Influence of Bionic Leading-edge Protuberances on the Horizontal Axis Wind Turbine

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Abstract: The horizontal axis wind turbine is prone to flow separation during operation, which can affect the flow characteristics of the wind turbine and lead to performance degradation. As one of the methods of passive control, the leading-edge protuberances of the humpback whale have been proven to suppress flow separation and enhance performance. This study employs biomimetic principles to investigate the flow control mechanism by adding bionic leading-edge protuberances to the wind turbine blades. The three parameters (Amplitude, Attenuation and Number) that control the protuberances are nonlinear and non-uniform. The influence of leading-edge protuberances on the aerodynamic performance of the wind turbine is analyzed by Computational Fluid Dynamics method. The results indicate that the addition of protuberances can improve the airfoil performance, increase the low-pressure area, and delay the flow separation. For the single leading-edge protuberance, the pressure coefficient of the peak section decreases, and the pressure coefficient of the trough section on both sides increases. In this research, the bionic protuberance parametric structure applied to the blade leading-edge of horizontal axis wind turbine proposed is a supplement to the existing bionic design method, which provides new research data for improving the design of wind turbine blades by using biomimetic principles, and holds practical value for guiding practical applications.

Keywords: Leading-edge protuberance, Horizontal axis wind turbine (HAWT), Flow control, Pressure coefficient, Numerical simulation

Declaration of competing interest:

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Conflicts of Interest:

This abstract has not been published or presented elsewhere in part or in entirety and is not under consideration by another journal.