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Analysis of the Vibration Behavior of a Small-Scale Wind Turbine Blade under Johannesburg Wind Speed

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Abstract : The wind turbine blade may sustain structural damage from external loads such as high winds or collisions, which could compromise its aerodynamic efficiency. The wind turbine blade vibrates at significant intensities and amplitudes under these conditions. The effect of these vibrations on the dynamic flow field surrounding the blade changes the forces operating on it. The structural dynamic analysis of a small wind turbine blade is considered in this study. It entails creating a finite element model, validating the model, and doing structural analysis on the verified finite element model. The analysis is based on the structural reaction of a small-scale wind turbine blade to various loading sources. Although there are many small-scale off-shore wind turbine systems in use, only preliminary structural analysis is performed during design phases; these systems' performance under various loading conditions as they are encountered in real-world situations has not been properly researched. This will allow us to record the same Equivalent von Mises stress and deformation that the blade underwent. A higher stress contour was found to be more concentrated near the middle span of the blade under the various loading scenarios studied. The highest stress that the blade in this study underwent is within the range of the maximum stress that blade material can withstand. The maximum allowable stress of the blade material is 1,770 MPa. The deformation of the blade was highest at the blade tip. The critical speed of the blade was determined to be 4.3 Rpm with a rotor speed range of 0 to 608 Rpm. The blade's mode form under loading conditions indicates a bending mode, the most prevalent of which is flapwise bending.

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