

# ADVANTAGES OF WTG DRIVE-TRAIN CONDITION MANAGEMENT WHEN USING A COMBINATION OF OIL METAL CONTAMINATION AND VIBRATION ANALYSIS

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## Abstract

Cost effective drive line condition management is one of the key issues to accomplish or even surpass the estimated energy production in wind turbine generators. A drive line failure can easily cause prolonged downtime and very expensive service or replacement work. Therefore, it is important to develop the condition monitoring systems and analysing methods.

Modern condition monitoring systems developed for wind turbine generators must have precisely considered measuring instruments and highly automated analyzing tools. One service engineer must be able to give a statement of each possible upcoming failure based on the instruments and analyzing tools while following hundreds of wind turbine generators. Most challenging monitoring objects are the slowly rotating machine parts in the drive line.

In this paper, instrumentation effectiveness in combination with oil metal contamination and vibration analysis is presented. Practical condition management results with failure cases of medium speed permanent magnet wind turbine generators are shown.

## Problem

Very often, accuracy and cost effectiveness comes up when condition management of wind turbine gears is studied. Daily surveillance of WTG gear fleet must be effective because one analyst must be able to handle hundreds of devices and, at the same time, every failure has to be found. A wind turbine drive-train can face several different failure modes, which require extensive and reliable instrumentation.

The combination of oil metal contamination and vibration analysis has been studied before on machines with high rotation speeds [Dempsey, 2000]. However, there are many challenges in monitoring machines with low rotation frequencies and especially medium speed gears. Low rotation frequency demands a long measuring time and very often this can be hard because of the limited memory of the measuring device and it is not easy to gain a proper time domain signal from a wind turbine where the rotation frequency varies during the measurement. Varying load and rotation frequency is problematic when the Fourier transform is calculated because this has the effect that regular impacts do not show up clearly in the spectrum. This was also discovered by Zimroz, Urbanek, et al. [Zimroz, Urbanek, et al., 2011]. With low rotation speeds the energy of impacts is low and this is why they can be hard to find from the background noise of the vibration spectrum.

Oil metal contamination can provide valuable information about the existence of a failure but it does not say anything about the root cause itself. This is why we need a combination of oil metal contamination and vibration analysis. With low rotation frequencies vibration levels do not rise over alarm limits but they do provide valuable information about the root cause of a failure when it is first detected with oil metal contamination surveillance.

## Hardware

In this case, the condition of the gear is monitored using the Moventas condition management system (CMA5). It is a remote monitoring system for wind turbine gears. It recognizes possible damage to gears and other mechanical components in advance, even before they start to interfere with the turbine operations. The system consists of different sensors and the main unit, which collects and processes the measured data. The measured data is then transferred to a server, where it will be analyzed in greater depth.

In this case, the monitoring system has three Moventas intelligent vibrations sensors (IVS-20), which all measure spectrums, time domains and key values in all three directions, one GasTOPS MetalSCAN full flow oil particle counter and other sensors for measuring temperatures and oil quality.

## Analysis methods

Daily monitoring routines (Figure 1) consist of checking instances of exceeding the alarm limits of every monitored gear. If abnormal behavior is found, a closer inspection is performed for the trends of those measurements. Spectrum and time domain analysis are used for finding the root cause of a possible failure.

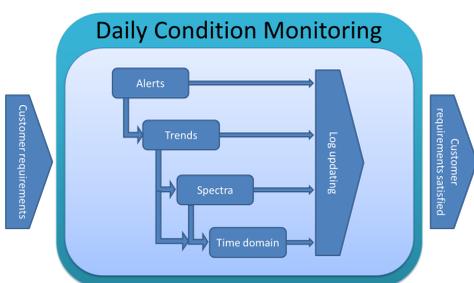


Figure 1. Moventas' daily condition monitoring process.

## Medium speed gear

In this paper, we concentrate on remote monitoring of a medium speed gear (Figure 2), which has one planetary gear and one helical stage. The ratio of this gear type is 1:28 and the nominal rotation speed in the output shaft is 464 RPM.



Figure 2. Construction of a medium speed gear.

## Case: Broken tooth in medium speed gear

At the beginning of December 2011, an unexpected rise in oil particles was detected with alarm limit monitoring (Figure 3). At the same time, there was no change in overall vibration levels or bearing temperatures (Figure 4).

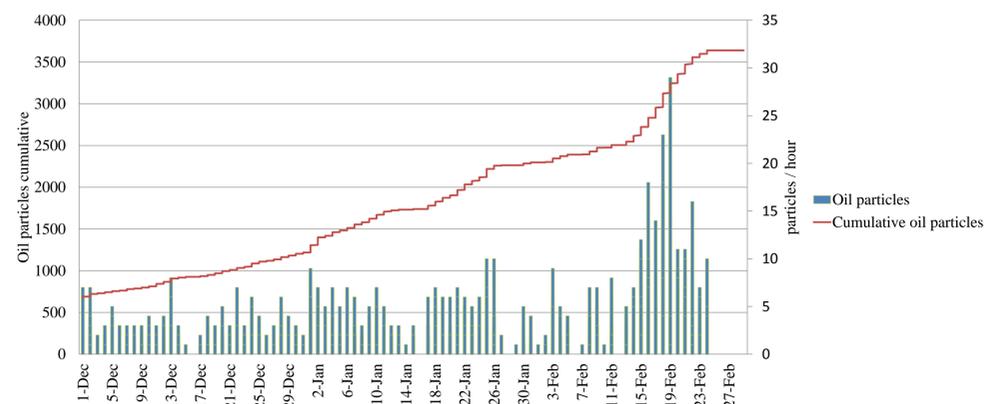


Figure 3. Failure can be seen from the rise in oil metal particle contamination.

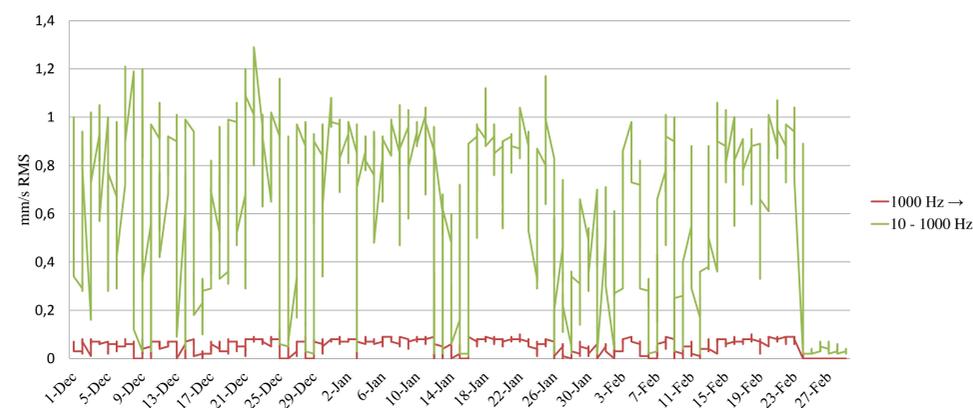


Figure 4. Overall, vibration velocity has remained steady despite of failure.

Closer analysis of vibration spectrums pointed out that there was a possible failure in the medium speed stage. This can be seen in the velocity spectrum (Figure 5), where there are side bands on both sides of the rotation frequency of the medium stage.

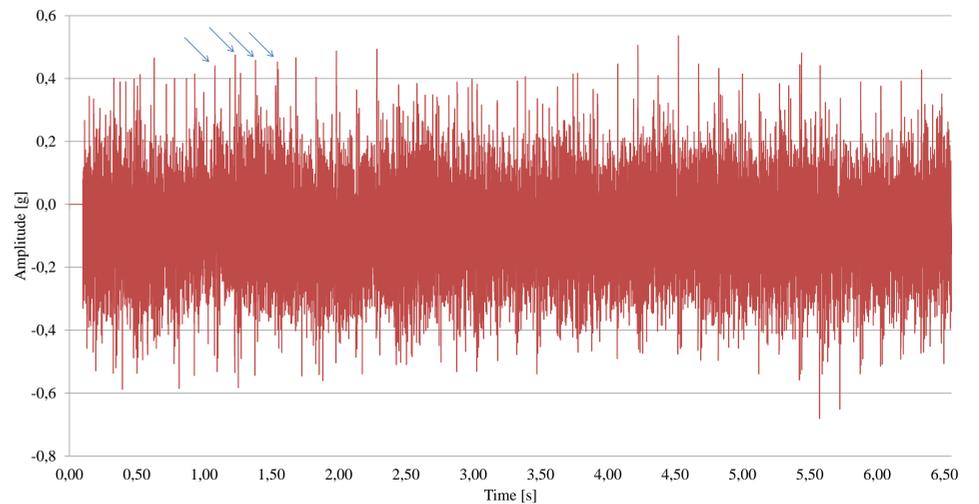


Figure 6. Measured time domain signal showed clear hits, which corresponded to the rotation frequency of the medium stage.

This gave the first hint that there was a failure in the medium stage, which was verified by analyzing the time domain signal where there were clear hits (Figure 6).

When root cause of failure was identified the client was informed and Moventas' field service engineer was sent to make a visual inspection of the gear. During the visual inspection, a broken tooth was found in the medium speed stage. The tooth was not yet totally broken but it was cracked (Figure 7).

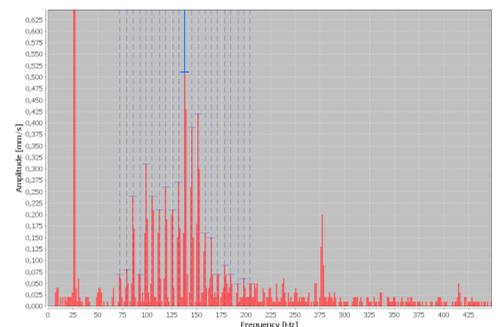


Figure 5. Velocity spectrum with side bands corresponding to rotation frequency.



Figure 7. Visual inspection of gear showed a broken tooth.

## References

- Dempsey, P.J., A Comparison of Vibration and Oil Debris Gear Damage Detection Methods Applied to Pitting Damage. 13th International Congress on Condition Monitoring and Diagnostic Engineering Management, 2000.
- Zimroz R., Urbanek J., Barszcz T., Bartelmus W., Millioz F., Martin N., Measurement of Instantaneous Shaft Speed by Advanced Vibration Signal Processing - Application to Wind Turbine Gearbox. Metrology and Measurement Systems, Vol. XVIII (2011), No. 4, pp. 701-712. 2011.

## Conclusions

In this case, a failure could not be found if vibration analysis was the only method in the condition monitoring because the vibration levels remained steady despite the failure. Nevertheless, the root cause of the failure would be impossible to find without vibration measurements and spectrum and time domain analysis.

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