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Detecting Yaw Bearing System Faults

A Remote Condition Monitoring Strategy Can Avoid Uneconomical Operations

Detecting Yaw Bearing System Faults

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Without a doubt, the wind turbine has evolved dramatically over the last few years in terms of reliability, technology, efficiency, size and total share of energy production. These ongoing improvements are increasingly benefiting consumers from all around the world, making wind energy not only an accepted part of the world energy supply mix but also an important one. Along the same lines, however, there are also stricter requirements for uptime and the levelised cost of energy. The tolerance for downtime and unnecessary maintenance costs is becoming less and less, thus making the role wind turbine condition monitoring plays in the overall wind turbine healthcare strategy more and more critical.

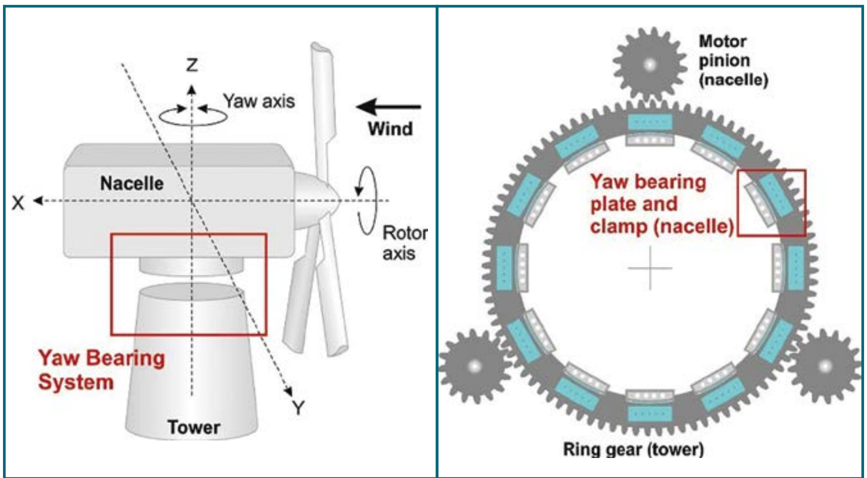

Figure 1. The yaw bearing system on a wind turbine (left) aligns the blades into the wind. It consists of the ring gear, yaw motor and the yaw bearing clamp assemblies (right, looking down from the nacelle)

The Brüel & Kjær Vibro Surveillance Centres have been remotely monitoring thousands of wind turbines from all around the world for the past 18 years. Many machine faults have been detected and diagnosed during this time within the drive train. This article, however, describes a situation where faults were detected and diagnosed in an entirely different but important component: the yaw bearing system. It is this system that bears the enormous static and dynamic loads of the nacelle and blades and allows the nacelle to align itself into the wind.

Yaw Bearing System

Located between the nacelle and tower (Figure 1, left), this system allows the nacelle to rotate on the tower to align the blades in the direction of the wind. If the blades are not perpendicular to the wind, the wind turbine will not produce the maximum potential power, resulting in lost revenue. The yaw bearing system is also designed to bear the static weight of the nacelle, as well as resist the enormous dynamic loads that occur due to the rotating drive train and blades.

The system consists of a toothed ring gear that is fixed to the tower (Figure 1, right). Yaw motors turn several pinion gears on the ring gear to rotate the nacelle. The load bearing components consist of axial and radial glide bearing pad segments that sit on the ring gear, as shown in the figure. The bearing pad normally includes a pre-tensioning system, which consists of a spring and an adjustment screw, as shown in Figure 2. This ensures that there is no looseness between the glide bearing segments and the ring gear and that there is even wear on all the guide bearings. If the glide bearings are not properly pre-tensioned, this can damage the glide bearings and adversely affect the ability of the nacelle to turn.

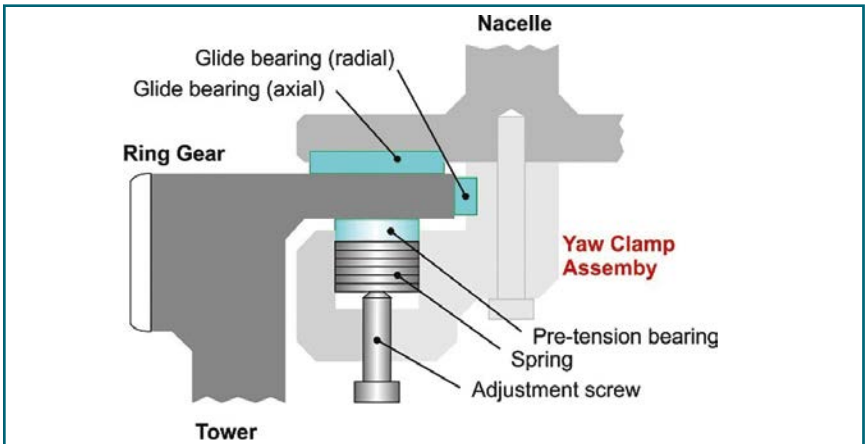

Figure 2. Cross section of the yaw clamp assembly on the ring gear

Observations

The monitoring system configuration for detecting the faults is shown in Figure 3.

The vibration descriptors of the signal from the accelerometers located on the main bearing (not shown) and on the tower (Figure 4) for a wind turbine exceeded the alert limits in February. The overall root-mean-square vibration signal, not shown, remained within acceptable limits. There were no faults found in the main bearing or blades, so the spring packs on the yaw clamp assemblies were replaced and the wind turbine put back into operation in May, when the vibration levels returned to normal. The vibration increased again more dramatically in September.

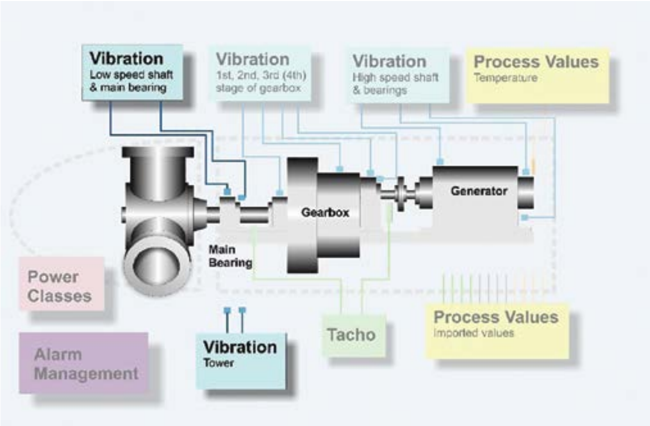

Figure 3. Typical monitoring strategy for a wind turbine like the one in this case study. The accelerometers located on the tower and the main bearing detected the yaw bearing system fault

Interpretation

The fault detected appeared to be unique. The time signals for the wind turbine proved to be ideal for the initial analysis. At both times, in February and September, there appeared to be a random impact seen in the time signal from the accelerometers on the tower (Figure 5) and main bearing (not shown). Because of the randomness of the impacts, it was initially difficult to pinpoint the exact cause, as the problem could be related to the blades, the main bearing or the yaw bearing system. No problems were found in either the blades or the main bearing, so the yaw bearing system was suspected. The yaw bearing system bears the enormous static and dynamic loads of the nacelle and blades, and allows the nacelle to align itself into the wind. The spring packs for the yaw bearing clamp assemblies were replaced in May, and the high vibrations disappeared. The high vibrations returned again in September unexpectedly. Again, the yaw bearing system was suspected.

Advice/Action

Both faults were a unique occurrence for the wind park. A medium severity level was initially assigned to the first fault because it was present for some time and never exceeded the danger limits. A higher severity was assigned to the second occurrence of the fault, partly because it was more dramatic and partly because it was the second time the same fault symptoms occurred. In both cases the fault development was carefully followed.

Feedback After Service

When the wind turbine was shut down for the first time, the main bearing and blades were checked and found to be fine, so attention was given to the yaw bearing system. It was decided to change all the pre-tensioning spring packs in the system. When the wind turbine was restarted, the vibration levels returned to normal (Figure 4, top). However, after only three and a half months of operation, the same fault symptoms occurred again but more dramatically. The yaw bearing system was disassembled again, and this time it was observed that many of the axial gliding bearing plates were damaged. These were re-machined, the spring packs changed a second time and the wind turbine put back into normal operation.

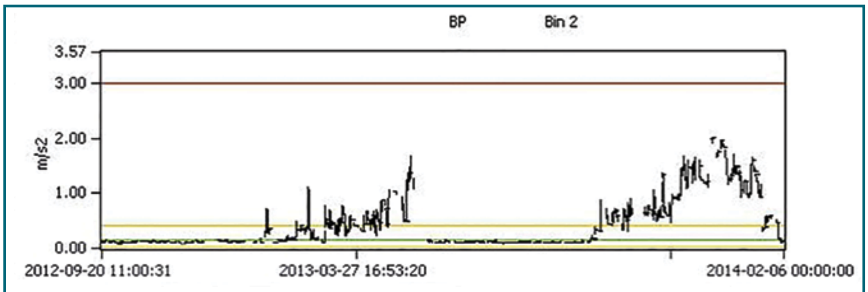

Figure 4. Bandpass acceleration vibration descriptors from the tower accelerometers both before and after repair

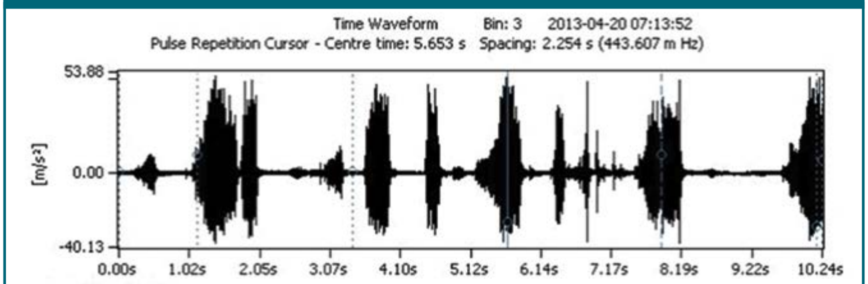

Figure 5. A vibration impact signal is visible, which appears random

Conclusion

It is believed that the yaw plates were damaged due to a rocking motion of the nacelle on the tower caused by the loose yaw bearings. The random motion of the rocking is believed to be due to the variable wind conditions and loading. There was no imbalance in the blades that would connect the rocking motion of the nacelle to the rotation of the blades. Over an extended period of time with loose bearings, the bearing plates were damaged by the continuous impacts to a point where the new pre-tensioning springs were not capable of compensating for this.

Summary

An effective remote condition monitoring strategy can avoid uneconomical operations, costly downtime and consequential wind turbine damage. This case study demonstrates that there are critical components in the wind turbine other than the drive train that need to be effectively monitored, like the yaw bearing system. It demonstrates that there can be more than one problem occurring at the same time. If the loose yaw plate bearings are not monitored and serviced in time, a catastrophic failure could occur that would render the yaw system non-functional, thus requiring a complete shutdown or operation at only partial power for a period of time. ■

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