WindSTAR

Wind-Energy Science, Technology, and Research
Industry/University Cooperative Research Center

Intelligent Damage Detection from Wind Turbine Blades Using Acoustic Excitation

Principal Investigator:
Murat Inalpolat, University of Massachusetts Lowell

Co-Principal Investigators:
Christopher Niezrecki, University of Massachusetts Lowell
Yan Luo, University of Massachusetts Lowell

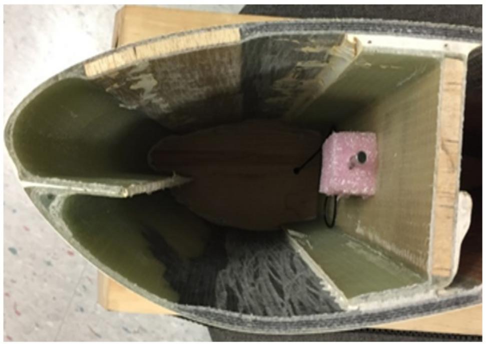
Student Researchers:
Christopher Beale, University of Massachusetts Lowell
Ioannis Smanis, University of Massachusetts Lowell

IAB Mentors:
Adam Johs, EDP Renewables
Ben Rice, Pattern Energy

In this project, a novel acoustic sensing technique was used to detect cracks, holes, delaminations and trailing edge splits from wind turbine blades. Acoustic speakers were used to excite the blade's cavity from internally and aerodynamic noise due to wind from externally. Wireless microphones were used for the cavity-internal passive detection and a single microphone located underneath the nacelle was used for the external active detection of damage. The main focus of this project was on the field tests on a full-scale turbine blade as well as signal processing and machine learning algorithm development to enable this technology.

This project enabled the team further develop a state of the art acoustics-based structural sensing and health monitoring technique, which requires efficient algorithms for operational damage detection from wind turbine blades. The team initially focused on the passive acoustic detection aspect of the project. A renewed passive damage detection test campaign was initiated on a fullscale blade undergoing flapwise fatigue testing at the Wind Technology Testing Center (WTTC) in Charlestown, MA. This approach leverages the energy caused by the wind/flow-induced noise, exterior to the cavity. It is inexpensive, in-situ, and effective to detect holes, cracks and leading/trailing edge splits in bonded surfaces. The blade can be continuously monitored and when damage is originated, the internal acoustic signature should change due to the changes in the transmission loss (caused by the hole or crack) and/or the distorted acoustic pressure field. The sound field inside the blade should be significantly different when the blade cavity is no longer sealed to the fluid passing over the exterior of the blade. A single microphone inside the blade cavity can be used to track the differential noise component caused by the damage, which essentially couples the blade cavity to the exterior airflow.

The team has also worked on the active detection part of the project. For this part of the project, a utility scale turbine blade that exists at the WTTC has been utilized. The blade-internal cavity has been ensonified by acoustic speakers and blade-external microphones have been used to detect any changes in the acoustic transmission loss due to damage. After the aforementioned tests, the team has been developing a suite of preliminary damage detection algorithms that will be used to detect damage under operation.



A close-up of a blade-internal microphone used for in-lab acoustic detection tests.

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