Sensors & Controls

Improving machinery productivity with oil condition sensing.

Contents

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1. Introduction

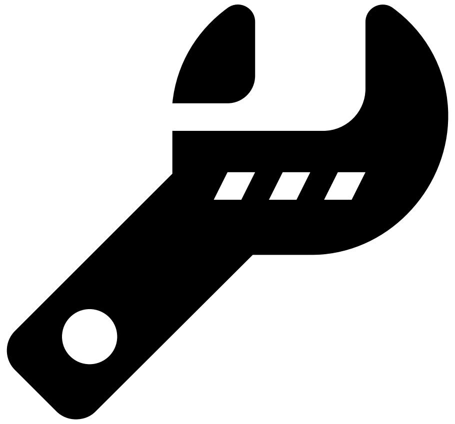
In a competitive global economy, maintaining and improving operational efficiency is an ongoing challenge service engineers and plant managers have to face. Part of this is ensuring machinery output is maximised and hours of non-productive and expensive downtime is kept to a minimum.

Maintenance strategies have been developed with the help of new sensor technologies, whereby machinery health is monitored to optimise service windows or detect early signs of failure.

Machine failure is immediately identifiable by examining oil. A failure progresses with time, microscopic excavation of machine surfaces produce wear debris which enters the oil. If you are working to prevent unscheduled downtime, this is the best place to start.

Oil debris monitoring is one technique which analyses the lubricating oil for metallic particles that guides engineers to the possibility of component breakdown or high wear rates.

2. Costs of maintenance / downtime



Industry analysts estimate that downtime costs at least 5 percent of productive capacity, with many losing as much as 20 percent of their total productivity.

For example if a food packaging line is running a product at 350 parts per minute, contributing 7 pence each, every minute stopped will cost £24.50. If ten minutes per day were lost this would result in £61,250 and 40 lost hours of product time over the course of a year.

A recent study by Oracle Corporation estimates that equipment downtime can cost large businesses an average of £68,761 per hour. Oracle shows that for a large company, reclaiming just one percent of downtime can be worth as much as £5,059,753 per year, while an average sized company can save £687,616 per year.

Unplanned downtime costs are attributed to the following:

- The cost of labour, plus the potential cost of overtime hours to make up for lost output.
- Repair costs, replacement costs or expenses from wasted material which could be even more if the machine produced inaccurate products over time.
- Higher production costs from bottlenecks, products in other stages of the manufacturing process slowed down or halted.
- Costs of temporary fixes until a permanent solution is found -possibly requiring another period of shutdown.
- Parts and delivery costs including late delivery charges.

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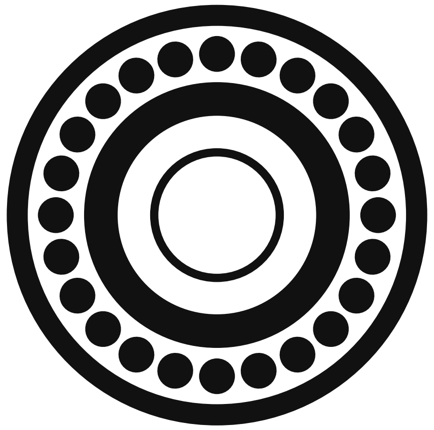
3. Common causes of bearing failure

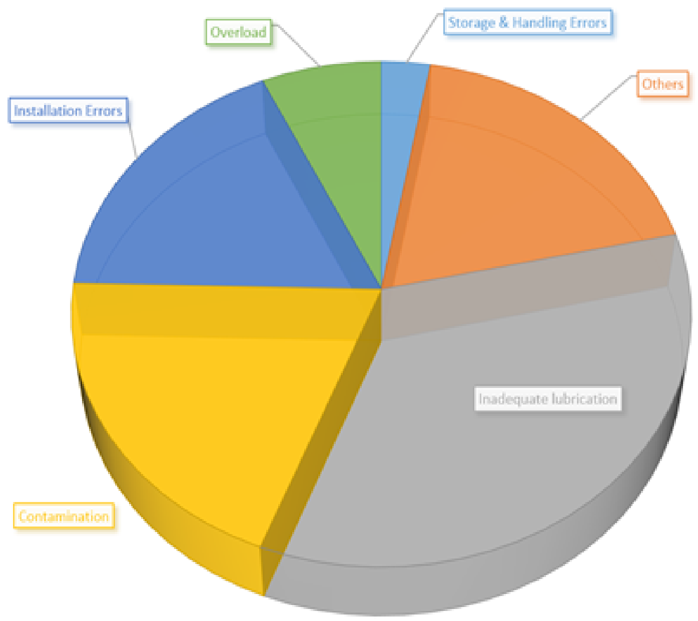


Gearboxes are fundamental in a limitless range of machines and applications. Gearbox failure can cause complete machinery breakdown, expensive in repairs and lost output.

There are many ways that gears and bearings can fail and the causes of these failures are varied. Most failures start in a small way without any outward indication.

Whether the starting point for a failure is low oil level, water in oil contamination, oil contamination, overloaded or misaligned components, one of the earliest signs of gearbox problems is physical decay of bearings, gears or shafts. A result of fatigue, corrosion, inadequate lubrication or overload this decay manifests itself by shedding metallic particles into the lubricating oil.

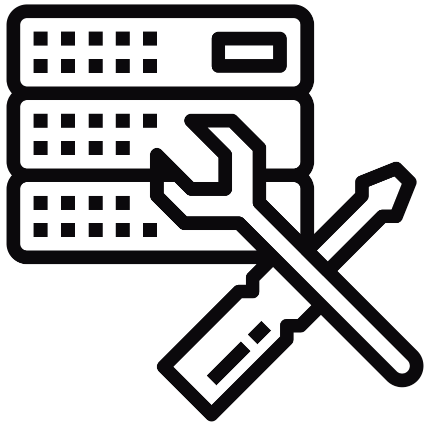
With the aid of condition monitoring tools, plant engineers who are able to identify and analyse the size and quantity of these particles get the earliest notification for an asset inspection.



- Inadequate Lubrication 34.4%
- Contamination 19.6%
- Installation Errors 17.7%
- Overload 6.9%
- Storage & Handling Errors 2.8%

Source: SKF USA

4. Maintenance strategies



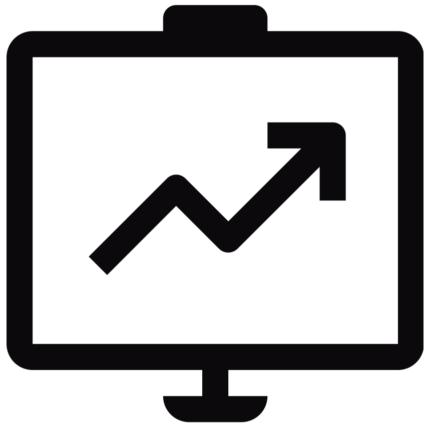
The traditional model of maintenance has been a run-to-failure approach where repair and maintenance occured when the piece of equipment fails. The principle drawbacks are the loss of production and revenue, this is because repairs are typically more expensive than if the fault had been repaired before failure occurred.

Preventative maintenance is a planned programme, where it is carried out at fixed time periods in scheduled maintenance windows, such as regular oil changes. The benefits are that through regular maintenance, breakdowns are less likely and the activity can be scheduled, while reducing non-productive downtime.

Predictive maintenance (PdM) uses sensors and analysis to monitor the health of the machinery, generating alerts when a potential failure is detected. This provides the Engineer with the insight to carry out maintenance only when it is required, but with enough warning that machine failure is prevented. It also means that components or oil are only being changed when required. Therefore PdM gives the double benefit of reducing downtime and keeping maintenance costs low.

Oil debris condition monitoring is one of the techniques that can be used to support a PdM strategy.

5. Benefits of condition monitoring



The key benefits of condition monitoring as part of a predictive maintenance programme are;

- Better risk management and planning
- Defect elimination
- Reduction in the number of non-value adding, intrusive maintenance tasks
- Increased reliability and availability, providing higher production rates without significant capital investment.

6. Condition monitoring techniques

The development of advanced PdM strategies has been facilitated by new sensing technologies becoming available.

Traditionally, techniques such as laboratory oil analysis have formed a part of machinery conditioning monitoring programmes. Although these techniques provide different advantages, the time frames when they are undertaken can be longer than it takes for a fault to develop. Emerging sensor technologies provide continuous, real-time monitoring providing a sufficient time for remediation to be carried out before a failure event.

There are a number of parameters that can be used to measure machinery condition. Vibration is a very common technique as it can be used across all moving machinery; in particular electric motors.
Oil quality can be determined through viscosity or the acid number, indicating oxidation.
Simpler measurements such as temperature and changes in sound emission are also used.
Water in oil can be detected through dielectric measurement and lubricant levels through a level sensor.

Debris in oil is another effective measure of condition. The key advantage of this technique is it detects the start of a problem directly by catching the evidence of failure before the effects that other condition monitoring techniques measure, thereby giving the earliest warning. For example, if a bearing starts to fail, small amounts of debris will disperse into the oil and will quickly be picked up by the sensor. It will often need the failure to develop significantly before it will begin to cause vibration from which a vibration sensor will be able to indicate a problem. The ability to analyse the debris can also provide guidance to the source and cause of the developing problem.

The most appropriate criteria will be determined by each application, but may require more than one sensor to provide comprehensive data. The more parameters measured, the better the effectiveness of PdM.

Oil debris sensors are complimentary with other condition monitoring sensors, such as vibration or oil quality, to form a clearer picture of machinery health.

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7. Case example

Research conducted at Monash University in Melbourne, Australia, induced failure in gearboxes including misalignment, oil contamination, tooth fracture and others, under controlled conditions.

The gearboxes were monitored using vibration and oil analysis (ferrous density) during progression of the failure. The researchers concluded that, on average, oil analysis provided 15 times earlier detection of upcoming failure compared to vibration analysis. In the case of tooth fracture, however, vibration provided an alarm before oil analysis. They concluded that both are companion technologies for the best early detection results.

8. Development of the oil condition technology

Gill have identified that combining debris monitoring with additional parameters (water-in oil contamination, oil presence or temperature indication) in one sensor would provide engineers with enormous benefits over other monitoring techniques.

Plants would have the potential to accurately monitor data on some of the most common causes of machinery downtime, either independently or in combination with other techniques. Furthermore capturing the earliest warning sign of problems inevitably prevents the costs of damage and repair before expensive unplanned downtime occurs – making large savings.

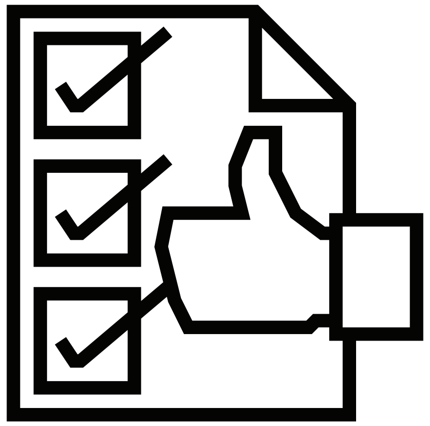
Because the sensor is monitoring continuously it offers the maximum Failure Developing Period (FDP) between when it is possible to detect a failure until a breakdown occurs. The FDP varies depending on application and type of failure, but typically the sensor could provide between 1 – 12 weeks' notice of a breakdown occurring.

Gill has developed a programmable inductive condition monitoring sensor to help plant managers achieve the above as part of a PdM strategy.

A powerful magnet in the end of the sensor captures particles from the oil for measurement and retains them preventing further damage.

Installation costs are an important factor in the overall cost-of-ownership; making equipment easy to fit on installed machinery is another key consideration. The sensor probe is designed to fit a drain plug aperture, with the processing electronics separated to make the probe compact and keep the electronics away from any local high temperature locations, improving reliability.

9. Conclusion



Predictive maintenance has three main objectives;

- Minimising the time the equipment is being maintained
- Minimising the production hours lost to maintenance
- Minimising the cost of spare parts and supplies

To achieve these targets, equipment needs to be monitored in real time for the maintenance and failure characteristics appropriate for that particular asset reflecting its critical operational function.

An oil debris sensor that monitors some of the primary causes of gearbox and transmission failure provides maintenance engineers with a technique which realises the benefits of a predictive maintenance programme.
Monitoring technologies such as particle counters give an absolute measure of every particle in the oil, but the cost of purchase and installation are prohibitively high and rely on filtration to remove debris from the oil flow.

Particle counters provide a comprehensive picture of debris in oil, but their cost and ROI restricts them to the largest, most critical equipment. The Gill oil debris sensors' lower cost of ownership makes it available to a wider range of machinery applications.

Incorporating the Gill oil debris sensor into machinery individually or alongside complimentary monitoring technologies provides engineers with an additional, cost-effective, tool to drive improvements in machinery productivity while reducing the costs of manual maintenance.

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