Brüel & Kjær Vibro

Application Note

Case story - Early detection of wind turbine faults using remote monitoring

Four case studies demonstrate how an effective remote condition monitoring strategy avoids costly downtime and consequential damage.

Introduction

Brüel & Kjær Vibro Surveillance Centre has been remotely monitoring several hundred wind turbines over the last 4 years. A number of diagnosed faults have been documented for wind turbines over this period and four of these case studies are described in the article, based on the actual Alarm reports prepared for one of our customers, a wind turbine operator. In each case machine downtime has been minimized and repair costs reduced since early fault detection and diagnosis has avoided a catastrophic failure from occurring, which could lead to extensive consequential damage.

Monitoring Strategy and Configuration

The monitoring strategy used on the four different wind turbines includes over 100 scalar vibration and process parameters that are automatically monitored, combined with a detailed signal analysis of the acquired time waveform signals.

The critical areas to monitor on a wind turbine are shown in Figure 1.

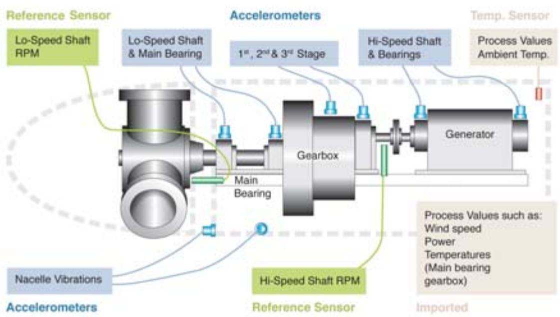

Figure 1. Sensor types and locations on a typical wind turbine generating unit train.

Monitoring wind turbines to an adaptive monitoring strategy is absolutely imperative for reliable, early fault detection. Unlike a baseload power station, a wind turbine is subject to a wide range of loading for different wind conditions. In order to distinguish between a vibration and process signal amplitude change due to a change in operating conditions and that due to a developing fault, it is necessary to use an adaptive monitoring strategy such as active power bins (e.g. power classes).

Case Story #1 - Wind turbine gearbox defect

Observations
Gearbox second stage gear mesh frequency (first order) exceeds the Alert alarm limit.

Figure 2. Gear mesh frequency trend of second-stage gearbox.

Interpretation
Detailed analysis shows sidebands around the first and second order gear mesh frequencies of the gearbox second stage, which confirm a gearbox fault.

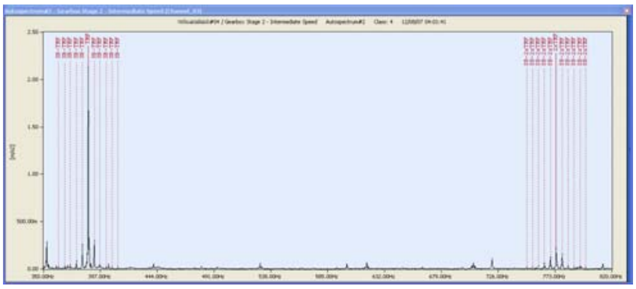

Figure 3. Envelope of second-stage gearbox.

Advice/action
The gearbox should be visually examined when convenient, paying particular attention to the second stage gear teeth condition. The gearbox mounting bolts and support structure should also be checked.

Feedback after service
Fig. 4 shows the metal shavings in the oil filter coming from the damaged second stage of the gearbox. A new gearbox was installed. The damaged gearbox required minimal repair since a catastrophic failure was avoided. The trend plot in Fig. 2 shows the gear mesh frequency trend before and after servicing the gearbox.

Figure 4. Oil filter of second-stage gearbox.

Case Story #2 - Coupling defect

Observations
Rapid rise in the first order RMS vibration magnitude exceeds Danger alarm limits. The other measurements indicate there was no rotor unbalance or bearing faults.

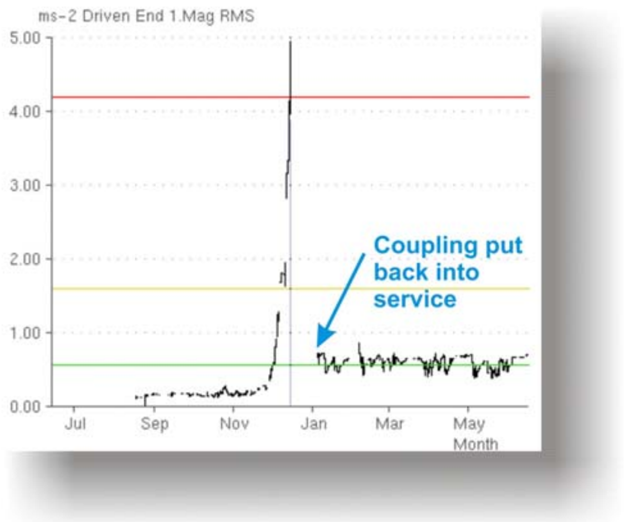

Figure 5. First order RMS trend of coupling.

Interpretation
The rapid rise in generator driven end first order magnitude indicates a change in the stiffness of the bearing or the coupling, possibly due to loose holding down bolts or structural components.

Advice/action
Inspect generator rotor, bearing and coupling for possible loose components.

Feedback after service
Fig. 6 shows the sheared coupling links. The trend plot in Fig. 5 shows the first order magnitude vibration trend both before and after servicing the coupling.

Figure 6. Sheared coupling links.

Case Story #3 - Bearing fault at generator driver end

Observations
Generator driver end BCU (Bearing Condition Unit) measurement exceeds Danger alarm limits.

Figure 7. BCU trend at generator driver end.

Interpretation
Further analysis using envelope plot confirms an inner race bearing fault. This is typically characterized by a series of harmonics from the inner race bearing fault frequency (BPFI).

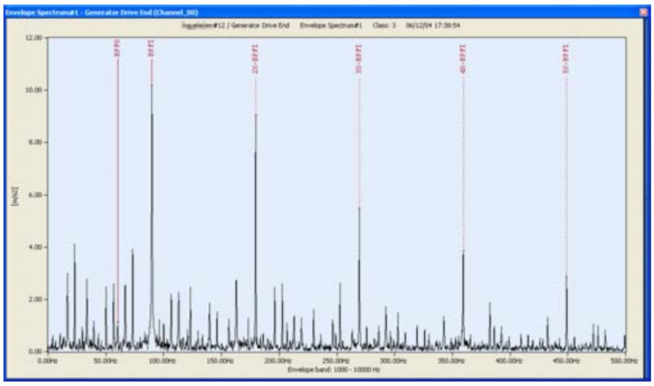

Figure 8. Envelope plot of generator end bearing.

Advice/action
The bearing should be checked as soon as possible and replaced, if necessary.

Feedback after service
Fig. 9 shows the damaged inner race. Fig. 7 shows the trend plot before and after replacing the bearings.

Figure 9. Damaged inner race of generatror end bearing.

Case Story #4 - Gearbox suspension support fault

Observations

Rapid rise in second stage gearbox overall vibration level to above Danger level in power bin 5 (>1200kW). progressive rise but below Alert level in power class 4.

The other measurements indicated there was no problem in the gears themselves.

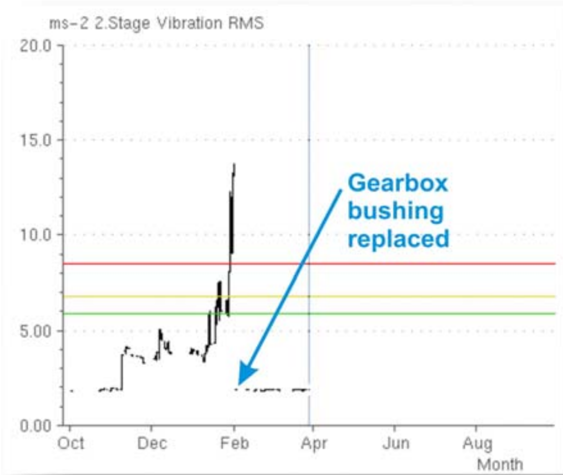

Figure 10. Overall vibration trend of second stage gearbox.

Interpretation

The rapid progressive rise in the second stage gearbox overall vibration level indicates a deterioration in the condition of, or looseness, in the gearbox support pads or structure. Because it occurs only at the highest active power bin, there could be a possible structural resonance resulting from a reduced structural stiffness due to looseness of the support structure.

Advice/action

The gearbox should be inspected immediately for mounting or looseness problems. It should also be visually inspected internally for possible contacting rotating parts.

Feedback after service

Fig. 11 shows the cracked rubber bushing on the support bracket (drawing on the right shows the location of the bushing on the gearbox). Fig. 10 shows the trend plot both before and after exchanging the bushing.

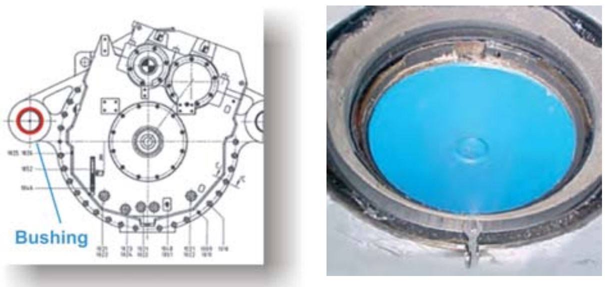

Figure 11. Gearbox support bracket.

Brüel & Kjær Vibro A/S
2850 Nærum – Denmark
Tel.: +45 7741 2500
Fax: +45 4580 2937
E-mail: info@bkvibro.com

Brüel & Kjær Vibro GmbH
64293 Darmstadt – Germany
Tel.: +49 (0) 6151 428 1100
Fax: +49 (0) 6151 428 1200
E-mail: info@bkvibro.de