Holistic power plant management

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HBM are leading the way with holistic structural health monitoring systems. Collecting more pertinent data leads to cost optimisation and complex life time predictions. Gilbert Schwartmann gives PES a more in depth insight...

With growing economic pressure on manufacturers and operators of wind power plants, structural health monitoring systems, etc. for measuring loads on blades, nacelles, towers and foundations have almost become the standard. The trend is clearly towards holistic systems for monitoring the plant as a whole. Hybrid measurement technology systems present an interesting new option for users here: they combine the best of "optical" and "electrical" measurement technology.

With installed power of almost 450 Gigawatts worldwide, wind power is no longer in its infancy. And although wind power has been used as a power source for thousands of years, the current form of this power generation is still young – and there are many as yet unanswered questions about its technological and commercial use. This also includes the question as to the possible service life of such a plant because so much empirical data is still lacking.

(Not only) in the offshore field are wind power plants exposed to strong physical forces, torsional moments and other influences. To be able to get the best possible economic benefit from a wind power plant, these circumstances inevitably raise questions for operators, investors and developers of wind plants:

- Is there a way of estimating the service life of a wind power plant?
- Are there means of controlling spare parts requirements as optimally as possible to reduce downtimes and maximise output?
- Are there efficient ways of ensuring the operators are always informed of the current condition of their wind power plant?

Modern measurement technology with structural health monitoring systems can help to obtain much better and more meaningful data to answer these questions than has ever been possible before.

Although structural health monitoring systems cannot predict the future, they can make it "measurable" and "predictable" to a certain extent.

What exactly must be considered when installing structural health monitoring systems (SHM) in wind power plants? At this point, we could go into great length about technologies and possible products. Actually this should be the second question when thinking about installing such a system. A clear consideration of the objective is more important than all other points: Can the structural health monitoring system really help me to obtain relevant data for the optimum economic use of the wind power plant?

Trend towards a holistic view

"Classically", structural health monitoring

systems are used in the drive train of wind power plants. This is also a logical approach to begin with: but considerable torques and loads occur in this central area at the heart of the wind power plant that has to be examined very carefully.

Many wind power plant operators have therefore recognised that this approach does not go far enough. They are aiming at an overall view of their plant, thus also for verification of the stability, condition monitoring after severe weather events (such as storms) or obtaining data for an estimate of the remaining service life of wind power plants.

However, these issues cannot be answered simply with a pure measurement on the drive train, they also need an expansion of the measurement systems on the towers, foundations and blades of wind power plants.

Fast amortisation of installation costs due to reduced downtimes

This holistic view is becoming ever more urgent given the economic demands being made on wind power. To remain competitive on the market the manufacturing costs for wind power plants keep having to be cut. This inevitably entails reductions in the materials used. But the more that is optimised here, the more important the availability of up-to-date data on the condition of wind power plants – for example, in order to prevent material cracking on towers or foundations as catastrophic events.

A holistic structural health monitoring system always pays for itself because users can recognise problems at an early stage and act when costs are low. Downtimes can thus be planned and minimised. In other words: the limited costs for the installation of a structural health monitoring system simply amortise themselves in no time at all by reducing the downtimes.

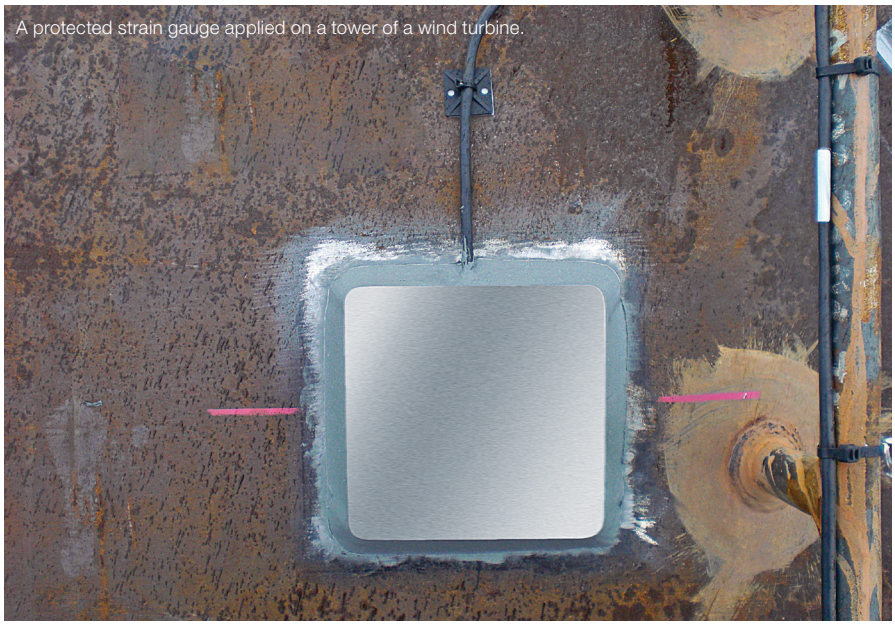
The components of a structural health monitoring system

What do these systems look like in practice? Just like every measurement system, a structural health monitoring system has is made up of three components: the sensor, which is installed on the components of the wind power plant that have to be monitored. For example, these can be strain gages to monitor stretching and stress in the material, or also sensors for other measurement quantities, such as temperature, force, tilt, torque. These sensors can be based on classic electrical measurement technology or on innovative fibre-Bragg-grating transducers. The type of application decides which system is the better choice.

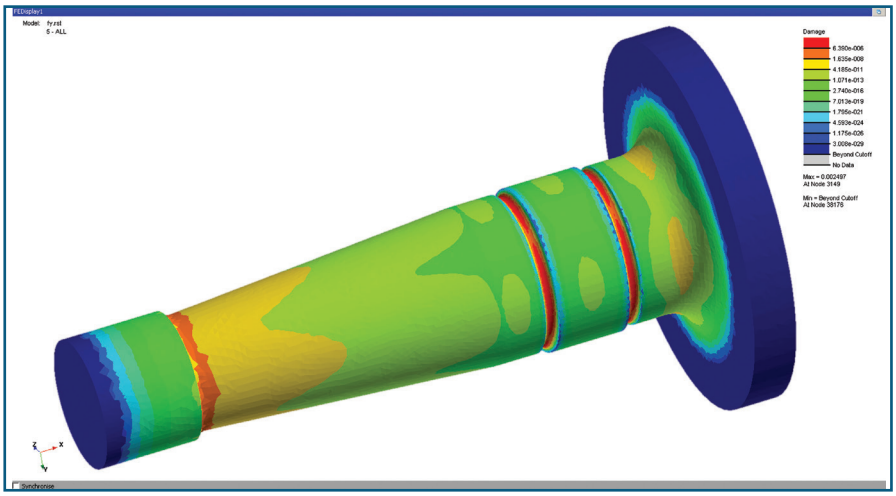
The measurement electronics is the second component in the measurement system: the measuring amplifier and data recorder that digitise the measurement data and possibly continuously store it locally. For optical sensors, these amplifiers are called “interrogators”.

And, finally, the third component, which is ultimately decisive for the user: the software. Here, the measurement data is displayed (visualised), and various calculations or triggers can be submitted in critical circumstances. This is also of interest for structural health monitoring tasks: modern measurement software now goes far beyond purely displaying and further processing the data.

Fatigue and load software, such as HBM nCode GlyphWorks, enables complex life time predictions and calculations, sometimes based on the plant’s CAD data. This software is already in use in many wind power applications.


A protected strain gauge applied on a tower of a wind turbine.

Virtual fatigue analysis using HBM nCode GlyphWorks software



Electrical and optical measurement technology: a comparison of two powerful technologies

But back to the typical measurement technology applications. As described, two different technologies are available for the sensors of structural health monitoring systems: optical and electrical measurement technology.

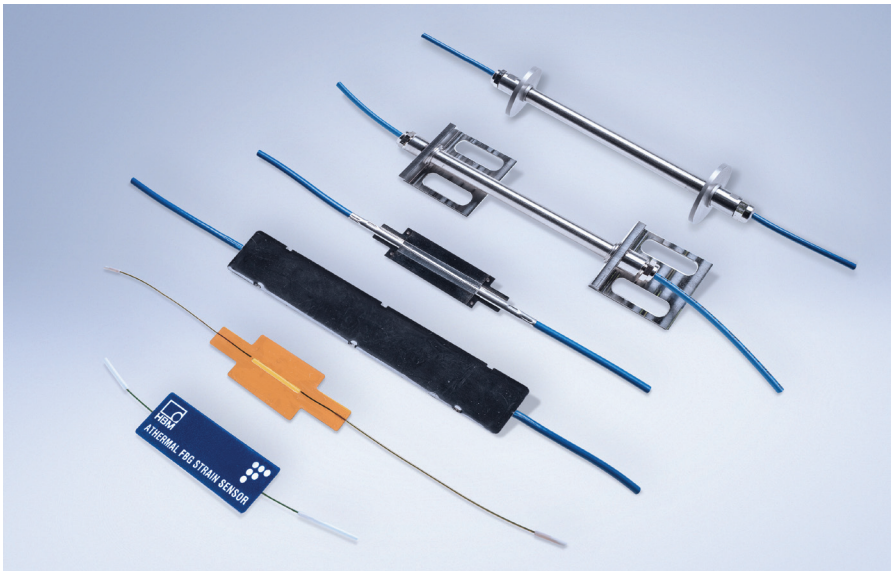
In particular, the optical measurement technology based on fibre Bragg technology has continuously gained in importance for monitoring systems for wind power plants in the last few years. Why is this?

As the name implies, optical sensors use light for measuring. The sensor comprises optical waveguides into which a special patter, the “fibre Bragg grid” (FBG) is incorporated. Due to the differences in the optical waves transmitted, it is thus possible to identify physical quantities.

These technological idiosyncrasies have several advantages for the use of fibre Bragg sensors in wind power plants. The optical sensors work “passively”, which means that they are immune to lightning strikes. They are highly resistance to signs of fatigue and allow measurements of very long stretches and with high numbers of load cycles. Thanks to the multiplexer properties (several sensors can be used in one optical waveguide with only one interrogator as amplifier module), the amount of cabling needed is reduced; furthermore, the optical sensors enable secure data transmission with hardly any information loss even along long cables.

What do these many good properties mean for the use of wind power plants? The answer is clear: they are predestined for the areas of wind turbines in which high numbers of load cycles and very long stretches occur and the amount of cabling needed is minimised. For example, this is the case for strain measurements on the blades of wind power plants where many optical strain sensors can be installed in just one cable (multiplexing).

The measurement technology supplier HBM Test & Measurement offers a broad range of optical FBG sensors and interrogators in the “HBM FiberSensing” product range – including products with sensors to measure strains, tilts, temperature and more. The “FiberSensing WindMETER” complete system is particularly recommended for the operators of wind power plants: this is a reliable total solution specially developed for monitoring the rotor blades in wind power plants. The system comprises a low-consumption opto-electrical interrogator for use in a wide temperature range as well as a set of fibre Bragg grid (FBG)-based strain and temperature sensors.



Optical sensors for different measurands from HBM FiberSensing

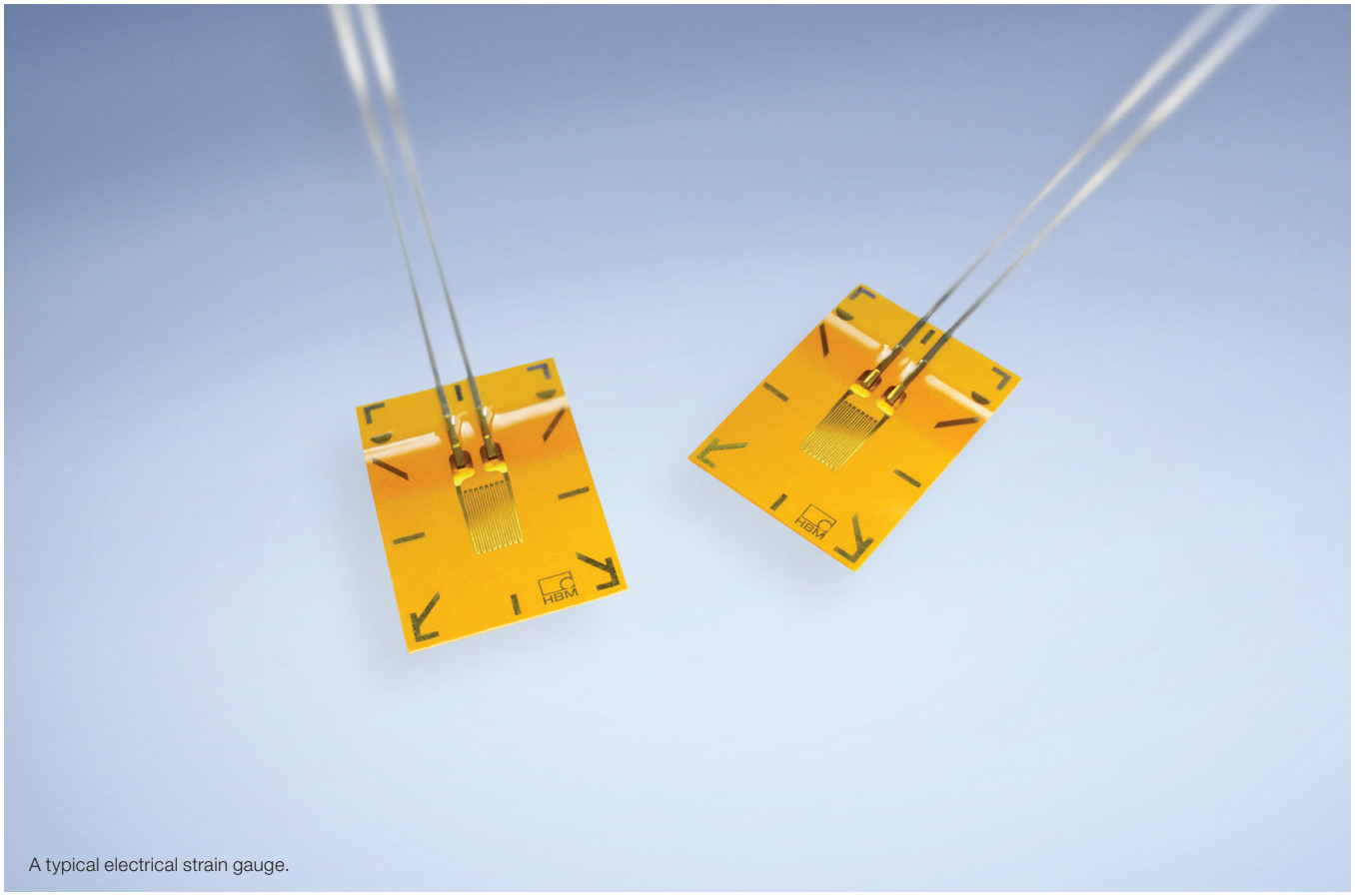

The SLB strain sensor for easy installation on wind turbines.

This innovative system offers permanent power with an installed measurement standard that enables automatic self-calibration of all measurement data every 10 ms.

WindMETER can be integrated in many different applications and supports solutions such as pitch, condition monitoring, load evaluation, validation of the rotor blade construction, vibration monitoring, ice detection. WindMETER can always be adapted to match customised requirements.

Hybrid systems: the best of both worlds

As already said, it is not only about monitoring wind power plant blades, but about considering stability as a whole. Here, many measurements can be carried out with optical measurement technology, but the use of hybrid systems is possible and sensible here in which the classic electrical sensor technology based on strain gages is used. This has the advantages of great reliability, simpler installation and lower costs.



A typical electrical strain gauge.

Thus, hybrid structural health monitoring systems are in use in which electrical measurement technology is also used. For example, they are suitable for installation on towers or foundations. HBM usually offers an "electrical toolkit" based on SLB strain gages and KMR force sensors for this area.

These sensors can be installed very easily in the parts of the wind power plant to be monitored and are ideally suited to outdoor use.

The SLB strain gages made of rust-proof stainless steel can be installed even more easily than conventional strain gages. SLB-700A is used to monitor strains under static or dynamic loads.

KMR force washers measure static and dynamic compressive forces and are particularly suited to monitoring forces, e.g. in production processes or screw connections. Due to degree of protection IP67 measurements in the open air are also possible.

In addition to these two sensors often used in wind power plants, HBM also offers a broad range of other sensors, as well as an extensive range of hundreds of types of strain gages, measuring amplifiers and data recorders with varying degrees of precision – and protection properties.

"At that time no one would have been able to predict the triumphant advance that wind power would make – but the results "made by HBM" are still a reliable compansion in the technological developments of the sector"

A modular system for the appropriate solution

Applying a structural health monitoring solution to the whole wind turbine is a complex task – but it is not impossible. In particular, it is easier if, like HBM as a supplier offering a whole range of measurement technology solutions across the entire measurement chain, a whole modular system of different sensors, measuring amplifiers and software packages are offered that can be optimally tailored to the measurement task in question. Ultimately, it is the objective of monitoring that determines the technology chosen, and not vice versa.

In the field of wind power in particular, many customers are relying on the installation services of technical specialists from HBM, which can even work offshore. Supplementary services, such as weighing entire wind power plants, are also offered.

Operators of wind power plants therefore profit from comprehensive measurement technology expertise with HBM, plus great application experience in the field of wind power. After all, HBM sensors were there as early as 1976 in the development of the first German wind power plants, the "GROWIAN". At that time no one would have been able to predict the triumphant advance that wind power would make – but the results "made by HBM" are still a reliable compansion in the technological developments of the sector. ■

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