Brüel & Kjær Vibro

Application Note

Condition Monitoring of Wind Turbines

Extensive monitoring of all bearings and gearbox using cost-effective, cell phone data transmission

Monitoring Solution Partnership

Brüel & Kjær Vibro and NEG Micon have started a long-term cooperation for providing products and services for machine condition monitoring, testing and analysis of wind turbines. As NEG Micon has long-term service agreements with many of their customers, an effective condition monitoring solution plays a particularly vital role in this capacity.

One of the immediate objectives of this cooperation is to fulfill the current certification requirements for onshore and offshore wind turbines in the German market. The long-term vision is to extend and optimize the monitoring solution for worldwide projects.

Stringent Monitoring Requirements

Germanischer Lloyd WindEnergie has one of the few certification procedures specifically aimed for wind turbines, and is major driver for drafting and implementing the international IEC 61400 wind turbine standards. Allianz Insurance recognizes this, as they are in the process of formulating a policy of reduced insurance premiums for wind turbine end-users that comply with the certification.

The stringent monitoring requirements that come out of this certification are extensive. The only other alternative for certification without condition monitoring is to replace all wind turbine bearings at fixed, relatively short intervals! This can be an expensive proposition, especially for offshore wind farms.

This Application Note focuses on the innovative technical approach that was adopted for implementing a condition monitoring system to cost-effectively meet the monitoring requirements.

Fig. 1 Frequent overhauls in a wind farm can be expensive!

Monitoring Strategy

As wind turbines play a more important and reliable role in the energy network, they become more sophisticated in both technology and size. This places bigger demands on maintenance with less tolerance for downtime. Therefore a **machine condition monitoring** strategy has been adopted for these machines. This means detecting and diagnosing faults at an early stage of development and trending them, so maintenance can be cost-effectively planned ahead of time and downtime minimized.

The primary components monitored in the wind turbine are the generator, gearbox and main bearing. Unbalance, misalignment and bearing and gear faults are the main potential failure modes. Most of the faults that can occur in these components develop slowly, so continuous monitoring is not necessary. It has been determined to be sufficient that a complete data set be monitored at four-minute intervals.

A wind turbine in principle operates over a wide range of speeds and loads. Therefore an **adaptive monitoring strategy** is used to increase the reliability, repeatability of monitoring over these varying operating conditions, while at the same time reducing the risk of false alarms. This is done by ensuring that changes in the measured vibration levels are due to developing faults only, and not due to changing operating conditions such as speed or load.

Five operating conditions have been established, as shown in the example given in Table 1.

Generator speed 1	Generator speed 2
-	150 – 375 kW
10 – 150 kW	375 – 800 kW
150 – 500 kW	800 – 1500 kW

Table 1 Operating conditions used for monitoring the 2-speed NM82 wind turbine in Hamburg, Germany

As seen in Fig. 2, a number of measurements are used in the monitoring strategy:

- Bandpass vibration measurements (all bearings)
- Bearing fault frequencies (main bearing)
- First and second harmonics (high-speed shaft)
- Gear meshing frequencies (each gear)
- "Residual vibration" for gearbox (overall RMS minus peak frequencies)
- Time waveforms
- Process measurements

The vibration measurements are triggered to allow for phase measurements to be made and for compensation of small fluctuations of speed.

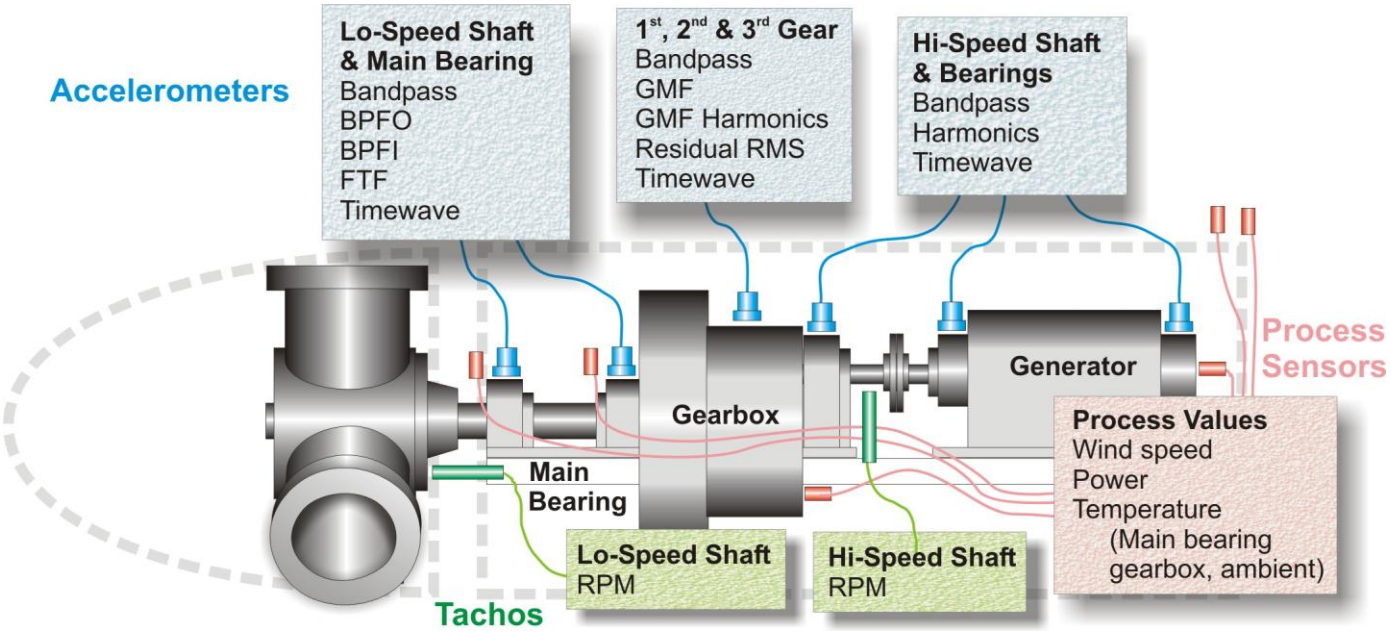

Fig. 2 Schematic representation of sensor locations on a typical wind turbine generating unit, and the corresponding measurements.

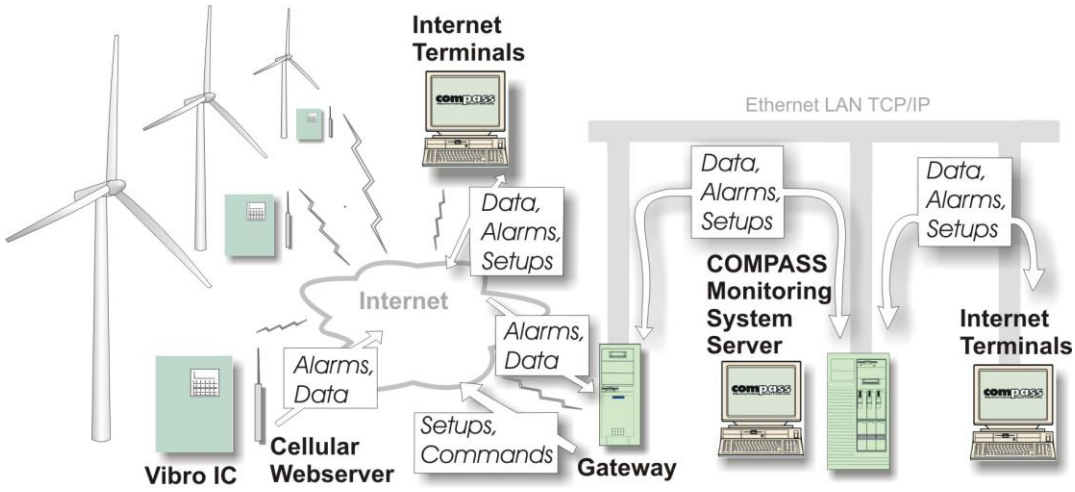

Fig. 3 Monitoring system configuration

Monitoring System Configuration

The basic monitoring system configuration - as shown in Fig. 3 - is based on a remote monitoring concept. Data is automatically collected from each wind turbine and sent via a cellular network and Internet server to a central diagnostic and system administration center. Because data display and system setup can be done via the Internet, access can be shared between the wind turbine manufacturer, the monitoring system supplier and other users, if needed.

The **Vibro-IC**, located in each wind turbine tower base, is the primary data acquisition and conditioning unit in the monitoring system.

A miniaturized **cellular web server** in each wind turbine tower base takes the measured data from the Vibro-IC over a RS232 serial connection and compares the measured values to alarm limits. If no alarm limits have been exceeded, mean values are calculated (standard deviation values also if requested) and stored in a buffer, and then later sent to the GPRS network provider, approximately once a day. If alarm limits have been exceeded, a complete set of the actual measured data is sent at short intervals.

In either case all data is placed on a secure Internet server by the GPRS provider, which is automatically accessed by the remote **data acquisition server** (DAS). The DAS also serves as the gateway for the **web servers** for general data administration purposes, and is also a data buffer for the monitoring system server **COMPASS**.

COMPASS automatically imports the data and stores it in the monitoring database. This is where faults are diagnosed, trended and monitoring reports are made. COMPASS is also used to change the alarm limits used in the web servers.

Monitoring Experience

The Brüel & Kjær Vibro and NEG Micon cooperation is currently in a project phase, where the monitoring parameters are being optimized.

The prototype monitoring system was installed on-site on an NM82 wind turbine (1.5 MW) in Hamburg, Germany, followed by two NM52 wind turbines (900 kW) in Schrepkow, Germany. NEG Micon has a long-term service agreement with these end-users for all matters concerning maintenance and monitoring.

Plans are underway to install the monitoring system in the NEG Micon factory on the NM110 wind turbine (4.2 MW). This newly designed wind turbine is targeted for offshore wind farm applications.

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