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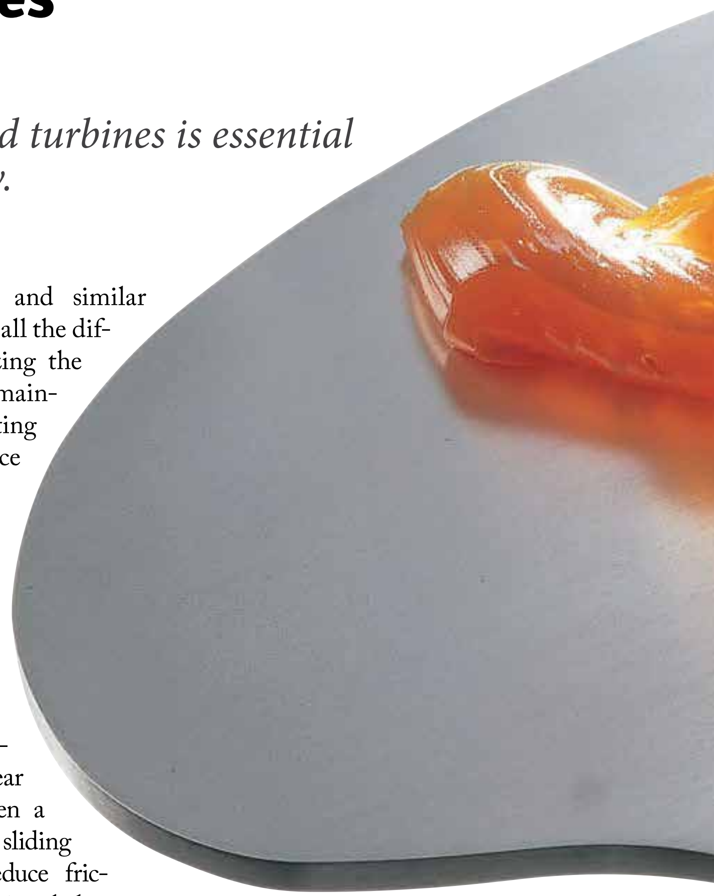
Lubrication Technologies for the Wind Farm

Finding the proper lubrication for wind turbines is essential for the best performance and longevity.

By Dayananda Raju



When wind turbines go down due to equipment failure or maintenance issues, the resulting unplanned shutdowns and time-consuming maintenance fixes can exact a heavy toll. When such incidents occur, wind farms must deal with exorbitant crane mobilization expenses, lost energy production, soaring costs per kilowatt-hour, and untimely delays in obtaining replacement parts in a burgeoning industry where demand for necessary components routinely outstrips supply. Onshore and particularly offshore, anything that can prevent a service trip will help boost overall wind-turbine return on investment (ROI).

Ultimately, the reliability of equipment stands tall as a central challenge for wind-farm operators. This challenge extends to the rolling bearings at all points in wind turbines, whose proper lubrication is essential for optimized performance and longevity.

Supplying the right lubricant in the right quantity at the right time is critical, but adhering consistently to this practice can present challenges of its own: What is the most practical way to dispense the lubricant — manually or automatically? How can over- or under-greasing be avoided? Are lubricant points difficult to reach, or are they inaccessible? Will maintenance staff be placed in harm's way?

How wind-farm operators approach and resolve these and similar questions can make all the difference in minimizing the need and costs of maintenance and promoting reliable performance of equipment.

DELIVERY SYSTEMS

Whether grease or oil, lubricants for bearings in rotating machinery — wind turbines included — serve to prevent wear and damage between a bearing's rolling and sliding contact surfaces, reduce friction and heat generation, help protect against corrosion, and keep out contaminants.

A lack of proper lubrication can bring a turbine to a standstill. Vibration, high mechanical loads, contamination, and moisture are all threats to turbine bearings. And improper lubrication certainly will take a toll on bearings: 36 percent of all premature bearing damage historically has been attributed to poor lubrication-related practices.

One of the most important steps on the road toward proper lubrication is deciding how to deliver lubricant effectively to all the lubrication points in a nacelle. A variety of manual-lubrication tools have been developed — some quite advanced and user-friendly — and grease guns rank high on the list.

A recent innovation in grease guns for wind farms uses a 12-volt lithium-ion battery for maximum power and efficiency with the capability to quickly deliver grease at up to 8,000 psi (551 bar). Its three-point base keeps the tool upright for user convenience and helps prevent dirt and debris from entering the motor. The tool is relatively lightweight and ergonomically constructed to help reduce operator fatigue and allow for easy access to tight areas. Such grease guns can further allow for secure hose storage and easy threading of the grease barrel by integrating a hose holder and tube guide.

As an alternative when hoses may get

There is no "universal" one-size-fits-all lubricant solution for every application. (Courtesy: SKF USA)

in the way, a handheld and rechargeable battery-driven grease gun combines portability with a user-friendly interface to maximize efficiency and accuracy. With such a tool, lubricant flow rates can be precisely adjusted and an integrated grease meter dispenses the proper amount of lubricant to prevent possible over- or under-greasing. A visual display assists workers by showing battery charge level, amount of grease dispensed, pump/motor speed, and even blocked lubrication points.

But what if lubrication points are difficult and/or unsafe to access? What if too much or too little lubricant is dispensed? When manual lubrication will be impractical for these or any other reasons, single-point or fully automatic centralized lubrication systems can deliver the

ALSO IN THIS SECTION

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goods. Systems for various locations in a wind turbine have been engineered to dispense exact and clean quantities of appropriate lubricant where and when required.

Automatic delivery of lubricant will surely lift a heavy burden from the shoulders of the maintenance staff.

According to industry averages, 10 to 20 percent of the uptower time involved in servicing a turbine is spent on re-lubrication (technicians crawling around in the cramped nacelle and hub to grease lubrication points numbering from 10 to more than 80 with several different greases in each turbine). And, in the case of conventional manual lubrication methods, over- or under-greasing (leading to potential failure) always is an unwanted possibility; lubrication intervals may be sporadic or ill timed; contaminants can inadvertently be introduced, and equipment performance may be compromised

With an automatic lubrication system, bearing life can be lengthened by delivering frequent, correct amounts of grease to each bearing. Precisely controlled amounts of lubricant — dispensed at pre-set intervals — keeps bearings coated and enables them to perform to their rated capacity.

A SYSTEMS OVERVIEW

Single-point automatic lubricators. These inject the precise and correct amounts of contaminant-free grease and often will be used for the re-lubrication of pitch bearings and other bearings in moving parts. They inherently minimize the risks of over- or under-greasing and can supply lubricant 24/7 for periods up to a year as governed by a preset automatic timer.

Single-line lubrication systems. In this centralized configuration, a central pump station automatically delivers lubricant through a single supply line to a lubricant metering device. Each metering device serves one lubrication point and can be adjusted to deliver the precise amount of required grease or oil. A single-line system can pump long distances and within a wide temperature range. Components in corrosion-resistant designs will especially benefit offshore applications.

Progressive lubrication systems. These dispense small measured amounts of lubricant at frequent and intermittent intervals. The grease flow created by the system's pump is proportioned by progressive metering devices and distributed to each bearing according to need. Metered quantities of lubricant are fed progressively in predetermined ratios from master feeders to the lube points. The lubricant does not leave the respective feeder until the preceding one has discharged its volume.

If a lube point does not receive any lubricant, regardless of the reason, or if a secondary feeder is blocked, the entire lubrication cycle is interrupted, and the system will

The Lincoln 20-volt PowerLuber grease gun can be used for multiple lubrication applications. (Courtesy: SKF USA)

provide a signal to alert operators to the problem. Integrated system control and monitoring is another plus for this and other centralized systems.

TIPS FOR SUCCESS

Centralized lubrication systems can be applied to all bearings at a turbine's rotor shaft, blade pitch, and azimuth positions, as well as non-rotating applications inside the turbine. Stationary systems can supply grease accurately to main shaft, generator, blade, and yaw bearings. For the rotating blade bearings, lubrication systems can be equipped with a follower plate.

Decision-making for the most appropriate lubrication system will depend, in general, on the application and, in particular, on a range of other parameters, such as the operating conditions (variations in the operating temperature and lubricant viscosity), accuracy requirements for lubricant quantities, turbine system geometry (size, dimensions, and symmetry), and monitoring demands, among others.

When planning, installing, and subsequently implementing a centralized lubrication system inside a wind turbine, these guidelines can help:

- Determine the number of lube points.
- Choose the proper lubricant for the temperature, speed, and load conditions.
- Calculate appropriate dispense rates and quantities for the application.
- Choose pumps consistent with the type of actuation and system capacity.
- Consider monitoring as an integral requirement for the lubrication system.

After a lubrication system is up and running, measurable benefits can be realized at every turn:

- No more chances of over- or under-greasing.
- Lubricant consumption can be brought into line with requirements.
- More informed and timely lubricant purchasing decisions can be made.
- Lubrication-related breakdowns can be reduced.
- Turbine productivity, reliability, and availability can be improved.

Single-point automatic lubricators inject the precise and correct amounts of contaminant-free grease and often will be used for the re-lubrication of pitch bearings and other bearings in moving parts. (Courtesy: SKF USA)

In the case of existing equipment in the wind-turbine aftermarket, generally populated with older and/or smaller machines, operators have the option to upgrade their lubrication programs with the latest advanced technologies. It's never too late.

Regardless of application or system, close attention should always be paid to the specific type of lubricant required for the turbine main shaft, yaw, and blades. There is no "universal" one-size-fits-all lubricant solution for every application. The proper grease will provide proper lubrication whether the turbine is operating or in standstill mode, installed onshore or offshore, or in extreme temperatures or conditions.

One more guideline on the path to sustained success: partnering with a knowledgeable specialist can help in implementing the best lubrication practices for any installation, new or old.

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Foam Rings and Turbine Foundations

Foam rings are still used in the grout trough of a turbine foundation to prevent the grout from making contact with the anchor bolts.

Foam rings are still predominantly used today and the process is no more sophisticated than it was at the beginning. (Courtesy: NTC Wind Energy)

By Joe Bruce

When it comes to wind-turbine foundations, it seems appropriate to reflect on the traditional way foundations have been built and how their structural integrity can be improved and, at the same time, save money and enhance safety.

One of the traditional ways foundations are built has been by using foam rings in the grout trough to prevent grout from making contact with the foundation anchor bolts. Should the grout make contact with the rods, it could interfere with tensioning by not allowing the rod to pull through the grout as it is being pulled from above. Theoretically, the foam also would prevent grout from moving into the bolt sleeve, which spans the full depth of the pedestal and allows the rod to move within the foundation as the tower sways back-and-forth, acting like rubber bands alternatively under compression and expansion.

SAME PROCESS

Foam rings are still predominantly used today and the process is no more sophisticated than it was at the beginning. First, the bolt sleeves are sealed at the top by placing a bead of caulk around the rod within the bolt sleeve. Then, someone has to cut the foam into rings equivalent in length to the prescribed grout depth. The rings are dropped over the rods in the grout trough and often have to be wrapped with common duct tape to keep them from splitting when the base is set. It's a throwback from the days of the backyard mechanic. It's hard to believe a multimillion-dollar machine is being built using caulk, foam pipe insulation, and duct tape.

Right now, a couple of employees are handed sharp knives and told to cut 14,000 two-inch rings (enough for 100 average foundations) by quitting time and then make sure the first aid kit is ready. After a day of cutting foam, those two-inch rings end up being long or short, either of which diminishes their functionality. Then comes the job of caulking and taping — a tedious task at best.

THE EARLY DAYS

Back in the early days, grout was poured into an open foundation, and the base was set in the grout. It was not uncommon to find the foam rings floating in the grout. Cementitious grout also was used, which, if allowed to contact the rod, would generally break away from the rods as they were pulled through the grout during tensioning. Occasionally, while setting the base on the grout-bed, the grout would push into the base-flange boltholes where it would interfere with the proper seating of the washer and nut during tensioning.

Happily, some things have changed for the better. Now high-strength, flowable epoxy grout is used, and the grout is applied with the base in place using forms. This has proven to be a superior material and method of grouting. But the superior grout also makes it that much more important that the rods be protected from contact with the grout. But, foam is still predominantly used.

The ongoing trend toward heavier and taller turbines means more grout and supporting leveling shims in the grout trough, adding to the potential for voids. Basically, the more hardware in the trough, the greater the potential for voids. Unfortunately, with the base down, it is difficult to detect those voids.

ADDING TO THE PROBLEM

The use of foam rings inadvertently adds to the problem. Each ring of foam creates a void in the grout, further reducing the overall compressive strength of the grout bed. Applying some basic math: a foam ring 2 inches tall and ½-inch thick, having an ID of 1 5/8 inch displaces 6.676 cubic inches of grout. If the grout reaches 14,000 pounds of compressive strength when cured, the loss of compressive strength in a foundation with 140 foundation anchor bolts is more than 13 million pounds or 6,500 tons. A total of 6.58 cubic feet of grout in that foundation has been displaced. Admittedly, the remaining grout is more than enough for structural integrity, and in foundation design, engineers compensate for potential grout voids. But why not eliminate as many voids as possible, increasing the quality and structural strength of the foundation?

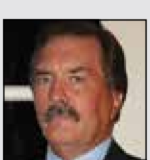
Though the industry has an excellent record for foundation integrity, the trend is increasingly toward engineers building in design excesses to ensure their design will not fail. At some point, the cost versus the benefit of these design excesses will have to be examined. If the foam rings in the foundation could be eliminated, perhaps some money could be saved by reducing the size and depth of the grout trough or by reducing the compressive strength requirements of the grout in order to have a better foundation.

Grout sleeves are useful for over-wintering foundations. (Courtesy: NTC Wind Energy)

IRONCLAD GROUT SLEEVE

The advent of NTC Wind Energy's patent pending IronClad Grout Sleeve addresses all of the concerns listed above. These injection-molded parts slide easily over the rods but fit tightly enough to seal around the bottom of the rod and stay in place, negating the need to caulk around the top of the bolt sleeve. At the same time, the thin walls of the polyethylene parts displace little grout. At 3 1/2 inches tall, grout sleeves are intended to project into the flange slightly, protecting the entire exposed portion of the rod and allowing the rod to easily move during tensioning. Like foam rings, grout sleeves allow the rod to move laterally within the bolt sleeve to line them up during base setting.

Grout sleeves are also useful for over-wintering foundations. By placing a ½-inch ring of caulk around each rod and installing the sleeves on top of the wet caulk, the sleeves provide a protective seal against water and mud draining into the bolt sleeve within the foundation.



Joe Bruce works with J.W. Bruce & Company, LLC. dba NTC Wind Energy and has a bachelor's of science from California Polytechnic State University. Bruce joined Norm Tooman Construction — Wind Energy Division in 2001 with his father-in-law, Norm Tooman. Together, they developed and patented multiple products for wind-turbine foundation construction and corrosion protection. Their signature product is the IronClad bolt cap, which was the first bolt cap for wind-turbine foundation applications and still the most used in the industry.