Wind Turbine Blade Damage Detection by Acoustic Measurements using the m+p System

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The Structural Dynamics and Acoustic Systems Laboratory (SDASL) at UMass Lowell is currently working on the development of an acoustics-based sensing technology for wind turbine blade damage detection. The team uses a laboratory-scale wind turbine to carry out preliminary tests, where they measure the acoustic frequency response functions (FRFs) between the actively controlled acoustic speakers inside the blade cavities and the microphones both inside and outside the blades and on the tower (see Fig. 1).

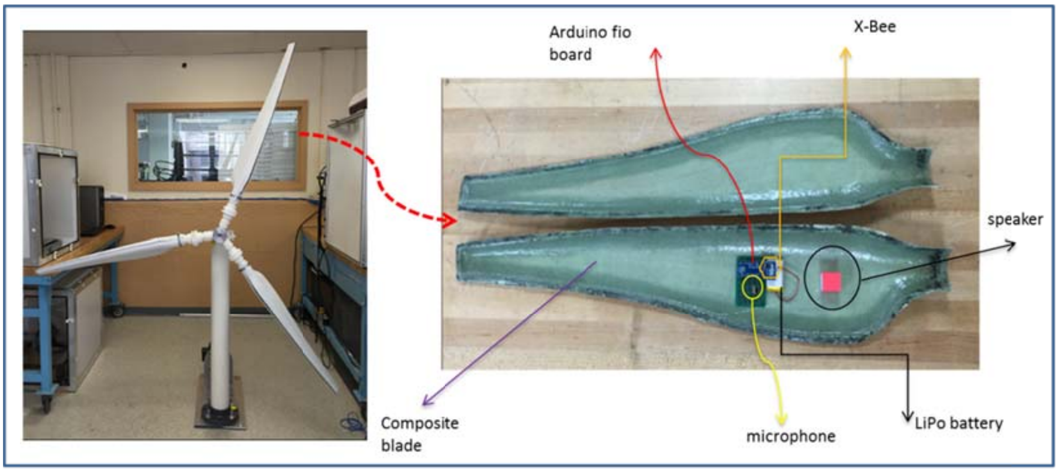

Fig. 1 The laboratory-scale wind turbine and a close-up view of the acoustic sensing circuitry inside one of the blades.

The datasets collected are obtained in order to establish a baseline FRF between the source and the sensing element within the blade cavity. The main idea is that the FRF will deviate from this baseline FRF when damage occurs. The cavity of the composite blade is expected to be in complete isolation to the outside when there is no damage.

Initially, pure tone signals were used to acoustically excite the cavity from inside and National Instruments PXI 64-channel data acquisition system powered by m+p data acquisition software was utilized in order to collect the signals from a microphone inside the blade and another microphone located outside the blade but located on the tower of the subscale turbine. All of the measured signals were transmitted to the PXI DAQ system. The sound pressure spectra obtained from the operational (rotating) and healthy blade and when the same blade has an intentionally created 3 mm tip hole are compared in Fig. 2.

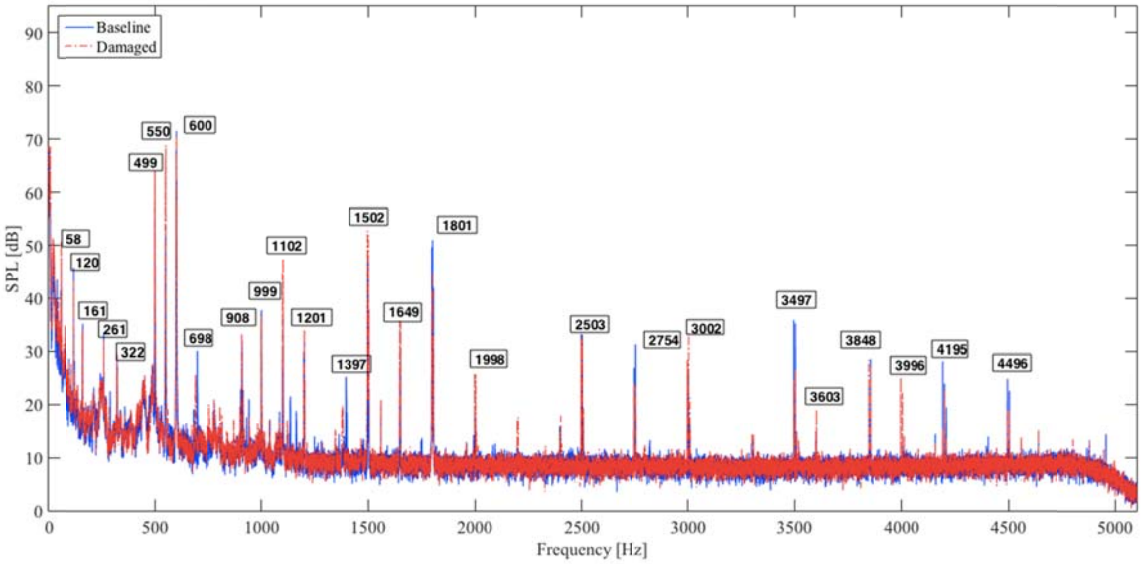

Fig. 2 Comparison of the SPL spectra (FRF assuming a unit volume velocity) obtained by a blade external microphone located on the subscale wind turbine with non-rotating baseline blades and when one of the blades had a tip hole (D = 3 mm)

This set of data was taken when all three turbine blades were ensonified by their internal speakers generating three different tones at 500 Hz, 550 Hz, and 600 Hz, respectively. Although the speakers generated pure tones at discrete frequencies, the signals get distorted by the cavity acoustics and thus the corresponding spectra have multiple harmonics ($f_i = i.500$, $f_j = j.550,\ f_k = k.600\ Hz,\ where\ i, j\ and\ k\ are\ the\ harmonic\ \#$) of the intended pure tone signals. The comparison presented in Figure 10 not only indicate a SPL increase at 500 Hz (first blade with a damage), but also indicate the existence of other peaks, for instance the peaks located at $698\ Hz, 908\ Hz, 1397\ Hz\ etc$.