it automatically from sensors into a CMMS.



GE’s M&D Center in Atlanta collects more than 30,000 operating hours of data from a fleet of more than 1,500 gas turbine and generator assets.

“With our FaceTime-like feature, a technician in the field can literally call someone on their team, show them live measurements and video of the measurement point, and get their opinion,” he says. “It allows senior technicians and managers to coach the personnel from any location.”

Having in place an information infrastructure that encourages sharing across multiple sites also is powerful. Adds Reliability Solutions’ Dunton: “The companies seeing huge benefits have taken (data sharing) beyond networking and are using the technology to set up blogs and Internet sites where they can start to exchange information. By sharing data among plants, you can really start to see trends.”

Collaboration with virtual experts

Soliciting expertise from third parties helps plants avoid having to hire or train for additional skill sets. “The option to share data internally with other plants or with third-party vibration analysts is very popular,” says GTI’s

photo courtesy of Smartware Group

photo courtesy of GE Power & Water

Berberian. “Users can compare data for like machines with other facilities and collaborate to find solutions. Third-party analysts can access data immediately to help diagnose more-challenging machine issues.”

Shon Isenhour, partner at Eruditio (www.eruditio.com), says his company also is now seeing plants push their PdM information to outside experts for additional feedback and analysis. “Ten years ago you pretty much had to do it all at your plant, and if you couldn’t figure it out, your only real option was to bring an outside consultant in to review the data,” he notes.

Modern technology improves the quality of these services. Today, “People can email me high-resolution photos, vibration data, thermal images or other data wherever I happen to be,” says Reliability Solutions’ Dunton. “Thirty years ago, I’d get a grainy-looking fax and I couldn’t make anything out.”

Collaboration with equipment OEMs

IBM is seeing heightened collaboration among equipment manufacturers and plant maintenance teams. “These teams are experimenting with the types of insight available and various sorts of analytic models to measure performance against as-designed specs,” says IBM’s Bunzel.

GE, for its part, is working to develop more-collaborative relationships with customers and emphasize the company’s role in affecting customers’ profitability. “We’re using our knowl-

edge of GE equipment and power plants in general to develop analytics or algorithms that turn the data into something useful,” remarks Eggart. “Then we collaborate with the customer, wherever they are, about what we see in the data and how it can be used to optimize operations at the power plant.”

Collaboration among PdM solution providers

Providers of reliability solutions also are working together. “We work to ensure a smooth integration of ultrasound data into the customer’s CMMS/EAM software by collaborating with the software provider and sharing our knowledge and tools,” says UE Systems’ Messer.

“Looking at the technologies as a group rather than individual data streams allows defects to be identified even earlier,” suggests Eruditio’s Isenhour. “A lot of the major equipment manufacturers in the predictive field are looking at ways to get the technology to talk together so their clients can use multiple technologies to better understand equipment health.”

Collaboration among industry peers

Sharing of benchmarking data improves as reliability becomes easier to measure. “The interest in reliability as a source of strategic competitive advantage has become more pronounced of late,” says Azima DLI’s Hurlock. “We see more customers comparing performance across sites to define best practices and emerging interest in benchmarking sites and enterprises against industry best practices.”

Adds GE’s Eggart: “Our software takes Operational Reliability Analysis Program (ORAP) industry data and consolidates it into dashboards, so customers can benchmark their reliability or performance against other similar power plants around the world. Nobody ever wants to be at the bottom; they want to be in the top quartile.”

CH-CH-CHANGES

“Big Data is here and it’s changing the way PdM is done,” says Duke Energy’s Flagg. “It’s more analytical and data-driven, and you’re letting the computer do a lot of work that you used to do, so you can pay attention to the things that are misbehaving.”

But, he adds: “You have to be open to change. Have confidence in the software and the experts who are driving the program. We all use it and it works. A few people still don’t believe it, but I’m working on them.”

Even a little success begets more success, explains GE’s Eggart. “We hear things like, ‘I saved \$2 million on fuel costs last year because of this. Let’s collaborate some more.’ Once something works, people want to expand it. The money saved is real.”

Powering up PdM

As part of Duke Energy’s SmartGen project, a SmartM&D infrastructure was created to support a fleetwide network of sensors for online monitoring of critical plant equipment. All major rotating equipment was instrumented at more than 60 different plants. Around 30,000 total vibration and temperature sensors were installed; all of the equipment was modeled; and alarm levels were set. Now, anything out of normal operating range sends a notification to Duke’s main M&D center. Process data also is fed into the M&D center. Oil analysis was consolidated so that 28 different sites now use the same laboratory; this allows one SME to review the analysis for approximately 130 generating units. Equipment failures cost millions of dollars in lost power generation, but Duke Energy’s reliability program is slashing the losses. Avoided costs totaled \$4.3 million in 2014, even though SmartGen wasn’t fully operational at all the plants until late that year. In the first seven months of 2015, the avoided costs totaled \$5.85 million.



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SHAFT AND PULLEY ALIGNMENT

Sweat the small stuff to improve machine operating life

Alan Luedeking, vice president of Ludeca Inc.

The difference between successful and subpar asset management can be a matter of millimeters. Anecdotal evidence suggests that as many as half of machine breakdowns can be attributed to incorrect shaft alignment and its attendant problems: machine vibration, bearing damage, excessive seal wear and coupling damage. Its foundational importance in helping operators get the longest life and the best performance from their equipment—not to mention in creating a safer and more productive work environment—can't be overstated.

This article covers the basics of shaft and pulley alignment, both of which are critical to proper and precise machine alignment, as well as how laser alignment technologies can help form the hub of a proactive maintenance strategy.

SHAFT ALIGNMENT

Shaft alignment is the process whereby two or more machines (typically a motor and pump) are positioned such that their shaft centerlines of rotation are colinear at the point of power transfer from one shaft to another under normal operating conditions.

Of course, there are exceptions. Some coupling types—cardan shafts, for example—require a defined misalignment to ensure correct lubrication of the needle bearings when operating. But, in the context of our standard definition, here are few important points to note:

- “At the point of power transfer”: All shafts have some form of catenary due to their own weight; thus, shafts are not straight and the location where the alignment of the two shafts can be compared is only at the point of power transfer from one shaft to the next. This means at the coupling, and more specifically, at the flex planes of the flexible coupling.
- “Centerlines of rotation”: Do not confuse “shaft alignment” with “coupling alignment.” The coupling surfaces should not be used to define alignment condition because they do not represent the true rotational axes of the shafts. In addition, rotating only one shaft and using dial gauges to measure the opposing coupling surface does not determine the axis of rotation of both shafts.
- “Under normal operating conditions”: The alignment condition can change between the time of alignment,

with the machine stopped, and when the machine is running. This can be for a number of reasons, including thermal growth, piping stress, machine torque, foundation movement and bearing play. Because shaft alignment is usually measured with the machines cold, the correct alignment condition to be sought is not necessarily a zero-alignment condition. You may have to deliberately misalign to a specified target position to compensate for the anticipated positional changes that will occur when the machines are placed in service and put under load. Alignment condition should be measured by turning the shafts in their normal direction of rotation. Most pumps, fans, motors, etc., have arrows stamped on the end casing showing the direction of rotation.

The amount of shaft deflection in a machine depends upon several factors, such as the stiffness of the shafts, the amount of mass between overhanging supports, the bearing design and the distance between the supports.

For the vast majority of short-coupled rotating machines, this catenary bow is negligible, and therefore for practical purposes can be ignored. On long-drive machine trains (e.g., turbine generators in power generation plants or machines with long spacer shafts), the catenary curve should be taken into consideration.

Because shaft alignment needs to be measured and subsequently corrected, a method of quantifying and describing alignment condition is necessary. Traditionally, alignment has been described in terms of dial indicator readings at the coupling face or position values at the machine feet. The measured values from both of these methods are dependent upon the dimensions of the machines. Because there are many different methods for mounting dial indicators (reverse indicator, rim-and-face, and double-rim, for example), the comparison of measurements and the application of tolerances can be problematic.

A more modern and easily understandable approach is to describe machine alignment condition in terms of angularity and offset in both the horizontal (plan view) and vertical (side view) perspectives. Using this method, four values—vertical angularity, vertical offset, horizontal angularity and horizontal offset—can be used to fully express alignment condition.

Angularity describes the angle between two rotating axes, or the rate of change in offset along the centerlines of the shafts. Angularity can be expressed directly as an angle in degrees or in terms of a slope in mils/inch. This latter method is useful since the angularity multiplied by the coupling diameter gives an equivalent gap difference at the coupling diameter.

The angle is thus more popularly expressed in terms of gap difference per diameter. The absolute gap itself is not meaningful; it must be divided by the diameter to have meaning. The diameter is correctly referred to as a “working diameter” but is often called a coupling diameter. The working diameter can be any convenient value, such as 10”. It is the relationship between gap and diameter that is important.

Offset describes the separation between centerlines of rotation at a given point. Offset is sometimes incorrectly referred to as parallel offset or rim misalignment. The shaft rotation axes, are however, rarely parallel, and the coupling or shaft rim has an unknown relationship to the shaft rotation axes, due to possible out-of-roundness, eccentricity, or surface defects.

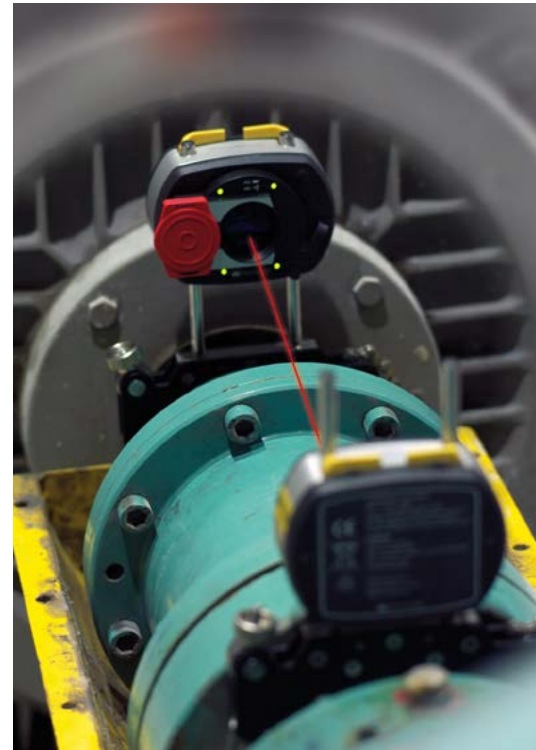
Given an angularity, the offset value varies depending upon the location where the distance between

two shaft rotation axes is measured. In the absence of any other instruction, offset is measured in terms of mm or thousandths of an inch at the coupling center. (This definition refers to short flexible couplings; for spacer couplings, offset should be measured at each power transmission plane of the coupling.)

For industrial equipment, the amount of misalignment that can be tolerated is a function of many variables, including RPM, power rating, coupling type, spacer length, design of coupled equipment and user expectations with respect to service life.

Tolerances based on RPM and coupling spacer length were first published in the 1970s. Many of the tolerances were based primarily on experience with lubricated gear-type couplings. Experience has shown, however, that these tolerances are equally applicable to the vast majority of non-lubricated coupling systems that employ flexible elements in their design.

One comment often heard is, “Why bother to align a machine fitted with a flexible coupling designed to take misalignment?” It’s true that flexible couplings are designed to take misalignment, typically up to 400 mils or more radial offset of the shafts. But the load imposed on shafts, and thus on the bearings and seals, increases



dramatically because of the reaction forces created within the coupling when misaligned.

Challenging plant operators is the fact that it is not always easy to detect misalignment on machinery that is running. The radial forces that are transmitted from shaft to shaft are difficult to measure externally.

Using vibration analysis or infrared thermography, it is possible to identify primary symptoms of misalignment, such as high vibration readings in radial and axial directions or abnormal temperature gradients in machine casings. Without such instrumentation, however, it is also possible to identify secondary machine problems that can indicate inaccurate shaft alignment. These include loose or broken foundation bolts, excessive oil leakage at bearing seals, loose or broken coupling bolts, and an excessive amount of grease or oil inside coupling guards.

New tools such as Ludeca’s Rotalign® Ultra system can help operations staff manage shaft align-

SHAFT ALIGNMENT TOLERANCES

RPM	OFFSET (mils)		GAP (mils/10")		SPACER SHAFT (mils/in.)		THERMAL GROWTH Growth = T × L × C Growth is in Mils T = Change in temp. °F L = Inches shim plane to shaft centerline C = Factor below: 0.0126 - aluminum 0.0100 - bronze 0.0059 - cast iron 0.0063 - mild steel 0.0074 - stainless
	EXCELLENT	FAIR	EXCELLENT	FAIR	EXCELLENT	FAIR	
600	5.0	9.0	10.0	15.0	1.8	3.0	
900	3.0	6.0	7.0	10.0	1.2	2.0	
1200	2.5	4.0	5.0	8.0	0.9	1.5	
1800	2.0	3.0	3.0	5.0	0.6	1.0	
3600	1.0	1.5	2.0	3.0	0.3	0.5	
7200	0.5	1.0	1.0	2.0	0.15	0.25	

All Speeds: Maximum Soft Foot Reading 2.0. Use OEM or in-house tolerances if available.

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ment more quickly and easily. The Rotalign Ultra, for example, enables wireless laser shaft alignment in three steps: Enter the machine's dimensions; sweep shafts less than a quarter-turn from any starting position; and view results for coupling and feet graphically, to scale. The Soft Foot Wizard feature measures the machine's soft foot condition and suggests corrective action, and a simulator allows users to experiment with different possible corrective solutions when the suggested ideal correction for perfect alignment is impractical or impossible to execute.

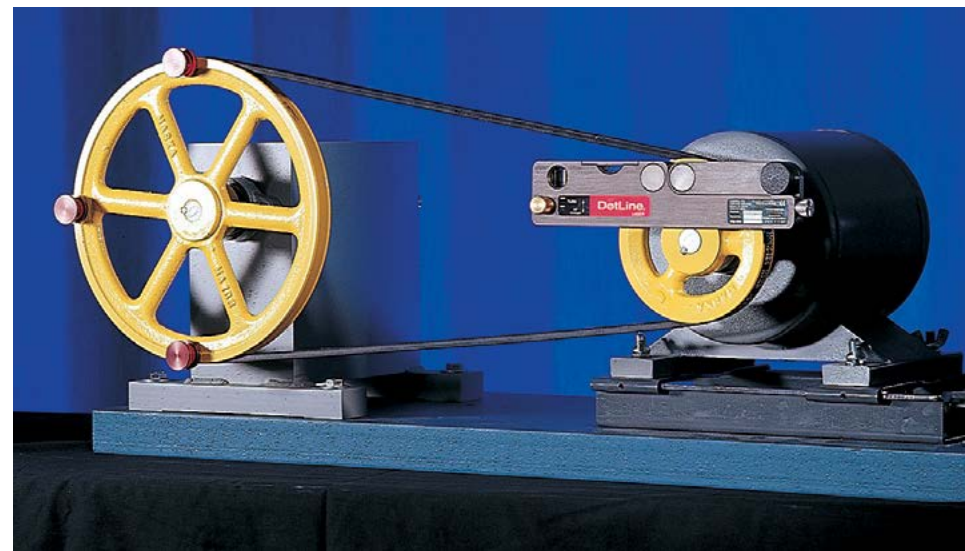
Good shaft alignment practice should be a key strategy in the maintenance of rotating machines. The benefits that accrue from adopting good shaft alignment practices begin with improved machine operating life, thus ensuring plant availability when production requires it. A machine properly aligned will be a reliable asset to the plant, and will be there when needed and will require less scheduled and unscheduled maintenance.

PULLEY ALIGNMENT

The use of flexible belt drives represents a significant percentage of all industrial power transmission applications, particularly when the speed of the driver and driven shafts are different or where shafts have to be widely separated.

During operation, a flexible belt experiences three types of forces as it rotates around a pulley: working tension (tight-side & slack-side), bending, and centrifugal force. Belts are designed to withstand these working operation states, provided that the selected belt meets the operating criteria.

The design life of the belt will be achieved and usually exceeded provided that no forces other than those just listed act upon the belt during its operating life, within tolerances. Forces generated by such conditions



as misalignment and loose or overly tight belts are killers of flexible belt drives. Useful operating life can be reduced by as much as 80% by poor pulley alignment. In addition to belt wear, the pulleys, bearings, and seals can all be damaged by inattention to basic installation requirements.

Three basic parameters describe pulley misalignment: horizontal angularity, vertical angularity (also called twist angle) and axial offset. These conditions usually occur in any or all combinations of alignment condition.

By far the most common and damaging installation error that occurs on belt drives is that of misalignment of the driving and driven pulleys. This is not usually due to carelessness on the installer's part; it is more often due to a lack of suitable tools with which to carry out the required alignment. For many years, at best a string, tight wire or straight edge were the only available tools with which to do the job.

Both methods rely entirely on the installer's eyesight to ensure that the alignment is correct. Neither method has any measurements documented; both rely upon the installer adjusting the driven pulley until the faces or grooves of the driven pulley touch the surface of the straight edge or tight

wire. The driven pulley is then rotated half a turn and then rechecked and adjusted. The measurement is then repeated until the pulleys appear to be in line. No angularity or inaccurate mounting of the reference line is measurable. The system is purely an estimate of the alignment of the two pulleys.

The newest generation of alignment tools calls upon lasers to produce far more accurate results. Ludeca's Dot-Line Laser® Pulley Alignment Tool, for example, has proved to greatly reduce downtime and the manpower needed to perform sheave alignment while simultaneously achieving far greater accuracy. This results in great labor savings and increased production uptime.

The visual estimates and string-and-straightedge strategies that were the crux of shaft and pulley alignment efforts at plants for decades do not suffice in today's perfect-precision-demanding manufacturing era. Investment in modern laser alignment technologies that can deliver unprecedented accuracy and do so in less time than traditional alignment methods represents an investment in the longevity of equipment and the productivity of the plant as a whole. ☐

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OIL ANALYSIS DELIVERS PUMP RELIABILITY

Take an integrated approach to oil and vibration analysis to help predict problems with lubricant cleanliness

By Mark Barnes, CMRP, Des-Case Corporation

In most plants, the single largest asset class are pumps. From small ANSI to large API pumps, pump reliability is critical. For this reason, plants pay particularly close attention to pump reliability and often track Mean Time Between Failure (MTBF).

In many plants, pump MTBF varies between 5-8 years depending on the maturity of maintenance practices. But with just a little effort, significant improvements to pump reliability and longevity can be achieved through the application of precision lubrication practices.

OIL ANALYSIS VS. VIBRATION ANALYSIS

According to SKF, a leading bearing and seals manufacturing company, there are many different causes of pump bearing failure. But a closer look at the data will reveal a much simpler picture. Looking at just three categories— particle contamination, corrosion, and insufficient lubrication – it's clear that issues related to the correct application, health, and cleanliness of the lubricant account for as much as 63% of all pump bearings failures, making lubrication arguably the most important aspect of maintaining centrifugal pumps.

For critical pumps, the value of predictive maintenance (PdM) cannot be overstated. Particularly for production critical assets, knowing that a pump is starting to fail months in advance allows for appropriate planning for corrective action to be taken. When starting a pump

PdM program, most reliability-focused companies start with vibration analysis and often with great success. The reasons for this are quite straightforward: with the high speeds at which pumps operate and their fairly simple mechanical design, even the most basic vibration analysis program can effectively diagnose impending bearing failure as well as a number of other potential failure modes.

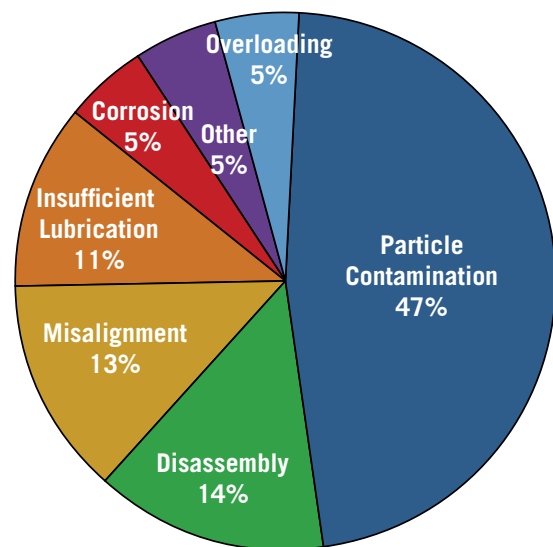


Figure 1. Root causes of pump bearing failures. (Source: SKF)

FAILURE MODE	VIBRATION ANALYSIS	OIL ANALYSIS	COMMENTS
Soft foot	Primary	Not applicable	Oil analysis will provide no indicator of soft foot problems until wear starts to occur inside the pump.
Shaft misalignment	Primary	Later term	While oil analysis will indicate alignment once wear starts to occur, vibration analysis is far better at proactively identifying alignment issues.
Bearing wear	Primary/ confirmatory	Primary	While oil analysis will often provide an early indicator of bearing wear, vibration analysis can localize the failure to a specific bearing and wear mode within the bearing (cage, out race, etc.)
Slinger ring/ flinger disc wear	Later term	Primary	While vibration analysis may indicate poor lubrication conditions through high frequency vibration, oil analysis is a better technology for identifying slinger ring or flinger ring disc wear. Where the ring/disc is metallic, the small sump size typically insures early detection through elemental analysis, while an elevated particle count can be an early warning sign when an elastomeric disc is used.
Wrong/degraded lubricant	Later term	Primary	Issues related to an incorrect lubricant or degrade lubricant can be easily be identified using oil analysis whereas vibration will not show a problem until wear starts to occur.
Particle or moisture contamination	Later term	Primary	Particle and moisture contamination are one of the major failure modes found in process pumps. Oil analysis can easily find these problems before reactive wear occurs.
Low oil level	Primary	Secondary	Lack of lubrication will show up in high frequency vibration analysis. However, simple visual levels checks are the best detection method.

Table 1. Common failure modes for process pumps (Source: Bryan Johnson, "Oil Analysis Success at a Power Generation Station," Practicing Oil Analysis Magazine, July-August 1998.)

Unfortunately, few companies choose to perform oil analysis on pumps. Oil analysis is about validating the health of the system as a whole. One of the main causes of premature bearing failure is contamination with particles or moisture, and while vibration analysis will provide an indication once the bearing starts to fail, oil analysis can proactively

warn of the potential for a contamination induced failure through careful monitoring of particle and moisture contamination within the oil. Likewise, other pump failure modes such as the correct oil or slinger ring wear are far better identified using oil analysis.

Table 1 summarizes the more common failure modes for pumps, and

which technology is best suited as a primary and secondary failure detection method. As the table indicates, both vibration analysis and oil analysis are necessary to successfully identify problems, with studies indicating that problems show up first in either vibration analysis or oil analysis in almost equal proportions.



Figure 2. Replacing a flat sight glass with a 3D sight glass is a simple inexpensive modification that can greatly enhance the reliability of oil level checks.

VISUAL INSPECTIONS

In addition to vibration and oil analysis, performing a basic daily or weekly visual inspection of pumps is an easy and effective way to identify emergent issues. Using an oil level indicator to check oil level, inspecting the color and clarity of the oil with a sight glass, recording bearing temperatures with a non-contact infra-red pyrometer, or looking at the color of the breather can all pinpoint an emergent issue. A basic lubrication check sheet similar to those used by pilots for pre-flights checks is also a good idea to make sure everyone's inspecting and expecting the same thing.

Oil Level

In order to ensure correct oil level, a visual level gauge should always be installed. The presence of oil in the oil bulb of a constant level oiler (CLO) should never be taken as an indicator that the pump is full. Any blockage in the line connecting the CLO to the oil sump can prevent oil from flowing into the bearing housing, and sunlight and time can cause the bulb of the CLO to stain such that the "bathtub ring" left behind might make it appear that sufficient oil is present when in actuality it could be completely empty.

Care should also be taken when filling a CLO. If the bulb is filled beyond 60-70% full, there may be insufficient headspace within the CLO to permit oil to flow into the bearing housing. To ensure correct oil level, many pump housings are equipped with a sight glass. But although these are effective when new, over time the glass can become stained making it very difficult to ascertain if the correct level of oil is in place, particularly in low-light areas. A simple solution to this problem is to replace the flat sight glass with a 3D sight glass, which offers viewing from any angle and helps make visual level checks easier and more accurate (see Figure 2).

Oil Color

Oil color can be a good indicator of a problem. A number of issues can cause an oil to change color, including oxidation, thermal stress, external contamination, or the presence of wear metals or other debris. Whenever oil is observed to have changed color, it's usually a good idea to extract a bottle sample and perform additional diagnostic tests. It should be noted that not all color changes necessarily mean something is wrong; for example, it's not uncommon for oil color

to change slowly over time due to the photocatalytic effect of sunlight.

Oil Clarity

One simple yet effective tool to help oil clarity is to shine a laser pointer through a 3D sight glass or level gauge (see Figure 3). Just like shining light through water vs. milk looks different, a change in an oil's opaqueness can be detected. Potential problems include water, solvents, detergents in the oil, or even the wrong lubricant was dispensed into the equipment.

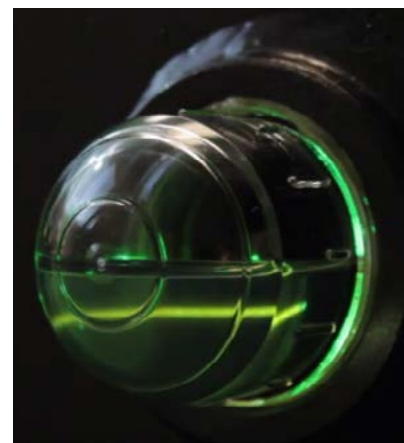


Figure 3. Shining a laser pointer through a 3D sight glass is a simple tool to inspect oil clarity.



Figure 4. An oil sight glass (bottom sediment and water bowl) installed on a drain is a great indicator of problems such as water ingress or degraded oil.

PRESENCE OF WATER

Oil sight glasses (see Figure 4) are commonly referred to as a bottom sediment and water (BS&W) bowl. These simple devices installed on the drain port can warn of whether water is present in your oil. Water in oil can either be free (separated on the bottom of the sump) or emulsified (mixed with oil in a cloudy suspension), and if you wait until the oil turns cloudy, it's often too late to prevent bearing damage.

A correctly installed sight glass can find the presence of water before it impacts the bearing.

SUMMARY

Having the ability to predict potential problems with lubricant cleanliness can help avoid contaminant or water damage that could be catastrophic to a pump's health and put a halt to production. Precision lubrication demands a proactive approach in order to avoid costly reactions to failures after they have occurred.

Ultimately, taking an integrated approach using oil analysis and vibration analysis is far greater than choosing one over the other. Having a good understanding of the possible or likely ways a pump might fail, then selecting the technology or technologies that are best able to identify the causative factors will always provide the best return on investment when it comes to condition monitoring. ☺



Mark Barnes, CMRP, is vice president of reliability services for Des-Case Corporation (www.descase.com). Mark has been an active consultant and educator in the maintenance and reliability field for over 17 years and has worked with clients around the world to design and implement lubrication improvement plans. He holds a Ph.D. in Analytical Chemistry. Contact him at mark.barnes@descase.com.

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8 REASONS MANUFACTURING FACILITIES CAN BENEFIT FROM PREDICTIVE MAINTENANCE

PdM is giving manufacturers a more efficient, data-driven method for managing routine equipment maintenance

By Eric Martin, Advanced Technology Services, Inc.

For many years, preventive maintenance (PM) has been the gold standard in manufacturing. On a regular cycle, crews take equipment out of service and perform routine tasks that are designed to, theoretically at least, keep it running in tip-top shape and prevent unexpected failures. Although PM does interrupt production, the impact is minimal compared to the extended downtime that can accompany equipment failures.

The problem with conventional PM is that schedules and tasks are based primarily on assumption and estimation, rather than fact. The PM routine is designed around experience and time – and not on actual in-service performance, wear-and-tear, or documented impact of production on the equipment. That means facilities might take equipment down for PM when it is not necessarily warranted, wasting valuable production time, crew resources, and parts and materials,

and still may not fully mitigate their risk of a failure.

Predictive maintenance (PdM) is giving manufacturers a more efficient, data-driven method for managing routine equipment maintenance to maximize production, safety and efficiency while ensuring ideal operation and reliability of equipment. Rather than relying on a regimented, and often arbitrary, schedule, PdM uses a conditions-based approach that measures and earmarks factory equipment, scheduling repairs and upgrades according to the machine's actual health and performance.

This approach has the potential to be a game-changer when it comes to optimizing maintenance, production and cost-efficiency, not to mention providing a more reliable method to detect and prevent potential failures. Why is PdM the wave of the future? Here are the top 8 reasons facilities why manufacturers should implement Predictive Maintenance.



1) PdM identifies problems typical PM and visual inspection cannot. PdM uses advanced diagnostic and sensing technologies, such as ultrasound, thermography, vibration, and oil analysis, to identify problems in situ and in real time – as the equipment is running. This provides performance data and insight that cannot be identified when the machine is taken off line for traditional PM, and it gives maintenance staff a clearer picture of the actual wear-



and-tear on equipment, rather than making assumptions.

2) PdM enables lean manufacturing. Traditional preventative maintenance techniques could take equipment offline far more than necessary, and still not provide assurance against a failure. PdM, on the other hand, can actually improve production and provide long-term savings. Performing maintenance when it is required avoids unnecessary halts in production and means less time, money, parts, and supplies consumed by unnecessary maintenance. In fact, PdM has been shown to eliminate as much as 30 percent of time-based PM tasks, freeing up those capital and human resources for other critical tasks.

3) PdM provides continuous insight to improve processes. The data and



analysis gathered through baselining, tracking and documenting equipment performance offers tremendous visibility that can inform production improvements. Knowing that specific conditions or factors help equipment to operate at peak performance, facilities can begin looking at environmental adjustments to ensure those optimal conditions. This not only extends the time between maintenance tasks, but also improves overall production results.

4) PdM technologies integrate with CMMS and other work order systems. By integrating these this data into maintenance software, PdM provides a seamless solution that adds no further burden to the workflow and ensures that repair/replacement work is conducted in a timely manner. This eases the supervisory burden, again freeing up those resources to address more strategic initiatives.

5) PdM can minimize recall and liability risk. In the event of a contamination or recall event, having a documented log of equipment statistics can help demonstrate that your facility took every possible precaution to prevent the situation. The data could help to provide some relief to help lessen the damage impact.

6) PdM can improve plant safety. By better understanding how equipment is performing and where potential risks lie, facilities can mitigate safety situations, such as fluid leaks, overheating, and dangerous electrical

or hydraulic situations that could put staff at risk.

7) PdM can aid in asset attrition planning. With greater insight into equipment performance, issues and expected useful life, facilities can better plan and budget for replacement. The data gleaned from PdM can help to optimize capital expenditure planning while ensuring daily optimal performance of the assets still in place.

8) Partnering with a PdM provider can amplify the benefits. Working with a PdM maintenance and industrial parts service provider enables consumer packaged goods companies to benefit from economies of scale, advanced analysis, best practices from across the industry, and preferred parts and components pricing. By taking advantage of best-in-class services, companies can save millions of dollars and reduce downtime by up to 65 percent by relying on the knowledge, experience and partner supplier networks of an integrated PdM provider.

As in so many other areas, data is becoming a critical asset in business success, and the manufacturing floor is no exception. By understanding more about exactly how process equipment is performing during production and reducing unnecessary downtime, manufacturers can find previously untapped opportunities to improve production efficiencies and save money. PdM is proving to be the template of the future for equipment maintenance, ensuring optimal performance, minimal downtime and maximum safety and productivity. ©



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ATS

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We Make **Business** Run Better.



The Smarter Way to Maximize Machine Availability.

Every day, maintenance technicians face the challenge of ensuring maximum machine availability while keeping the amount of materials consumed by maintenance and repairs to a minimum – a demand that existing preventative maintenance models are usually unable to fulfill.

Advanced Technology Services (ATS) uses predictive technologies to identify problematic issues in a premature stage that cannot be detected by visual or other equipment inspections. This proactive approach helps prevent catastrophic failures and considerable downtime. Our team of certified technicians establishes the necessary data collection points for capturing and comparing machine status on a routine basis. Predictive Maintenance can be scheduled annually, semi-annually or quarterly based on your facilities needs providing analysis reports along with improvement recommendations.

Our Predictive Maintenance certified technicians:

- Isolate and identify degrading components
- Monitor machinery condition on a service schedule
- Infrared thermography assessments
- Ultrasound testing
- Vibration analysis
- Oil analysis

As in so many other areas, data is becoming a critical asset in business success, and the manufacturing floor is no exception. By understanding more about exactly how process equipment is performing during production and reducing unnecessary downtime, manufacturers can find previously untapped opportunities to improve production efficiencies and save money. PdM is proving to be the template of the future for equipment maintenance, ensuring optimal performance, minimal downtime and maximum safety and productivity.

Benefits of Predictive Maintenance

Maintenance

- Identify potential failures
- Scheduled repairs
- Reduced downtime

Operations

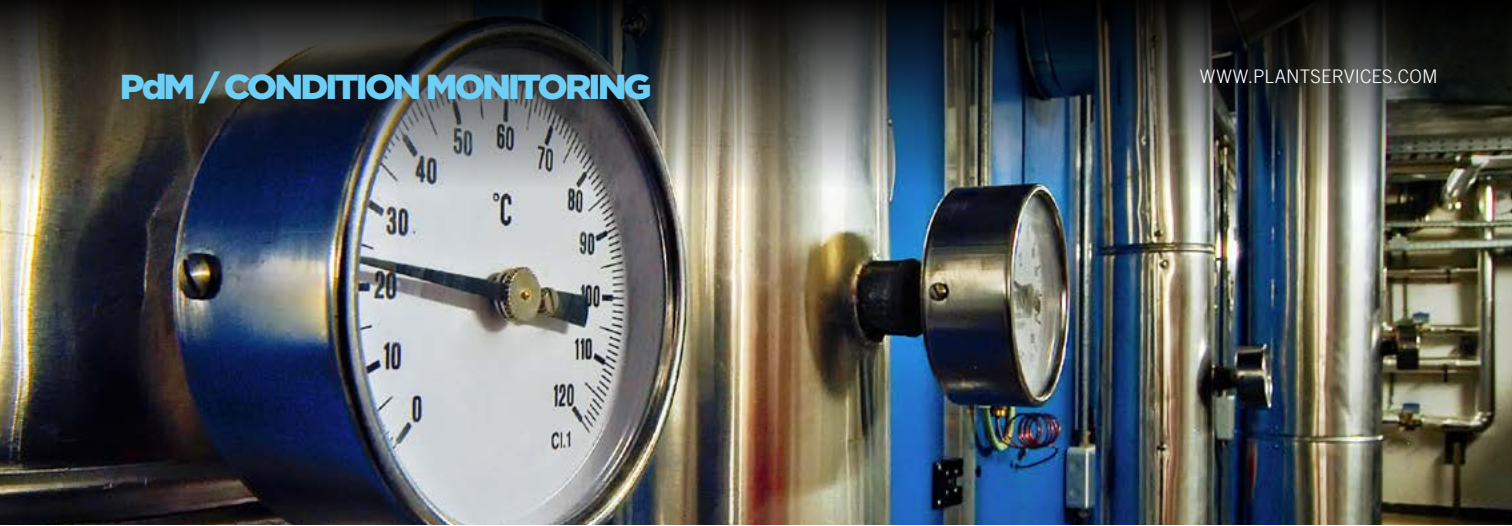
- Increased machine reliability
- Better equipment reliability
- Increased profitability
- Improved workforce utilization

Purchasing

- Reduced maintenance costs through reduction of repeat failures
- Reduction of supplier base
- Achieved cost savings goals
- Reduction of Energy



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LAY A STRONG FOUNDATION

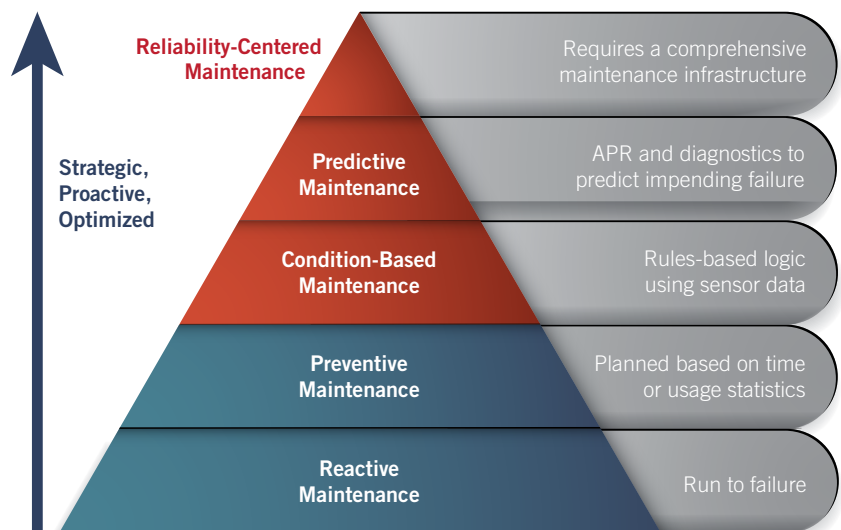
Combine known rules with machine learning for better maintenance decision-making

By Kim Custeau, Schneider Electric

It's no secret that organizations today are focused on driving efficiencies throughout every area, and are at the point where their focus is on maintenance efficiency and effectiveness. As a consequence, in order to reduce unplanned downtime and maximize labor efficiency, the new generation of plant personnel are empowered to act before equipment failure occurs. From an asset management perspective, organizations are leveraging industrial data and analytics while integrating all the various elements of a maintenance system. Keeping plant equipment running is critical, but how do plants accomplish that when capital and operational expenditures are extremely limited?

The Enterprise Asset Performance Management (EAPM) approach is about empowering the enterprise, transitioning from a corporate view of assets (i.e., managing the lifecycle through improved maintenance visibility and standardized practices) to a holistic, integrated, and operations-centric view. These solutions enable customers to exceed safety, reliability, and performance goals through data collection and analysis coupled with actions and optimization for proactive maintenance execution.

This vision involves being able to build connections from the sensor or smart device assets all the way up to the ERP systems, making valuable information from the plant floor more accessible and delivering context to plant teams on the device of their choice in order to learn and make better decisions over time. The idea is to have a broad portfolio for users to collect information on assets, analyze it, determine the next course of action, and then use that action to further refine the next set of actions.





In other words, this is a continuous improvement program, bolstered where appropriate by automated workflows and predictive modeling, one that starts with an understanding of the Maintenance Maturity Pyramid. The pyramid represents a different kind of approach to take for the different kinds of assets that exist, one that follows the integrated EAPM model.

At the bottom of the pyramid, plant personnel often say, “we have to move away from reactive maintenance modes.” A more accurate statement is, “for this specific set of assets, reactive is the right way to perform maintenance, because failures do not otherwise affect my process, and letting these assets run to fail costs less than the effort to replace them ahead of schedule.”

The next level is where preventive maintenance (PM) programs come into play, and workflow automation begins. On the majority of your assets you can set up PMs, you can identify a time frame, and then use the OEM manual to set up and schedule periodic work. You’re starting to create automated ways to remind you that for these pieces of equipment, you have this specific regular maintenance action to take.

Moving up the pyramid, condition-based maintenance (CBM) represents the initial stage of a more proactive maintenance approach. The primary benefit of condition-based approaches is that they can automate the maintenance process through the monitoring of user-defined rules that initiate necessary maintenance activities. Condition-based approaches and technologies are commonly employed to monitor industrial asset performance when the asset condition is known and definable using rule-based or algorithmic logic.

In essence, instead of executing a PM in reaction to elapsed time, plant personnel can create a maintenance strategy that is based on one or more conditions, and can have each of those conditions (or combinations of conditions) trigger events. This does not require any user intervention – the system automatically creates a work order that is then assigned to a team member to execute.

To take it to the next level of the pyramid, organizations need to tie in predictive maintenance (PdM) approaches to model the performance of critical assets. The combination of known rules (CBM) plus advanced pattern recognition and machine learning (PdM) results in a robust industrial asset analytics platform where you can look at the model and identify either a performance issue or an impending failure days, weeks or months before traditional practices.

With predictive maintenance, personnel know and understand the actual and expected performance for an asset’s current operational state. Access to contextual data then enables you to go back and look at previous maintenance and production data for that asset, combine that information, and make an informed choice of what action needs to be taken.

Laying the foundation to achieve these kinds of process automation benefits involves getting a baseline solution in place to manage assets: both a work management process to handle routine maintenance (including some PM) and an asset structure that makes sense. At that point teams need to start identifying critical assets, and understand exactly how they are operating; part of this effort includes identifying and monitoring the conditions in which these assets are operating.

The result is maximum economic return for all assets, either through early warning notification of equipment issues, through making the workforce more efficient, or through improved access to relevant and contextual information that can be served up on a mobile device. The benefits are real, with the value rooted in system connectivity which enables continuous improvement and better choices. It’s simply a matter of asking, what will an hour of downtime cost me, and what if I can prevent that? ☺



Kim Custeau is director of asset management at Schneider Electric. Contact her at Kim.Custeau@schneider-electric.com.

Additional Resources

FOR MORE INFORMATION CLICK ON THE LINKS BELOW



Parker's Approach to IIoT and Condition Monitoring

Industry has automated the machining process, and companies have constantly sought ways to maintain high product quality while improving production rates. Parker's SensoNODE Blue Sensors and SCOUT Mobile Software were specifically designed to eliminate challenges in everyday applications and fill-in information gaps. Through wireless connectivity, companies can: consistently and accurately diagnose assets for condition changes that help to predict problems and prevent downtime, respond to alerts that require immediate action to keep operations running, and monitor their processes and fine-tune them for optimal throughput and product quality.

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8 Reasons Manufacturing Facilities Need Predictive Maintenance

Every day, maintenance technicians face the challenge of ensuring maximum machine availability while keeping the amount of materials consumed by maintenance and repairs to a minimum – a demand that existing preventative maintenance models are usually unable to fulfill. Predictive Maintenance (PdM) is proving to be the optimal, proactive approach for equipment maintenance ensuring peak performance, minimal downtime and maximum safety and productivity. Click below to find out the 8 Reasons Manufacturing Facilities Need Predictive Maintenance or visit www.advancedtech.com

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