north american WINDPOWER®
Reprinted with permission from the June 2008 issue

Solutions For Turbine Component Protection

The use of specialty lubricants in wind power generators can ensure higher reliability of units with minimal associated costs.

BY ARI-PEKKA HOLM & PETER MAGES

Wind turbines have seen rapid development during the past few years, and lubricants are of particular importance in this context. Lubricants play a vital role in ensuring that the components conform to the operating requirements of the wind turbine. Standard lubricants are often not able to keep up with the continually increasing performance expectations. An overview of the specific tribological requirements for several important wind turbine components and the benefits of using special, high-quality lubricants are provided herein.

Operating conditions

The main task of lubricants in a wind turbine is to ensure reliable operation of the machine elements. The elements face extreme environmental conditions which consist of dynamic, high-specific loads, vibrations, fluctuating temperatures and variable duty cycles. The risk of corrosion is always present from high humidity. At offshore locations, conditions are worse, and maintenance often cannot be provided in a timely manner.

Several factors should be considered when choosing suitable lubricants for wind power plants. Grease, for example, should be easy to pump and allow precise metering in centralized lubricating systems. Also, good wear protection under vibration increases bearing life during periods of idleness. When the power station runs at low speed, wear is provoked due to the lack of a sufficient hydrodynamic lubricant film.

Therefore, a good lubricant must contain suitable additives to counteract these effects. Furthermore, the lubricant's compatibility with elastomers and service temperature range should be considered. A common operating temperature of approximately 90 degrees C and a service temperature range of minus 40 degrees C up to 150 degrees C result in extended relubrication intervals. Experience has shown that commodity lubricants cannot meet the expectations of the wind industry. For this reason, more powerful special lubricants have been developed for the individual lubrication points.

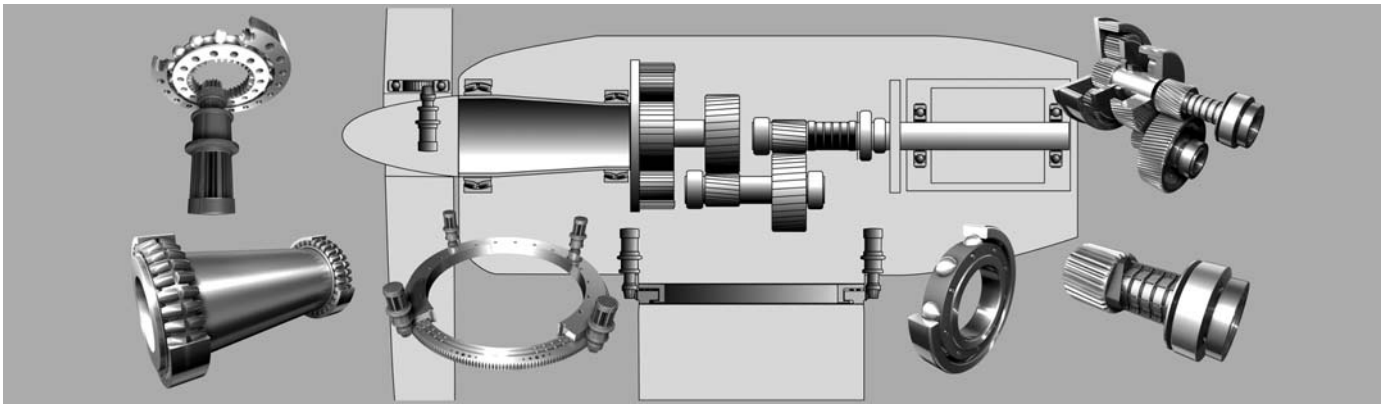
Consistent (lubricating grease) and fluid (lubricating oil) lubricants are used in wind turbines. Important lubrication points are the main gear, the main and generator bearings, the blade bearings and gear drives, and the yaw bearing and gears.

The increasing performance requirements of wind turbine gears have led to higher loads and temperatures in smaller spaces. Therefore, the main gearboxes of wind turbines are generally lubricated with synthetic oil. It should be noted that different base oil types – polyalphaolefin, polyglycol or rapidly biodegradable ester – are used to formulate these gear lubricants. Experience gained with standard synthetic lubricants has shown that these products cannot always meet the high requirements in terms of wear protection, micro-pitting and foam resistance, and residue formation.

However, special synthetic, high-performance gear oil offers higher aging resistance, improved load-carrying capacity and lower friction values. Compared with standard gear oil, special synthetics reduce temperature and power losses while improving service life and economical operation. These advantages contribute considerably to increasing the efficiency and energy output of a wind turbine.

Economical choice

The characteristics and performance of special gear oil offer significant benefits and cost-savings potentials. Improved reliability of the gears results in fewer unexpected repairs and less machine downtime. Lower oil consumption reduces the



Wind turbine components, shown here, require special wear protection. Illustration courtesy of Kluber Lubrication

strain on valuable resources, and longer service life allows cost savings due to lower purchasing and disposal volumes.

The savings potential offered by gear oils can be demonstrated by comparing the costs for the lubrication of the main gears of an average wind power plant while taking into account oil costs, gear maintenance and plant efficiency. Using high-performance gear oil allows significant savings compared with mineral oil.

Bearings

The essential bearings of a wind power plant (main, generator, yaw and blade bearings) operate under different conditions and pose different requirements regarding lubrication. The main bearing rotates slowly but is subject to high loads and vibration. By contrast, the generator bearing needs to cope with high speeds and high temperature. Blade and yaw bearings are subject to high loads as well, but also perform oscillating motion under strong vibration.

The tribological system that is formed by a lubricant and a rolling bearing in a generator is characterized by unsteady operation with dynamic loads in all directions. Different manufacturer designs and solutions also play a major role. The aim is to couple maximum relubrication intervals with small relubrication quantities.

Analyses of damages to wind energy installations have found that defects in generators are the second most frequent cause of failure. Damaged gears are the first. A considerable proportion of these generator failures are attributable to the lubricant. Significant lubricant-related causes of failure include the following:

- wrong choice of lubricant,
- unwanted additive reactions,
- copper or brass corrosion,
- wear from stop-and-go operation,
- wear from rolling bearing slip, and
- corrosion.

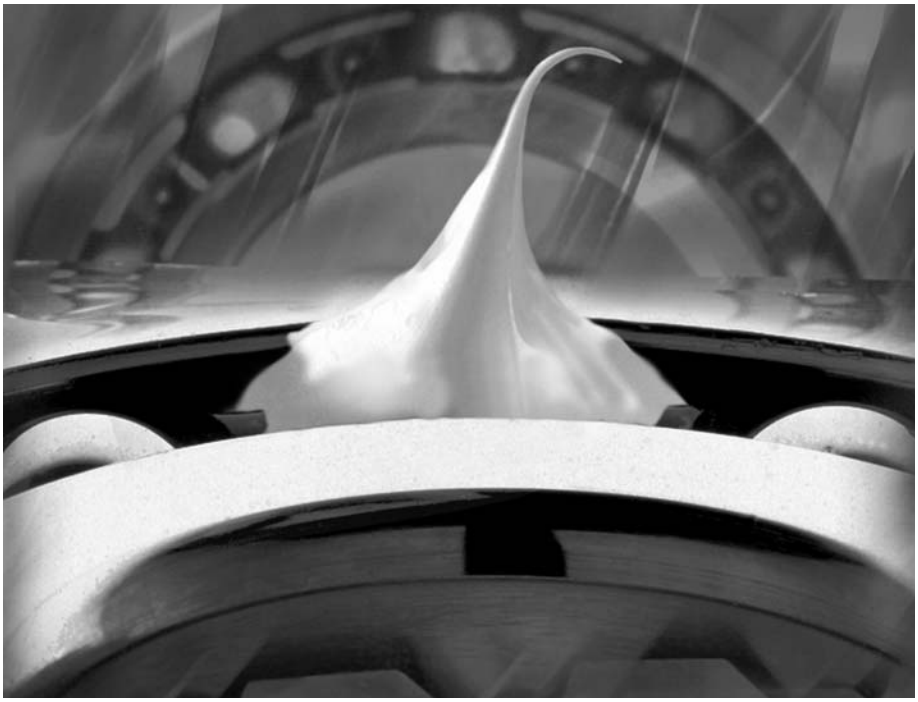
Consequently, a lubricant should be selected that maintains its full performance capabilities throughout an entire relubrication interval. When a system is at a standstill, the lubricant's primary job is to provide the rolling bearing components with sufficient protection against micro-wear. In addition, the components concerned have to be protected against all types of corrosion, particularly at low temperatures. The frequently encountered unsteady operation of a power station and the consequent, unsteady stresses on the lubricant constitute another significant requirement. The grease needs high mechanical stability to assure adequate lubrication over long periods.

In general, lubricants for rolling bearing applications in wind generators should provide ample capacity in all stress aspects that act collectively on the bearing. It is advisable to know with maximum accuracy the temperature, revolutions per minute, media influences and spectrum of vibrations. In the case of media and vibration factors, laboratory testing to find an "adequate" product formulation is exceptionally difficult. If incorrectly formulated, lubricants can entail other weaknesses, such as unwanted reactions or increased wear. Lubricants are required to meet the stipulations of the rolling bearing manufacturers, generator producers and system operators. The stipulations include the following:

- avoiding additive gaps,
- thermal stability during operation,
- mechanical stability,
- good relubrication characteristics,
- resistance to media,
- sufficient wear protection characteristics at standstill, and
- good corrosion-proofing characteristics.

The requirements placed on lubricating grease for the blade bearings of a wind power station are many and varied. The lubricant has to absorb the blade's vibrations. Moreover, in order to prevent wear inside the small movement space at the contact point, a protective film of lubricant is required between the bearing's raceways and rolling elements. Finally, the grease must not exert any adverse effects on the elastomer material of the cover caps and seals. The result could include corrosion damage caused by incoming water. Specialty lubricating grease meets all of these requirements.

On the exposed teeth of a wind power station's yaw and blade bearings, the lubricant will gradually migrate outward from the tooth flanks during operation. Falling lubricant



Bearing with grease Photo courtesy of Kluber Lubrication

will soil the equipment, and inadequate lubrication will lead to increased wear on the teeth. To avoid this result, special adhesive lubricants have been developed. Their high stability and adhesion, even at low temperatures of down to minus 40 degrees C, ensure reliable protection against wear and tear, and much cleaner equipment.

Reducing grease types

Because of the varied speeds, loads, sizes and functions of the individual bearings, operators of wind power facilities have resorted to using a variety of grease products for their generating units. In addition, most wind facilities use turbines from more than a single manufacturer, so different lubricant recommendations have to be observed. For the operator, the results are higher logistical, storage and disposal expenses, as well as the permanent risk of lubricants being mixed up. Most turbines are still manually lubricated, so service technicians have to access and carry a variety of lubricants.

One special grease serves the individual bearings and their various requirements without compromising lubrication performance. It contains a special mixture of base oils and a purpose-made additive package. Its wide service temperature range from minus 40 degrees C to 150 degrees C is a decisive factor for the problem-free operation of wind power plants.

As a specification for wind turbine use, most manufacturers stipulate a lower temperature range of minus 30 degrees C. A fast-running generator bearing produces a maximum temperature of approximately 90 degrees C. Due to the operating range of the special-purpose grease, the aging will be inhibited, relubrication intervals can be extended and operators have enough flexibility to schedule maintenance during periods of low wind turbine activity. The wide service temperature range from minus 40 degrees C to 150 degrees C is attributed to the synthetic and mineral base oil. A product containing only mineral oil would not be able to cope with these temperatures.

Good wear protection under vibration increases the operating life of bearings and helps prevent costly damage during periods of idleness. False brinelling is a major concern in this context. Even when the rotor is not turning, the oscillating motions of the blades will lead to forces acting on the bearings. When the power station runs at low speed, wear is provoked due to the lack of sufficient hydrodynamic lubricant film. Overall, the special-purpose bearing grease increases productivity by protecting against unplanned maintenance, reducing spare parts and limiting storage/disposal costs.

The total cost incurred due to the failure of a bearing should not be underestimated. In addition to accounting for material and labor costs for replacing the damaged bearing, the delivery time for a new bearing may leave the wind power plant idle. Moreover, costs can soar even higher if a damaged generator bearing causes the rotor and the stator of the generator to come into contact.

The replacement costs of the generator may total several thousand dollars. By comparison, the purchasing costs for a specialty lubricant that helps to substantially improve operational reliability are negligible. To supply a wind power plant with the special grease throughout its expected service life of 20 years, the operator will spend no more than a few hundred dollars. WP

Holm

Ari-Pekka Holm has a degree in business and engineering. From 1998 to 2005, Holm was a senior sales area manager in technical consulting and international sales with Kluber Lubrication. Since 2005, he has been the global accounts manager for wind energy, also with Kluber. Peter Mages is a state-certified machine builder. Since 1986, he has held positions in sales and application engineering at major lubricant manufacturers, including Kluber, with a focus on wind energy.

Mages