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Investigation into parameter influence of upstream deflector on vertical axis wind turbines output power via three-dimensional CFD simulation

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ABSTRACT

This paper presents the parameter influence of upstream deflector on the performance of vertical axis wind turbines (VAWTs). For this purpose, two counter-rotating straight-bladed VAWTs and the upstream deflector have been simulated via three-dimensional (3D) computational fluid dynamics (CFD), which is validated against experimental data. Parameter Influence of upstream deflector on VAWTs output power is investigated in this study. From the CFD results, it is observed that when the turbine is positioned outside the near-wake region, the aerodynamic power can increase significantly.) This research indicates that performance of VAWTs can be greatly improved by properly choosing parameters of the deflector.
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1. Introduction

Currently, a new trend of wind energy utilization in cities has arisen for sustainable urban development [1]. VAWT in the built environment is a promising alternative to HAWT, the advantages are mainly: Omni directionality without a yaw control; better aesthetics to integrate into buildings. Nevertheless, the efficiency of VAWT has been one of the major issues haunting the wind industry [2]. Therefore, many researches in recent years have been focusing on improving the efficiency of VAWTs, such as variable-pitch mechanism, chord optimization, active flow control technology and guide vane geometry etc.

The variable-pitch mechanism (shown in Fig. 1 *a*) can be used to increase the lift of blades at the upwind direction and reduce the drag at the downwind direction, so as to increase the power coefficient [3,4], as shown in Fig. 1 *b*. In addition to variable pitch, oscillating flap can also be used to adjust the power by changing the variation of lift and drag, which could make the power coefficient reaches 28% enhancement [5]. Chord and thickness are parameters critical to the aerodynamic performance of blades. Through optimization of blade configuration, the adoption of an optimizing rotor ensures a remarkable increase in the AEP [6]. Based on BEM code with a genetic algorithm, the optimization of chord distribution for Darrieus wind turbines is investigated. The achieved increase in the power coefficient is appreciable and up to 6%.) [7–9]. Comparison of distribution of the interference factor between pre-optimization and optimized is shown in Fig. 2. Active flow control (AFC) approaches include active-adaptive components that can replace the fixed single-point design vortex generators (VGs), which enable high performance under extreme and variable conditions and reduce noise of VAWTs [10] [11], as shown in Fig. 3. The experimental research showed that when considering overall performance improvements, increases in power of up to 38% were measured [12]. Omni-direction-guide-vane is designed to improve the performance of a wind turbine in terms of power output, rotating speed and self-starting behavior [13]. The experimental research showed [14–16] an improvement on the self-starting behavior where the cut-in speed was reduced, as shown in Fig. 4.

Based on the above improvement attempts, the efficiency of VAWTs can be improved significantly. However, negative torques of VAWTs still can not be avoided, which is caused by sudden decrease of the lift in the after-stall region till the angle of attack is below the

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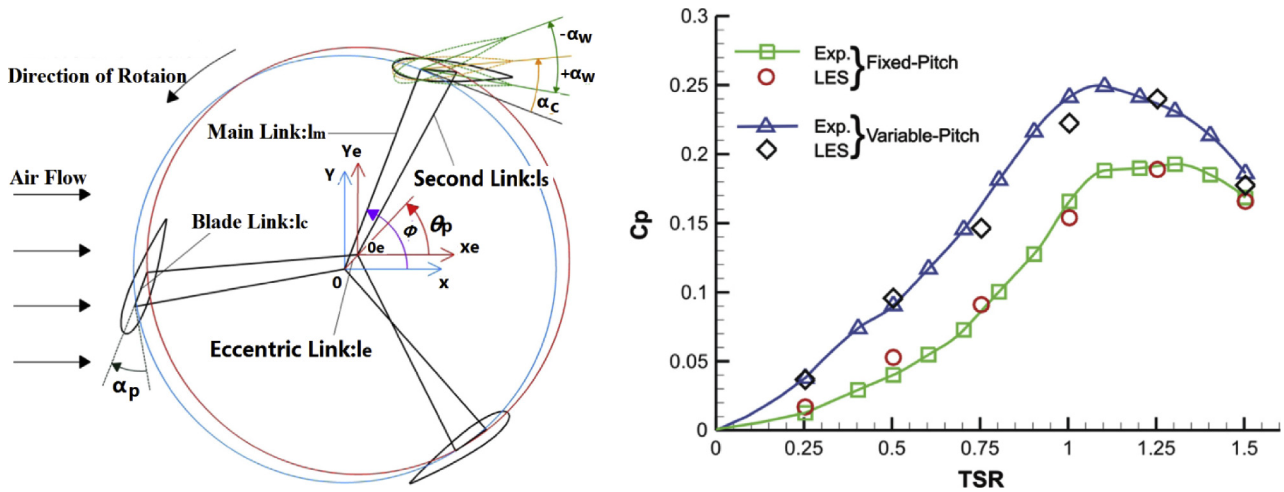
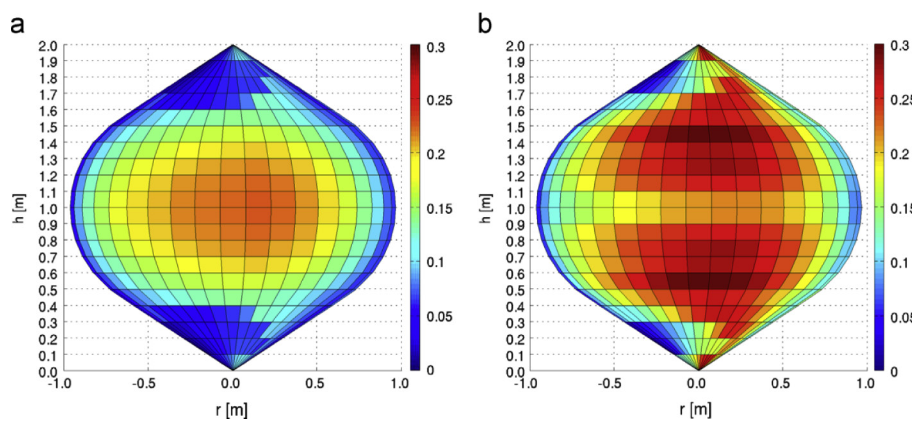


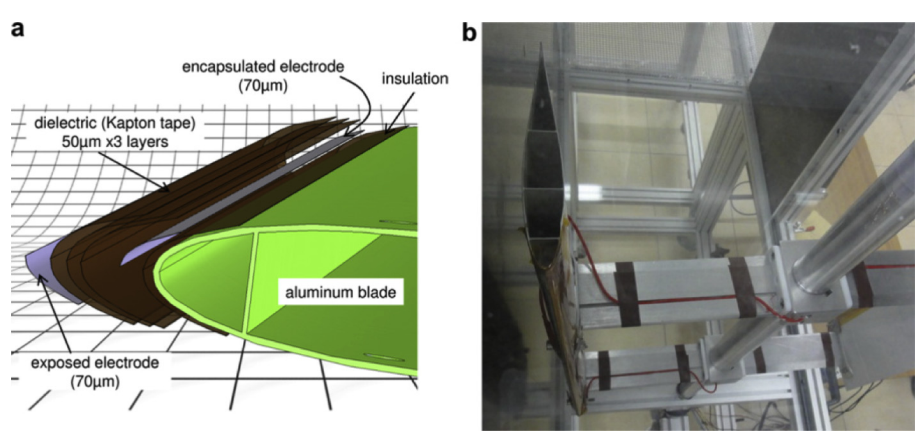
(a) variable-pitch mechanism [3] (b) C_p comparison between variable pitch and fixed pitch [4]

Fig. 1. Variable-pitch regulation.



(a) interference factor before optimization (b) interference factor after optimization

Fig. 2. Comparison of distribution of the interference factor on the swept area between pre-optimization and optimized [8].



(a) attachment of the DBD plasma actuator (b) tested wind turbine

Fig. 3. Efficiency improvement based on Active flow Control Technology [12].

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