Experimental and numerical study of turbulence effect on aerodynamic performance of a small-scale vertical axis wind turbine

Wekesa D.W., Wang C., Wei Y., Zhu W.

Abstract

The suitability of vertical axis wind turbines (VAWTs) in harnessing energy within a complex wind environment has increased their renewed interest. However, there still exists a huge knowledge gap about the aerodynamic performance of VAWTs operating in a turbulent flow regime. In this paper, an experimental method is presented for a deeper understanding of unsteady rotor aerodynamics under turbulent flow operating conditions. To carry out the investigation, we developed and tested a small-scale Savonius turbine in a wind tunnel. A systematic analysis of torque and power coefficients, including their variations at uniform flow, was also presented to predict the power performance. A mechanism to generate a turbulent flow was then created to analyze the effect of induced turbulence intensity on the aerodynamics and performance of the VAWT. Results revealed that the turbulence of the inflow impacted fluctuating aerodynamic loads on the turbine blade and, ultimately, its aerodynamic performance. In addition, simulations using a CFD code were performed to compare numerical data with experimental measurements. This analysis shows the effect of turbulence intensity on performance of small wind turbines, and the aerodynamics that causes the behavior.