Machinery Health Monitoring Using the Internet

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Analysis of machinery vibration requires some knowledge and experience, and today it is heavily supported by advanced electronics and software. Machinery maintenance decisions are not always straightforward; they may involve a number of factors related to production, availability of spare parts and resources. An expert's voice needs to be taken into account as it minimizes the risk involved. An exchange of opinions and discussions are crucial. One place to fulfill this need is via the Internet or an intranet.

The Internet allows everyone on-line access to the same resources. This means that everyone is viewing the same image, table or graph and listening to the same dialog. Additionally, a web solution is mobile; there is no need to install any software, set up a configuration or bring the latest data. All this is done on the server side and then offered to the end user. This makes all discussions more productive and less confusing.

Web-based solutions are helping industries reinforce their resources and efficiently utilize engineering consulting services. The Machine Mobile Monitoring (or M^3) solution, offered by ÅF Sound & Vibration, combines wireless monitoring hardware and Internet-based software. Machine behavior, performance and status are obtained quickly and efficiently. Information from different machines, often located at different places, becomes immediately available on any network device, including mobile phones. While a mobile phone has some advantages and limitations, a more comprehensive machine health analysis package is offered via Microsoft Silverlight.

A network of wirelessly connected modules is controlled by a host SQL server using an intranet or the Internet. All information about machines such as status, time records and spectra are available to users through the web service. Anyone authorized, anywhere is able to access the machine status and use the vibration-analyzing tools on any web-enabled device without any configuration or software installation.

ÅF Sound & Vibration provides several configurations including hardware with ATEX specifications. Each of the wireless units has four inputs for ICP sensors. These are simultaneously sampled at a high rate up to 102 kHz with a 24-bit resolution. For vibration measurements, ÅF recommends industrial, high-frequency accelerometers with double shielding for best EMI protection. Using accelerometers provides a possibility of evaluating machine vibration in accordance with ISO specifications as well as assessing the shock pulse effects produced by damaged bearings, gearboxes or insufficient lubrication.

In addition to vibration channels, each of the monitoring modules allows acquiring data about process parameters such as load, temperature, pressure, etc. Two tachometer signals can be used to capture the rotational speed.

ÅF Sound & Vibration also provides acoustic emission (AE) measurements in the frequency range around 100 kHz. The power of AE lies in the fact that it directly detects physical processes such as friction, impacts and metal removal which occur when machinery degrades. The key to the success of AE in the industrial environment lies not only in its high sensitivity to machine faults, but also in its inherent ability to make low-frequency vibrations audible.

Based on an M^3 solution, ÅF offers comprehensive support in machine diagnostics. This includes system commissioning, configuration and data analysis. Continuous contact with the customer and data access is ensured via the Internet. ÅF Sound & Vibration consultants specialize in problem solutions for different types of machine components such as gearboxes, bearings, electrical motors, etc. A particular interest is in low-RPM machinery and VFD motors. Machine Mobile Monitoring has been tested in the field, and several examples are given to prove the effectiveness of the approach, starting with a wind power application.

In recent years, wind power generation continues to increase, and there is a need to maintain wind turbines and prevent failures. Vibrations over a wide frequency range provide insight into lower frequency content, such as rotor imbalance, tower movement, etc. But they are also capable of revealing the high-frequency behavior known as a shock-pulse effects to track phenomena related to bearing deterioration or gearbox damage.

With advances in signal processing techniques, the acceleration signals are post-processed and converted to audible sounds. Through "cloud" technology, a mobile system can function as a traditional stethoscope, and it is helping service teams detect machinery problems and judge the degree of severity. Cloud technology also provides global and secure access to information without any installations. When analyzing vibrations in wind power applications, it is important to take into account wind conditions affecting the output power. A clear increase in distress values was observed at one installation around six months in advance when values extracted from the database were limited to the condition when turbine power output exceeded 1200 kW.

A cloud solution was extensively tested for pulp-and-paper machinery applications. By correlating bearing conditions to vibration signatures, it was possible to identify new problems and schedule repair service. An innovative approach was to use an SQL query to filter vibrations at similar operating conditions. This has been achieved by coupling envelope spectra and OPC parameters together. All signal processing as well as the SQL search was performed automatically in the cloud and was transparent to the end users. Results were reported as color maps. Those patterns were clearly understood without any extensive training.

A similar approach was implemented in analyzing vibration patterns on hydraulic motors driving twin-roll presses. The machine had not been analyzed on a permanent basis. Instead, a so called drop-in module was used. All instrumentation was provided in a single enclosure, including a long-life battery.

Due to a low rotation speed of 6 RPM, a number of dedicated processing techniques were developed and tested in the field. When the problem was identified, the vibration signature was displayed by a color pattern.

Two months later, high-frequency vibration testing was repeated during similar operating conditions. A significant increase in impacts was clearly noticeable. The motor failure happened 1.5 months after the second vibration analysis.

Monitoring of slow-running machinery differs slightly from conventional vibration analysis techniques. This is caused by the fact that the damage of slow-running bearings or gearboxes still appears as short-duration, high-frequency impacts. However, the impact signal energy is relatively small as compared to the energy of other vibration sources. Through proper digital signal processing, impacts induced by the damage can be enhanced.

An Apple iPhone stethoscope can be used to listen to damaged bearings. To regain the bearing information, the acceleration signal can be band-pass-filtered around 10 kHz. Since the human ear does not respond well in this frequency range, the signal is slowed down four times during MP^3 compression before being submitted to the server. After that, all frequency components appearing within the frequency range of 10 kHz were moved to the range of 2.5 kHz and can be clearly audible through the iPhone.

A final example examines an electrical motor being driven by variable-frequency inverters. VFD motors are used in a variety of variable-load applications. By varying the amount of current going to the stator portion of the drive, it is possible to adjust the motor's torque and maintain a specific speed regardless of load on the motor.

Since VFD motors have increased in popularity, a number of cases have been reported showing extensive bearing damage frequently caused by the electrical current going through the bearing. Motors driven by variable-frequency inverters often experience a premature failure.

By using acceleration signals and applying a set of band-pass digital filters, the bearing defect frequencies become clearly visible in the derived envelope spectrum. It was also discovered that, by applying the high-pass filters above 17.5 kHz, the bearing defect frequencies disappeared completely, leaving only the inverter frequencies. This explained why some motors, even those equipped with monitoring devices, failed without any warning. ÅF Sound & Vibration strongly recommends conducting a vibration analysis on VFD motors prior to installing any monitoring devices.

By performing a several tests on VFD motors, it was confirmed that the bearing faults are detectable for a wide range of inverters, from 5 to 23 Hz. An envelope spectrum, clearly reveals bearing defect frequencies on VFD motors.

In conclusion, Machine Mobile Monitoring utilizing cloud services opens new possibilities for sharing in-field experience and shortening the learning curve. Any experience gained on a particular machine is encapsulated in the form of an XML template. It is a sort of recipe prescribed in XML language, which is fully understood by machines and human beings. The template does not require any particular training. It is designed for structuring the enterprise hierarchy, as well as defining measuring points and setting up sequential order-of-signal processing techniques. It can be easily derived, modified or shared. SV

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