Manage Essential Assets with Automated Monitoring

Automated asset monitoring is the next step in predictive maintenance

Pete Sharpe, Nikki Bishop,
Robert Montgomery

In most facilities, real-time monitoring and protection of critical process equipment, such as large compressors or turbines, is standard practice. However, monitoring of second-tier equipment, such as pumps, blowers, fin-fans and small compressors, has traditionally been deemed cost-prohibitive or too difficult. While these unmonitored assets may not have been originally classified as "critical", a sudden failure of this equipment can still cause serious process disturbances, shutdowns, slowdowns or further damage to equipment.

Wireless technology has made it possible to justify real-time, on-line monitoring of essential assets as part of an overall site reliability initiative. Low-cost wireless sensors combined with pre-engineered monitoring solutions can automatically diagnose and alert operators and maintenance technicians at the onset of a developing condition. Using a remote connection, experts from around the globe can then access the details and assist with the troubleshooting, root cause analysis and resolution of the problem. A number of leading refiners and operating companies have recently installed wireless essential asset monitoring systems to improve their equipment availability, reduce unscheduled outages and minimize unplanned maintenance activities. This article will explain how remote automated monitoring works and how it can be used to improve productivity, reliability and safety.

Maintenance practices can be ranked on a scale with reactive maintenance (run an asset until failure) on one end and predictive maintenance (maintain an asset when a program indicates malfunction approaching) on the other. Advances in automated remote monitoring technology now make it cost effective and easy to extend the predictive maintenance end of the scale. By paying closer attention to assets that were previously monitored manually, maintenance expenses and costly process downtime can be reduced.

Consequences of equipment failure

The cost of equipment failure increases every year. While lost production, injuries and repair costs are immediate, a failure that results in a spill or release of hazardous material can create liabilities, like lawsuits, bad press and environmental impact that can go on for years.

The best way to prevent equipment failure is to institute a proper maintenance program. Both preventive and predictive maintenance programs can help prevent failures, but their effectiveness varies.

The simplest approach, preventive or periodic maintenance, is like changing the oil on a car every three months, regardless of how much the car is driven. Scheduling an oil change every 3000 miles can also be expensive and unnecessary, although if the cost of an oil change plus the inconvenience of being without your car is relatively low, this may be an acceptable method. Alternatively, today's cars can also use information from the car's engine control computer to determine vehicle operating conditions, calculate remaining oil life and inform the driver when it is time to change the oil. This is a simple form of predictive maintenance based on an internal computer model that does not involve any actual feedback from the engine or analysis of the oil. For industrial equipment, an outage required to pull out and rebuild a valve or pump can be expensive, so more sophisticated monitoring systems are used to decide when and how to make repairs. While predictive maintenance systems based on historical data and periodic manual measurements are better than simply following a schedule, on-line monitoring of the valve performance or pump vibration can detect developing equipment problems and predict more accurately when service is needed.

Good predictive maintenance programs rely on data from the field, whether from on-line measurements, handheld data collection, clip-board rounds or periodic

AUTHORS

Pete Sharpe is Director, Industry Solutions Development for Emerson Process Management. He has over 34 years of experience in the process control industry, in both technical and management roles, specializing in automation and Asset Management Systems. He is currently responsible for managing the engineering and development of Emerson's industry-specific solutions for monitoring and control of processes and plant assets. He holds a BS in Chemical Engineering from the University of Colorado and an MBA from the University of Houston.

Nikki Bishop, P E, is Senior Application Consultant at Emerson Process Management. With over 10 years of experience in the process control industry, her experience includes automation projects in industrial energy, pharmaceuticals, power generation, pulp and paper and refining. In her current role as an application consultant, she designs, deploys and manages integrated application solutions around specific unit operations or equipment. She holds a chemical engineering degree from Georgia Tech and is a registered professional engineer in the state of Georgia.

Robert Montgomery is the instrument technician for the Separations Research Program (SRP) at The University of Texas in Austin. Robert has provided instrument and operations support to the SRP pilot plant for 30 years. The unique SRP pilot facilities incorporate a wide variety of instrument technologies including HART, Fieldbus, Modbus and Wireless HART. The plant also has AMS, AMS Health Monitor and Asset Graphics installed to help manage the pilot plant. The pilot facilities are utilized by engineering, chemical, petrochemical and oil companies.

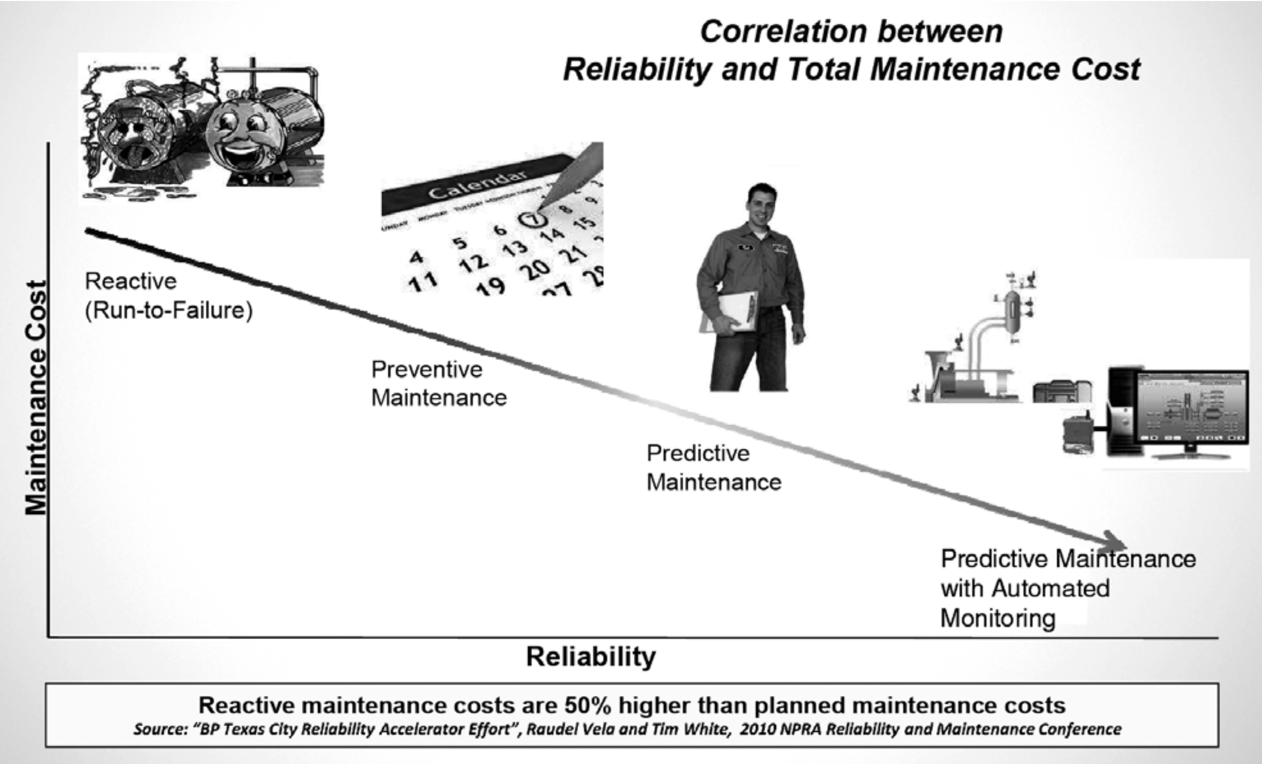

Fig. 1: More sophisticated maintenance programs save money on day-to-day maintenance.

inspections. On-line monitoring has historically been limited to those assets classified as critical, and has often not been applied to second-tier equipment. While second tier equipment may not be considered "critical," a failure can cause an outage, slowdown, or even worse. These "essential" assets are typically not installed with sufficient instrumentation for health and performance monitoring when the plant is originally built. This equipment often has spares — primarily because it is expected to fail between scheduled downtimes. For the essential assets whose failure can cause process upsets, on-line monitoring provides insight into developing equipment problems.

Automated monitoring detects conditions that may otherwise be missed and allows time for adjustments to be made before there is a problem or failure. Automated monitoring also helps avoid process-related faults, where process conditions may unintentionally induce faults on equipment. With advance warning of asset health degradation, it is possible to determine when service is necessary and bring asset monitoring into the control room. **Figure 1** shows how leading manufacturers have achieved higher availability at lower overall cost by moving from reactive, to preventive, to predictive maintenance and on to automated monitoring.

Components of a successful automated asset monitoring strategy

For a long time, automated monitoring of equipment at all levels was simply impractical. There were too many points, and the cost of adding sensors and transmitters was deemed prohibitive. That is no longer the case. What makes it all feasible today is the availability of ubiquitous, low-cost wireless technology — from smart field devices with wireless connectivity to smart phones, Internet-connected tablets and other devices that can deliver vital information in real time to systems and people who need it. Information on necessary maintenance actions can be sent to operators and maintenance personnel simultaneously, regardless of where they are, so action can be taken immediately, even automatically calling in the off-

Automated monitoring detects conditions that may otherwise be missed and allows time for adjustments to be made before there is a problem or failure. Automated monitoring also helps avoid process-related faults, where process conditions may unintentionally induce faults on equipment.

The redundancy inherent in wireless mesh networks makes these devices almost as reliable as wired units, and greatly reduces the installation cost.

site experts as necessary.

Wireless makes automated monitoring practical

Just a few years ago, the advent of digital technologies in the automation world spawned a whole new set of capabilities as suppliers built microprocessors into field devices and took advantage of digital communications protocols to embed intelligence in the field. Smart field devices like transmitters and control valves report not only their main process variables, but also a wide range of diagnostic information on their conditions using digital protocols such as HART, Profibus, or FOUNDATION fieldbus. Many routine analysis and adjustments can be made on line without a trip to the field.

Just as digital technology has engendered innovation in the capabilities of devices, widespread use of wireless field networks is poised to be the next major revolution in the automation industry. Protocols like Wireless HART make it possible to install field devices without the need for field wiring, using secure, encrypted wireless communications technology. The redundancy inherent in wireless mesh networks makes these devices almost as reliable as wired units, and greatly reduces the installation cost.

The ready availability of new wireless transmitters, from vibration accelerometers to acoustic sensors, makes it possible to install sensors in locations not previously considered like monitoring cooling towers, safety showers and steam traps. Vibration sensors can be more easily justified on rotating equipment like pumps, compressors and blowers for which changing vibration levels often signal impending problems. Other assets like valves, heat exchangers and cooling towers may utilize wireless devices to monitor temperature, level, pressure, position and sound. Modern Asset Management Systems (AMS) monitor, analyze and present this information to maintenance personnel and operators.

Organization

Simply putting in more transmitters, wireless or not, does not necessarily translate into improved reliability. An AMS can assimilate information from the assets, the process, control system and devices to create diagnostics that help identify and resolve performance issues. As more of the plant is monitored on line it is important that companies consider the impact on the organization and the business processes in order to use the technology most effectively. For example, fewer maintenance rounds to take manual readings are needed, and a typical inspection list for a monitored asset would require modification. Reliability engineers and maintenance technicians could start their day reviewing AMS alerts for any critical performance issues identified.

The ability of an organization to make changes to its

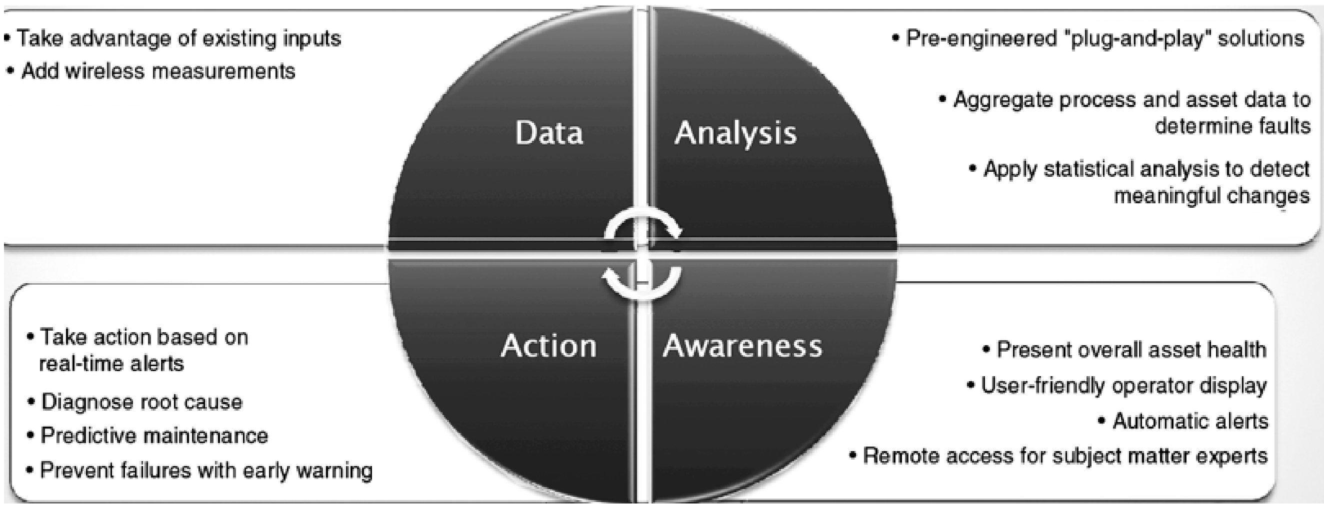

Fig. 2: The solution is not data collection alone. A successful asset management system collects meaningful data, analyzes the data to generate meaningful alerts, informs the appropriate person and allows them to take action to prevent failure.

Fig. 3: This cracked impeller in an aluminum plant was detected by real-time vibration monitoring.

Fig. 4: The Separation Research Program at the J.J. Pickle Research Center at the University of Texas–Austin has been conducting research on capture and removal of carbon dioxide from power plant stack gas. The center monitors essential assets on-line, which makes it possible not only to see when an asset is nearing failure, but to follow long-term trends and make adjustments to prevent future problems.

Fig. 5: Wireless vibration sensors were installed on this stripper bottoms pump and motor.

day-to-day operating practices is as critical as the technology itself and can determine the program's success. Collecting data is just the beginning of an asset monitoring program. Having the systems, people and processes in place to take action on an alert is what creates value.

A growing number of companies are starting to embrace the concept that these asset monitoring and response teams don't necessarily need to be on site. The ability of a rotating equipment specialist anywhere in the world to log in and remotely access equipment performance data to help troubleshoot a compressor means that the specialist can be centrally located, supporting a number of plants. These "Intelligent Operations" or iOPS centers are starting to spring up in industries such as mining, upstream production, gas processing and air separation plants where operations can be quite geographically spread out. While accessing information across a company WAN is not new, a 24x7 dedicated remote operations facility for planning, controlling, operating and maintaining a number of plant sites is quite revolutionary.

When you consider the prospect of a remote team monitoring a plant site which they may never have actually been in, some premises start to become clear. First, the system must aggregate the process and asset data together and highlight statistically meaningful changes in perfor-

As more of the plant is monitored on line it is important that companies consider the impact on the organization and the business processes in order to use the technology most effectively.

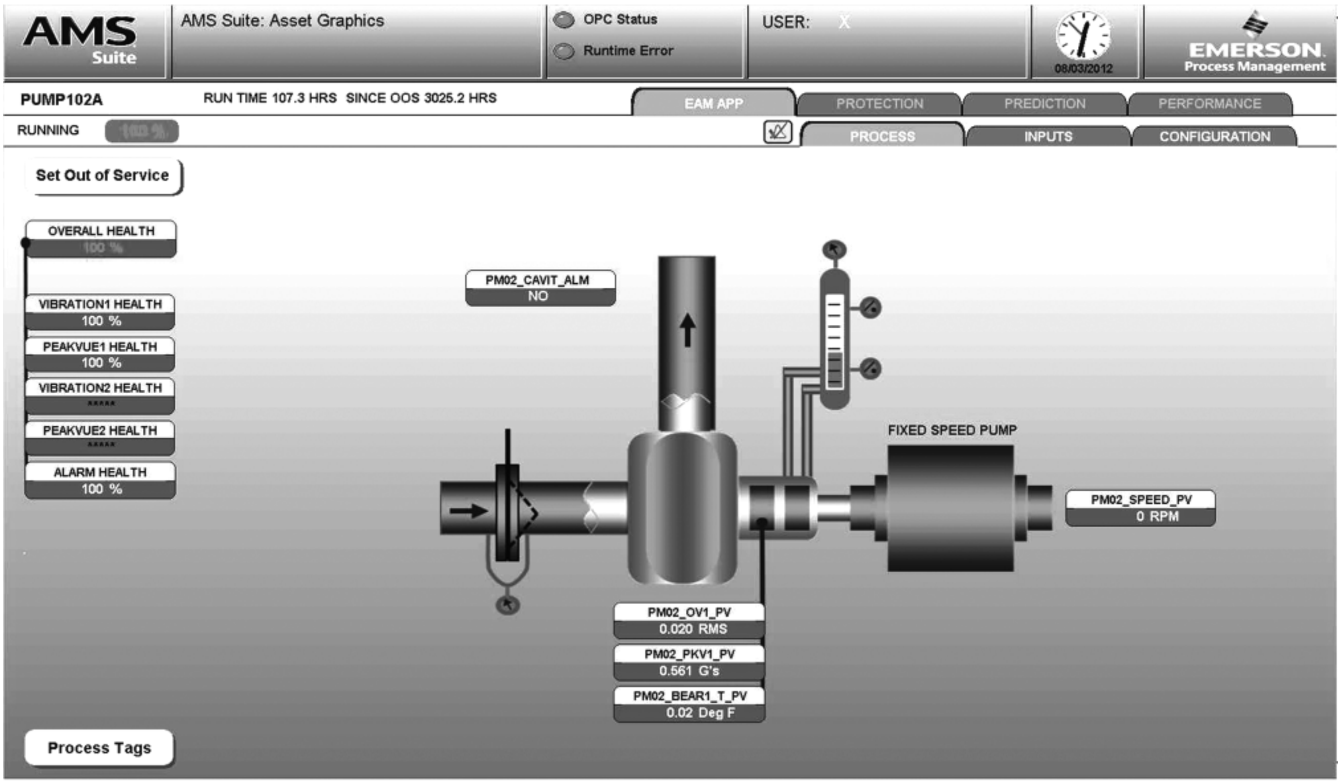

Fig. 6: Emerson's AMS Asset Graphics software solution analyses the data from the sensors for cavitation, vibration, and bearing temperature.

mance. Searching for tag names is verboten or forbidden. Remote operations are not about watching trends. The system must automatically detect when something is not right and raise an alert that will instigate some action. The first-responder to an AMS alert in an iOPS center may not be the expert in that specific area, but will engage the right persons and help coordinate a response with the site team.

After awareness of an issue comes analysis by the subject matter experts. The system should support the ability to drill down and provide more detailed access for experts to diagnose root cause. From their offices (or a remote iOPS center) a rotating equipment specialist can review wave forms and spectral vibration data to help analyze a bearing issue. Asset, instrumentation and control system alerts can be sent to appropriate personnel in real-time, if email or pager notices are acceptable. Armed with an iPad, internet access and the appropriate authority, a user can remotely access the system, perform the analysis and initiate a work order to repair it. **Figure 2** shows how the pieces fit together.

Security

As with any remote monitoring application, security is of utmost importance. Since essential asset monitoring is a read-only application that works alongside the control system, it is inherently less risky than other monitoring applications. Remote access is provided through secure VPN access combined with multiple firewalls, and remote functionality is limited by user-based security. Any asset issues can be detected and diagnosed remotely, but local coordination is used whenever system or asset maintenance needs to be done.

Since essential asset monitoring is a read-only application that works alongside the control system, it is inherently less risky than other monitoring applications. Remote access is provided through secure VPN access combined with multiple firewalls, and remote functionality is limited by user-based security.

A few examples

There is much anecdotal evidence that on-line monitoring of the health of control systems, field devices and assets can help reduce plant upsets and downtime. A simple example of how automated monitoring can help:

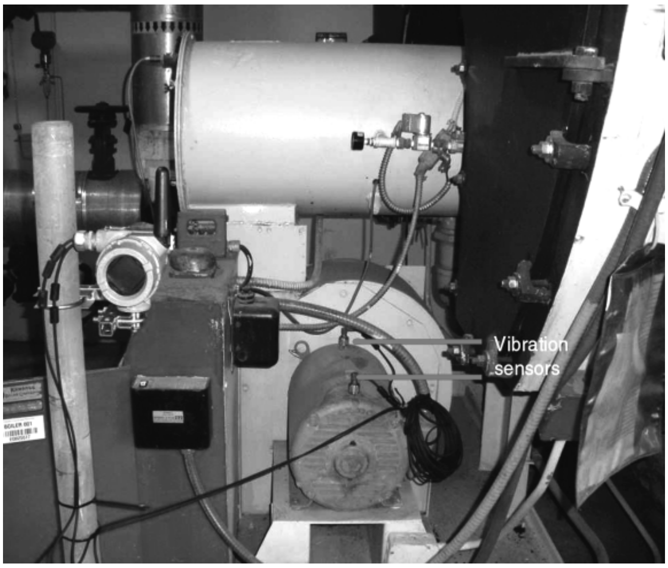

Fig. 7: The vibration sensors on the boiler blower have prevented some major problems.

Instrument air pressure to an important valve in a chemical plant fell below its normal value, resulting in poor response to control and the potential for a runaway exothermic reaction. The plant's monitoring system detected the problem and alerted both the operator and the maintenance department. The situation was corrected with no shutdown, no process disturbance and no safety incident.

In another case, a Gulf Coast refinery embarked on a three-year study of the possible savings from predictive maintenance and valve diagnostics. The result was a saving in maintenance expense of $100,000 per year, and the improvements in process control and plant availability yielded even greater benefits than the maintenance savings.

A North American refinery had a significant number of process pumps that were checked with handheld vibration sensors manually, once a month. As part of a reliability improvement program, a number of the most critical pumps were fitted with wireless vibration devices. These devices were brought into the plant's historian for display, reporting and trending, giving the operations and maintenance departments access to information that was previously unavailable. Within the first 24 hours of operation, a critical pump problem was detected and resolved before it caused further process issues.

Remote monitoring of cooling tower in refinery

PEMEX, a government-owned oil and gas exploration and production company in Mexico is the world's fourth largest oil producer. The Pemex refinery in Tula, Mexico is a 325 mbpd facility with 10 distinct process plants contained within the refinery. One particular process area, the alkylation plant, experienced multiple emergency shutdowns due to cooling tower failure. With a total production of almost 8000BPD in the alkylation plant, an eight hour shutdown required for repair of the cooling tower equated to a staggering loss of $59 million for each shutdown. Even when production was only slowed, not shut down completely, production loss carried a hefty price tag.

The ability of an organization to make changes to its day-to-day operating practices is as critical as the technology itself and can determine the program's success. Collecting data is just the beginning of an asset monitoring program. Having the systems, people and processes in place to take action on an alert is what creates value.

The major issue for cooling towers was the lack of instrumentation. Existing instrumentation was old and most was out of service. The corrosive environment required frequent instrumentation maintenance. Site personnel performed three rounds per day, manually gathering data, a process which is not only time consuming, but dangerous and also results in poor readings. Without vibration data on the fans, it was difficult, if not impossible, to prevent failures. Without measurements for water quality, such as pH and conductivity, it was difficult to cost-effectively dose chemicals which led to increased water and chemical costs. Good measurement data was required to resolve these issues.

Four wireless networks and a total of 122 wireless devices were installed on four cooling tower sections.

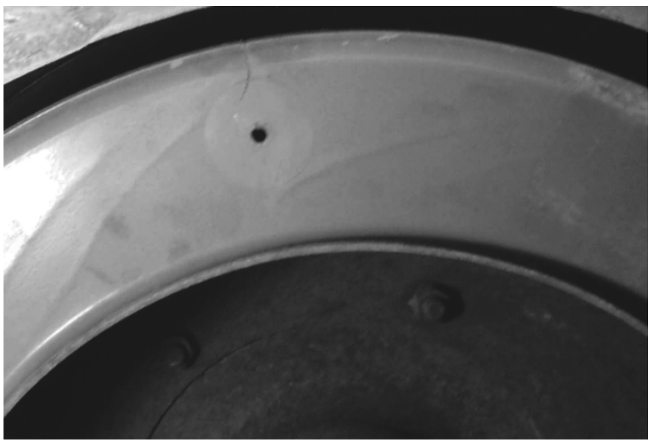

Fig. 8: Examination revealed a defect in the blower wheel.

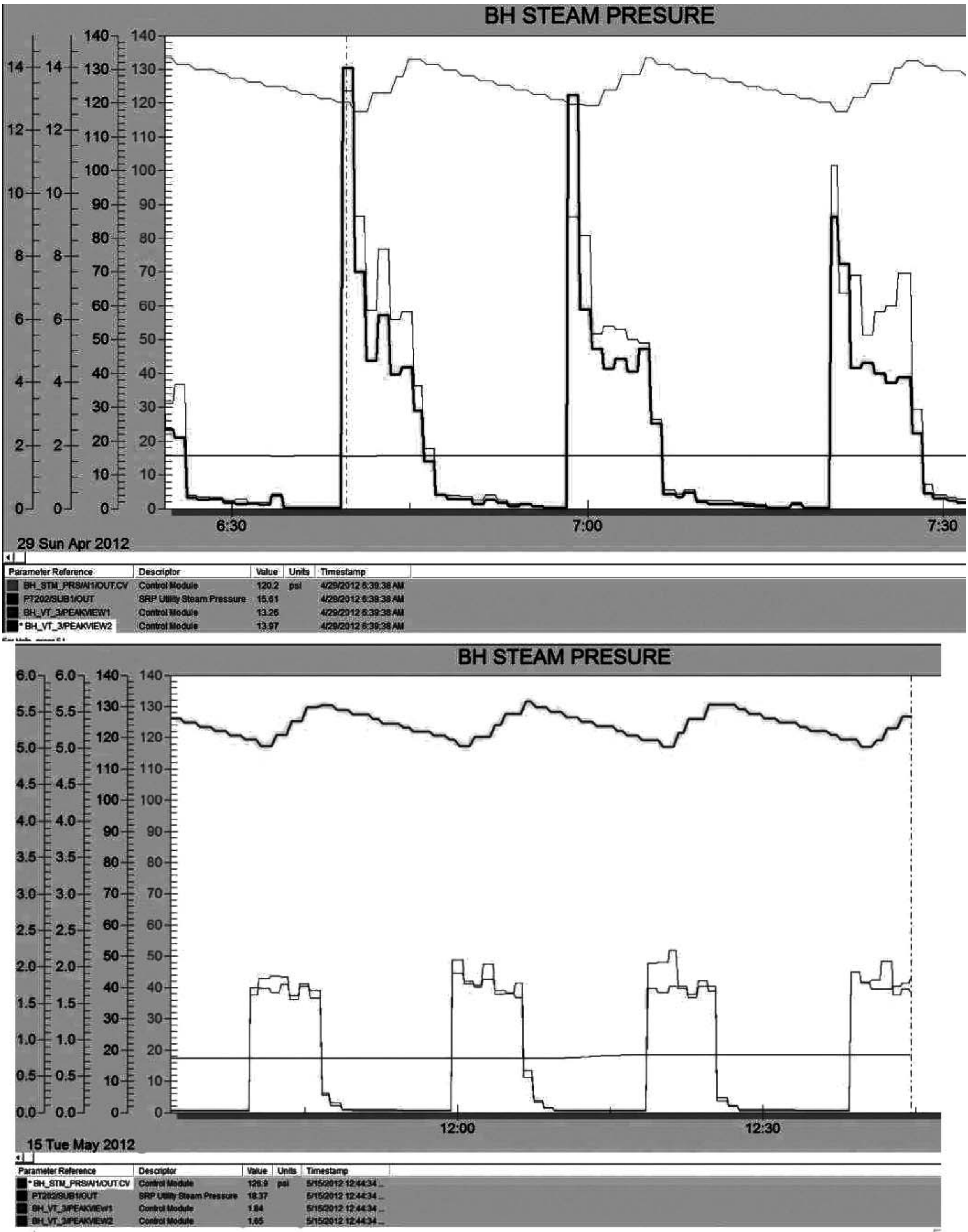

Fig. 9: The blower vibration history plots show that repairing the blower wheel reduced vibration levels from 4 to 14 g (top) down to 1.5 to 2 g (bottom)

Rough enclosures were used to protect the instruments from the harsh environment, and for burglary protection.

Typical measurement points include fan vibration, basin level, pressure and temperature on the water supply and return, and supply water pH. The wireless gateway data

Remote operations are not about watching trends. The system must automatically detect when something is not right and raise an alert that will instigate some action.

was integrated into the legacy DCS via Modbus, and a backhaul network with 802.11 Wi-Fi radios provided data integration via OPC communication to other host systems. The new automated monitoring infrastructure provides early detection of asset health degradation and allows time for repairs to be made before failure. Water costs can be better controlled, reducing the cost of chemicals as well as the cost associated with water supply and disposal. Fouling has been reduced and thus, efficiency increased, through tighter water chemistry management. Two out of three manual rounds have been eliminated, a reduction from almost 9000 hours per year to less than 3000. As this system continues to evolve, the plan is to reduce the manual rounds further to less than 1000 hours per year.

Future plans include integration with Emerson's AMS Asset Graphics solutions for process and asset data aggregation and analysis. This system will provide alerts associated with asset related faults as well as process related faults. For an in depth analysis of continuous vibration data, a CSI 6500 Machinery Health Monitor system will be installed. Wireless measurement data coupled with preconfigured solutions for data analysis will further increase the reliability and availability of the cooling towers.

Remote monitoring of pilot plant

The Separation Research Program at the J.J. Pickle Research Center at the University of Texas–Austin (Fig. 4) has been conducting research on capture and removal of carbon dioxide from power plant stack gas, a process that involves absorber columns, stripper columns and their associated heat exchanges, pumps and blowers. Since the loss of any of these assets would shut down the process, the center has installed a number of health monitoring sensors and software to help identify when an asset needs servicing.

The center installed wireless sensors on a number of these essential assets; the stripper bottoms pump and motor for example, with the sensors indicated by the red arrow in Fig. 5. Emerson's AMS Asset Graphics: Essential Asset Monitoring software provides the analysis, as shown in Fig. 6; the system monitors for cavitation, vibration, bearing temperature, strainer plugging, seal fluid leaks and hydrocarbon leaks.

The vibration sensors on the boiler blower have prevented some major problems. Fig. 7 shows the locations of the sensors. This particular blower supplies air to a package boiler that produces steam for the whole facility. The blower operates intermittently and historically experienced mechanical integrity issues that required it to be rebuilt at least twice since it was installed. Shortly after the monitoring system was installed, an alert was triggered when the vibration levels began to greatly exceed normal levels. Examination revealed a defect in the blower wheel (Fig. 8). The blower vibration history plots from AMS Suite show that repairing the blower wheel reduced vibration levels from a peak of 14 g (Fig. 9, top) to 2 g (bottom).

In order to ensure that alerts were not missed, a remote monitoring infrastructure was implemented. With this system, critical alerts are routed to trained personnel automatically. Whether it is a cavitating pump or a system health issue such as an overloaded PC or failed backup controller, alert information is routed to the right person right away so that action can be taken. Secure remote access was also set up so that subject matter experts could log in and help diagnose any issues and determine the proper corrective action. The remote monitoring system continues to evolve and additional features will be added, such as automated reporting on a periodic basis, and text or email alerts to maintenance or operations personnel.

Summary

Today's predictive maintenance systems have evolved a long way from the simple systems of the past. The combination of wireless monitoring, remote access to off-site experts and more sophisticated analysis software can and does save companies many thousands of dollars every year, both in maintenance costs and in uptime.