InTech

Embedded
motor condition monitoring, diagnostics

Embedded condition monitoring and remote diagnostics prevent equipment failure, reduce energy consumption, improve reliability

By Adam Krug

Only a very small percentage of critical motors and motor loads in the U.S. actually are equipped with any sort of condition monitoring. This lack of adoption largely stems from the costs and complexity of conventional condition monitoring equipment.

Industry-leading solid-state, motor control technology provides customers with the ability to monitor parameters, albeit not the exact same parameters, to gain a more precise and real-time perspective on performance, far more simply than traditional condition monitoring methods.

For the purposes and scope of this discussion, *condition monitoring* makes use of sophisticated technologies and tools to assess equipment condition, so as to predict potential equipment failure. Condition monitoring is a key element of predictive maintenance and enables scheduled maintenance. Fundamentally, it aims to prevent equipment failure and the spectrum of associated costs.

Imminent damages or failure is identified by a deviation from an established reference value. While condition monitoring does not directly predict failure, it identifies machinery or equipment that is failing or imperfect; equipment with latent problems is at

greater risk for failure. Further, it is typically more cost effective to address conditions that could cause failures, rather than cleaning up once a failure has occurred.

Employing new intelligent overload relays as a supplement to traditional condition monitoring provides customers with a cost-effective means to increase the percentage of assets covered by condition monitoring within a facility. This helps end users protect more equipment from a pending motor or load failure, on
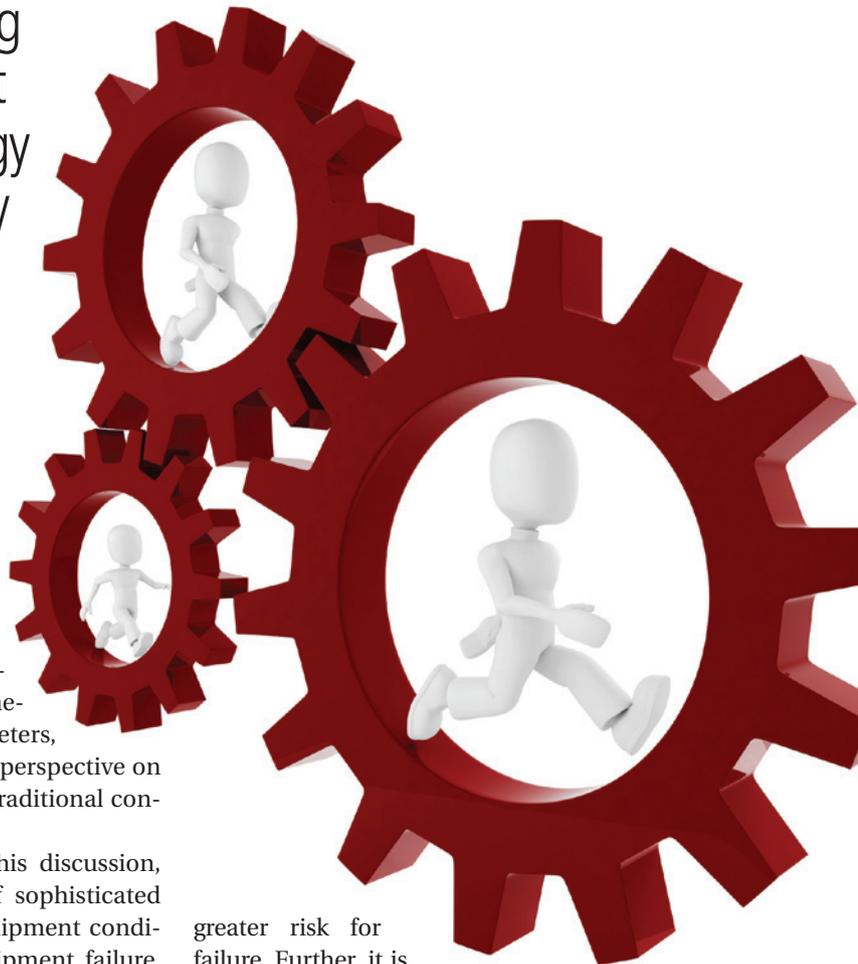
loads that otherwise would have been left unmonitored. Ultimately, this means:

- Improved uptime
- Reduced maintenance costs per repair
- Reduced energy consumption

Traditional approach

Condition monitoring typically includes the following technologies: Vibration sensors, pressure transducers, RTDs and other means of measuring temperature, infrared scopes, and other various sensors to record performance data.

Traditional implementation requires sensors to be mounted on motors and pumps and then hardwired back to a device to gather the data, such as a centralized computer system. This data then needs to be interpreted by trained personnel, who are able to understand the output from these sensors. Ultimately, traditional condition monitoring methods are complex and costly.

Typically, this data is gathered continuously and logged in a central computer, or it is taken by teams of inspection crews, who record performance readings on a set schedule. In most instances, inspection crews are trained specifically on signal processing and sensor analysis and typically outsourced to a third party. Whether facilities outsource these teams to third parties or have in-house personnel dedicated to spot inspections, there are significant costs and opportunity costs associated with such methods.

Moreover, motors and pumps are not all conveniently located; many are in hard-to-access areas and can require more than one inspector to comply with OSHA regulations. When trained professionals perform their analysis from a remote location, the data is required to be streamed and passed through an IT firewall or transmitted via an outside modem.

All of that said, the traditional approach to condition monitoring can be largely effective. But, due to the costs and complexity involved, this type of attention is typically reserved for only the most critical and expensive capital equipment. Most users calculate the value of the asset as the capital costs of replacement, as well as the effect that asset has on productivity and throughput.

The lack of implementation of traditional condition monitoring despite its value is evident in a U.S. Department of Energy (DOE) study on motor monitoring practices. According to a recent study on critical loads, the U.S. manufacturing sector has nearly 32M motors rated 500 horsepower (HP) or less. Of the 141,000 critical motors driving pumps, fans, and compressors, only 1% has monitoring today; these are typically motors rated at 200HP or more. In other words, there are a high percentage of critical loads at low horsepower where condition monitoring is not being used. The result is unscheduled

downtime or inefficient operation of equipment, which translate into:

- Reduced throughput
- Environmental fines
- Energy waste
- Higher maintenance costs
- Increased capital expenditure
- Reduced profitability

Notably, downtime costs, maintenance costs, and energy usage are critical concerns for end-users, according to an Eaton Survey. Further, according to a similar study by the DOE, there is the potential for tremendous cost avoidance; if users added monitoring to their motors and pumps, they could recognize an aggregate, annual $23 billion of energy cost avoidance.

A means for greater asset coverage

Increased adoption of advanced motor overload relays and fieldbus communi-
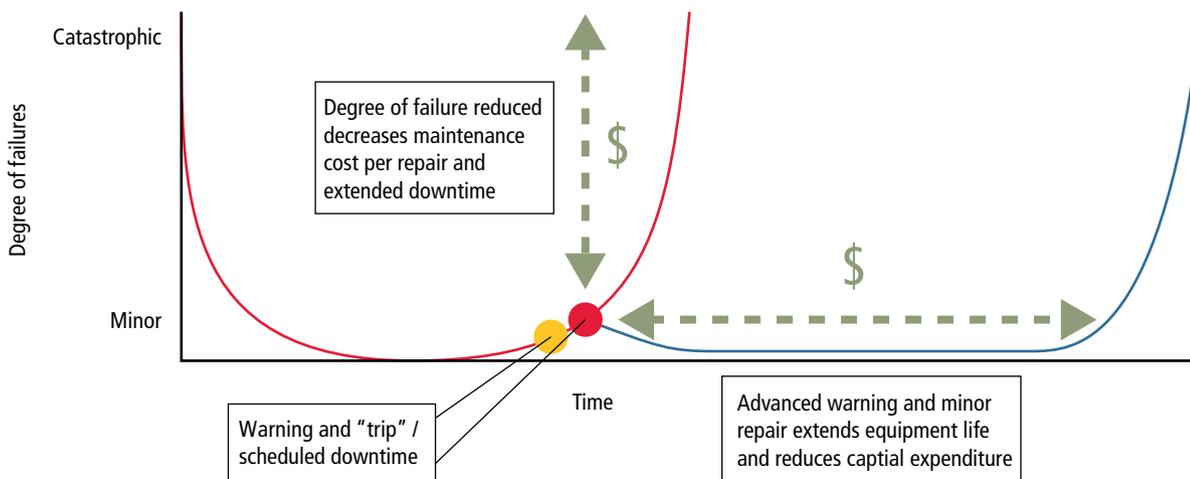
The spectrum of ways condition monitoring adds value.

cations is game changing; it allows for greater system reliability and tremendous potential for cost and energy savings. The starter-based technology is "sensorless" and nonintrusive. Further, a starter is necessary with every motor installation. Simply put, advanced overload and monitoring relays provide a cost-effective solution, with greater motor coverage for condition monitoring. They yield performance data and energy usage information that can be monitored and acted upon either by personnel or control schemes within the higher level plant systems.

Maintenance optimization

With intelligent pump, motor, and line quality monitoring, customers are able to eliminate unnecessary inspections and only send personnel when data indicates an issue. With an understanding of the fault type or pending fault type, the right person with the appropriate skill set can be deployed to address specific issues. In other words, if a clog is detected, a 40-year veteran need not be sent to address the issue at hand; send individuals with appropriate experience and expertise to address defined issues. Additionally, an understanding of fault type enables personnel to come equipped with the appropriate tools; costly second trips are avoided, and service time is reduced. Simply put, optimized maintenance means:

- Scheduled downtime
- Eliminate unnecessary inspections
- Optimized labor skill sets
- Reduced service time

Armed with a remote look at the performance of their motors, customers are able to optimize maintenance and reduce costs. Motor or pump operation can be checked from any computer in a plant or facility, and even from home. Trending data collection allows for the detection or prediction of potential motor failure conditions. Further, when conditions are indicative of an imminent failure, customers are able to switch to spare or secondary motors or pumps and avoid downtime.

Low power conditions

Though much of the discussion to this point has been regarding the advanced overload relays' ability to provide remote data monitoring, the goal of this data is to prevent failure of an asset. Overload relays can act on their own data with a high degree of flexible protection settings. One such setting not widely associated with overload relays is low power protection.

Low power conditions, where real power provided to the motor falls below normal operating conditions, can cause mechanical failure and/or excessive heating by running a pump in deadheaded or starved condition—damaging expensive seals and ultimately failing the pump. New overload relays are able to detect low power conditions with protective fault settings and avoid associated costs and downtime.

For example, an under power situation occurs when a pump continues to run against a mostly closed valve—overload relays can extend equipment life, reduce downtime, save energy, and reduce maintenance. Without the use of an advanced overload relay, the pump would continue to run because a float limit switch would not drop—as the water level would not decrease. A second pump would likely be turned on to compensate. And so, two pumps would be running and performing the work of one pump, essentially. In the meantime, the seal of the first pump would be heat-aging, shortening its usable life. Today, such a situation can be monitored, detected, and avoided. Wasted run-time hours can be avoided, with the protective-fault, under power feature. The overload relay would take the first motor offline, and the second pump would come online and complete the pumping activity—the first pump would be saved from doing non-value add work. Further, the wear on components would be reduced; the overload relay would have taken the first pump offline, preventing the heat-aging of the seal. Energy consumption would be reduced, as only one motor would be running (instead of two). Maintenance is reduced by avoiding the unnecessary use of equipment.

Driving, delivering energy savings

In the U.S., motors use approximately 71% of the electrical energy in a typical industrial facility. The large population of motors in the 20 to 300HP range are consuming the majority of the energy. Little monitoring (less than 1%) is done on low horsepower motors.

Advanced overload relay advantages

- No large investment need apply
- Achieve 100% motor coverage
- Continuous data
- Non-invasive and no firewall issues
- Data for action locally or on the system level
- Optimize labor practices—targeted inspections

As every motor needs an overload relay anyway, today's overload relays with advanced monitoring do not necessitate a burdensome capital expenditure. New overload relays provide continuous data on all motors, versus spot-checked data taken by inspection teams on only the most critical. Further, they reside in motor control centers, and they are able to communicate on standard industrial protocols and tie into SCADA, PLC, and DCS systems. There are no firewalls to penetrate, as data does not require interpretation. Control circuits and registers allow for data to drive action locally or at the system level.

With the data provided by today's relays, maintenance teams can be scheduled when changes are detected and before downtime occurs, allowing for optimized use of personnel time. Armed with real-time, remote, continuous information, customers are able to find the needle in the haystack—or spot a potential issue before it causes downtime or energy waste. Armed with real-time information at the motor or motor-driven load, spot checks can be transformed into targeted maintenance for real or detected variations.

Motor system energy use (GWh/Yr)
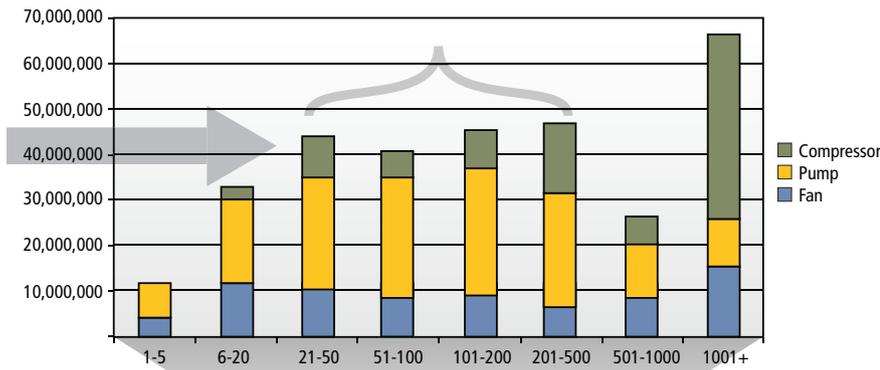
Motor system
energy use

Overload relays able to monitor energy and power factor are able to:

- Avoid peak demand charges
- Shed non-vital loads
- Identify and rectify increased consumption
- Identify discrepancy between equal loads
- Identify power factor line items

Overload relays with advanced monitoring and flexible communications capabilities allow customers to observe abnormal and inefficient operation in real time. For across-the-line loads, today's overload relays are able to do more than protect the motor. They allow customers to see consumption at the specific load and facilitate real-time equipment monitoring. Using industry protocol communications and central SCADA systems, customers can catch increased consumption in real time and control consumption and avoid downtime; situations can be rectified before extra energy costs are incurred. Commands over the fieldbus allow remote shutdown of non-vital assets, while side-by-side com-

parisons of similarly sized assets and comparisons made over time enable the identification of inefficiencies.

As many plants must run continuously, it is critical to be able to prevent equipment failure and scheduled downtime to address detected problems. Continuously monitoring key failure indicators with remote monitoring solutions helps facilities respond to equipment problems sooner. The early detection of system degradation—through condition monitoring and predictive diagnostics—is critical to productivity and the bottom line. To gain greater asset coverage, overload relays with advanced remote monitoring capabilities can supplement traditional condition monitoring methods—and yield significant energy and cost savings, while improving system reliability and reducing maintenance.

To meet new energy efficiency standards, many facilities will need to adopt and implement new and existing technologies, including VFDs, advanced overload relays with on-board electronic metering and monitoring, and asset man-

agement products to help make informed decisions that can improve operational efficiency. To propel energy efficiency, it is critical to provide support, education, and training for plant operators, engineers, and production workers.

Consequently, the increased demand for remote monitoring, advanced control methods, condition monitoring, and predictive diagnostics is not surprising. Customers are increasingly seeking devices that save energy, optimize their maintenance schedules, and provide greater system protection to reduce overall costs and downtime. Remote monitoring devices allow customers to monitor conditions in hard-to-access areas, trend in real-time motor conditions that could otherwise go unnoticed, and dispatch maintenance personnel before a problem occurs. Motor control system design focuses on power optimization and extended equipment life. Remote monitoring of asset conditions allows for optimal and timely predictive maintenance actions to prevent equipment failure and inefficient operation.

ABOUT THE AUTHOR

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