Håvard Devold, ABB, Norway, considers how digitalisation and big data can help to reduce maintenance costs.

A DIGITAL AGE

Every year, oil, gas and petrochemical companies invest billions of US dollars in maintenance. And yet, equipment failure is the main cause of heavy production losses. With the industry's large investment in maintenance, should the resulting procedures not be more effective?

As much as 40% of net OPEX in the oil and gas industry is spent on scheduled and unplanned maintenance. The main reason that maintenance operations are not more successful is that traditional routines are based on service time, rather than actual requirements, despite the fact that 70 – 90% of failures are unrelated to equipment age.[1]

The problem with such an approach is that considerable effort is devoted to devices that are working perfectly well. It also does not address the reality where 20% of the equipment tends to cause 80% of the issues. Maintenance costs are further inflated by the desire to be on the 'safe side'.

Making matters even worse, up to 40% of production losses can be attributed to preventable operator errors[2] where, in a typical plant, this could account for 1 – 2% of a plant's total production capacity. Given that more maintenance means more human involvement, the result of excessive maintenance can be that plants actually become less reliable.

However, with the help of digitalisation, the hydrocarbon industry can now start to address this issue by moving to condition-based and predictive maintenance, directing efforts to the point of need.

New technologies unlock untapped opportunities

Digitalisation uses technology to do things differently. Today's advancements offer opportunities for asset monitoring that were simply not there only a few years ago. Sensor prices have declined significantly over the last decade, driven by consumer digital device growth. At the

Figure 1. Maintenance is based on priority and need, instead of a time-based schedule.

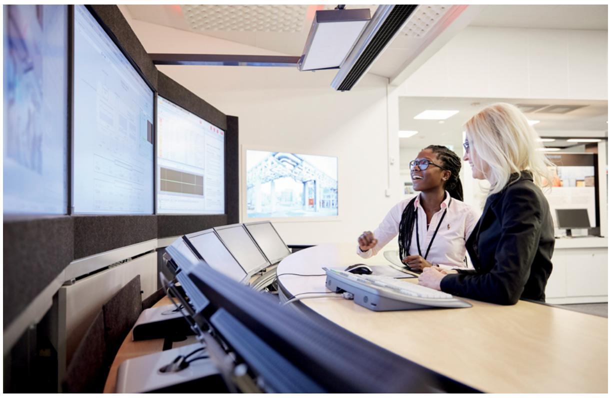

Figure 2. Critical assets are monitored remotely to identify pending failures.

same time, secure cloud data storage solutions have become viable and wireless networking technologies are now capable of delivering data speeds of up to 1 GB/sec. Tying all of this together, computer processing power is now sufficient enough to handle the petabytes of data being generated.[3]

Using these technologies, sensors can be fitted to components that need monitoring. Data can be processed and service teams alerted to issues that need addressing based on actual need, rather than because a certain amount of time has elapsed.

Equipment can be serviced before a fault occurs. This reduces downtime, cuts costs and improves safety. In fact, well-executed digitalised maintenance has been shown to result in 15 – 40% cuts in actual maintenance costs. Using the earlier mentioned figure of net OPEX in scheduled and unscheduled maintenance being 40%, and assuming a 30% reduction in maintenance costs through digitalisation, this translates into a 12% reduction in total operational costs.

The number of failures during operation can also be cut by over 90% and improve plant availability by 2 – 3 %. In fact, small improvements in uptime can end up being the largest contributor to improved earnings.

Looking at the impact on maintenance efforts alone, implementing a digital maintenance system, including the purchase of required sensor technology, typically pays for itself within a year.[4]

Strength in numbers

While analyses of components, systems and plant performance are used to detect and diagnose faults locally, further possibilities are offered by fleet analytics, used to estimate the likelihood or frequency of events. When data is collected from a large amount of identical equipment operating under similar conditions, it becomes possible to build a precise model of that device's degradation process. Highly reliable predictions of when a fault will occur can be made.

Data can be mined from an operator's own fleet of sensors and devices, or even across external plants and other industries via third-parties, such as ABB. The larger the data set, the greater the accuracy in drawing conclusions that can be used to predict future performance of specific items within an individual plant.

Underpinned by traditional methodology

While the new and more efficient maintenance regime makes full use of digital technologies, its framework is still based on a traditional failure mode and effects analysis (FMEA).

FMEA is a structured way of approaching equipment failures and their possible causes, which has traditionally been done manually.

With the new maintenance concept, digital technologies are used to gather the data to feed into the analysis. A system can be built whereby every piece of equipment is represented by a digital model. The full range of failure modes for all types of equipment can be mapped and the consequences of each calculated. All available information, such as data, feedback and expert opinions – bolstered by artificial intelligence – can be used to build and refine these models through sophisticated analytics, improving the accuracy of failure predictions on an ongoing and continuous basis. With digitalisation, FMEA becomes a powerful tool.

Decisions can be taken on the most up-to-date understanding of real maintenance requirements, as opposed to theoretical ones. FMEA data combined with asset criticality helps develop a more efficient and effective work schedule than before. Rather than going through a list of time-based actions, service teams address issues based on level of priority, business needs and actual conditions.

A question of when and how

Unfortunately, predictive maintenance cannot be applied to every piece of equipment. Low value items with no significant production impact should be run to failure, provided spares are available. The cost of getting things wrong is too small relative to the cost of investing in the technology needed for a more sophisticated approach.

For business-critical equipment whose failure harms production, the maintenance choice depends on the

Figure 3. Intervention occurs when equipment indicates that it needs servicing.

Figure 4. Digitalised maintenance can cut operational costs by 12% and increase availability by 2 – 3%.

ability to predict problems and whether the time between the first indication of a fault to functional failure, known as the 'P-F interval', is meaningful.

Where P-F intervals are too short to take action or there are no methods or instruments for identifying developing failures, traditional time-based, preventative maintenance according to manufacturer guidelines is recommended.

In all other circumstances, condition-based or predictive-based maintenance should be chosen to maximise performance and minimise cost. Failure modes are remotely monitored using sensors and dedicated analyses are performed, which analyse the equipment itself and/or its environment for clues to drive maintenance work.

In condition-based maintenance, intervention occurs when the equipment indicates that it needs servicing. A pressure drop might indicate a filter needs changing; this signal would drive the maintenance activity irrespective of what the manual says about filter change frequency.

Predictive-based maintenance goes a step further. Data internal and external to the device, coupled with a model of the degradation process as described above, is analysed to predict failure. If a motor bearing starts to vibrate, under certain process parameters and temperature fluctuations, this might suggest its remaining life is three weeks. Here, action could be taken within two weeks and still avoid breakdown.

A virtuous circle

While condition monitoring is necessary, it is insufficient to capitalise on the opportunity available through digitalised maintenance. A shift in culture is required. If new technology is introduced without changing the way the workforce operates and makes use of it, it is unlikely that the full potential of the technology will be realised.

Routine and reactive habits must give way to proactive activities. Employees need to trust the data provided by the new digital ecosystem and adapt their work processes accordingly. Staff and data must complement each other.

Wacker Chemie is using a remote-enabled service delivery system to improve production and allow predictive maintenance through the continuous monitoring and visualisation of key performance indicators. By tracking over 100 control loops at its Bavarian ketene cracking plant, it conducts maintenance more effectively, saving 35 days of analysis time per year and decreasing OPEX by 20%. Moreover, problem solving is enhanced through 24/7 visualisation.

Another chemical company is using wireless sensors on its rotating machines to optimise a fleet of 60 000 assets at a plant where some 80% of issues had been caused by this equipment. By knowing what is going to fail and when, predictive maintenance activities are delivering fewer unexpected failures, thereby increasing its production efficiency and minimising operational costs.

A further example of deploying a more predictive maintenance regime is in process vessel and pipework inspections to comply with statutory requirements to check for possible degradation. Traditionally, this has been done through periodic internal visual inspections of the equipment. This is not only hazardous but also extremely costly considering the preparation and production losses associated with the vessel shutdowns required. By using data to identify the areas of greatest risk, companies can apply a risk-based philosophy to determine vessel condition and where maintenance or repair is needed.

In addition to intervening only when required, further cost savings can be realised through non-intrusive inspections (NII). NII leverages recent advances in technology and understanding of deterioration mechanisms to identify or confirm problems such as corrosion without the safety and cost implications of employees placing themselves in toxic, poor visibility areas, and operators having unnecessary production shutdowns. The non-invasive nature of such testing also minimises vessel disturbances that could create new problems.

With condition-based monitoring, maintenance staff can spend their time on tasks that add business value, rather than inspections that potentially lead nowhere and may introduce new issues.

A predictive, condition-based maintenance approach facilitated by digitalisation provides many linked benefits, including:

- Higher uptime.
- Reduced repair and maintenance costs.
- Longer equipment lifetimes.
- Higher return on assets along with improved profitability.
- Better planning and execution of plant and business processes.
- Enhanced collaboration on equipment maintenance and performance across locations, engineering disciplines and organisational levels.
- Optimised maintenance work orders.
- Easier and more effective root cause analysis.
- Health and safety improvements.

The cost of doing nothing

Maintenance costs can be direct or indirect. Direct costs include payments to employees and contractors, as well as those associated with keeping spare parts and tools. Indirect costs typically represent a higher cost factor and include the opportunity costs of lost production, increased actual production expenses and reduced quality.

An issue of even more importance relates to critical safety incidents. Here, the indirect costs can be extremely high, such as the complete destruction of a plant, serious environmental damage and even death. Events like these tend to arise out of multiple safety issues, each potentially non-critical, which align to result in an unmanageable disaster. These extremely negative outcomes can happen if systems are not available to perform the correct action and/or operators fail to respond correctly to critical events.

A digitalised maintenance system will address the direct costs of maintenance. More significant, however, are the benefits related to indirect cost reduction and, longer term, the avoidance of critical safety incidents. The ultimate cost for those choosing to ignore the opportunity offered by digitalisation may be great.

By embracing digitalised maintenance, operators can improve efficiency and offset the challenge of lingering low oil prices. With this model, intervention comes at the right time, in the right measure. Fully functioning equipment is not needlessly serviced or replaced. Faults are identified before they impact production. Unnecessary maintenance, which may introduce new faults, is avoided.

A maintenance organisation that intervenes just at the point of need might be just the energy boost that the hydrocarbon industry needs.

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