JULY/AUGUST 2009

WIND SYSTEMS

FEATURES

AVOIDING SHOCKS TO THE SYSTEM

DEPARTMENTS

Welcome to the New G&E

G&E's NEW Product Lines include:

- CNC Hobbing Machines
- CNC Gashing Machines
- Combination Hobbing/Gashing Machines with interchangeable heads for external & internal gears
- Custom gear related equipment
- CNC Retrofit and Rebuilding of existing G&E equipment

G&E has been a pioneer in high-speed gear gashing with large diameter carbide inserted cutters. We offer heavy duty gashing heads for internal and external applications. Our new machines have a rugged design and our heads utilize today's state of the art gashing cutter technology. We continue to work with the top cutter manufacturers to optimize the results of our machines.

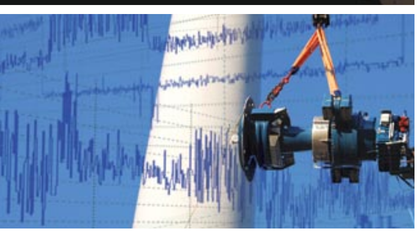
Largest Builder of Wind Energy Gashers in North America and Maybe the World???

RP MACHINE ENTERPRISES, INC

www.rpmachine.com • sales@rpmachine.com
T: 704-872-8888 • F: 704-872-5777

Visit us at booth #401 at Gear Expo 2009 September 15-17

FEATURES




SUFFERING FROM
TENSION?
TAKE TWO... CALL ME...
Dr. Stress
Foundation Tensioners
Tower Flange Tensioners
Gear Box Tensioners
Blade Bolt Tensioners
AZTEC
24/7/365
TECH SUPPORT STAFF
"WHEN THE WORK IS"
CRITICAL
LEADERS IN THE TORQUE AND TENSION INDUSTRY
ISO 9002: 1994 Registered QMS
Bolting.com
1-800-233-8675
www.bolting.com
520 Dallas Street League City, TX 77573 Ph: 281-338-2112 Fax: 281-332-1780
TORQUE TENSION CALIBRATION PRODUCTS SERVICES

DEPARTMENTS

VOLUME 1 NO. 2

RESOURCES

Wind Systems magazine, published by Media Solutions, Inc., is printed entirely on Forest Stewardship Council certified Domtar Lynx paper. FSC certification ensures that this paper contains fiber from well-managed and responsibly harvested forests. The FSC logo also signals our commitment to improving the environment. *Wind Systems* paper is also Rainforest Alliance certified. Publications mail agreement no. 40624074 Return undeliverable Canadian addresses to:PO Box 503 | RPO West Beaver Creek | Richmond Hill, ON L4B 4R6

EDLETTER

We would first like to thank all of you who stopped by our booth at WINDPOWER 2009 held recently in Chicago, and to congratulate the American Wind Energy Association (AWEA) for an incredibly professional and informative conference. We were gratified by the positive reception we received, and we'd like to show our appreciation by presenting you with another rock-solid issue of *Wind Systems* magazine.

This month you'll read "Getting Smart about Wind and Demand Response," an excellent article by Darren Brady, senior vice president and COO of EnerNOC, Inc., and Rob Gramlich, who is senior vice president for public policy at AWEA. John Coultate, Ph.D., of Romax Technology, has penned "Wind Turbine Gearbox Durability," and Rob Schlesinger, P.E., of DEHN, Inc., discusses protecting electrical systems from lightning strikes in "Avoiding Shocks to the System." In "Brushing Up on Turbine Generator Maintenance," Paul M. Kling, Russ Tallyen, and Roly Roberge of Morgan AM&T share news of new designs and materials that are leading to longer brush life, and Dr. E. Becker and Paul Poste of PRÜFTECHNIK Condition Monitoring explain why the technologies they've developed improve the reliability and performance of wind parks. Anders Troedson, of The Switch Controls and Converters, Inc., describes teaming up a permanent magnet synchronous generator with a full power converter in "Wind Drive Train Ride-Through Performance."

As for our columnists, Kathleen O'Dell of the National Renewable Energy Laboratory writes about the Wind Turbine Gearbox Reliability Collaborative (GRC) in this month's installment of her technology column, and James Drew Hussin of Hayward Baker, Inc., discusses how a mat foundation bearing on aggregate piers is an efficient and economical alternative to traditional deep foundation systems in his construction column. Parthiv Amin and Shawn Doner of Winergy Drive Systems describe lubrication quality as a key driver for gearbox reliability in their maintenance column, and Michael Miller of DC Power Systems encourages "whole-systems" thinking in his small wind column. AMSC Windtec GmbH is our company profile—thanks to Jason Fredette for sharing their story with us—and Craig MacPhee, president of Big Mac's Custom Pressure Washing, makes a powerful case for the importance of pre- and post-erection tower cleaning and maintenance as our Q&A subject.

As I've done before, I'd like to extend an open invitation to all of our readers to contact me at the e-mail address listed below with any story ideas you may have or technical articles you'd care to submit. We look forward to hearing from you!

Russ Willcutt, editor
Wind Systems magazine
russ@windsystemsmag.com
(800) 366-2185

WIND SYSTEMS

David C. Cooper
Publisher

Chad Morrison
Associate Publisher

EDITORIAL
Russ Willcutt
Editor

SALES
Brad Whisenant
National Sales Manager

CIRCULATION
Teresa Hall
Manager

Jamie Willett
Assistant

Kassie Hughey
Assistant

ART
Jeremy Allen
Art Director

Michele Hall
Graphic Designer

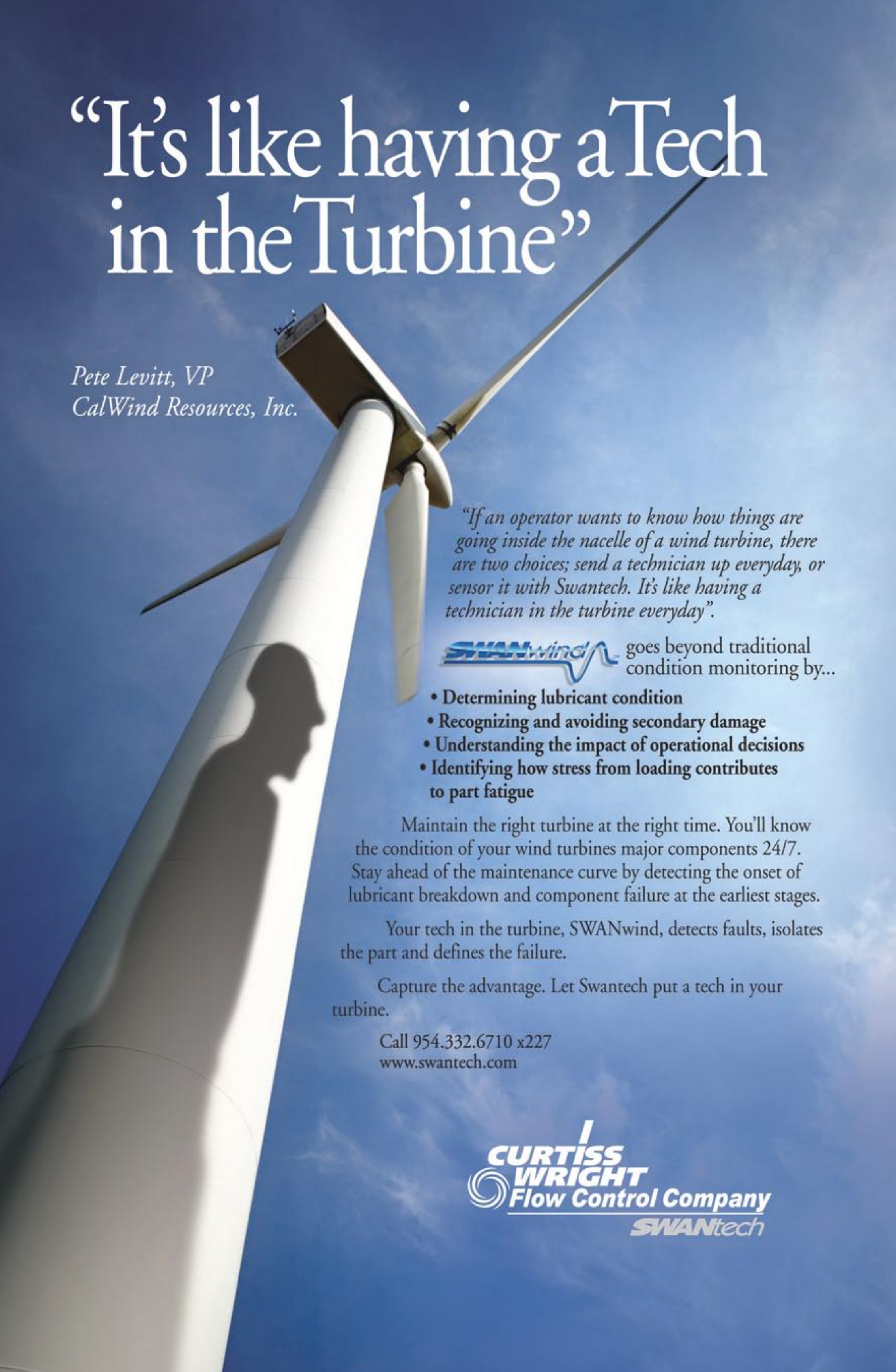
CONTRIBUTING WRITERS
Parthiv Amin
Dr. E. Becker
Darren Brady
John Coultate, Ph.D.
Shawn Doner
Rob Gramlich
James D. Hussin
Paul M. Kling
Michael Miller
Kathleen O'Dell
Paul Poste
Roly Roberge
Robert Schlesinger, P.E.
Russ Tallyen
Anders Troedson

media@solutions
PUBLISHED BY MEDIA SOLUTIONS, INC.
P. O. BOX 1987 • PELHAM, AL 35124
(800) 366-2185 • (800) 380-1580 FAX

David C. Cooper
President

Chad Morrison
Vice President

Teresa Hall
Operations


"It's like having a Tech in the Turbine"
Pete Levitt, VP
CalWind Resources, Inc.
"If an operator wants to know how things are going inside the nacelle of a wind turbine, there are two choices; send a technician up everyday, or sensor it with Swantech. It's like having a technician in the turbine everyday".
SWANwind goes beyond traditional condition monitoring by...
• Determining lubricant condition
• Recognizing and avoiding secondary damage
• Understanding the impact of operational decisions
• Identifying how stress from loading contributes to part fatigue
Maintain the right turbine at the right time. You'll know the condition of your wind turbines major components 24/7. Stay ahead of the maintenance curve by detecting the onset of lubricant breakdown and component failure at the earliest stages.
Your tech in the turbine, SWANwind, detects faults, isolates the part and defines the failure.
Capture the advantage. Let Swantech put a tech in your turbine.
Call 954.332.6710 x227
www.swantech.com
CURTISS WRIGHT
Flow Control Company
SWANtech

NEW ACCURA 3D COORDINATE MEASURING MACHINE FROM CARL ZEISS

Carl Zeiss Industrial Measuring Technology (IMT) has introduced the new ACCURA®. By systematically implementing customer requests, it has developed a multi-sensor capable measuring system that permits fast, economical, precise, and flexible measurements.

Measure dynamically, precisely and safely: Thanks to the steel and aluminum components, the new ACCURA measuring machine bridge is extremely rigid and thin. The CARAT® coating (Coated Ageing Resistant Aluminum Technology) on the aluminum parts ensures long-term stability of guideway behavior. The low weight of the moving parts improves the dynamics. This allows the ACCURA to achieve a maximum vectorial travel speed of 800 millimeters per second—50 percent faster than its predecessor—in the Performance Package configuration. This speed demands increased protection measures. Therefore, the Performance Package contains a special safety system: laser scanners monitor the protection zone around the measuring machine during the high-speed mode. If the safety system registers movement within this zone, the machine speed is automatically lowered within one second. Once the disruption passes, ACCURA reaccelerates to the original measuring speed. The enhanced air bearings also play a key role in the dynamic behavior of the bridge. Thanks to the thinner air gap, they are more rigid and require less compressed air than previous air bearings.

Foam insulating technology enables higher temperature independence: The ACCURA bridge features a new, high-performance insulation—foam insulating technology. At minimal thickness, the housing covers ensure temperature resistance. This guarantees the required precision even on the shop floor.

Freely selectable temperature range (20-26°C): Measuring machines must be operated at constant temperatures to avoid temperature-dependent deformations. A fixed measuring lab temperature of 20°C is standard. The new ACCURA can be operated with the same precision at other temperatures between 20 and 26°C. The measuring lab temperature can therefore be set appropriately and you save air conditioning costs.

Tailored to customer demands: As with a versatile modular system, customers can configure the ACCURA to fit their requirements. Based on their current tasks, they select the ideal configuration, i.e. sensors. Special software, such as GEAR® PRO for gears and HOLOS® NT for freeform surface measurements, is integrated along with CALYPSO®, the standard CAD-based measuring software from Carl Zeiss. Subsequent modifications can be made very easily. The ACCURA is available at a very economical price for this performance class. If requirements change, different sensors and software can be easily added. Whether cut, shaped, or molded parts, plastic or steel—all options of coordinate measuring technology are available. The ACCURA also permits the integration of MASS® technology from Carl Zeiss. Combined with an RDS articulating probe holder, MASS permits the fast, measuring program-guided change between contact sensors and the ViScan® and LineScan optical sensors during a CNC run. The contact measuring sensors of the VAST® family and the DT single-point sensor can also be used in various configurations.

The new ACCURA is currently available in four sizes, each of which offers a large measuring range—even with an integrated stylus changer. For more information contact Chris Grow at (763) 744-2400 or cgrow@zeiss.com. Go online to www.zeiss.com.

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.

WINDPOWER 2009 A HUGE SUCCESS FOR AWEA, WIND INDUSTRY

The U.S. wind energy concluded the world's largest wind conference held May 4-7 in Chicago, which hosted 1,280 exhibiting companies and more than 23,000 attendees. "The size and breadth of this show are a clear indicator that the wind energy industry is a hub of business activity even in this hesitant economy," says AWEA CEO Denise Bode. "What we heard loud and clear from the industry assembled here in Chicago was a call to enact a national Renewable Electricity Standard (RES) to secure a stable and growing market for renewable energy."

A poll released by AWEA at WINDPOWER showed that more than 75 percent of Americans, including 71 percent of independents and 62 percent of Republicans, support an RES requiring that 25 percent of the nation's electricity be generated from renewable energy by 2025. Show highlights include:

- Siemens announced it will open a wind turbine nacelle manufacturing facility in Hutchinson, Kansas. Investment in manufacturing facilities in the U.S. has accelerated over the past two years, with over 55 wind turbine and wind turbine component manufacturing facilities announced, added or expanded in 24 states in 2008(see page 12);
- Exhibitors from 48 states, and representatives from all 50 states and from 70 countries were present at WINDPOWER, demonstrating the industry's national and international scope;
- The exhibition hall exceeded 290,400 square feet—more than the 2008 (168,700 square feet) and 2007 (92,500 square feet) WINDPOWER shows combined.
- WINDPOWER welcomed over 23,200 attendees, up from 13,000 in 2008, 3,600 in 2004 (which was also held in Chicago), and 1,000 in 2001;
- Five Governors (Chet Culver of Iowa, Jim Doyle of Wisconsin, Jennifer Granholm of Michigan, Pat Quinn of Illinois, and Ted Strickland of Ohio) addressed the conference. The Governors of Kansas and Pennsylvania were also present. States and their offices of economic development are competing to attract wind turbine supply chain companies and create good jobs. At least 19 state or regional economic development offices were exhibiting at WINDPOWER.
- Secretary of the Interior Ken Salazar, Energy Secretary Steven Chu (via a taped speech), and Federal Energy Regulatory Commission Chairman Jon Wellinghoff also addressed the conference. Secretary Salazar pointed to new rules for offshore wind farms that open the way for the U.S. to become a leader in offshore wind power. Both noted the value of a national Renewable Electricity Standard in creating jobs, helping hold down costs for consumers, and diversifying the nation's electricity portfolio. "At no time in our history has the time for a new energy policy been so urgent. This is an opportunity that Americans cannot afford to miss," Salazar said.

- T. Boone Pickens, who planted wind energy firmly in the public consciousness with his high profile campaign, again pointed to the need to get off foreign oil by using more renewables to produce electricity and more natural gas for transportation. He predicted Congress will eventually pass comprehensive legislation, including an RES, because the American people support it.

AWEA is the national trade association of America's wind industry, with more than 1,900 member companies, including global leaders in wind power and energy development, wind turbine manufacturing, component and service suppliers, and the world's largest wind power trade show. AWEA is the voice of wind energy in the U.S., promoting renewable energy to power a cleaner, stronger America. The WINDPOWER 2010 Conference & Exhibition will take place May 23-26 in Dallas, Texas. To learn more go to www.awea.org.

WANZEK MAKES BIG JUMP ON LIST OF TOP U.S. CONTRACTORS

For the second year, Wanzek Construction, Inc., has held a position on *Engineering News-Record* (ENR) magazine's list of the Top 400 Contractors in the United States. The list ranks the 400 largest general contractors in the United States according to the previous year's revenue. In 2008 Wanzek appeared on the list for the first time, holding position number 345. This year the company took a 168-point jump into position 177, after doubling revenues to more than $400 million. In 2008 Wanzek's national portfolio of heavy/civil and industrial construction projects included, most notably, the installation of approximately 1000MW of wind energy generation capacity.

Wanzek Construction, a MasTec company, specializes in heavy and industrial projects throughout the country for the market sectors of power, renewable energy, industrial process, heavy/civil, and wind energy construction. For more information contact Jason Kaufman, vice president of business development, at (701) 282-6171 or jkaufman@wanzek.com. Visit online at www.wanzek.com.

WIND TURBINE ACTUATORS FROM TRELLEBORG SEALING SOLUTIONS

Trelleborg Sealing Solutions supplies a specially engineered sealing configuration to AVN Energy A/S, a leading hydraulic actuator manufacturer for wind turbines. Meeting the dynamic criteria due to constant movement of the actuator, the sealing system offers maximized seal life, contributing to minimal turbine maintenance requirements.

Stall machine turbines being replaced by continuous pitch systems has put extreme demands on hydraulic actuators. The position of stall machines would shift only once every 10 minutes, but in continuous pitch wind turbine systems the nacelle and angles of the blades constantly change in small amounts once every rotation, 15 times per minute on average. This means that instead of producing six long strokes per hour, the turbine's hydraulic actuator must now initiate 900 short strokes in the same period, 24 hours a day and seven days a week, for a targeted 20-year period.

"Customers have high expectations from our products, and the number-one requirement of the wind turbine manufacturers is reliability," says Poul Kristensen, export sales manager at Denmark-based AVN Energy A/S, one of the world's leading suppliers of actuators for wind turbines. "Maintenance of turbines is difficult and costly. On land it is hard enough, but offshore it is really tough. And when the windmill is switched off for maintenance, it is not producing energy and losing income. On top of that, operators are often penalized if supply targets are not met. So a primary objective for them is to minimize routine downtime, while stoppages due to component failure have to be avoided at all costs."

Having worked with Trelleborg Sealing Solutions on stall machines, AVN approached it to jointly develop a sealing system to meet the challenging requirements of continuous pitch systems. The specified solution is a complex arrangement of seals ranging from O-Rings to specialist Turcon® PTFE based geometries and Slydring® in Orkot®. The unique configuration is specially engineered to enhance lubrication and optimize friction characteristics, while preventing any external leakage. For more information contact Donna Guinivan at +44 121 746 3621 or donna.guinivan@trelleborg.com. Visit online at www.tss.trelleborg.com.

TORQUE CERTIFICATION PROGRAM FOR WIND INDUSTRY FROM SNAP-ON INDUSTRIAL

Snap-on Industrial has announced the launch of a torque certification program designed specifically to meet the needs of the growing global wind industry. Snap-on Industrial, a division of Snap-on Inc., is a global leader in the design, manufacture, and distribution of hand and power tools, specialty tools, storage solutions, and training to meet the needs of industry.

"Torque certification is particularly sensitive in the wind-power industry because mistakes can be both expensive and time consuming," says Frederick Brookhouse, business and education partnership manager. "In developing this training program, our goal is to outline a curriculum that builds on what Snap-on has learned in certification programs it has spearheaded in the automotive market. As a company we've learned what works and what doesn't work in creating an effective training program."

Torque is the turning motion used to tighten or secure a fastener around an axis point. The amount of force used in a particular task is measured in Newton meters, or foot pounds. The Snap-on torque certification program, developed in collaboration with educators, explores both torque theory and proper use and

application of equipment; testing for certification focuses on equipment use.

The 16-hour certification course is designed as a component to an existing wind-power technician training course. The Snap-on torque certification program will be integrated into wind-power technician courses currently available at Lakeshore Technical College in Cleveland, Wisconsin; Gateway Technical College in Kenosha, Wisconsin; Texas State Technical College in Sweetwater, Texas; Cerritos College in Cerritos, California; and the multi-campus Frances Tuttle Technology Center in Oklahoma.

The torque curriculum includes modules on theory, technique, mechanical torque wrenches, electronic torque wrenches, hydraulic torque wrenches, torque multipliers and safety. It is designed to cover every aspect of torque, from the basics through master-level skills. Current wind-power curriculum incorporates the study of electrical and electronic components, electrical safety, working in confined spaces and working at height.

"The understanding and proper application of torque is a mission-critical element of a viable and sustainable wind-power industry in the U.S.," Brookhouse says. "This industry needs strong training programs to meet the burgeoning demand for manpower. Snap-on Industrial is uniquely positioned to provide this customized, specialized training and we're working to apply that knowledge today."

To learn more contact Dale Alberts at (262) 656-6559 or dale.l.alberts@snapon.com. Go online to www.snapon.com.

INNOVATIVE LUBRICATION SOLUTION FOR WIND POWER APPLICATIONS FROM KLÜBER

Klüber Lubrication, a world-wide manufacturer of specialty lubricants, showcased three innovative, specialty lubricants for the wind power industry at WINDPOWER 2009: Klüberplex® BEM 41-141, Klüberplex® AG 11-462, and Klübersynth® GEM 4-320 N.

Klüberplex BEM 41-141 is high-performance grease with a special blend of base oil and additives to cover the different lubrication requirements of the individual bearing applications within wind power stations. The beige grease is ideal for pitch and yaw bearings (high stresses, oscillations, vibrations), main bearings (low rpm, high stresses, vibrations), and generator bearings (high rpm and temperatures). Klüberplex BEM 41-141 can be used in all bearing applications which allows consolidation of lubrication inventory.

Another unique product is the priming and operational lubricant, Klüberplex AG 11-462 an effective lubrication for open gears. Klüberplex AG 11-462 is esthetically neutral because it is white in color and provides excellent adhesion as well as superior protection against high loads and corrosion.

In addition to its grease products, Klübersynth GEM 4-320 N is outstanding, synthetic oil for enclosed gear drives subject to a wide range of service temperatures. Compared to standard oil, Klübersynth GEM 4 N shows excellent wear protection for gears and bearings, ageing and foaming resistance, cleanliness, and greater efficiency. Klüber's "ADDED value" program has made it easy for manufacturers and operators to simplify their lubrication program. For more information please visit www.klubersolutions.com/wind.

SIEMENS TO BUILD U.S. WIND TURBINE PRODUCTION FACILITY

Siemens intends to build a new production facility for wind turbines in the United States. Initially, 400 new jobs are expected to be created in the new wind turbine production facility in Hutchinson, Kansas. When production begins at this facility, Siemens will be able to even more effectively meet the strong demand for wind turbine equipment in North and South America in the future.

"The United States already is and will continue to be one of the world's fastest growing wind energy markets. We are thus intensifying our commitment to this green technology to further expand our leading global position in this field," says Peter Löscher, CEO of Siemens AG. "We are already the leading green infrastructure giant, and by making these investments we will become even greener."

With revenues totaling EUR19 billion in fiscal year 2008, Siemens now has the world's largest portfolio of environmental technologies. Construction of the 300,000 square-foot nacelle production facility is scheduled to begin in August 2009. The nacelles to be produced in Kansas will weigh 90 tons and the first nacelle is expected to be shipped in December 2010. All nacelles produced in Hutchinson will be used in the company's reliable 2.3-MW wind turbine product family. Initially, the factory's planned annual output is approximately 650 nacelles, or 1,500 megawatts (MW).

"Just two years ago we opened a rotor blade manufacturing facility in Fort Madison, Iowa. By expanding our investment in Kansas we are strengthening our presence in the U.S. and, at the same time, we are increasing the proximity to our U.S. customers. This new location will enable us to serve them more rapidly and cost-effectively," says René Umlauft, CEO of Siemens Energy's Renewable Energy Division.

Hutchinson is near the geographic center of the continental United States and offers a viable workforce and excellent transportation logistics. The factory will include direct loading onto rail, which will provide easy access to project locations throughout the U.S. and Canada. Shipments can also be made utilizing the barge facilities at the port of Catoosa, located 250 miles from the plant. Kansas also has excellent wind conditions. In terms of wind energy potential, this centrally located state ranks third in the U.S.

Since entering the wind industry in 2004, Siemens has greatly expanded its worldwide manufacturing network. In addition to opening and consequently expanding the wind turbine blade manufacturing facilities in Fort Madison, Iowa, and Engesvang, Denmark, the Danish facilities in Brande and Aalborg have been expanded, and a new R&D center in Boulder, Colorado, was established. Siemens' global wind power business has grown from approximately 800 employees in 2004 to more than 5,500 today, which equals an increase of approximately 650 percent. To learn more visit www.siemens.com/energy.

STANLEY PROTO INTRODUCES EXTRA-LARGE COMBO WRENCHES

Stanley Proto Industrial Tools has expanded its already-extensive line of combination wrenches with the addition of 23 new extra-large combination wrenches. The new wrenches are designed to

meet the needs of users in heavy industries.

These big wrenches are the epitome of heavy duty. They come in standard and metric sizes, with openings that range from 2 9/16 to 4 in., and from 55 to 80 mm. Lengths go up to 3 ft., giving users the leverage they need to work on stubborn fasteners. Heads are made from drop-forged steel for strength and durability. Open ends are precisely machined for a firm grip on fasteners, while 12-point box ends help users work quickly and help improve accessibility (a 12-point head need only be lifted and turned 30 degrees to re-engage the fastener, while a six-point head requires a 60-degree turn.) The inside edge of the box end is countersunk around its entire circumference to ensure that it slips easily onto fasteners. Wrenches with opening sizes up to 2 ¾ inches or 70mm come with a satin finish, protecting them against corrosion and providing a slip-resistant grip. Larger sizes have a non-reflective black oxide finish for use where non-plated products are required.

Stanley Proto Industrial Tools has been making durable, high-quality hand tools for more than 100 years, having grown from a small machine shop to a worldwide supplier. Its tools are developed according to strict ergonomic standards, with features that let users work faster and easier, including enhanced shock absorption and reduced slip. For more information contact E. (Lenny) Acuna, project coordinator, at (609) 208-2684 or (800) 800-TOOL. Send e-mail to elinore.acuna@directgroup.net. Go online to www.stanleyproto.com.

NEW APPLICATIONS FOR SECOND WIND'S TRITON SODAR

WindLogics and Second Wind, Inc., have announced that WindLogics has purchased two Second Wind Triton™ sonic wind profilers and plans to use the Triton data with SCADA data in a new study on an operating wind farm. Commercially released in 2007, the Triton has heretofore been used mostly in wind resource assessment studies, usually in conjunction with meteorological tower measurements. "WindLogics is a well-respected meteorological firm, and we're excited to see them finding new uses for the Triton," says Second Wind COO Larry Letteney.

WindLogics is known worldwide for providing independent wind resource assessment services throughout all phases of a project, from studies through finance and eventually operation. "Remote data collection is playing a growing role in our work," says Mark Ahlstrom, WindLogics CEO. "This year WindLogics will be deploying two Tritons at an operating wind farm. We're working with the University of Minnesota to use the SCADA and SoDAR data to develop a high-resolution model predicting wake effects and enabling improved wind farm design. The Tritons will provide reliable and continuous wind profiles under these complex conditions."

For more information on Second Wind call (617) 776-8520 or go online to www.secondwind.com. Contact WindLogics at (651) 556-4239 or www.windlogics.com.

ROMAX TECHNOLOGY SUPPORTS SAMSUNG'S ENTRY INTO WIND ENERGY MARKET

Samsung Heavy Industries is to enter the wind energy market with the support of technical solutions and product engineering company Romax Technology. Romax has been selected by Samsung to assist in the development of its first product, a large-scale onshore wind turbine.

The Korean company is determined to bring Samsung's brand of quality design, expert manufacture, and high value to the wind industry. As one of the world's largest shipbuilders and with vast experience of heavy industry, Samsung is well placed to enter the wind energy market and realize its ambitions to become one of the leading suppliers of wind turbines. The turbine will be their first product for the wind energy market.

A number of specialist companies will work on the turbine concept, coordinated by Samsung's engineering team in Korea. Romax have been identified for their experience in gearbox design and expertise in drivetrain systems engineering. The UK-based consultancy will provide dynamic analysis of the drivetrain as well as consultancy services for the development of key drivetrain components to ensure the final design is efficient, robust, and achieves a long life.

Romax will use its advanced simulation and analysis software, RomaxDesigner, to aid them in the development of the drivetrain components and will support Samsung through the certification process. Throughout the project Romax will be working closely with other companies involved in the project, including fellow UK consultancy Garrad Hassan, who are developing the turbine concept and supplying load data.

As a new entrant into the global wind turbine market, Samsung needed to ensure its new product will get to market quickly. "Time is a critical factor for our success in wind energy and that is one of the key reasons we selected Romax. Not only for their expertise in gearbox design and drivetrain analysis, but also for their ability to work effectively and quickly within our existing engineering team," says Dr. Jaedoo Lee, Samsung project manager.

"It is a great privilege for Romax to work with Samsung on their first venture in wind energy," says Andy Poon, director of renewable energy at Romax Technology. "Samsung is a globally recognized company and well known for quality and technically advanced products—values that align well with the Romax philosophy. We are looking forward to delivering Samsung quick and effective solutions that will help them realise their ambitions in wind energy."

For more information about Samsung Heavy Industries go to www.shi.samsung.co.kr/eng. Visit Romax Technology at www.romaxwind.com.

GE ENERGY'S 2.5-MW WIND TURBINE TO BE LAUNCHED IN NORTH AMERICA

Following its successful debut in Europe and Asia, GE Energy has announced that its 2.5-megawatt (MW) wind turbine is coming to America. The 2.5xl, which is the latest evolution of the company's wind turbine technology, will be launched in North America in 2010. More than 100 of the 2.5-MW machines already have been installed in seven countries and have compiled more than one million operating hours. In addition, GE has received more than one gigawatt of commitments over the next year and a half to provide the 2.5xl wind turbine for projects across Europe—enough clean, wind-generated electricity to meet the needs of more than a million households.

The 2.5xl represents GE's most advanced wind turbine technology in terms of efficiency, reliability, and grid connection capabilities. The 2.5xl is designed to yield the highest annual energy production in its class and builds upon the success of GE's 1.5-MW wind turbine, the world's most widely deployed wind turbine with more than 12,000 now installed. The electrical system design of the 2.5xl, which includes a full-power converter, is 50 and 60 Hz compatible, which will facilitate the launch of the 2.5xl in North America. In addition, the 2.5xl design allows it to be transported with similar equipment as the 1.5-MW. Most of the 2.5xl machines for European projects have been manufactured at GE Energy's wind turbine facility in Salzbergen, Germany, which recently was expanded to help meet Europe's growing demand for wind turbines. The 2.5xl units for North America will be assembled in Pensacola, Florida.

"Despite the economic downturn, we continue to see opportunities for continued growth in the U.S. wind industry and that growth can be accelerated as our customers gain greater access to the federal economic stimulus funds," says Victor Abate, vice president or renewables for GE Energy. "Adding the 2.5xl wind turbine to our technology portfolio for North America greatly expands our capabilities to meet the diverse needs of our customers in these challenging times."

GE Energy is one of the world's leading suppliers of power generation and energy delivery technologies, with 2008 revenue of $29.3 billion. Based in Atlanta, Georgia, GE Energy works in all areas of the energy industry including coal, oil, natural gas and nuclear energy; renewable resources such as water, wind, solar and biogas; and other alternative fuels. Numerous GE Energy products are certified under ecomagination, GE's corporate-wide initiative to aggressively bring to market new technologies that will help customers meet pressing environmental challenges. Learn more at www.ge.com/energy.

EGC PRESENTS TURBINE BOLTING COST-SAVINGS STUDY

Loss of clamp load and fatigue are common failure modes for bolted joints subject to dynamic loads. These conditions are the result of insufficient bolt tension during installation tightening, as well as the inaccuracy of typical torque/tension methods used to complete periodic in-service fastener checks. Critical bolted joints on wind turbines—such as tower, bearing, hub, and blade connections—are subjected to complex cyclic loads throughout their 20-year life.

By insuring fastener tension is maintained within +/-5 percent of design specification, Rota-Bolt® load-monitoring fasteners assure equipment reliability and safety while providing increased operation uptime and reduced maintenance cost benefits over the life of wind turbine bolted joints.

EGC Enterprises, Inc., manufacturer of Rota-Bolt fasteners for North America, has published a study covering bolted joint tightening and maintenance for wind turbines. The study illustrates the cost and time savings benefits, as well as operating efficiency improvements achieved via use of RotaBolts. The time and cost required to complete typical slew-ring bearing bolt in-service checks using standard torque/tension maintenance checks (+/-30 percent accurate) are compared to RotaBolt fingertip load monitor in-service checks (+/-5 percent accurate).

It is clearly shown that by introduction of Rota-Bolts as standard hardware for important and frequently maintained wind turbine connections, the results are increased operating uptime and greatly reduced time to perform in-service fastener tension checks. RotaBolts allow 100 percent tension verification in less time than it takes to complete a typical 10 percent torque check of standard fasteners. To request a copy of the study contact Brian Newcomb at (800) 342-0211 or briann@egc-ent.com. Go online to www. egc-ent.com.

AMSC SIGNS CONTRACT WITH ACCIONA ENERGY

American Superconductor Corporation, a leading energy technologies company, announces that it has received an order worth more than $10 million from ACCIONA Energy, a division of ACCIONA SA and a world leader in renewable power, for its new Dynamic VAR Ride Through (D-VAR RT) solution. Building on AMSC's highly successful D-VAR platform, which provides critical dynamic reactive compensation required to connect many wind farms around the world to the power grid, the company's D-VAR RT product enables individual wind turbines to continue operating smoothly by "riding through" voltage disturbances on power grids that might otherwise interrupt their operation. The D-VAR RT product meets stringent grid interconnection requirements, including Spain's new Procedimiento de Operación 12.3 requirement for both existing and new wind turbines.

According to the Global Wind Energy Council, Spain was the world's third largest wind power market at the end of 2008, with an installed base of more than 16,000 megawatts (MW). Disturbances such as momentary voltage dips can disconnect many wind turbines and cause instability on the transmission grid. Developed by Spain's transmission system operator Red Electrica de España (REE), P.O. 12.3 requires that wind turbines remain connected to the grid through such events.

After extensive field testing and operation by an AMSC-ACCIONA Energy team at a wind farm with one of Spain's most difficult climates, the D-VAR RT solution recently received official certification of compliance. ACCIONA Energy has initially ordered D-VAR RT solutions for an important amount of first-generation "squirrel-cage" wind turbines that are currently providing more than 250 MW of electricity in Spain to meet P.O. 12.3. AMSC will deliver all of the D-VAR RT solutions covered under this contract to ACCIONA Energy over the next few months.

The D-VAR RT solution can be installed inside or outside the tower of any wind turbine, enabling turbine manufacturers as well as wind farm developers, owners and operators to easily add the systems to new wind turbines or retrofit existing turbines. Utilizing AMSC's PowerModule® PM3000W wind turbine converter, this scalable solution is designed for a wide range of wind turbines with power ratings from 500 kilowatts (kW) up to 10 MW. The powerful, cost-effective technology provides low and high voltage ride through capabilities to keep wind turbines running through grid disturbances. This product is based on AMSC's patented D-VAR platform, which is supporting more than 3,300 MW of power at 40 wind farms around the world.

"With more than 6,000 megawatts of wind power installed and more than 15,000 additional megawatts in development, ACCIONA Energy is a global clean energy powerhouse and is an ideal first adopter for our new D-VAR RT solution," says Timothy Poor, AMSC's vice president of global sales and business development. "We see great potential for this product in Spain and other countries that adopt similar standards in the years ahead as wind power continues to play a more prominent role in the world's electricity supply."

ACCIONA Energy has been a renewable energy pioneer in its home market for well over a decade. In 1994, the company established its first commercial wind farms. Acciona is currently present in more than 30 countries on five continents, making it one of the world's leading wind turbine manufacturers and wind farm owners and operators.

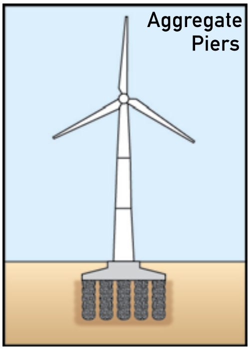
As a key player in the Spanish market, ACCIONA has contributed decisively to the growth in wind energy by developing and adapting innovative solutions that enable wind to become a main energy contributor. In this context, Acciona Energy has been involved in several technical working groups and committees with the aim of developing these new ride through standards. For more information on AMSC go to www.amsc.com/dvrt.html.

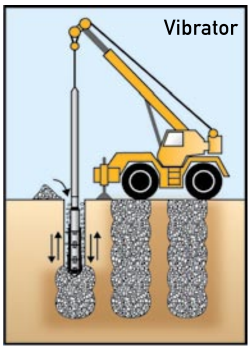
James D. Hussin
Hayward Baker, Inc.

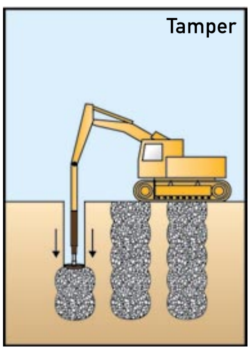
Performed properly, a mat foundation bearing on aggregate piers is an efficient and economical alternative to traditional deep foundation systems.

WHEN THE GEOTECHNICAL EXPLORATION at a planned wind turbine tower location reveals that the subsurface conditions are weak and compressible, a deep foundation system consisting of a mono-pole or drilled/driven piles is often recommended by the geotechnical engineer. However, often the poor soils can be strengthened and stiffened economically to enable the tower to be constructed on a shallow mat foundation. One ground improvement technique consists of constructing a regular pattern of dense aggregate piers within the weak soils. This process is referred to by several names such as aggregate piers, stone columns, or vibro-replacement. Aggregate piers are typically constructed using one of two tools: a down-hole vibrator, or a tamper. Both methods are available as a design-build service by specialty contractors.

The vibrator is a specially-built tool consisting of a ±18 inch diameter closed end steel casing with an internal electric or hydraulic motor spinning an eccentric weight. The rotating eccentric weight causes the vibrator to oscillate horizontally. The vibrator can be suspended from a crane, excavator, or attached to a fixed-mast drill rig. The vibrator penetrates the ground by means of its weight or drill rig down-thrust and is assisted by the vibratory energy and, occasionally, water jetting. Aggregate is placed in lifts, each of which is compacted by repeated penetration of the vibrator. This action both densifies the aggregate and laterally displaces the aggregate to compress the surrounding soils. The vibrational energy will also densify surrounding granular strata, which enables liquefaction mitigation that is fully verifiable with post-construction geotechnical field testing.







The tamper is a proprietary tool consisting of a beveled tamper powered by a top-drive hydraulic hammer. The aggregate pier is constructed by vertically compacting one- to two-foot lifts of aggregate with the tamper system. Aggregate piers constructed in cohesive soils with either technique perform similarly. However, because the tamper applies vertical energy to the aggregate rather than horizontal energy, the tamper method does not densify surrounding granular strata. This lack of soil densification limits the ability to provide fully-verifiable liquefaction mitigation with a tamper.

Aggregate piers do not simply transfer the load to a deeper stratum like a traditional deep foundation, but instead work together with the surrounding soil to produce an improved composite beneath the foundation. The resulting soil/aggregate composite is much stronger and stiffer than the original soils, providing increased bearing capacity and reduced settlement. If uplift resistance is required for the foundation, anchor bars can be incorporated during pier construction and tied into the mat foundation. If additional uplift resistance beyond that provided by the piers is required, soil or rock anchors can be installed.

A quality control program is essential to assure the successful performance of an aggregate pier foundation. Field-scale testing should be performed at the beginning of the program to verify construction quality and design parameters. Consistent pier quality is ensured by monitoring the construction procedure and aggregate quantity. If liquefaction mitigation is required and granular soils are present, post-construction geotechnical penetration testing between piers is required to verify that the required densification is achieved.

When properly designed and constructed, a mat foundation bearing on aggregate piers is an efficient and economical alternative to traditional deep foundation systems for many wind turbine sites with difficult soil conditions.

James D. Hussin is a director with Hayward Baker, Inc., the leading specialty foundation and ground improvement contractor. He can be reached at jdhussin@haywardbaker.com. Go online to www.haywardbaker.com.

Parthiv Amin and Shawn Doner
Winergy Drive Systems

Lubrication quality is a key driver for gearbox reliability in wind turbines. This installment focuses on choosing the best type and how to maintain it.

OIL IS A KEY LIFE-CYCLE DRIVER OF A GEARBOX, and proper maintenance is important. The primary purpose of oil is to provide lubrication and protection to rotating mechanical parts such as gears and bearings, and it's used as a coolant for the gearbox as well. Each of these components' life-cycle design is based on certain lubricant properties and cleanliness standards of the oil. Most gearboxes are designed with an independent lubrication system; the gearbox lubrication system is designed to circulate oil through the gearbox via a motor-pump combination, cooled via a cooler, and filter particles through filters in the pump. Maintaining quality of the oil by changing typically every two years, replacing filters, maintaining oil cleanliness, proper records, consistency of maintenance, keeping oil in its original state (oil monitoring program), and checking oil flow periodically can impact the life of the gearbox, under normal conditions, more than any other influence. This, coupled with other normal wind turbine maintenance practice, is the best way to ensure extended life.

Oil in a gearbox is designed for wind conditions and is specifically approved for wind turbine use. An important fact to note is not to mix one type of oil with another in a gearbox. In most cases different brands of oil are not compatible with another brand.

Brand: Typically, OEMs have a preference for the brand and type of oil used. This is based on their experiences and testing, as well as gearbox manufacturers. However, the perpetual question of which oil is better is best based on end user experience. Winergy, for example, has at least four different types of oil approved for use in our gearboxes based on several factors. In most cases, however, only one brand/type of oil is approved by an OEM for use in their turbine. In addition, OEMs approve a type of oil so it has consistent use of and performance throughout its supply chain of gearbox manufacturers.

Over a period of time, with a large installed base and a variety of turbines in a given wind farm or in a fleet or portfolio of an end user, the driver for oil specification will be end users. With several types of oil in a wind turbine portfolio it becomes difficult to manage oil changes, track maintenance, and monitor oil integrity. Not to mention the cost of maintaining several types of oil in stock for a fleet with a variety of turbines, as well as a risk in training of staff to ensure the correct type of oil is refilled or replaced and not mixed in a gearbox. Plus there are also economies of scale or leverage in being able to standardize on a brand of oil for its fleet. All these factors and experience in fleets will drive toward end user preference.

Approval: Winergy has an extensive oil qualification program to meet the loads and life-cycle design of gearboxes as specified by the OEM. An oil approval process is costly and can take up to two years based on several factors such as work load, urgency of new oil approval, availability of test stands and, more importantly, the demonstrated benefit, in a similar application, of a new brand of oil.

Oil is tested for paint/primer compatibility, since the oil comes in contact with primer on a gearbox in close proximity to gears and bearings, and also externally during inspections and maintenance. Another area of interaction involves the sealing materials in a gearbox to ensure that they do not deteriorate due to contact with the oil. Also, load tests such as dynamic test under various loads, gear micro-pitting, and scuffing. Non-load testing factors such as filtration, flow/viscosity tests, temperature range, and interaction with moisture are also examined. Bearing life testing is one of the key test criterions for approval of an oil by bearing suppliers to ensure compatibility with the material and assurance of life-cycle calculation validity. Finally, any new brand of oil has to go through field testing to see its impact in real-world application and loads.

Each OEM and gearbox manufacturer, as well as lubrication companies, are sensitive to mixing brands of oil for compatibility and other issues. It is best to follow a very extensive process when replacing oil with a different brand. One of the key elements of this process is a hot flush with the addition of a concentrated cleaning agent in a light viscosity oil through the gearbox to ensure no residue of the previous brand is in the gearing, bearings, or pockets of the gearbox, or in the lubrication/cooling system. The flushing procedure is also important for the purpose of removing contaminants such as sludge from the gearbox and lubrication system. There are companies that specialize in flushing and proper disposal of oil in compliance of various regulatory and local land lease requirements. Consult your OEM and/or gearbox manufacturer if you are contemplating a change in brand of oil. Chances are the brand of oil you want to use may be pre-approved by a manufacturer, or they can share experience based on data or known performance in the field.

Parthiv Amin is president of Winergy Drive Systems, and Shawn Doner is service sales engineer.
Call (847) 531-7400 or visit www.winergy-ag.com.

Kathleen O'Dell
National Renewable Energy Laboratory

Gearbox designers and manufacturers follow stringent standards for designing and building gearboxes, but failures persist. This group is seeking a solution.

GEARBOX RELIABILITY IS A CRUCIAL ISSUE for the wind energy industry. The gearbox and its supporting components (i.e. shafts, generator, brakes, and lubrication system) account for roughly 30 percent of the turbine's capital cost, excluding foundations and site infrastructure, and the gearbox is the most expensive component to repair or replace. Recurrent gearbox failures have plagued the industry since the technology's inception, and they continue to prevent turbines from achieving their intended 20-25 year lifespan. Although gearboxes have evolved over the past two decades, failures persist. "The end users and owner-operators say we're only getting five years, or in some cases three years out of these gearboxes," says Sandy Butterfield, principal engineer at the National Renewable Energy Laboratory (NREL) and project lead for the U.S. Department of Energy (DOE) Wind Turbine Gearbox Reliability Collaborative (GRC).

The GRC is a multi-year effort by the DOE Wind Program that brings together leading wind turbine manufacturers, wind plant operators, gearbox suppliers, and consultants from around the world. Its goal is to validate the typical design process—from the wind turbine system loads to bearing rating—through a comprehensive dynamometer and field-test program. To achieve this the GRC will conduct field and dynamometer tests, and analysis on two identical 750-kW gearboxes that have been modified to reflect current 1.5-MW turbine configurations. The gearboxes will be heavily instrumented to measure all pertinent bearing and gear reactions. One gearbox will be tested in a wind turbine in a nearby wind plant, and the other on NREL's 2.5-MW dynamometer at the National Wind Technology Center.

The field tests, planned to begin this summer, will show the real bearing reactions under start up and shut down transients, high wind operation, control induced torque transients, and high nacelle accelerations. The dynamometer tests will try to reproduce loads measured in the field on the dynamometer and compare internal gear and bearing reactions to those measured in the field. Most commercial dynamometers can only apply steady torque loads instead of the high transient loads and non-torque loads that wind turbines actually experience. NREL's dynamometer is capable of applying both torque transient loads and non-torque loads. Other aspects to be investigated include:

- *Forced lubrication*—New wind turbine designs channel lubrication directly to the bearing races where low revolutions per minute at high torque cause a lot of heat and pressure. GRC gearbox modifications will include forced bearing lubrication, including the planet bearings, which are difficult to reach
- *Oil cleanliness*—New turbines have more aggressive filtration systems. The GRC lubrication system will have 10-micron filtration in the main lubrication loop, 3-micron filtration in a low-flow kidney loop, and condition monitoring equipment to measure and record particle counts in the lubrication system during operation.
- *Condition monitoring*—The GRC turbines will incorporate condition monitoring systems that implement stress wave, vibration, and lubricant monitoring techniques to detect problems that could lead to system failure.
- *Micropitting*—Prevalent in wind turbine gearboxes, micropitting occurs on gear teeth and bearings and can cause bearing failure.
- *Load distribution*—Uneven distribution of loads can damage gear and bearing components.

The GRC will also be conducting an analysis round robin to validate gearbox design tools. In the past wind turbine manufacturers used simple gearbox models to predict the lifetime performance of new designs, but design tools have become much more sophisticated, including finite element models of the gearbox housing, shafts, gears, and bearings. This level of sophistication has been used in the automotive industry with great success, but has never been validated for wind turbine application. The GRC offers researchers a unique opportunity to validate these new design tools and processes using previously unavailable test data. The final result will be a new design guideline developed with the participation of all members of the collaborative.

As work progresses, researchers plan to develop a GRC Failure Database containing information provided by gearbox rebuilding shops that have been trained to inspect and disassemble wind turbine gearboxes to preserve crucial failure data. The purpose is to provide members of the wind industry with information to help prevent failures and avoid costly repairs in current and future wind plants.

Gearbox reliability is crucial, and the efforts of the GRC are specifically targeted at understanding and mitigating this issue to improve reliability, reduce costs, and encourage increased deployment of wind energy to produce clean electricity.

Kathleen O'Dell is a communications specialist with NREL. Call (303) 384-6957, e-mail kathleen.odell@nrel.gov, or go to www.nrel.gov.

Michael Miller
DC Power Systems

Whole-systems thinking is critical to the success of small wind installations since each decision informs and affects all the rest, from foundation to maintenance.

IN ORDER TO SAFELY WITHSTAND the relentless forces of Mother Nature, and to provide a full service life with minimized maintenance, small wind power projects must be designed as complete systems, rigorously tested, and professionally installed. Consider the following: Turbine manufacturers provide rectification and control equipment and tower procurement engineering specifications for use with their systems. Towers are individually built to accommodate a turbine's head weight, lateral thrust at maximum designed wind speed, mass offsets, deflection limits, and natural harmonic frequencies, to name only a few of the variables accounted for. Foundations are engineered to specific soil types and are different depending on tower type. Inverters and balance of system components are different for each system. With all these moving parts it is absolutely critical that small wind system designers and installers carefully consider the entire system as a whole prior to procurement and installation.

Turbine size and type should be optimized for the desired energy yield. It is unlikely that it will be possible to easily upsize or change out the turbine head once the tower is assembled, making proper sizing up front important. Turbine voltages can run from 12 volts to 400 volts, depending on whether the machine will be charging batteries, driving a water pump, heating homes, or connecting to the grid. Turbine voltage will also affect wire sizing, so this is also an important component of the planning process.

Towers are built for small wind systems as non-tilting monopoles: tilt-up monopoles operated with a gin pole, hydraulics, or screw jacks; self supporting lattice; guyed lattice; guyed flanged pipe monopoles; scissor towers resembling a trebuchet, and many others. Each tower should be designed to work with the turbine selected, and it should be provided with stamped engineering documents for the tower and foundation design valid in the state the system is being installed in. Tower selection is based on the site, which always dictates the height of the tower based on surface roughness, turbulence, proximity to obstacles, and often zoning laws and regulations. Each design has its advantages, ranging from affordability to ease of install, but long-term O&M should rank high on the list of considerations to avoid expensive crane visits each year for routine turbine maintenance. For this reason climbing facilities—including tie-off locations, climb safety devices, and work platforms—are a must on taller towers, which may also be available with hinged tower feet to allow for easier dropping of the machine for repairs beyond the scope of a tower climber. Where shorter towers can successfully be used, tilt-up monopoles up to 60 feet are available with some being hydraulically actuated, making the job of raising and lowering the system easier, more efficient, and safer than with traditional gin pole systems. Foundation designs vary with each tower and can be concrete, driven pile, screw pile, or even mobile designs, in some cases. In each case the foundation must be matched to the tower height and design, and the loading characteristics of the turbine used.

Balance of system components are different with each project. For battery charging systems they can be as simple as a charge controller and dump load resistor, or as complex as a mid voltage turbine with a voltage limiter and third party charge controller to accommodate longer wire runs where needed. Straight grid tie systems usually involve the manufacturer's controller/rectifier, a voltage limiter, and a third party UL 1741 listed inverter. Hybrid systems allow for interaction between the turbine, a solar system, backup generator, battery bank, and the grid. All systems require strict adherence to NEC standards for disconnects, markings, grounding, and fusing, as well as utility interconnection standards in the case of grid tied systems.

Each piece of the system affects the entire project. Careful consideration of the interrelated nature of the individual components, their suitability for the application, and assurance of their compatibility with each other are crucial to success. Building a small wind business requires efficiency and thorough preparation. Unexpected issues arise with each job, but through careful planning and cooperation with your supplier, they can be minimized. Adopt a whole-systems approach and your small wind projects will flow more smoothly, resulting in quicker and more-profitable installs with reduced operation and maintenance costs.

Michael Miller is wind division sales manager for DC Power Systems. Call (707) 395-3173, e-mail mmiller@dcpower-systems.com, or go to www.dcpower-systems.com.


Our Masters Take Motion
to an Art Form
In this collection, the certified masters at Overton Chicago Gear elevate the concept of motion to an art form. Examples of their work appear across the globe, forever moving, powering entire communities. But to truly understand the brilliance of the art, you need to look deeper, going past the facade to the inner workings and close-tolerance gearing. There you will find perfection.
OCG
OVERTON CHICAGO GEAR
PROCESS-DRIVEN PRECISION
(630) 543-9570 | www.oc-gear.com | info@oc-gear.com
100% Employee Owned

AMSC WINDTEC

By Russ Willcutt

Interested in entering the wind-energy market, have experience manufacturing large parts, but none specific to producing turbines? Here's the company you need to call.

THE SYNERGY WAS APPARENT FROM THE START. American Superconductor (AMSC) had been selling electrical systems and core components such as its PowerModule power converters for wind turbines for many years. One of its customers, Windtec—which is based in Austria—had begun incorporating these systems into the wind turbines it designs. Windtec was an engineering firm that provided technology and licenses to third parties who wanted to manufacture their own wind turbines. Orders to Windtec licensees began to increase, soon attracting the notice of AMSC's executives. "The result is that American Superconductor acquired Windtec in 2007," according to Jason Fredette, director of investor & media relations, "and the wholly-owned subsidiary was renamed as AMSC Windtec GmbH."

Since 1995 Windtec has been involved in developing complete electrical and mechanical designs for wind turbine applications, but the resources provided by AMSC have allowed it to accelerate its growth, in particular with the supply of wind turbine converters and electrical systems. "Windtec has a really unique set of offerings," he says. "They design wind turbines from the ground up, of course, but they can also step in and help a company interested in building their own turbines to scale up for operation. Windtec will license its turbine designs to the company, help design its manufacturing line, and then identify suppliers for all the key components they'll need, including gearboxes, blades, towers, etc. They will help the company localize these supply sources to keep costs down, and also assist in getting reference turbines up and running and certified."

Fredette describes the perfect candidate for this service as an established heavy industry business with a strong balance sheet that knows how to build large pieces of equipment but lacks the specific expertise required to enter the wind industry. "These companies have an option," he says. "They can build their wind business from scratch, searching for engineers to create proprietary designs for them and teams to assemble them, which takes quite a bit of time, or they can work with Windtec, license its designs, and literally begin production in about a year."

Proof of this model's success is easy to quantify, especially in light of the huge companies that are currently involved. Since 1996 Fuhrländer, of Germany, and China's Sinovel have collaborated with Windtec, with the former manufacturing 600 kW and 1.5 MW turbines while the latter currently produces 1.5 and 3 MW turbines, with a 5 MW model to be launched in the coming years. Among the remaining 12 Windtec customers under contract are Wikov of the Czech Republic, Korea's Doosan Heavy Industries and Hyundai Heavy Industries, India's Inox and Ghodawat Energy, Turkey's Model Enerji, TECO of Taiwan, and AAER Wind Energy, which is located in Canada. All are focusing on manufacturing turbines between 1.5 MW and 3 MW in size, and all are scheduled to commence production by the end of 2011. "Windtec had three of these customers when it joined us," Fredette says, "and the rest of them have come onboard since that time."

AMSC in its entirety is heavily involved in R&D, focusing on a number of different areas pertaining to wind-power generation. As more output is required from wind turbines, it will become increasingly important to discover ways of delivering more power without adding to the weight of structural turbine components, such as the generator. As a manufacturer of superconductor wire, AMSC has developed an especially power-dense material that will allow generators to produce much more power—sometimes doubling its output—without adding significant weight. In partnership with TECO-Westinghouse—manufacturer of motors and generators for the wind market—it is helping design superconductor-enhanced generators. Begun in 2007, it is partially funded by an award from the National Institute of Science and Technology's Advanced Technology Program. Another research initiative focuses on designs that have been developed by AMSC Windtec for a 10 MW wind turbine, with tests currently being conducted into its economic feasibility. This project, known as a Cooperative Research and Development Agreement (CRADA), involves the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) and its National Wind Technology Center.

"Our objective is to have these 10 MW turbines available to the market by the time offshore wind really starts taking off," according to Fredette. "We're thinking that market will be growing nicely by the middle of the next decade, and that's when we'd like to have this technology available."

Separate from its Windtec subsidiary, American Superconductor already offers a variety of innovative technologies for the wind industry, including its D-VAR system, which is comprised of an integrated array of PowerModule power converters, regulating and stabilizing voltage levels by injecting dynamic reactive power, or VARs, into the power grid at precise locations where voltage problems can occur.

Windtec's roster of customers is fairly full, and there are only so many licenses available, so it must be very selective in selecting the companies it chooses to work with. Still, it is always looking for new opportunities—in the United States, in particular. "But you've got to be very serious about this and willing to act aggressively," Fredette says. "You don't approach the wind-turbine manufacturing market tepidly."

Call +43 (0) 463 444604-0, e-mail sales@amsc-windtec.com, or go online to www.amsc-windtec.com

GETTING SMART ABOUT WIND AND DEMAND RESPONSE

Smart grid technologies can help operators accommodate the incremental variability and uncertainty added by wind energy in a more efficient and cost-effective manner.

By Darren Brady and Rob Gramlich

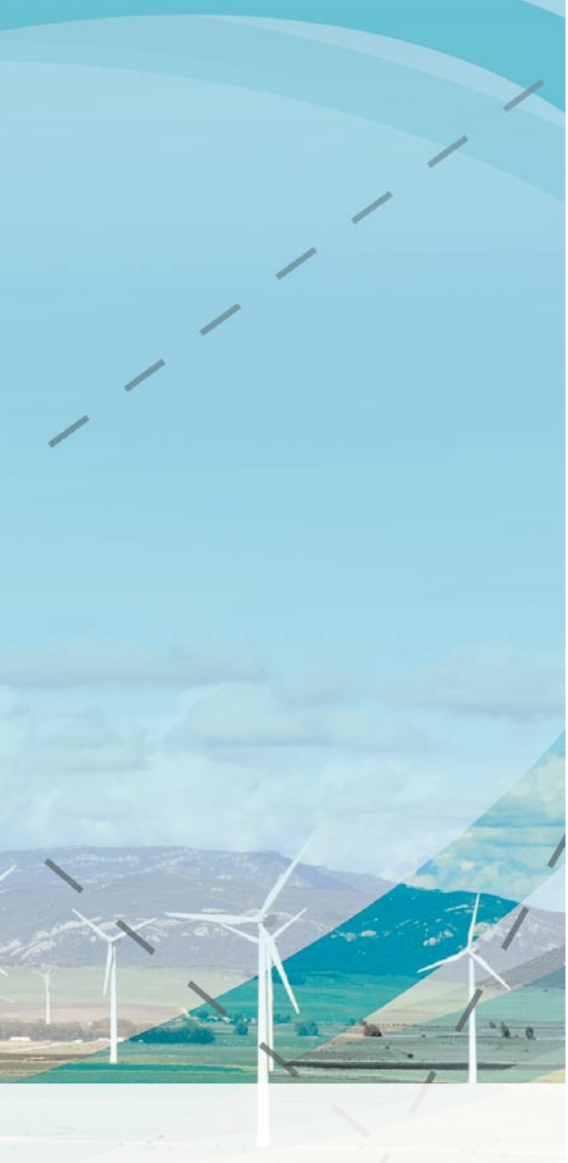
Darren Brady is senior vice president and COO of EnerNOC, Inc. (www.enernoc.com), and Rob Gramlich is senior vice president for public policy at the American Wind Energy Association (www.awea.org).

VARIABILITY AND UNCERTAINTY have been an inherent part of managing the power system since Westinghouse and Edison built the first central station power plants in the late 1800s. While power system engineers have developed a number of supply-side mechanisms to keep electricity supply and demand in balance during the intervening century, recent technological advances have made it possible to use demand-side assets like demand response (DR) resources for this purpose as well. Though not essential for achieving high levels of wind penetration, smart grid technologies can help grid operators accommodate the incremental variability and uncertainty added by wind energy in a more efficient and cost-effective manner.

WIND ENERGY AND GRID VARIABILITY

To understand how demand response and smart grid technologies can facilitate wind integration, it is important to understand how wind energy is integrated with the grid today. Wind energy is a *variable resource*—its output varies depending on the wind speed. While wind energy output can be predicted with a high degree of accuracy through the use of wind energy forecasting, there is always some uncertainty about future wind output simply because weather systems are not perfectly predictable.

However, it is important to keep in mind that there is already a huge amount of variability and uncertainty on the power grid today,



with demand for electricity fluctuating drastically with changes in the weather and supply dropping unexpectedly as power plants experience outages that can instantaneously take 1,000 megawatts or more of supply offline.

Grid operators continuously accommodate this variability and uncertainty by increasing and decreasing the output of flexible generators—power plants such as hydroelectric dams or natural gas plants that can rapidly change their level of generation. These flexible resources are known as "operating reserves." Instead of backing up each power plant with a second power plant in case the first one suddenly fails, grid operators pool reserves for the whole system to allow them to respond to a variety of potential unexpected events.

System operators use two main types of operating reserves: "spinning reserves" (regulation reserves plus contingency spinning reserves), which can be activated quickly to respond to abrupt changes in electricity supply and demand; and "non-spinning reserves" (including supplemental reserves), which are used to respond to slower changes. Spinning reserves are typically power plants that are held below their maximum output level so that they can rapidly increase or decrease output as needed. Hydroelectric plants and combined cycle natural gas plants are typically the first choice of system operators for spinning reserves because their output can be changed rapidly with only minimal declines in efficiency.

Non-spinning reserves are inactive power plants that can start up within a short period of time (~10-30 minutes), if needed. These are typically hydroelectric or single-cycle natural gas turbines because of their rapid and efficient start-up capabilities. Usually, non-spinning reserves that are made available are not actually used, as they are only activated if there is a large and unexpected change in electricity supply or demand. As a result, the emissions and fuel use associated with slower-response non-spinning reserves are even lower than fast-response spinning reserves. Consequently, slower-response non-spinning reserves are much less expensive than second-to-second spinning regulation reserves. In New York State, for example, 30-minute non-spinning reserves are less expensive by a factor of 50 on average.

The same operating reserves that are used to accommodate non-wind variability and uncertainty are used to accommodate the added variability and uncertainty that comes with high penetrations of wind energy. While adding large amounts of wind energy to the electric grid may make it necessary to increase the quantity of reserves that need to be held ready, the increase in needed reserves is typically modest, in part because changes in aggregate wind generation often cancel out uncorrelated changes in electricity demand.

Dozens of peer-reviewed studies have unanimously concluded that there are no technical barriers to achieving high penetrations of wind energy, but rather only modest increases in system operating costs related to the need to hold additional reserves. These studies have found that the costs of integrating wind energy penetrations of 10-20 percent or more with the electric grid are typically less than half of a cent per kilowatt-hour ($0.005/kWh), or about 10 percent of the average wholesale cost of wind power.

Another reason why these costs are low is that changes in the total energy output from wind turbines spread over a reasonably large area tend to occur very slowly. While occasionally the wind speed may suddenly change at one location and cause the output from a group of turbines to fluctuate rapidly, regions with high penetrations of wind energy tend to have hundreds or thousands of turbines spread over hundreds of miles. As a result, it typically takes many minutes or even hours for the total wind energy output of a region to change significantly. This makes it possible for utility system operators to primarily accommodate wind's added variability through slower-response non-spinning reserves, which as established above are much less expensive than second-to-second spinning reserves.

These wind integration studies, as well as decades of grid operating experience in European countries with high penetrations of wind energy, unanimously support the conclusion that high penetrations of wind energy can be accommodated through the use of conventional reserves. These studies have concluded that wind integration is a cost issue—not a reliability issue—and there are no technological barriers to achieving higher wind penetrations. That said, smart grid applications such as DR can play a valuable role in making the grid more flexible, thus reducing the cost of accommodating all types of variability, including that introduced by wind energy.

DEMAND RESPONSE FACILITATES ECONOMICAL INTEGRATION

Demand response resources are well poised to provide grid operators with low-cost, efficient flexibility to handle variability on the power system, including incremental variability introduced by wind energy.

Demand response is increasingly providing grid operators and utilities with more flexibility in their control rooms. Whereas in the past DR was equated with interruptible tariffs that could rarely be called or relied upon, today's technology-enabled DR is providing dispatchers with an additional option to address both planned and unforeseen system needs.

As explained previously, wind energy output tends to be relatively constant over periods of time less than 10 minutes, with significant variations only tending to occur over periods of 30 minutes or more. These characteristics match nicely with the capabilities of most demand response resources, making them ideally suited to accommodate the incremental grid variability added by wind energy. Rather than procuring traditional supply-side generation to provide operating reserves, systems planners are better served to procure demand response resources that can provide similar operational characteristics with a smaller environmental footprint and at a lower cost.

Demand response resources have been proven to be able to participate in 10-minute response reserves markets with strenuous rules and performance standards, such as the PJM Interconnection's Synchronized Reserves Market and the Electric Reliability Council of Texas's (ERCOT) Load Acting as a Resource program. In fact, most major grid operators are now procuring DR to provide such reserves products. The Independent System Operator of New England (ISO-NE) is continuing its Demand Response Reserves Pilot, and the New York ISO has implemented its Demand Response Ancillary Services Program.

For the rare occurrences when there are large and unexpected fluctuations in electric supply or demand, whether caused by load forecast errors, unanticipated wind fluctuations, or conventional generation or transmission failures, DR again can be of service. Demand response resources played an important role in accommodating unexpected variability on Texas' power grid on February 26, 2008, when an event was largely caused by an unexpected increase in electricity demand. While initial reports blamed this variability on an unanticipated decrease in wind output, it subsequently became clear that an increase in electricity demand combined with the failure of conventional generation to come online as scheduled were larger contributing factors. Regardless of the cause of the event, demand response resources were deployed and able to quickly and efficiently accommodate the unexpected variability.

Equally important, all major electric grids in the U.S. have significant amounts of emergency demand response resources, able to respond to capacity shortfalls or other system contingencies. While many emergency-based DR programs have day-ahead dispatch options, an increasing number can be activated within 30 minutes or less, such as the ISO-NE Real-Time Demand Response program or ERCOT's Emergency Interruptible Load Service.

In addition, utilities throughout the country are purchasing DR with characteristics that combine aspects of short-term reserves programs and emergency programs. These programs, sometimes called peaking alternative demand response, are procured in lieu of building a new combustion turbine or signing a power purchase agreement with an independent generator. With response times as short as 10 minutes, and the ability to call the resource for as much as 100 hours per year, these programs are an increasingly common and flexible resource that can serve to complement grid variability in regulated, vertically-integrated utility systems. Importantly, unlike some of the open market programs, which have specific operational triggers, these utility programs often grant significant amounts of flexibility to the control room, giving operators the ability to dispatch these programs at their discretion. Like open-market emergency programs (and unlike spinning/non-spin reserves programs), these utility DR programs can shift loads for hours of time, which is important when addressing forecasting errors.

FUTURE SMART GRID APPLICATIONS

Smart grid technologies will further facilitate wind integration in a variety of ways. Most apparent is the ability for technological advancements to improve demand response solutions. While some DR providers today already can automate complex commercial and industrial end-user loads and integrate their control into building management systems, smart grid technology will expand the types and manners of loads that can be controlled. Dynamic control solutions that maximize the amount of DR capacity available and minimize its response time, all while making participation easier and less obtrusive to customers, will ensure that there is an increasing amount of high-quality demand resources able to complement wind.

An additional area where demand-side resources can complement wind energy is by reshaping system load to better match that of the wind resource. With today's inflexible power system and outdated transmission grid, in many regions the supply of electricity exceeds demand at night or other periods of low demand. This can cause low or even negative power prices, and can force wind generators to curtail their output by pitching the wind turbine blades out of the wind. Wasting free, zero-emissions energy is an undesirable outcome. Demand response tools can help solve this problem by shifting peak energy use to off-peak hours when wind output tends to be higher.

For short periods of low demand and high wind availability, DR technologies can temporarily increase load and utilize the wind resource. For example, cold storage facilities or HVAC systems could be triggered to "pre-cool," adding demand when there is excess power and reducing the need to cool the building during daytime periods.

Such activity could be "dispatched" like a traditional DR event through new programs or encouraged through new innovative rate structures that pair "smart rates" with smart meters. While many commercial and industrial customers already have interval metering and are exposed to some type of dynamic pricing,

almost no residential or small commercial customers are similarly equipped. With advanced metering infrastructure fully deployed, customers of all rate classes can be put on innovative rate structures that discourage consumption when the grid is stressed and encourage it when the grid is not. Consider a critical peak pricing (CPP) rate that also included a wind power pricing (WPP) rate that was activated during periods of low demand and high wind availability. Just as customers on CPP rates see a spike in prices during periods of peak demand, customers on a CPP/WPP rate would also see a reduction in price during particularly gusty periods at night. Commercial and industrial DR providers would work with their customers to automate load control in response to such price signals, as they do today in response to high prices. In the future, DR providers and homeowners themselves will also likely have more loads available at off-peak times that can be called up—electric vehicles.

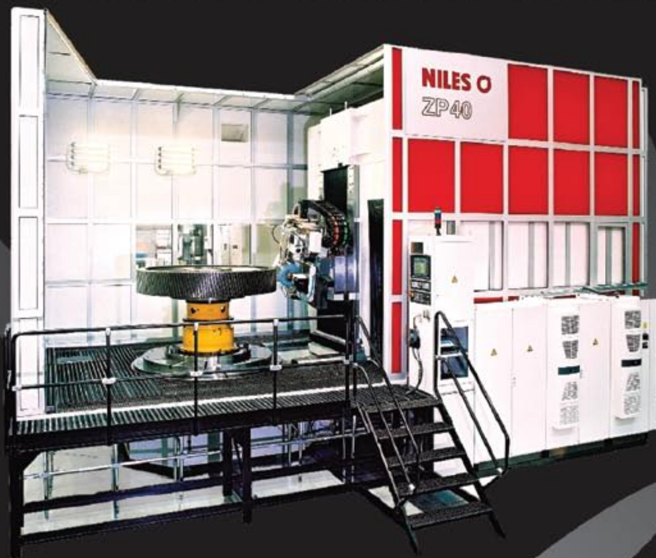
In addition to facilitating the deployment and use of DR, smart grid technologies can also be used on the transmission system itself and in power system control rooms to make the grid more flexible and better able to accommodate variability. "Smart" computing and communications technology, including both hardware and software applications, can facilitate the following operational changes that will greatly improve the flexibility of the power system:

- Faster resource dispatch intervals: Scheduling and dispatching power plants and demand response resources for 5-minute, 10-minute, or 15-minute periods, instead of for the hourly periods used in many regions, can greatly reduce the cost of accommodating intra-hour variability on the power system. One wind integration study calculated that 10-minute scheduling reduces wind integration costs by 40 to 60 percent relative to hourly scheduling. Similarly, power flows on transmission lines can be dynamically scheduled to better accommodate intra-hour variability.
- Virtual balancing area consolidation: By allowing excess electricity supply in one region to be netted out with inadequate supply in a neighboring region, the cost of accommodating variability on the grid can be greatly reduced. This is particularly true for regions with high wind penetrations, as changes in wind output in one region are typically not highly correlated with changes in another region.

HAVLIK GEAR

WE'VE EXPANDED WITH A NEW LOCATION.

OUR NEW GEAR GRINDING AND MANUFACTURING FACILITY HOUSES ONE OF THE LARGEST GRINDERS IN NORTH AMERICA.



KAPP NILES

The ZP 40 grinding machine features the ultimate in design construction with true hydrostatic guideways and rotary table. The work table is direct drive. Nodular cast iron is used for the machine beds, columns, and all sub-assembly housings, for stability. The machine accuracy is therefore assured for a long lifetime.

The ZP40 is designed to profile grind spur and helical external and internal gears using dressable corundum or sintered grinding wheels. An integrated measuring device further increases machine's flexibility. The ZP machine can be set up to accommodate application-specific requirements for maximum flexibility, high precision and optimum productivity.

It is specifically designed to accommodate shaft pinions, mating bull gears and internal ring gears.

Extended capacity for gears and profiles is:

- Internal and external gear grinding up to 4m(160") OD x 1.5m(60") face.
- The ability to inspect lead, profile and spacing up to 4m (160")

Havlik GEAR

Div. of Havlik International Machinery Inc.

455 Sheldon Dr., Cambridge, Ontario N1T 2B7 tel 519-624-6240 fax 519-624-4119

www.havlikgear.com

- Better integration of wind energy forecasting: While current wind energy forecasting techniques are advanced, smart grid technology can help better integrate forecast results into power system operational decisions, allowing reserves to be allocated more efficiently.
- Dynamic line ratings: Ambient weather conditions such as wind speed are not taken into account when calculating the transfer capacity of a transmission line, which decreases as temperature increases. Tension monitors on transmission lines can determine the real-time capacity of a line, and smart grid technology can communicate the results to grid operators. This will allow more power to be safely loaded onto transmission lines during periods when the wind speed is higher, which will also tend to be periods when wind energy output is higher.

MAKING THE GRID SMARTER

Policymakers at a variety of levels—including the staff of state Public Utility Commissions, the Federal Energy Regulatory Commission, and the Department of Energy—can play an important role in ensuring that resources and other incentives are directed towards the smart grid technologies that hold the most promise for making our power system cleaner and more efficient. The technologies discussed in this article, namely technologies that facilitate greater use of demand response as well as transmission-level technologies that enhance the flexibility of the power system itself, have tremendous potential for facilitating wind integration while making the power grid more efficient for all users.

REFERENCES

1) Based on average ancillary services prices from November 13, 2007 to November 12, 2008, available at www.nyiso.com/public/market_data/pricing_data/dam_ancillary.jsp
2) For a library of these studies, see www.uwig.org/opimpactsdocs.html
3) While wind output gradually decreased over the course of several hours that afternoon, wind output was constant, or gradually increasing, over the actual hour when electricity demand began to exceed supply. Moreover, the gradual decrease in wind output was accurately forecast at least a day in advance, but unfortunately the wind forecasting system was only in pilot testing phase and not yet integrated into system operations at that time. For more information, see ERCOT's report on the incident: interchange.puc.state.tx.us/WebApp/Interchange/Documents/27706_114_577769.PDF
4) See www.uwig.org/AvistaWindIntegrationStudy.pdf.

WIND DRIVE TRAIN RIDE-THROUGH PERFORMANCE

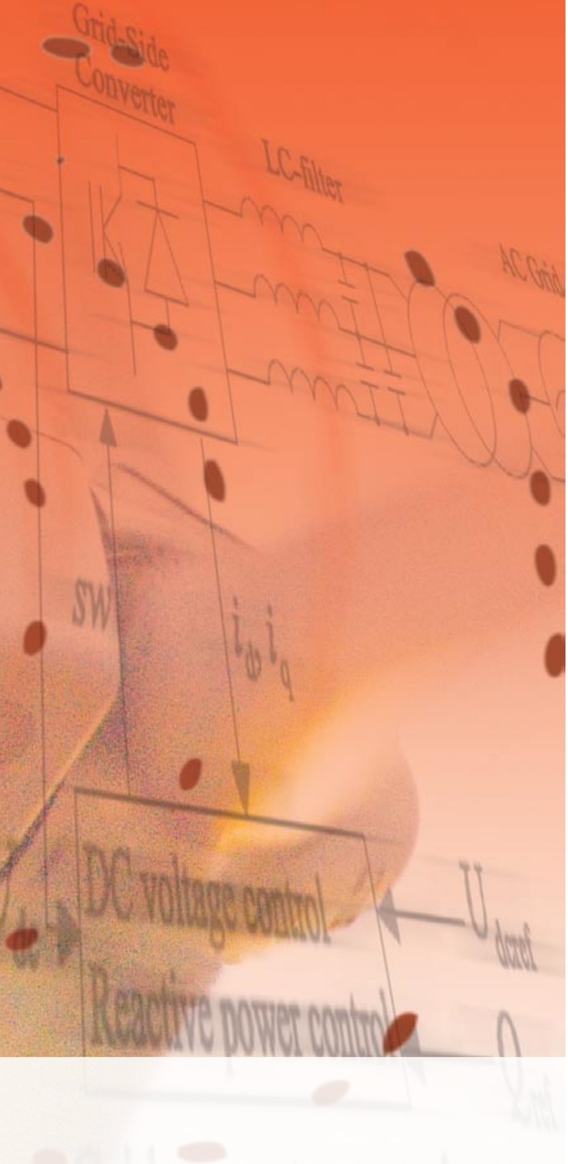
The permanent magnet synchronous generator, combined with a full power converter from The Switch, offers stellar fault ride-through performance, efficiency, and reliability.

By Anders Troedson

Anders Troedson is vice president and general manager of emerging businesses at The Switch Controls and Converters, Inc. Call (603) 886-9010 x105, e-mail anders.troedson@theswitch.com, or go to www.theswitch.com.

AS WIND TURBINES BECOME a significant part of our electrical generation capacity, it is increasingly important that the performance of the wind turbine is similar to the performance of our conventional power generators. Both hydro and nuclear power generators and coal fired and natural gas fired generation plants utilize conventional synchronous generators. Reactive power injection in these traditional power generators is determined by controlling the excitation current of the generator. Also, since most electric loads are inductive, thereby absorbing inductive reactive power, the traditional power plant is normally injecting reactive power to help support the system voltage and balance the reactive power in the system. These same grid support features, as well as ride-through capabilities, are now also required from wind turbines, and the actual performance depends very much on the type of wind turbine drive train the wind turbine manufacturer has selected. The most common drive train used at the moment is the so-called doubly fed system shown in fig. 1.

A newer wind turbine drive train technology, using a permanent magnet synchronous generator in combination with a full power converter, is increasingly becoming more popular in the wind turbine industry. The very largest wind turbine manufacturers in the world have all introduced this newer permanent magnet generator technology for wind turbine appli-



cations. Several factors—including improved grid fault ride-through capability and higher low speed efficiency, as well as lower maintenance requirements—are all factors driving this technology shift. In this paper we will further study the actual ride-through results achieved from full scale field tests on a large wind turbine using a permanent magnet generator with full power converter.

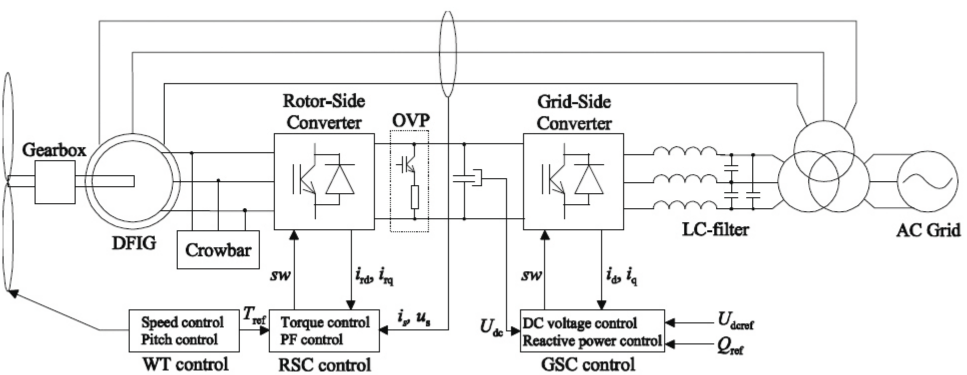
GRID CODE REQUIREMENTS

Utility Grid Code requirements are frequently referencing the guidelines defined by E.ON (E.ON, Grid Code—High and extra high voltage. Bayreuth 2006, E.ON Netz GmbH) for grid interface requirements, which are applicable to wind turbines. Fault ride-through (FRT) is one of the key requirements of these grid codes. The FRT requirements define how deep and long the grid voltage dips have to be managed by the turbine drive train and its power converter. Requirements for capacitive reactive current injection are also defined in this standard. The main function of the injected reactive current is to the support grid voltage during the voltage dip event.

POWER SYSTEM COMPARISONS

Full power converters (FPC), combined with permanent magnet synchronous generators (fig. 2), represent the newest technology in wind power market. FPC has many advantages compared to older technologies. The main advantages of FPC during FRT events are the fully decoupled and separately controlled grid

Fig. 1: The common doubly fed wind generator (DFIG) drive train. Typically some 70 percent of the generated power is fed directly from the generator stator winding to the grid transformer. The remaining 30 percent of the power is controlled by a reduced size (30 percent) power converter, which also is used to control the output power from the stator winding via the rotor winding.



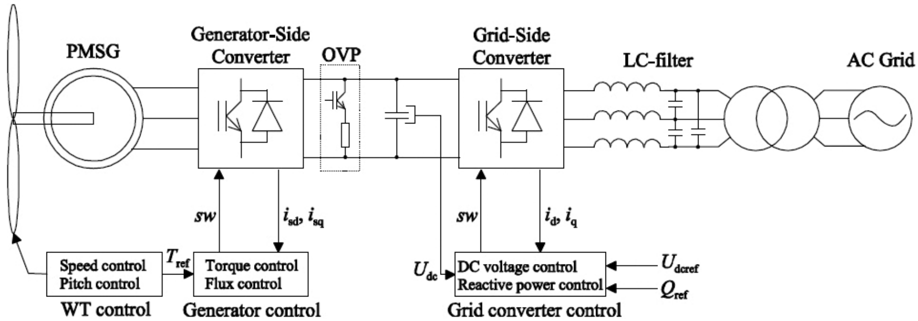


Fig. 2: The picture shows the principle of the permanent magnet wind generator drive train with its full power converter, which rapidly is becoming the preferred drive train technology for modern wind turbines.

currents and generator torque. This means that the active and reactive grid currents, respectively, can be set at the most advantageous levels for ride-through during a FRT event. The generator torque can be precisely controlled, which helps to control the DC-link voltage in the converter. Therefore, the FPC is a very robust and flexible topology, and the software-based control algorithms are easy to implement. From a hardware design standpoint it is usually also necessary to add over-voltage protection in the DC link in the form of a brake chopper unit to further prevent DC over-voltages during a sudden grid event. As mentioned previously, the doubly fed induction generator (DFIG) drive train (fig. 1) has been the most commonly used wind turbine drive train topology so far.

Compared to the permanent magnet generator and its FPC, the DFIG requires additional protection circuits and components such as a so-called crowbar in the rotor circuit

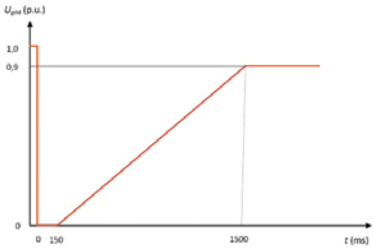


Fig. 3: Voltage dips requirements according to E.ON '06. The wind turbine has to ride trough voltage dips events as defined by the red line.

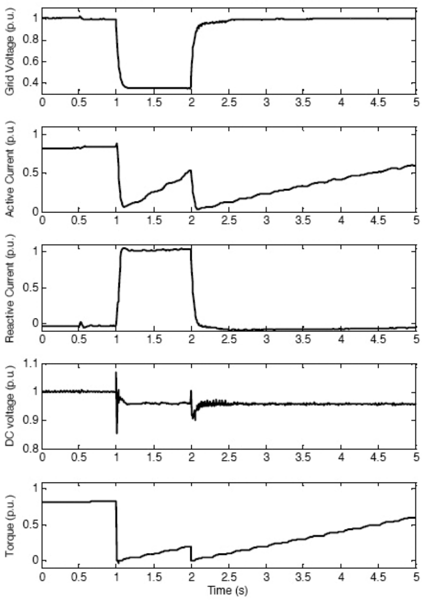


Fig. 4: The main results of FRT measurements during a created actual grid event using a full power converter.

and a static switch in the stator circuit. These are typically required to achieve acceptable FRT during a grid event. Without these protection circuits, the behavior during fast transients and voltage dips can be unexpected. Despite these additional components, the reactive current injection capacity for the DFIG is usually insufficient to meet the latest grid code requirements. This is because the DFIG drive train has a reduced power converter with a reactive current injection capacity of only about 30 percent.

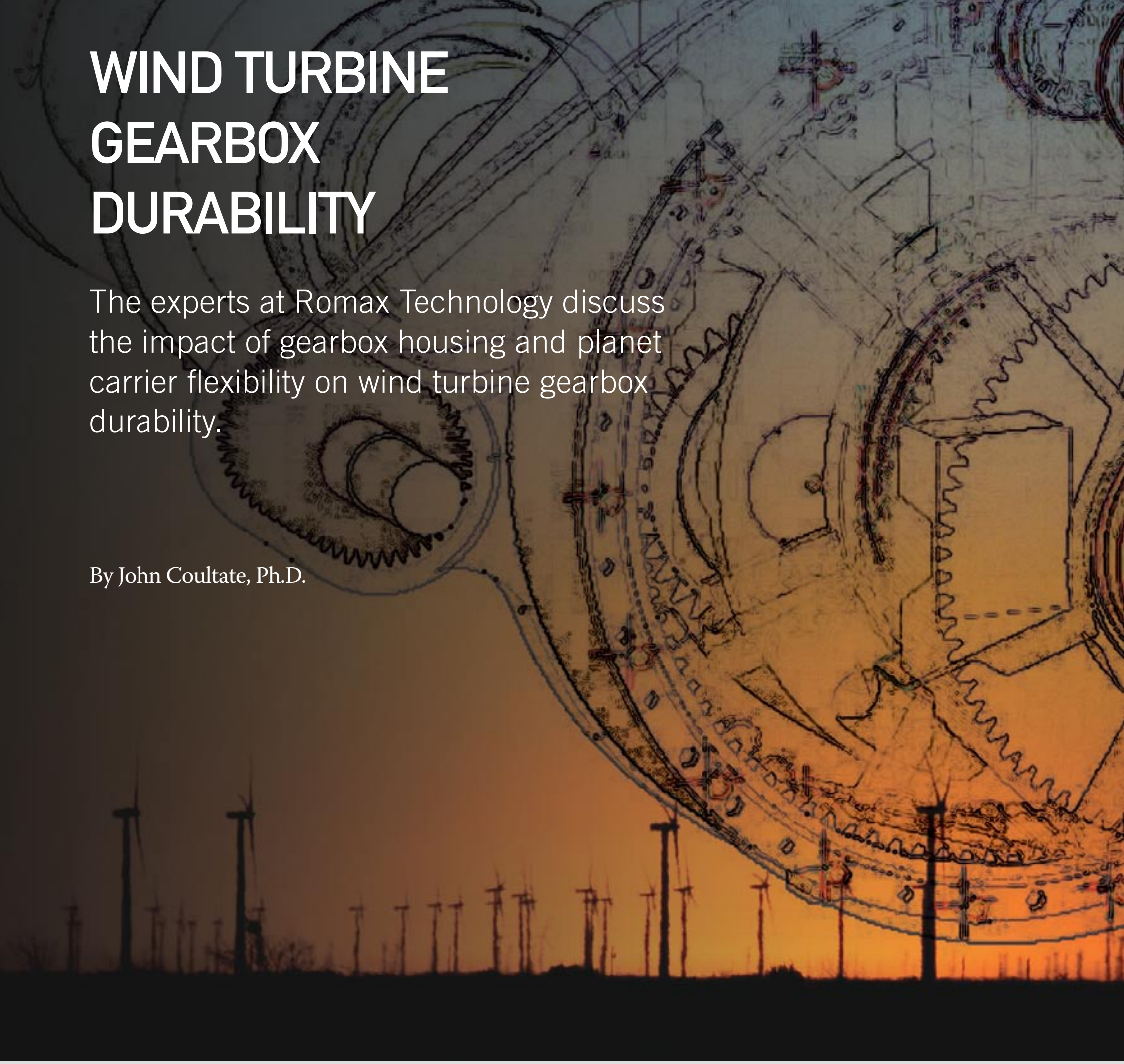
TESTING AND RESULTS

Special field measurements have been performed to verify the FRT capabilities of The Switch's FPC drive train on an actual operating wind turbine. The voltage dip was gener-

Fig. 5: These pictures show a permanent magnet and synchronous generator (top) and its 1.6 MW full size power converter (bottom).

ated by using large phase to ground switched inductors on the medium voltage side of the turbine's step-up transformer. The actual grid voltage during the voltage dip event is 25 percent of the nominal grid voltage at the connection point, without the supporting effect of The Switch's full power converter. The active power from the wind turbine before the dip event was approximately 80 percent of nominal. The results can be found in fig. 4, showing that the FPC drive train rides trough the voltage dip event without any problems. Close to nominal reactive power is produced during the voltage dip, which improves the actual voltage level in the point of common coupling of the wind turbine. The generator torque is rapidly ramped down to avoid overvoltages in the converter DC-link.

In summary, the permanent magnet synchronous generator combined with a full power converter offers the best fault ride-through performance, the highest efficiency, and the most reliability of modern wind turbine drive trains.



WIND TURBINE GEARBOX DURABILITY

The experts at Romax Technology discuss the impact of gearbox housing and planet carrier flexibility on wind turbine gearbox durability.

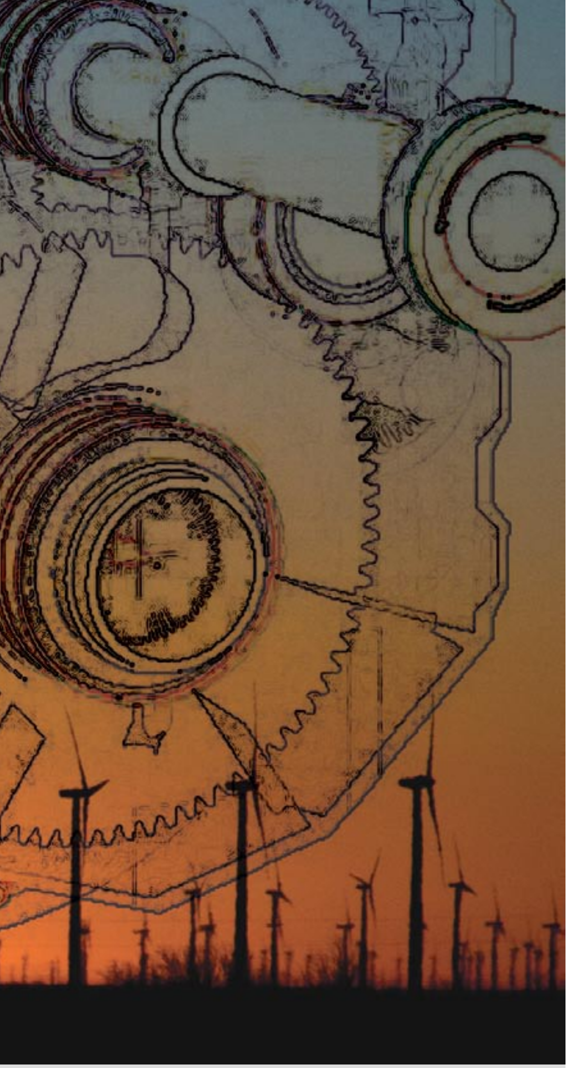
By John Coultate, Ph.D.

John Coultate, Ph.D., manages wind turbine drivetrain consultancy and analysis projects at Romax Technology. To learn more call +44 (0) 115 951 8878, e-mail sales_wind@romaxtech.com, or visit www.romaxtech.com.

THE RELIABILITY OF WIND TURBINES is a major issue for the industry. Wind turbine failures can be extremely costly in terms of repair costs, replacement parts, and in lost power production due to downtime. Generally the gearbox is not the most likely component to fail in a wind turbine, but a gearbox failure can have a major effect on the turbine availability. If a gearbox failure occurs, the lead time on replacement components such as large bearings or gears can be significant. If the wind turbine is offshore, there can be added complications and delays associated with needing a suitable maintenance vessel, lifting apparatus, and the right weather conditions before any maintenance can take place.

If a gearbox failure occurs, forensic analysis of the failed components allows us to understand the failure mode and the root cause behind a failure. Romax Technology undertakes forensic analysis using a combination of expert knowledge in bearings and wind turbine gearbox design, as well as a range of software simulation tools to provide detailed gearbox analysis. As the wind turbine industry matures, an increased understanding of failure modes and root causes means that we can guard against gearbox failures at the design stage.

Wind turbine gearboxes are generally designed using a range of different software simulation tools, computer models, and calculation methods. Models applied across the in-



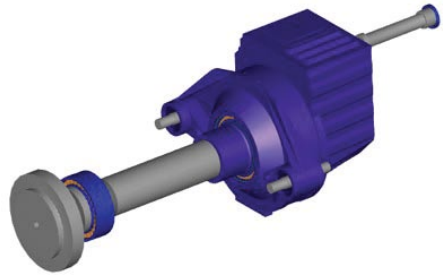


Fig. 1: The fully detailed RomaxDesigner software gearbox and drivetrain model.

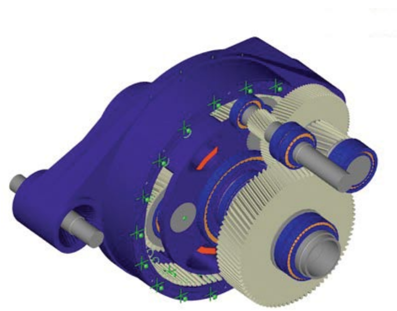


Fig. 2: The planetary and parallel gear stages in the fully detailed RomaxDesigner gearbox model.

dustry range in complexity from simple gear contact models and bearing stiffness models to fully-fledged whole system simulations. Our RomaxDesigner software allows us to generate full gearbox and drivetrain models that incorporate all major component interactions and flexibilities. Non-linear bearing models, gear mesh models, shaft deflections, gearbox housing deformations, and interactions with the nacelle bedplate and gearbox mounts can all be considered in a single, fully-coupled analysis. By calculating accurate operating loads and misalignments for each gear and bearing in the system we can determine gear and bearing stresses and predict individual component lives. Complex interactions in planetary gear sets are accurately modelled, allowing us to calculate load sharing between each planet gear load path.

The question remains: What level of detail is required in a model to accurately represent a wind turbine gearbox? Simple models are useful because they can be quickly and easily used to test different design concepts, but the only way to reliably capture all of the component interactions is to use a single fully-detailed model. Currently, wind turbine gearbox design standards do not explicitly recommend the consideration of gearbox housing flexibility or planet carrier flexibility in the design process. However, in operation, each element will flex under load. We conducted detailed research at Romax Technology to investigate the influence of different flexibilities within a gearbox and drivetain model and assess their impact on the predicted durability of the gearbox.

The drivetrain and gearbox model used for this research is based on the gearbox currently being utilized by the Gearbox Reliability Collaborative (GRC), a research program led by the National Renewable Energy Laboratory

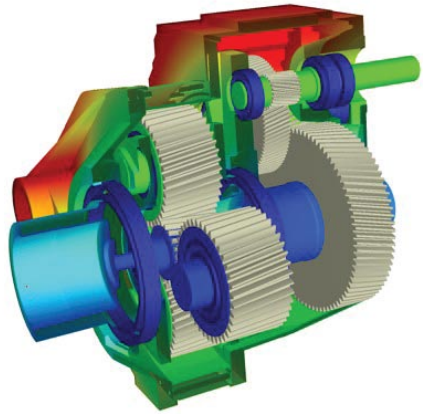


Fig. 3: Deflection analysis in RomaxDesigner using the fully detailed gearbox model including flexible housing.

(NREL). Field and dynamometer tests are being performed in order to build up a complete understanding of the behavior of the gearbox. Results from these tests will be used to support the predictions made using our simulation models. The gearbox itself is rated at 750kW and consists of a single planetary gear stage and two parallel helical gear stages.

Four gearbox and drivetrain models of differing complexity were created for this research. All models included flexible shafts and accurate representations of the gears including detailed gear contact models and mesh stiffness. The simplest of the four models included simple bearing models with linear stiffness and no clearance, a rigid planet carrier, and no housing flexibility. The second model was similar, but all of the bearings were replaced by non-linear bearing models incorporating flexible raceways, clearances, and detailed contact mechanics. The third model was more detailed again, this time including a flexible planet carrier as well as the detailed non-linear bearing models. The final model was fully detailed and included flexible housing as well as the non-linear bearings and flexible planet carrier. Fig. 1 shows the fully detailed gearbox and drivetrain model, and fig. 2 shows the planetary and parallel gear stages inside the detailed gearbox model.

There are many factors in a design that can influence gear life, but a potentially major contributor to poor gear life is high misalignment between meshing gears. The four gearbox models were analyzed under a simulated load of 100-percent torque, and simulated rotor weight acting on the mainshaft and the misalignment of each gear mesh was calculated. Fig. 3 shows an example of deflection analysis using the fully detailed gearbox model in RomaxDesigner.

Analysis results clearly showed that the calculated gear mesh misalignments depended strongly on the amount of detail and flexibility in our gearbox model. Fig. 4 shows the variation of misalignment for each gear mesh. For the sun gear to planet gear mesh, the simplest gearbox model predicts only 50 percent of the misalignment calculated using the fully detailed model. The relationship between these results and the gear tooth load distribution for the sun gear

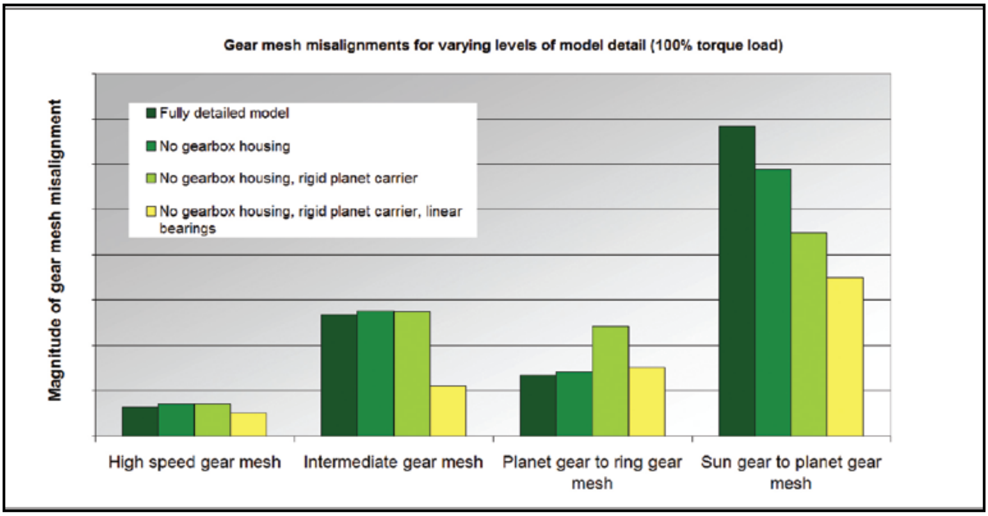


Fig. 4: Gear mesh misalignments for varying levels of model detail.

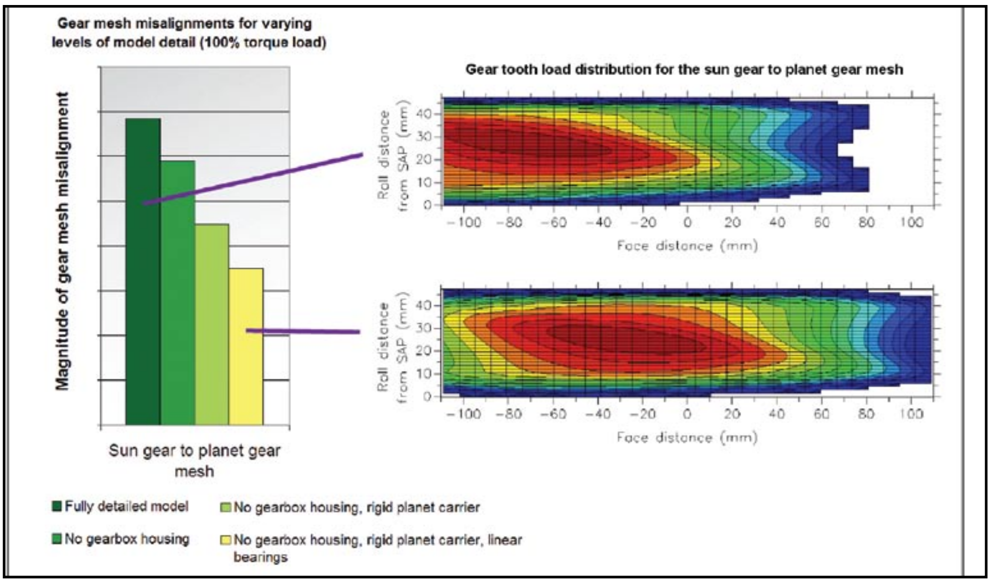


Fig. 5: The relationship between gear mesh misalignment results and gear tooth load distribution for the sun gear to planet gear mesh.

to planet gear mesh is shown in Fig. 5. These results show that the simplest model predicts a good tooth load distribution (i.e. the load is fairly centered on the tooth and well distributed) but the fully detailed model predicts a poor contact pattern with high edge loading.

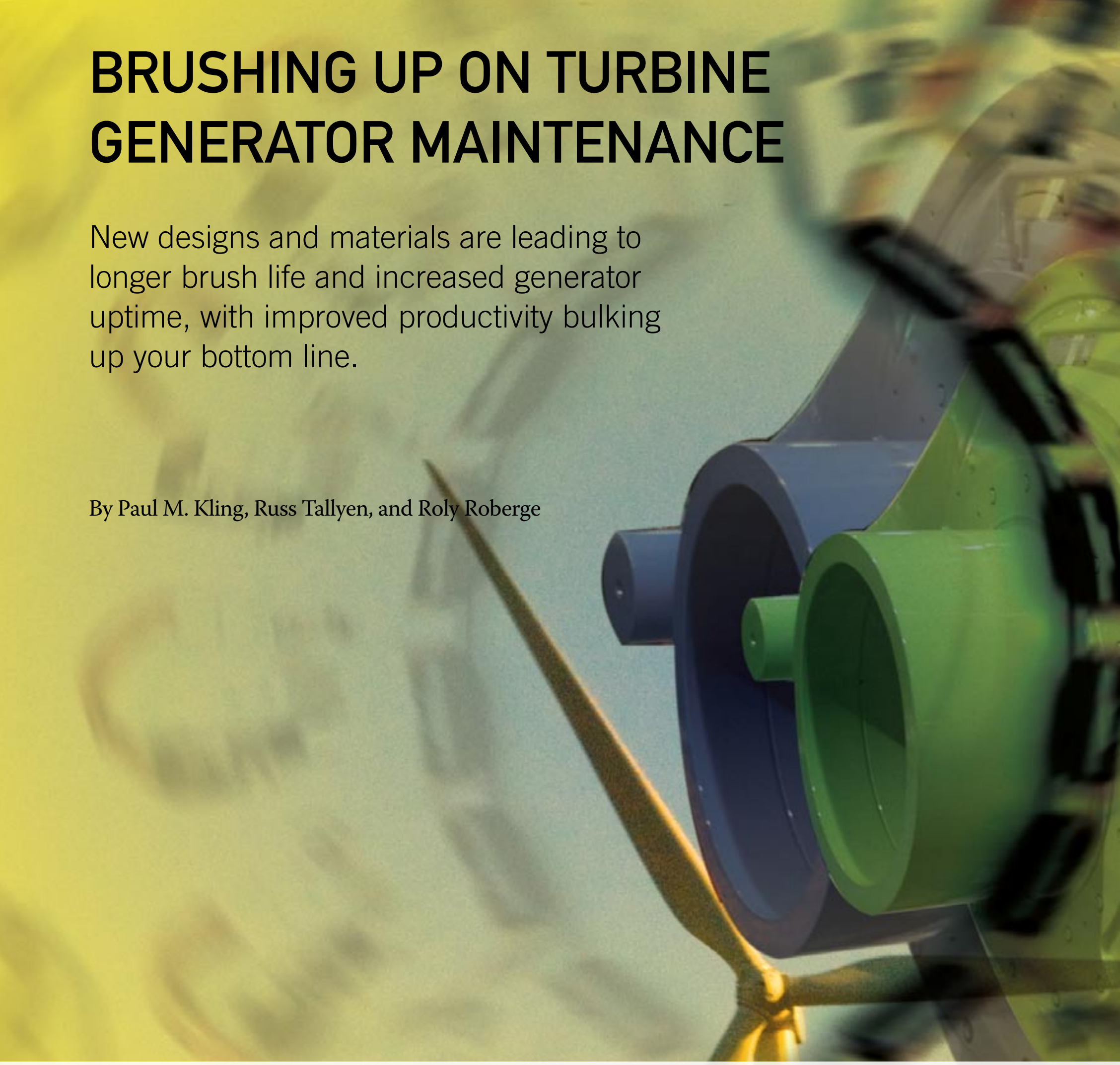
We concluded that it would be a very dangerous assumption to omit any of the structural flexibilities from the gearbox model, as these could lead to an underestimation of gear mesh misalignment and inaccurate prediction of gear tooth load distributions. These factors both lead to an inaccurate prediction of the gear life for this gearbox.

The impact of this on the wind turbine industry is clear—underestimating gear life at the design stage can lead to gearbox failures later in the field.

BRUSHING UP ON TURBINE GENERATOR MAINTENANCE

New designs and materials are leading to longer brush life and increased generator uptime, with improved productivity bulking up your bottom line.

By Paul M. Kling, Russ Tallyen, and Roly Roberge



Paul M. Kling is wind segment manager, Russ Tallyen is application engineer, and Roly Roberge is engineering manager at Morgan AM&T. To learn more call (864) 458-7700 or go to www.morganamt.com.

FROM THE PIERCING COLD of Mongolia to the oppressive desert heat of the American West, wind turbine generators are subjected to extremely harsh environments, along with other challenges including sudden changes in wind speed, very low humidity, and the on/off cycling of the actual generator unit. Carbon brushes and related assemblies are of a small size, but very critical component to generator efficiency and output. Original design issues can lead to maintenance issues, which will result in higher maintenance costs and significantly reduce generator reliability. Leading-edge laboratory equipment, coupled with years of experience in carbon brush technology, has led Morgan AM&T to develop advanced materials to address these extremes.

Poor turbine performance has occurred at numerous wind farms throughout North America, requiring solutions that are currently in development. There are major problems identified with symptoms of poor brush life, heavy dusting, and damaged rings, which are the results of friction chatter, brush instability, and low spring force. These symptoms are the direct result of deficiencies in some of the original OEM designs. Overall efficiency is reduced, and operating costs and maintenance requirements are increased, which in turn creates complaints from the site managers who are challenged to keep them operating, since downtime is unacceptable and costly. Out of warranty turbines become the problem for the owners when the OEM design creates problems

that carry forward. Once the warranty expires the costly brushes, maintenance, and excessive dusting all become the responsibility of the owners or operators.

These additional costs in labor, parts, and wasted non-producing power time can build to the point of making a wind farm a less than an attractive investment. The correct financial decision is to fix these problems, which can provide payback over the life of the turbine in the range of 10-20 times the initial cost, depending on the condition of slip rings and the overall maintenance practices at wind farm.

The problems are found to be in the existing brushes, brush holders, and rigging. The holders are fabricated from stamped metal plates and spot welded in place, and they are only about half the length if the brush is encased or supported. Brush instability is the result, and this situation is conducive to arcing. Rapid brush wear, excessive heat, and ring damage are the manifestation of arcing, all possible causes of a flashover. In some cases the temperature was high enough to distort the thin walls of the holders, binding the brushes in the holder, increasing the arcing, and eventually bring about failure of the unit.

Also, because of the design, one brush in each holder is placed in a "stubbing" orientation. Stubbing, or "leading," is when the rotation of the ring surface is into the toe, or long side, of the brush. This design is a major contributor to a condition called friction chatter, which causes the brush to vibrate or bounce at a very high frequency. It is almost always accompanied by some arcing since bouncing brushes don't conduct current very well, so slip ring roughening due to electrical etching is the end result. Figure 1 represents radial-mounted brush holders created from superior materials that have improved carbon brush performance.

Low spring force was found to be another contributor to performance problems. Springs need to operate smoothly and have the proper force applied to the brush to maintain contact with the moving surface of the ring. Low brush pressure—the spring force/cross sectional area of the brush—can cause higher contact resistance, threading, and arcing. Threading is the machining of the slip ring by particles in the brush face. These particles are trapped in the porous brush face and work-hardened, creating a tool that machines the ring surface. Brush pressure should also be equal (within 10 percent) on all brushes to avoid the difficulties arising from selective action, which is the unequal current distribution among the brushes.

Lastly, the original brushes are made of a high metal content material and are not adequately designed for environmental conditions such as low humidity. Brushes with a high metal content have a tendency to perform poorly at low current loads, causing threading. The resulting product is poor combination of cost and longevity. A new design of the brush holder system has been developed to combat these problems, directly and easily mounting in place of the original holders. The design also stabilizes the entire unit.

These upgraded units are precisely machined with tight tolerances and high quality materials instead of the original stamped metal, resulting in a strong and sturdy unit. The holders are designed to encase the entire length of the brush to provide stability, and the fine finish of the carbonway aids in reducing brush to holder friction. To eliminate the friction chatter the holders are mounted radially, at 90° to the ring surface. The number of brushes is increased from four to six per ring, which increases the cross sectional area of the material, reducing

Fig. 1: Power ring and ground ring brush assembly.

Fig. 2: Wind generator brush with EZ connector.

the amount of load per brush and allowing a lower metal content brush to be used.

Spring force is significantly improved over the original coil spring design. A revolutionary spring clip assembly utilizes a constant force spring. This spring clip assembly is designed with a removable spring, which can be replaced at a very minimal cost during each brush change to insure adequate spring force. Constant force springs maintain a 10-percent differential to fight selective action, and this design applies a constant force to utilize approximately 65 percent of the total brush length. The brushes are an aerospace-grade material that films equally well in low and high load conditions, and it has been developed specifically to perform well in the low humidity atmospheres in which numerous wind farms operate.

Brush replacements are convenient, with a plug-

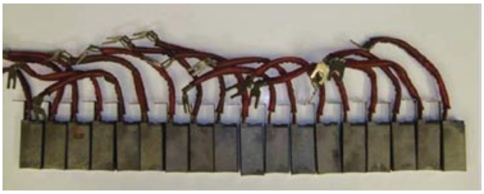


Fig. 3: Even carbon brush wear with no ring wear after two years of operation.

in terminal connection, which reduces the brush replacement time by half. No tools are required that must be carried up to the nacelle, resulting in no dropped screws, tools, or scraped knuckles—all benefits to the technician, and time savings for the owners/operators. Figure 2 displays a wind turbine generator brush with the labor-saving EZ connector.

In field testing the results are impressive. The design improvements have achieved no ring wear or damage, a low wear differential between brushes, and less dust. These units can be cleaned every six months, and brush replacements intervals are about every 24 months. Wind farms that are having significant issues with the original stamped holders have found this solution as a way to alleviate serious failures. The final result is a greatly improved efficiency, reduced operating costs, and increased turbine uptime.

Going beyond developing complete solutions requiring modifications to the holders and springs, in many cases Morgan can work with existing structures, providing replacement brushes that outperform the OEM supplied brushes. Benefits include:

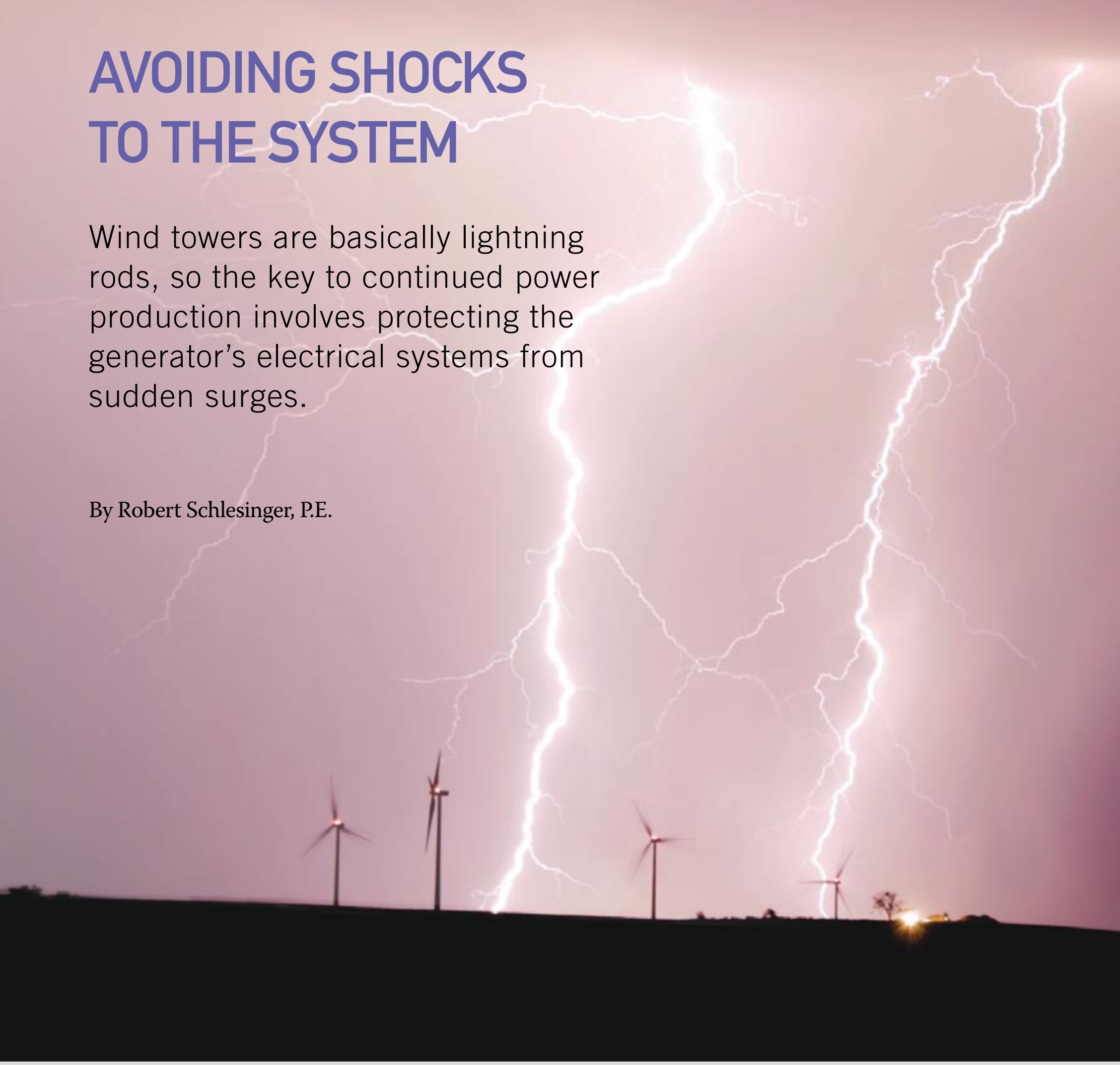
- Exceptional performance from no load to high load
- Low friction through superior film formation
- Endurance through extreme atmospheric conditions
- Contamination tolerance
- Excellent lifespan with minimal slip ring wear
- Low brush to brush wear differential (selective action)
- Engineering and performance specific to your application

Overall, selecting the correct carbon brush for your application can reduce slip ring wear (fatigue), maximize brush life (fig. 3), and contribute to the overall generator performance. The professionals at Morgan AM&T are available to help you choose the most robust grade for your wind-turbine applications.

AVOIDING SHOCKS TO THE SYSTEM

Wind towers are basically lightning rods, so the key to continued power production involves protecting the generator's electrical systems from sudden surges.

By Robert Schlesinger, P.E.



Rob Schlesinger, P.E.—an electrical engineer and a senior member of the IEEE—is director of business development at DEHN, Inc. He can be reached at (949) 376-4960 or rob.schlesinger@dehn-usa.com. Go online to www.dehn-usa.com.

TO A THUNDERSTORM A WIND TOWER appears as a lightning rod, meaning that generators are highly susceptible to the effects of lightning. They are by design the tallest structure in the area, frequently found where lightning occurs regularly, and they have many conductors for power and communications running from uptower to ground level, therefore susceptible to induced electromagnetic effects from lightning discharges. They also have sensitive electronic measurement and control systems that can easily be damaged or upset and are connected to the utility grid, exposing the system to yet additional issues for damage or disruption of service.

While a direct strike by lightning to a blade or the nacelle may be thought to be the greatest cause of concern, and certainly would have the most dramatic effect, it is not the most common occurrence to have an effect on the operation of a wind generator. A recent study reports the following interesting statistics:

- 7-10 percent of all lightning faults involved blade damage
- 43-51 percent involved control system damage
- 20-32 percent involved damage to the power system

While the most noticeable and catastrophic events involve the very expensive blades, this represents a relatively small percentage of all events compared to the more frequent and less-cata-

strophic faults affecting the electrical system (63-83 percent of the lightning faults involved damage to electrical/electronic systems). This includes components of the power system, instrumentation, and measurement and control systems, yet these seemingly less-dramatic failures still render the generator inoperable. Furthermore, the repeated exposure of sensitive electronics to these transients will shorten their otherwise long life expectancy.

There is technology available that attempts to divert a lightning stroke from a blade tip to earth, thus saving mechanical parts of the wind generator the damage they would otherwise experience. This, however, does not mitigate the effect that the electrical system will experience. A direct strike to the wind generator or nearby structures will cause a local ground potential rise that, when referenced to distant points that are connected by power or measurement, control or instrumentation circuits may show many tens of thousand of volts between them. Strikes to power lines, nearby strikes, or even cloud-to-cloud discharges will induce transients onto circuits of sufficient magnitudes to cause insulation or dielectric breakdown of critical components, deterioration of those components, or even what may appear as erroneous signals on control circuits, causing PLC and controller to mis-operate.

The issues of these transients or surges affecting power and control systems are manageable by the use surge protective devices that are strategically located, properly rated for the necessary voltage protection level, and rated sufficiently to discharge the magnitude of current associated with the lightning affect. This last parameter is key, because if the SPD is not able to discharge the associated lightning current, it too will be destroyed. Figure 1 is a representation of two wave forms of equal magnitude, with the longer one (10/350 μsec) having about 25 times the energy of the shorter one (8/20 μsec). Lightning current discharges associated with direct strikes are more closely represented by the longer duration wave, while induced caused transients are of the shorter duration.

Depending upon the application, the proper SPD must be selected to be capable of discharging current associated with the event. That must take into expected magnitude of the current, as well as the duration.

The basic concept of protection is "equal potential bonding," where all conductors can be bonded during the occurrence of a transient so as to have all equipment terminals at an equal potential. This is accomplished by directing lightning flashes to ground through air terminals and a well-bonded conductor system and using properly placed, rated, and coordinated surge protective devices, or SPDs. These devices use technology based on spark gaps, metal oxide varistors (MOVs), silicon avalanche diodes (SADs), and gas discharge tubes, with each having their own characteristics.

Transients appearing on energized conductors are managed by use of lightning and surge protection devices, which discharges these transient voltages and associated currents. Lightning current arresters are designed, rated, and tested for discharge impulse currents with a 10/350 μs wave shape characteristic. Electromagnetic fields caused by direct and indirect flashes—as well as by internally switched or utility switched components—will introduce lower energy transients on conductors, and they too must be managed by the use of SPDs, which are designed to handle lower energy transients defined by 8/20 μs wave shapes.

The distinction between lightning current ar-

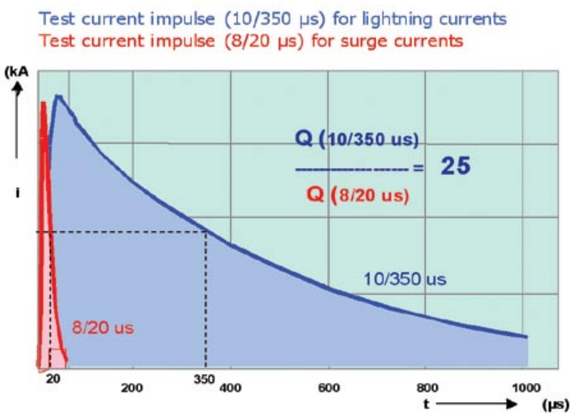


Fig. 1: Comparison lightning/ surge discharge current wave shapes.

resters and surge protective devices, and the determination of where to place each, is covered by the Lightning Protection Zone (LPZ) concept referenced in standard IEC/EN 62305. This concept defines boundaries between high-risk exposed lightning strike areas and other areas that are differently affected by lightning currents and their induced counterparts.

These devices must be selected and placed properly within the system. The selection is based upon their ability to adequately discharge the transient currents, to continue to be available for future occurrences, to limit the voltage drop across them to protect the components and systems for which they are intended, and not to disrupt the function or performance of the system while installed or during their operation. Because of the number of parameters that must be met, different technologies are used, with each having their virtues and weaknesses. The key to properly protecting a system is selecting the correct technology or combination of coordinated technologies to meet all requirements and placing them in the correct critical locations.

In summary, the key of lightning and surge protection is to:

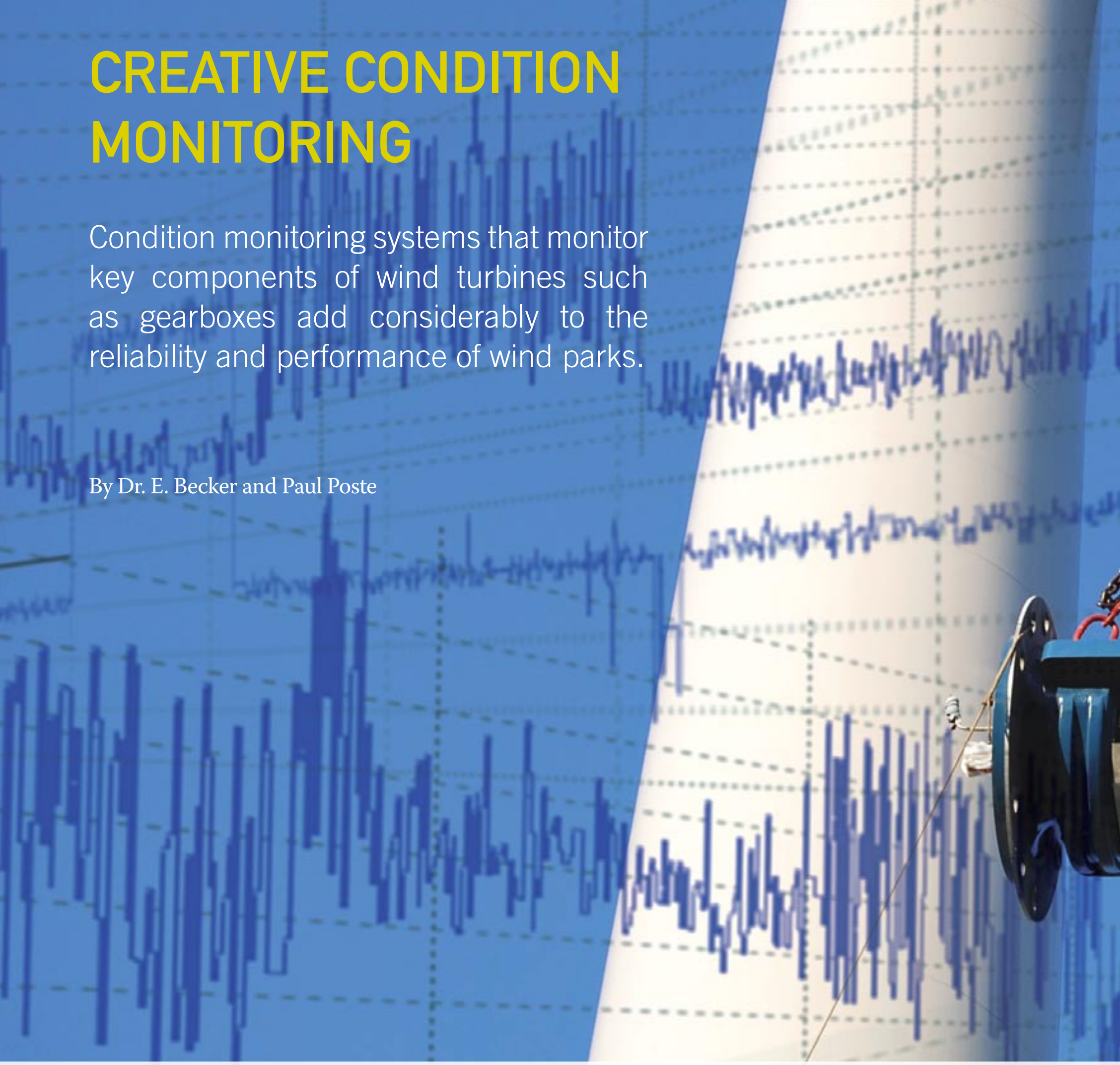
- Direct lightning currents to ground by use of air terminals and properly rated conductors.
- Properly bond all non energized conductors to prevent any potential differences on them.
- Use SPDs between conductors, and between conductors and ground where over voltage transients may appear.
- Apply SPDs as close to, and before equipment to be protected and use Lightning Protection Zone concept as a guide for determining placement and ratings.

Fig. 2: Example of a combination of Class I and Class II SPD, using coordinated spark gaps and metal oxide varistors.

Fig. 3: Example of coordinated SPD for control circuits using coordinated gas discharge tubes and silicon avalanche diodes.

- Select SPD based upon correct discharge current (Class I, II, or III) ratings and the correct signal application.
- Use correct sized and properly routed conductors to minimize voltage drop.

As to what is accomplished by using surge suppressors, they can protect equipment and components against catastrophic failures caused by transients; against the constant deterioration of dielectric/insulation materials when exposed to transients over long periods of time, which leads to premature failures, and; protect systems from mis-operation due to erroneous signals, which are actually unwanted transients. The result is improved system efficiency, reliability, increased system integrity, less downtime, less maintenance costs, and improved service.



CREATIVE CONDITION MONITORING

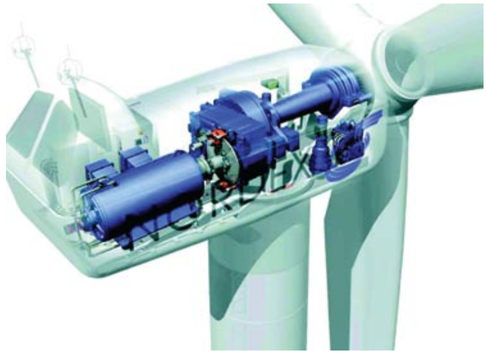
Condition monitoring systems that monitor key components of wind turbines such as gearboxes add considerably to the reliability and performance of wind parks.

By Dr. E. Becker and Paul Poste

Dr. E. Becker and Paul Poste are with PRÜFTECHNIK Condition Monitoring, which is based in Ismaning, Germany. To learn more contact U.S. representative LUDECA at (305) 591-8935, info@ludeca.com, or www.ludeca.com.

CONDITION MONITORING IS A MACHINE maintenance tool that is becoming a component of long-term service packages provided by some wind turbine manufacturers. In general, the actual condition of rotating machinery can be measured and evaluated offline using mobile measurement equipment and online using permanently installed devices. Today it is state-of-the-art for onshore and offshore wind turbines to be equipped with vibration-based condition monitoring.

Wind turbine gear manufacturers are being challenged to supply gears with a reduced mass-to-output ratio that are low in noise and vibration and that provide the required operating reliability and lifespan. Figure 1 shows the most widespread Danish drive train design, with a planetary/spur gear. Experience in the wind energy sector shows that some gear types of this design did not meet the new requirements and needed retrofitting after only a few thousand hours of operation. Because of the high incidence of gear damage found, German insurers introduced a so-called review clause in 2002 as a "cost deterrent" to encourage an improvement in operating life. It requires that all roller bearings in a drive train be replaced after either 40,000 operating hours or five years, whichever is earlier, unless an appropriate Condition Monitoring System (CMS) has been installed. This review clause has also been used by insurers to modify insurance contracts and introduce less



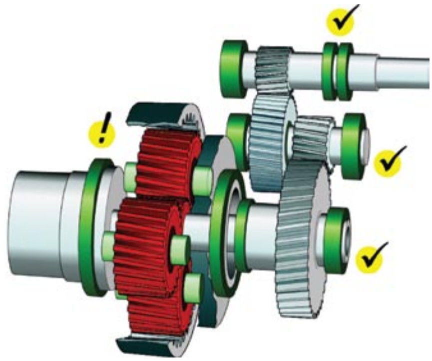


Fig 1: Drive train and planetary/spur gear for wind turbines up to approximately 2 MW.

favorable write-offs for the policyholder. Additionally, Allianz has stipulated CMS operational requirements that include comprehensive testing procedures before a CMS system is approved for use. While Allianz will only accept inspected online CMS in its insurance contracts, the Gothaer Insurance Company drew up guidelines for mobile condition monitoring by independent inspectors. In 2003, GL WindEnergie expanded insurer requirements and made a certified CMS obligatory for GL-certified offshore wind turbines.

In the meantime, in Germany, several thousand mobile vibration measurements have been performed on wind turbines, and some 1,000 online condition monitoring systems have been installed. Experience has shown that condition monitoring on the main gears of the drive train presented a number of problems. In some cases, gearboxes were unnecessarily dismantled due to diagnostic errors, and CMS results were misused for legal disputes between the operator and manufacturer. Notwithstanding these early problems, and independently of insurer demands, operators of small wind turbines are becoming increasingly interested in integrating simple condition monitoring systems into their wind parks. These systems permanently record diagnostic parameters of components and indicate any changes in their operating condition (fig. 2).

A range of condition monitoring solutions is now available on the market that is also certified by leading German insurers and by GL WindEnergie. Many of them are mobile monitoring solutions that can, for example, be linked up with an analysis service or diagnostics center. Low-priced online models are available for use in fixed-speed and variable speed wind turbines that do not require a dedicated computer in the wind turbine, even when used on variable-speed turbines with resampling. Data can be sent from these systems via e-mail to a remote service center.

VIBRATION-BASED CONDITION MONITORING

Various levels of condition monitoring are possible. Level 1 condition monitoring of wind turbines is based on threshold monitoring of broadband vibration parameters. The so-called vibration severity is often used. In accordance with ISO 10816-3, it classifies vibration velocity amplitudes in the frequency range 10 to 1000 Hz as a function of turbine output. The threshold values for wind turbines are as yet undefined but are currently being prepared by a VDI workgroup (a German engineering association). Gear manufacturers and system manufacturers like to stipulate in the contract the vibration severities and velocities in the frequency range of 10 Hz to 100 Hz. However, this only applies to acceptance testing on test benches. Level 2 condition monitoring is performed by monitoring the thresholds of band-selective diagnostic parameters, which are tracked at fixed speeds and variable speeds. Frequency spectra are measured when the CMS is put into operation and when the thresholds are exceeded. The spectra are sent to a diagnostic center by e-mail. Level 3 condition monitoring is based on in-depth diagnoses and takes place after measurements are taken, for example, in a diagnostic center. It works with amplitude spectra, envelope spectra, cepstra, time analyses, and other special procedures. Level 2 and Level 3 condition monitoring use the empirical evidence from the spectral analysis of gears, toothing, rotors, roller bearings, and electrical parts, such as significant vibration patterns and damage characteristics typical for these parts.

It is the task of Level 2 and Level 3 condition monitoring to correlate the components in the spectral analyses with the individual drive train parts and to set suitable frequency bands and warning and alarm thresholds for each measurement location. In total, the Danish drive train design depicted in fig. 1 has about 200 bands that must be set and monitored if the condition monitoring strategy is to be in accordance with the Allianz Center for Technology (AZT) and GL WindEnergie certification. In addition, practitioners know that several harmonics and/or sidebands appear in frequency spectra such as those of tooth mesh frequencies—a phenomenon that further increases the number of frequency bands.

If the operator wishes to measure a tooth breakage in a planet gear, an adequate number of passes and about five minutes of measuring time are needed to measure any disturbances. For information on the bearing condition of the planet gears, suitable filters in the envelope spectrum must be selected and rotational frequency excitations in the envelope spectra monitored. Another important diagnostic tool for planetary bearings with spherical roller bearings is sideband analysis. Bearing play results in multiple sidebands that influence the acoustic and vibration-related running characteristics of the planetary stage.

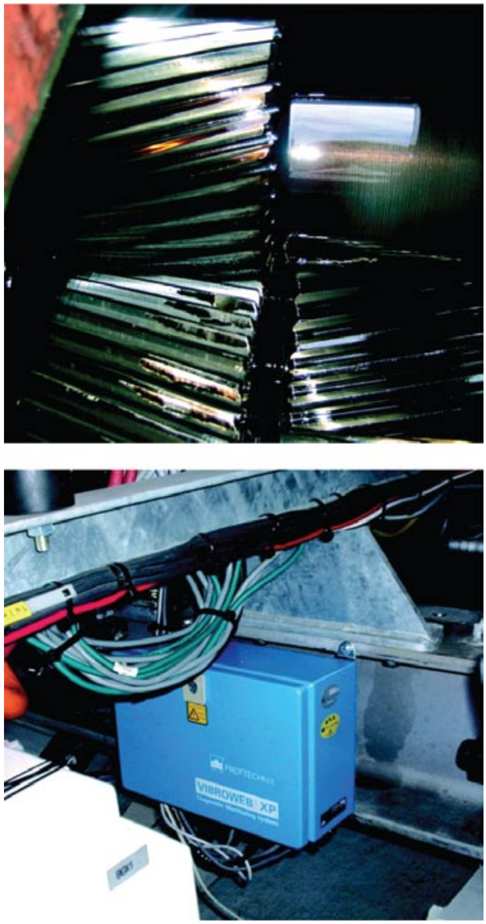


Fig. 2: View of tooth damage in a wind turbine gear and a CMS mounted on the main carrier of a wind turbine.

Analysis of roller bearing and gear conditions is relatively straightforward if the frequency or order spectra remain unchanged over a period of weeks, months, or years, and if diagnostic parameters remain stable. Monitoring can be performed using so-called "traffic light" frequency spectra or by monitoring the corresponding diagnostic parameters. If the warning threshold is exceeded or the yellow area in the traffic light frequency spectra is reached, e-mails containing the frequency analyses are sent to the service specialist. The affected wind turbine is given a higher diagnostic priority, and diagnostic specialists are able to directly monitor the affected turbine and activate further special analyses. An alarm message is issued if the red area is reached. Additional diagnoses and selective maintenance can be planned for and prepared.

Fig. 3: Typical measurement locations for mobile measurement and view of a VIBXPERT unit.

Depending on the type of damage, advanced warning of up to six months can be achieved.

MOBILE MONITORING

Experienced engineers are aware that the load on gears with planetary stages, helical gearing, and tooth corrections has a significant influence on vibration characteristics. When testing gear loads, the rule generally applies that measurements should occur at a minimum of 20 percent of rated torque and at the rated rotational speed. In the wind energy sector, it is state-of-the-art today for leading gear manufacturers to test wind turbine gearing at the rated torque and to measure and record parameters such as the frequency spectra of the vibration velocity during test runs. Such constant load conditions over extended periods only exist in exposed mountainous regions or offshore. In the case of onshore wind turbines, the mean wind force changes more or less hourly and the gear loads are influenced by wind gusts.

To perform mobile measurements, the minimum load should be present, and the effect of wind gusts should be averaged by using sufficiently long measurement periods. Moreover, repeat measurements must be measured in the same load window. Because of the unpredictability of wind speed, etc., external measurement technicians who have to travel long distances to make specific measurements rarely meet with the same wind conditions. It is for this reason that mobile condition monitoring solutions have been developed, making it possible for engineers to confine their vibration-based condition measurements to wind speeds of six to 10 m/s over extended measurement periods. The measurement locations, diagnos-

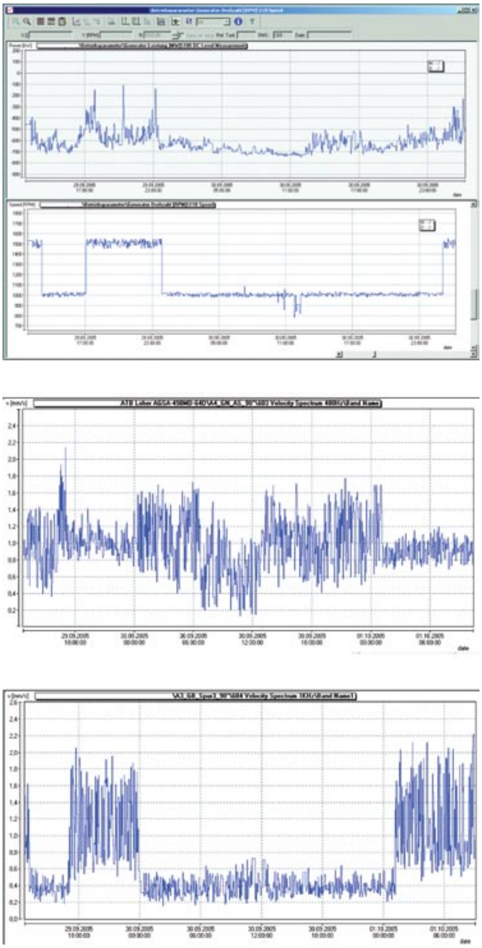


Fig. 4: Measurement of various parameters for a fixed-speed, stall-controlled turbine with a pole-changeable generator measured over a three-day period.

tic procedure and measurement route can be prepared and all results saved for the specific turbine. The measurement results can then be downloaded from the Internet.

ONLINE MONITORING

Fixed-Speed Stall-Controlled Turbines: Medium-sized wind turbines often use multipole generators that rotate at approximately 1,005 rpm at wind speeds up to six m/s and then switch to a higher speed of around 1,505 rpm at greater wind speeds. In this way the wind turbine can be operated close to maximum capacity at both low and high wind speeds. Figure 4 shows an example of various parameters for this type of turbine with a pole-changeable generator measured over a three-day period: the generator power; the generator speed; the vibration severity of the gearbox, which is measured radially; and the vibration severity of the generator. The output signal in kW was taken from the control unit, the amplitudes of the vibrations in mm/s were determined using the frequency spectra measured online, and the speed in rpm was obtained by non-contact measurement. In this type of chart the varying load conditions can be identified and it can be concluded that, in this particular case, the rotational vibrations in the generator decrease at greater output. The reason for the high vibration amplitudes was a pronounced tooth correction that only took effect at the rated load. A requirement for this type of analysis and interpretation is knowledge of the gear design, and of course a suitable condition monitoring system. It is common that two-stage or three-stage spur gears are usually used up to approximately 450 kW, and planetary stages only come into use in the gear input stage in larger turbines.

If the threshold limit in fig. 4 is exceeded, an e-mail notification containing the associated frequency spectra can be automatically sent to a diagnostic center. If the threshold is not exceeded, it is sufficient for the CMS to independently extract the diagnostic parameters from the frequency spectra and store a value once per minute. Since the parameter values in the circular buffer will be overwritten after some time, insurance companies demand that the parameter values be e-mailed on a regular basis, for example once per day, and stored in a service database. If the wind turbine is not running, or if the vibration values barely change, the data is compressed to avoid the transmission of large data volumes. Some CMS can continuously provide information on how the gear vibrations change at each of a pre-selected number of locations as a function of the wind load. Some insurance companies in Germany reward this diagnostic strategy with fewer wind turbine inspections and improved write-off conditions.

Variable-Speed Turbines: Turbines that exceed 1.5 MW tend to employ variable-speed drive trains in which any change in wind speed results in a change in the rotational speed. Rotational speeds can occasionally vary by as much as 60 percent of the maximum speed. This variability influences the measured vibration spectra and gear characteristics of the turbine. Additional factors are blade pitch variations, load changes, dynamic load such as from oblique incident flow, and loads from the converter control unit acting on the generator side. The most common system today in geared variable-speed wind turbines is the doubly fed induction generator, but it is gradually being replaced by fully rated converters. Due to the controlled operation of the wind turbine, both systems can be operated efficiently

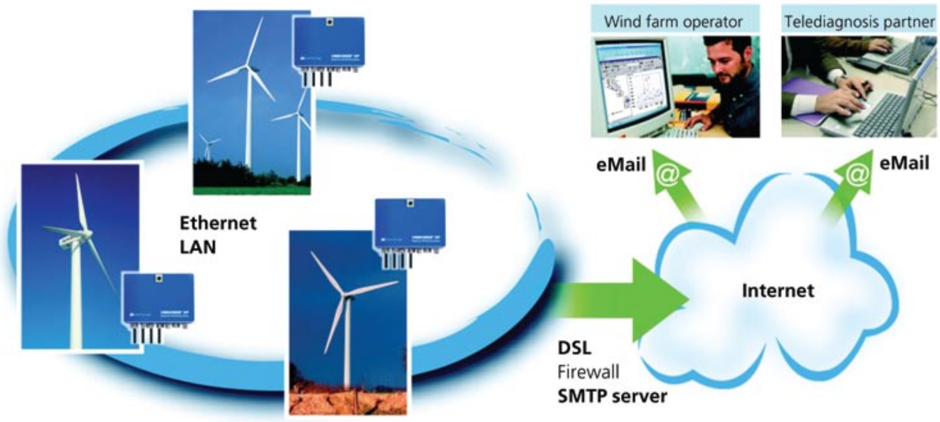


Fig. 5: Data management structure with e-mail data transmission.

at low winds as well, and damped control can reduce mechanical loads in the drive train. In high winds, the rotor output is additionally limited by pitch control or stall/active-stall control.

With respect to condition monitoring this means that not only the output, but also the gear-specific excitation frequencies vary with the wind speed. The frequency spectra measured over extended periods blur to such a degree that it becomes impossible to distinguish the individual frequency components and valuable diagnosis information is lost. In such cases order analyses are essential to obtain well-defined spectral analyses in variable-speed wind turbines. Thus, instead of determining the average frequency spectrum, some CMS solutions determine the order analyses by means of resampling. Wind-related rotational speed fluctuations are accounted for in the vibration signals and the diagnostician is provided with familiar diagrams, although now in the form of an order spectrum. Experience has shown that in addition to the gear design, the system and control parameters also have an effect on the vibration characteristics, which vary with the manufacturer and machine. To be able to distinguish operation-related influences on vibration from condition-related influences, the vibration and diagnostic parameters and the condition diagnosis are measured as a function of the operating parameters: rotational speed, generator output, and wind speed. AZT and GL WindEnergie require that all CMS certified to their standards must always send measurement results to a monitoring center to permit the data to be processed again in their entirety.

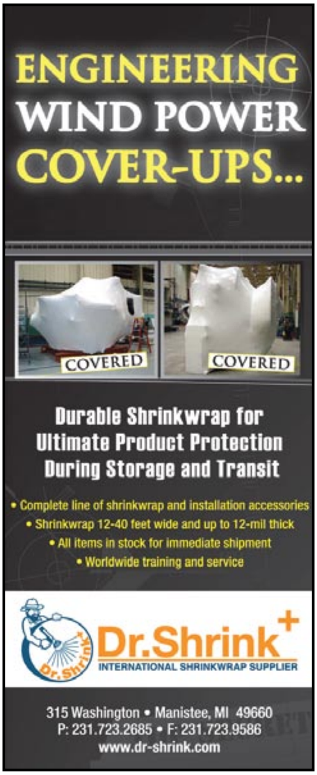
MONITORING CENTER TASKS

Field experience indicates that a certified condition monitoring hardware system does not necessarily lead to reliable fault diagnosis. The result depends on the correct installation, parameterization, and implementation of the online CMS, as well as on a rapid and appropriate response to notifications of a change in condition.

The costs and the time spent by personnel for condition monitoring increase rapidly if measurement data is "collected" from several hundred turbines via telephone modem and specialists must travel to the wind farm to change programming, alarm, and threshold values. To overcome these problems, e-mail data transfer systems with central data storage automate as many routine tasks as possible and avoid needless lost time collecting data. The operator and turbine manufacturer can decide whether they would like to purchase the hosting service with condition diagnosis on call or a teleservice package. Figure 5 shows an example of a basic data management concept. The wind turbine data from the wind farm is sent to the monitoring center via Ethernet. The control center and the diagnostic center have access to the databases. On this basis, condition monitoring and service experience can be built up in partnerships and managed centrally.

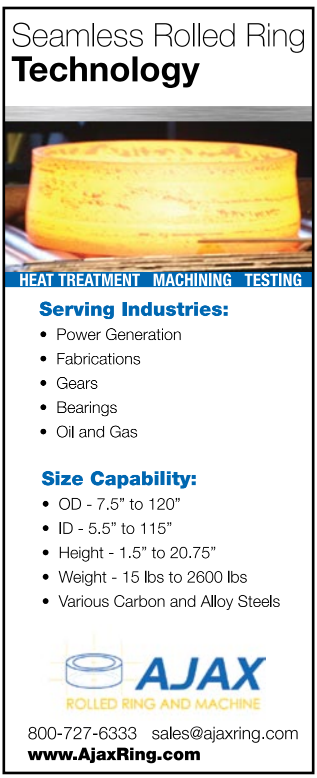
In the monitoring center, the incoming measurement data are routinely checked, threshold values are adjusted if necessary, condition reports are prepared and incoming alarms and warning messages are responded to. Measures that can be taken to deal with incipient damage are suggested. The employees of the monitoring center must be familiar with the special characteristics of the wind turbine being monitored to distinguish whether an exceeded threshold is due to random or operation-related causes or due to damage-related alarms. Condition-based maintenance becomes reality.


GEAR BASICS
for the
WIND POWER INDUSTRY
Finally! A Basic School for Non-Experts!
Do you have people who are new to GEARS?
Do your purchasing, engineering, sales and management people need to know more about GEARS?
Cole Manufacturing Systems, Inc. offers a beginning gear training course designed to your exact needs.
• Terminology of Gears
• Gear Functions and Basic Formulae
• Manufacturing & Inspection Methods
• Interpretation of Inspection Data
• Applying Inspection to Correct Problems
THE COURSE CAN BE ON-SITE IN YOUR PLANT OR TRAINING FACILITY, OR OFF-SITE AT A NEARBY FACILITY. WE COME TO YOU!
(248) 601-8145
FAX (248) 601-0505
Email: dsmith@colemfgsystems.com
www.colemfgsystems.com


ENGINEERING
WIND POWER
COVER-UPS...
COVERED
COVERED
Durable Shrinkwrap for Ultimate Product Protection During Storage and Transit
• Complete line of shrinkwrap and installation accessories
• Shrinkwrap 12-40 feet wide and up to 12-mil thick
• All items in stock for immediate shipment
• Worldwide training and service
Dr.Shrink
INTERNATIONAL SHRINKWRAP SUPPLIER
315 Washington • Manistee, MI 49660
P: 231.723.2685 • F: 231.723.9586
www.dr-shrink.com

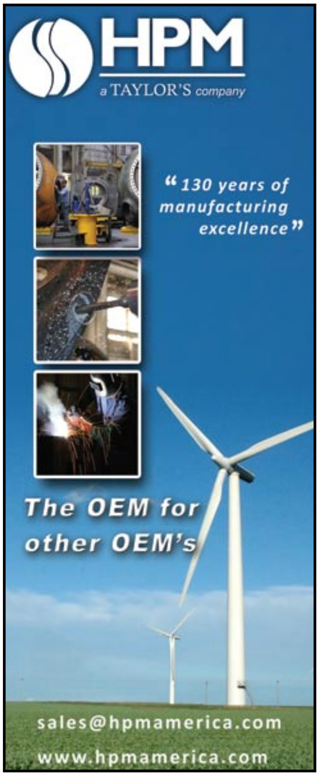

PROTECT
YOUR BOLTS
YOUR FOUNDATIONS ARE NOT COMPLETE WITHOUT PROTECTING THE ANCHOR BOLTS WITH IRONCLAD™ BOLT CAPS
NORM TOOMAN CONSTRUCTION, INC.
THE STANDARD OF THE INDUSTRY.
IRONCLAD BOLT CAPS
800.359.0372
NORMTOOMANCONST.COM


Gearbox
Repairs & Overhauls
We are well-equipped to support you with any emergency breakdown, schedule repair or preventative maintenance services.
• 24 x 7 availability
• Complete gearbox, cylinder & mechanical overhauls
• Repair journals, housings, shafts, linkages, etc.
• Fabricate replacement parts
• Since 1967
PAMCO
MACHINE WORKS, INC
EST. 1967
(626) 358-8288
pamcomachine.com


Seamless Rolled Ring
Technology
HEAT TREATMENT MACHINING TESTING
Serving Industries:
• Power Generation
• Fabrications
• Gears
• Bearings
• Oil and Gas
Size Capability:
• OD - 7.5" to 120"
• ID - 5.5" to 115"
• Height - 1.5" to 20.75"
• Weight - 15 lbs to 2600 lbs
• Various Carbon and Alloy Steels
AJAX
ROLLED RING AND MACHINE
800-727-6333 sales@ajaxring.com
www.AjaxRing.com

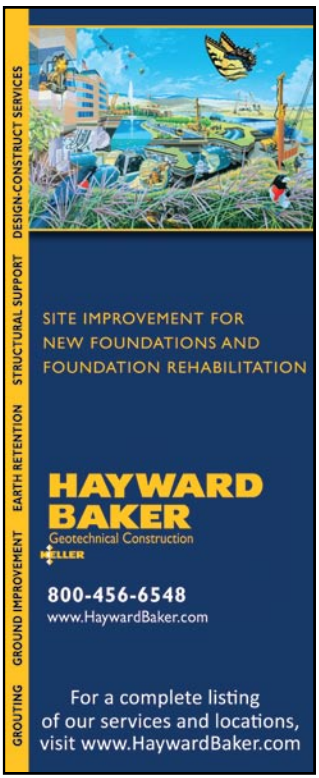

"WHEN IT HAS TO BE RIGHT"
THE GEAR WORKS
Wind Turbine Gearbox Repair Services
· Custom Wind Gear Manufacturing
· Large Gear Grinding to 2.6m
· Gear Metrology Laboratory
· Large Gearbox Assembly to 20 Tons
· Gearbox Testing
· 50 Years of Gearbox Repair Experience
· 24 Hour Factory Operation
· ISO-9001 Registered
THE GEAR WORKS – SEATTLE, INC.
500 S. PORTLAND STREET · SEATTLE, WA 98108-0886
PHONE: 206.762.3333 · FAX: 206.762.3704
EMAIL: SALES@THEGEARWORKS.COM
THEGEARWORKS.COM

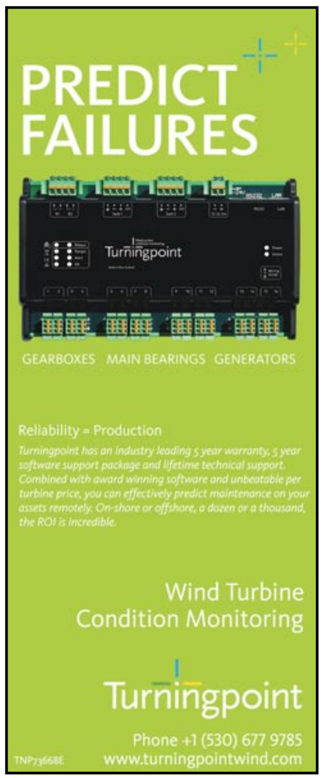

MAXIMUM
STORAGE
in minimum
space
USA
Stor-Loc
Modular Drawer System
STOR-LOC MODULAR DRAWER SYSTEM
880 N. Washington Ave. Kankakee, IL 60901
Toll Free: 1.800.786.7562 • Fax: 1.800.315.8769
email: sales@storloc.com
www.storloc.com


HPM
a TAYLOR'S company
"130 years of manufacturing excellence"
The OEM for other OEM's
sales@hpmamerica.com
www.hpmamerica.com


Wind Power Needs Port Power.
PORT CORPUS CHRISTI
Call John Valls
361.885.6158
jvalls@pocca.com
portofcorpuschristi.com


Still waiting on your perfect teeth to arrive?
Visit us at Gear Expo Booth #734
For YOUR perfect teeth!
Quality Parts
Friendly Service
On-Time Delivery
Celebrating 20 years
ISO 9001:2000 and AS 9100:2004 Certified
Complete Gear Manufacturing
Raycar
GEAR & MACHINE CO.
4884 STENSTROM ROAD • ROCKFORD, IL 61109
PHONE: 815-874-3948 • FAX: 815-874-3817
sales@raycargear.com
www.raycargear.com


GROUTING GROUND IMPROVEMENT EARTH RETENTION STRUCTURAL SUPPORT DESIGN-CONSTRUCT SERVICES
SITE IMPROVEMENT FOR
NEW FOUNDATIONS AND
FOUNDATION REHABILITATION
HAYWARD BAKER
Geotechnical Construction
KELLER
800-456-6548
www.HaywardBaker.com
For a complete listing
of our services and locations,
visit www.HaywardBaker.com


PREDICT FAILURES
Turningpoint
GEARBOXES MAIN BEARINGS GENERATORS
Reliability = Production
Turningpoint has an industry leading 5 year warranty, 5 year software support package and lifetime technical support. Combined with award winning software and unbeatable per turbine price, you can effectively predict maintenance on your assets remotely. On-shore or offshore, a dozen or a thousand, the ROI is incredible.
Wind Turbine
Condition Monitoring
Turningpoint
Phone +1 (530) 677 9785
www.turningpointwind.com
TNP73668E

ADINDEX

Craig MacPhee
President, Big Mac's Custom Pressure Washing

WHY WOULD SOMEONE WANT THEIR WIND TURBINES WASHED?

For one thing, when you're erecting turbines in somebody's back yard, they want them to look nice, so it really helps in terms of your relationship with the community. People can get touchy about how these windmills look, and they might not say anything when they're clean, but they're sure to notice when they're dirty. But there are more important reasons, including improved aerodynamics of the rotors. These things have usually been shipped from overseas, spending months on the ocean, so they're covered with salt spray and even rust that's dripped off of the steel cages that contain them in transit, and they'll be streaked with grease from the dock cranes, too. Some trucking companies will tape lights to them during shipping, and dust and grime will accumulate on the adhesive that's left behind once the tape is removed. And all of that's just on the outside. We do a thorough external and internal cleaning before the tower is erected, and you'd be surprised by how much dirt can accumulate inside while they're laying on the ground at the site. There can be just one little slit in the tarp that covers them, and since these farms are found in extremely windy areas, the tower will fill up with dirt in no time. We've found tires inside of them, trees, and a foot of mud once. We've yet to come across anything we can't clean up, or off. We clean everything inside and outside before the windmills go up—including debris around the job site—and then we offer an interior maintenance program where we'll go back and do any cleaning that's necessary post erection. The way we approach it is that, if we'd just bought a four-million dollar car, we'd want it to be delivered clean.

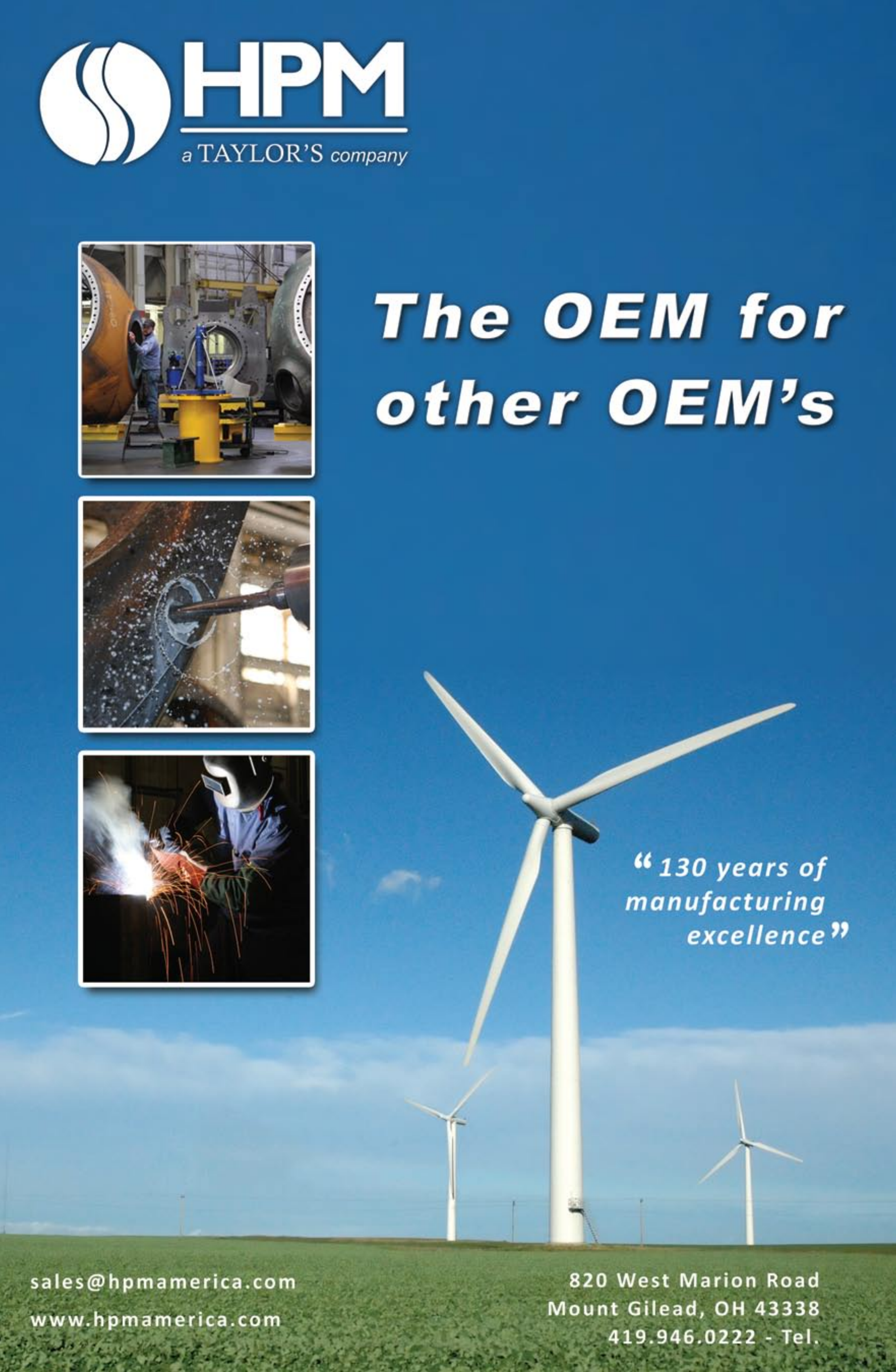
WHAT OTHER SERVICES DO YOU PROVIDE?

One thing we'll do that others don't usually offer is touch-up painting. This saves the contractors from having to hire somebody else for that. We also take care of punch-list completion items. We'll go in and complete their checklist, making sure that all the ladder bolts have been properly tightened, tensioned, and torqued, for instance, and then we'll mark them as proof that the work has been done. So between the cleaning, painting, and punch-list work, we can handle quite a few different functions all at once, which increases efficiency. Our team is made up of people from a wide variety of different backgrounds, such as construction management, shipping and receiving, and quality control, so we have an understanding of what our customers are looking for. We know that you just can't keep ironworkers and crane operators idle because that's costing you a ton of money. Sometimes people will go out and hire a local pressure washer who doesn't have experience cleaning wind turbines. On paper it looks like you're saving money, but it's exponentially more expensive than working with us because they will take four times as long. Plus we're trained to operate equipment such as aerial lifts, which they would have no reason to know how to do, so you're paying for them to learn how to use the equipment on the job. We know how important it is for our work to be done, and for the turbine and components to be cleaned and ready to fly by the time the ironworkers arrive. You won't have to wait on us.

WHAT ABOUT SAFETY? ARE YOU INSURED?

Safety is of the utmost importance on every wind farm, and I put the safety of my men and others first no matter what. Everyone on our team is trained and certified in first-aid and CPR, and we use the very best safety equipment available. We have a strict safety program, and we stick to it. We also carry a two million-dollar liability policy, and workman's comp, which you won't find with a local pressure washer company. We specialize in wind turbines and are insured accordingly. No matter where the job is located we're going to approach it professionally and with an inside understanding of what the customer needs. Even though some of these might seem like small points, wind-energy professionals in the field know they all matter, and that's why we get so much return business and so many referrals. Having repeat customers really is the best endorsement you can have.

Call (989) 550-2197, e-mail info@bigmacwind.com, or go to www.bigmacwind.com


HPM
a TAYLOR'S company
The OEM for other OEM's
"130 years of manufacturing excellence"
sales@hpmamerica.com
www.hpmamerica.com
820 West Marion Road
Mount Gilead, OH 43338
419.946.0222 - Tel.