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COMMUNICATION HUB FOR THE WIND ENERGY INDUSTRY

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OFFSHORE SUPPORT SERVICES

DECEMBER/JANUARY 2014 - ISSUE 20 | £7.50

MONITORING WIND TURBINE PERFORMANCE THROUGH USED OIL ANALYSIS

Modern offshore wind turbines are sophisticated machines, operating in demanding environments. Unscheduled downtime caused by equipment failure can have a significant impact on the operator's bottom line and, in more severe climates where ambient temperatures can reach as low as -40°C, result in substantial delays to restarts. In order to keep wind turbines operating at full capacity, and to avoid the expense of unplanned maintenance, it is important to select the right lubricant.

INNOVATIVE TESTING

By using innovative tests to monitor the in-service performance of selected lubricants, maintenance professionals will gain the insight needed to optimise wind turbine operation and minimise unscheduled downtime. This article explores how a sophisticated oil analysis program can help address the challenges in wind turbine lubrication, looking specifically at the use of advanced synthetic gear oils in the main wind turbine gearbox.

USED OIL ANALYSIS

One of the most popular maintenance programmes being implemented is Used Oil Analysis, a series of laboratory tests that can determine the condition of equipment components and the condition of the in-service lubricant. Alongside the use of high quality lubricants, oil analysis helps maintenance professionals extend equipment component and lubricant life, provide early warning signs of contamination, and minimise unscheduled maintenance.

In order for O&M managers/engineers to improve productivity and potentially increase profitability through oil and equipment monitoring there are a number of elements to be considered.

START OFF WITH THE BASICS

There is a certain protocol that should be followed to help ensure the accuracy of oil analysis results. First, maintenance professionals should always use a clean, dry container to draw oil samples to ensure an accurate result. Most oil analysis companies will provide the sample bottles for the oil samples to be collected. Usually only 100 ml is sufficient for a standard test suite.

Wind turbine maintenance engineers should where possible draw the oil sample from the appropriate system (main gearbox or hydraulic system) whilst the oil is circulating. Where this is not possible the oil sample should be taken as soon as possible after the system has been shut down, ideally within 30 minutes.

It is critical to ensure consistency that oil samples should always be taken in the same manner and from the same sampling point. There are various system points where oil samples can be taken. Fixed sample points such as on filter units (prior to filtration) are common. If no sample points exist then consider fitting a sampling point. Oil samples can also be taken using a vacuum pump and tubing but take care to use the same length of tubing so that the oil ample is drawn from the same depth each time, which should be approximately midway of the oil level. The tubing is disregarded each time it has been used.

To identify the most appropriate sample point, it is imperative to consult with your oil analysis provider and machine manufacturer for application-specific advice. Once the location has been identified, it should be noted in the maintenance records so samples can always be taken from the same place.

Also, do not sample a turbine immediately after an oil change or after a large amount of make-up oil has been recently added unless the purpose is to just to confirm the oil cleanliness, which can indicate if the oil change has been carried out in a clean manner.

PUTTING OIL TO THE TEST

For many years ExxonMobil has been tracking their advanced synthetic gear oil in the main gearboxes of a wide variety of wind turbines, including different models, sizes and those exposed to many different challenging environments. From January 2000 to August 2013 data on approximately 46,700 oil samples was reviewed. When characterising the performance of the lubricant, an in-depth test slate is usually run. However, in this review the focus was on system wear, oil oxidation stability, viscosity retention and water contamination – the most relevant tests for determining proper gearbox operation. The used oil tests listed below trace the results of using ExxonMobil's advanced synthetic gear oil, Mobilgear SHC™ XMP 320, in the main wind turbine gearbox.

WEAR AS INDICATED BY THE PRESENCE OF IRON AND OTHER METALS

Inductively coupled plasma spectroscopy is used to determine the presence and concentration of wear metals in oil. Iron, copper, chrome, aluminium, lead and tin define this category, with iron the predominant wear metal in wind turbine reducers. As shown in Figure 1, ExxonMobil examined the iron content of 32,000* samples, showing no trend for iron content increase with the used age of the oil, thus verifying the excellent long-term wear protection provided by the lubricant.

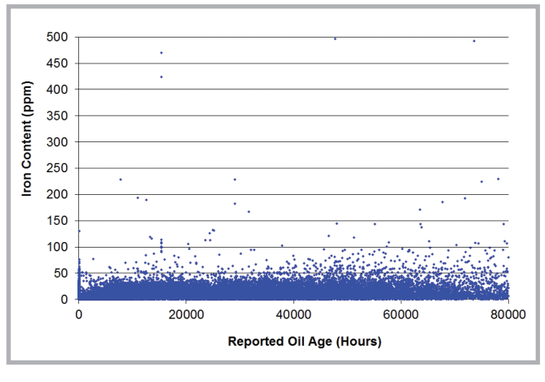

Figure 1 – Iron Content Vs Oil Age

VISCOSITY RETENTION AS AN INDICATOR OF FILM STRENGTH

Viscosity is a measure of a fluid's resistance to flow and most used oil analysis laboratories report it as kinematic viscosity at either 40°C or 100°C. ExxonMobil found that there was no oxidative thickening or shear over time, suggesting the lubricant stayed in viscosity grade throughout the reported service (Figure 2). This is an important finding as it confirms that the oil is able to maintain film strength and provide excellent wear protection throughout its service life.

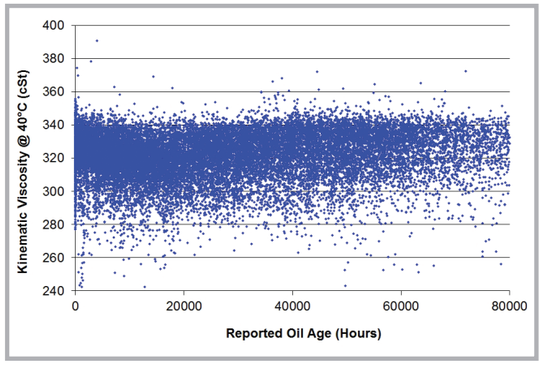

Figure 2 – Kinematic Viscosity Over Time

OIL OXIDATION AS DETERMINED BY TOTAL ACID NUMBER

As oils oxidise over time, chemical change occurs and acid number of the lubricant can rise indicating the lubricant starts to break down. The Total Acid Number (TAN) is the amount of potassium hydroxide in milligrams that is needed to neutralise the acids in one gram of oil and is used as one of the indicators that a lubricant needs changing. As the TAN value of the oil increases, viscosity rises and the lubricating potential of the oil is compromised, leading to increased wear. In addition, the corrosive tendencies of the oil will increase, further exacerbating component wear.

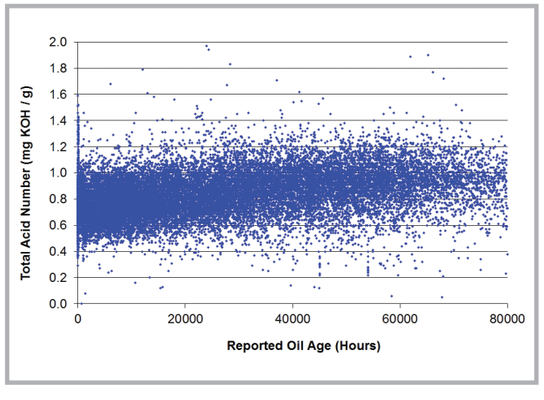

Figure 3 – Total Acid Number over Time

In Figure 3, ExxonMobil examined the results of the samples, demonstrating that over the extended lifetime of the product (3-5 years) TAN shows very little increase over the new product value of 0.9 mgKOH/g (some scatter is evident due to test variability). This means that the life of the advanced synthetic lubricant was not impacted by turbine gearbox operation.

SERVICE WATER LEVELS AND WEAR POTENTIAL

Water as a contaminant is most relevant as its presence may cause additive depletion, viscosity drop and corrosion of components. Figure 4 shows the water concentration in the oil over time, with exceedingly low levels of water in the oil, ensuring no free water and thus protecting against potential corrosive wear. This indicates that certain high performance synthetic lubricants can help reduce downtime and help prolong service performance.

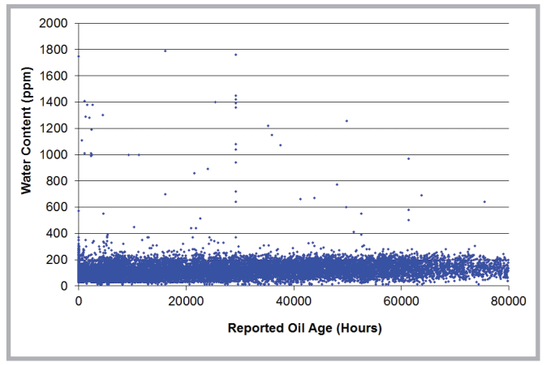

Figure 4 – Water Concentration Over Time

LONG-TERM SUCCESS

By following the recommendations and some of the key in-service oil analysis tests detailed in this article, maintenance professionals can benefit from optimised equipment performance, minimised maintenance and improve turbine availability. Selecting an oil analysis provider that has application-specific expertise, intimate relationships with OEMs and a comprehensive online oil analysis offering will also help maintenance professionals achieve their company's productivity goals as well as their own.

** 32,000 samples with stated running hours*

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