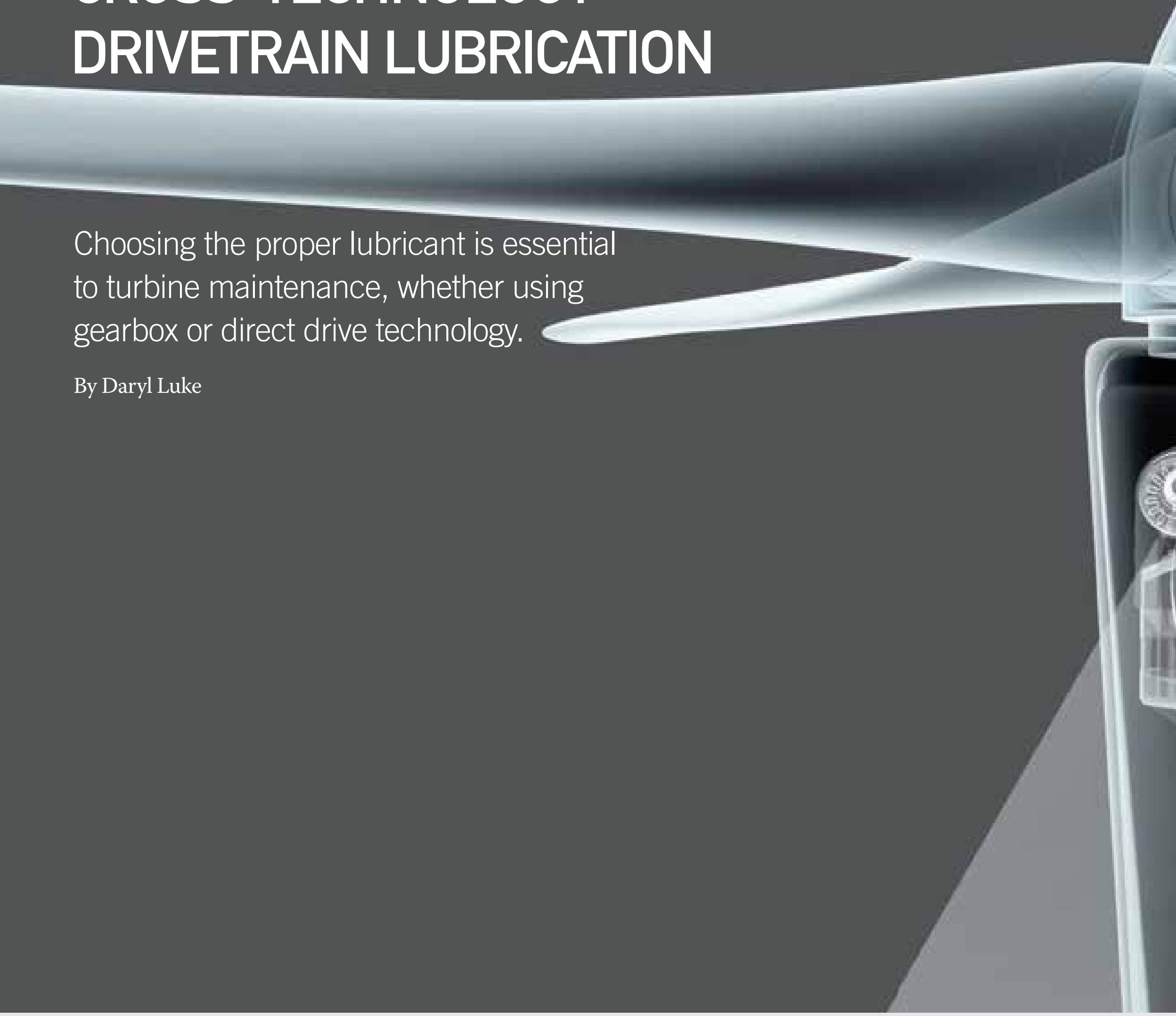
CROSS-TECHNOLOGY DRIVETRAIN LUBRICATION



Choosing the proper lubricant is essential to turbine maintenance, whether using gearbox or direct drive technology.

By Daryl Luke

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WIND POWER CONTINUES TO GROW despite the global economic turndown and predictions are that wind power can meet 8 percent of the world's electricity consumption—compared to 2.26 percent today.

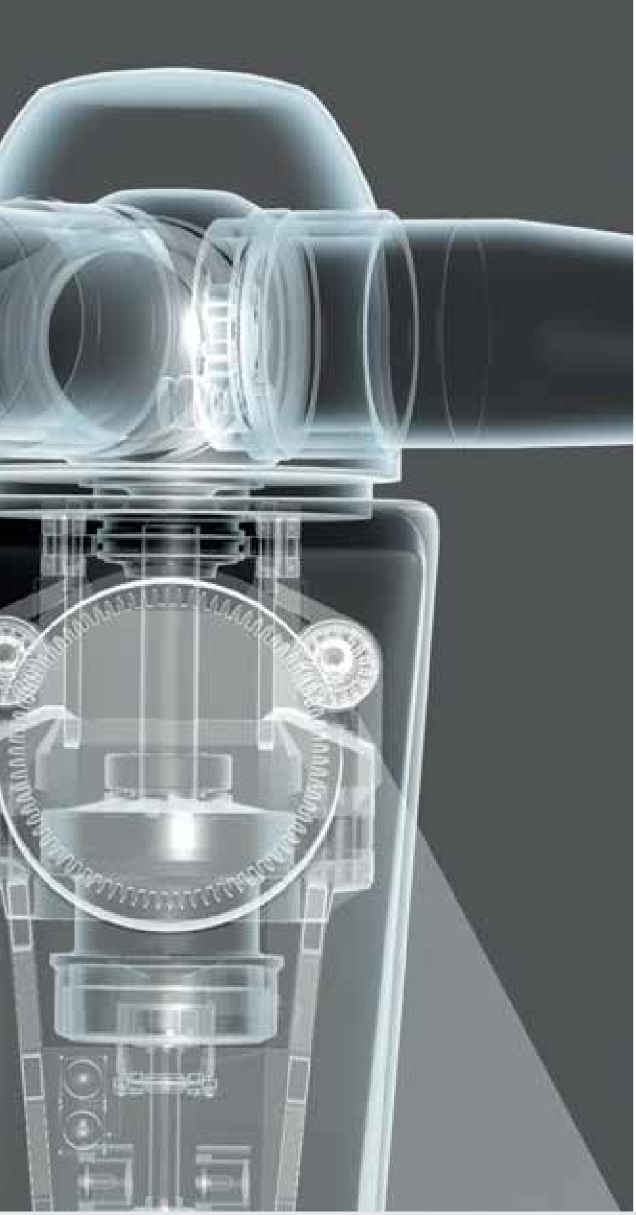
Growth rates will slow in coming years compared to the end of the previous decade, but these are still well above industrial norms.

Offshore wind turbine installations also will increase over the next few years, as turbine manufacturers and operators minimize the land environmental impact.

This growth is good news for suppliers to the wind industry such as lubricant manufacturers. However, with this growth technological advances in wind turbine designs and the increasing search for locations with higher wind speeds—including offshore options—mean that turbine manufacturers must constantly keep pace, which in turn is placing more stress on the lubricants used.

TYPES OF WIND TURBINES—DIRECT DRIVE VS. GEARBOXES

Essentially in wind turbines there are two main ways of transmitting power from the blades into electricity—through either a gearbox system or a



direct drive system (some systems have both, often called "hybrid systems"). The former being oil-lubricated and the latter normally grease-lubricated.

Opinions vary on which type of system is the more favorable considering the inconsistency of information in the public domain. However, gearbox turbines provide the majority of systems (approximately 79 percent) currently commissioned and in service, although the proportion of direct drive systems is expected to increase in the near future.

Direct drive turbine useage has grown from around 18 percent in 2006 to 21 percent in 2011; and this is expected to climb to 29 percent by 2020, with wind turbine manufacturers such as Siemens and GE shifting from gearbox turbines to permanent magnet direct drive turbines [1].

As gearbox turbines continue to dominant the wind market focus in this article is given to those systems.

GEARBOX DRIVEN WIND TURBINES

With the relatively high stress on wind turbines (e.g. high wind conditions and emergency stops), the right choice of lubricant is crucial to the smooth running of gearboxes and the overall performance of turbines. Indeed, investing in the right lubrication could help to save a typical operator managing 50 wind turbines up to $250,000 year-on-year.

To identify the right lubricant, operators need to initially understand what can go wrong with the gearboxes. While it is true that the causes behind many failures are the way the gear meshes and bearings are aligned, the choice of lubrication can have a major impact of failure rates.

MICROPITTING

Micropitting is surface fatigue that can result in micro-cracking and the formation of minute micropits which can sometimes give a metal surface a frosted or grey appearance. In some instances, micropitting can cause whole gear teeth to break off.

Although micropitting accurately describes the appearance and mechanism of the problem, it is sometimes also referred to as fatigue scoring, flecking, frosting, glazing, grey staining, microspalling, peeling, and superficial spalling.

This condition occurs under mixed-film elastohydrodynamic lubrication (EHL)—where oil film thickness is of the same order as surface roughness average, and where load is borne by surface asperities and lubricant. In addition to contact stress due to normal loading, sliding between gear teeth causes tractional forces that subject asperities to shear stresses.

Micropitting is complex, unpredictable and difficult to control, despite extensive research on the problem. That said, there are ways to help prevent it happening in the first place. Engineers should maximize lambda (using a thicker film to coat the gear teeth and prevent them from touching), optimize gear geometry, optimize metallurgy, optimize lubricant properties, and protect surfaces during running-in.

Testing of different lubricants can actually show how micropitting can progress with inferior lubricants. Figure 1 shows how lubricants can performance under speed and load, giving rise to potential catastrophic pitting.

BEARING FAILURE

Bearings are among the most important components, but are often very fine and can damage easily. In particular, the bearings which support the shaft that holds gear teeth in place have very fine tolerances and can be damaged by even small particles.

The potential causes for bearing damage are numerous. For example, working beyond the original design specifications, speed, load, and temperature could all change due to the varying requirements of a site. Also, careless handling and seals that are too tight can cause insufficient bearing clearance while inadequate or unsuitable lubrication can also cause failure.

Damage can be split into two categories. In the first instance, primary damage occurs. Signs of primary damage include: wear, indentations, smearing, surface distress, corrosion, and electric current damage .

Primary damage can then lead to more serious secondary damage, including flaking and cracks—which can ultimately cause equipment failure. Even at the primary damage stage, bearings may have to be scrapped because they are causing excessive internal clearance, vibration and noise. Most failed bearings show signs of both primary and secondary damage. Another issue that can shorten bearing life is the impact of wear particles from the gear box,such as those emitted from micropitting.

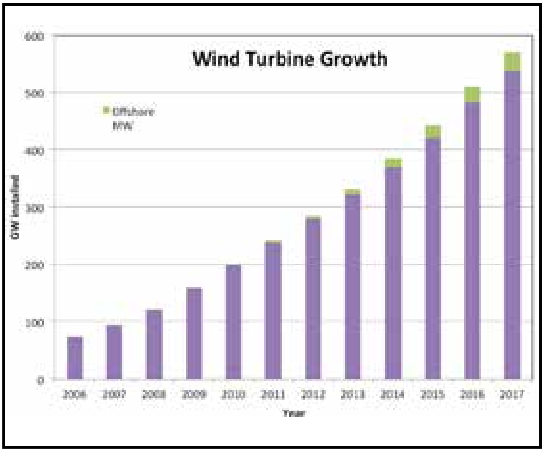


Figure 1: Wind Turbine Growth.

FOAMING

Foaming most likely occurs during periods of high wind, when the turbine is operating at high speed. These higher loads cause severe churning, pushing air into the oil. This means the lubricant doesn't pump or circulate, reducing its effectiveness. Additionally, this can cause oil level fault alarms, which could lead to the turbine being stopped at the most favored time for energy production, and unnecessary climbs for maintenance crews to investigate.

GEARBOX LUBRICATION

Proper lubrication is one way of helping eliminate many challenges that occur in goth gearbox and overall turbine maintenance. Using an inferior lubricant for turbine maintenance can save money in the short-term, but can cause risky long-term effects. Potential annual cost savings resulting from the switch to an appropriate gear oil is estimated at up to $5,000 per turbine. This takes into account associated reductions in the typical number of oil changes, as well as labor and parts cost savings. If you include potential lost revenue due to turbine downtime and the cost of fully replacing a gear box, the savings could be considerably higher.

DIRECT DRIVE WIND TURBINES

Direct drive systems do not use a gearbox. Rather, they offer slow movement of all the parts of the wind turbine's systems, resulting in reduced wear and tear of the system and superior reliability. Direct drive turbines have been in the wind power market for a long time, but have risen in popularity in recent years due to the issues explained above for gearbox-driven turbines. Direct drive turbines been quoted to be more reliable than gear box systems. However, there are drawbacks to direct drive systems, as explained below.

GLOBAL AVAILABILITY

There are some concerns regarding the global availability of rare earth metals used to make the magnets in direct drive systems. China, which supplies about 95–97 percent of the global demand, introduced export quotas in 2004, and later a 40 percent cut in the quota in 2010, for various reasons such as:

- Environmental considerations – Reports of toxic pollution surrounding rare earth mines.
- Increasing domestic demand – Chinese demand is forecasted to exceed the average global rate of growth.
- Conservation of resources – Aiming to slow the rate of exhaustion of Chinese reserves.
- Encouragement of higher value manufacturing investment - Export taxes and quota restrictions resulting in rare earth products cost up to three times more for firms outside China than domestic ones. This may be intended as an incentive to foreign manufacturers to relocate to China and invest in the Chinese higher-value manufacturing industry.

Alternative sources are expected to become available from the U.S. and Australia by 2014, and are predicted to help meet the anticipated global non-Chinese demand. However, the expected increase in use of electric vehicles (which also

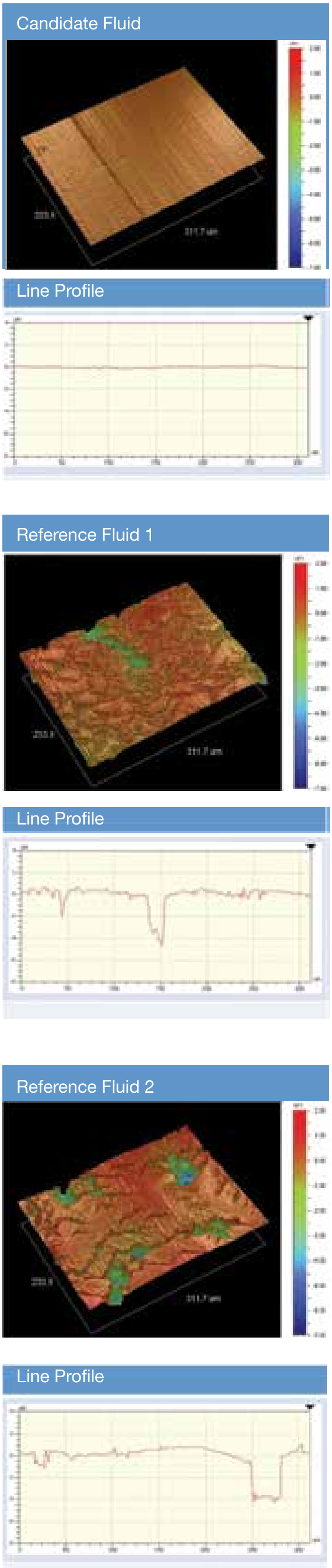


Figure 2: Comparison of 3D Optical Microscopy and Profilometry1/2 Area 3 (=230 x 310 um^2

require rare earth minerals) will likely contribute to an increase in demand.

NOISE GENERATION

The blades on direct drive turbines turn faster and generate more noise on average when compared to gearbox-driven turbines. This can be an issue on land, but is less of an issue for offshore turbines.

INDUSTRY IMAGE

Direct drive systems, given the noise and rare earth ecological aspects, are seen to go against the industry image of socially responsible, sustainable, and environmentally-friendly electricity generation, when compared to gear box technology.

COST AND WEIGHT

In the past, direct drive turbines have been slighted due to higher costs and heavier nacelle weight when compared to gearbox-driven turbines. However, in recent years several turbine manufacturers have been researching emerging direct drive technologies with significant reductions in weight and (until recently) reduced costs.

DIRECT DRIVE LUBRICATION

Lubricant selection is more standardized for gearbox systems than direct drive systems, as industrial gear oils are fairly well specified and can be used in gear boxes produced by varying OEMs. Conversely, the greases used in direct drive systems appear to be less well-defined, leading to a plethora of greases for similar applications and direct drive producers.

HYDRAULIC DRIVE TRAIN

Although the two primary types of wind turbine drive train systems are described above, hydraulic technologies have been introduced in recent years. The advantages of hydraulic drives are:

- Very compact nacelle
- High torque/weight ratio

Disadvantages are:

- Emerging technology has yet to be proven or widely adopted for the wind industry
- Unknown reliability for wind applications
- Asset Earning Power (AEP) unproven

With wind energy continuing to grow, further technological advances like hydraulic drives will likely be introduced. However, the high costs of testing—especially in offshore applications—mean that the speed of introduction could be relatively slow.

CONCLUSION

Whatever system is used, the proper lubrication can help to enhance performance, lifetime, and productivity, as well as reduce downtime. All of this can help to deliver commercial benefits and competitive advantage. With increasing pressure on turbine machinery to work harder and last longer, lubrication remains as important as ever as a key function of wind turbine maintenance.

[1] Global Data. Wind Turbines Go Back to Basics, Nov 28, 2012