The Future of Machinery Monitoring Technology

In spite of the growing sophistication of the maintenance of our machinery, we still have not effectively combined the scheduling of maintenance with the process and production sides of our plants. This combination of maintenance and process engineering functions is critical if we are to maintain and increase our ability to complete. We can no longer look at maintenance and process management as two separate and distinct activities.

In looking at a typical machinery application, be it a compressor, turbine or any other large rotating machine, there are several aspects of the "maintenance" problem. Often a plant finds that interest in the health of a machine is divided into two separate and distinct areas. The first is the maintenance world as we have traditionally defined it, which is the care of the mechanical and electrical characteristics of the machine to keep it operating. This is typically different from the process world, which is the production activity in which this machine takes part. In most plants production and maintenance are separate, yet both deal with the same expensive and generally very sophisticated machinery.

The problem is, in spite of the growing sophistication of the maintenance of our machinery, we still have not effectively combined the scheduling of this activity with the process and production sides of our plants. This combination of maintenance and process engineering functions is critical if we are to maintain and increase our competitiveness. We can no longer look at maintenance and process management as two separate and distinct activities.

System generalists versus specialists

Future engineers will become more concerned with total machinery monitoring, combining process engineering and maintenance concerns. This is somewhat a return to years ago, when "Good Ol' Charlie" alone would take care of the machine train and the process.

He was an expert in all aspects of maintenance and the process in which the machine took part. I believe that, in spite of the technical specialization of recent years, and the divisions of plant management that have separated these functions, tomorrow's process engineers and maintenance managers will be one and the same. They will possess the tools, knowledge and experience necessary to deal with total machinery health and process efficiency. This will be required to reduce plant staffing – tomorrow's competitive environment will not allow for over-specialization of staff and to provide the coordination and knowledge needed to address total machine efficiency monitoring.

The emphasis will be placed on engineers and managers who understand the overall impact of maintenance decisions on production, and the role that output plays in profit maximization. The trend toward plant-wide and mill-wide management will place even greater emphasis on the integration of process engineering and maintenance management.

An historical perspective

Technology has played a leading role in both productivity improvements and maintenance management concepts. As we look back over the past 30 years at any plant in American industry, we see that technology has changed, and has changed rapidly. Several years ago, the technologies employed to monitor machinery health and process efficiency were mechanical in nature. Sounding rods determined bearing health; mechanical float level gauges determined tank level positions; electromechanical relays controlled actuators. These were common tools used by plant operators and maintenance engineers to maintain the plant processes.

Mechanical devices eventually gave way to the electronic age, first embodied in analog technologies. The analog years gave us some tremendous strides forward; our ability to control processes by means of closed loop technology and our ability to monitor machines provided large gains in plant productivity and efficiency. Eddy current probes were utilized with drivers that transformed electrical signals into meaningful displays that could be easily read by an operator or maintenance engineer.

Improvements in analog technology led us from discrete transistor devices through highly sophisticated operational amplifiers and large scale integrated analog circuits. These technological innovations enabled manufacturers of control and monitoring equipment to provide higher performance products at lower cost. These improvements were steady, though perhaps not staggering, in impact and gave continuous benefit/cost improvements year after year.

The years of technological change were far overshadowed, however, by the impact of digital technology. Older analog circuits gave way first to discrete digital devices. These devices, through their use of digital logic techniques, created circuitry that was much more accurate, reliable and free from drift and long term performance degradation.

The digital revolution created its own rapid technological change as device size decreased, gate speeds steadily increased and overall performance increased dramatically, as the cost of components fell. The increased space available on circuit boards allowed the incorporation of many more features, functions and benefits that had previously been impossible. Features became selectable. Products became configurable. All this – and at a lower cost!

Perhaps, however, the most staggering impact we have yet to fully see, for we are now in the microprocessor age. As all of us know, the use of microprocessors has become prevalent in our lives. They are in our cars, our appliances, our appliances, our telephone systems, our toys; they are literally everywhere in our society. The wide ranging impact of these devices is truly monumental. There is no parallel in history that can be drawn to show us what a profound impact on our lives these devices will have. As was the case with both analog and discrete digital technologies before them, microprocessors are now themselves being improved, enhancing performance and lowering costs dramatically.

For those of us who manufacture products utilizing these technologies, the rate of developmental change leaves us facing critical problems in introducing new products and managing life cycles of older products. Life cycle management issues become critical when base technology is changing every 18 months, and this places greater importance on understanding one of the fundamental rules of managing technology enterprises.

We do not design or manufacture the microprocessor or memory; we take these devices from the Motorola's and Intel's of the world and innovate unique circuitry. When placed in operation, this circuitry solves a business problem for our customers. If we fancy ourselves as creators of base technology, we will not serve our true role, which is the design and manufacture of solution oriented products. We cannot react with a new product every time Motorola or Intel makes an announcement. If we did so, our products would be extremely costly, we would have very little life cycle management, and you, as users, would have a confusing array of new products to choose from every three months. One of our great challenges is to choose system architectures that will grow and be viable for many years, such as the Motorola 68000 series or the Intel series of processors. This enables us to introduce compatible products of lasting value to the end user.

What does the customer want?

Another of the challenges a technology manufacturer faces is the need to determine what its customers want and what problems need to be solved. Customer focus groups, market surveys, plant visits, seminars and technology conferences are all ways of finding the elusive answer. Several things though can be generalized about what plant operators currently demand from technology:

1. Products that have a life cycle exceeding 10 years.
2. New products that are compatible with the existing architectures that they last purchased (even 10 years earlier!).
3. Zero defects and 100% reliability of products as they come out of the box.
4. Products that are easy to use; operators, with minimum training, can take advantage of the technology to ease their maintenance and process problems.
5. Fault tolerant technology that is easy to maintain and provides a minimum cost in terms of necessary on-hand spares.
6. Low installed cost.

The business challenge

At the users' "plant floor" level, the challenge is to justify to their management technology that will bring real and measurable gains to plant productivity and availability. Traditionally, the marketing of preventive and predictive maintenance technologies have centered around an "insurance" concept. That is, the technology is required to prevent a failure and unscheduled down time. Computer based systems can now predict upcoming down time, which will allow plant maintenance and production to schedule down time in the most optimum fashion, maximizing process throughput and minimizing resultant costs.

As mentioned earlier, as process management and the maintenance function grows closer together, I believe we will find maintenance technology easier to justify, because it will have real and measurable impact on throughput and productivity. What used to be justified as a maintenance expenditure can now be justified as a process and productivity improvement project. This makes return on investments easier to justify to management, and provides more capital to allow continued investment in maintenance and other technologies.

The future

In general, the future will see a dramatic acceleration in the improvement in performance/cost ratios. In terms of base technologies coming to us as a supplier, the performance/cost ratio will improve at compound rates approaching 50% per year. In addition, some technology trends will be prevalent throughout the coming years.

Hardware as a state of mind

The future will see the distinctions between various types of monitoring and control architectures blur. Distributed Control Systems (DCS), Programmable Logic Controllers (PLC), Smart Drive Systems, Vibration Monitoring Systems, Personal Computer Based Systems, Mini-computer Based Systems and dedicated single board microprocessors are performing many of the same functions. What used to be separate and distinct hardware architectures are tending toward a strategy where the functionality and personality of the devices are dictated by the firmware resident in them.

We are seeing much of this already. A drive system, DCS or PLC can all tackle the same application with roughly the same set of tools. Systems will become even more flexible. As there is less dependence on hardware redesign for innovative changes, users will see the ability to easily upgrade equipment by changing firmware to add new features and more power.

Greater computing power at the microprocessor level

While many thought that microprocessor developments would end at 8 bits, 16 bits or 32 bits, we will see more powerful microprocessors developed and introduced.

Split architecture machines that combine classic Von Neumann with Harvard architecture, such as the Motorola 68030, 68040 and RISC-based machines, will provide ever increasing computing power.

Additionally, the introduction of single chip parallel processing machines provide another quantum leap in computing throughput at the microprocessor level. This power will continue to grow, bringing mainframe and mini-computing applications down to the microprocessor level.

Distributed intelligence

As computing power grows, we will see the distribution of intelligence in system applications. What was once done in mainframe and mini systems, such as machinery diagnostic workstations, will be implemented in a micro-based environment. As control systems have become distributed in the last several years, we shall see the same trend in maintenance technology.

Greater capacity and less expensive memories

The old saying "memory is free" is not entirely true, but in spite of pricing blips to the contrary, memories will become more dense and less expensive on a per byte basis. We are now talking about 64 megabyte single chip memories. This is a trend that will combine with the evolving power of the microprocessor, to continue to push intelligence down to the board level.

Imbedded expert systems

This rapidly growing computing capability will allow the imbedding of expert system technology down to the microprocessor level. Expert system technology will become prevalent in all of our everyday decisions, including alarming critical machinery, emergency shut down systems, even the inclusion of the logic of "Good Ol' Charlie", the 30-year maintenance man, into a microprocessor based machinery diagnostic system.

This capability will provide a large improvement in our ability to diagnose machinery and process problems. It will also allow for the integration of all process and maintenance information; total machinery health and process efficiency will be monitored and diagnosed through a single workstation. An operator will not only be concerned about the maintenance of machinery, but about efficiency and productivity through the process as well.

Plant-wide data flow

Plant-wide and mill-wide systems are upon us. All of these trends will help create systems that link distributed intelligences together. Workstations will reside in plant engineers' and plant managers' offices; all plant data will be available. As communication system technology evolves and we link various functions, such as finance, production, engineering and sales, we will see true plant-wide management become a reality.

As we gain the ability to move large amounts of data around, our systems must also serve as "filters". Otherwise, we may present the operator with a bewildering amount of raw data, making any intelligent decisions nearly impossible. Thus, the system must take the raw data and turn it into information that the operator can act on.

One can envision a "data hierarchy". At the lowest level is raw data from a transducer, perhaps, in the form of an analog 4 to 20 mA signal. The next step in the hierarchy is information that could be a digital monitor taking the analog signal and converting to useful engineering information, such as spectral data. This information would then be alarmed by sophisticated spectral alarming techniques, which would create knowledge for the user and possibly make decisions on machinery shutdowns or maintenance actions.

At the highest level, knowledge is converted to wisdom. Knowledge of an impending shutdown on a critical machine could be sent to a plant computer that could combine this knowledge with information on plant orders, capacities, time-to-repair and other business variables to reschedule production, keeping the plant operating in an optimal fashion. This transformation of data to wisdom grows even more critical as system capability to collect data and transmit it to the operator increases.

Smart sensor

The trend in sensors, whether they be pressure, temperature, flow or vibration, is toward adding increased capability, or "smarts", at the local level. As microprocessor chips become more powerful, smaller and less costly, manufacturers, such as ourselves, will design in features to enhance functionality and reliability. There are tremendous benefits to be derived from auto calibration, remote rearranging, infinite ranging and scaling capability, remote sensitivity adjustments and self-diagnosis, as well as outstanding linearity and accuracy for the sensor itself. Additionally, the use of smart technology will make system calibration much simpler and will actually reduce the manufacturing variability that is inherent in existing transducer designs. Ultimately, these improvements will provide dramatic decreases in data acquisition and maintenance cost per point.

Prescient fault analysis

Prescient fault analysis is the ability to see suboptimal conditions well before they occur. This concept utilizes all of the above trends. Expert systems, large computing throughput and a large memory access capability will enable the system to communicate potential faults while suggesting to the operator the steps necessary to avoid the condition.

We will be using predictive maintenance and condition monitoring systems 15 years from now that, frankly, we cannot envision today. I cannot tell you with great certainty exactly where we will end up in this exciting field, but I can tell you it will truly be a wonderful journey and that, as users, you can look forward to more beneficial, cost-effective products as we all embrace emerging technologies.

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