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Characterization of Rotor Aerodynamics of the Laboratory-scale Miniature Wind Turbines

Jason Wolf
Cleveland State University

Jordan Thomas
Cleveland State University

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Washkewicz College of Engineering

Student Researchers: Jason Wolf and Jordan Thomas

Faculty Advisor: Wei Zhang

Abstract

Wind energy has become a major contributor to energy production from renewable sources and is expected to increase its portion to the overall energy supply. Wind-tunnel testing of miniature wind turbine models plays an important role in understanding the turbine wake effects and interactions of wind farms with the incoming flow. However, previous research has often not carefully quantified the rotor aerodynamic characteristics of the mini wind turbines, i.e., how the power and thrust coefficients vary with respect to the tip speed ratio, and to what extent they represent the field-scale wind turbines. This work focuses on developing a robust method to measure the power and thrust coefficients and control the tip speed ratio. Using a series of resistors to change the resistance of the circuit, we can control the tip speed ratio of the model and estimate the power coefficient. The thrust coefficient is measured directly using a 3-component force balance. Results from two independent measurements are compared with the theory. Wake generation of the mini-wind turbine is also observed by flow visualization. This research serves as a foundation to design mini-wind turbines that can better match the field-scale wind turbine aerodynamic characteristics.