Future of Condition Monitoring, Computerized Maintenance and Plant Reliability & Maintenance

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The purpose of this essay is to show how future developments in electronics, analysis and network communications will come together in the future to affect condition monitoring, plant reliability and maintenance.

Chris Staller of ICM Technologies, Inc., presented a very credible view of the past and the near term future for condition monitoring in Chapter XIV of the Handbook for Operating Equipment Asset Management published by Penn State Applied Research Laboratory on the internet in early 2000. He points out that condition monitoring systems often were the first electronic systems installed in power generating, manufacturing and continuous process plants. These have become more available as cost and size have decreased and communications links, such as are available through the internet, have improved.

The problem impeding near term progress that Chris sees now is lack of vision in bringing together (integrating) condition monitoring (CM) technologies, control (process variables), maintenance and enterprise systems. Presently, on-line systems are centralized and very complex. He contends that when CM technologies take the form of distributed modules that are smart enough to accommodate the complexity of CM/PdM data (e.g, vibration, lube oil condition, motor current analysis) that real breakthroughs can be achieved. In his view, collection of data using portable data collectors and walking routes will be limited to only a few (most trouble prone) machines. I would add that new failure modes in machines can be managed by smart systems only when people can characterize them and add this intelligence to the knowledge base of key indicators. Root cause analysis (RCA) and failure modes and effects analysis (FMEA) will become tools of machinery asset managers and maintenance personnel as surely as wrenches and screw drivers are today.

Machinery condition will also be linked to product quality directly in more and more manufacturing processes. Leaders in this area may be found in the steel industry. At Dofasco Inc., in Ontario, Canada, condition monitoring of the descale system is used to assure surface quality as slabs are turned into long thin strips in a hot rolling mill. At LTV Steel in Ohio, USA, condition monitoring is used to detect incipient “chatter” affecting the surface quality of cold rolled strips. Both sites won reliability achievement awards from the Association of Iron & Steel Engineers within the past 2 years for their efforts.

The chapter referenced above on future developments predicts that “smart” conditioners and sensors will be emerge that share a common interface standard, such as that being developed under sponsorship of the Machinery Information Management Open Systems Alliance (MIMOSA). Each “smart” sensor will have its own unique record (e.g., the Transducer Electronic Data Sheet - TEDS, residing in a Smart Transducer Interface Module – STIM, that can be accessed via a network node). They will be calibrated in place, when required. When combined into networks, these distributed intelligent sensors and conditioners will be able to provide condition indication to operators and information to management so support systems can be triggered to act in a timely fashion. Staller point out that in this way condition indication will become as valuable as process variables are today, integrated into the business model for operations and financial decisions.

Concurrent with or slightly ahead of the likely developments forecast by Chris Staller will be a rapid increase in capacity and simplification of data transmission and communications switching technology. At the present time, a network used to ferry data such as process variable or condition monitoring information relies (depending on size of the network and number of nodes) upon thousands to millions of switches for proper routing. If the “pipe” carrying the data is made of copper, electrical or electronic “switches” are used. For glass fibers or (light) paths through open space, optical switches at nodes perform the routing function(s) even better. This is because you can manage with fewer of them due to their ability to filter and handle all bit rates or protocols the same way (eliminating separate ports for different bit streams).

Switches have been one of the keys to cost reduction in communications. Without them you would have to have separate transmission paths (wires or fibers) between each place you wanted data to originate from and travel to. Further economies for data transmission and number of required switches and transmission paths in a network can be obtained by using different parts of the frequency spectrum for different types of information. Time Division Multiplexing (TDM – used in radio frequency transmission of CM data) has also been used to reduce the number of paths and/or switches. All of these methods run up against some natural limits (e.g., bandwidth, time, power required, cost).

This is about to change and in dramatic fashion due to a development called Wave Division Multiplexing (WDM) using the approach developed under direction of Simon Cao of Avanex. Rather than using switches for connectivity the photons of light carrying the data carry their own routing information. Cao calls these “smart photons.” They steer themselves. An analogy made is between a railroad with its many switches controlled by someone other than train operating engineers and a highway system with many cars, each of which may take any number of different entrances, off ramps or alternate routes, depending upon the will of the drivers. In the Avanex approach, shape and allowable spread of the light waves are kept under strict control. Phase and polarization are adjusted to add variations allowing more and more light paths and routing instructions to be carried on a single glass fiber. The approach far out-distances older, competing approaches - even those that use WDM.

George Gilder, in his Technology Report of October 2000, from which much of the above technical discussion was derived, equates this revolution in what he calls the “Telecosm” to the prediction made 30+ years ago in the form of Moore’s Law. Still valid today, Moore’s law says that the number of transistors in an electronics device (such as in an Intel CPU) will increase capacity by a factor of two (2) times every 18-24 months. The practical result of Moore’s law has been the continual reduction in cost for increasingly powerful and compact electronics devices such as computers.

Cao’s Law hasn’t been formulated exactly, yet. But, consider that the current number of wavelength bit-streams in a single fiber available commercially from the industry leader today, Corvis Corporation, is about 160. Their approach is running up against some of the natural limits mentioned above. Avanex has achieved 1000 bit-streams in experiments and expects to eventually achieve a level of hundreds of thousands of bit-streams in a single fiber, using their approach that has no such natural limits. According to George Gilder, Cao startled attendees at the Telecosm Conference with the report of Avanex experiments and future expectations.

Putting all of the above together allows for longer term predictions of what is coming in the fields of condition monitoring, plant reliability and maintenance.

- Smaller, less costly, more sophisticated packages with multiple condition monitoring analysis capabilities, artificial intelligence (expert rules, fuzzy logic, self learning (neural network) algorithms and other features that make them “smart”) may be massed produced under a single design for distributed installation in a wide range of machines. These packages may have a million lines of code or more. (For more on artificial intelligence applied to condition monitoring, see Chapter XIII of the Penn State Handbook referenced above.)

- Smart packages will be linked by network architecture that uses the WDM approach developed by Avanex, where the marginal cost of last (or next) bit-stream used approaches zero. This is because the routing instructions come with the bit-stream rather than having to be “switched” externally. Switch-less links will be made between “smart” packages or sensors and/or to a master analyzer which directs integrated CM, process, asset management support and other indicators to operators and support decision makers or their expert system equipped analyzer(s) and decision support devices.

- When failure modes and potentially injurious incipient degradation not preprogrammed are detected, the “smart” packages may be updated remotely using the new, less expensive network technology. Application of RCA and FMEA will be used to decide what symptoms or degradation indicators to monitor.

- The end result of all of this can be improvements in production line reliability, reduction in man hours and other costs resulting from corrective maintenance, more “uptime,” better product quality, higher throughput and lower unit conversion cost.

However, until more resources are devoted to CM and machinery reliability improvement by management, this will continue to be one of the least exploited areas for cost reduction and quality improvement needed by manufacturers to compete more effectively in an increasingly global marketplace.