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STRUCTURAL HEALTH MONITORING OF WIND TURBINES– NECESSITY FOR FURTHER PROGRESS

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Introduction

Strain measurement is the history of HBM for more than 60 years. The so called experimental stress analysis (ESA) – was always a main business of HBM. Structural Health Monitoring (SHM) is the logical application of this knowledge in Wind energy. In the design and test phase you may validate finite element designs, learn about characteristics and fatigue behaviour of prototypes by using HBM sensors and DAQ systems and finally understand the structural envelope and dominant load cases by using HBM analysis software, which allows you to predict fatigue damage in the design of key components.

Acquiring data at the application

HBM started wind applications very early. In the famous “Grovian”, a pioneering German wind turbine project HBM installed the strain measuring chains. Even it was a giant at its time; “Grovian” was finally taken down 1987 for trouble with the whole structure. Anyway, for us it was an extensive source of experience in wind energy generation. And things moved on very fast. Our customers are increasingly looking for is a combination out of a wide range of different measurement components and a service capable to puzzle them all together [1], [2]. On a larger scale we are conducting wind projects since about 10 years and we conducted approx. 20 larger projects since then. It started in the time that FINO and RAVE paved the way for Germany’s first offshore wind park >>Alpha Ventus<< [3]. With the growing number of references we found out, that we needed a better segmentation of business. We have own engineering competences, able to establish measuring concepts for the whole structure. We can do that from customer specifications via project management, installation and commissioning to the running wind turbine. HBM offers a world-wide distribution network. Furthermore our service teams are operating in the different wind farms worldwide. We have trained teams in Germany and Norway, both certified according GWO.

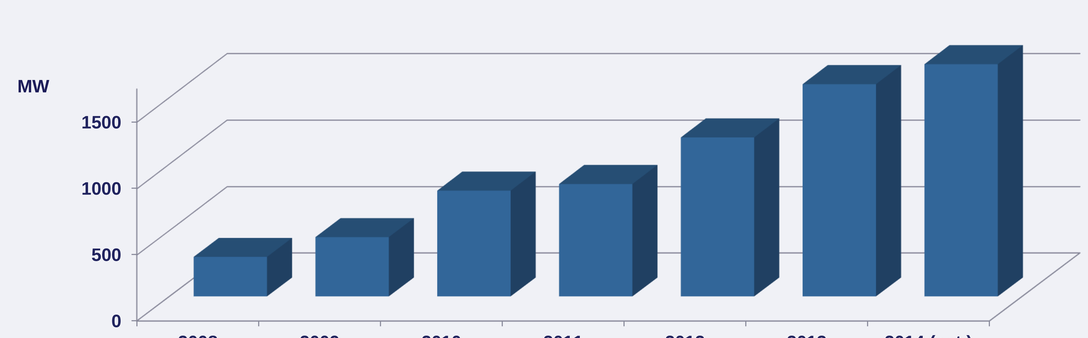

Fig 1: Offshore wind power newly installed worldwide [6]

For strain measurement lifetime aspects are discussed with the choices out of electrical strain gauges, the use of strain transducers or even optical strain gauges [4]. But data acquisition may be even more important as the data have to be conditioned so they are there synchronized, centralized and organized to be finally qualified and classified as OK/NOK.

Identifying potential weaknesses in critical components already during the design phase of the wind power system can be done by the advanced analysis and fatigue software “nCode DesignLife”. This software for structural integrity certified by DNV·GL Renewables certification can be used for the design of cast and forged structural machinery components in wind turbines. Monitoring the status of rotor blades, towers and foundations also under water is a challenge, but at the same time it allows a perfect insight to the status of the structure. After you have you done this you are able to collect operational data over the years of operation. These data will be needed to be visualized, preferably as web based life data in an appropriate manner, so you can monitor defined limits and finally generate reports.

Wind blade monitoring is becoming crucial due to the increasing capacity of generators and, consequently, of larger blade sizes. Moreover, the increasing number of off-shore facilities creates a need for reliable real time monitoring solutions. HBM's Optical Measurement technology that is based on fiber Bragg gratings (FBG) has generated a great deal of interest. This technology comprises optical strain gauges (SG) and interrogators, i.e. data acquisition systems with suitable software. HBM successful with FBG technology at Wind Energy 2014. HBM has expanded its position in this field through the acquisition of Portuguese FBG specialist FiberSensing, underlining the importance of this topic. HBM is confident that the expansion of its product portfolio will enable it to optimally support its wind energy customers' products with suitable technical solutions.

HBM Fiber Sensing

Fig 2: New company logo >>HBM FiberSensing<<

HBM FiberSensing WindMETER system is a complete optical monitoring solution specifically designed to be installed in wind blades. The system consists of an interrogator and a set of passive fiber Bragg grating (FBG) strain and temperature sensors, featuring inherent insensitivity to environmental induced drift. The system allows high resolution to be attained even for long fiber leads and connections with losses.

Trends reflected in measurement tasks

If we look the market as recent figures show, wind energy is on the road of success. Installations are on track and hit a seventh consecutive annual record last year. For its large generation capacity- will be a long term driver of energy generation [5]; [6]. Recently, clear trends have emerged in wind power applications such as higher towers and longer blades. The new sizes are needed for more profitable operation and the final report of “Upwind” [7], a joint project of the European Union, sees no reason why this trend should not continue. The successor project is on the way. However, there is a contradiction in the ever increasing dimensions and the move from onshore to offshore; it has brought about the demand for higher reliability due to much higher service costs because turbines have become less accessible. This is why we believe Structural Health Monitoring for wind turbines is a necessity for further progress in the field.

Fig 3: Influences to onshore and offshore turbines : As for an offshore application the turbine has to withstand wind and wave oscillation lifecycles over 20 years go into billions (Picture Source: HBM)

Environmental conditions are tough and there are billions of load cycles. Anyway, you could design a more lightweight turbine by keeping the present level of reliability. For this you need a reliable measurement of mechanical quantities. This is vital to meet the high standards required for the design of offshore turbines with an expected lifetime of 20 or even 25 years [8], [9]. For towers and foundations this challenge can be solved by foil type strain gauge or transducers such as strain meters, force transducers and accelerometers [10]; [11]. For blades made from composite material and exposed to high strain optical strain sensors using FBG are advantageous [12].

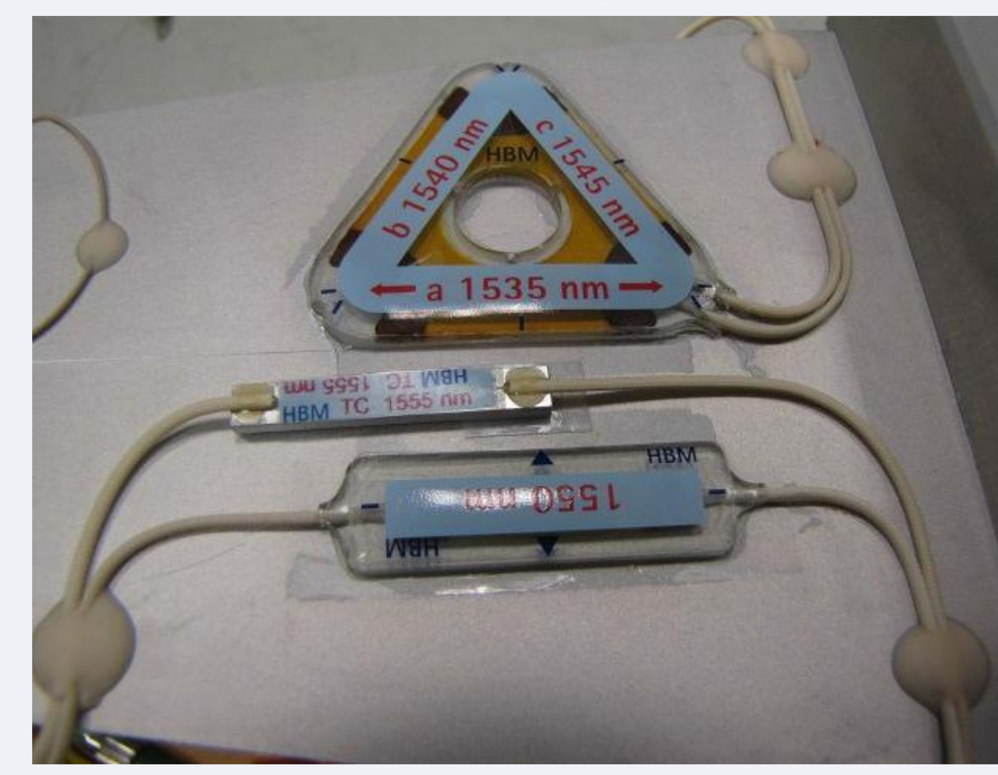

Fig 4: Different types of optical strain gages >>OptiMet<< by HBM

To further optimize the design of wind turbines; manufacturers have an interest to analyse data. According to GL Renewables certification as well as German BSH is not enough to just monitor the drive train, but also towers, foundations and blades have to be monitored [13], [14], [15].

Conclusions

Today’s wind turbines are getting larger and taller than in the past. Due to economic threshold this superlative is strongly related to offshore applications and also the portion of offshore turbines out of all wind turbines will further grow [16], [17]. SHM can help to reduce downtime and keep availability during operation very high. It can also help to extent life time and finally using the methods described above, major components of wind turbines such as blades, towers and offshore foundations could be operated safely, or even redesigned without any loss of reliability and a contribution to more economic wind turbines can be made as well.

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