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EFFECTS OF GROUND AND VELOCITY PROFILES ON AERODYNAMIC PERFORMANCES OF SMALL-SCALE VERTICAL-AXIS WIND TURBINES

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Abstract

The past few decades have been marked by an immense interest of the scientific community in making better use of renewable energy sources, particularly wind energy. One of the suggestions is to increase the number of small-scale vertical-axis wind turbines in urban environment. However, given that they mostly operate in adverse conditions (irregular wind speeds, Earth's boundary layer, vortex trail of surrounding objects), it is necessary to pay special attention to the numerical and experimental estimation of their performances. The conceptual design of small-scale wind turbines usually begins with detailed simulations of the encompassing flow field.

Considered medium-solidity wind turbine rotor comprises three straight blades. Its aerodynamic analysis is complex since blades undergo a wide range of angles-of-attack during every rotation. This induces numerous flow instabilities, separation and interaction between the oncoming blade and the vortex trail detached from the previous. Those are some of the main reasons for the decreased efficiency of this type of wind turbines. On the other hand, their main advantages include: structural simplicity, omnidirectional operability as well as operability in "dirty" winds.

Three-dimensional numerical simulations of fluid flow around a small-scale vertical-axis wind turbine have been completed for ten different working regimes. Transient computations of incompressible, viscous flow have been performed by finite volume method. Aerodynamic performances of the investigated rotor in idealized, uniform velocity stream and a power-law profile (corresponding to Earth's boundary layer) have also been compared. Computed values of power coefficient indicate that a performance reduction of 1-4 % can be expected in real working conditions.

Keywords

Vertical-axis wind turbines, Velocity profile, Ground effect, Finite volume method, Power coefficient.

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