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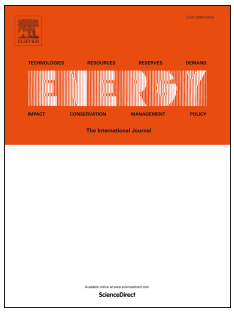

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Ying Wang, Gaohui Li, Sheng Shen, Diangui Huang, Zhongquan Zheng

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Influence of an Off-surface Small Structure on the Flow Control Effect of Horizontal Axis Wind Turbine at Different Relative Inflow Angles

Ying Wang[1,2] Gaohui Li[1] Sheng Shen[1] Diangui Huang[1 *]
Zhongquan Zheng[3]

1. School of Energy and Power Engineering, University of Shanghai for Science and Technology, Shanghai, 200093;
2. School of Engineering, Faculty of Engineering and Built Environment, the University of Newcastle, Callaghan, Australia;
3. Aerospace Engineering Department, University of Kansas, Lawrence, Kansas 66045-7621,USA
(Tel: 021-55897317, Email: dghuang@usst.edu.cn)

Abstract: Under different relative inflow angles, this paper studied the control mechanism of off surface small structure which was referred as micro-cylinder. With varying positions, the effect of micro-cylinder to reduce the flow separation on the horizontal axis wind turbine blade was investigated and the following results were found: (1) Under the condition with 13m/s of wind speed, when it is closer to the blade tip, the relative inflow angle decreases gradually and tends to a stable range. The optimum micro-cylinder on each cross section gradually approaches to the blade leading edge with the decrease of relative inflow angle. (2) The optimal effect has not been achieved when using the integrated micro-cylinder A which is from the optimal micro-cylinder segment on each cross section. Due to the complexity of flow field, the flow field at the cross sections could be influenced by the upper and lower parts of the flow field. (3) Under different stall conditions, setting a proper micro-cylinder in front of the blade leading edge can effectively suppress the flow separation on wind turbine blade without influencing the wind turbine stability. In this way, the aerodynamic performance of wind turbine can be improved effectively with increasing of power coefficient.

Keywords: Horizontal Axis Wind Turbine; Flow Separation; Aerodynamic Performance; Micro-cylinder; Numerical simulation

1. Introduction

Renewable energy is a good alternative to cope with the rapid and large consumption of non-renewable resources including coal, petroleum and natural gas, etc. As one type of renewable energies, wind energy can be captured by turbines to convert the wind kinetic energy into electrical energy [1-6]. Compared with vertical axis wind turbine (VAWT) and other types of wind turbines, the horizontal axis wind turbine (HAWT) has been widely utilized due to its relatively high efficiency [7, 8]. Meanwhile, the methods of improving the aerodynamic performance of HAWT have become a researching focus all over the world [9].

Flow control is a method to improve the configuration as well as flow field for common objectives including lift increase, drag reduction, mixing enhancement and noise reduction. Through passive or active control, these objectives may be accomplished. Active control is unsteady and requires extra energy input, while passive vortex generators, such as Gurney flaps, fixed mini tabs, dimples, grooves, riblets and roughness elements and also splits or slots, etc. are