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# Vibroacoustic Modulation of Wideband Vibrations and its Possible Application for Windmill Blade Diagnostics

**Authors :** Abdullah Alnutayfat, Alexander Sutin, Dong Liu

**Abstract :** Wind turbine has become one of the most popular energy productions. However, failure of blades and maintenance costs evolve into significant issues in the wind power industry, so it is essential to detect the initial blade defects to avoid the collapse of the blades and structure. This paper aims to apply modulation of high-frequency blade vibrations by low-frequency blade rotation, which is close to the known Vibro-Acoustic Modulation (VAM) method. The high-frequency wideband blade vibration is produced by the interaction of the surface blades with the environment air turbulence, and the low-frequency modulation is produced by alternating bending stress due to gravity. The low-frequency load of rotational wind turbine blades ranges between 0.2-0.4 Hz and can reach up to 2 Hz for strong wind. The main difference between this study and previous ones on VAM methods is the use of a wideband vibration signal from the blade's natural vibrations. Different features of the vibroacoustic modulation are considered using a simple model of breathing crack. This model considers the simple mechanical oscillator, where the parameters of the oscillator are varied due to low-frequency blade rotation. During the blade's operation, the internal stress caused by the weight of the blade modifies the crack's elasticity and damping. The laboratory experiment using steel samples demonstrates the possibility of VAM using a probe wideband noise signal. A cycle load with a small amplitude was used as a pump wave to damage the tested sample, and a small transducer generated a wideband probe wave. The received signal demodulation was conducted using the Detecting of Envelope Modulation on Noise (DEMON) approach. In addition, the experimental results were compared with the modulation index (MI) technique regarding the harmonic pump wave. The wideband and traditional VAM methods demonstrated similar sensitivity for earlier detection of invisible cracks. Importantly, employing a wideband probe signal with the DEMON approach speeds up and simplifies testing since it eliminates the need to conduct tests repeatedly for various harmonic probe frequencies and to adjust the probe frequency.

**Keywords :** vibro-acoustic modulation, detecting of envelope modulation on noise, damage, turbine blades
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