Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 110 (2017) 304 – 309

Energy Procedia

1st International Conference on Energy and Power, ICEP2016, 14-16 December 2016, RMIT University, Melbourne, Australia

Investigate the feasibility of high aspect ratio vertical axis wind turbine

Bavin Loganathan[a], Pritesh Gokhale[b], Teera Kritpranam[a], Panarat Jitthanongsak[a], Abhijit Date[a,*], Firoz Alam[a]

[a]*School of Engineering, RMIT University, Melbourne 3000, Australia*
[b]*Faculty of Mechanical Engineering, Technische Universität Chemnitz, Germany*

Abstract

The paper aims to investigate the performance of the high aspect ratio vertical axis wind turbine with numerical method and to present some experimental results. Aerodynamics with numerical method is a major prospect of the investigation. Computational fluid dynamic software, ANSYS CFX, is employed to analyze drag force generated from the influence of blade shape. Two types of turbine blades have been investigated with aerodynamics prospects, namely shape-design model and mechanism model. Power coefficient of each models are calculated and compared. Turning force to reverse force ratio has been used to compare different shapes of the turbine blade. It has been found that the mechanism model, with power coefficient of 16.2 per cent, offers better capability of harnessing wind energy than shape-design model.

Peer-review under responsibility of the organizing committee of the 1st International Conference on Energy and Power.

Keywords: vertical axis wind turbine; blade design; numerical method; ANSYS CFX; high aspect ratio; power coefficient; harnessing wind energy; blade mechanism; flapping blade

1. Introduction

Modern wind turbines are categorized into two configurations by their rotor operating principles; horizontal axis wind turbines (HAWTs) and vertical axis wind turbines (VAWTs). HAWTs are currently the most prevailing

* Corresponding author. Tel.: +61399250612
E-mail address: abhijit.date@rmit.edu.au

Peer-review under responsibility of the organizing committee of the 1st International Conference on Energy and Power.
doi:10.1016/j.egypro.2017.03.144

configuration around the world. They utilize the created lifts to spin the shaft and generate electricity. Their rotor orientations nowadays are upwind and downwind configurations. Mechanical and electronic system have been attached to the HAWTs to improve the efficiency by autonomously yawing their swept area to align with the wind and pitching their rotors to the optimum angles[1, 2]. VAWTs on the other hand are capable of using either or both lift and drag to generate electricity. Lift-driven type primarily takes advantages of generating lift force to rotate the shaft. Knowledge of aerodynamic airfoil has been applied in blades design and construction[3]. Drag-driven type uses drag force as an essential source to generate electricity. In practical operation, torque is generated by the difference between drag forces in each side of the rotor. The resultant force then rotates the turbine in proper direction to harness energy from the wind. Combination of lift and drag driven type is also exist. Figure A1 and A2 in the appendix show different types of HAWTs and VAWTs in present time.

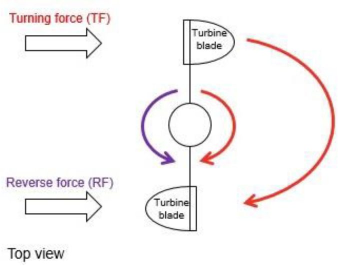
Both HAWTs and VAWTs distinctly have their own advantages and limitations. The major advantage of HAWTs are the high efficiency in converting wind energy into mechanical energy[4]. Self-starting at low wind speed is achievable due to its high aspect ratio blades. As they have widely fabricated around the world, their production cost is lower than those VAWTs. The horizontal model however has many limitations including noise generations, complex mechanisms, shorter service time, large area for operation and high maintenance costs[5]. The vertical axis wind turbines on the other hand offer omnidirectional operation. Installation, operation and maintenance costs are low as the generator and controller always locates at the turbine base. Disturbance from generating noise is also minimal. In addition, more number of VAWTs can be installed in a certain area than those of HAWTs. Nevertheless, the VAWTs need initial startup from generator until they reach sufficient speed for power production. Furthermore, manufacturing cost is high as they are relatively not widely used globally. Low efficiency in generating power is also a limitation of this type of wind turbine[5].

Drag type VAWTs have been chosen to investigate in this project due to their versatilities in practical operations over HAWTs and lift type VAWTs. The major consideration is drag type VAWTs does not involve the variation in pitch angle of the blade for optimum performances[1, 6]. Although high aspect ratio has been expressed to improve performances of HAWTs[7], none of research papers have not investigated its effect on VAWTs. Furthermore, High aspect ratio blade also has potential for VAWTs to overcome self-starting limitation by producing torque from high moment. This research will fulfill the gap in these areas by investigating on the best of selected shapes with high aspect ratio of the turbine blades and its performances whilst maintaining its structural strengths in operating conditions.

2. High aspect ratio VAWTs blade investigation

The purposes of this section are to identify important parameters for blade design with consideration on aerodynamic prospect. The blade will be designed by considering on creating high turning force while minimizing the reverse force. The turbine hence will rotate about desired direction. Different blade shapes have been justified their performance by turning force to reversed force ratio. Figure 1 (a) illustrates a diagram of drag type wind turbine in practical operation.

$$\text{Turning force to reverse force ratio} = \frac{\text{TF}}{\text{RF}} \quad (1)$$



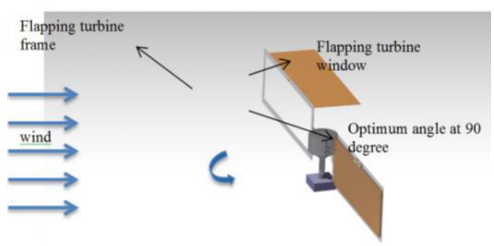


Fig. 1 (a) Turning and reverse force; (b) Flapping blade wind turbines