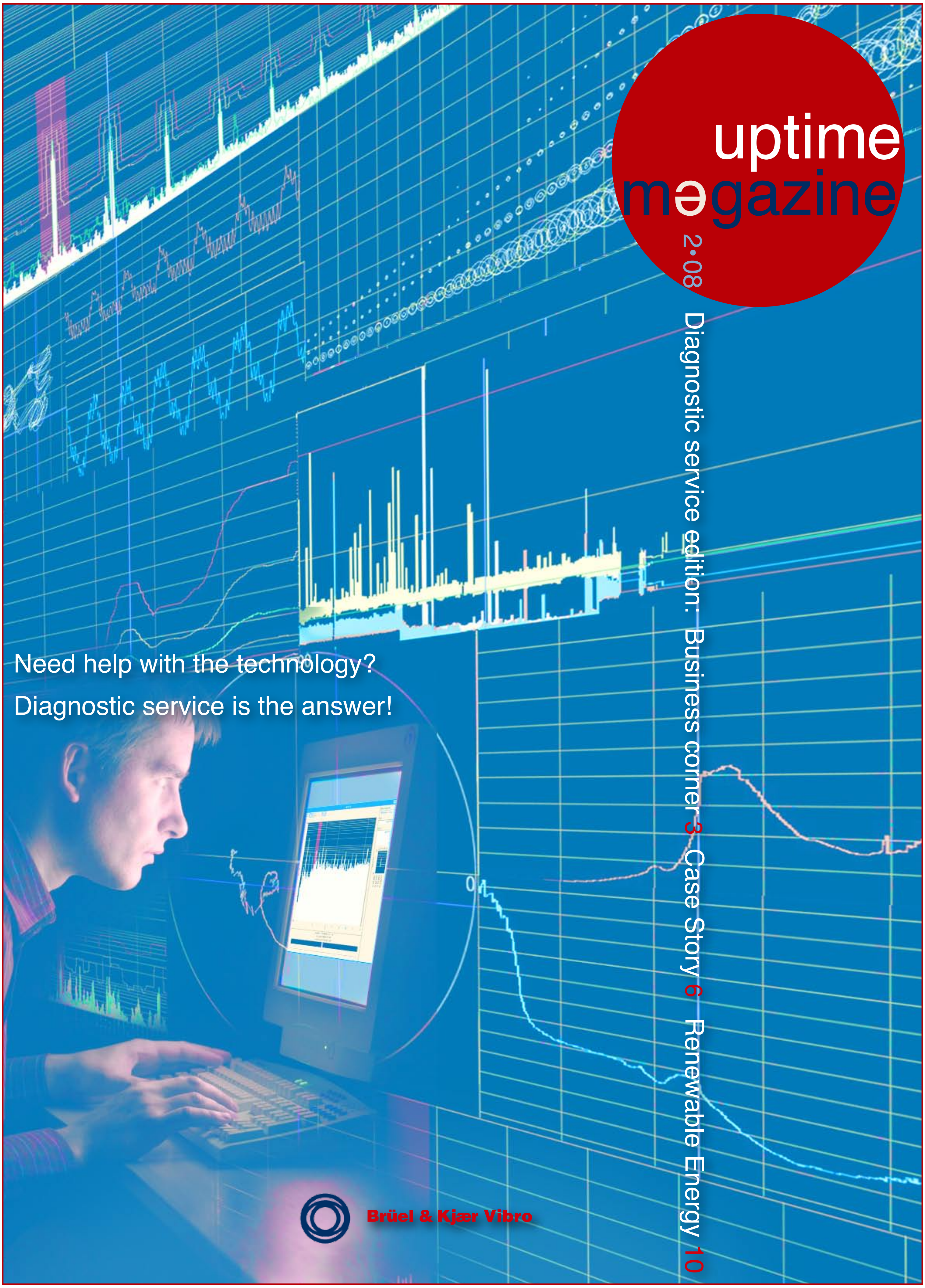
uptime magazine

2·08

Diagnostic service edition: Business corner 3 Case Story 6 Renewable Energy 10



Need help with the technology?

Diagnostic service is the answer!

Brüel & Kjær Vibro

uptime
megazine
2•08

3 **Business Corner #1**
Global Partner Network

5 **Business Corner #2**
Successful monitoring results using diagnostic services

6 **Case Story**
Bearing problems on instrument air compressor at LNG plant

10 **Renewable Energy**
Condition monitoring system requirements for wind turbines

12 **Events**

Brüel & Kjær Vibro

Uptime Megazine is a newsletter published by Brüel & Kjær Vibro to keep you up-to-date with new machine monitoring trends and technologies.

This issue of Uptime focuses on diagnostic services.

If you have comments, ideas or case stories, please contact:
The Editor, Uptime Megazine,
Brüel & Kjær Vibro,
DK-2850 Naerum, Denmark.
Tel.: +45 7741 2500
Fax: +45 4580 2937
E-mail: info@bkvibro.com

Copyright 2008, all rights reserved
Editor-in-cheif: Torben Ekvall
Managing Editor: Mike Hastings
Design&Production: Gitte Blå Design

Diagnostic Services - A Personal Touch to Monitoring Solutions

No matter how sophisticated technology becomes, or how dependent we are on our computers and artificial intelligence systems, it is us who are the masters of this technology. Not the other way around!

There is an enormous amount of research being conducted today to find effective models or algorithms that can automatically diagnose and analyze incipient faults. We developed our own neural-network based automatic expert diagnosis system, ADVISOR, which has been successfully used in many industries for the last 15 years for that same purpose. Such intelligent methodologies have been proven to greatly reduce the work load of the condition montoring specialists, but they can never replace them!

Therefore, in addition to providing analysis tools, we also provide the services of our own specialists to aid in diagnosing problems.

Brüel & Kjær Vibro takes pride in the diagnostics service we have been providing for the last 50 years, and we have a team of experienced, well-repected specialists to show for this. This is reflected by the long-term service agreements we have with many of our customers, which often include diagnostic services.

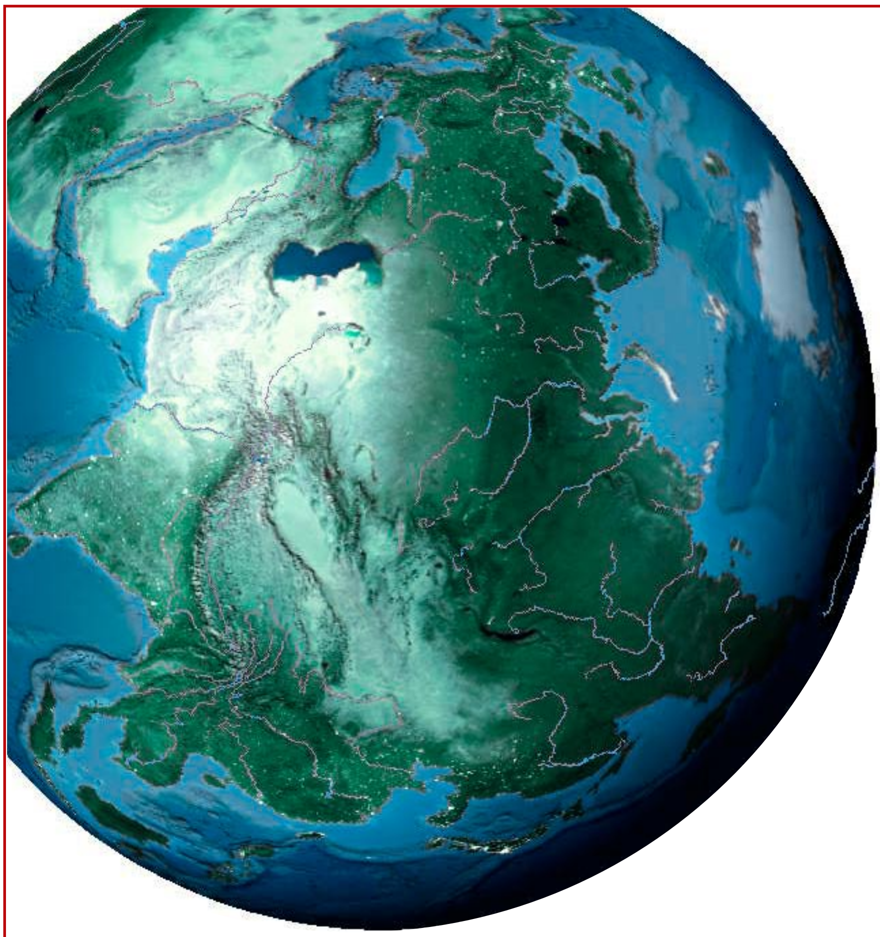
In an upcoming issue of Uptime, we will talk more about the after-sales services we offer, but in this issue we will focus on one specific topic; diagnostic services used to solve a customer's specific problem.

Richard Bechelli
Diagnostic Specialist

Global Partners
- A unique strategy to bring sales and support close to you

Global partner meeting in Darmstadt, Germany, 2008.

Machine safety and condition monitoring solutions are playing an ever increasing roll in optimising industrial machine Operation & Maintenance worldwide. Advanced signal processing technology, system integration and remote access capability have all made significant contributions to the overall monitoring system capability. However the same technology also presents challenges to many customers in selecting, implementing and maintaining such monitoring systems.



Our sales and support centres are presently providing the targeted support necessary to eliminate these hurdles. In order to support market growth in your local area, Brüel & Kjær Vibro have undertaken a complete renovation of their worldwide network of local agents and distributors. These indirect sales channels have been consolidated under a new umbrella called the Global Partners Network, which has vastly improved the way we do business.

Firstly, the global reach has been optimized so important markets like yours are included and duly represented. The previous conglomeration of agents and distributors with widely varying levels of technical expertise has given way to a systematic, worldwide network of partners with sales and support capability for integrated systems, plant-wide safety, hand-held devices and compact monitors, all adapted to the local markets needs. This well-defined focus homogenizes our approach and eliminates grey and conflicting areas of sales and technical expertise.

Consequently the training, support and qualification of our partners is undertaken more efficiently.

The key for all partners is adding value to the sales and support process. One consequence of this is that the Partner concept is not necessarily limited to specific geographical areas. Some partners are working inside a direct Brüel & Kjær Vibro sales area because of a special connection they may have to a particular customer or industry.

Brüel & Kjær Vibro also have a greater responsibility with the new organisation and have therefore allocated dedicated sales and marketing resources to ensure:

- Marketing material, demo equipment and training is allocated more effectively.
- An open dialogue has been established so we can further refine the sales approach.
- A Global Partner meeting is held each year in order to monitor the progress of our indirect sales, make improvements in how we manage our sales and support, and for making plans for the future.
- A Sales Partner newsletter is also given out quarterly.

What are the bebefits of all this? To make it easier and more accessible for our customers (and sales partners) to find the appropriate Brüel & Kjær Vibro solution to manage their machine monitoring needs. ■

Successful Monitoring Results using Diagnostic Services

business corner

Diagnostics is the cornerstone to a condition monitoring application, and therefore it represents a fundamental part of the business done by Brüel & Kjær Vibro.

Our primary focus is on two important areas in diagnostics and analysis:

- Developing diagnostic tools for our condition monitoring systems that assist the specialist's job
- Providing Brüel & Kjær Vibro specialists to undertake diagnostics as an after-sales service function

Diagnosis, by definition, is a conclusion of an analysis of symptoms aimed at determining the cause or nature of a machine condition.

The Compass family of condition monitoring systems offer diagnostic tools that greatly reduce the workload of the customer's specialist. This means the specialist has time to look after more machines, or even several plants. This effectively reduces the cost of using a specialist without compromising the reliability of the condition monitoring strategy.

Brüel & Kjær Vibro also offers a team of qualified specialists who work with a number of industries and machines. Due to the high downtime costs, we have long-term service agreements with several of our customers that include diagnostic services.

This issue of Uptime contains a case story from an LNG plant that clearly demonstrates the effectiveness of a condition monitoring strategy and the enormous potential it has in reducing downtime expenses associated with catastrophic failure and consequential damage. Futhermore, the case story highlights the importance of diagnostics and the important role of an after-sales service department to deliver such a solution.

The case story is from one of our specialists, Stefan Burggraaf, based in the Holland sales office. He regularly travels to client sites to help the customer's rotating equipment engineer to keep an eye on the machines. As a result of his frequent trips, he developed intimate knowledge about the customer's machines, which in return helps him tackle some of the more difficult diagnoses. The customer also benefits from this special insight into the maintenance and operation of the machines. Together, they build a strong working relationship and mutual understanding that makes everyone's job easier, but most importantly results in more productivity from the customer's machine fleet. ■

Figure 1 Stefan Burggraaf, on the right, next to one of the machines he is doing dianostic services on.

Bearing problems on instrument air compressor at LNG Plant

The instrument air compressor serves a critical role in an LNG plant as well as in other industries. It provides clean, dry air that is used in a range of control and shutdown valves.

In this case story a bearing fault was detected and diagnosed while the compressor was still under warranty.

case story

There are three instrument air compressors per train at the LNG plant.

The 3-stage oil-free centrifugal compressor is driven by a 90 kW motor though a gearbox and uses tilting pad journal bearings.

The units were relatively new and still under warranty at the time of this case story.

Monitoring Strategy

All the instrument air compressors at the LNG plant are instrumented both for safety and condition monitoring.

The following measurements are monitored for safety monitoring:

- Axial thrust – DC displacement
- First and third stage impeller bearings - Overall bandpass measurements from the radial displacement sensor (10-5k Hz, RMS P-P, mm)

The safety monitoring system has duplicate sensors and monitoring modules for redundancy.

There are a number of condition monitoring measurements that are monitored for the entire compressor train. Those that are monitored from the displacement sensors of the first and third stage impeller bearings include the following:

- DC measurement for shaft position
- 1/2 magnitude for bearing stability monitoring (RMS P-P, mm)
- First order vector (magnitude and phase, RMS P-P, mm)
- 2nd, 3rd and 4th order magnitude (RMS P-P, mm)
- 6% constant percentage bandwidth spectrum, (CPB, 16.3-1.03kHz, RMS, mm)
- FFT spectrum (500Hz span, P-P, mm)
- Dual time function (orbit)

Because of limited access there is no displacement sensor on the second stage impeller bearing. Instead, an accelerometer is used on the casing of the impeller. The measurements from this sensor are similar to those monitored by displacement sensors on the first and third stage impeller bearings.

Observations

The bandpass vibration level on the inboard bearing of the first stage impeller had exceed the alert alarm limits, so special attention was given to monitor its progression. As seen in Fig. 2 the vibration trend had been increasing steadily for about one year. After a few months the vibration level subsided again but after two

Instrument Air Compressor	
Date put in service	April 2005
Power	90 kW
Flow capacity	200 Tonnes/day
Outlet pressure	10 bar
Speed	50 Hz

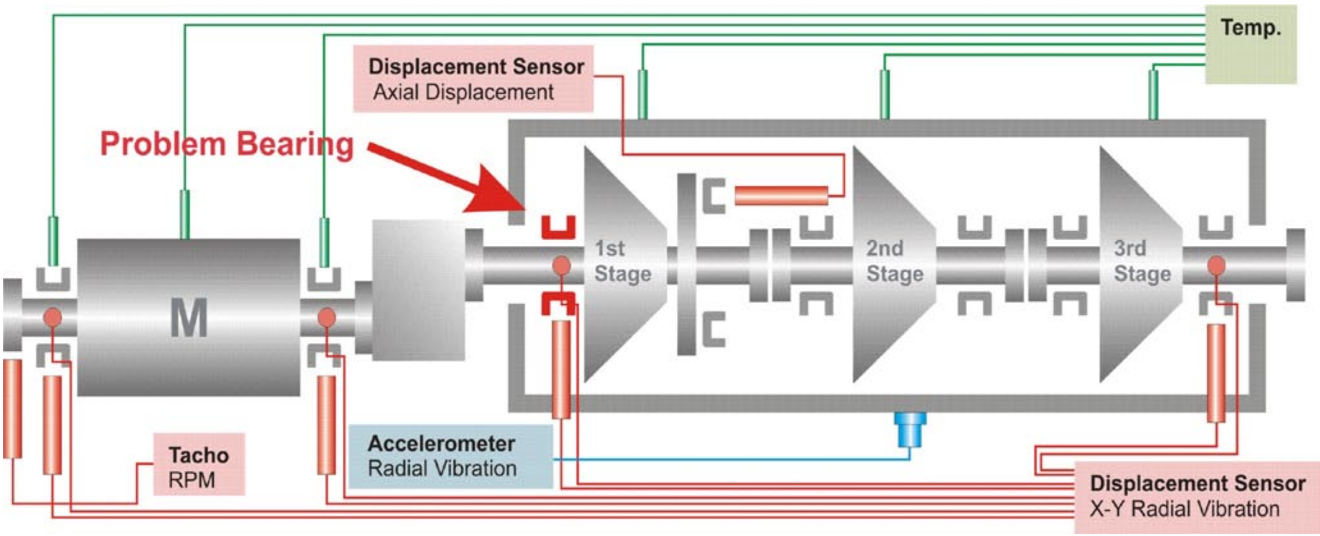
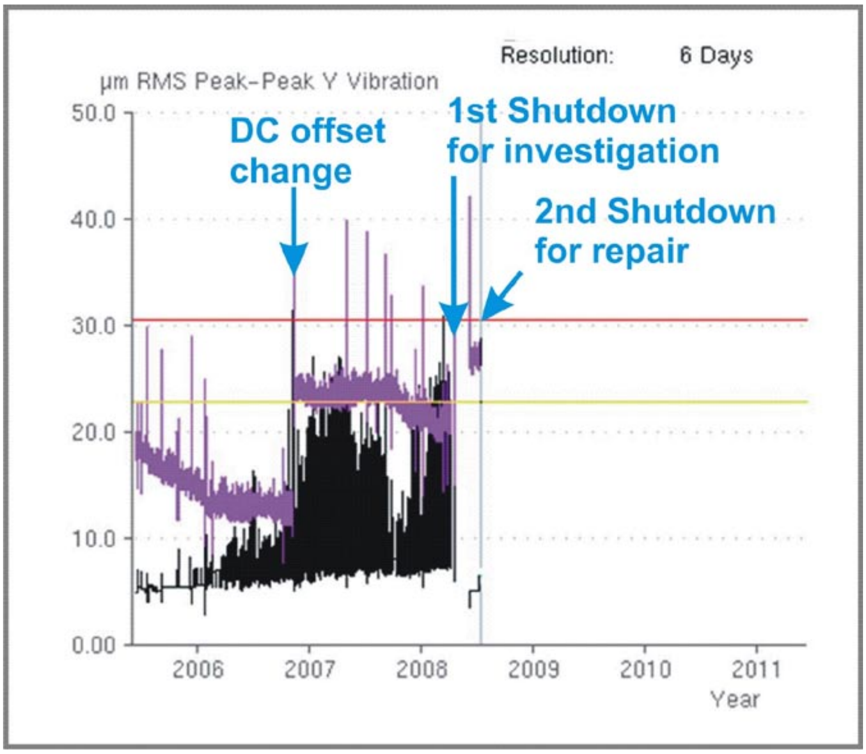


Figure 1. Sensor configuration of the instrument air compressor. There are also a number of imported process parameters from this machine train not shown here (these include suction and discharge pressure and temperature, and motor current). The bearing where high vibrations were detected is shown in red.

Figure 2. The bandpass vibration level (black) from the inboard bearing of the first stage impeller. The DC vibration displacement (purple) shows shaft position, (an offset change was made at the end of 2006).



years since the upward trend first started, the vibration level exceeded the alert alarm limits once again. It was decided to shut down the machine to investigate the problem.

After a quick investigation nothing was found that required immediate attention so the compressor was put back into service. The vibration levels remained above the alert alarm limits so a series of tests were done by the customer to try and identify the problem (e.g. changing the lubrication). They were not able to reduce the vibration levels, so Brüel & Kjær Vibro was asked to look into it and evaluate the problem. As the vibration levels were increasing towards danger alarm limits, the machine was shut down.

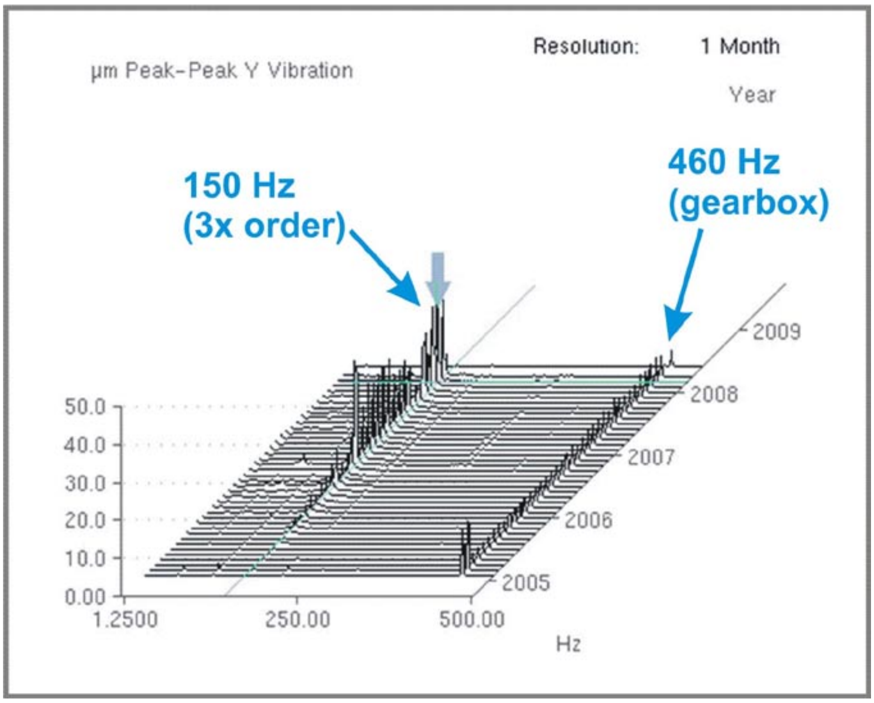


Figure 3. The 3rd order harmonic dominates the vibration response in this spectrum plot (FFT). The 460 Hz signal component from a gearbox pinion remains unchanged, thus precluding the possibility of a fault with this portion of the gearbox (higher frequencies not shown in this plot).

Diagnostic Analysis

One of the first observations in the spectrum plot shown in Fig. 3 was that the third order harmonic of the running speed from the inboard bearing of the first stage impeller started to increase more than two years before the shutdown. The band-pass vibration level increased for a while, decreased, and then increased again. This could be the result of a bearing fault that initally smoothed itself out for a while and then the fault re-developed again. The DC vibration displacement shown in Fig. 2 shows a relatively linear change in shaft position over the course of three years. This indicates gradual wear of the bearing.

Because the compressor was still under warranty, the manufacturer was contacted to investigate the bearing deterioration.

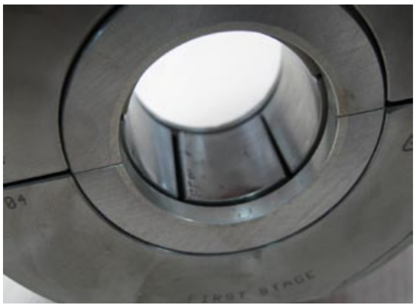


Figure 4. Fretting on the first stage impeller bearing, presumedly caused by a manufacturing defect.

Root Cause Analysis

The manufacturer has determined that the fretting on the first stage bearing (Fig. 4) was due to poor bonding of the bearing surface as a result of a manufacturing defect. This evaluation is based on the fact that the high vibration levels had already started an upward trend not long after commissioning.

The scratched bearing surface for the second stage impeller (Fig. 5) was most likey due to to foreign object that entered the bearing during commissioning. The burnt oil on the bearing surface from the 3rd stage impeller (Fig. 6) was most likey due to carry-over water ingress.

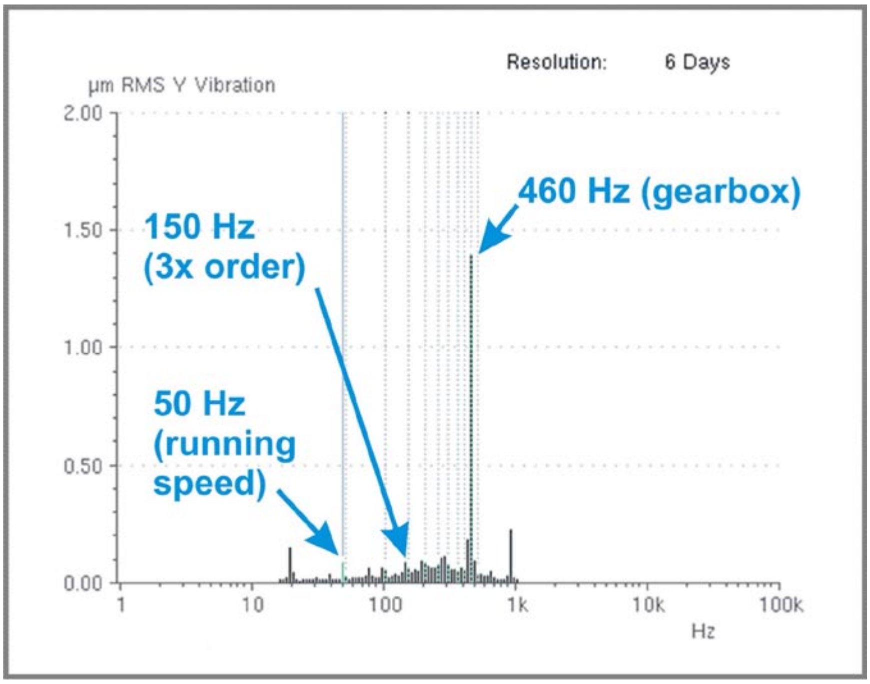


Figure 7. The 3rd order harmonic disappears from the spectrum (cpb6%) after the bearings are replaced

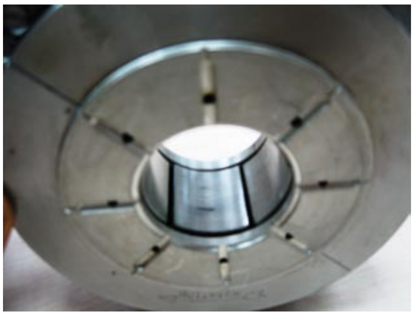


Figure 5. Scratch on the second stage impeller bearing

Figure 6 . Burnt oil on the third stage impeller bearing

After Repair

The manufacturer replaced all the bearings and the intercooler drain lines were checked for proper draining of water to avoid carry-over. The inlet air filter was also thoroughly inspected for damage and openings. Fig. 7 shows a spectrum plot (constant percentage bandwidth measurement of 6% centre frequency) where the third order harmonic for the most part disappears.

Conclusion

Brüel & Kjær Vibro's COMPASS system successfully detected a fault at an early stage of development while the compressor was still under warranty. The monitoring system played a vital role here since four harmonics are individually monitored. The vibration response of different machine faults manifests itself with different harmonics, and in this case it was the third harmonic that gave the earliest indication of a bearing fault. The fault was slow to develop, so long term trend capability was necessary to follow its progression.

Diagnostic assistance provided by Brüel & Kjær Vibro was able to determine that it was a bearing fault. The compressor manufacturer was contacted, and by looking at the vibration data during their root cause analysis, they were able to determine that one bearing was failing prematurely due to a manufacturing fault. Therefore all bearings were replaced while the compressor was still under warranty. ■

Condition monitoring system requirements for wind turbines

Wind turbine generators (WTG) are expected to deliver energy with optimal availability and minimal Operation & Maintenance cost just like any other energy generating turbine. Condition monitoring systems have proven invaluable in reducing maintenance costs and maximizing uptime in conventional power stations over the years, but can the same machine condition monitoring system be used on a WTG?

Wind energy is the fastest growing renewable energy technology in the world. Production is currently increasing around 30% each year, and there is no sign of it slowing down. Wind power generation has increased five-fold between 2000 and 2007, and it is expected that world wind energy generating capacity exceeds 100 GW this year. Because WTG play such an increasingly important role in the energy market, there is increasingly more pressure to be price competitive with other forms of energy. That means wind turbine availability has to be maximized and Operation & Maintenance costs minimized, as is done in the other types of power stations.

Plant-wide condition monitoring systems have been successfully reducing downtime and maintenance costs in nuclear and thermal power stations over the last 15 years. The same systems are flexible enough to be used also in the petrochemical and process industries. We have been doing this for the last 15 years. So it is only natural to use the same monitoring experience and system technology for the emerging wind turbine generator market, isn't it? The answer is no!

Condition Monitoring System Configuration

A modern plantwide condition monitoring system, like COMPASS, will use approximately 400 input/output channels for monitoring a 1000 MW power plant with four steam turbines. The input/output channels will be hardwired to 90 monitoring modules arranged in 8 cabinets with a total of 16 racks. The monitoring modules perform signal conditioning on the input signals for generating scalar measurements for both safety and condition monitoirng purposes. A monitoring server is remotely connected to the racks over a network for storing and displaying data in plots.

A similar plant wide condition monitoring monitoring system for a WTG windfarm would be both impractical and uneconomical. First of all, there is no instrumentation hall in a wind turbine park, so all monitoring hardware has to be inside the WTGs. Each wind turbine requires between 10-12 channels, which corresponds to one - possibly two - monitoring modules in a rack-mounted system. The rack is almost empty! This can be very expensive if the wind turbine park has 30 or more WTGs in it. Not only are the half-empty racks not very cost-effective, but they use up valuable space within what is considered to be already cramped quarters inside the nacelles. It would be completely impractical to connect cables from several WTGs to a single rack to fill it up. The botton line is that a WTG requires a dedicated hardware system to be both cost and space effective, and fit for the purpose.

Machine Construction

The relatively simple machine construction of a steam turbine train rests on a rigid foundation and turns at high speeds. The turbo-generator sets have proven designs that have been operating for many years. The potential failure modes of these machines are well documented, and relatively easy to detect and diagnose.

A WTG drive train on the other hand rests on a non-rigid foundation and employs a complex planetary gear box that turns at slow speeds. The potential failure modes here are not so easy to detect and diagnose. They require a more comprehensive monitoring strategy to identify weak signals where there is heavy dynamic variation that overlaps with signals from other vibration sources. Many of the WTG components are new designs with very little maintenance history, so some components potentially fail before their life expectancy has been reached. This requires a

Figure 1. Typical rack-based system in the back, for thermal power plants (COMPASS). The laptop sized system in front is dedicated to wind turbines (3652).

comprehensive monitoring strategy with specialized measurement techniques to ensure a wide range of potential failure modes can be detected. Monitoring to alarm limits is a necessity, but in a WTG application, there can be many alarms that occur under such conditions. Therefore an intelligent Alarm management system is needed to suggest the severity of the alarms so the system operator is not “drowning in blinking lights”.

Machines and Operating Conditions

Steam turbines are operating at steady load for long periods of time, with little change in operating conditions.

WTGs operate within a wide range of operating conditions. Vibration and process parameter amplitude values vary not only due to developing faults, but also to operating conditions. In order to detect faults early and to accurately trend them, these two phenomena have to be de-coupled. This is done using what is called an adaptive monitoring strategy. This strategy is important for all types of machines, including steam turbines, but it is especially important for WTGs.

Monitoring and Diagnostics Support

A steam turbine power plant may have four or so generating units, each consisting of a single generator, several turbine stages, and a number of auxiliary machines such as pumps, fans and motors. All data can be trended and analyzed from a single server.

A wind farm can consist of up to 30 or more wind turbines, each consisting of the main bearing, gearbox and generator. All of this data can also be saved to a single server, but there are considerably more critical machines to look after than for a typical power station. The complexity of the analysis can be especially time consuming for a WTG application. A centralised centre for wind turbines is an important alternative to traditional diagnostic support services where faults are both detected and diagnosed, and recommended action is directly reported to the customer service group. This “back-office” type of diagnostics and analysis service is especially important for a wind farm since there is no vibration safety monitoring done to protect the WTGs. As the diagnostics are done remotely at the Surveillance centre, there is no need for a local diagnostic server or database for the customer’s IT department to take care of.

Compliance

There are several standards that govern steam turbine monitorings, but not so for wind turbines. Germancher Lloyd is the current de facto certifying body for condition monitoring systems on WTGs. The insurance company Allianz has also taken a keen interest in how these assets are monitored from an insurer’s point of view.

Conclusion

Wind turbine monitoring requires a system that is specifically dedicated to wind turbines.
You can find out more about Brüel & Kjær Vibro’s Wind Turbine Monitoring System (Type 3652) on our website www.bkvibro.com. ■

events 2009

15th International Seminar
on Hydropower Plants
Vienna, Austria
November 26-28, 2008

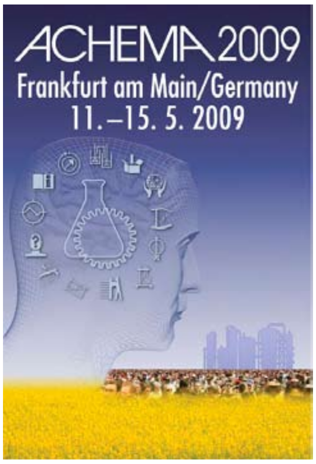
26-28 Nov. 2008

15th International Seminar
on Hydropower Plants
Vienna, Austria
"Hydropower Plants in the context of the climate change"
We will present a paper entitled "Integrated Vibration, Process Monitoring at Hydropower Plant Momina Klisura, Bulgaria" Session B6
www.viennahydro.com

16 - 19 March 2009

EWEC 2009
Marseille, France
European Wind Energy Conference & Exhibition

www.ewec2009.info



11 - 15 May 2009

ACHEMA 2009
Frankfurt am Main, Germany
29th International Exhibition-Congress on Chemical Engineering, Environmental Protection and Biotechnology
www.achema.de