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Performance Analysis of Diffuser Augmented Wind Turbine with Swept Rotor

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Abstract:

This research presents a new performance analysis of wind turbines with diffuser (DAWT) and curved blades (sweep effect), considering the influence of diffuser efficiency and thrust, in which a formulation for-wake flow speed proposed by Vaz & Wood (2018). Blade element theory has been extended to include diffuser efficiency in the axial velocity formulation by Vaz & Wood (2018), which in turn modifies thrust and power. A correction for the high thrust on the rotor proposed by Vaz & Wood (2016) is also added, in which a quadratic equation is used to incorporate the losses in the diffuser. An algorithm was developed and implemented to evaluate the performance of wind turbines with diffuser and sweep effect based on the Blade Element Momentum Theory (BEMT). The impact of the diffuser is evaluated by the augmentation factor, the ratio between the turbine efficiency and the Betz-Joukowsky limit. The comparison between the experiment and the algorithm takes into account the same rotor and diffuser used by Hoopen (2009), optimizing just the blade with the sweep effect. The model was validated in comparison with experimental data from Hoopen (2009) and shows good agreement with the power, torque, thrust coefficient and augmentation factor. The results obtained experimentally by Hoopen (2009) are: power of 531.0 W, torque of 7.10 N.m and thrust coefficient of 0.80. The current search results using the rotor with straight blades, are: power of 532.6 W, torque of 7.10 N.m and thrust coefficient of 0.77. The optimized rotor with a forward sweep effect that presented the highest power was the 40º one: power of 541.60 W, torque of 7.22 N.m and a thrust coefficient of 0.63. The optimized rotor with backward sweep effect that obtained the highest power was the 30° one: power of 542.3 W, torque of 7.23 N.m and a thrust coefficient of 0.69. The augmentation factor and power coefficient achieved a considerable gain in increased performance with the rotor optimized at 30° and 40°. Therefore, applying the sweep effect in a DAWT can result in a considerable increase in its performance.

References:

HOOPEN, P.D.C. **An Experimental and Computational Investigation of a Diffuser Augmented Wind Turbine: with an Application of Vortex Generators on the Diffuser Trailing Edge**. M.Sc. Thesis, Faculty of Aerospace Engineering, Delft University of Technology. 2009.

VAZ, J. R. P.; WOOD, D. H. Aerodynamic optimization of the blades of diffuser augmented wind turbines. **Energy Conversion and Management**, Elsevier, v. 123, p. 35-45, 2016.

VAZ, J. R. P.; WOOD, D. H. Effect of the diffuser efficiency on wind turbine performance. **Renewable Energy**, Elsevier, v. 126, p. 969-977, 2018.