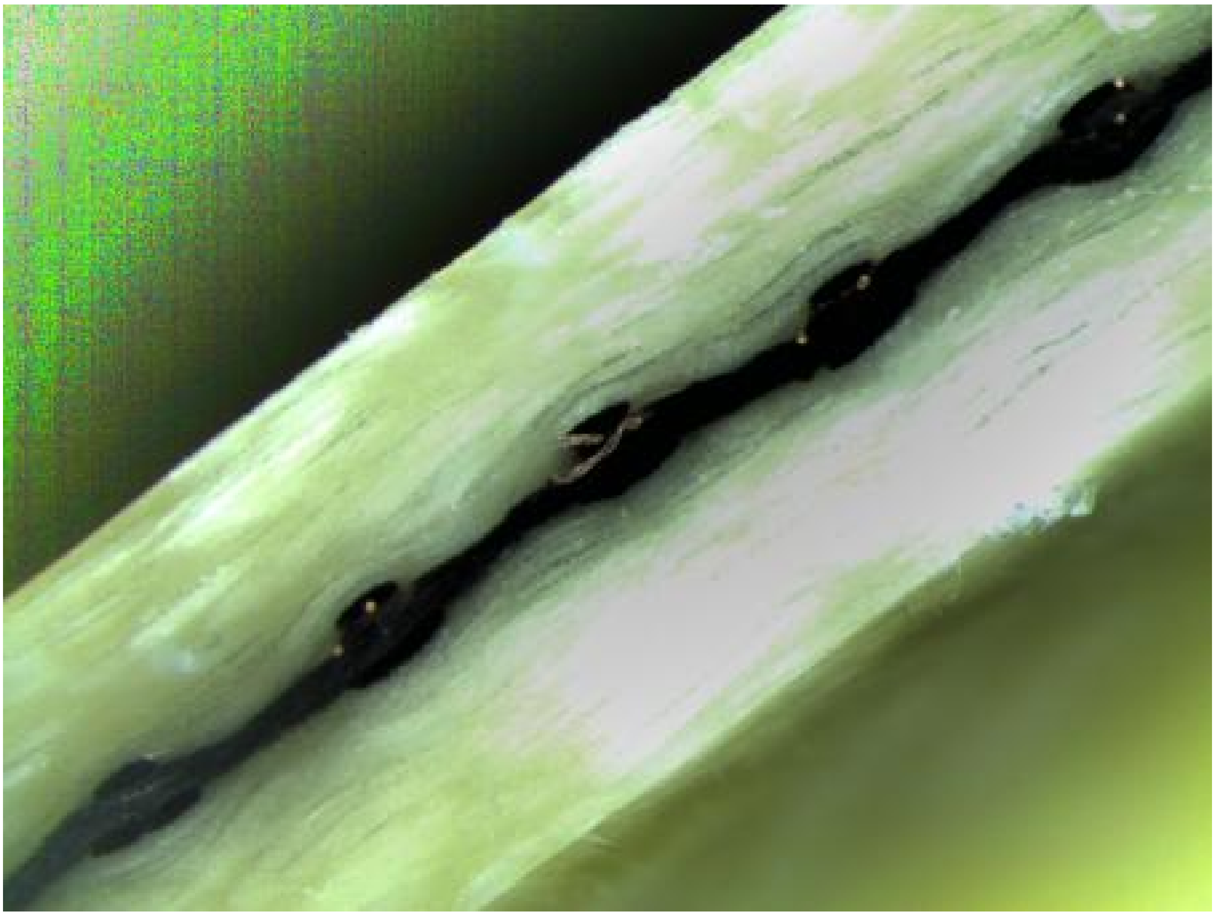
Integrating structural monitoring into wind turbines: sensor strips for rotor blades

About this project



SWING

Integrating structural monitoring into wind turbines: sensor strips for rotor blades

Markets:

Material: Others (Sensory yarns), Glass fibres, Metal fibres, Others (Sensory yarns), Others (Sensory yarns), Thermoset plastics, Others (Copper wire), Yarns, rovings, Others (Sensory / capacitive yarn), Glass-fiber reinforced plastics (GFRP), Others (Sensory glass fibre and copper wire yarn)

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This project is funded by the Technology Transfer Programme Leichtbau (TTP LB) of the Federal Ministry of Economics and Energy.

Technology Transfer Program Leichtbau

Context

Wind turbine rotor blades are predominantly made of fibre-reinforced composites and are subjected to high and varying loads during operation over many years. As the behaviour of these materials over long periods can only be predicted to a limited extent, rotor blades are often designed with safety margins. This can lead to increased material usage or mean that the actual remaining service life of a rotor blade is not fully utilised.

This is particularly relevant for older wind turbines. Once their standard operational lifespan has expired, their continued use must be validated through complex tests and assessments. As these procedures are time-consuming and costly, potential lifespan extensions are often not implemented. At the same time, many existing sites are only of limited suitability for the construction of new wind turbines.

Various sensor systems are already in use for the condition monitoring of rotor blades. However, these often only detect stresses or damage at specific points or indirectly. This means that local changes along the length of the large component can only be assessed to a limited extent. Furthermore, many solutions involve high costs or a complex integration process. There is therefore a need for a cost-effective technology that can be deployed over a wide area and is capable of directly measuring stresses within the rotor blade.

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Purpose

The aim of the researchers in the SWING project is to develop a functionally integrated blade for structural monitoring of rotor blades. The integrated sensor technology is designed to measure strain not only at individual measurement points, but also across larger areas of the component. To this end, the researchers are further developing a capacitive measurement system capable of determining stress conditions along the length of the rotor blade. Capacitive sensors utilise changes in electrical properties to measure mechanical deformations.

The project partners aim to demonstrate that the sensor technology can be integrated into a stiffening rib without significantly impairing its structural function. At the same time, the aim is to create a robust and repeatable measurement system that delivers reliable data even under real operating conditions.

In addition, the project team is developing an evaluation and communication unit that converts the recorded measurement signals into usable information on loads, deformations and potential damage. The technology is intended to lay the foundations for more robust service life assessments, thereby enabling longer service lives, maintenance tailored to actual needs and a more efficient use of resources. Furthermore, the project team is investigating the extent to which bio-based and circular materials can be used in the manufacture of the lamella.

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Procedure

The researchers are initially developing capacitive sensor yarns and investigating their measurement behaviour under mechanical stress. On this basis, they are designing textile sensor structures capable of detecting strain over longer distances. The project partners then integrate the sensor yarns into narrow textiles, which allow the sensors to be positioned precisely within the final component.

In the next step, the project partners incorporate the textile structures into the reinforcing lamellae. To do this, they use pultrusion, a continuous process for manufacturing fibre-reinforced profiles. In the process, they investigate how the sensor technology can be integrated reliably and what influence the manufacturing parameters have on measurement quality.

At the same time, the project team is developing evaluation electronics with associated software for recording and interpreting the sensor signals. The researchers then test the technology in the laboratory and under conditions close to real-world applications. To this end, they are carrying out load and endurance tests and investigating the functionality on rotor blade demonstrators. The project partners are using the insights gained to further develop the sensor technology, the evaluation system and the manufacturing process, and to assess the technology’s suitability for use in wind turbines.

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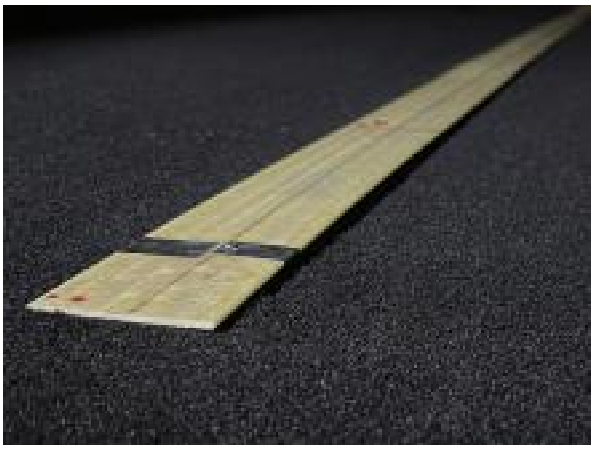

Funding duration:

Funding sign:	03LB2073	**Funding amount:**	EUR 740 thousand

Final report

Further websites foerderportal.bund.de/foekat/jsp/SucheAction.do?actionMode=view&fkz=03LB2073A - SWING in the federal government’s funding catalogue

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Project coordination

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English (EN){{ Projektpartner }}

Aero Dynamik Consult GmbH

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Lightweighting classification

	Realisation
Offer	
Products Parts and components, Semi-finished parts, Machines and plants, Materials	✓
Services & consulting Testing and trials, Engineering, Simulation	✓
Field of technology	
Design & layout Hybrid structures	✓
Functional integration Sensor technology, Material functionalisation	✓
Measuring and testing technology Component and part analysis, Materials analysis	✓
Modelling and simulation Loads & stress, Life-cycle analysis, Materials	✓
Plant construction & automation Plant construction	✓
Recycling technologies Others (Extension of service life and useful life)	✓

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Lightweighting classification

	Realisation
Manufacturing process	
Additive manufacturing Others (Wrapped sensor yarn, knitting)	✓
Coating (surface engineering) Others (Circumvention)	✓
Fibre composite technology Others (Pultrusion)	✓
Forming	
Joining	
Material property alteration Others (Sensor integration)	✓
Primary forming Pultrusion	✓
Processing and separating	
Textile technology Yarn & roving production, Knitting, laid web production, Others (Sensory yarns)	✓

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Lightweighting classification

	Realisation
Material	
Biogenic materials Others (Sensory yarns)	✓
Cellular materials (foam materials)	
Composites Glass-fiber reinforced plastics (GFRP), Others (Sensory glass fibre and copper wire yarn)	✓
Fibres Glass fibres, Metal fibres, Others (Sensory yarns)	✓
Functional materials Others (Sensory yarns)	✓
Metals Others (Copper wire)	✓
Plastics Thermoset plastics	✓
Structural ceramics	
(Technical) textiles Yarns, rovings, Others (Sensory / capacitive yarn)	✓