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White Paper

Effective condition monitoring: An enabler for Predictive Maintenance

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Goals

Before thinking about what to measure, it's important to be clear on your motivations for implementing a condition monitoring (CM) program and exactly what you want to achieve. Motivations could be: regulatory compliance, cost reduction, improved build quality or a host of other drivers – but there has to be a compelling reason as monitoring comes at a price!

Some organizations may decide that they want to move away from a reactive maintenance strategy to become predictive, with the goal of preventing future failures and turning them into planned events. A solid and very valid reason – so long as it can achieve an acceptable return on investment (ROI).

Some organizations want to implement a CM program to stay competitive: industries, such as food and beverage, operate under significant financial pressures with small margins and high competition. With conventional asset management practices exploited, these organizations are looking for the next level of savings (using the 80/20 rule, they're now focusing on the 20%). Organizations operating in low value, low margin, high volume environments will feel the most pain from unplanned downtime. For example, component manufacturers losing an hour of production could see their margin wiped out for an entire week.

Maintenance downtime is less disruptive for specialized or niche areas such as aircraft components and F1 suppliers, as they operate in a very different competitive environment and do not use mass-production methods, often having increased flexibility to work on weekends if a weekday is lost due to downtime.

Feasibility

Once you understand your aims, the next stage is to qualify them. Whilst money isn't the only motivation, using a financial argument is one of the best ways to quantify the benefit: what is the cost of your unplanned downtime, directly and indirectly (additional labor, spares inventory, out-of-hours maintenance, damage to customer relationships, etc.)?

Quantifying the current situation can be a difficult task as organizations operating in the reactive sphere often have no idea of the amount of resource actually being used. Downtime events may be recorded, but short stoppages, changeovers and the various wastes that are generated in scrap product, rework, labor, power and utility usage can result in a significantly higher cost than what is often recorded. This can lead to statistics such as downtime often being underestimated by almost 300%!

Once the current situation is understood (downtime, lost revenue, etc.), an organization can look to fully understand the costs involved in implementing a CM program, including training, any necessary hardware, software and a gradual but complete change of operational practices.

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CM experience

Another key factor in what to measure is the organization's current exposure to CM, as the initial implementation and follow-up is where many fail. This can be due to a variety of reasons including: lack of commitment from the management level across operations and engineering, no knowledge of CM practices, unclear objectives, budget constraints that doesn't support even basic training, overspending any initial budget on instruments that are never used or inappropriate, or a reluctance to change.

For more experienced CM operations with internal support in place, and perhaps a successful pilot program to build on, what to measure may be very different – perhaps an expansion of assets being monitored, more complex monitoring of existing equipment and deeper analysis for predictive maintenance and Remaining Useful Life (RUL) predictions.

Scale and investment

With enough people, CM can be carried out manually – the aerospace industry has been performing manual analysis for longer than almost any other industry. Realistically, with hundreds or thousands of assets sometimes in one area alone, the only economically viable way forward for industrial companies is through automation. This is the only way to leverage the knowledge and expertize of the people tasked with performing CM on the front line. They will not disappear with automated CM; on the contrary, their input will become more important, now focussed on harnessing and acting upon more specific information from tools that will direct their focus and attention on the few assets that need imminent attention, rather than on hundreds that are performing reasonably well. Automated CM allows the more mundane issues to be dealt with automatically and the experts to be able to focus their strengths on the really interesting and difficult issues.

It is also the only way to successfully aggregate information across different platforms simultaneously and in different geographical locations. There's a plethora of additional benefits:

- It takes fewer people to cover many asset types
- It can move outside of four walls to different locations
- Information is gathered at very short intervals of minutes rather than weeks or months
- Artificial intelligence (AI) algorithms and machine learning can do the heavy lifting computation that a human cannot
- Training and CM skills required are minimal
- Costs are fixed or scalable depending on need
- Automated systems rarely get sick or take holidays!

The downsides are that you really do need an existing or developing CM system, hardware may need to be deployed and cultural change is required. The best results will be through human-to-system interaction and they sometimes need a nudge, changes made with assets that are not reported can be detrimental, and to get the best out of it you sometimes need to see failures.

Of course, there are an increasing number of 'dark factories' which are totally automated – particularly in the automotive and logistics sectors, for example Ocado and Amazon. In an autonomous world, AI is needed to replace human presence. Over time, an increase in dark factories is anticipated as companies look to move more and more people out of hazardous, unpleasant and/or noisy environments. It will be interesting to see just how widespread this approach will become.

How much to invest in CM?

When considering whether to invest in a predictive maintenance solution, it is important to understand the potential savings for your business before looking at how much to budget. If the numbers don't add up, then you may need to rethink your CM ambitions.

Calculating potential savings
The fundamental case for CM is that it saves you more than it costs. Discounting safety-cases in industries such as oil & gas and aerospace, there are two areas where cost savings can be achieved:

1. You need to understand the current cost of downtime in your business. At a base rate, a CM solution should reduce this level by at least 20%, but over time this can extend to 40-50%.
2. You should consider the value of your assets and the saving that can be achieved by extending the asset life.

Consider payback
ROI is also an important factor when investing in a solution. Essentially, this brings a defined timescale to the budget calculation – and organizations are increasingly demanding payback within the same financial (budget) year as the investment.

An evolving journey of continuous improvement
When starting out, you should understand the benefits and limitations of sensor solutions and where they are going to deliver value. You may decide to start small, focusing on one particular high-value or critical asset to demonstrate the value of the CM solution and learn from the process, then look to extend more widely. Over time, regular scheduled maintenance will be reduced and preventative jobs will increase to provide a forward-looking approach with a much better understanding of the current and future condition of your machines at any given time.

How much should you invest in CM and prognostics?
The simple answer is that you should make the correct investment for the return you're likely to achieve in these areas:

- Safety / quality / throughput improvement
- Reduction in downtime
- Extension of asset life

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What to measure

Having assessed the program basics and with a clear focus, the original question of what to measure can be addressed. This can be broken down into two categories: assets and data.

Assets

Every plant has one or more critical parts. By looking at the top 10 failures in the last month and year in the CMMS database, critical assets can be identified. Understanding the consequences and risks of failure of each asset means that a critical priority list can be compiled.

Reviewing historical operational data/maintenance records and downtime reports to see where the problems are provides a list of problematic assets to supplement the list of critical assets. Sometimes it's the little things that are problematic, for example a food production line being stopped related to a lubrication problem and the special food grade oil not being in stock.

Data

Positioning sensors on the 'knee' of an asset rather than the 'heart' results in plenty of data but nothing with any useful meaning. Essentially the correct sensor is required in the correct place, measuring in the correct way to detect the things that identify a potential failure. For example, electrical signals can give an earlier indication of a problem than a temperature sensor as, by the time the temperature increases, the problem could be at a critical point and the monitored asset will generally need replacing rather than maintaining.

"I use an analogy about a scenario of going to visit a GP and describing symptoms of shortness of breath or chest pains. The GP would use a basic CM instrument, his stethoscope, to listen to your back for breathing and chest for heart function… he or she wouldn't put it on your knee!"

Andy Gailey, Productivity Engineer and Director, Uptime Consultant Ltd.

As well as pure sensing, information on states should also be fed into the CM system such as the type of work currently being carried out. For example, one machine manufacturing two different types of crisps will run differently depending on what it is producing, and therefore will produce a slightly different dataset. By knowing which mode (regime) the machine is in, data can be better interpreted. Equally, the same motor could be used in the same facility but at a different load, speed and environment.

An example of this from the food industry would be a Cornell-type centrifugal pump that in snack food manufacture is used on products with ambient-temperature water to flume potatoes, but the same type of unit is also used in hot oil fryers to pump vegetable oil at 180°C. The stresses in one far outstrip the other and they have very different levels of criticality or importance to the business. Risks and consequences must be carefully weighed.

The operating environment can also kill assets, for example: corrosive atmospheres, excessive heat, lack of ventilation, water ingress, chemical use, vibration and debris. And they're not very good for us either!

If the basic training or skills are missing, then asking engineers used to reactive work to deploy CM sensors and technology on assets will typically result in the incorrect equipment being targeted with sensing that produce outputs giving little or no value.

CONCLUSION

As you can see, condition monitoring can be a minefield, so it's not surprising that so many try and fail. Without a clear idea of what you want to achieve and its viability, it is impossible to ensure that the correct assets are being monitored with the right sensors.

Start simply, with known issues and easy ways to collect the data, then build from there.

The familiar adage applies: KISS – Keep It Simple Stupid.

About the authors

ROBERT RUSSELL

Rob is the Chief Technology Officer at Senseye. After graduating with a BEng in Mechanical Systems Engineering, Rob spent 20 years designing and deploying asset management and condition monitoring systems within the aerospace, defense and transport sectors.

Having a mechanical engineering background in the software sector has enabled him to bridge the gap between the end user and his software teams. Since 2015, Rob has guided the vision for the ongoing development of Senseye's first complete automated PdM and prognostic solution, fit for the IIoT.

About Senseye
Senseye™ is the leading cloud-based software for predictive maintenance. It helps manufacturers avoid downtime and save money by automatically forecasting machine failure without the need for expert manual analysis. Its intelligent machine-learning algorithms allow it to be used on any machine from any manufacturer, taking information from existing Industrial IoT sensors and platforms to automatically diagnose failures and provide the remaining useful life of machinery.

ANDY GAILEY

Andy is the founding director of Uptime Consultant Ltd. A Mechanical Production Engineer by trade he spent his formative years in turbine manufacture, prototype machining and motorsport, before going onto work for PepsiCo International in the snack food sector for over 20 years.

Between 2006-2015 Andy developed, tested, and ran the condition monitoring and lubrication program for the largest snack food plant in Europe, saving six figure sums annually for the business. If it rotates and breaks then Andy is interested in mitigating or stopping that pain.

About Uptime Consultant
Founded in 2015 by Andy Gailey, Uptime Consultant Ltd is a Productivity and Reliability consultancy with an holistic approach to achieve productivity and efficiency improvements. Experienced within the automotive, food, beverage, water, power and utilities sectors, the company delivers engineering maintenance strategies, management, training and mentoring, and is very active in the emerging and existing fields of connected devices and sensors used in condition monitoring.

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