

Vibration spectrum of a wind turbine rotor blade.

Possible future Applications

- Highly spatially resolved vibration data for validation of simulation models
- Structural and aerodynamical optimization of rotor blades
- Evaluation of the structural condition of a plant – lifetime extension or repowering?
- Detection of hidden damages by performing regular control measurements
- Localization and analysis of sources of altered vibrational behavior and/or damages
- Identification and quantification of noise emission and noise sources during operation

Further Information

www.iosb.fraunhofer.de/en/projects-and-products/distant-vibration-measurement-wind-turbines.html

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Laser Doppler Vibrometry

Measuring Vibrations of Wind Turbine Blades during operation

nawrocki alpin
GmbH

Gefördert durch:



aufgrund eines Beschlusses
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Innovative approach for the investigation of wind turbines

Non-contact, from a distance and without installed sensors: Camera-based localization and precise tracking enable laser vibration measurement on rotor blades during operation.

Problem and technical Approach

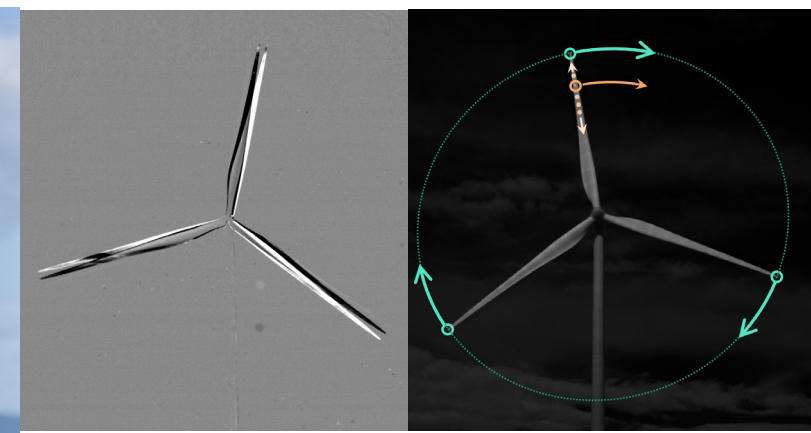
From our everyday experience we know how much vibrations and noises can tell us about the functional state of technical devices such as cars, washing machines or air conditioners. Vibration sensors therefore monitor the behavior of large machines and installations such as wind turbines and ensure safe operation. They are also used during their development and optimization.

Costs and technical feasibility limit the number of sensors that can be fitted to the components of a plant. Permanently integrated sensors may not be replaceable if damaged.

In order to be able to capture vibrations at any desired point for detailed investigations or for the development of wind turbines, Fraunhofer IOSB is developing a distant measurement method. It is based on laser Doppler vibrometry, in which an optical sensor uses a laser to register the longitudinal movement of the object's surface with high precision. The combination with a tracking system also allows vibration measurement on rotor blades during operation by tracking the laser to the respective measuring point.



Laser Doppler vibrometer mounted on a pan-tilt unit.

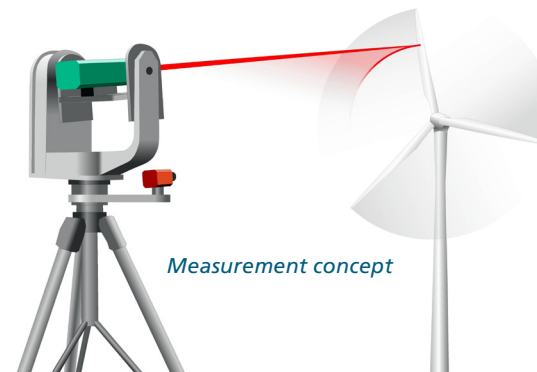


*Left: Differential image of two successive camera frames.
Right: Detecting the rotor blade tips for tracking a measurement point with the laser.*

Status, Results and Objectives

Laser Doppler vibrometry is an established technique for non-contact vibration measurement on stationary objects and machines over short distances. In previous projects, Fraunhofer IOSB was able to refine it for measurements on moving objects as well as over longer distances. Initial measurement data demonstrated the feasibility of using it on wind turbine rotor blades during operation.

Based on the findings from previous studies, an optimized system was built specifically for this application in the current project »WEALyR«. Together with the project partner, the company Nawrocki Alpin GmbH from Berlin, IOSB is investigating the information and conclusions that can be gained about wind turbines with this measurement method and which applications can be based on it.



Laser Doppler Vibrometry and Tracking

In contrast to commercially available devices, the Fraunhofer IOSB's specially developed laser Doppler vibrometer operates at an infrared light wavelength of 1.5 μm . This allows the device to be operated eye-safe even with higher laser powers, which are necessary for the measuring distances of several 100 meters. The greatest technical challenge concerning the resulting data is to separate the vibration movements to be measured from the rotary motion of the rotor, which is up to 1000 times larger and faster.

To control the tracking, the camera of the tracking system must operate in the wavelength range of the laser. Image processing algorithms detect the rotor blade tips in these images and calculate a virtual 3D model of the rotating rotor from their movements. To suppress the stationary image background, the differential images of successive frames are used. Based on the virtual model, the computer controls a pan-tilt platform to follow a desired measurement point on the rotor blade with the laser. A control loop uses the detected position of the laser in the camera image for stabilization.