WIND STATS NEWSLETTER

Vol. 23, No. 3
Summer 2010
ISSN 0903-5648

WindStats Newsletter
P.O. Box 1623
DK-8250 Egaa
Denmark
Tel: +45 8636 5900
Fax: +45 8622 1850

Subscription rates

Full Service Subscription: Four issues of *WindStats* a year, plus twelve issues of *Windpower Monthly* a year (includes full access to *Windpower Monthly's* online article archives).

Basic Subscription: Four issues of WindStats a year, plus twelve issues of *Windpower Monthly* a year (online article archives access not included).

(Prices US$/Euro)

	One year	Two years	Three years	Four years
Full service	688	1239	1754	2200
Basic	471	860	1210	1518

(Euro prices include VAT)

Printed in the UK by Stephens & George Print Group, Merthyr Tydfil, Wales, on 100% vegetable soya based inks on paper from sustainable forests.

WindStats is published by Haymarket Business Media, 174 Hammersmith Road, London, W6 7JP

Benefits of lubricant analysis in wind turbines

BY EIZE DE VRIES

In 2009 about 85% of all wind turbines installed around the globe were fitted with a gearbox, a key component in so-called gear-driven systems. The dominant role of these wind turbines has remained largely unchanged for years, with an average 82-86% global share (MW based). The only mature alternative to gear-driven systems has been the direct drive (no gearbox) configuration. That segment has been dominated by one player: Enercon of Germany, since 1992. But recently another source has made its presence felt: China's Goldwind.

Premature failure

But wind turbine gearboxes have a notorious reputation for their lack of long-term reliability and continue to be prone to premature failure. According to wind industry statistics, average operational gearbox lifetime—depending on make and model—seems to be limited to about ten years. Despite the years of awareness of these problems, there are still numerous cases for the need for repeated premature gearbox exchange. In some cases these happen as frequently as only having been operating for one to three-years. Gearbox exchanges are not limited to any specific wind turbine make or model, but some suffer more than others. They are an industry-wide fact of life. Considering they are designed for a 20-year operating lifetime, this thorn in the side of the wind industry is still having a substantial impact on wind turbine reliability and the industry as a whole.

Early gearbox problem detection could save turbine operators considerable sums of money. To start with, early detection could help avoid lengthy downtime if remedies are planned ahead of time. This could also be beneficial to the gearbox and wind turbine suppliers since early detection may help prevent catastrophic and costly failures from developing down the line. It should also be noted that early detection and proper communication usually contributes to maintaining good working relations between all involved parties and for maintaining their reputations.

For reasons of their own, wind farm owners and operators consider it essential to obtain detailed and reliable information on the actual technical status of their gearboxes. This information should incorporate a predictive capability that signals the earliest signs of failure issues and on available and reliable historic data.

End of warranty

Having reliable data readily available can also prove essential in cases where a dispute has developed between a wind turbine owner/operator and the gearbox supplier. These types of disputes generally boil down to two key questions: who is to be held legally responsible, and who is to bear the full or partial cost of fixing the problem.

Independent specialists can play a role, not only for analyzing problem causes but also in preventing lengthy and often harmful court cases between the involved parties, who will likely have to work together once the issue is settled.

One of the most critical legal periods during a wind turbine's operational life is when the installation approaches its end-of-warranty period. The warranty period is typically two to five years, during which the original equipment

In This Issue

manufacturer (OEM) is responsible for the turbine's upkeep. The OEM's obligations, depending on warranty contract terms, usually incorporates bearing all costs for remedying failures and often also provides financial compensation for loss of energy production during downtime. Once the warranty period expires, the legal responsibility for turbine upkeep usually shifts from the OEM to the owner/operator.

In practice, though, gray areas often come into play after the warranty period ends. These gray areas can manifest themselves as questions such as: who should be held responsible if a gearbox fails within, say, a few months (and sometimes even years) following the warranty's expiration? Many wind experts are in agreement that this type of question is, by definition, a complex one to address, both from a technical and legal point of view. Perhaps the single most important reason for this is that certain gearbox issues have 'incubation periods' that take time to manifest themselves before more concrete problems can be identified.

Oil filter content analysis

Two Dutch firms, DeltaRail BV and Windkracht Beheer, joined forces in 2001 with the goal of developing a reliable and effective oil filtration-based method capable of determining actual gearbox condition and historical trends-based predictive data.

DeltaRail's predecessor was founded around 1890 as a 'technical support group' within the newly established, state-owned Dutch railways. The group's main responsibility soon evolved into addressing a wide variety of technology-related issues including component failures within locomotives and train wagons.

The chief causes behind these component and systems failures often turned out to be linked to inadequate lubrication and/or a combination of insufficient lubricants. At the same time, demand was gaining for much-improved insight into new, advanced methods that could extend component life.

An initial focus point for technicians was a sustained effort to substantially increase the time between oil and grease service intervals. This effort led to the introduction of improved lubricants with superior performance as well as adapting components and systems to more adequately meet operational demands.

The main incentive for developing better lubricants was based on the fact that trains often traveled as many as 300,000 kilometers a year, thus requiring frequent servicing—a costly and time-consuming affair.

Lubricated systems

From his Utrecht-based oil laboratory, lubrication technical consultant Gerrit van Middelkoop used this historical example to illustrate that professional upkeep of mechanical systems is not a new concept. "Our lab has specialized in condition monitoring of lubricated systems in a wide range of industrial machinery and appliances for decades.... We currently conduct structural third-party machinery monitoring services on over 6000 individual systems."

Van Middelkoop adds that a key factor for success was proven through the extensive cooperation and information exchange between the organization's chemical specialists and technical lubrication experts. "The most important benefit was that the long-term efforts resulted in high-level, theoretical and applied expertise regarding oil filtration sample analysis and the interpretation in linking specific metal deposits to specific machine damages."

Today, the original state-owned railway's technical support group owner is UK-based DeltaRail Group, which is active internationally and employs a staff of 450.

Windkracht Beheer has accumulated over two decades of experience in the upkeep of industrial installations and since 1992 has also specialized in wind turbine technical inspections and wind farm upkeep. Through his daily involvement with wind turbines, company owner-director Aad Hijdra regularly came across serious gearbox issues, including catastrophic failures. Dissatisfied with the then current oil analysis methods used in the wind industry, he approached DeltaRail in 2001 for assistance. His main aim was to find a better method to determine the actual condition of wind turbine gearboxes with the aid of advanced oil analysis and reinforced by professional interpretation.

Oil filter deposits analyses

By means of their combined talents in oil analysis and their wind industry technical expertise, the new partners decided to build on a tried and tested DeltaRail method. A key feature of this method is that metal particle deposits that accumulate in the main oil filter are analyzed for their origin, size, shape, color and, if necessary, also materials characteristics. They then put the technology into practice and continued refining the methodology between 2001 and 2005, which they claim has proven its worth many times over in a range of Dutch and Belgian wind projects. The track record involves both the analysis of the main causes behind multiple—often highly complex—gearbox failures and in early-stage detection and accurately predicting failures in the making.

The partners say that on specific background aspects linked to oil sampling: "It is essential that oil samples are always taken at the same spot within a lubrication system in order to guarantee a representative, systematic and standardized sample-taking." Unfortunately, in real-life practice this is far from standard in the industry. For instance, if oil samples are taken at random, non-standardized locations within the lubrication system, it can result in substantial differences in the size of particles and quantity actually found. They refer to one example of a faulty gearbox where an oil sample taken by a manufacturer showed it to be completely clean, but the particle content in the filter told a totally different story. An analysis of the main causes behind the large discrepancy revealed that lubrication oil flow within the gearbox was so fast that metal particles simply did not have time settle and therefore remained undetected.

Magnetic plug

Another method is to analyze metal deposits that have accumulated and settled at the magnetic plug located in the oil sump. However, their positions are non-standardized and can be located on the sides or bottom.

According to Hijdra and Van Middelkoop, the first step to take with any

Condition monitoring systems

In order to gain improved insight in to the condition of gearboxes and other main components, the manufacturers of the original equipment are increasingly fitting their wind turbine with condition monitoring systems (CMS). These advanced systems usually comprise a number of sensors and additional instrumentation such as a gearbox metal particle counting device fitted somewhere in the lubrication circuit. The sensors are fitted at function-critical places within a turbine drive system, like the main rotor bearing, generator bearings, and various gearbox spots. They typically monitor actual temperature and/or vibration levels. A second common built-in CMS capability is the ability to record changes to initial temperature and/or vibration levels known as reference values. Metal particle counting devices can also form part of a CMS.

gearbox damage is to try to establish the prime cause and problem source. For this, endoscopic gearbox condition or damage inspections are quite common in the wind industry. "In our opinion, the real added value of this method is limited. The main reason being that a majority of the bearings of both low-speed and medium-speed planetary gear stages cannot be inspected because they are located largely out of view," say the partners.

In support of their own methodology, they argue that a majority of modern wind turbine gearboxes are fitted with a so-called full-flow main oil filter, and/or a partial-flow by-pass filter. A full-flow filter can be viewed as a kind of funnel that accumulates any metal or non-metallic deposits that have entered the lubrication circuit somewhere along the line. Some of the main contributing factors—and also essential preconditions to the success of oil filtration analysis—are oil filter exchange by independent technicians and properly identifying and marking each filter. The latter is essential when inspections are being conducted on multiple turbines in a wind farm.

Proof of principle

Early trials with the new oil filtration method were conducted in 2001 at the request of a Dutch client for four of its 750 kW wind turbines. Two of these were suspected of being headed for a gearbox failure. "As part of this end-of-warranty gearbox inspection we removed the oil filters and analyzed the content in DeltaRail's lab," says Hijdra. Analysis results confirmed that the two suspect gearboxes were indeed showing signs of developing major problems that would likely result in gearbox failure. Early signs of component degradation in the two remaining units were also detected.

The wind turbine supplier as well as the gearbox supplier confirmed similar inspection results on the first two units and the gearboxes were exchanged. However, both the turbine supplier and the gearbox supplier denied that similar problems were developing in the gearboxes of the other two machines.

"We did record all our main findings and conclusions on the condition of the four turbines in a detailed report for the client," states Hijdra. "Two years later the remaining two gearboxes did, indeed, develop similar failures. The client went to court and won the case supported by our data."

In another more recent end-of-warranty example, an owner of a 2 MW-class turbine called for a detailed gearbox inspection. The unit had already been exchanged twice within a five-year period, recalls Hijdra. "Prior to the inspection, the client had reported evidence of gear surface damages (micro-pitting). Due to the fact that this turbine make/model was relatively unknown to us, we decided on a comprehensive, multi-pronged strategy involving the analysis of both full-flow and by-pass filter contents." Additional samples were taken from the oil sump's magnetic plug, oil dipstick and sump inside bottom section. "The main filter, which was only two months old, was already filled up with deposits," he adds. "Analysis of the contents revealed a combination of low-grade steel and brass particles originating from bearing roller casings, a clear sign that things were indeed very wrong inside."

Interpretation crucial

Conducting a professional and accurate oil analysis is only one side of the coin, argue Hijdra and Van Middelkoop. "Some 'routine' oil labs have specialized in rather standard routines whereby oil samples are only being processed with standard oil analysis equipment. But in our view real added value can only be provided by a combination of dedicated equipment and simultaneously being capable of offering clients high-level, in-house capabilities for essential oil analysis results interpretation."

They quote having come across several highly complex gearbox failure cases where it proved necessary to also study the original engineering drawings.

Hijdra and Van Middelkoop stress the importance of a systematic wind turbine inspection project approach. "Each new inspection should commence with an inventory of the site-specific situation including a list of the turbine's main specifications and the main features characteristic to a given make and model. Second, the inventory must include all key variables such as location-specific environmental factors and sometimes even tower height as a system dynamics influencing overall factor. Perhaps most important in the entire process chain is to never make the mistake of solely relying on past experience and standard routines since each new project requires a dedicated, custom-developed approach."