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Off-warranty should not mean off-line

Matt Fielder, Industrial Market Development Manager for the Hydraulic Filter Division of Parker Hannifin, explores ways in which wind turbine operators can maintain reliability as installed turbines gradually come off-warranty.

Global demand for renewable energy is booming. The fastest developing sector is wind energy, currently expanding at around 25% per annum, with the number of installed turbines increasing by around 30,000 units each year. In Europe alone there are now 25,000 wind farms and this number is forecast to double by 2015, while globally the sector is expected to be worth some 109 billion US dollars by 2020.

These are phenomenal rates of growth by anybody's standards. Yet, while the spotlight has largely been on the future it is essential that we do not forget the tens of thousands of turbines already in operation. Many of these have been installed for three years or more and, on both land and at sea, have had to operate for extended periods in some of the most hostile and arduous conditions. Perhaps more to the point, a growing number of turbines are now reaching the end of their manufacturers' warranties but will still be expected to function reliably and at minimal operating cost for at least a further ten to fifteen years.

Industry analysts estimate that at present some 70% to 80% of turbines are still under their original manufacturers' warranty but that within twelve months this situation will change dramatically; indeed, by the end of 2010 it is predicted that there will be more turbines in North America operating out of their original warranty than will be covered;

inevitably, this trend will grow as the industry matures making the challenge of maintenance and repair an ever more critical issue for wind farm operators.

Running costs

Based on existing industry figures, it is generally considered that around 10% of the annual cost of generating wind power can be directly attributed to turbine maintenance and repair. As turbines age, however, this figure rises, approaching 35% for turbines that are nearing the end of their operating life.

The process of calculating operating and maintenance (O&M) costs is rarely straightforward and is complicated by variables such as location, environment and factors that may have been unforeseen at the time of design and installation. For example, it is now recognised that the effects of turbulence from the tips of rotating blades can intensify the loads on downwind turbines if they are positioned too close together; in turn, this can result in increased wear on gearbox and generator shafts, bearings and seals. Similarly, the trend to produce ever larger rotors and towers is placing high levels of stress on internal and structural components leading to earlier than predicted failure rates.

Clearly, as more and more turbines come on-stream and as growing numbers reach the end of manufacturers' warranties the need for effective maintenance and repair strategies for wind farm operators becomes increasingly important. As a result, there is a growing drive to ensure that critical systems are as robust and long lasting as possible, to minimise both failure and wear rates and reduce the need for routine maintenance. In addition, for reasons of both cost efficiency and health and safety, there is now a growing impetus to minimise the amount of maintenance that is carried out at the top of each turbine tower by modularising key operational units and/or moving them to ground or sea level.

Before looking at ways in which the O&M costs of turbine systems can be minimised, it's firstly important to understand some of the things that can affect operating costs, especially within the various hydraulic and associated systems that make up much of the operational systems within a typical turbine.

In particular, the logistical difficulties in carrying out regular routine maintenance and emergency repairs on turbines located in remote inaccessible locations, and increasingly at sea, continue to have a significant effect on margins. Indeed, the task can be extremely difficult, with skilled engineers needed to climb towers in order to carry out work that, even with the attendant safety requirements, is both time consuming, expensive and a potentially risky exercise.

As a result, it is essential that wind turbines are developed that operate as efficiently as possible, with the minimum amount of manual intervention. Many turbine manufacturers are now achieving this goal by integrating the latest generation of hydraulics technology into their products.

Hydraulics in wind turbines

The latest hydraulics technology, from manufacturers such as Parker Hannifin, can commonly be found in the nacelle of a wind turbine to control the pitch of the blades and the yaw of the nacelle, maximising the turbine's power generating efficiency and protecting the equipment in high winds. Another use of this equipment is in low maintenance hydraulic gearboxes that are helping wind farm operators to reduce costs considerably.

In pitch control systems, the angle of the rotor blades is altered slowly and precisely to achieve optimum generating output. The blades are either turned into the wind to increase rotational speed if the wind speed falls, or out of the wind if wind speed increases, causing the rotational speed of the blades to decrease in order to protect the turbine from damage. This is typically achieved by installing three pitch control

systems in the hub of the turbine, one for each blade. These systems employ hydraulic cylinders that vary the angle of the blades through a cam action.

Likewise, the yaw, or rotational position of the nacelle is continually adjusted to obtain maximum efficiency from the turbine. In the same way that output is optimised by tilting the angle of the blades so that they are facing into the wind, the nacelle too must be rotated horizontally about the axis of the tower in response to the changing wind direction. Hydraulically powered yaw control systems are able to offer a simple, compact direct drive, reducing the frequency of maintenance required in comparison with other methods, such as electromechanical control.

While these systems are enabling the efficiency of wind turbines to be increased significantly, the hydraulics must be protected from potential particulate and water contamination, the primary cause of failure in lubricated and hydraulic equipment. Indeed, a range of effective filtration and condition monitoring solutions should be used if consistently reliable operation, and therefore minimised operating costs, are to be achieved.

Filtration

Effective inline filtration technology is an essential element to capture particles before they reach sensitive components in all large capacity turbines; including those that have alternative methods of pitch and yaw control such as electromechanics. Gearbox problems typically account for the majority of unplanned maintenance requirements, and with turbine gearboxes required to gear up the low speed input shaft to provide a high speed output for the turbine, the filtration of both lubricating and hydraulic fluids is crucial.

Where hydraulic control systems are used, effective filtration technology is especially important, extending maintenance intervals and increasing the reliability of pitch and yaw systems. A comprehensive range of filtration technology has been developed

specifically for filtering out particulate and water contamination from hydraulic fluid to just a few microns.

Without this technology, precision engineered system components such as cylinders, accumulators and valves can suffer from reduced performance levels and premature failure, ultimately reducing the efficiency of the wind turbine and raising costs for operators. However, the design and specification of filtration systems requires considerable care to prevent restriction to the fluid flow and, thus, reducing the efficiency of a hydraulic circuit. If they are not properly designed or sized, pressure loss across filters can significantly reduce the performance of hydraulic systems, increasing energy consumption and the associated challenges of heat management.

As well as machine performance, correct filter selection must allow for overall operating conditions. By their nature, filters will require periodic cleaning and replacement to ensure efficient operation of equipment. Filter packages should be sized to ensure that the required frequency of intervention matches that of the overall equipment maintenance strategy in order to minimise the cost and disruption associated with filter care.

In answer to this, the leading designers and manufacturers of filtration systems for wind turbine hydraulic machinery are constantly refining the design of their equipment in order to maximise performance and minimise the associated drawbacks. In addition, recent advances in filter materials modify the composition and construction of standard glass fibre materials to improve their strength and dirt holding capacity while also reducing resistance to flow. Parker's Microglass III material, for example, can reduce dynamic pressure across the filter by 8% while improving contamination loading by 15% typically, compared with conventional filter material.

While this fluid filtration technology effectively removes contaminants that find their way into a hydraulic system, contamination levels also need to be recorded and analysed in

order for essential maintenance to be scheduled before problems occur. However, taking samples from a hydraulic system in a wind turbine to a laboratory for testing is extremely impractical, which is why many wind farm operators are now using the latest particle counting technology, such as that developed by Parker Hannifin, as a real time, onsite solution.

Condition Monitoring

Particle counters or portable analysers, such as Parker's icountPD, offer a fast and accurate measurement of contamination levels in hydraulic fluids, using a process called light obscuration, light blockage or light extinction. Essentially, the shadow of any particles suspended in a fluid passing across a light source causes a voltage drop across a light sensitive diode; the signal generated as a result of the shadow is dependent on the size of the particle and the speed at which it passes across the light.

The icountPD can also be built into the hydraulic system, including the lubrication or power transmission circuit, along with remote monitoring devices to provide end users with a real time look at solid contamination levels in accordance with ISO cleanliness codes. Indeed, this high performance device can identify particles down to 4 μ in size, providing an early warning of wear and potential component failure, as well as the option for an integral moisture sensor to detect water contamination without requiring a separate stand alone unit.

Furthermore, the latest generation of particle counters feature robust constructions, making them ideal for use in the hostile environments in which wind turbines are typically located. Their compact, portable nature makes the devices ideal for field use, while their powerful internal computers offer results that are consistently accurate, removing the subjectivity associated with manual, laboratory based testing methods.

Conclusion

While the latest hydraulics technology is offering an effective and reliable method of optimising the efficiency of wind turbines, in order for the technology to fulfil its full potential it is essential that effective filtration and condition monitoring devices are also considered and included from the design stage onwards. By accurately monitoring contamination levels, and ensuring that any contaminants that do enter the system are filtered out, operators can benefit from turbine control systems with long, low maintenance service lives, ultimately increasing the power generating capacity of turbines and reducing operating costs considerably.

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