Acoustic Emission as a Tool for Condition Monitoring of Oscillating Bearings

Dennis RÖLLINGER *, Domenic BOOS *, Tobias VRAETZ *, Karl NIENHAUS *
* Institute for Mining and Metallurgical Machinery, RWTH Aachen University,
Wüllnerstraße 2, 52064 Aachen, Germany
droellinger@imr.rwth-aachen.de

Abstract

Driven by the economic pressure, the manufactures are steadily up scaling their wind turbines. In a quest for cost reduction and lower environmental impact, rotor diameters can be considered as one of the key parameters. One example is the B75 blade made by Siemens with an astonishing 75m total length. But with increasing size of turbine blades comes the need for a more sophisticated load control. Modern Pitch Control Systems with a built-in intelligence make it possible to control the pitch of each blade independently. The so called Individual Pitch Controls (IPC) is quite effective in reducing the fatigue loads but goes hand in hand with a higher stress on the bearings. According to the exemplary report on a collaborative research project “Load reducing control systems for multi-megawatt wind turbines in the offshore sector” the Fraunhofer IWES et al. comes to the conclusion that the bearings of pitch systems undergo a significant increase in fatigue damage which makes a permanent IPC not practical. Design modification of bearings on the one hand and highly sophisticated condition monitoring systems on the other hand could contribute the solution to this challenge. However, conventional condition monitoring systems have their limitations when it comes to the monitoring oscillating bearings. One potential tool for the monitoring of pitch bearings is Acoustic Emission Technology. The high bandwidth and high data sampling rate of modern Acoustic Emission Systems offer the measured information that is needed to estimate the damage during small angular rotation. At the same time this creates huge amounts of data that has to be recorded and processed. Our goal is to develop hardware with implemented data reduction algorithms to allow the usage of Acoustic Emission technology with data sampling rates in the two-digit range outside of a laboratory. In the poster, it will be outlined which burst detection algorithms has been chosen and how the interaction of state-of-the-art hardware with implemented data reduction methods could make Acoustic Emission a tool for condition monitoring of pitch bearings.

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Univ.-Prof. K. Nienhaus, Dipl. Wirt.-Ing., D.Röllinger, Dipl. Wirt.-Ing. F. D. Boos, T. Vraetz M.Sc.

The introduction of new load-reduced regulatory actions in form of a modern single-blade adjustment can lead to an increase in stress for the pitch system of wind turbine generator systems[1]. The monitoring of these highly stressed, oscillating pitch bearings is a challenge for many conventional condition monitoring systems. The problem is that oscillating movement cannot be described by a sequence of pulses. Especially in this case the burst detection provides a valuable contribution to the development of a system that is able to monitor the condition of these bearings. Of particular interest is the combination of the burst information with angular information. It seems therefor reasonable to create an angle-based burst parameter in order to monitor this specific type of bearing. For one thing, the analysis has to provide a burst per angle unit parameter, for another the overrun rate of an individual bearing part. These parameters can be used not only to schedule maintenance programs or major repairs but also to increase lifetime of a bearing with status-related control programs.

To achieve these objectives a very high date sampling rate, instead of envelopes, is crucial. The required level of resolution is achieved with a raw data sample measurement in frequency range of 100 MHz with an oversampling of > 10 MHz. Due to the high resolution signal detection within the double-digit MHz range and the continuous data recording, a huge amount of data (several gigabytes) needs to be handled in short time which presents a major challenge especially in remote monitoring applications. Streaming of the data and a subsequent analysis on a PC is not feasible.

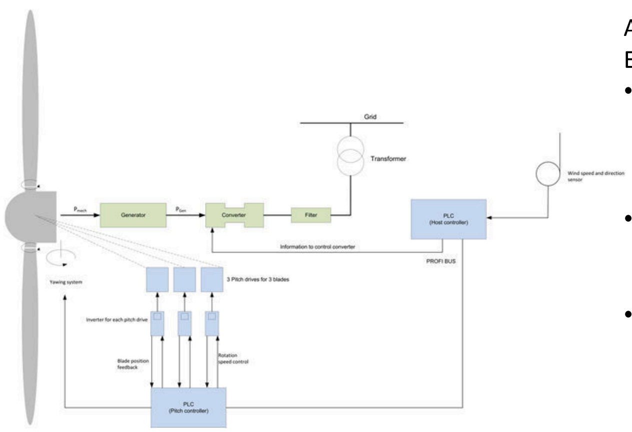
It was out of this situation that the project MAEX (Multianalysis Acoustic Emission data eXtractor) was created. A fundamental objective of MAEX is the reduction of data in real time to allow a practical application of acoustic emission in the field. Within the research project a powerful hardware will be developed that is able to process the high amount of data. Additionally our experience in Burst Detector Fusion and other algorithms, yet to be developed, will be used for a data reduction and AE parameter extraction in real time. The combination of powerful hardware and the implementation of new data reduction methods are the main objectives of the MAEX research project.[2]

Acoustic Emissions (AE)

- Relatively new in the area of condition monitoring
- Does not need full circulation of a bearing for damage accumulation
- Application especially for wind turbine bearings (pitch bearings)
- Basic Principle : Burst Detection

MAEX

- Condition Monitoring of oscillating pitch bearings
- Development of a ruggedized measuring system
- High sampling rates up to 10MHz
- Analyzing bearing life
- Parameter calculation on system in realtime



Application to Wind Energy Production

- Upscaling of wind turbines lead to individual pitch control
- Pitch lead leads to highly stressed pitch bearings
- Almost zero rotational speed of a pitch bearing leads to a novel CM method

ZIM Zentrales Innovationsprogramm Mittelstand

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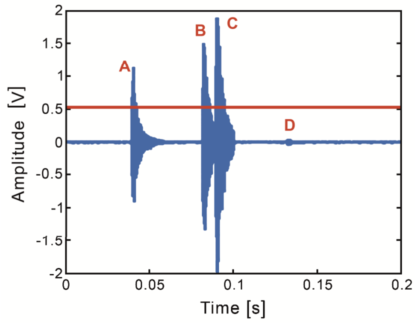
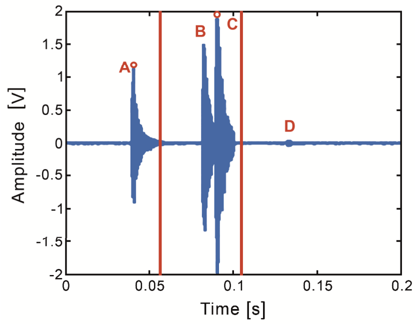
Burstdetection Algorithms:

a



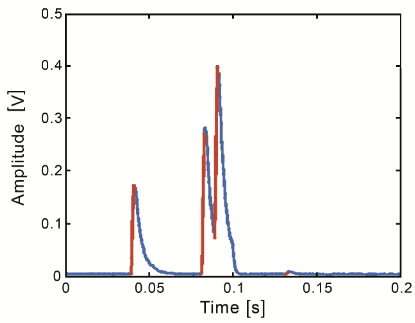
Detecting Bursts using a static (dynamic) threshold is a common method for analyzing AE Bursts

b



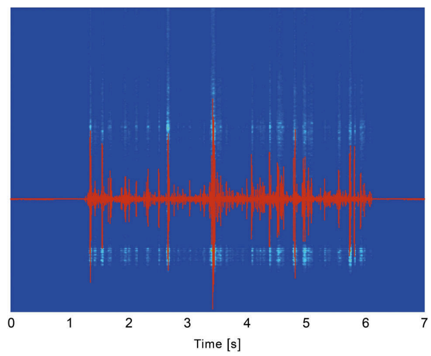
Analyzing an AE Signal vertically rather than horizontal leads to an exact burst maximum

c



Because of the short rising time of an AE Burst it is possible to detect them using a slope indicator

d



Each Burst excites an individual (based on sensor) frequency spectrum

References

[1] Shan, M. et al., "Field Testing and Practical Aspects of Load Reducing Pitch Control Systems for a 5 MW Offshore Wind Turbine", EWEA 2013

[2] Nienhaus, K et al., "Condition Monitoring of Oscillating Bearings with Acoustic Emission Technology", In Proceedings of the International Acoustic Emission Symposium, Sendai (Japan) 2014