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Healthy Machines

Mark T. Hoske -- 3/1/2006

'Excuse me, I'm not feeling well: slowing here, running hot there. A few non-critical errors are cropping up, and my cutting edge is getting dull. Don't push me past 93% capacity, if you're relying on me. At 85% though, I guarantee I can last another week before I call in sick. May I please e-mail the doctor now with a list of my needs?'

Few human assets provide that kind of information. Yet, if you're not getting that level of predictive intelligence—and more—from your machines, you're wasting time and money on scheduled maintenance and unplanned outages—and you don't have what you need to optimize production. You're bidding on jobs based on your best guess of current production costs and may not discover actual production cost until you're so committed that prospects for recovery are dim.

Better, simpler designs, more sensors, diagnostics, communications, and software predictive analysis tools and related training ensure machine health, safety, and productivity of machine operators and the connected supply chain.

Sensing machinery health

Various types of measurement technologies used in or with machines can proactively predict needed maintenance or repair, suggests Deane Horn, product manager for online machinery health, Emerson Process Management, asset optimization division. 'Some machines were designed wrong, some machines are installed wrong, and some machines are used wrong; 40-50% of machine anomalies are process induced (used wrong). What does this mean? Machines are failing because operations staff doesn't realize the impact that they have on machine health. Process procedures could be changed to avoid 40-50% of machine failures.'

Horn says:

- Portable walk-around vibration data collectors for essential machines provide advanced troubleshooting;
- Permanently installed monitors track the plant's most critical assets. The most critical machines can be defined as those that drop production by 50% or more when they're suddenly down;
- Sonic scans find money leaks, such as steam traps, and confirm problems, such as low bearing grease;
- Oil analysis confirms problems and determines root causes, such as bearing problems due to bad oil filtration or water in the oil, or verifies bearing problems by finding metal particles in the oil;
- Infrared instruments non-intrusively find hot spots inside a motor, while it is running, and hot fuses or bus bars; and
- Process control monitors temperatures and pressures, which don't actually give machine health diagnosis, but can give symptoms, to be assembled for diagnosis.

Data in context is information; 'Integrating process control with vibration monitoring is the complete picture of machine health,' Horn says.

Hello? Can you hear me?

Networked interfaces—wired or wireless—enable proactive communications with operators, maintenance staff, material suppliers, and original equipment manufacturers. OEMs, with customer permission, can communicate with the machines, gathering information to ensure optimal performance, help facilitate repairs, and improve future designs.

PPL Susquehanna LLC had remote Internet-based troubleshooting help from Berkeley Process Control for automated welding equipment processing canisters of spent nuclear fuel. A service contract for the Berkeley Automated Welding System provided remote real-time connectivity—through an enabled TS-5112 touchscreen and secure Internet connection—to show the user interface and process parameters.

Berkeley engineers could remotely view and actuate machine motion, change and view parameters, and navigate and run through diagnostics with PPL staff, faster than phone-based troubleshooting. An intermittent connection at an I/O terminal block was identified as the problem source, saving at least two days compared to dispatching a technician, the company says.

Proactive services

Such machine-to-machine efforts (M2M) are among 'main technologies being applied today to help companies move from a reactive- to a proactive-service model,' says Peter Fowler, a vice president for Siemens wireless modules. M2M technology allows manufacturers to remotely connect to and monitor the machines they are contracted to service, Fowler says, increasing visibility into equipment performance and real-time notification of needed maintenance services before the machines go down.

'One major challenge in industry today is that the company responsible for outsourced maintenance is often not at the plant, but rather is dispatching and doing remote maintenance for several different customers,' complicating connections.

Cellular wireless technologies such as 'Siemens Mobile, through its partnership with nPhase, allows product manufacturers and the companies that service equipment to run their businesses

proactively versus reactively. They can intelligently dispatch technicians where and when appropriate, reducing service calls and overall costs while improving service and customer satisfaction.'

Timely actions from data

Fowler says most machines access a significant amount of sensor data about vibration, temperature, oil pressure, etc. via a controller, often exposed through serial interfaces in traditional industrial protocols like Modbus. 'The challenge is getting this information back to an enterprise platform where it can be evaluated and acted upon.

'Most factories are locally networked; there's a need to expand connectivity to companies responsible for maintaining and servicing the equipment,' says Fowler; 'such methods are far more productive in achieving the result—greater efficiency at reasonable cost.'

Adoption of new PdM technologies is poised to explode as monitoring systems are integrated with a machine's control system, says Chris DeFilippo, sound and vibration product manager, National Instruments. 'Programmable automation controllers (PACs) are increasingly deployed in intelligent maintenance systems,' he suggests, since they already include diagnostics with control.

PACs add flexibility to predictive maintenance, since a PAC user isn't constrained by a particular dedicated system's capabilities and can choose a list of appropriate variables to measure: vibration, thermal imaging, ultrasonics, power quality, and other parameters, DeFilippo suggests. At a local decentralized level, a PAC has the processing capabilities to perform advanced analysis, such as spectral analysis, multiple order tracking, level measurement, and alarm triggering, he says.

Criteria to decide

A machine failure seems to be a catalyst for online monitoring adoption, says Emerson's Horn. When a protection system misses a shutdown, or an unmonitored machine destroys itself, then management will fast track online, predictive vibration monitoring.

Why wait? To implement online monitoring, Horn suggests, begin by looking at best practices, existing process knowledge, and a little theory:

- Start by reviewing each asset, ranking its criticality. This will determine how thoroughly you need to monitor a machine—online or portable technology, or if you should just let it run to failure. Will this machine stop production? Could it be a safety issue? How easy is it to get spare parts? Are there environmental concerns?
- Next, what is the asset type? Is it high speed, what are the failure modes, what is the machine's history of failure? This will help in assessing the technology needed to diagnose failure modes (vibration, sonic, infrared, oil analysis, temperature, and pressure).
- Next, look at other machines in the area, those connected in a train, foundations, piping, operating modes, product type, changing process states. All these parameters and conditions should be correlated with the predictive analysis technologies for the complete picture.

Some monitored information is well understood with documented benefits, Horn adds, but correlating process conditions with measurements will show a previously unseen problem and enable a path of continual improvement.

What's it worth?

Because of considerable paybacks of predictive maintenance technologies and processes, they are driving a shift in maintenance approaches, explain Vishnu Raman, CEO, and Daniel Konstantinovsky, marketing analyst, Veits Group. Machine maintenance has progressed over the last three decades from being mostly reactive/failure maintenance (RM) to preventive maintenance (PM) to predictive maintenance (PdM).

PdM paybacks/benefits vary by industry and by company, say Raman and Konstantinovsky; it has been a big challenge to readily quantify the benefits from this program. Generally PdM program cost savings is bigger compared to a PM or RM program. Studies by Emerson Process Management, Raman and Konstantinovsky say, indicate that if PdM's cost multiple is 1x, then PM equals 5x, and reactive maintenance could exceed 15x. Cost savings can come from avoiding downtime as well.

On average, unplanned downtime cost of a typical process industry 'can represent 1-3% of revenues and 30-40% of profits annually; for large capital equipment, costs may be 1-3% of asset value per year,' says SmartSignal's John Kerastas, as cited by Raman and Konstantinovsky. Another payback source is avoidance of unnecessary preventive maintenance and the associated costs of materials, labor, and overhead, they say, reducing maintenance inventory and associated carrying costs, which can be 25% of inventory value.

Independent surveys indicate the following industrial average savings resulted from initiation of a functional PdM program:

- Return on investment: 10x;
- Reduce maintenance costs: 25-30%;
- Eliminate breakdowns: 70-75%;
- Reduce downtime: 35-45%; and
- Increase production: 20-25%.

Raman and Konstantinovsky add that cost savings can be much higher since there is significant benefit from reduction/elimination in secondary equipment damage from a PdM program. PdM reduces unnecessary maintenance. Labor costs can also be reduced due to fewer work orders for maintenance, they say. Insurance premiums can also be reduced with PdM programs. PdM can also be viewed as a safety initiative by shop labor, increasing worker morale positively impacting production, quality, tardiness and such. According to Raman and Konstantinovsky, these contribute 10-30% additional savings.

Good medicine: machine health products

Perhaps thousands of products contribute to or monitor machine health, to help avoid the bitter pill of breakdowns. A few examples follow.

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For system integrators with appropriate expertise, go to www.controleng.com/integrators.

Built-in maintenance triggers

ABB's standard drive for a host of industrial applications, the ACS550 series, features ac built-in maintenance triggers, which makes drive and driven-equipment care easier than before, the

company says; the triggers help users schedule maintenance of the drive and its associated equipment in stand-alone applications. The 'Maintenance Assistant' feature can prompt users to perform a task within specific monitored intervals by monitoring energy consumption, running hours, or motor revolutions. Users can set limits so the drive annunciates when these limits are reached, flagging when the drive, motor, or driven equipment should receive preventive maintenance, previously handled by separate software or PdM system. It's easy-to-set-up operator interface can be navigated as simply as a mobile phone. Detachable, multi-lingual alphanumeric control panel features two soft keys, the function of which is shown on the easy-to-read display. Automatic energy optimization software is available via the operator interface.

Controller and tool kit monitor calibration

Berkeley Process Control's BX controller and Semiconductor Toolkit software provide built-in utilities to recognize component health problems before critical failures occur, while devices are still within the tools. That functionality provides the ability to monitor calibration points, wafer mapping system, and mechanical integrity of a wafer handling system.

Mined information yields predictive analytics

Macsea, a provider of diagnostic and predictive CBM software, offers Predictive Analytics to improve operating efficiencies and reduce manufacturing costs. This data mining predicts future probabilities and trends in Macsea Dexter software to automate the process of monitoring, diagnosing, and predicting machinery health for any equipment. Data management and analysis occur continuously, alerting operators when problems are detected, at that point or predicted in the future, to reduce maintenance costs and breakdowns. The software allows organizations to streamline operations by analyzing in real-time, how a specific piece of equipment is performing and predicting future trends and performance. This gives managers the ability to fine-tune plant operations at every stage. To create an accurate predictive model, Dexter continuously collects data and builds a statistical model. Predictions are made with their related probability of occurrence. To increase precision and validity, the model is constantly revised with additional data. The Macsea site offers a free demo.

Vibration, temperature, speed, motor flux

Emerson Process Management's CSI 9210 Machinery Health Transmitter can analyze sensor data for vibration, temperature, speed, and motor-flux data to determine machine health. It's been designed to assess the health of motor-pump machine trains. Data are analyzed inside the device and only results are published to the control system. CSI 9210 uses FOUNDATION fieldbus (FF) communications protocol, making information available to an FF-compliant host system. It produces two main analysis results, machinery health values, and machinery alerts, with an onboard process system that evaluates the data to determine what problems may be developing in the machine train by comparing other process values associated with the pump system, like pressure, temperature, and flow rate.

Transmitter monitors vibration measurements

Wilcoxon Research, a supplier of quality vibration sensors and sensor networks, expanded its 4-20 mA loop-powered vibration transmitters, the Wilcoxon Intelligent Transmitter (iT) Series, to allow customers to select from a full line of features at the time of order, including displacement measurements, and true peak and peak-to-peak detection. Options for the iT Transmitter, signal-conditioning modules that make online vibration monitoring available for less, now include four outputs of RMS, peak, true peak, and true peak-to-peak; measurement of acceleration, velocity or displacement; and a selectable full scale that can be specified in standard or metric units.