Predictive Motor Maintenance (PdM): Use it or Lose It (Money)

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Photo courtesy of Integrated Power Services

Regardless of where you do business, when discussing, analyzing or worrying about "The Economy" these days, you're not thinking Main Street—you're thinking global. With that stipulation, it is also accepted wisdom that quality products and sharp pencils are not enough to be and remain competitive. Accordingly, everyone is looking for an edge, an advantage, in order to beat back—or at least keep up with—the competition.

One area that can help in that regard is predictive motor maintenance (PdM). Granted, it's not the most exciting of manufacturing endeavors, but ignore doing it at your own peril. Aside from the green results realized, robust PdM ensures that your operation is running on all cylinders and at the same time saving significant energy dollars. One can also think of PdM as a quality assurance hedge—i.e., you could be manufacturing the re-invented wheel on your shop floor, but if the motors used in their production are not up to par, you can count on downtime that you'll never get back, as well as the occasional product defects that result from faulty motor operation.

Call it "best practices" if you like, but common sense seems even more appropriate. Consider: On one hand your product or products are selling well. New orders and new customers? Indeed, yes. But then get a gander at your bottom-line production costs and suddenly things don't look so rosy.

For the unconverted, the U.S. Department of Energy/Energy Efficiency and Renewable Energy reports that "Motor-driven equipment—such as pumps, air compressors, and fans—consumes about 16 percent of all the energy used in U.S. industrial applications. Industry as a whole consumes more than 700 billion kWh and spends more than $30 billion annually for electricity dedicated to motor-driven systems."

Not exactly chump change. The report continues: "Plants can begin reducing this energy usage and cost by selecting motor-driven equipment with the highest possible energy efficiency, and implementing effective system management practices."

And of special interest to the manufacturing big-boys—and U.S. taxpayers—"The D.O.E.'s Industrial Technologies Program (ITP) works with the nation's most energy-intensive plants to uncover opportunities for reducing energy use and costs while maintaining—or increasing—productivity. ITP resources can also help industrial plants reduce maintenance costs, improve the reliability and efficiency of their motor-driven systems, and minimize unscheduled downtime." Perhaps we can all agree that the program is a positive example of our tax dollars at work.

The G also has *free software* available; e.g., *MotorMaster+* and *MotorMaster+ International* are capable of assisting plant managers in maintaining and managing their motor-intensive production lines for greater energy efficiency. According to a non-D.O.E. report cited by the department, the two packages "have already helped industry save more than $2.4 million and 50,700 MWh annually."

So what are you waiting for? Perhaps our discussion with some motor mentors will convince you that, for optimum plant efficiency, conducting rigorous PdM is a significant step in that direction.

But first, some perspective: Is PdM an important consideration for manufacturers?

"Unfortunately, no," says Dr. Howard Penrose, vice president of Glen Ellyn, Ill.-based Dreisilker Electric Motors, Inc. "Over 60 percent of manufacturing/industrial facilities perform *reactive* maintenance, sometimes even if they have the technology and the ability to perform PdM inspections. There is a greater recognition of the importance of PdM, but the effort necessary to implement and sustain depends on the will of the company, managers and personnel."

That response begs the question: Is conducting PdM difficult? Are special skills required?

The short answers, provided by Covington, are "Very" and "Yes."

Expanding on the topic, Penrose explains that "PdM programs are as complex or simple as required by the application. For instance, a non-critical DC motor may only require periodic inspections of the brush height and tension and insulation testing. The program may or may not include vibration analysis if it is determined to be cost-effective. On the other hand, motor circuit analysis, electrical signature analysis, PD (partial discharge) testing, vibration analysis, laser alignment checks, infrared analysis, oil/grease analysis, and additional, advanced testing may be required on more critical machines. It is important, however, to select PdM practices that meet both the needs of the application and the ability to support them."

Their answers anticipate the next question: Can one assume (as did this reporter) that PdM is all about the software."

While "Software is used to support the method of analysis (vibration analysis, MCE [motor carrier evaluation], etc.)," according to John Covington, senior vice president of marketing for South Carolina-based IPS (Integrated Power Services). Penrose adds that "The idea behind 'predictive maintenance' is a series of tests and inspections to identify trends in the condition of equipment. The result is the ability to estimate remaining life once a fault is detected. Software can assist with the process, but is not the backbone of a PdM program."

Another software-related issue relates to various vendor packages' adaptability to different motor-driven environments. Just how application-specific is it?

"Most applications are configured based on the equipment or process they are measuring," Covington says. "A motor is motor, a fan is a fan, in any industry." Penrose adds that "there are software packages from overall trending systems to individual programs for specific PdM test equipment."

With software just a cog in the PdM process, Penrose says that "The key to PdM programs is the correct selection of tools and inspections to detect the potential problems that you may have with a machine. This selection can be made using manufacturer recommendations, equipment history or tools such as the reliability-centered maintenance (RCM) process."

Touching briefly on another aspect of PdM field testing: dangerous?

"Limited—if proper PPE (personal protective equipment) and safety precautions are observed," says Covington.

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"Field testing electric motors requires the technician to be aware of electrical shock and arc flash hazards, as well as potential energy and rotating component dangers," Penrose says. "However, most of the test equipment manufacturers have developed safety plugs, which a technician can plug their equipment into without having to open a cabinet."

As with other industries, standards abound for the motor industry, including PdM. Published by the IEEE (Institute of Electrical and Electronics Engineers), are they stringent?

"Absolutely; anyone that says they aren't don't doesn't understand the industry," Covington states.

"The only teeth that a standard has is that it demonstrates consensus that a particular method or action is 'standard' within the industry," Penrose points out.

"It does, however, require an understanding of the standards in question. For instance, many think that the insulation standard is 1MegOhm plus 1 MegOhm-per-kilo-volt rating of an electric motor. However, not only is this not correct in modern motors, but the purpose of this value is to determine if the insulation system is in a condition to be subjected to higher stress electrical tests, not whether the insulation system is satisfactory for operation. There are no 'standards' police to ensure that a standard is followed, other than safety, environmental, manufacturing and certification standards."

Revisiting for a moment the foot-dragging by some U.S. manufacturers relative to PdM—is it about older-technology, "old warhorse" motors vs. new-technology efficiencies?

"Actually, no," says Penrose. "There is a misunderstanding that goes back many years where incorrect information got out that energy efficient motors were less reliable and more sensitive to electrical systems than standard motors. This was, in fact, due to a study on a non-energy-efficient electric motor that had a marketing stamp on it. Instead, energy and premium efficient motors are found to have better engineering, higher quality materials and greater reliability than standard-efficient electric motors."

And then there is the "size matters" issue with PdM. Or does it?

"Yes," says Covington. "They have different operational complexities based on size."

"The scope of work to maintain a larger motor may be significantly greater than a smaller electric motor," Penrose points out. "For instance, comparing a 100 hp, 3-phase, 460-volt motor to a 5,000 hp, 3-phase, 4,160-volt motor can be very different. If the 100 hp is a totally enclosed, fan-cooled motor, the maintenance department may grease the bearings on a schedule, perform vibration analysis and maybe insulation resistance or motor circuit analysis testing. On the other hand, if the 5,000 hp is a WPII (*weather-protected; the WPII motor is defined by NEMA MG1–1.25.8.2*) enclosure, inspections may also include winding temperature by RTD (resistance temperature detector), continuous monitoring of vibration, checking and cleaning filters, oil analysis, bearing RTD monitoring, etc."

Electric motor testing is divided into two segments—static testing and dynamic testing.

What's the difference?

Penrose explains that "Static testing relates to tests performed while an electric motor is turned off (locked and tagged out). The purpose of this type of testing, when referring to motor circuit analysis, is to be able to detect insulation failure/degradation. The types of testing and detection of insulation faults cannot be performed, at this time, while a machine is energized. Dynamic testing evaluates the condition of the power, air gap, rotor, bearings and any components that may be loose or misaligned."

"Static (testing) is offline, or stationary," says Covington, and it "typically involves more electrical testing. Dynamic is running and tends to be more mechanical."

And speaking of testing, does PdM for AC motors differ markedly from DC versions?

"Yes, (in that it's) rotor vs. armature; stator vs. main poles and inner poles," says Covington.

"While there are some similarities such as with vibration analysis for bearings, the brushes, armature and commutator—as well as the power supply—for a DC machine add complexity to a program," says Penrose. "One of the reasons for the popularity of AC over DC motors is that the AC motor is less complex and easier to manage and maintain. The DC motor has brushes, brush holders, carbon dust, contact surfaces, additional wiring, field and interpole coils that generate significant heat, etc. The program may include such PdM inspections as checking the brushes and commutator."

Any discussion of PdM should include some attention to a close cousin of PdM—condition-based monitoring (maintenance) (CBM). While the latter is grist for another time, we asked where it might fit—if at all—in the PdM universe.

"Condition-based is the extension of PdM, with service requirements established based on pre-determined, alarm-level status limits," says Covington.

Penrose adds that "The concept behind condition-based maintenance is the recognition that standard maintenance practices will actually cause equipment failure. CBM involves performing maintenance tasks based upon condition inspections and/or testing of the machine. The end result is normally a significant cost savings and increased availability of equipment, with the cost savings being an average of three-to-four times that of a reactive maintenance program. Reactive programs: generate a significant level of unpredictability of production; cause MRO stores to increase; result in the need to increase inventory; and inflict unnecessary stress on company employees."

What follows is some necessarily brief attention to several PdM-related issues that readers may be unfamiliar with.

Voltage imbalance—big problem?

"Not too often," Covington believes, but it does "create current unbalance and excessive heat in three-phase induction equipment."

With a different take, Penrose believes that "Voltage unbalance is still a relatively prevalent problem. The optimal unbalance is less than 2 percent from the average voltage in order to maintain efficiency. Past that point—up to the maximum of 5 percent unbalance—the motor must be de-rated due to heating caused by circulating currents. Most of the time, the unbalance is caused by unequal loading of single-phase systems on transformers. (But) some of the time, it can be caused by loose connections. The proper method of correcting the unbalance is by first identifying it and then correcting the problem, such as balancing single phase loads."

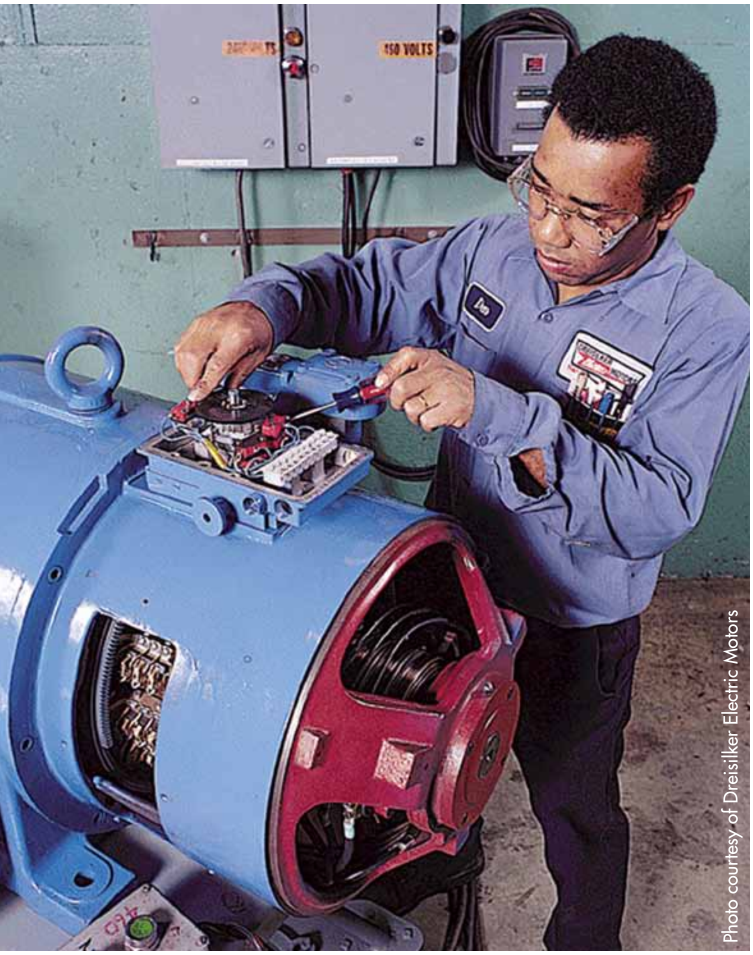
Photo courtesy of Dreisilker Electric Motors

Infrared thermography—a common method of motor testing?

"Some companies will use infrared for electric motor testing," Penrose says. "It can accurately determine ball bearing temperatures at the bearing housing, detect unusual hot spots and some level of misalignment, and other issues visually. It's most powerful application in relation to electric motors, however, is the inspection of connections and disconnects inside electrical panels."

Dynamic motor analysis.

"Online electrical signature analysis (ESA)—sometimes referred to as motor current signature analysis (MCSA)—has been available since the early 1980s. This technology can detect most power supply, electric motor and some bearing issues, (as well as) load-related problems through a reading from the motor control center or disconnect. Instead of going out to each motor in a plant, the ESA technician can get virtually all of the readings in a fraction of the time from the motor control center."

We close with responses from Penrose and Covington to the question, What's "hot" in today's PdM world?

Covington: "The cost of differed maintenance based on not responding to a predictive indicator of some type is an emerging issue."

Penrose: "The biggest issue that seems to exist related to PdM is follow-through by decision-makers on findings related to the program. This mystery often relates to providing urgency in a language that the decision-maker can understand. For instance, when performing PdM and a fault is detected, if you state that a bearing is going to fail in 30 days, it had better fail on day 30—not 29 nor 31. The reason is that most people do not understand that PdM findings are *estimations* based upon *experience*.

"In other cases, the PdM program may be used to determine the risk-of-failure of a machine and no action may be performed other than planning for equipment failure. If this is not communicated to the PdM techs, frustration results."

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