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# Designing for Wind Turbine Reliability

Advancements in motion control are pivotal to delivering greater system reliability and serviceability as wind turbines grow larger and move offshore.


Source: Parker Hannifin

Condition monitoring systems provide an ability to start trending micrometer-sized particles which the human eye can't see. Measurements can be monitored on a continuous basis to prevent damage and optimize the use of the filtration system.

Motion control technology is addressing two of the key issues that the wind power industry faces as it matures: moving offshore and the use of bigger turbines. But the clear focus is on system reliability, which has become the number one design challenge that wind turbines must address.

In addition to a technology focus on gearboxes and generators, suppliers are looking at the entire drive train and how to use technologies such as gearbox health management tools, condition monitoring, ac brushless servo motors, and precision cooling systems to provide robustness and serviceability that the next generation of this alternative energy demands.

"Instead of focusing solely on the gearbox as in the past, OEMs are focusing on the complete electromechanical drive train," says Dheeraj Choudhary, business unit manager for Global Renewable Energy at Parker Hannifin. "If we look at the wind turbine drive train from where the rotor shaft connects to the gearbox and on the other side where electrical energy comes out of the turbine, there are tremendous opportunities for boosting system reliability and serviceability."

Choudhary says that turbine design teams are now taking a pragmatic approach on the need for reliability and serviceability in the drive train of offshore wind turbines. The focus is on larger wind turbines (4, 5, 7 and up to 10 MW) developed for offshore operation, and on ways to keep the drive train stable by deploying optimum conditioning and cooling for the various key components such as bearing, gearbox, generator and converter.

"It is a well-known fact that if the bearings and gearbox are well-lubricated, cooled with clean oil, have no moisture or humidity present, and employ a good filtration package, the gearbox is less likely to fail," says Choudhary. "If we can monitor the gearbox using a condition monitoring package that includes trends from temperature, pressures, vibration and cleanliness of the oil and moisture, we can reliably predict failure or prevent failures by knowing what will happen in the gearbox over a time horizon."

## Remote Monitoring

With the trend moving toward larger turbines and offshore applications because of the availability and consistency of the wind, an important focus is on the serviceability and service intervals of these offshore installations. This is driving suppliers to better control of the temperatures in the gearbox and to the optimization as well as monitoring of the cleanliness of the oil in the system. To get service people on board in an offshore turbine, it normally means you need a ship or helicopter. As a result, suppliers are improving the lubrication systems and increasing the lifetime of the filters, so it's a maximum of once a year to service the unit; and sometimes the service interval is increased to 18 months.

Users can employ an online connection to assess when they need to schedule maintenance on the turbines. Some of these systems, including Parker's, constantly measure the pressure differential over the filter element and communicate the information over industry-standard electronic protocols that can be accessed remotely. With ability to program these devices, reaching a threshold of pressure level indicates it is time to change the element. Remote monitoring also allows for preventative and scheduled maintenance events that reduce the cost of service.

Parker also offers systems to monitor the condition of the gearbox lube oil with respect to the amount and type of dirt in the bearings or gearbox. If everything is running smoothly and there is no extensive wear on the bearings, it is normally OK to use an 18-month service interval, but performance is also dependent on the gearbox itself, vibration, alignment, loads and other factors.

"We have also introduced modularity into the system, so instead of using one large filter we are specifying two or three optimum size and mesh filters on the gearbox lubricating system to better perform service and further condition the oil while keeping pressures consistently low in the system," says Olli Rantanen, marketing manager at Parker's Filtration Group. "The lifetime of the components is vital along with serviceability. We know that, in many gearboxes, people are using a lot of connectors and hoses to connect different components which means there is always a possibility for leakage, not to mention the drop in efficiency of the package."

Parker's design approach to these applications is to integrate multiple functions into a patented uni-package which combines the process and the control parts of the total system, plus optional functions including bypass filtration if that is needed.

A third important area is condition monitoring. Normally if there is any oil condition monitoring at all in these systems, it is metal residue monitoring — which means that only the large metal particles are monitored, not for size but for count.


Source: Moog Inc.

**Moog's new line of frame size 6 brushless servomotors (PM series), designed specifically for the wind market, combines high reliability, compactness, high power density and a unique capability to be able to be controlled in sensorless mode.**

"We know that if a system is starting to degenerate, it produces a lot of smaller particles before the big particles start to appear," says Rantanen. "Instead of measuring particles that are 100 microns or bigger we can start trending micrometer-sized particles which the human eye can't see. You almost need dedicated laboratory equipment to view particles of this size."

Parker has introduced new tools for this type of monitoring and developed a system to do this online with the gearbox without taking samples to a lab. The key is that measurements can be trended on a continuous basis and specific commands can be used to prevent further damage or optimize the use of the filtration system.

## Trend to AC Brushless Servo Motors

"The key in wind turbine applications is reliability and availability, which means the wind turbine must be available to produce energy whenever there is wind," says Mauro Gnecco, North American wind market manager for Moog Inc. "The challenge for system suppliers is to make sure that components are reliable and robust enough to support that environment which means balancing features, performance and cost."

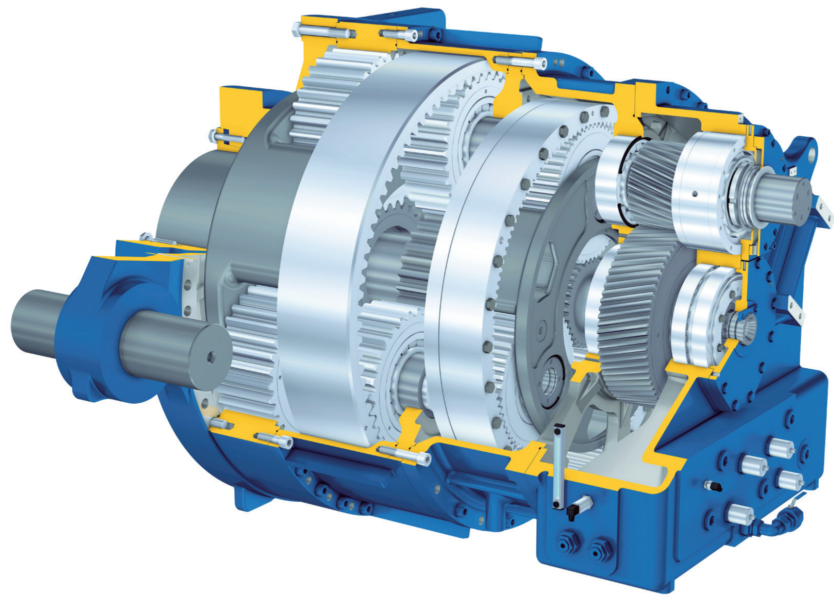
Electric pitch control systems are typically located in the rotating part of the turbine (hub) and include one rotary actuator (electric motor and gearbox) connected to each blade. Power and control electronics allow the motors to develop the right torque and follow a motion profile provided by the turbine controller. A power back-up system allows the motors to bring the blades into a safe position, even in case of power loss, and a set of encoders (one per blade) supplies blade position feedback.

With wind turbine applications, whether they are offshore or not, the environment is harsh because system components are essentially outdoors within a hub that is not weatherproof. Ambient operating temperatures range from extremes of -40 to 50C. This means that the actuators and motors need special attention paid to sealing, and the ability to meet performance requirements throughout the full temperature range.

Moog offers new ac brushless servo motors rated for IP65. The body of the motor is a single piece with two end caps to create fewer connections and places for water to permeate the motor. The grease and lubrication systems have to be selected to deal with the wide fluctuation in temperature ranges and, in very cold temperatures, the motors are designed to self-heat via the controller on start-up.

"The rigorous environmental conditions apply to the controls as well, plus all of the components in the control cabinet. Up in the moving rotor as well, the system must be designed to withstand the vibration and shock of it being continuously rotated," says Rob Nicholl, engineering manager at Moog Inc. "Reliability is key because the motion system functions as the key safety system of the wind turbine."

Moog is focusing on supplying highly reliable integrated electric pitch systems to the wind industry. Even though they offer pitch systems using different types of motor technologies (dc brush type motors, ac induction motors and ac brushless servo motors), the focus is on systems using ac brushless servo motors.



Source: Bosch Rexroth Corp.

**The new Redulus GPV-D gearbox from Bosch Rexroth is targeting multi-megawatt turbines. It is slender and compact due to its differential design concept with two planetary stages, one differential and one spur gear stage.**

"Traditionally, dc motors have been applied to pitch systems but there is a current trend to applying more ac synchronous motors to eliminate the brush failure mode," says Nicholl. "Throughout the rest of industry and aerospace applications, there is a general belief that ac motors are inherently more reliable, even though they haven't been widely accepted in the wind industry yet."

## Differential Gearboxes

"The trend in the wind industry we have seen is a continuing move toward larger-size turbines," says Parveen Gupta, director of Wind Energy — U.S. sales for Bosch Rexroth. "Until last year, the most common size installed in the U.S. was 1.5 megawatts. But the trend is larger and larger systems, and turbines in the 2 to 2.5 megawatt range will be more or less a standard for onshore wind turbines over the next several years."

Gupta says a clear trend is more systems going offshore or actually "near shore" where they are typically installed between three to five miles off the coast. The advantage is a smooth flow of wind, the turbine is not in anybody's backyard, and the noise issue is gone. For all those reasons, wind turbines are moving to offshore locations but a major problem is regular periodic maintenance which has the potential to become prohibitively expensive.

"Because of quality and reliability issues, people are talking about using a direct drive system rather than a gearbox for large offshore applications," says Gupta. "We see some benefits in that but; by the same token with developments to increase reliability and improved quality, we believe you can have a very good solution with a gearbox in the system even up to 5 or 6 megawatts."

With the demand for higher power density and compactness growing, Rexroth's differential gearbox, Redulus GPV-D, offers more compact drives and minimizes the weight by providing a multiple power-split gearbox design solution.

Gupta says that unlike conventional generator gearboxes in the multi-megawatt class, four or more planetary gears do not revolve around the sun wheel in the input stage. Instead, the Redulus GPV-D offers two input stages each fitted with three planetary gears, and the advantages of a static determination paired with freely adjustable sun pinions.

Another key design feature is a thin outer diameter with only a slightly greater total length. With turbine capacities increasing, it offers up to a 15 percent weight advantage over gearbox concepts currently in use without a decrease in reliability.

"There have been tremendous improvements in terms of planning and doing preventative maintenance rather than repairs after a catastrophic failure," says Gupta. "Along with the trend toward larger turbines typically located offshore, there is a rise in condition monitoring solutions that enable users to predict and plan for maintenance."

Lubrication is the key to the reliability and operating life of gearboxes, and this applies in particular to gearboxes for wind energy plants due to the difficult conditions in which they operate. This is why Rexroth is offering main gearboxes featuring their own cooling lubrication system with particle monitoring and water content sensors. Another development from Rexroth is a blade control monitoring system that detects damage and ice build-up by analyzing the natural frequencies of the elastic bodies.

Gupta says that while engineers are generally concerned about the reliability of the gearboxes, often what actually limits bearing life is lubricating fluid or oil which becomes too dirty or too hot. The push to condition monitoring is one way to manage these important assets. DN