SEPTEMBER 2011

WIND SYSTEMS

FEATURES

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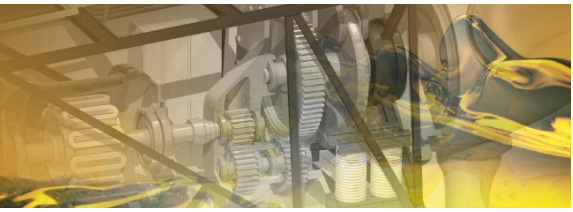

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EDLETTER

During a recent conversation with a vision scientist for a medical publication we produce, I mentioned that we also publish a magazine devoted to wind energy. She pulled up our Web site on her laptop and said "you know, whenever I see one of those wind turbines I think 'now *that's* the future.'" I felt the same way flying into Frankfurt, Germany, last June, as we swooped past community wind towers scattered across the landscape on our approach to the airport, their rotors just beginning to bite into the early morning breeze. There's something about harnessing our planet's natural forces to create the energy we need that most people find deeply appealing, and the more reliable–and attractive–wind turbines can be made, the more quickly they'll be accepted, both in people's minds and in their communities. Now *that's* the future!

In this issue we present a suite of articles devoted to lubrication, along with others on drivetrain design and communications systems. Ted Vasiliw of Castrol Industrial has written "Extending Gear Oil Performance," describing the attributes of the next-generation Optigear Synthetic X 320 for wind turbines, and Joe O'Connor describes Shell's development of a new generation of high-performance industrial lubricants in "The Winds of Innovation." Mike Moore of Shermco Industries has contributed "Lubricating Wind Components," providing a helpful maintenance checklist, and and Matthias Deicke and Martin Lubahn of Winergy outline the development of the HybridDrive system in "Drivetrain Gear Design." Susan Schnelbach of Banner Engineering writes about remote monitoring and control solutions in "Reliable Wireless RTU Systems," and Bjorn Hedges, Jason Hayes, and Thomas Halpin of NAES share the benefits of Voice over Internet Protocol (VoIP) systems in "An Online Communications Solution."

As for our columnists, Susan W. Stewart of Penn State's Wind Program ponders the extraction of wind energy from lower average wind speed sites in her technology column, and Ron Krizan of the NAES Corp. advocates planning ahead for successful crane walks in his construction column. Merritt Brown of Rev1 Renewables suggests adopting a predictive–rather than a scheduled–maintenance program in this month's installment, and Anne Puhalovich of the Professional Logistics Group explores the benefits of barge transport for wind components in her logistics column. Quaker Chemical is this month's company profile, and Brent Godfrey, industry and application specialist in wind power at Sandvik Coromant, is this month's Q&A subject.

As you know, the Canadian Wind Energy Association (CanWEA) will be holding its Annual Conference & Exhibition October 3-6, 2011 in Vancouver. With more than 250 exhibiting companies, and some 2,500 wind experts gathered from all around the world, this will be an excellent opportunity for networking, educational advancement, and much more. So be sure to take advantage of CanWEA 2011!

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Operations

TEREX ENABLES OFFSHORE TURBINE REPAIRS

A Terex CC6800-1, owned by MAXIKraft Kran- und Schwerlastlogistik GmbH, recently removed the rotor and nacelle of a 5MW wind turbine at a height of 90 meters. The assignment, which was performed on behalf of wind farm operator BARD, was part of a series of repairs at the Hooksiel offshore wind farm where the turbine was located.

From the very start the MAXIKraft team was faced with a series of unique challenges. "To start off with, an offshore lifting operation is obviously much trickier than a land-based assignment, since the wind and sea can act up at any moment and cause a great deal of instability," says crane operator Raik Hanisch. During the project the heavy-lift pontoon Giant 4 was in charge of bringing the Terex CC6800-1 to the site, just offshore of Hooksiel in the north of Wilhelmshaven. It also became responsible for providing the stability required for a total of four lifting operations. The first operation consisted of removing and lowering the turbine's 170-tonne rotor, which had a diameter of 127 meters, so that the 280-ton nacelle could be removed during a second lifting operation. Once the repairs were completed the components were lifted and installed back on the tower in the opposite order.

The MAXIKraft team used an LFVL boom configuration to tailor the crawler crane to the job. The combination of a 90-meter main boom and an 18-meter fly jib allowed the unit to easily reach the required working height. Meanwhile, a 250 ton counterweight on the superstructure in addition to a 80 ton central ballast on the carrier and a Superlift ballast weighing 240 tons allowed the crane to operate freely within a working radius of 22 meters, making it possible to complete all work right on schedule. "The way the project moved along smoothly showed that the Terex CC6800-1, with its capacity and its enormous flexibility in the way it can be configured, should be the first choice of anyone who is planning to lift this type of large weight," says project manager Steffen Lehmann, "and also when working under difficult operating conditions."

The 1,250-ton Terex CC6800-1 lattice boom crawler crane, featuring a maximum load moment of 13,952 mt, is designed for industrial operations worldwide. Its components, which have been dimensioned for a maximum transportation width of 3 to 3.5 m and feature low transportation weights ranging from

Companies wishing to submit materials for inclusion in this section should contact Russ Willcutt at russ@windsystemsmag.com. Releases accompanied by color images will be given first consideration.

15 to 50 tons, allow for worldwide, cost-effective transportation. More information on Terex can be found at www.terex.com.

VESTAS PARTNERS WITH ONTARIO STEEL AND TOWER FACTORIES

Vestas has announced its wind-turbine towers will be manufactured by CS Wind in Ontario for future wind-energy projects in the province. Essar Steel Algoma in Sault Ste. Marie, Ontario, will provide the steel for the tower sections. Meanwhile, the towers will be made at CS Wind at its new tower-fabrication facility in Windsor that celebrated its grand opening May 26. At the CS Wind facility steel plates will be rolled, formed, shaped, welded together, and then transported to wind-energy projects in Ontario. The factory is expected to deliver its first tower to Vestas in November 2011.

"The Vestas Towers business unit has created a tremendous opportunity for us to be working with such experienced and trusted manufacturers in Ontario," says Martha Wyrsch, president of Vestas-Canadian Wind Technology, Inc. "This provides Vestas with a tremendous sense of confidence going forward in the Ontario wind-power market."

Vestas aims to work with local manufacturers such as CS Wind and Essar Steel Algoma to meet local-content requirements and help grow the Canadian wind-energy market. As the number-one automaker in North America, and second only to California in industrial output, Ontario has a broad and rich manufacturing base from which to draw.

"This is an exciting time and opportunity for CS Wind and for Windsor," says Sandra Pupatello, minister of economic development and trade minister, and also Windsor MPP. "These types of partnerships with both a turbine provider and a tower manufacturer show the extent that the renewable energy sector reaches into our economy."

Vestas, which has a sales office in Toronto, had its first wind turbine installed in the Ontario market in 2001. Vestas has 232 turbines in operation in the province for a total of 390 MW, enough to power more than 100,000 homes in Ontario. Vestas also provides service and maintenance to ensure safe, reliable operations of its wind turbines throughout Canada. Vestas has supplied more than 1,000 turbines in all 10 Canadian provinces—1,683 MW of installed wind capacity—which provides enough electricity to power more than a half-million homes. More information is available at www.vestas.com.

DUKE ENERGY CHOOSES SIEMENS TURBINES TO BUILD KANSAS WIND FARM

Duke Energy will use 73 Siemens wind turbines, each capable of generating 2.3 megawatts of emission-free electricity, to build its first wind farm in Kansas.

Duke Energy Renewables—a commercial business unit of Duke Energy—will build, own, and operate the 168MW Ironwood Windpower Project in Ford County, approximately 150 miles west of Wichita. Topeka-based Westar Energy will purchase all of the electricity and associated renewable energy credits produced by the site under the terms of a 20-year agreement.

Duke Energy Renewables plans to start construction of the Ironwood Windpower Project in the fall of 2011. The wind farm, which is expected to reach commercial operation by mid-2012, will be capable of generating enough electricity to power more than 50,000 homes. "The Ironwood Windpower Project, which will help Westar deliver clean energy to its customers for decades to come, marks another milestone for Duke Energy," according to Greg Wolf, president of Duke Energy Renewables. "It's our first wind farm in Kansas, and it will put us well over 1,000 megawatts of wind power capacity in the U.S."

Each nacelle will be supplied by Siemens' new 300,000 square-foot manufacturing facility in Hutchinson, Kansas. The facility, which opened in December 2010, produces nacelles for Siemens' 2.3MW and 3.0MW wind turbines.

"We are delighted that Duke Energy has once again chosen Siemens' highly advanced wind turbines and service solutions, and we look forward to working closely with them to advance their renewable energy plans in the U.S.," says Jan Kjaersgaard, vice president and general manager of Siemens' Americas Wind Power business. "We are especially proud that the nacelles for these turbines are being assembled at our Hutchinson facility, marking the first time Kansas-built nacelles will be operating at a Kansas wind farm."

Duke Energy Renewables owns nearly 1,000MW of generating capacity at nine U.S. wind farms: four in Wyoming, three in Texas, one in Colorado, and one in Pennsylvania. Since 2007 Duke Energy has invested more than $1.5 billion to grow its commercial wind and solar power businesses. More information can be obtained by visiting www.duke-energy.com and www.siemens.com/energy.

ZERO-MAX OVERLOAD SAFETY COUPLINGS

Zero-Max Torq-Tender overload safety couplings protect critical rotating power transmission components from torque overloads. Torq-Tenders serve both as a safety device and as a coupling in a power transmission system. Protecting motor and drive systems from jam-ups and excessive overloading,

Torq-Tenders are extremely effective. They can be manufactured for systems requiring frequent washdowns. With the addition of an O-ring seal and simple housing modifications, the couplings resist contamination and are easily washed.

Simplicity of operation is an important Torq-Tender benefit. When a power transmission system's load exceeds the preset precision-tempered torque spring rating, the drive mechanism pivots out of an engagement slot, disengaging the prime mover from the load providing overload protection. When the overload is removed and the speed is reduced, it resets itself automatically. The single position re-engagement point maintains equipment timing and positioning.

Available in torque ranges from 2 to 3000 in-lbs., Torq-Tenders provide tamper proof preset torque settings. The precision torque settings do not require costly and potentially risky calibration procedures. As a coupling it can handle up to 1.5 degrees of angular misalignment and a maximum parallel misalignment of 0.005 to 0.015 inch. "Torq-Tender couplings are an inexpensive way to protect expensive complex drive systems from torque overloads," says Kevin Wells, regional sales manager. "Torq-Tender couplings provide a dual function as a coupling and an overload safety device. They provide overload protection for paper converting, packaging, printing, and PCB fabrication systems."

Torq-Tenders are available in many standard sizes. From the smallest, TT1X (torque ranges 2 to 60 in-lbs) to the largest TT4X (torque ranges 750 to 3000 in-lbs), there are many precision preset factory torque ratings available. Additional Torq-Tender designs for a variety of mounting configurations are detailed in a new catalog. For more information call (800) 533-1731, e-mail sales@zero-max.com, or go to www.zero-max.com.

NEW WIND MEASUREMENT SYSTEM FROM VAISALA

The Vaisala WTS wind measurement system is specifically engineered for wind resource assessment, power curve measurement, and monitoring operational wind farms. It allows customers to accurately understand and manage the impact that weather has on their operations and business, and as a result make better decisions.

Vaisala has over 70 years experience in weather measurement, supplying leading technologies

for critical applications used in aviation, energy, and climate reference sites, for example. In the United States Vaisala's wind sensors can be found at the National Weather Service's Automated Surface Observing System (ASOS) sites and most airport Automated Weather Observing System (AWOS) sites.

Vaisala's wind measurement system combines this expertise with clear industry feedback. "With alternate energy sources being the need of the hour, the wind energy industry is receiving billions of dollars worth of investments globally," according to Richard Pyle, segment director of weather critical energy. "For its success, it requires economical investment grade equipment that provides accurate and reliable measurements. Combining several decades of experience in weather observation, and working closely with the wind energy industry, Vaisala has designed affordable world class systems that maximize certainty and minimize risk and long term costs for investors, developers, and operators."

The measurement system includes five configurations that offer customers a choice of specialized features. These include a cold climate option, which ensures performance in the harshest weather conditions, and an option that employs sensors designed to last more than 20 years and is largely maintenance free. Each wind measurement wystem includes a combination of sensors, which provide superior accuracy and quality with low life cycle costs, a world-class data logging system, power supply, and a tower. Vaisala also offers a full suite of installation and support services, which coupled with partner offerings create a turn-key observation system that maximizes data availability, and supports financial analysis and reporting, including energy yield analysis.

Customers can choose from a number of ownership options. They can own or lease the equipment, or use it as a complete service with Vaisala managing the equipment, collecting and reporting the data as per customer needs. The products are now available globally, with the leasing option available to customers in the U.S., Canada, Germany, Finland, Sweden, the U.K., and France. Learn more at www.vaisala.com.

AUSTAL LANDS CONTRACT FOR OFFSHORE SUPPORT VESSELS

Following the launch of Austal's Wind Express series in mid 2010, the company is pleased to announce the award of a contract for the design and construction of three purpose-built 21 meter offshore support vessels (OSVs) for Turbine Transfers Limited, based in Holyhead, United Kingdom.

The Austal-built OSV catamarans will be used to transport service crews and equipment to the many offshore wind farms that are located off the coastlines of several European countries. Turbine Transfers is a well established fleet owner that has been supporting wind farm owners and operators for a number of years. The company currently owns and operates a fleet of 18 vessels. The Austal-built OSVs will be the first that Turbine Transfers has commissioned outside the United Kingdom.

Managing Director of Turbine Transfers Captain Mark Meade says that Austal was selected based on the Western Australian company's extensive experience in the design and construction of innovative aluminum vessels. "We have no doubt that Austal will successfully apply their extensive design and construction experience to the wind farm industry with their first Wind Express contract," he says. "We look forward to taking delivery of these three vessels, which were designed to provide comfortable transits and safe turbine step-offs, whilst capably servicing Europe's growing wind farm industry."

Austal Chief Executive Officer Andrew Bellamy notes that the contract award is an important first step for Austal in becoming a supplier to the growing European renewable energy market. "Supporting the currently installed offshore generating capacity is today an attractive market opportunity, but the projected growth in new wind farms and wave generator capacity over coming years makes this market sector a strategic component of the Austal Group's commercial vessel business," he says, adding that Austal brings a wealth of intellectual property to the needs of this new market and has already demonstrated this to Turbine Transfers by designing highly efficient vessels that will achieve greater speeds with a level of fuel efficiency that is superior to that of similar sized vessels in the Turbine Transfers fleet.

Austal has adopted an advanced fine entry chine hull form that, in association with a high tunnel height, will enable the vessels to operate at speeds of up to 30 knots with targeted seakeeping ability in up to 2 meters significant wave height. Due for delivery in May 2012, the vessels will be built at Austal's Henderson shipyard. To learn more visit www.austal.com.

Ron Krizan, P.E.
NAES Corporation

Lack of proper planning or poor scope definition during crane walks predictably results in schedule issues and unexpected costs. Here's how to prepare your path.

TRACKED CRANES PERFORM NEARLY all of the new wind farm construction in North America. One challenge is moving the nearly 1,000,000-lb machines between turbines without performing either a full or partial breakdown, which can take days to complete. Lack of proper planning or poor scope definition during the crane walks predictably results in schedule issues and unexpected costs for the most expensive piece of equipment on the site.

Permitting issues are the first to appear, but they can typically be resolved with time and paperwork. It is a safe assumption that a permit either needs to be obtained or at least addressed whenever the crane is in the vicinity of any of the following: roads (local, state, and federal), railroads, wetlands, airfields including glide slopes, and utilities.

All public roads will require permitting or a permission process even for the simplest crossing. Typically these permits address the who, what, where, why, and when, with in-depth details on making sure the contractor fully understands traffic control. An excellent reference when dealing with traffic control issues is the Manual of Uniform Traffic Control Devices (MUTCD). It is recognized by all 50 states and provides the minimum standards that must be met.

Railways have their own special rules in regards to crossing their tracks, and the process is usually quite lengthy and involved. If permission is granted, unique costs such as paying for a railroad employee to "flag" trains as well as additional insurance or bonding may be required while you are operating within their right of way.

Most crane paths will steer away from wetlands for the obvious reasons, but they may be forced to cross small navigable streams. These seasonal streams are not always obvious and often get confused for simple drainage ways or ditches, which may not require permitting. When in doubt it is best to have a professional make the delineation before environmentally sensitive areas are disturbed.

Overhead power lines and utilities can literally add thousands of dollars to your construction costs if not properly thought out or arranged in advance. Due to the high cost and effort required to break down a crane, it is usually more cost effective to simply work with the local utility to temporarily de-energize and remove the line while the crane crosses. The owners of these lines have limited staff and require as much advance notice as possible to coordinate this effort. Simple solutions, such as converting short overhead sections to underground at key crane crossings, can be scheduled well in advance and often with minimal costs. Define whose responsibility it is to coordinate with the utilities and ultimately pay for their time in the construction scope before it becomes an issue.

Even after all of the permitting and overhead utilities are squared away, you may not be able to effectively move your crane across the site because of poor soil conditions. Since the temporary crane paths are not designed to be converted into the permanent roads, you need to make use of what materials you have on hand. This means leaving the surface vegetation in place whenever possible to help bridge the load put down by the crane. Most construction companies will use the appropriate roller just prior to making the crane walks. Care needs to be used to run the vibrator sparingly, however, or not at all since vibrations on native soils tend to aggravate any moisture problems. Also mark out and note where the underground collector lines either intersect or run parallel to the crane path. No matter how good the compaction effort was in the backfilling of these trenches the crane will still further compact those areas, risking potential damage to the new cable.

Regardless of what type of soils the wind farm is sited in, you will inevitably require crane matting to traverse a portion of the crane walks. Both contractors and owners need to fully understand who is responsible for supplying and paying for the placement of those crane mats. Waiting to debate over who should have supplied the mats as a multimillion-dollar crane is stuck is going to cost everyone money in the long run. Many times it is well worth the expense to have crane mats on hand should inclement weather require them. There is a thriving secondhand market for crane mats, where used mats can be purchased and resold again at the project's end with only minimal net cost. With a little upfront due diligence, most of the risks associated with the crane walks can be eliminated before the main crane ever hits the site.

Ron Krizan, P.E., is engineering manager for NAES Corporation, the world's leading provider of comprehensive services to industries that generate or consume power. He can be reached at ron.krizan@naes.com. Go online to www.naes.com.

Merritt Brown
Rev1 Power Services, Inc.

Where an OEM scheduled maintenance plan takes only component life into account, a predictive program will include an assessment of the failure mode for each event.

SURPRISINGLY, MAINTENANCE PRACTICES in the wind industry are still guided mostly by time-based activities. Meant to be a proactive approach to servicing multimillion-dollar equipment, the scheduled maintenance activities are performed at routine intervals, combining the most conservative engineering estimates with a bit of luck that we catch failure events before they occur. Throw in 50 percent reactive maintenance, and now you have the maintenance program for a modern wind farm.

If we believe that following the time-based maintenance program offered by the OEM is all it takes to achieve a successful 20-year operation of our wind project, we should think again. In the hierarchy of maintenance strategies, time-based maintenance—or better termed preventative maintenance (PM)—is among the least effective means of identifying when components will truly fail. Because the engineering used to determine maintenance intervals on wind turbines is based on expected component life, unpredictable and abnormal conditions that affect individual components are completely ignored in this methodology. Time-based PM can have dramatically different results at two identical turbine projects at different locations, merely because of ambient conditions such as weather, actual runtime, and project operation variables. If an oil system bypass alarm comes in intermittently before the next scheduled maintenance cycle, then it is apparent the basis of a purely time-based interval to replace the filter is inaccurate. Likewise, if you are replacing such a component prematurely, then the failure cause is probably unknown.

To appreciate the difference between simply following a scheduled maintenance program and using actual failure data to build a more predictive program, consider the light bulb. A manufacturer states that it should last a year when used every day. So just before the year is over, you decide to change the bulb. This is preventative maintenance. On the other hand, since you see this light bulb on a frequent basis, you realize that it starts to flicker around the tenth month in service. You predict that it is soon going to burn out, so you go ahead and replace it before it does. This is called predictive maintenance. Evolving your preventative maintenance program into a predictive one is not a difficult process. Some critical PM tasks should always be conservative; safety equipment inspections, fall protection devices, and emergency stop function tests should follow a rigid schedule. Reminded constantly that OEM time-based maintenance can be a flawed proposition, you can apply technical discipline when evaluating early component failures that can lead to a more predictive approach to your maintenance program.

The goal of a preventative maintenance schedule is to improve turbine reliability by periodically inspecting and replacing components before they wear out. In fact, the life of a component has absolutely nothing to do with its inspection frequency. The life of any particular component is going to be different across all of your turbines, where some seem to last forever and others may fail repeatedly and in between maintenance cycles. To reduce failures then, maintenance would have to be performed on an excessively frequent interval and well in advance of the detection of a component failure. You would likely not benefit much by increasing the frequency of preventive maintenance as a means to improve detection of component failure, as the cost of performing the maintenance activity will increase directly with frequency. Also, increased frequency of some PM activities can be detrimental. In the case of gearbox inspections and filter replacements, there is always a chance that the turbines are returned to service in a worse contaminated condition, causing a maintenance-induced failure that degrades the intent of the preventative maintenance.

In a move to predictive maintenance, your objective should be to understand the length of the time between when a problem first occurs (an intermittent oil bypass alarm) and the time for which a failure occurs (the filter is completely blinded and will compromise the system). Where an OEM scheduled maintenance plan takes only component life into account, a predictive program will include an assessment of the failure mode for each event and a determination of the period of time that is available after a problem is first discovered. This change will allow some traditional and less critical PM tasks to move from the scheduled service list to a predictive type of program. While detecting potential failure of a component from its initial indicator is a far superior program than simply using time-based inspection and replacement strategies, it isn't enough to raise the victory flag. As each potential failure is identified, you should also determine the root cause of failure. Understanding the failure mode is critical in eliminating the cause and assuring that the failure will not occur again.

A review of your PM frequencies provides an opportunity to reduce the preventive maintenance effort while growing your maintenance program into a predictive model. It is important to understand the approach used with OEM scheduled maintenance plans and how failure detection can be applied to increase reliability and prevent undesirable turbine outages.

Merritt Brown is vice president of Rev1 Renewables, an energy services company supporting wind, solar, and biomass clients worldwide. To learn more call (866) 738-1669 or go online to www.rev1renewables.com.

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Susan W. Stewart, Ph.D.
Penn State Wind Energy

Turbine technology is rapidly evolving to meet the stringent demands of grid stability, reliability, and economic extraction of wind energy from lower average wind speed sites.

THE 2010 ANNUAL WIND TECHNOLOGIES Market Report by Ryan Wiser and Mark Bolinger, both of Lawrence Berkeley National Laboratory, was released in June 2011. It can be downloaded at www1.eere.energy.gov/windandhydro/pdfs/51783.pdf. This report has noted a decline in capacity factors for U.S. projects over the last few years (fig. 34). This is not because there has been less wind, as the trend is found when the projects are broken out by the year in which they were developed. While there are certainly several factors that may be contributing to this trend, it is reasonable to conclude that it is largely because the low hanging fruit has been developed. Sites which were found to have an excellent wind resource within close proximity to transmission lines, as well as an accessible road system and other conducive economic, political and social contributing factors, have undoubtedly been established as wind generation facilities already. As transmission constraints are increasing, developers are thus taking interest in lower wind speed sites. Additionally, on average, class 4 wind sites are 100 miles from a major load center, compared to 500 miles for class 6 wind sites. Therefore projects are becoming more challenging from an economic perspective, and wind turbine technology is rapidly evolving to meet the ever more stringent demands of grid stability, reliability, and economic extraction of wind energy from lower average wind speed sites.

Making lower wind speed sites more economical is part of the challenge. One way industry is addressing this issue is by moving away from the "one size fits some" offering of products to having multiple blade length options for a single generator size, or alternatively multiple generator ratings for a specific rotor in their product lineup. This is because there is an optimum ratio of generator rating to rotor area (specific rating, kW/m2) for each site-specific wind condition. This rating is typically in the range of 0.3 to 0.6kW/m2, with lower wind speed applications being at the lower end of this range and stronger wind resources at the upper end. Ideally there would be a plethora of options both in terms of generator size and rotor size to optimize performance for each application. Additionally, studies that model the wake flow effects of wind farms have found that overall farm performance can be improved with use of variable sizes of turbines within a wind farm. The question then is would the added cost of servicing multiple turbine types, which may require entirely distinct service contracts and crews, negate the economic gains of the performance enhancement?

As this trend of lower capacity factor development continues, design options will ultimately be needed that can help meet site specific resource constraints and allow for design optimization under specified wind resource and economic conditions. For instance, sites that experience more severe extreme winds or turbulence than is considered palatable now due to limitations of these characteristics in existing IEC wind classifications will eventually be of interest for developers, as well. Product families of turbines could be developed that employ load alleviating devices for these sites with more-severe wind characteristics.

> "Now that the modern MW-plus scale horizontal axis wind turbine has experienced strong market growth, companies can justify the expense of designing new components with specialized attributes."

Another way to enable the use of lower wind speed sites is to keep operation and maintenance (O&M) costs at bay, thus improving system reliability. Until very recently the wind industry was too small to drive the needed design modifications to commercial off the shelf products from other industries. Many standard parts were used, designed for other purposes. This led to some of the unanticipated reliability issues with wind turbines experienced over the last decade. Now that the modern MW-plus scale horizontal axis wind turbine has experienced strong market growth over the last several years, companies can justify the expense of designing new components and manufacturing processes that have the specialized attributes required for the demanding operating environment a wind turbine experiences. This shift is evident in the gradual reduction in O&M costs over recent years, also reported by Wiser and Bolinger (fig. 36), for more recent projects.

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Anne Puhalovich
Professional Logistics Group, Inc.

Barge is a third viable form of transport for wind components, especially in strategically located wind farms near water access or for the import or export of components.

TRADITIONALLY, THE MOST COMMON method of transporting large wind components has been via specialized truck transportation carriers. In recent years rail transport has been effectively utilized by large volume manufacturers such as GE, Vestas, and Siemens. In special cases, however, there is a third option for moving components that takes advantage of the extensive inland water systems in North America.

Barge transportation is an excellent and viable transportation mode to move large, heavy components. Depending on the origin and final destination, barge allows for the mass movement of goods to or from southern Gulf ports using the inland river system, or using the Great Lakes St. Lawrence Seaway System for transportation to and from northern ports in the region. There is also the Columbia River system in the northwest, but it has a much smaller geographic reach. Barge has strong advantages when component are imported or exported because at some ports, such a New Orleans, components can be directly discharged from an ocean vessel into the barge while in the river, avoiding double handling and some port fees. Towers and wind blades have been successfully moved via barge for several years. Up to this time nacelles have not moved via barge in the river system, but there is little technical limitation for this form of transport if the conditions are right.

Barge transportation is a clean, economic mode of transport that avoids the congestion of cities and towns that trucks and rail must mitigate. The barge equipment along the rivers and lakes is standardized and, if required, can be reinforced for the heaviest of components. There is a wide range of service providers for barge movements, including asset based and non-asset based companies. When considering a barge move, the barge service provider will draw up a schematic of the laydown configuration and the securement plan. Typically customers are buying the entire barge, and the better the utilization of the barge equipment the more economical the transit costs. If possible, double stacking components using frames is a good way to increase utilization.

Different equipment runs in the different inland seaway systems, smaller box hopper barge are used for river transport and are not suitable for travel on the Great Lakes. Box hopper barges can access the closet Great Lakes ports such as Burns Harbor, Indiana, or Milwaukee, Wisconsin, but it is not recommended that they travel far in the Great Lakes. Similarly, Great Lakes vessels, which are much larger than the hopper barge, are not used in the river system. If a shipment needs to travel on both the Great Lakes and the inland river system, a transload must occur from one vessel type to another. Also, the Great Lakes vessels are subject to the Jones Act, which requires U.S. to U.S. port moves be service by a U.S. flag ship. This restriction limits carrier option. U.S. to Canadian ports do not have the same restrictions.

Transit time is another challenge for barge. It is the slowest form of transport, and enough time needs to be built into the delivery schedule to ensure components arrive on time. For instance, a barge move from Houston to central Illinois could take up to 25 days, and a move from New Orleans to central Illinois can take 15-20 days

Another disadvantage of barge is that the system in the northern part of the country is shut down four months out of the year—December through March—due to freezing on the waterway. The inland river system shuts down just north of St. Louis, Missouri, where the Mississippi and the Illinois Rivers intersect. The one important exception is the Illinois River, which is open year around

Available barge vessel capacity and pricing is dictated by market conditions. Since the waterways are mostly used to transport commodities such as grains, fertilizer, and coal, the availability and pricing will be highly influenced by factors in those markets. For instance, last year a large amount of grain was being exported from the Port of Duluth, which increased traffic and competition for this port. This year pricing and capacity has been greatly influenced by the spring flooding. Also, many ports do not have the crane capacity to lift to lift some of the heaviest components. Cranes will need to be brought in for the project and mobilization costs should be consider in the total economics of the move.

Barge is an important, viable, and economically advantageous option for moving components within a specific geography. Barge options should especially be considered when importing and exporting overseas.

Anne Puhalovich is project leader with Professional Logistics Group. For more information go online to www.prologisticsgroup.com.

QUAKER CHEMICAL

By Russ Willcutt

For the past eight decades this company has been producing industrial fluids and compounds used in virtually every imaginable manufacturing operation.

IT BEGAN IN 1918 as a small company producing industrial compounds for surrounding machine shops and textile manufacturers in Conshohocken, Pennsylvania, just northwest of Philadelphia. Quaker Chemical has since expanded into a global entity, publicly traded on the New York Stock Exchange and with a business presence and production facilities in every major manufacturing country including China, Brazil, Spain, Mexico, and The Netherlands, among others. Hardly a day passes when you don't benefit from an item made using Quaker products.

"No matter what kind of car you drive, for instance, certain components were manufactured using our products," according to Peter Skoog, technical manager for fluid power products. "In fact, our QUAKEROL hot mill lubricant is used in the vast majority of rolled steel operations."

Skoog's responsibilities include acting as a liaison between industry and the company's R&D labs, developing formulations to meet customer requirements. When end users have questions about hydraulic fluids, gear oils, fire-resistant fluids, or gearbox lubricants, he is the go-to guy. "And that means I will go to see them and observe their manufacturing operation so that I can provide solutions," he says. "From concept to disposal, I'm part of the process and available to answer any technical questions our customers may have. I'm also here to make sure that new products developed in our laboratories make a clean transition to our commercial groups."

As for the company's structure, it operates in three broad divisions—primary metals, metalworking, and fluid power—which focus on myriad markets including aerospace, automotive, bearings, coatings and construction materials, heavy duty equipment, tube and pipe, marine, and mining. For companies manufacturing wind components, Quaker Chemical offers products for a wide variety of applications such as QUAKERDRAW® metalforming/drawing lubricant, QUAKERCUT® cutting oils and honing and lapping fluids, QUAKERCOOL® and QUAKERAL® machining and grinding coolants, and others such as FERROCOTE® corrosion preventive and QUAKERCLEAN® metal cleaner. It also has a synthetic lubricant developed especially for filling gearboxes, protecting against micropitting and providing extended service life over standard formulations. Beyond manufacturing the company has developed the STA CRETE® and STA-NATURAL® coatings for concrete—ideal for wind tower foundations—and the SS1500 abrasion resistant 0-VOC epoxy coating, which can be used to protect blades and other parts of the structure such as the hub and nacelle.

Known for being heavily involved in research activities, Quaker partners with OEMs and others in developing products for new—and sometimes experimental—applications, such as power storage systems for off-peak periods of low or no wind. "And that's one of the things I enjoy most about my job," Skoog says, "having the opportunity to be involved in new and developing technologies. It's exciting to work with people who have a big idea and the entrepreneurial spirit to bring it into reality."

"For companies manufacturing wind components, Quaker Chemical offers products for a wide variety of applications, and it also has a synthetic lubricant developed especially for filling gearboxes."

More than merely a supplier, Quaker Chemical is a knowledge-based company with information and service resources on which its customers can rely. Committed to continuous improvement, all of its production facilities are ISO 9001 certified, and some are also ISO 14001 certified for environmental management and rated by accredited companies such as Lloyd's, the British Standards Institute (BSI), and Det Norske Veritas (DNV).

"Having spent more than 90 years working in just about every basic-process manufacturing industry you can name, we've acquired a tremendous amount of knowledge and expertise," Skoog says, "and we make all of it available to our customers. That's especially true of the wind industry, which we look forward to supporting in the coming years as it continues its growth throughout North America and around the world."

Call (610) 832-4000, e-mail info@quakerchem.com, or go online to www.quakerchem.com.

INNOVATIVE DRIVETRAIN DESIGN

As the heart of a wind turbine, the drivetrain must provide reliability, serviceability, and high efficiency. According to Winergy, the HybridDrive more than delivers.

By Matthias Deicke and Martin Lubahn

Matthias Deicke is head of electrical systems at Winergy AG. Martin Lubahn is head of sales at Winergy Drive Systems Corporation. Learn more at www.winergy-group.com.

THE COST OF ENERGY plays an increasingly important role in today's world. This applies to all different types of energy production. Since wind energy is one of the most important sources for renewable energy production nowadays, it is closely monitored regarding the cost of energy and wind energy's potential for a high return on investment.

The factors that influence the energy production costs of a wind turbine are the lifecycle costs, which include costs for the overall wind turbine construction, maintenance, and service costs, as well as the output generated during the lifecycle. Therefore reliability, serviceability, and high efficiency—as well as a compact wind turbine design—are the key requirements for wind turbines. Since the drivetrain is the "heart" of a wind turbine, during the design phase all those aspects have to be especially considered.

The conventional drivetrain design consisting of a three-stage gearbox, coupling, and generator is a very reliable concept and is the standard drivetrain for wind turbines, which has a track record of almost 150 GW globally installed base. New concepts, like the HybridDrive are especially designed

Fig. 1: Modular design allows easy handling in nacelle.

to meet these requirements for compact design, high efficiency, and great serviceability. Every concept has its own advantages, so it is not possible to talk about the "perfect" drivetrain design. But, each drivetrain meets the specific requirements of a single customer so that he/she has the choice of which concept should be employed in its wind turbines. In the following article the HybridDrive concept is introduced and the major advantages explained.

COMPACT AND EFFICIENT

The main focus of the HybridDrive is its compact design. A two-stage gearbox is directly connected to a permanent-magnet-operated generator, which means that the length of the drivetrain can be shortened by about 35 percent. Although the HybridDrive has an extremely compact design, it has a very high efficiency. If the efficiency of the HybridDrive is compared with other technologies that are available, it has a peak value of more than 94 percent. This means that it achieves the best annual efficiency of all the existing technologies.

Its compact dimensions present various advantages for the design of a wind turbine. If the HybridDrive is used to replace an existing wind turbine design, it is possible to utilize the space that has been saved for the converter and transformer instead of locating these in the tower. This choice of location for the transformers reduces the low-voltage cable (energy) losses, which improves efficiency. If the objective of the wind turbine manufacturer is to construct the nacelle to be as compact as possible, this can also be achieved with the HybridDrive. Any configuration is possible with the HybridDrive, whether it is positioned with just one bearing, a dual-bearing rotor shaft, or with a converter and transformer in the tower.

Depending on the concept, the costs for the tower can be reduced as a result of the reduced weight of the nacelle; not only this, transportation is easier as the nacelle dimensions have been reduced. The customer is free to choose which concept he/she wants to focus on.

MODULAR DESIGN

A well thought out maintenance concept was already taken into account in the early design phase of the HybridDrive. Despite its compactness, the HybridDrive has a modular design, which enables individual parts to be disassembled or replaced for maintenance purposes. The benefit of this is active risk management. For example, the service crane of the nacelle can lift the individual modules, so that even when large-scale service is necessary, there is no need for an external crane. This considerably reduces service and maintenance costs. The reliability and quality of the HybridDrive is optimized,

Fig. 2: Generator directly married with the gearbox.

as there is only one supplier involved who is responsible for the design and quality assurance of the core of the wind turbine: its drivetrain.

The advantage of the HybridDrive concept over directly-driven wind turbines is that it only uses 20 percent of the quantity of rare earth materials that are required for a direct drive. As a consequence, dependency on one particular raw material is considerably lower, and costs can be more easily calculated over the long term. Since the sourcing and production of rare earth material is currently still under discussion, it is also possible to design the HybridDrive without any permanent magnets at all.

The first prototype of the HybridDrive has an output of 3MW and is intended for use in an offshore turbine. The concept can also be easily implemented for the 6-7MW power range.

TEAMING UP FOR TECHNOLOGY

Winergy introduced the HybridDrive drivetrain concept as a new member of its product family this year at Hannover Fair and at AWEA WIND-

POWER 2011. The HybridDrive will be employed for the first time in the Fuhrländer FL 3000 wind turbine system. The project is the result of a long-term partnership between Winergy AG, Fuhrländer AG, and W2E Wind to Energy GmbH, and is to be completed within one year. As described, the HybridDrive sets itself apart as a result of its compact dimensions and the combination of a two-stage planetary gearbox and a medium-speed synchronous generator in one unit. The drivetrain is supplemented by a frequency converter.

The new FL 3000 wind turbine uses the "Larus Compact" drivetrain concept already proven in the FL 2500. This concept integrates components in order to maximize security and technical availability. The wind turbine will have a rotor diameter of 120 m and a rated power output of 3MW. The wind turbine system is suitable for use up to wind class IEC 2a.

CONCLUSION

The new HybridDrive is an exciting and competitive drivetrain design. Both the conventional drivetrain and the HybridDrive have their advantages, as each offers the opportunity to reduce the cost of energy, when employed for the right application. Ultimately, the customer must decide which concept fits his/her requirements best.

Fig. 3: The Winergy HybridDrive at a glance.

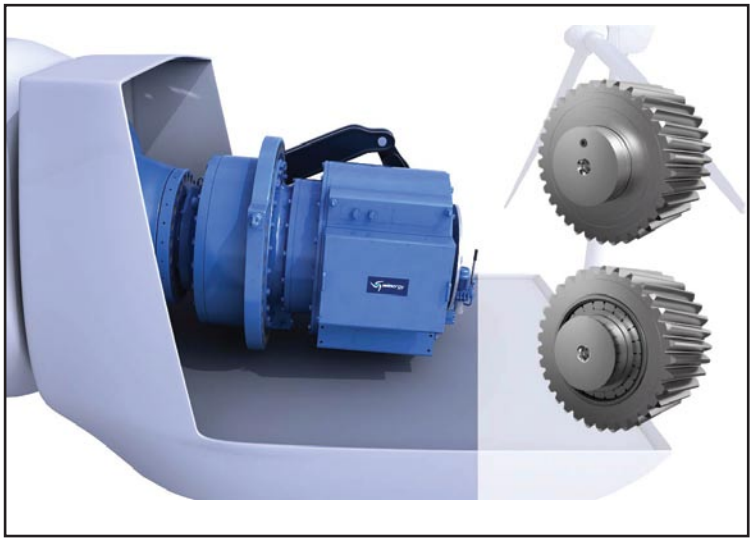

Fig. 4: Design allows both for journal bearings or rolling element bearings.

Technical specifications

Power rating	3000 kW	3000 kW
Torque	2000 kNm	2500 kNm
Weight	25t	31t
Type	PZFG 2456	PZFG 2535

THE WINDS OF INNOVATION

The wind turbine industry has emerged as a driving force for the development of a new generation of high-performance industrial lubricants, as Shell explains.

By Joe O'Connor

Joe O'Connor is product application specialist at Shell Lubricants.
Go online to www.shell.com/lubes.

THE STANDARD GEAR OIL TEXTBOOK has been ripped up and rewritten following recent advances in wind turbine technology. The loads on the lubricant are now so great, the operating conditions are so harsh, and the need for reliability is so vital that the lubricants—like other aspects of wind turbine technology—have become increasingly sophisticated. The development of these fluids is pushing at the boundaries of known science.

At Shell we can offer a unique insight into the challenges of developing a lubricant that meets the requirements of the wind turbine industry. Creating a next-generation gear oil can take up to five years at a cost of millions of dollars. It has to undergo more than 300 separate laboratory and rig tests before it is even considered for a field trial. These tests measure a multitude of parameters such as wear protection, load carrying capability, shear stability, resistance to foaming, filterability, and micropitting protection.

Clearly, developing a lubricant that meets the exacting standards of the wind turbine equipment manufacturers is a substantial challenge, but it has led to a wide range of highly advanced lubricants that are used across other industrial sectors. The

technological advances we make in developing these lubricants are ultimately benefiting users in sectors such as mining and manufacturing. When a customer selects a lubricant for their operations that they know meet the requirements of the wind turbine industry, they can be sure that it will deliver value to their operations, whatever the challenges.

The wind turbine sector is effectively the space race of the power sector, with innovations and advances appearing at an astonishing rate. The lubricants are an integral part of this development cycle.

WIND: THE FASTEST GROWING POWER GENERATOR

The wind turbine industry is the world's fastest-growing option for power generation. The annual growth rate is at some 25 percent through the on- and offshore developments being pursued all over the world. Europe and Asia are driving this growth along with the United States, where wind power contributes 42 percent of all new generating capacity. Global wind power capacity is expected to more than double between 2008 and 2013.

Wind turbine installations and structures are increasing in size to maximize power generation capacities: the turbines can stand up to 150m high and have a rotor span of 100m. In 1996 the average turbine rating was 600kW, but this is increasing rapidly and most new ones are about 2–3MW, with some at 5MW. Several companies and research programmes are even planning or investigating wind turbines of up to 10MW output or more.

Such developments will help to maximize returns on investment and reduce the cost of producing electricity from wind power. However, this expansion in generating capacity introduces various challenges for the turbine and component manufacturers, wind farm operators, and service companies that need to ensure that the equipment works reliably and requires minimal maintenance. A modern wind turbine is expected to generate electricity continuously when wind speed is available, to operate unattended, and to have extremely low maintenance requirements.

This is a complex technical challenge. The wind turbines sit on top of high columns, and many installed units have to be robust enough to withstand both very high and very low temperatures, from sub-Arctic cold to blistering desert heat, as well as salt-laden winds and rain. The rotors can also be static for periods of time, all of which place specific challenges on the lubricants.

DESIGNED TO MEET CHALLENGES

The main gearbox, which drives the generator and is the heart of most wind turbines, comes under enormous strain. Reliability is imperative. A major reliability concern is gearbox micropitting, which results from factors such as case hardening and the surface roughness of the gear teeth, as well as inappropriate lubricant selection and application.

Given the gearbox's size, the lubricant's short recirculation times and the potential for air entrainment in the system, good air-release and anti-foaming characteristics are vital properties for the gear oil. Excessive foaming can cause the oil level to rise above the maximum, which may result in unplanned turbine shutdown and loss of power to the grid.

To deal with these challenges Shell Lubricants has developed Shell Omala S4 GX 320, a synthetic gear oil that provides excellent performance in the areas requiring added protection against common failure modes, including micropitting and bearing wear. The product offers distinct advantages over conventional gear oils, particularly for product life. Field trials have shown it has up to four times the oil life of conventional mineral oil-based products, which enables the intervals between maintenance to be extended. The lubricant also gives excellent wear protection and is designed to reduce micropitting wear on gear teeth, which helps to extend the life of gearbox components and prolong operation.

Shell Omala oils have delivered value to customers across a wide range of industries. For instance, one customer in an industrial application reports virtually eliminating gearbox failures and saving over $50,000 a year by switching to Shell Omala S4 GX. The oils have also extended oil-drain intervals: some equipment manufacturers approve Shell

Omala S4 GX for four-year drain intervals, and some customers have extended their oil-drain intervals by up to five times.

However, a wind turbine's lubricant-related challenges are not limited to the gearbox. The massive blades of a wind turbine are supported using grease-lubricated blade bearings that, if insufficiently lubricated, can fail through fretting and false brinelling. Again, the lubricant must be able to operate at temperature extremes and have corrosion-protection qualities.

As a result, Shell formulated Shell Rhodina BBZ grease using experience gained from developing greases for helicopter rotors. This is designed to protect bearings against fretting corrosion, moisture contamination, and false brinelling at temperatures as low as –55°C.

Shell Rhodina BBZ is establishing a track record with both customers and major wind turbine manufacturers. It is lubricating the blade bearings of many wind turbines globally through our listings with leading blade bearing suppliers such as IMO, Liebherr, Rollix and Rothe Erde, and wind turbine manufacturers including Vestas, Acciona, Gamesa, Dongfang New Energy Equipment, Sinovel Wind Group, and Siemens Wind Power.

OPERATING IN EXTREME CONDITIONS

For wind turbines that operate in ultra-low temperatures, Shell Tellus S4 VX is recommended for the hydraulic systems. Through its specially selected base fluids, it has the widest operating temperature range in the Shell Tellus range, so it can be used in wind turbines that operate in extreme climates.

Operators that need to run hydraulic equipment in extreme cold have benefited from using Shell Tellus S4 VX because it can help to deliver high levels of equipment availability. Start-up is easy, and maintenance requirements are reduced. Crucially, it also helps to improve efficiency because the energy losses through pumping hydraulic fluid at low temperatures are controlled. The product is recommended or listed by Svendborg Brakes and by wind turbine manufacturers including GE Wind Energy, Voith Turbo, Vestas, Dongfang Wind Turbines, Sinovel, REpower, Nordex, and DHI.

The yaw gear, which is mounted on the tower and enables the nacelle to rotate, is also subjected to huge forces. For these applications Shell developed Omala S4 WE, an advanced, synthetic industrial-gear lubricant formulated using specially selected polyalkylene glycol base fluids and additives. Shell Omala S4 WE offers outstanding lubrication performance under severe operating conditions, including improved energy efficiency in

comparison to mineral-based products, long service life, and high resistance to micropitting.

ACCELERATING INNOVATION

A recent report by the International Energy Agency (IEA) suggested a target of 12 percent of global electricity from wind power by 2050, and said that there is no fundamental barrier to achieving or even exceeding this goal. It expects investment costs to continue decreasing: by 23 percent for onshore installations and 38 percent for offshore projects by 2050.

Nevertheless, the IEA counsels that increased efforts in wind technology research and development are essential. That is why Shell is working hard to develop lubricants that will meet the industry's challenges, and it is not working in isolation. It collaborates with leading wind turbine manufacturers, component suppliers, and industry associations to understand emerging lubrication needs, the rapidly changing industry, and manufacturers' specifications.

Every component in a wind turbine is technically challenged, pushed to the limits and operating on the edge of known science, and the lubricant is no different. Equipment design and the lubricant's capability will be key to the larger, more-reliable units that the industry is striving for. Shell is committed to facilitating this by advancing the state of the art in lubricant technology.

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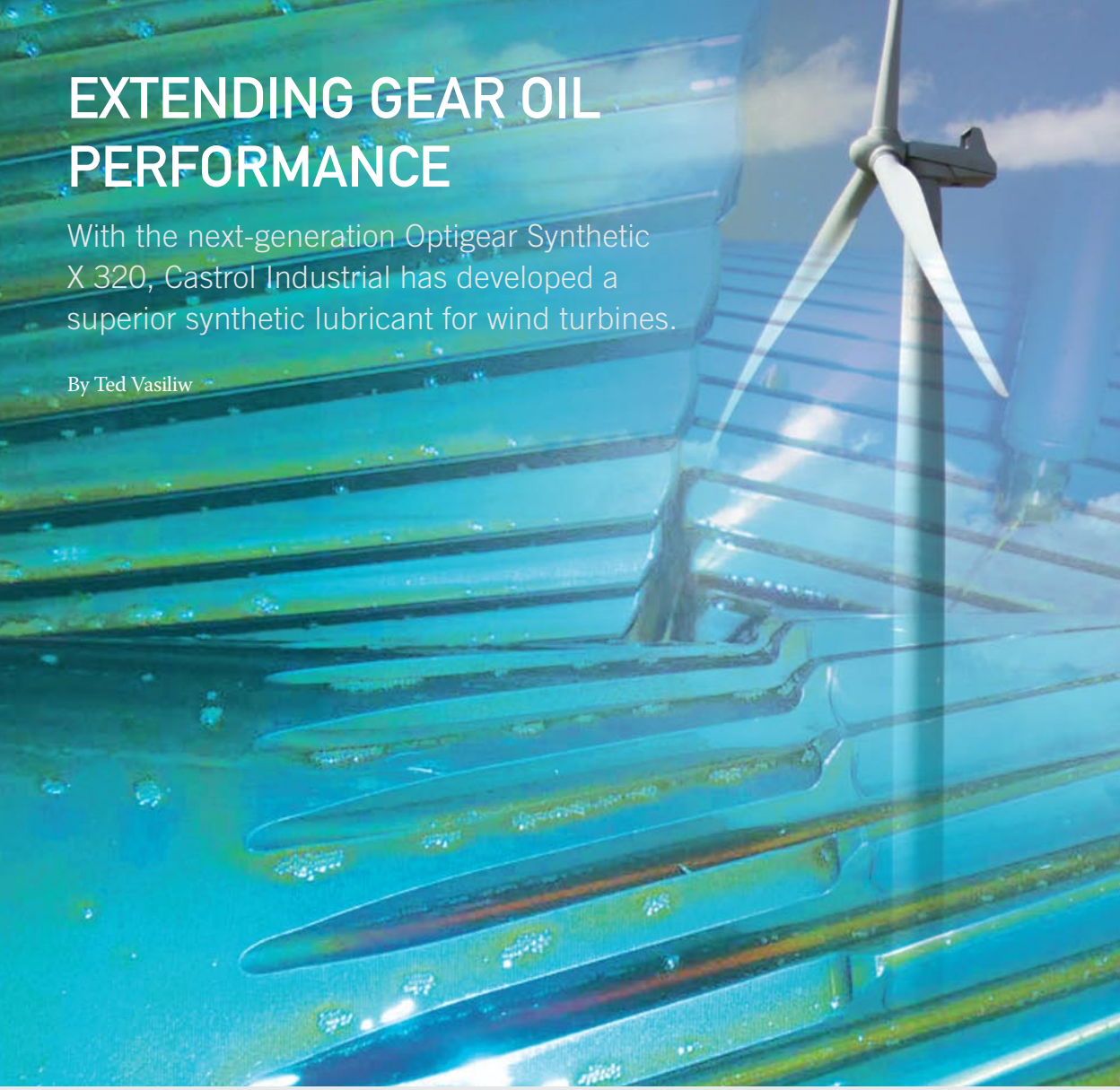

EXTENDING GEAR OIL PERFORMANCE

With the next-generation Optigear Synthetic X 320, Castrol Industrial has developed a superior synthetic lubricant for wind turbines.

By Ted Vasiliw

Ted Vasiliw is wind aftermarket technical manager at Castrol Industrial North America. He can be reached at ted.vasiliw@castrol.com. Contact technical support at (877) 641-1600, and go to www.castrolindustrial.com/windenergy/.com

MORE THAN A DECADE AGO CASTROL Optigear® Synthetic A 320 (OGSA 320) was developed to meet specific criteria developed by the National Renewable Energy Lab (NREL) for use in wind turbine gearboxes. OGSA 320 was submitted along with products from other major lubricant suppliers. The gear oils were tested against specific criterion that included operating temperature range, protection against micropitting wear, and the ability to last up to 20 years in the gearbox.

Castrol Optigear Synthetic A 320 outperformed all other oils in the micropitting resistance tests due to its unique Microflux-Trans® (MFT) anti-wear and anti-scuffing additive system. Under extreme loads the organo-metallic additives in the MFT system enhance the gear surfaces by plastic deformation. This smoothing of the surfaces increases the load bearing surface area, thereby reducing wear and lowering friction.

Visual evidence of MFT's surface smoothing effect can be seen in figures 1 and 2. Figure 1 shows a highly magnified wear scar surface from an SRV wear test with a conventional gear oil. Figure 2 show the SRV test surface using MFT surface-active technology.

Castrol Optigear Synthetic A 320 quickly became the industry standard for wind turbine gear oils and gained

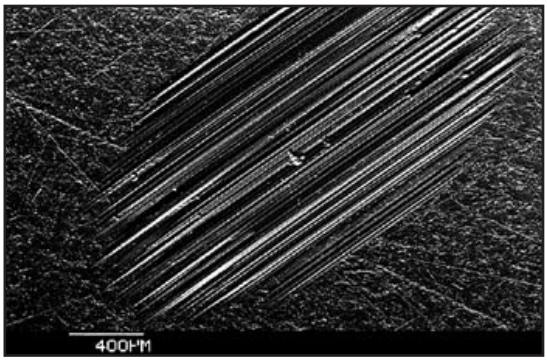

Fig. 1: SRV magnified surface with conventional gear oil.

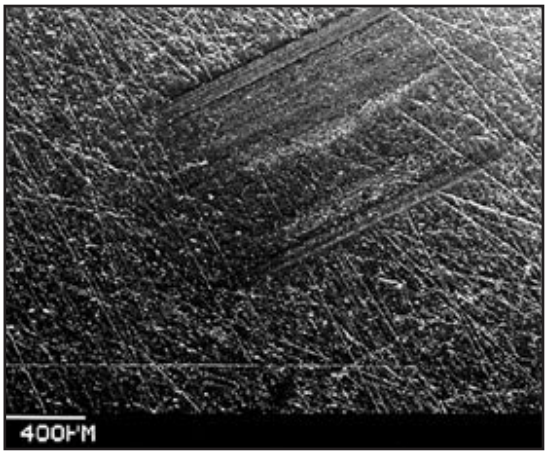

Fig. 2: SRV magnified surface with MFT technology.

approval from many of the wind turbine OEMs for first fill, in large part due to its superior micropitting protection. OGSA 320 has been operating successfully in over 17,000 turbines worldwide.

PERFORMANCE ISSUES ARISE

With the original goal of a 20-year life set forth by NREL—note that the current gearbox lifespan is expected to be 10 years—the anti-wear and anti-scuffing MFT additives were formulated in robust proportions. It is known that the MFT additive package is somewhat hygroscopic and will take up certain amounts of water. This was not an issue in the field until wind farms began to expand from arid climates to more-humid locations such as the Midwest and Upper Midwest regions of the United States.

In a very small percentage of turbines filled with OGSA 320, water content became an issue. Where water determination by Karl Fischer results showed greater than 500 ppm water, some turbines experienced precipitation of the additives. The resulting additive fallout residue caused premature filter loading, and in some cases false low oil level alarms due to interference with the low oil level sensor. Even with this additive fallout, however, levels in the oil remained above the minimum specifications and wear protection of the gears and bearings were never compromised. Additionally, oil life did not appear to be negatively affected.

In an attempt to mitigate and respond to these issues caused by high water content, Castrol Detergen® System Cleaner (DSC) was added to the gear oil in small percentages in several turbines. DSC has been in the Castrol product line for more than 20 years and is an oil-based cleaner containing detergents and dispersants. It dissolves sludge residues and is routinely used for cleaning industrial gearboxes and hydraulic systems prior to oil changes. After it was added to the problematic wind turbine gearboxes,

improvements were quickly noted: additive residues were eliminated from the filters, and false low oil level alarms stopped.

LABORATORY TESTING VERIFICATION OF WATER EFFECT

The additive precipitation described above, and reduced additive levels also presented in a small percentage of field cases. In early 2010 Castrol performed extensive laboratory testing to validate the effects of water on OGSA 320, and to verify positive field experience that DSC can reduce the negative effect water engress has on the additive system.

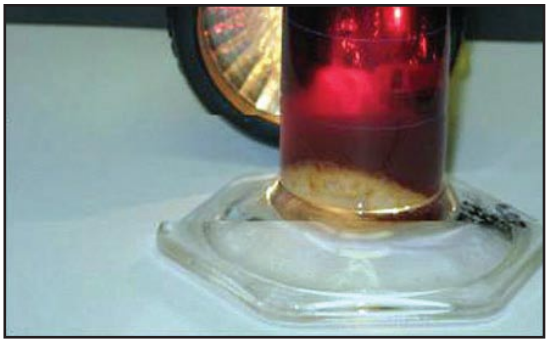

Fig. 3: Sample with 750ppm water—fallout present.

Water Effect on Optigear Synthetic A 320 Additive System

Four samples were prepared: 1) control sample new OGSA 320; 2) OGSA 320 with 500 ppm water; 3) OGSA 320 with 750 ppm water; and 4) OGSA 320 with 1,000 ppm water. Visual inspection confirmed that there is no additive fallout in the OGSA 320 control sample without water. However, in the water-contaminated samples the field experience was confirmed and certain additives were seen to precipitate out and cause a residue. Figure 3 shows the sample with 750 ppm water, and a light brown sludge can be seen at the bottom of the cylinder.

The Optigear Synthetic A 320 additive system consists of magnesium (Mg), molybdenum (Mo), zinc (Zn), and phosporus (P) typically in levels ranging from 1,200-1,800 ppm for new oil, with minimum limits on used oil from 400-3,000 ppm. Spectrographic analysis of the top and bottom layers of the oil samples found approximately 2X the levels of Mg and Mo on the bottom as compared to the top layers of the sample with 750 ppm water. This confirmed that the residue was indeed additive fallout. Of the three, the sample with 750 ppm had the most dramatic difference between the top and bottom layers. Based on this testing, the following conclusions can be made regarding the water effect on the OGSA 320 additive system:

- OGSA 320 with no water added is stable with no additive precipitation;
- At water levels over 500 ppm, additive precipitation and fallout can occur;
- With 750 ppm water added, OGSA 320 can form additive fallout residue, particularly of the Mg and Mo components of the additive system;
- Water at these levels does not have a significant impact on P and Zn.

Castrol Detergen System Cleaner Effect on Additive Precipitation

Laboratory testing and field experience clearly indicate that certain additives, primarily Mg and Mo, can precipitate out of solution and form residue when OGSA 320 is exposed water contamination in excess of 500 ppm. To investigate the effect DSC can have on mitigating this issue, 2- and 5-percent dosages were added to the samples with 500 and 750 ppm of water and fallout present. After the DSC was added, the samples were agitated and allowed to cure for 48 hours. The DSC immediately cleaned up the residue fallout in both samples. Figure 4 shows the sample with 750 ppm water and 5 percent DSC with no fallout present.

Spectrographic analysis of the top and bottom layers of the oil samples confirmed that the additives went back into solution. The amounts of Mg and Mo in both layers were approximately equal and back to normal. This supported the visual conclusion that the fallout residue became soluble back into the oil. Based on testing, the following conclusions can be made regarding the effect of DSC on additive precipitation:

- DSC caused the precipitated additive components to go back into solution;
- OGSA 320 that had additive fall out residue in the presence of 750 ppm water appeared clear with no distinct layers after the addition of 5 percent DSC;
- At 5 percent DSC added, the amounts of Mg and Mo in both the top and bottom of the oil sample layers became approximately equal;
- DSC does not have a significant impact on P and Zn.

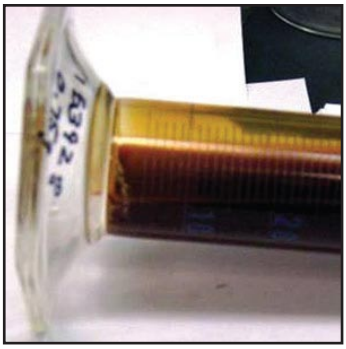

Fig. 4: Sample with 750ppm water and 5% DSC—no fallout present.

Castrol Detergen System Cleaner Effect on Wear Protection, Foaming, and Filter Life

After it was determined by lab testing that the addition of DSC had the desired positive impact, further test-

ing was performed to see what effect the DSC would have on other key performance properties of OGSA 320. For all of these tests, three samples were used: 1) control sample new OGSX 320; 2) OGSX 320 with 750 ppm water and 2 percent DSC; and 3) OGSX 320 with 750 ppm water and 5 percent DSC.

SRV wear tests were performed on the three samples. The addition of 2 or 5 percent of DSC did not have any significant effect on either wear scar diameters or the coefficient of friction of OGSA 320 as compared to the control sample. In fact, a scar diameter of 0.44 mm was reported for the DSC and water containing samples, which is lower than the 0.50 mm scar diameter for new OGSA 320.

ASTM D-892 foam test was performed on the three samples. All of the samples (without DSC added) were placed in a 60 C oven for two weeks and tested. As expected, the control sample exhibited excellent anti-foaming properties in all sequences of the test. The presence of 750 ppm of water greatly increased foaming, especially at the elevated temperature of sequence II. The two samples with 750 ppm water were then dosed with 2 and 5 percent DSC, and all samples were placed back in a 60° C oven for two weeks. The sample with 2 percent DSC with 750 ppm water reduced foaming by one half, versus the sample without DSC. At 5 percent DSC level foaming was practically eliminated in both the sample with 750 ppm water and the control sample.

Filter life is impacted by many variables that are not related to the oil, such as external contamination. However, filterability of the oil as measured in the amount of oil-generated particles remaining on the filter media also impacts filter life. To test this, 25 mLs of each sample was filtered through a 2.7 micron filter. The filter papers were carefully weighed before and after filtering and after being dried, and the results reported in percentage of mass change. Mass change of the filter is directly related to the amount of additive precipitation. With 750 ppm water in OGSA 320 and without DSC, the percentage of mass increased by 2.6 times due to the additive fallout. With 2 percent DSC added to the sample with 750 ppm water, the percentage of mass change is about equal to a new OGSA 320 sample without water or DSC. With 5 percent DSC added the percentage of mass change was reduced more than 10 times versus the sample with 750 ppm water and no DSC, and five times lower than the new OGSA 320 sample without water or DSC. Laboratory testing conclusions showed that:

- Certain additives, especially Mg and Mo, can precipitate and fall out of solution from OGSA 320 in the presence of 500 to 1,000 ppm water;
- The addition of low concentrations of DSC has no adverse effect on SRV friction or wear properties;
- With DSC added, OGSA 320 easily passed all foam tests

Fig. 5: Gears after three years using Optigear Synthetic X 320 and 90 days DSC.

and outperformed new oil (without water or DSC);

- Filterability is significantly improved with DSC even better than clean oil with no DSC;
- Any negative effects due to water contamination are completely mitigated by a low dosage treatment of Castrol DSC.

FIELD EXPERIENCE WITH DSC

Subsequent to the laboratory testing, DSC has been added to more than 140 turbines filled with OGSA 320 and operated for three to six months. Since oil sample intervals are generally six months, we have only been able to review about 40 recent samples to compare the results to samples prior to the addition of DSC. The results have been good. Molybdenum levels are all well above the minimum requirements, and they have stabilized nicely. Cleanliness levels are good, and there have been no reports of any residue in the filters and filter housings that have been inspected. Neither have any issues concerning shortened filter life, or false oil level alarms caused by residue, been reported. A gear inspection of one turbine which had been in operation for three years using OGSA 320, and had 5 percent DSC added 90 days prior, showed clean gear tooth surfaces with no signs of pitting or wear (fig. 5).

Even in high humidity areas, a reduction in water content has been documented in many cases. In one controlled study of 10 GE 1.5MW wind turbines located in the upper Midwest, a 28 percent average reduction in water was reported after 60 days of adding DSC.

CONCLUSION

The addition of 5 percent Detergen System Cleaner to water-exposed Optigear Synthetic A 320 provides a safe, long-term solution to all known issues involving the precipitation of gear oil additives and resulting sludge formation. This solution does not impair the performance of the oil and will potentially extend the life of Optigear Synthetic A 320 fluid and system filters, while maintaining optimum wear protection. Currently the effect of the DSC as a long-term solution has only been tested with OGSA 320.

Where issues concerning water contamination of OGSA 320 are present, the addition of a small amount of DSC will enhance the performance of the oil and potentially extend its useful life. Wind farm owners can realize significant cost savings by extending the life of the oil by one or more years, and avoiding costly oil changeouts, while at the same time being confident that their wind turbine gearbox components are being protected from wear.

NEXT GENERATION GEAR OIL

Being cognizant of the issues with OGSA 320, Castrol has developed the next generation in wind turbine gear oil: the Castrol Optigear Synthetic X 320. It has higher resistance to micropitting than its leading competitors, can provide greater protection to gearbox components, and extend the life of the gearbox. This product is more tolerant of water and performs exceptionally well in the most adverse conditions in any part of the country, with better filterability. Optigear Synthetic X 320 has several OEM first fill approvals for wind turbine gearboxes and is a great choice for a second fill gear oil to maximize the life of the gearbox and reduce total cost of ownership. Optigear Synthetic X 320 can last up to seven years before an oil change, resulting in a potential savings of up to $250,000 versus a typical competitor's oil, which could need an oil change in this time.


WIND
SYSTEMS
Just as its name implies, *Wind Systems* magazine addresses all aspects of this booming industry, providing information pertinent to landowners and managers, site developers, maintenance workers, economic development professionals, construction companies, tower and component-parts designers and manufacturers—in short, everyone involved in the systems central to and surrounding wind power generation. Brought to you by Media Solutions, Inc., publishers of *Gear Solutions* magazine (www.gearsolutions.com).
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AN ONLINE COMMUNICATIONS SOLUTION

Voice over Internet Protocol (VoIP) systems provide exceptional communications solutions for the wind industry, as NAES explains.

By Bjorn Hedges, Jason Hayes, and Thomas Halpin

Bjorn Hedges is plant manager of the White Creek Wind I and Harvest Wind facilities, Jason Hayes is systems manager at Bergelectric, and Thomas Halpin is operations manager at IndustrialENET. Go online to www.naes.com, www.bergelectric.com, and www.industrialenet.com.

THE WHITE CREEK WIND I and Harvest Wind farms are owned by four consumer-owned utilities and operated by the NAES Corporation. NAES plant staff investigated solutions to upgrade the existing communications system at these facilities located in south central Washington State, selecting Bergelectric—one of the nation's top electrical contractors—to develop and install a state of the art Internet-over-fiber solution. This communications solution provides an example of how to outfit a wind station with outstanding and cost effective safety and communications capabilities. Bergelectric designed the VoIP (Voice over Internet Protocol) system, partnering with IndustrialENET for its resilient industrial network solution and experience in the wind industry. IndustrialENET has developed communications solutions for the wind industry since 1997, including supplying Ethernet switches for more than 10,000 wind turbines.

As with many wind farms, the White Creek Wind I and Harvest Wind facilities are constructed over a large geographical area, in this case approximately 40 square miles. In order to find a site with large enough parcels, and with lower property costs, these two sites were developed in a remote area void of cellular or hardwired phone service.

At the White Creek Wind I site, and magnified with the

addition of the Harvest Wind Project site, there was concern with the poor coverage for site communications. Both sites used two-way radios with the signal amplified by a single radio repeater. For maximum coverage, the repeater was installed in a wind turbine that had a battery backup system to maintain communications during grid outages. Even with selecting a turbine that provided maximum "line of sight" coverage, however, there were holes where radio contact could not be maintained.

Further, the radio system provided communication between radios only; that is, crew to crew, or between the crew and the O&M building. During periods of limited staffing, such as when on-call crews must respond to an issue on a Sunday, offsite communication was not available. In the event of an emergency, a technician could not call for emergency services using the radio system. Cell phone coverage, which was also very limited, did not provide a suitable alternative form of communication. Plant staff had to ensure that there was always a staff member at the O&M building whenever crews were working—a rather inefficient use of plant labor.

INVESTIGATING ALTERNATIVES

For the past year NAES plant staff studied solutions to address the communication coverage, including technologies that provided additional benefits such as Wi-Fi routers in the towers, cell phone repeaters mounted on the met tower, radio repeaters, satellite phones, and others. Two viable technologies were investigated further.

First was an improved radio system that provides minimum coverage from a safety standpoint. This system involves installing a second repeater to provide coverage over the entire site, along with a link to allow for simultaneous use of multiple repeaters. With the addition of a phone switch, the radios can also be used as a telephone allowing for offsite communication during emergencies or for technical support. As with any radio system, however, multiple conversations cannot occur simultaneously. If a technician is on a support call, which could easily last 30 minutes or more, no other onsite (two-way radio) or offsite (emergency) calls can be made.

The second technology that was investigated provided Internet access over fiber optic cabling to meet not only the minimum coverage for safety, but also to provide significant benefits for technician tools and turbine monitoring. This system makes use of two spare fiber optic cables already in place at the base of each tower, extends those fibers up the tower into the nacelle, and terminates them in a fiber-Ethernet switch that includes a VoIP phone and an Ethernet port (fig. 1). The phone allows for communication between towers, the O&M building, and offsite. The Ethernet port allows technicians to access the site servers providing instant access to electronic manuals, the SCADA system, turbine work history, the Computerized Maintenance Management System (CMMS), and more. Further, with a static IP (Internet protocol) address in each tower, any Internet-based electronics such as cameras, vibration monitors, and sensors can be easily installed and then accessed from any Web-based interface.

In the final analysis the enhanced radio system met the minimum requirements for safety coverage, yet failed to provide the capability to conduct multiple simultaneous conversations. The Internet-over-fiber solution, though significantly more expensive than the enhanced radio option, met not only the minimum safety coverage, but also provided technicians with access to all pertinent manuals, history, and operational programs, as well as providing a platform for future monitoring needs. The Internet-over-fiber option was the final recommendation.

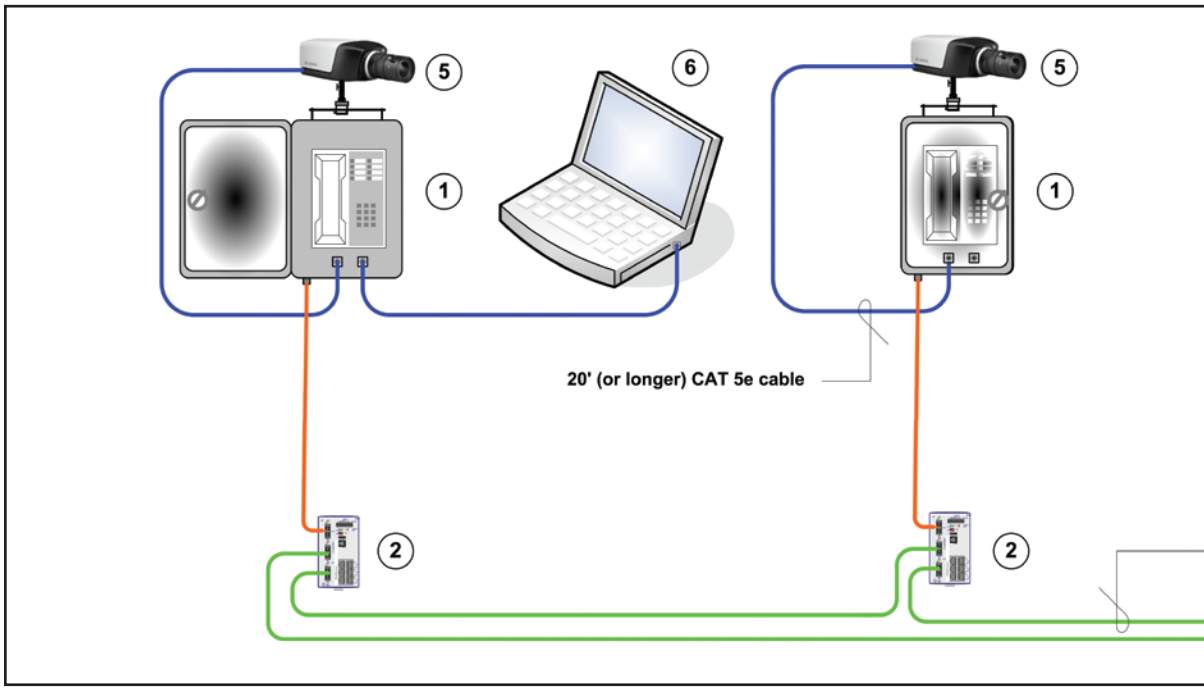


Fig. 1: VoIP system diagram for wind.

DESIGNING THE SYSTEM

The communications infrastructure at wind farms typically utilizes fiber optic cabling connections amongst the wind turbine generators, and in most cases, between the O&M facility and substation as well. In some cases wireless capabilities are also built into the communications system. When designing the technical requirements for the communications system many key factors need to be considered, including enhanced 911 (E911) calling features, availability, quality of service, ambient conditions, open standards, security, and system vulnerabilities.

It is also good design practice to provide multiple Ethernet ports to allow connectivity to other edge devices, such as cameras, laptops, Wi-Fi devices, and perhaps even IP-enabled testing equipment and instruments.

CRUCIAL FEATURES

Enhanced 911 (E911) is paramount in cost justification and is an important component to the system. Features should include user definable CALLER ID of 911 calls by location, automated call recording of all 911 calls, and notification of 911 calls in progress to all operator group members, including the extension that made the 911 call.

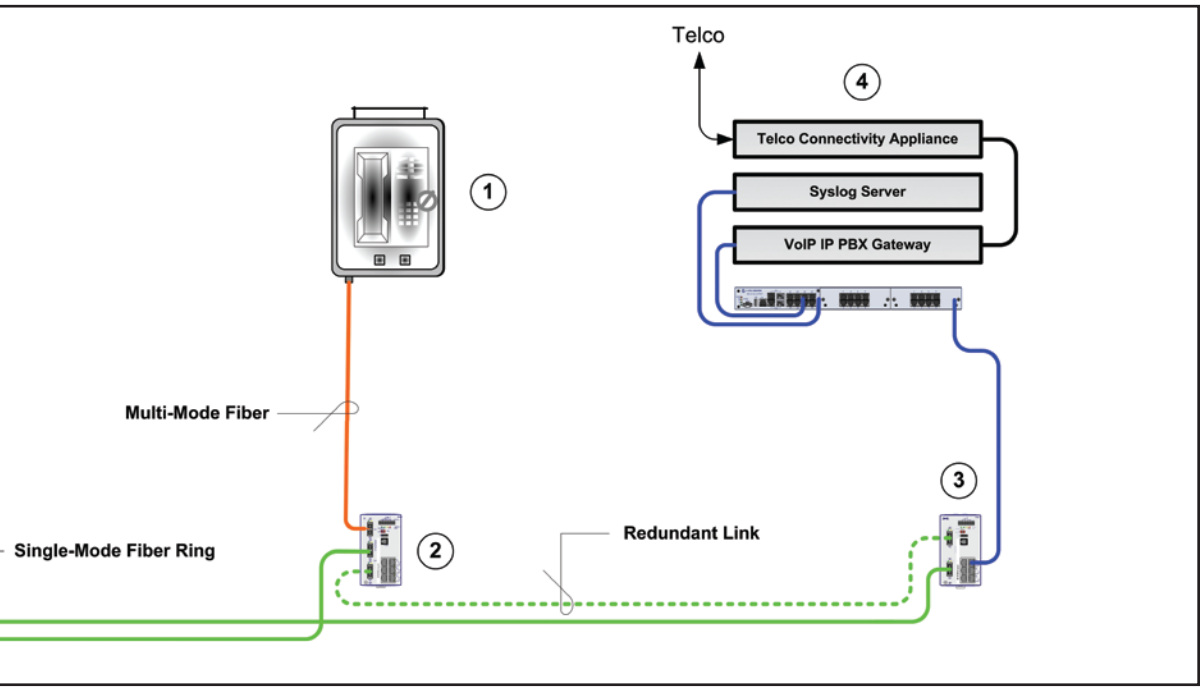
The call should be recorded in Call Data Recording (CDR) format and generate a "syslog event" as well. With proper set up on a syslog server, this event can be emailed to the appropriate emergency services as soon as the call is made. Syslog is a standard for logging program messages that separates the software that generates the messages from the system that stores them and the software that reports and analyzes them. It also provides devices that would otherwise be unable to communicate a means to notify administrators of problems or performance. Syslog can be used for computer system management and security auditing, as well as generalized informational, analysis, and debugging messages. It is supported by a wide variety of devices like printers, routers, and receivers across multiple platforms. Because of this, syslog can be used to integrate log data from many different types of systems into a central repository.

REDUNDANCY IMPORTANT

A failure in the communications system can sever the very link needed to communicate an emergency. Knowing when there is a single point or multiple points of failure is important so that corrective action can be taken immediately. This is possible only if the network is composed of managed switches with robust redundancy protocol/s enabled, and with the fiber media constructed into a ring since folded rings are common in the wind industry.

When wireless is used, the system needs to include two radios on each side of the communications link, with one radio configured as the primary link and the other as the backup link. In this case, the Rapid Spanning Tree Protocol (RSTP) is common.

Redundancy and link failures need to be alarmed back to a network management system that is capable of notifying staff, either by continuous monitoring or via email, if there is a link failure between the switches, radios or an edge device, such as the telephone. The first backbone link failure will go unnoticed until a second failure occurs, by which time either a portion or all of the network will have been severed, possibly resulting in the inability to make a call. Refer to fig. 1 when considering the following:



1) Each nacelle includes a VoIP telephone and managed Ethernet switch located in a water tight enclosure with a clear door, as well as one FX multi-mode port and three TX RJ45 ports (FX = Fast Ethernet over optical fiber, and multi-mode fiber is typically used for distances less than 6 miles and is less expensive than single mode fiber, which is typically used for distances greater than 6 miles);

2) If desired, a down tower managed switch can include two FX single-mode ports, one FX multi-mode port, and six TX RJ45 ports;
3) Managed switch configured as the redundancy manager, located in an IT room or substation and connected to the nacelle system via both a standard link and a redundant link;
4) The connection to the telephone company/service provider includes the Telco Connectivity Appliance, a VoIP IP PBX Gateway, a Syslog Server that supports E911, and a Layer 3 (preferred) managed switch;
5) IP camera mounted with a spring clamp and connected with 20 foot Cat 5e cable;
6) Edge devices (laptop computers, etc.) can be connected to allow access to system manuals and Internet connectivity.

INDUSTRIAL COMMUNICATIONS EQUIPMENT

To avoid equipment failure at the turbines, use only robust industrial rated communications equipment that can survive the ambient conditions, shock, vibration, and equipment line power anomalies at the site. Deploy only industrial-rated Ethernet switches that follow industry standard practices and approvals. The same requirements should apply to all the devices, whether located in the turbine or in any harsh environment, such as in the substation or elsewhere.

PLANNING THE VOIP SYSTEM

The VoIP system is composed of a gateway—which is a computer or a network that allows or controls access to another computer or network—connecting the telephone service to the local area network (LAN), and in most cases the wide area network (WAN) as well. It is very desirable that the gateway will support the VoIP Session Initiation Protocol (SIP), which is an IEEE Open Standard. This way, you can choose from a number of different suppliers when selecting the telephones. The telephones can either plug directly into an Ethernet switch or be wireless, as in the case of also including a Wi-Fi cloud over the site. A good gateway architecture that includes redundancy from the Telco (telephone company) side is recommended, along with using a combination of any two of the following services: Plain Old Telephone System (POTS) lines, T1, PR1, DSL, and an Internet Telephony Service Providers (ITSP) SIP trunk. Keep in mind that the lower the power requirements for these options, the better. Back up both the VoIP gateway and the syslog server with a UPS (uninterruptible power supply) system designed to keep the system up and running for a predetermined amount of time, typically several hours. How long might an emergency last?

ENCRYPTED CONNECTION

A Linux operating system running on the VoIP gateway is a better choice than using an Open Source Architecture, such as Windows. This way, there is a greatly reduced risk to vulnerabilities and hacker attacks.

The Secure Shell (SSH) allows a secure remote channel to be opened between the gateway and any remote programming station. SSH uses encryption to provide a secure connection to the gateway over an unsecured network, such as the Internet. This secure level of support is highly desirable when provisioning SIP trunks and performing troubleshooting and maintenance.

ENSURING VOICE QUALITY

Quality of service is very important when using VoIP, as packet loss and delays can make the voice transmissions useless. Therefore the network system of switches and/or appliances should support prioritization, especially if the network is intended to share other media such as video and Internet connectivity.

With prioritization, you can select which data packets are sent first over the system, ideally the VoIP has the highest priority. If a large amount of video data is to be transmitted over the network, then implementation of an IEEE 802.1Q VLAN (Virtual Local Area Network) is recommended to virtually separate the video traffic from the VoIP traffic. VLAN architecture can also be used to secure the VoIP network from the network ports intended for the edge devices (laptop computers, etc.) and that traffic.

INTERNET-OVER-FIBER SOLUTION

Between July 19 and December 2, 2010, NAES plant staff worked with Bergelectric to install Internet access in the 132 wind turbines at the White Creek Wind I and Harvest Wind facilities, as well as a telephone equipped with the Enhanced 911 (E911) technology. Each nacelle is now equipped with a NEMA 4 box that includes the fiber-to-Ethernet switch, a VoIP telephone, a power supply, and a surge protector. The box also doubles as a laptop stand.

The project is already showing the potential to lower insurance premiums and labor services costs. The E911-enabled phone and IP connection for various devices such as computers, cameras, and sensors are not only increasing safety for maintenance personnel, but are also enabling them to be more efficient. Technicians can now access electronic work instructions, contact technical support, access manuals and diagrams, and operate the SCADA system, all while at the top of a wind turbine, eliminating the time consuming up-and-down process to climb the tower or the use of a radio-to-phone middleman.

LUBRICATING WIND COMPONENTS

Shermco shares the secrets of lubrication route planning, application, sampling, testing, and analysis of rotating and static wind generation components.

By Mike Moore

Mike Moore is vice president of sales at Shermco Industries. Call (888) SHERMCO or (972) 793-5523, e-mail info@shermco.com, or go online to www.shermco.com.

EQUIPMENT LUBRICATION is the lifeblood of any electrical system, from the large-scale wind farm to the small single-pole 20-amp circuit breaker in our homes. Whether the lubrication is in the form of grease, oil, or powder the proper selection and application is huge, and the consequences of not correctly applying and maintaining lubrication through the life of the electrical system can be disastrous.

Considering all of the related training seminars, certifications, application tools, manufacturers' published data, and the overall industry awareness about the importance of lubrication, the failure of rotating machines should be rare and unheard of. But the truth is that lubrication-related failures happen every day, and with a high cost to production, reliability, and worst of all to safety. This article will explain some of the common terms and best practices that an owner/operator of a wind farm can use to keep his or her equipment properly lubricated so they don't get burned by failures and downtime.

LEARNING THE LINGO

Understanding "lubrication lingo" is important when dealing with electrical equipment. Think

about the physical properties of lubrication with these terms and how they can apply to electrically driven mechanical devices.

Lubrication: The process or technique employed to reduce wear of one or all surfaces in close proximity and moving relative to each another by interposing a substance called lubricant between the surfaces to carry or to help carry the load (pressure generated) between the opposing surfaces.

Elastohydrodynamic lubrication: Opposing surfaces are separated by just a few microns of lubrication, but there is interaction between the raised solid features called asperities, and there is an elastic deformation on the contacting surface, enlarging the load-bearing area whereby the viscous resistance of the lubricant becomes capable of supporting the load.

Boundary lubrication (also called boundary film lubrication): The bodies come into closer contact at their asperities; the heat developed by the local pressures causes a condition which is called stick-slip, and some asperities break off. At the elevated temperature and pressure conditions, chemically reactive portions of the lubricant react with the contact surface forming a resistant layer or film on the moving solid surfaces (boundary film) which is capable of supporting the load and major wear or breakdown is avoided.

Oil viscosity: Viscosity is the capacity of a fluid to provide resistance, and thus friction, to an opposite laminar movement of two adjacent layers. If you have high viscosity there is a high resistance to flow, whereas a low viscosity is a thin fluid. Viscosity should be appropriate for the load and speed of the application at operating temperature. This will help to insure maximum protection and component life.

Grease consistency: The consistency of grease is one of its most visible characteristics, and the consistency of grease should be appropriate to the application as it affects the ability to reach the areas to be lubricated. An NLGI (National Association of Lubricating Grease Manufacturers) grade 2 grease is the most commonly used grease in electric motor and generator applications.

Oxidization resistance: Oxidation resistance is a behavior of lubricant greases that are exposed under static (in-service) conditions and influenced by the atmosphere for a prolonged period of time. Electric motor greases should have outstanding resistance to oxidation, as this extends the life of bearings running at high speeds and high temperatures, such as greases with a high ASTM D 3336 oxidation life.

Anti-wear and extreme pressure additives: Anti-wear or AW additives are for lubricants that help prevent metal-to-metal contact between parts of gears and bushings and usually contain zinc or phosphorous compounds. Extreme pressure (EP) additives are commonly used in applications such as gearboxes or where there is a thrust load on bearings. AW additives are used with lighter loads such as hydraulic and automotive engines. EP additives can shorten the life of the grease and should not be used where they are not needed.

Dropping point: The dropping point of lubricating grease is the temperature at which it passes from a semi-solid to a liquid state. It is used in combination with other testable properties to determine the suitability of greases for specific ap-

plications. It is applicable only to grease that contains soap thickeners made of fatty acids or metallic salts.

So what does it all mean? In layman's terms, "lubrication" really means reducing the surface friction between two components with oil or grease that creates a small amount of pressure to keep the two components equally apart. Lubricants also act as a coolant to contact areas and can assist in the removal of wear products. While carrying out these functions the lubricant is constantly replaced from the contact areas either by the relative movement (hydrodynamics) or by externally induced forces. Without lubrication you will likely have equipment seizures that are similar to the welding together of components... or even get burned, literally and physically!

KEEPING IT LUBED

The average gearbox takes a lot of abuse, and when applied to wind it is actually an extreme engineering challenge due to the difficulty in properly assessing the loads—in particular the non-torsional loads that pass through the gearbox—and how these affect bearings and gears. A gearbox absorbs additional loads introduced by the rotor such as shaft bending through a single bearing assembly and deflections of the bedplate and main bearing, not to mention alignment issues. This makes for a nasty mess that could propagate additional points of failure due to lubrication contamination. These contaminants create issues like micro-pitting, which can lead to wearing and changes in gear teeth shape and reducing gear accuracy, increasing vibrations, noise, and eventual misalignment and failure. Most gearbox manufacturers utilize a special gearbox oil filter, which helps ensure maximum oil cleanliness. This is a key factor in environments where dust and debris can get into gearboxes and eventually lead to contact fatigue failures.

Many motor and generator bearings are lubricated with an automatic greasing system. These auto lubrication systems promote improved operating times and longer maintenance intervals, typically one year or longer. Additional benefits are lower costs for repairs, spare parts, and lubricant, and greater bearing life from regular, exact amounts of lubrication. This system minimizes or eliminates safety risks associated with hard to reach lubrication points, increases corrosion protection from the elements, and significantly reduces the amount of wasted lubrication.

Lubrication issues on a cir-

cuit breaker can cause catastrophic results. The overall safety of the electrical worker has become a higher priority at the wind farm, and we cannot forget about what the lack of lubricant, and hardened lubrication, can do to an overcurrent protective device such as a circuit breaker. In 2007 The International Electrical Testing Association (NETA) performed a study of overcurrent protective devices tested on a normal and routine basis. This data was supplied by its member companies and analyzed a cross section of electrical equipment in North America. The survey yielded data about the average condition of electrical equipment currently in service throughout the United States. Of the defective devices found in the survey, 51.4 percent had lubrication issues with the breaker mechanism or operator.

Circuit breakers create a huge lubrication challenge since most of them remain static in the closed position and do not operate for months or even years at a time. When these protective devices are called on to operate and interrupt faults they may be slow, sluggish, or may not operate at all due to the factory lubrication drying out and/or hardening over time. This creates a coordination nightmare, and it increases arc duration and incident energy exposure. This situation can render the best electrical safety program, training, and PPE less effective, it can affect the results of the arc flash study, and worst of all it can lead to an electrical worker getting burned.

GETTING BURNED

It can be said that many of the lubrication issues that face the wind industry are very similar to those that exist in general industry. As a third party insulating oil and lubricant testing laboratory, many lubrication pitfalls are noted while analyzing wind generator oil and grease samples.

Lubrication quantity: An insufficient amount of grease and oil will lead to excessive wear and overheating, eventually leading to catastrophic failure. Excessive amounts of grease allow the rollers to slide in the journal, causing heating and scoring. Conversely, large amounts of grease can migrate into the generator windings creating potential contamination and electrical insulation issues.

Lubrication storage: Humidity, moisture, sand, and other contaminants are typically found in many samples. A drum of oil stored in the sun and allowed to cool during the night can collect as much as a gallon of water within a few weeks of being stored in such conditions. These same conditions will occur within lubricated systems like hydrau-

lic reservoirs and gear cases. In these conditions, water-absorbing filtration systems should be considered.

Lubricant corrosion: Red/brown areas on balls, raceways, cages, or bands of ball bearings are symptoms of corrosion. This condition results from exposing bearings to corrosive fluids or a corrosive atmosphere. In extreme cases, corrosion can initiate early fatigue failures.

Lubrication sampling/trending: Contamination of lubricants by dirt, wear metals, water, or other particulate matter cause over 70 percent of lubrication related equipment failures.

Lubricant incompatibility: Incompatibility can be caused by something as simple as mixing two different greases or oils to the same lubricated component. Incompatible greases may be indicated when the oil in the grease begins to leak past the bearing seal within minutes of regreasing a bearing. Incompatible gear oils may cause oil seals to soften, shrink, or harden, resulting in a leak. Excessive foaming in a hydraulic reservoir may be the result of mixing two incompatible hydraulic oils.

Lubricant color: As oils age in service, it is normal for them to thicken and become darker in color. If an industrial oil becomes thicker and turns brown or almost black in color in an abnormally short period of time, however, the cause is almost always temperature related. Excessive operating temperatures will cause the oil to oxidize prematurely causing the viscosity to increase and the color to darken. Greases can also oxidize if a bearing is continually over greased.

Lubricant failure: Discolored (blue/brown) ball tracks and balls are symptoms of lubricant failure. Excessive wear of balls, rings, and cages will follow, resulting in overheating and subsequent catastrophic failure. Ball bearings depend on the continuous presence of a very thin (millionths of an inch) film of lubricant between balls and races and between the cage, bearing rings, and balls. Failures are typically caused by restricted lubricant flow or excessive temperatures that degrade the lubricant's properties.

Lubricant contamination: Many of the gearbox and generator manufacturers utilize epoxies and specialty glues to attach bearing covers, inspection ports, and filler caps. Many times trace to large amounts of these substances are found in grease and oil samples, or worse implicated in bearing failures of gearboxes and generators. The largest majority of sample data has shown that high ferrous and ferrous particles are usually present. Large amounts of sand and epoxies contribute to excessive wear, overloading, and overheating that eventually leading to catastrophic bearing failure.

TO-DO LIST

To maintain reliable systems, during the uptower inspection process you should have or develop an inspection, testing, and sampling route for the gearbox main shaft bearings and yaw/pitch gears. Typical time frames for the inspection process are:

- ☐ Monthly—visual inspection of the machines anchorage, alignment, oil levels, filters, pumps, valves, coolers, heaters, manifolds, and piping to connect components, as well as vibration sampling and analysis on the rolling elements.
- ☐ Quarterly—monitor the condition of the lubricating fluids through sampling and testing to determine wear and contamination levels for metals, viscosity, particle count, water/moisture, total acid number and oxidization/nitration through sampling and trending of gearbox oils and gen-

erator greases. If contamination is an ongoing issue, routine weekly sample cycles can help predict failure allowing for a pre-planned outage window for component repair/replacement.

- ☐ Every four to six months—perform lubricating oil filter changes, apply grease to gear teeth and slew bearings. Check and top off oil lubricants in yaw/pitch gears.
- ☐ Annually—inspect contact and wear patterns of gears and bearings on the rolling element with the use of borescope/videoscope cameras.

When maintaining collector substation and circuit breakers, develop electrical maintenance programs that employ a lubrication component as part of the program. You should develop the program based on national consensus standards (see references). Adopting a complete maintenance and lubrication plan will significantly reduce the risk of catastrophic equipment failure. With the high growth rate of wind power, understanding the impact of proper lubrication on high stress equipment is essential to achieve a high availability. Lubricating materials, procedures, and test methods are continually improving, providing invaluable tools for maintenance personnel that improve the operation and safety of wind power generators. So keep it lubed, and it will keep you from getting burned.

CONCLUSION

In spite of the high lightning risk that wind power system installations are exposed to, they can be protected by the application of Surge Protection Devices and Lightning Protection Systems. Regarding SPDs, one must give thoughtful and careful consideration to the placement of the SPD on the system and what they are intended to protect, the connection from the system to the SPDs, and the proper bonding of all grounded members and the ground system. Also check for the adequate discharge rating of the SPD, the voltage protection level the SPD provides, the suitability of the SPD for the system it is applied to, and consideration to failure mode of SPDs and status indication. Also be mindful of local and remote status indication and easily replaceable modules, and the suitability of SPDs on systems so as not to affect normal system function, specifically on non-power systems.

REFERENCES:

1) IEEE STD 902-1998 (Yellow Book) Guide for Maintenance, Operation and Safety of Industrial and Commercial Power Systems.
2) NFPA 70B, Recommended Practice for Electrical Equipment Maintenance.
3) International Electrical Testing Association (NETA) ANSI/NETA MTS-2011 Standard for Maintenance 1) Testing Specifications for Electrical Power Distribution Equipment and Systems.

RELIABLE WIRELESS RTU SYSTEMS

New standalone remote monitoring and control solutions enable an innovative class of wireless applications. Banner Engineering provides the details.

By Susan Schnelbach

Susan Schnelbach is technical content architect for wireless products at Banner Engineering Corp. Go online to www.bannerengineering.com.

WIRELESS TECHNOLOGY WAS ONCE limited by inadequate bandwidth, early integrated circuit design, and insufficient power management technology. Improvements to today's wireless networks allow robust monitoring and control, even in remote and harsh applications or classified areas.

Bidirectional communications, fully-acknowledged data transfer, and configurable default output conditions now make remote and field-based monitoring and critical control a reality. Low power systems and high capacity battery packs provide a lower cost and more reliable solution than previous technology. These alternative power options have increased the usability of sensor networks because the systems are no longer limited only to locations wired for power. New systems enable cost-effective monitoring that is scalable down to a single point.

Today these improvements to RF technology make wireless an ideal solution for a wide variety of applications including field-based agribusiness, remote power generation, and water management systems. Process measurements such as operational status, temperature, rotational counts, and other crucial information can now be easily monitored and con-

trolled remotely, even in locations not wired for data transfer or power.

REMOTE I/O MONITORING IN THE PAST

Historically, wireless remote terminal unit (RTU) systems incorporated a number of different components, including an RTU, radio, solar panel, and rechargeable battery pack, as well as input and output terminals. Once all these devices were selected users still had to purchase an outdoor enclosure and integrate the disparate components into a single, cohesive system. These older systems were difficult to purchase and install in part because of the number of components and vendors required to complete the monitoring system.

Older monitoring systems were complicated to maintain over time. They required large solar panels and batteries to operate because of the diverse power requirements of the components, making these monitoring systems too expensive, or too large, for small, single-point monitoring systems. To be cost effective, installing these systems required wiring as many I/O points as possible back to each remote node. Ironically, it required a significant amount of conduit wire and time to connect a dozen or more I/O points to the traditional large wireless RTU panel. Once they were set up, these systems could not be easily relocated if the application location changed.

REMOTE I/O MONITORING AND CONTROL TODAY

Today, many remote monitoring solutions are available that offer more reliable wireless communication while integrating many of these components into a single, palm-sized, inexpensive unit. A radio and I/O terminal contained within a single housing rated for outdoor use eliminates the need for an additional enclosure. These new wireless industrial I/O devices are easy to install and then move to a new location as requirements change.

With the radio, power controller, I/O terminals, and RTU components included within a single, water-resistant housing, fewer mechanical and wiring issues need to be incorporated into a maintenance schedule, resulting in valuable time and cost savings without sacrificing capabilities. A single wireless I/O device can collect both digital and analog sensor readings and forward this data to a central collection point for analysis. This ability to log and track data across a wide area creates new opportunities for operators to identify trends that need an immediate response.

EVOLUTION OF RF TECHNOLOGY

Just as packaging improvements have made wireless monitoring systems easier to install, radio communication technologies including Frequency Hopping Spread Spectrum (FHSS) have improved network reliability. When using FHSS as a communication method, the frequency range is split into several channels. Data packets are transmitted using these channels randomly in a pattern known only to the master device, or gateway, and the nodes. If interference is detected on one channel, both radios hop to the next channel and resend the data packet, minimizing unsuccessful transmissions in high interference environments.

Another method of ensuring successful data transmission is by using Time Division Multiple Access (TDMA), which divides communication time into specific time slots for each node and guarantees all devices within a radio network have time to transmit and receive data packets. When multiple radios are not trying to communicate with the master device at the same time, data collisions and radio interference are minimized. Using

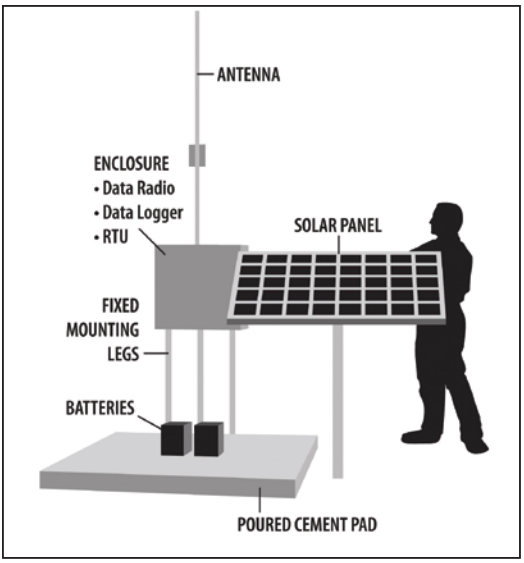


Fig. 1: Historically, wireless remote terminal unit (RTU) systems incorporated a number of different components including an RTU, radio, solar panel, and rechargeable battery pack, as well as input and output terminals.

TDMA to avoid data collisions also prevents wasted power resources in resending data packets.

Bidirectional transceivers on both ends of a communications link ensure fully acknowledged data transmissions on both ends of the wireless link. Polling and site survey capabilities monitor communication integrity either at the radio master device (gateway) or locally at each radio node. A site survey is a signal strength analysis conducted by the gateway to determine the reliability of the radio signal received by the node. If a site survey is conducted before installing the devices, the test ensures each node is positioned at an optimal location. New industrial wireless solutions have site survey capabilities built into every device, ensuring the wireless communication link can be monitored even while application data is being exchanged.

Gateways poll their nodes at specific intervals to verify the radio communications are operating. If a gateway identifies a radio link that is not operational based on an unsuccessful poll, these new systems are capable of reacting deterministically. Deterministic response capabilities drive specific outputs to a user-defined state when wireless links temporarily fail, ensuring control over the network and system responses.

POWER MANAGEMENT SYSTEMS

To accommodate remote monitoring needs in locations without power, optimized wireless I/O devices using advanced power management technology can operate from a single battery pack for several years. State of the art power management systems can now be configured to extend battery life up to 10 years. This extended life span is achieved by putting the entire system in a low-power mode that consumes very little power.

The power management system can be configured to periodically sample the sensor and report data at defined intervals. These intervals can be configured from a few samples per second to a few samples per hour with the longer sampling intervals corresponding to longer battery life. Typically, a five to 10 year battery life is achieved by optimizing the sensor's sample rate while preserving power to provide constant radio communication.

Integrated power management systems are also beneficial when using solar power. Typically the entire solar panel system can be significantly smaller, less expensive, and easier to install. With power options that include solar panels or battery packs, radio devices can now be installed over a wide geographical area, extending the range of data collected over many miles.

A growing class of power-managed sensors, including temperature, relative humidity, ultrasonic, and others take advantage of independent power sources to operate for years without replacing batteries. These sensors and their radios can even operate using wired power in ideal conditions and then switch to a battery module if the wired power fails.

COST EFFECTIVE SCALABILITY

Now multiple sensors can be connected to a single radio node, and dozens of radio nodes can exist within a single radio network. Hundreds of sensor readings can be aggregated into a single gateway device before being forwarded to a host-controlled system, such as an HMI or PLC, for analysis.

Further extending a wireless I/O network are serial data radios, backhaul devices that receive serial data from another data radio and forward that data to another serial device miles away. Chaining data radios can expand a wireless I/O network indefinitely. This backhaul architecture enables limitless scaling for everything from single-point data collection to 10,000 data point applications while retaining the cost advantage associated with minimal wiring for power or I/O transmission.

Today's wireless technology enables remote monitoring solutions that were previously unaffordable or impractical to install. Compact, reliable, inexpensive wireless I/O monitoring devices can now be installed in isolated, low-signal count locations for data collection. These compact devices can be easily relocated as the application changes.

REMOTE MONITORING APPLICATIONS

The new generation of wireless remote I/O is particularly suitable for small, single-point measurements such as monitoring motor temperatures in isolated locations. While previous remote monitoring technology was too expensive or too bulky to use for low-signal count applications, current technology makes these applications easy to install and use regardless of scale. For example,

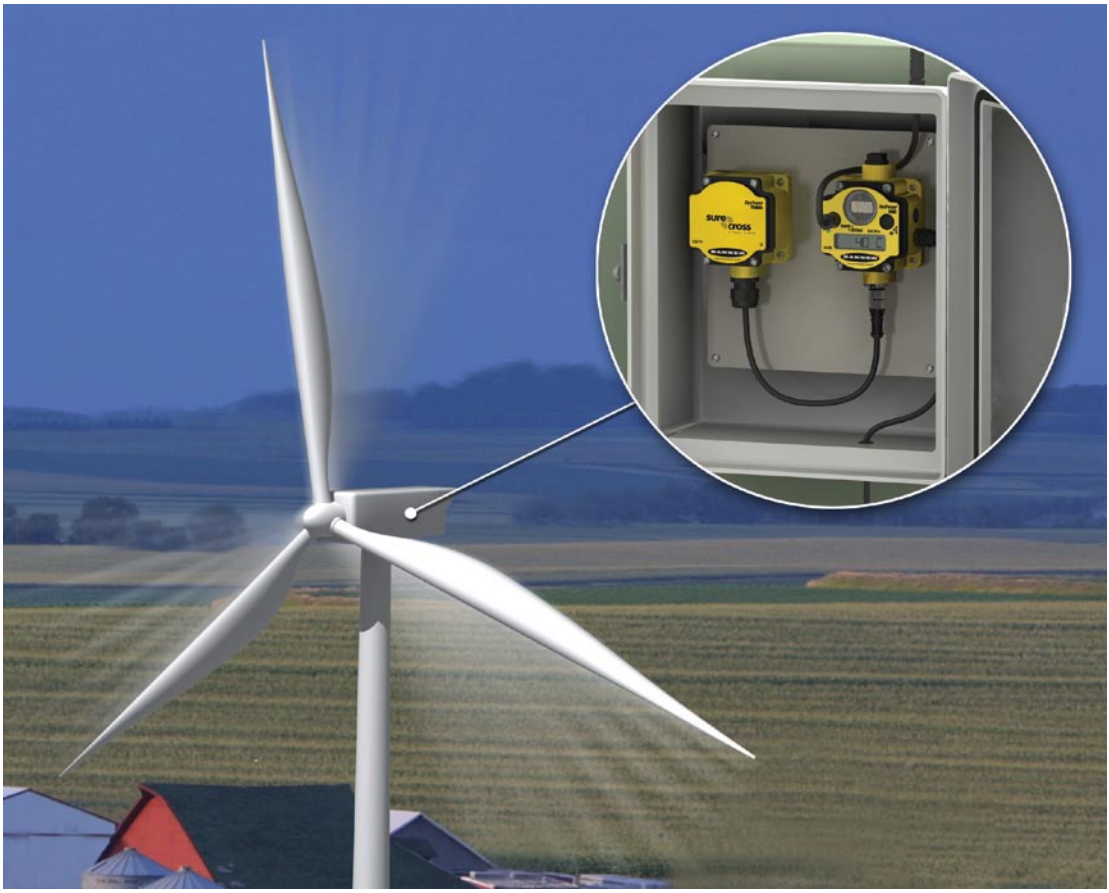


Fig. 2: New wireless products and sensors offer reduced installation time, multi-year battery life, reliable radio communications, and simple integration for remote monitoring applications.

a single wireless I/O device and power-optimized temperature sensor can reliably monitor motor temperatures and report the measurements back to a central location. The "peel and stick" installation allows this device to be easily moved and reinstalled depending on the requirements of the application.

Because these devices are more compact than past systems and are certified for a wide variety of environments, they are easy to retrofit into existing applications, particularly on mobile assets such as trucks or boats that must enter and exit hazardous locations or areas rated to require intrinsically safe equipment. These devices can be installed in a broad range of environmental conditions ranging from outdoor installations exposed to weather to applications within hazardous or explosive locations.

In the case of wind turbines, a common predictive maintenance application involves monitoring bearings, gearboxes, shafts, and generators for excessive vibration. When excessive vibration is detected, repair crews can be scheduled to correct the problem before a complete failure occurs, saving time and money. In many wind turbine installations there are already sensors installed on the turbine to detect blade pitch, strain, and load. Using wireless technology to gather and transmit this information eliminates the need for costly, maintenance-intensive slip rings.

Data from accelerometers can be collected from up to 48 wireless nodes on a wind farm and wirelessly transmitted back to a central control point for logging and analysis. Depending on the distance the data needs to travel, MultiHop data radios may be integrated into a data collection network to extend the reach of the wireless network, or the data may be pushed up to a satellite or cell modem. Today's wireless technology makes retrofitting existing installations quick and easy.

CONCLUSION

Whether an application needs to be a cost-effective solution for single-point monitoring or scalable up to 10,000 data points, the new generation of wireless products and sensors offer reduced installation time, multi-year battery life, reliable radio communications, and simple integration into existing plant-wide control systems. These new wireless networks offer a simple solution to increase productivity and reduce labor costs without sacrificing ease of use.

ADINDEX

Brent Godfrey
industry and application specialist, wind power/Sandvik Coromant

TELL US ABOUT YOUR ROLE IN REPRESENTING SANDVIK COROMANT TO THE U.S. WIND INDUSTRY.

For the past couple of years my responsibilities have involved focusing on our customers in the United States who machine components of all types for the wind industry. I travel around the country visiting these companies and asking about the toughest machining challenges they face so that we can help provide a solution. I will listen carefully, learning everything I can about their particular application, and then I can suggest a standard or modified tool from one of our product platforms. At the same time I'm able to take that information back to our design engineers and develop a custom tool that perfectly matches the customer's requirements. Sandvik Coromant has been designing and manufacturing metal-cutting tools for nearly 150 years, and we're the world's leading producer of tools for turning, milling, and drilling, so we possess a wealth of knowledge and experience to share with the wind industry.

CAN YOU GIVE US EXAMPLES OF SOLUTIONS YOU'VE PROVIDED TO YOUR WIND CUSTOMERS?

Think of the hub of a wind turbine. It's a huge rounded component that typically has three holes that the blades pass through. The diameter tolerances on those holes are very tight, and it needs an extremely smooth surface finish as well. These hubs are cast, and when they arrive at a machine shop the holes are generally pretty rough and the whole component is covered with scales. One of our customers was having a really hard time coming up with an efficient way to finish machine these holes, so we developed a customized version of our CoroBore tool that ended up being more than five feet in diameter. The tool worked perfectly for the customer, which saved them a ton of cycle time and allowed them to produce more hubs than ever before. Along the same lines, many wind components are extremely large, and it's very time consuming to move them around to work on different areas when they're mounted on a machine. We met with another customer who explained that what they needed was a longer tool that would allow them to reach into tight spaces to machine features on components without having to reposition them so often. The problem, though, is that if you simply lengthen the shank of a standard tool you'll get a great deal of vibration, which makes it impossible to get a good cut or finish. The length to diameter ratio on some of these tools approaches 10:1, and sometimes even 14:1. That's where our anti-vibration "silent tools" come in. These are milling, turning, and even boring tools with a dampening device mounted inside the shank, which allows the tool to be extended deep into a component and perform its machining function with no vibration. This feature in particular has really been a godsend for our wind customers, increasing both productivity and the quality of the finished component.

MATCH UP SOME OF YOUR PRODUCTS WITH THE WIND COMPONENTS THEY'RE USED TO MANUFACTURE.

If you're manufacturing connecting rings you'd be interested in the CoroDrill 880, which basically doubles your drilling speed, and T-MAX P negative roughing inserts for the turning operations. For hubs you could also use the CoroDrill 880 along with the CoroMill 390 for shoulder milling, the CoroMill 331 for back facing, and the CoroMill 345 for face milling. Products like our roughing disc cutters, CoroCut grooving system, CoroTurn products, and new-generation carbide grades are perfect for the production of the slewing rings. For the turning operations use T-MAX P roughing inserts and then finish turn with our Wiper inserts. The CoroDrill is great for drilling holes in the flange of the main shaft. Just about everything I've mentioned can be used to manufacture parts like the main frame, gearbox housing, and torque arm. We also have a wide selection of cutting tools, inserts, and accessories for producing gearboxes, shafts, ring gears, planetary carriers, and the foundation of all our tooling systems is the Coromant Capto coupling. As important as these tools are, however, they're really only part of the package we offer. The rest consists of the knowledge we have to share with our customers, because their success is necessary in order for us to achieve our own goals. And it's been my experience that the manufacturing companies that are partnering with Sandvik Coromant are producing more components, more quickly, and at a higher level of quality than their competitors. I am extremely confident when I meet with our customers, because I know that we can back up everything we say.

Call (800) SANDVIK (726-3845) or visit www.sandvik.coromant.com/us/wind.

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Contact your Sandvik Coromant representative for
more information about these and other new solutions.

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Your success in focus

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