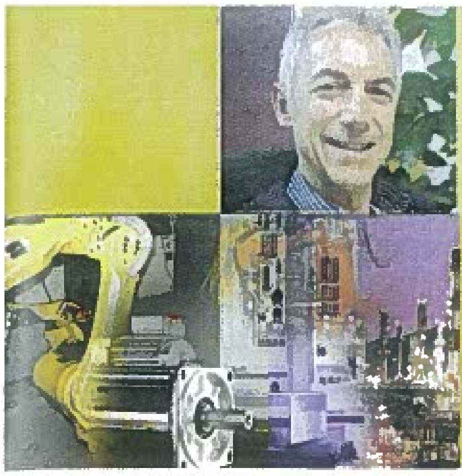

Increasing equipment life through predictive health monitoring

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With the maintenance skills shortage and high cost of dedicated equipment-health instrumentation, a number of big corporations are looking at intelligent technology to assist in keeping maintenance costs down.

Manufacturing companies across all sectors are constantly trying to reduce high maintenance costs by implementing various models of maintenance strategies. Depending on a range of factors such as asset sizing, complexity and criticality, larger companies will adopt a comprehensive type of maintenance strategy such as reliability centred maintenance (RCM). This is the process used to determine, systematically and scientifically, what must be done to ensure that physical assets continue to do what their users what them to do. RCM is an engineering framework that enables the definition of a complete maintenance regime which includes reactive, preventative and predictive maintenance approaches.

While the reactive includes a run-to-failure or ad hoc approach, the preventative approach includes both planned/scheduled programs as well as condition-based maintenance (CBM) programs. This is summarised as depicted in the diagram in Fig. 1. Generally speaking, between the two, the CBM model has proved to be more cost-effective than the scheduled based maintenance, from a time and capital investment perspective in achieving positive results.

The traditional model of preventative maintenance is based on scheduled maintenance and these programs normally rely on accurate estimates of equipment working hours, typically set at program inception and then rarely updated thereafter. Infrastructure set-up costs are lower but part replacement costs can be high.

This maintenance methodology typically reduces the instances of unexpected equipment breakdown and can certainly prevent considerable production losses and disruption. Companies that have effectively implemented this methodology have realised improved equipment availability and reduced breakdowns. They do however have a problem in balancing the necessary and unnecessary maintenance efforts. The challenge therefore is that equipment may be serviced either unnecessarily or too late to prevent equipment from failing.

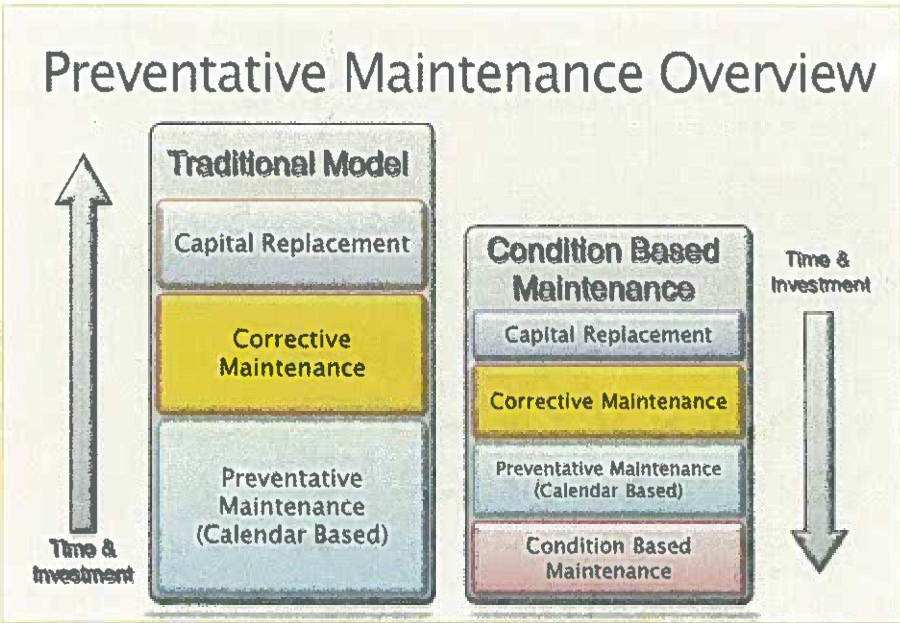

Fig. 1: Preventative maintenance overview.

This is where the CBM model can be a more appropriate approach as a preventative maintenance measure. In this case equipment is only serviced when required by measuring the actual operating hours and sending the data to the planned maintenance system when maintenance is due. This will ensure that the equipment is maintained only when the defined operating hours have been reached. This method works well when the defined operating hours correspond with the health of the equipment. For instance, when a pump is pumping non-corrosive fluids, it may last longer than the manufacturer-recommended running hours, but when it is pumping more corrosive fluids, it may not last for the full hours before breaking down.

The CBM approach of preventative maintenance requires investment in dedicated health monitoring instrumentation like vibration, temp, pressure devices, etc. These tools work well and can identify when a piece of equipment is not healthy. Tools like this typically consist of a combination of automation and control infrastructure like software and specialised dedicated instruments installed on equipment. Due to the expense of these solutions, they are normally only implemented on critical pieces of equipment, but they add great value and the ROI is justifiable with lower part replacement costs.

Most of the above maintenance technologies are applied to individual pieces of equipment which in turn may be components of a bigger piece of equipment comprising the plant. This makes it even more difficult to maintain schedules, as taking a component off-line for maintenance may also shut down a major piece of plant equipment. If one thinks for instance about a furnace or boiler, they all consist of individual pieces of equipment

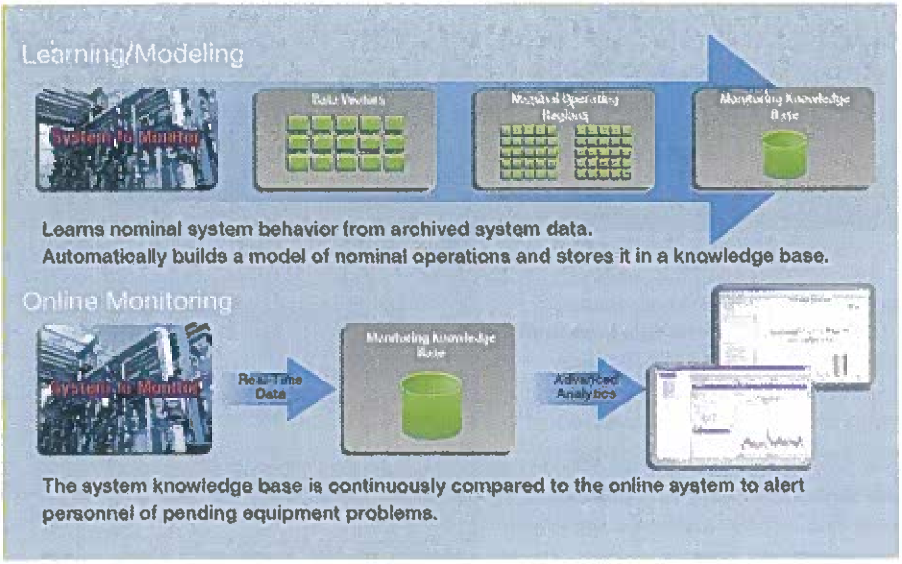

Fig. 2: Learning/modelling and online modelling.

that in an integrated way make up a fully functional system with a specific purpose. Due to the number of components that make up this system, it is difficult to determine if the system as a whole is healthy. In this case only some highly experienced engineers are able to assess and identify equipment health using variables from the individual components in order to form a mental picture of the system health in an integrated way.

The lack of experienced engineering skills is affecting manufacturing companies, both locally and worldwide, resulting in less focus being put on the balancing of planned maintenance schedules with actual overall equipment health. It is also true that once implemented, these schedules are followed slavishly and little time is spent trying to match and fine tune them with overall equipment health. Experienced maintenance and process engineers are able to use their senses as well as equipment performance to identify a system that is unhealthy. Unfortunately, this skill cannot be taught in a classroom and only comes with experience.

As a further complexity, it is well understood that in addition to the occurrence of potential unplanned breakdowns, unhealthy equipment or systems also affect plant performance and efficiency. Unhealthy systems use more energy; waste more materials, are resource intensive and can result in substantial product losses. This has a series of degrading collateral effects which cause plant cost escalation and technical impoverishment.

What is needed to assist companies is a solution that will not only identify unhealthy equipment or systems before they break down, but that can also delay unnecessary maintenance when equipment is still healthy enough to continue operating without breaking down. If this can be done in an intelligent way without installing any dedicated specialised instrumentation, so much the better.

This is where the predictive maintenance approach has a role to play and luckily, technology has advanced to such a degree that it is possible to utilise such approaches to introduce intelligence that can monitor equipment health and determine potential equipment failure long before the fact. Some of the major companies in South Africa are using, or are contemplating using technology of this nature on their critical assets to help them increase equipment performance and reduce maintenance costs.

At the top end of the scale, these kinds of technologies bring maintenance philosophy and anomaly detection into the realm of real time "asset intelligence" where intuitive and sophisticated modelling software analysis systems have merged with user friendly interaction, graphical outputs, web-based reports and diagnostic decision support capabilities.

They use the principles of modelling, historical data analysis and pattern recognition focussed on equipment health to predict equipment failure and raise an early warning.

How does this work. First, one or more equipment health models are built by identifying process and equipment-specific variables that can potentially indicate the health state of the equipment within a process or plant system. Then historical data is used within the models to build patterns of equipment behaviour. The patterns are cleaned up by removing data related to breakdowns and other ill-health incidents. This establishes baseline patterns for healthy equipment behaviour. The models are then implemented in real-time and compare real-time behaviour against the pattern.

When the real-time data starts deviating from the healthy pattern, it is an indication of equipment ill-health and steps can be taken. The technology typically also indicates the major variable responsible for the deviation

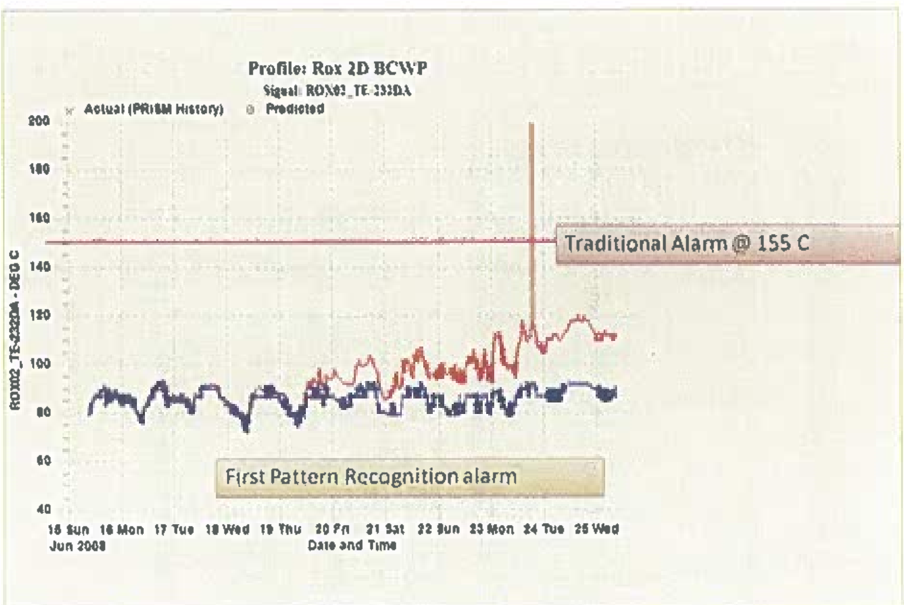

Fig. 3: First pattern recognition alarm.

from the healthy pattern, assisting engineers in pin-pointing potential problems. The last step would be to set up alarm limits for deviations.

Furthermore, different models can be built for different seasons if ambient conditions influence equipment performance or for different raw-material feeds if they affect equipment performance. Multiple models can also be built depending on different phases of the equipment life-cycle. For instance, equipment will behave differently before and after refurbishment, and so the same model cannot be used in both cases as it may give false alarms.

Because this technology uses typical process variables in combination with standard equipment variables, it takes into account not only variables that indicate the state of individual components, but also of the process variables that influence equipment performance. This has the advantage that it can pick up incremental changes over long periods that would not normally be identified by operators or engineers. For instance, increased power use and reduced pressure may indicate that a pump impeller has been eroded and that the pump is close to failure.

Early indications from a number of site installations are that this technology can accurately predict imminent equipment failure and reduce unplanned breakdowns. A secondary effect is that equipment as well as process performance is increased and in some instances, planned maintenance cycles can be lengthened considerably.

This technology provides an early warning to the problems that are occurring in real time. It can be of great benefit for any company that has a mature maintenance approach and a plant wide automation infrastructure that is well networked and that can gather real-time process data into a plant historian for further analysis purposes.

The main benefits of intelligent predictive maintenance approaches can be summarised as follows:

- Improved asset availability.
- Reduces forced outages.
- Improves preventative maintenance and reduce reactive maintenance.
- Improves the understanding of balance between plant utilisation vs. plant availability.
- Improves the leverage of resources and costs across the fleet.
- Improves operational support to plant staff.
- Captures retiring work force asset expertise in an automated system.
- Enables online CBM applications.

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