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Study the Effect of Winglet Height Length on the Aerodynamic Performance of Horizontal Axis Wind Turbines Using Computational Investigation

- **ملخص البحث (السادس) باللغة الإنجليزية**

Tip vortices are one of the most critical phenomena facing rotary wings such as propellers and wind turbine blades and lead to changes in the aerodynamic parameters of blades. The winglet (WL) device is considered one of the most significant passive flow control devices. It is used to diminish the strength of vortices at the blade tip, enhance the aerodynamic characteristics of turbine rotor blades, and thereby increase the overall turbine efficiency. The main objective of this research is to improve the aerodynamic characteristics of wind turbines by adding a winglet at the blade tip. An optimum turbine blade profile was taken to build the turbine rotor geometry. The turbine has three blades with a radius of 0.36 m, and the NACA4418 airfoil blade sections were used to build the blade profile. The computational domain was created by ANSYS software, and the model was validated for spalart-allmaras and k-w SST turbulence models with experimental measurements. The computational model was solved for blade shapes without and with tip winglets. Various winglet height lengths per blade radius (WHLR) of 0.008, 0.02, 0.04, 0.05, 0.06, 0.07, and 0.08 were studied for a 90-degree cant-angle and a constant design tip speed ratio of 4.92. Generally, the results illustrate that the performance characteristics of the turbine rotor were improved by using the tip winglet. The lift-to-drag ratio coefficient (C_L/C_D) and power coefficient (C_p) are increasing with increasing WHLR until they reach the highest improvement value, and then they start to decrease gradually. The optimum WHLR is about 0.042, with a percentage improvement in the lift-to-drag ratio (C_L/C_D) and power coefficient (C_p) related to the blade without winglet of about 11.6% and 6.9%, respectively, and an increase in the thrust force of 14.8%. This is mainly caused by decreasing the vortex strength near the tip region and improving the characteristics of stall behaviors.