Brüel & Kjær Vibro

CASE STUDY

Detection of High-Speed Coupling Looseness

The high-speed coupling on a wind turbine transmits power from the output shaft of the gearbox to the input shaft of the generator. The current wind turbine coupling design uses a flexible composite disc or a flexible disc pack linkage that is connected to both ends of a fiberglass tube. These ends allow slight misalignment between the shafts, which can occur when the drivetrain flexes under load. The coupling is designed to be robust and does not require a lot of maintenance but if a fault occurs and is not detected in time, it can pose a risk to nearby machinery and result in lost production.

MACHINE/INDUSTRY/PROCESS

There have been several multi-MW wind turbines in the recent past where a defective high-speed coupling was detected by the Brüel & Kjær Vibro condition monitoring system and diagnosed by the Brüel & Kjær Vibro Surveillance and Diagnostics Service Centre. An example of one such coupling defect is presented in this case study.

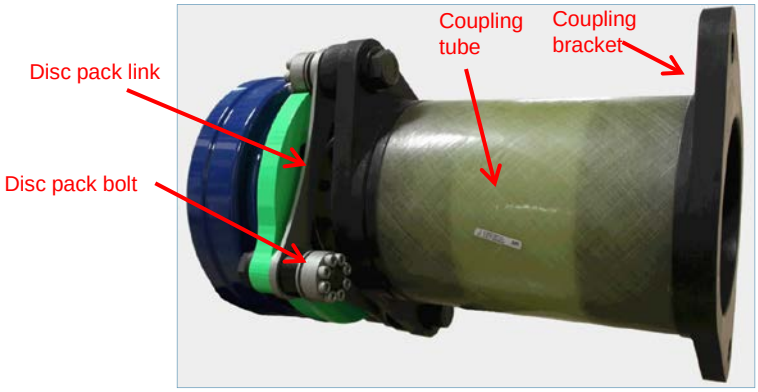

Figure 1: High-speed coupling of a wind turbine showing the flexible disc pack link structure on the left (gearbox side). The disc pack on the right (generator side) have been removed for clarity. Some high-speed couplings have an eccentric composite disc instead of the disc pack link structure.

OBSERVATION

The alert alarm limit was exceeded on both sides of the high-speed coupling of the wind turbine, as shown in Figures 2-3. The Brüel & Kjær Vibro Diagnostic Group was automatically informed and took immediate action to evaluate the situation, as the vibration levels were rising rapidly.

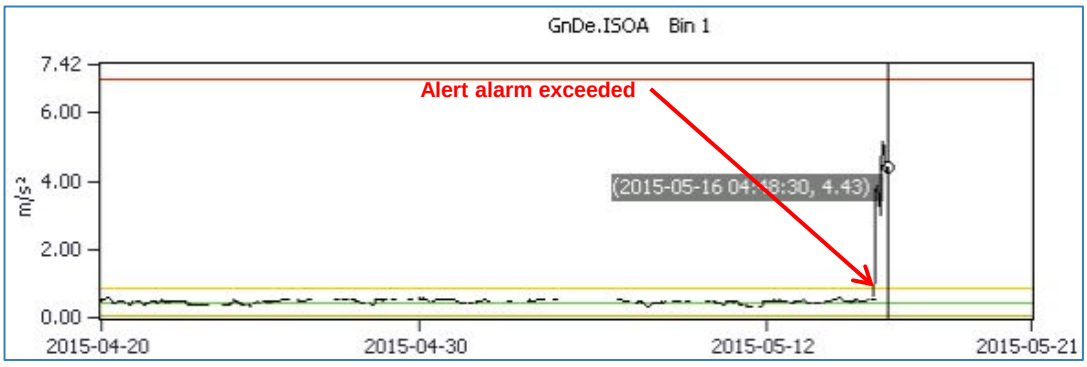

Figure 2: The vibration amplitude suddenly increases on the generator side of the coupling up until shutdown. (Discontinuity of the trend is due to measurements being displayed only for a specific power class.)

DIAGNOSIS

The Brüel & Kjær Vibro Diagnostic Group quickly analyzed the alarm situation and determined the fault was a defective high-speed coupling, as shown in Figure 4.

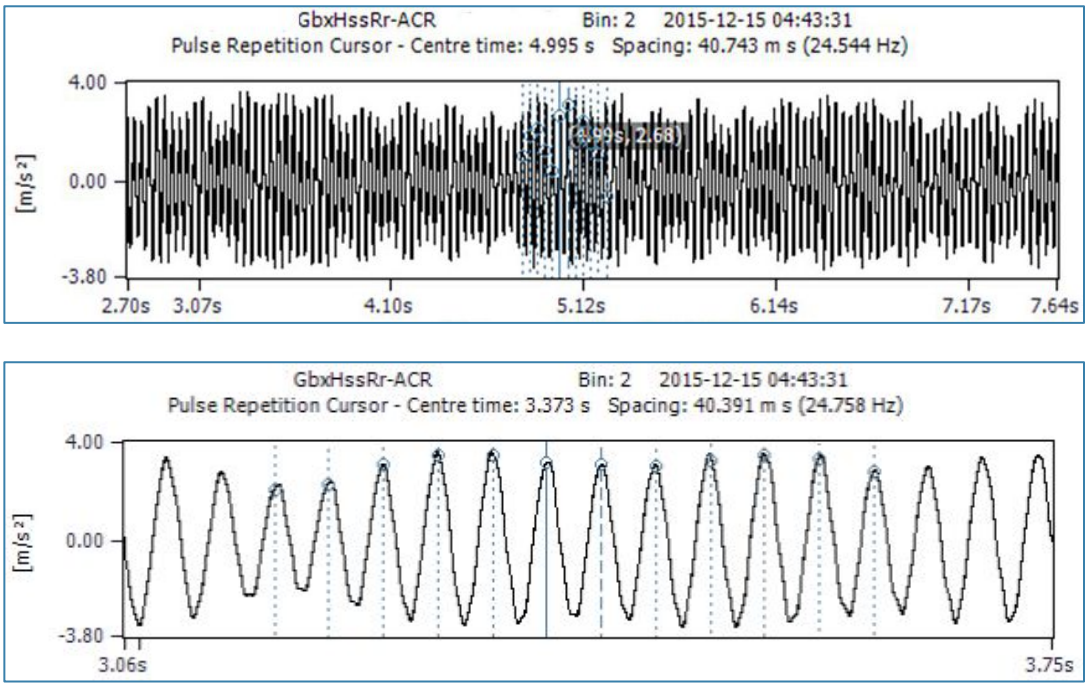

Figure 4: Filtered time signal, recorded immediately after the alarm (zoom shown on the bottom). The high amplitude of a specific frequency that corresponds to the generator speed indicates a fault in the high-speed coupling.

After identifying the coupling fault and its severity, the Diagnostic Group immediately issued a Severity 1 Alarm report (the highest severity) to the customer, who was also contacted by phone. The report recommended the following to the maintenance crew:

- Subject: Gearbox High Speed Stage – composite coupling defect
- Action required immediately
- It is recommended to stop the turbine to inspect the coupling between High Speed Stage and the Generator
- Provide feedback to bkvcm@bkvibro.com after the maintenance work has been carried out

DIAGNOSIS (Cont.).

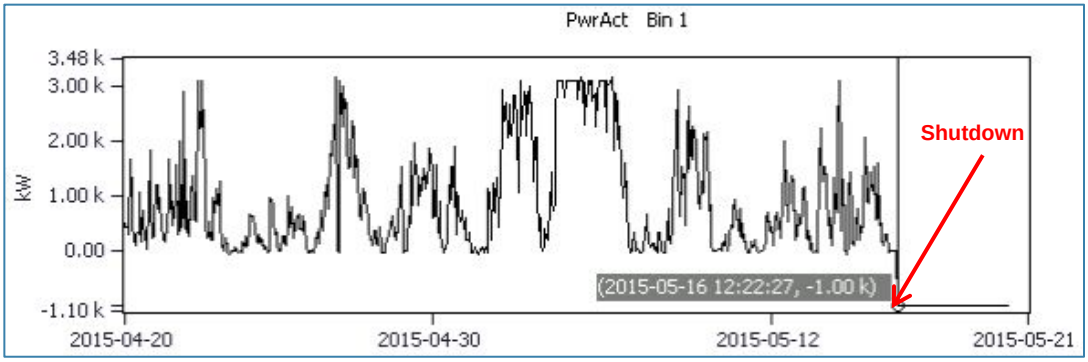

Figure 3: Active power generated by the same wind turbine up until shutdown.

RESULTS/FEEDBACK

As recommended by the alarm report, the wind turbine was stopped immediately by the customer and a site inspection was done the next day. Figures 5-7 show the results of this site inspection. It was determined that two of the coupling bolts had loosened themselves free, most likely due to incorrect torque settings.

Figure 8 shows the vibration levels of the high-speed coupling after the coupling bolts were replaced and all the bolts properly torqued.

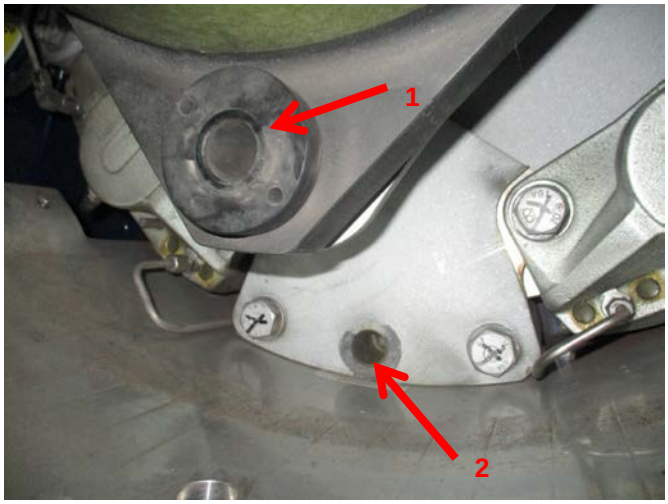

Figure 7: Location of the two bolts that were loosened free due to vibration:
1. *One of the two coupling bracket bolts on gearbox side*
2. *One of the bolts between the disc brake calipers*

Figure 5: A coupling bracket bolt was found inside the coupling shield.

Figure 6: One of the bolts between the disc brake calipers was found lying on the floor plate

RESULTS/FEEDBACK (Cont.)

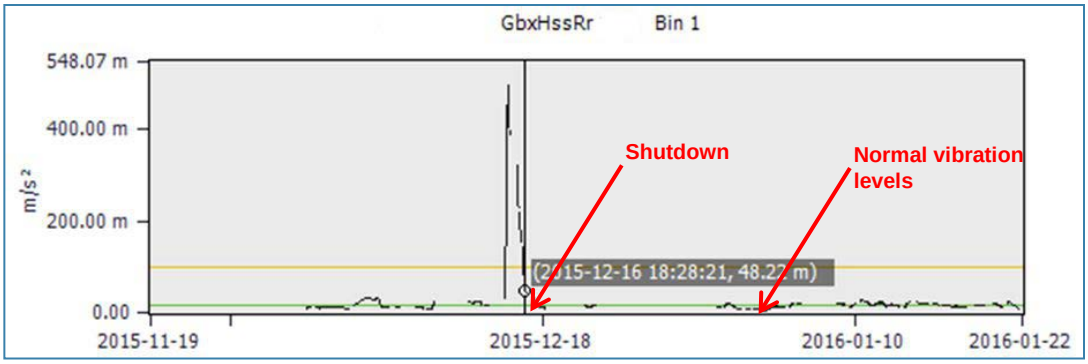

Figure 8: Vibration amplitude levels after the two coupling bolts were replaced and all bolts were properly torqued.

BENEFITS/COST SAVINGS ESTIMATION

Fortunately the wind turbine was stopped in time to avoid damage to the coupling and secondary damage to the components nearby. There is very little lead time to stopping the machine if a coupling fault is detected. Early detection is therefore imperative. When a high-speed coupling, some weighing close to 100 kg, breaks apart at operational speed, it can damage the generator housing, gearbox housing and even punch a hole in the side of the nacelle. This is because the broken coupling parts can fling themselves as high speed projectiles throughout the immediate vicinity.
A broken coupling can destroy all the sensors located around the coupling as well as the hydraulic brake lines, which would require a cleanup of the spilled hydraulic fluid. The pulverized fiberglass also presents a safety hazard during clean up.

A coupling can be replaced in a few hours, but there is at least two extra days of lost production due to the cleanup, reconnecting the hydraulic lines and repairing any other secondary damaged components. Total cost, in such a case, could exceed 50 000 €.

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