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Vibro-Acoustic Modulation for Crack Detection in Windmill Blades

Authors : Abdullah Alnutayfat, Alexander Sutin

Abstract : One of the most important types of renewable energy resources is wind energy which can be produced by wind turbines. The blades of the wind turbine are exposed to the pressure of the harsh environment, which causes a significant issue for the wind power industry in terms of the maintenance cost and failure of blades. One of the reliable methods for blade inspection is the vibroacoustic structural health monitoring (SHM) method which examines information obtained from the structural vibrations of the blade. However, all vibroacoustic SHM techniques are based on comparing the structural vibration of intact and damaged structures, which places a practical limit on their use. Methods for nonlinear vibroacoustic SHM are more sensitive to damage and cracking and do not need to be compared to data from the intact structure. This paper presents the Vibro-Acoustic Modulation (VAM) method based on the modulation of high-frequency (probe wave) by low-frequency loads (pump wave) produced by the blade rotation. The blade rotation alternates bending stress due to gravity, leading to crack size variations and variations in the blade resonance frequency. This method can be used with the classical SHM vibration method in which the blade is excited by piezoceramic actuator patches bonded to the blade and receives the vibration response from another piezoceramic sensor. The VAM modification of this method analyzes the spectra of the detected signal and their sideband components. We suggest the VAM model as the simple mechanical oscillator, where the parameters of the oscillator (resonance frequency and damping) are varied due to low-frequency blade rotation. This model uses the blade vibration parameters and crack influence on the blade resonance properties from previous research papers to predict the modulation index (MI).

Keywords : wind turbine blades, damaged detection, vibro-acoustic structural health monitoring, vibro-acoustic modulation
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