WearDetect

Oil Debris Sensor

Real-time ferrous wear detection – discover machinery failures faster

An introduction to Wear Debris Monitoring in the industrial marketplace

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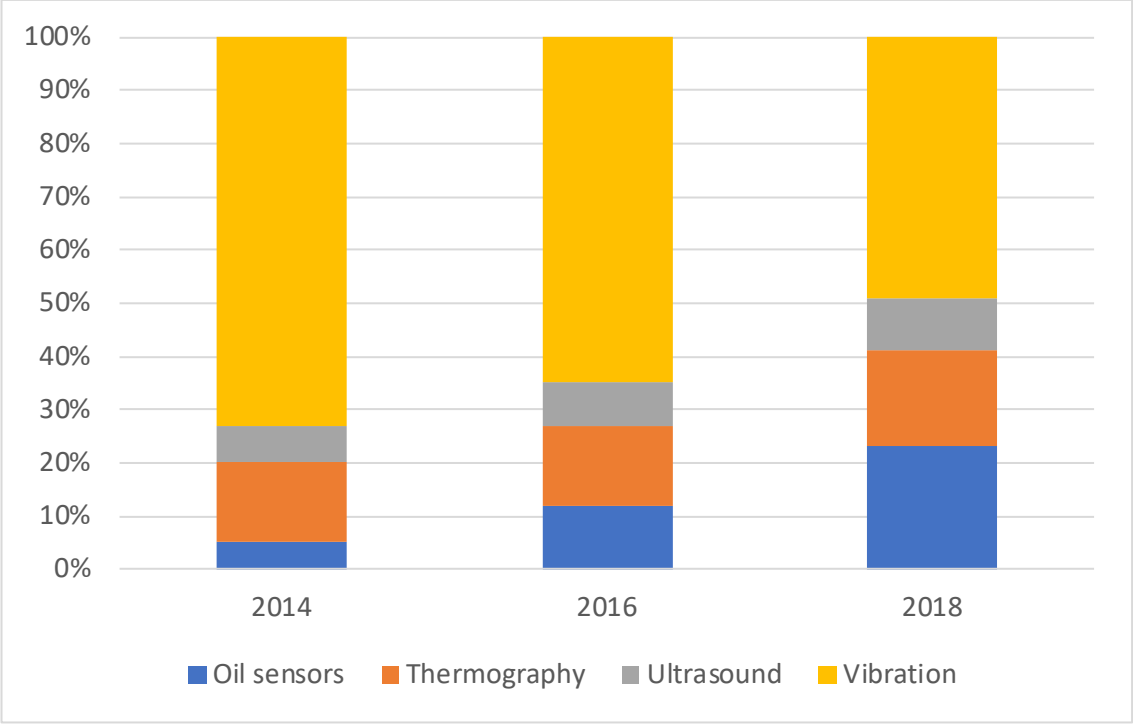
Issue 2

GILL

Modern Marketplace

Today a modern condition based monitoring (CBM) system may consist of many facets. Historically this space has been dominated by vibration monitoring, although this technology is now dropping market share when compared to other technologies. The largest gain in market share is oil sensing, which includes wear debris monitoring systems.



Source – Bureau Veritas SMRP 2019

One possible explanation for this is that operators are waking up to the fact that they need more than one point of reference to properly diagnose a fault with a particular piece of equipment. So operators with existing vibration programs are building their pool of data points through investment in oil sensing techniques. Many oil sensors will integrate seamlessly into existing vibration online monitoring controllers, maximising previous investments. It is also true that vibration sensing on low speed rotating assets is less effective than high speed assets. So it is also possible that more low speed gearboxes are being monitored, when compared to previous years.

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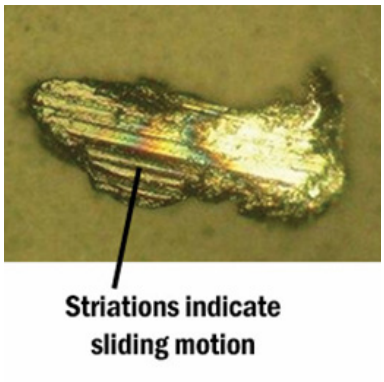
Technology History

Wear debris monitoring and wear debris analysis was first developed during the 70's and early 80's. The technology came to the fore in the market place in the 1990's and has been solidly established ever since. Modern processing and sensing techniques have allowed the proliferation of new smaller, low power, sensors which industry is adopting as the new standard, at an ever increasing rate.

Operational Theory

The principle is simple, contacting metal surfaces will start to break down, even at the most microscopic of levels. This is a simple fact of how gearboxes, bearings and engines work. Yes, we can reduce the friction between surfaces; oil and lubricant manufacturers are developing ever better grades and blends of oil to enable this. But what happens when a seal fails, water ingresses or the additives burn out and the lubrication properties are less than optimal?



Credit – Machinery Lubrication

Contacting surfaces start to break down for several different reasons. I'm sure you will have heard of friction, fatigue, fracture, impact and corrosion. Though this is not an exhaustive list, each of these causes of debris provides their own unique imprint when we examine a sample under a high-power microscope.

Now, in a perfect world, and looking for the absolute best result, we would take all the oil out of the machine leaving behind no residue. We would then examine each and every particle found in the oil and with absolute accuracy, identify what is happening inside the rotating asset.

You don't need me to tell you how impractical this approach would be.

Offline Analysis

The practical approach is to tap off a small sample of lubricant into a perfectly clean sample bottle, to avoid cross contamination, and send it to a lab for analysis. The drawback is that this sample, usually less than 0.5% of the total system lubricant volume, must contain debris representative of the whole lubrication system and overall condition of the machine. Therefore, the location from which the oil sample is taken, is critical to getting a good result.

Your lab will then examine this sample and provide you with a parts per million (PPM) count of any base metals as well as providing an overall assessment of the total metal content through a particle quantifier (PQ, PQI or FW) assessment. If necessary, they will examine the debris for the tell-tale signs of friction, fatigue etc. that we discussed earlier. The lab can then recommend an action based on the combined data from these results.

For the most critical business assets some operators pay specialist CBM companies to visit them, as regularly as weekly, to draw off oil samples for full lab analysis and trending. For most this level of investment is impractical, from a cash and often accessibility perspective. For example, could you imagine the cost and time implications of scaling multiple offshore wind turbines every week to take an oil sample!

Online Analysis

There is a growing trend within the world's largest manufacturing companies to augment this lab analysis with real time sensors. Many technologies exist to examine the volume and sometimes count of metal particles present in an oil system.

These real time or online sensors are looking to follow the trend of normal wear and inform operators as soon as the normal operating limits start to trend towards potential failure.

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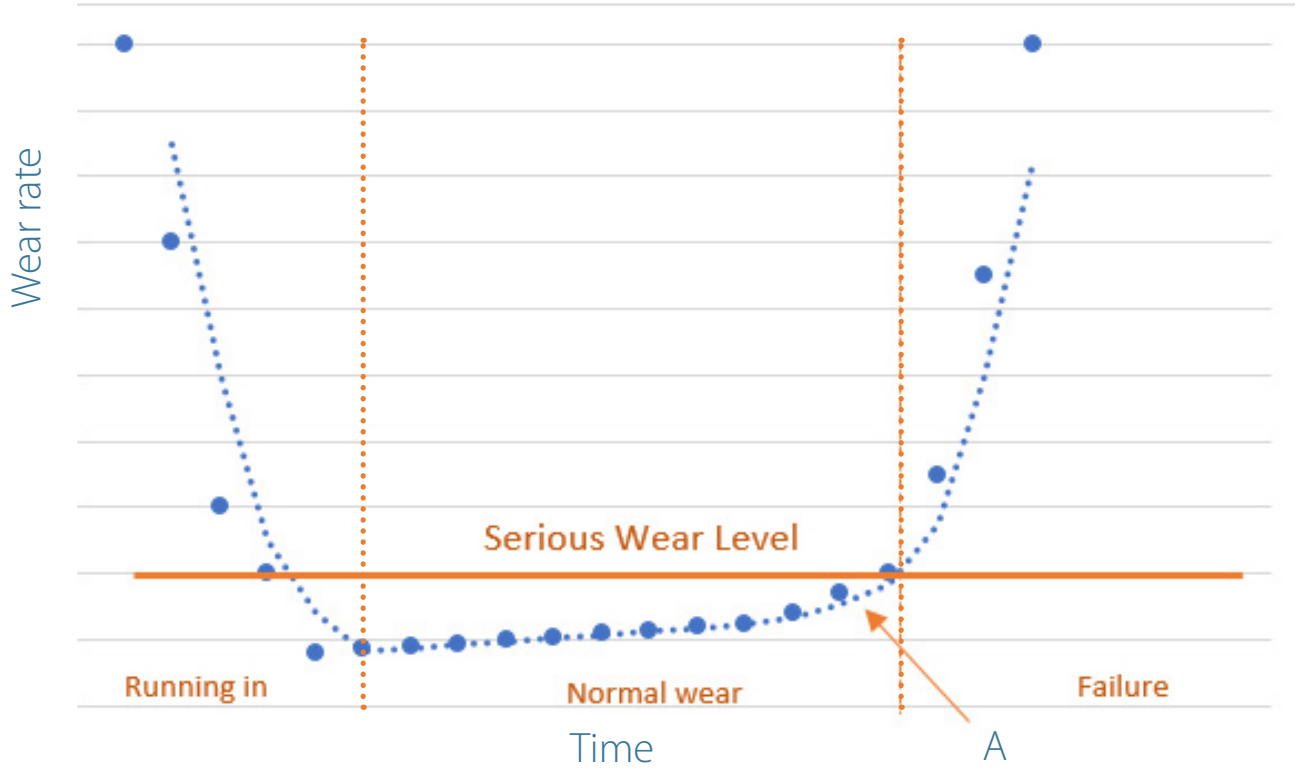
In the image below we see a typical "bath tub" curve as an asset moves from brand new to failure.



There will always be a period of high wear at the start of the life of the asset, or after a major rebuild, as the gear teeth polish against each other. This is known as running in or bedding in. After the initial running in period "normal" wear will occur. The critical point any operator needs to catch is the upward inflection of the line in the graph above, at the point marked A.

Real time sensors are crucial in pinpointing the inflection. Operators might get lucky and take a sample for lab analysis at this point, however the most likely scenario is that this golden window of opportunity will be missed and the machinery wear rate will inadvertently drift up the curve towards failure.

What a good online sensor will do is tell operators that a lab analysis sample should immediately be scheduled, outside of the normal 6 months to annual sample window, or perhaps just increase the frequency of oil sampling because

the duty cycle on a particular machine has increased. At the very minimum, a good hard look at a piece of equipment should be performed during the next planned shutdown. Approaching maintenance in this way can bring huge cost savings on all types of gearboxes where process is critical. For powerful 2 point, real time analysis we can overlay wear debris and vibration data in a complementary manner. In summary, catch everything, plan actions ahead and hit your uptime targets.

Any online/real time sensor is not a whole oil lab packed into a tiny box. If it were, oil labs would long since be a thing of the past. With any compact and affordable solutions there will always be constraints, but what an online sensor will do for us is provide continuous trend data of vital things like ferrous wear or particle count as it happens, giving us live machinery health information and advanced warning that something could potentially start to go wrong.

Final Summary

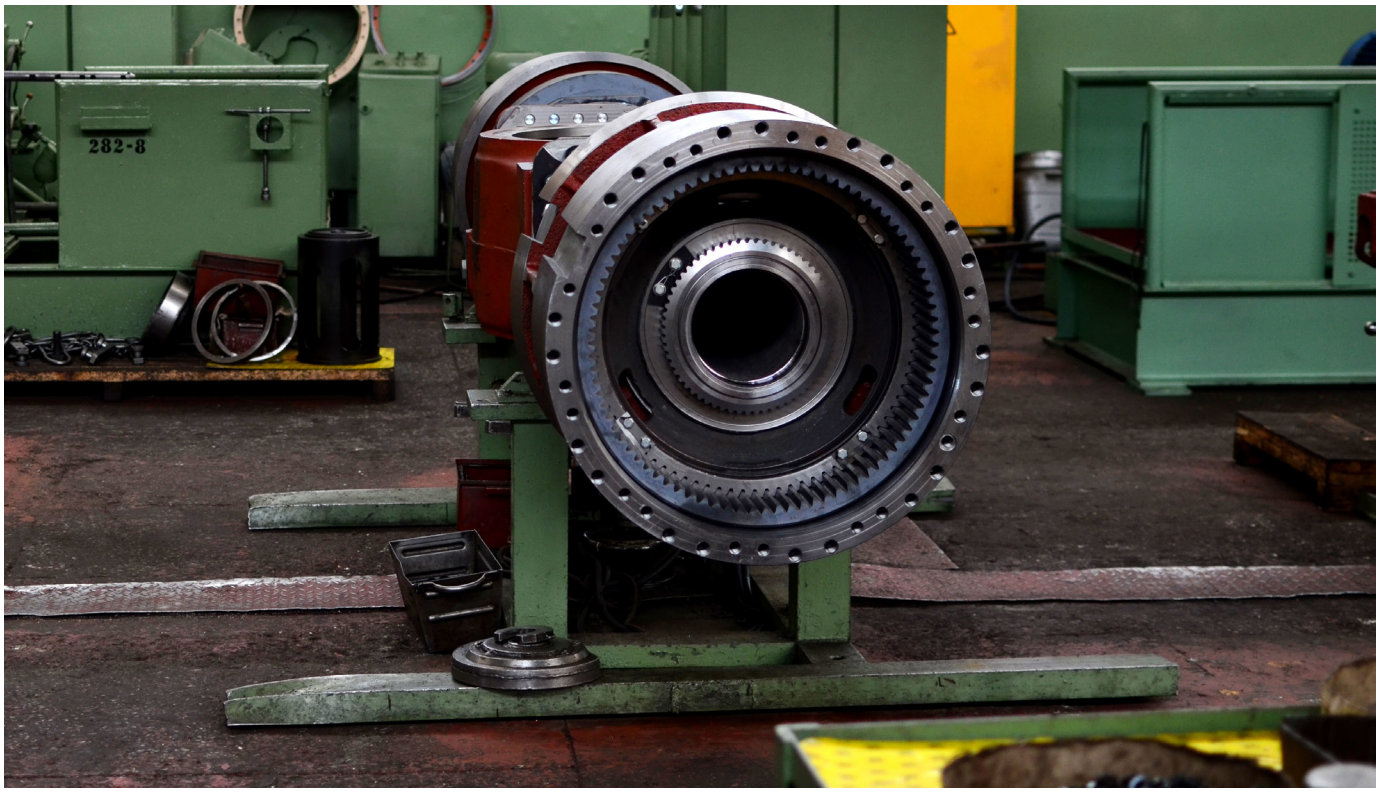
Wear debris monitoring should be the backbone of any quality CBM program. Independent market data is showing us that modern companies are investing significantly more in oil sensing and wear debris monitoring, compared to previous years. This could be related to the proliferation of instrumentation on low speed rotating assets, where vibration monitoring is known to be less effective.

With so many great tools and services available there couldn't be a more relevant time to be investing in online wear debris monitoring.

If you want to find out more about condition based monitoring and WearDetect Oil Debris Sensor take a look at our *Condition Monitoring: Reduce Downtime, Keep your Machinery running* video at gillsc.com/condition from **Gill Sensors & Controls Limited.**

References - The Wear Debris Analysis Handbook – B. Royland & T. Hunt

Case Study: Wear Debris Monitoring



Motor and gearbox drive system

The Background

April 2020 – Gill Sensors & Controls is proud to be part of the condition based monitoring program for one of the USA's original and most successful manufacturers of Aerospace components. This company can boast all the major aerospace and defence contractors on their list of satisfied customers, including NASA for whom they manufactured components for a space program.

In order to maximise the economic efficiency of the equipment the company operates it is essential for the plant to be running 24 hour per day. As in many industrial settings, if a machine is down and time is being lost then the financial penalties are often very heavy. The team at Gill recently learned of an extreme case in the pharmaceutical world whereby a gearbox breakdown of more than 30 seconds would cause lost revenues in excess of €5million due to the need to scrap a batch of cancer treatment drugs.

The Application

In one particular application, WearDetect Oil Debris Sensor was deployed on a steel grinding mill. This critical part of the manufacturing process operates 24 hours per day, however, the large planetary gearbox that the sensor is installed on is running at 50% duty cycle due to material loading/unloading times. Quite often this piece of equipment will operate for 6 months to 1 year before being stopped for scheduled maintenance tasks. The company has twin machines in order to manage the demand and maintain output, albeit reduced, when either machine is down for servicing.

Periodically the planetary gearboxes will require a rebuild, so in order to keep the machines running a third gearbox is held in rotation. Following a recent refurbishment, the gearbox currently on rotation was being instrumented and tested ready for approval for use on the main grinding machine. The gearbox was fitted with vibration Sensors and WearDetect Oil Debris Sensor. This approach of combining traditional vibration with the new generation of miniaturised oil sensors is becoming common place within industry. With this installation the operator decided to install WearDetect Oil Debris Sensor in the oil return line. The operator created their own adaptors to place the debris sensor probe into the oil flow. Gill now offers a specially designed 'in-flow' adaptor to optimise debris capture and make this type of installation quicker and easier.

Did you know?

Real-time analysis of oil condition has been identified by independent assessors as the fastest growing sensor technology in the condition-based monitoring industry.

Ref Bureau Veritas – SMRP Conf. 2019

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During testing, the operators noted that the 'fine' channel on the Gill device was registering the collection of some debris. For maximum accuracy, Gill recommends performing a custom calibration. In this case, however, the operators used the out-of-the-box settings which suited their application.

The 4-20mA signals from the sensor are read and displayed in the plant room however, the operator chose the premium version of the sensor with the local coloured LED display for a quick reference at the site of the gearbox.

The Results

On visual inspection of the debris sensor probe it was noted that the sensor had collected a number of shards of ferrous debris. Although the operator's adaptor, to fit the sensor into the oil line, was less than optimal it did collect enough debris to indicate the early stages of an issue. Gill's 'in-flow' adaptor has been designed to focus the debris collection to the tip of the probe, as debris attached to the side of the probe is outside the measurement region.

Whilst it is common for new and repaired gearboxes to generate debris during a bedding in period, these 'fine' debris readings were a cause for concern for the operators. When overlaid with vibration data a clear picture emerged that there was a potential issue with the rebuild of the gearbox.

The Value

Using the combined data from WearDetect Oil Debris Sensor and vibration sensors this operator was able to make the call to reject the gearbox before it was installed onto the main grinding mill. Imagine, if you will, a scenario whereby either of the gearboxes operating the grinding machines fail or require a major service. If the third rotation gearbox had been switched in whilst carrying a fault, the company could very quickly be left with only one operational gearbox out of the three that it owns. The company would also have lost a significant amount of engineering time to switch over the gearboxes, which can sometimes add up to days of effort. In a circumstance such as this the investment in condition based monitoring equipment could be repaid more than 10-fold through avoidable downtime.

This is a great example of how the combined data from the Oil Debris Sensor and vibration sensors can work together to get a better picture of a problem. On its own abnormal vibration from a refurbished gearbox could be put down to the rebuild, creating a new vibration profile. A trigger from the debris sensor alone could be put down to the new gears polishing. In summary, when these two great data sources are related, we have a powerful tool set for fault diagnosis.

Where to buy

Gill sells its products through a worldwide network of trained distributors, so you can count on the very best advice for your application.

For further information on the WearDetect Oil Debris Sensor range, including manuals and datasheets, please click below.

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