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A Review on H-Type Rotor Vertical Axis Wind Turbine Performance

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ABSTRACT

Angle of attack is a well-developed and widely-used approach in modern horizontal axis wind turbines in operation. However, its application in vertical axis wind turbines (VAWTs) is restricted by the obscurity in its functional mechanism. After, a single tube stream model composed of genetic algorithm and MATLAB Simulink simulation modules is built to search for angle of attack that can maximize turbine torque. A MATLAB Simulink model is used as a performance evaluation tool because of its high computational efficiency. It is Variable pitch (VP) approach to increase the peak torque coefficient of the straight-bladed vertical-axis wind turbine (VAWT). The VP-approach provides a curve of pitch angle designed for the blade operating at the rated tip speed ratio (TSR) corresponding to the peak torque coefficient of the fixed pitch (FP)-VAWT. It describes the effects from four aspects, including the lift, drag, angle of attack (AoA), and torque, through a comparison between VP- VAWTs and FP-VAWTs working at three TSRs.

Keywords : Wind Turbine, MATLAB, Pitch, Angle of Attack, Lift, Drag.

I. INTRODUCTION

The wind is caused by solar energy and approximately 2% of sun's energy is converted into winds. The surface of earth heats and cools unevenly, creating air to flow from high pressure to low pressure. Wind is renewable sources of energy and it is sustainable for the future generations as wind power is inexhaustible and requires no fuel. Wind turbine power production depends on the interaction between the rotor and the wind. The wind may be considered to be a combination of the mean wind and turbulent fluctuations about that mean flow. Horizontal axis wind turbine designs use aerofoils to transform the kinetic energy in the wind into useful energy. Vertical axis wind turbines (VAWTs) may have either drag-driven or lift-driven rotors. It has been used for water pumping and other high-torque applications. When vertical axis turbines have been used for electrical power generation they have nearly always used lift-driven rotors. This means that a large fraction of the rotor tends be located close to the ground in a region of relatively low wind. Productivity may then be less than that of a horizontal axis machine of equivalent rated power, but on a taller tower.

Types of wind turbine: The wind turbine is generally classified into two types:

Horizontal Axis Wind Turbine (HAWT): In Horizontal Axis Wind Turbine (HAWTs), the main motor shaft arranged horizontally. The nacelle, rotor shaft, generator and the transmission system are placed at the top of the tower. Horizontal axis wind turbine are being parallel to the ground, the axis of blade rotation is parallel to the wind flow.

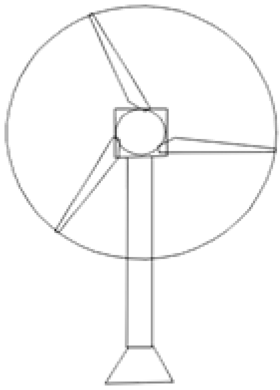

Fig. 1: Schematic diagram of horizontal axis wind turbine.

Vertical axis wind turbine (VAWT): In Vertical axis wind turbine (VAWTs), the main rotor shaft arranged vertically. Vertical axis wind turbines have existed since older days due to they do not take advantage of the higher wind speeds at higher elevations above the ground compare to horizontal axis turbines. A vertical axis machine need not be oriented with respect to wind direction, this is because the shaft is vertical, and the transmission and generator can be mounted at ground level allowing easier servicing and a lighter weight, lower cost tower.

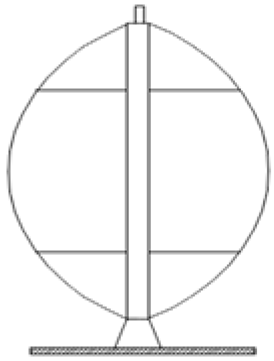

Fig. 2: Schematic diagram of horizontal axis wind turbine.

Airfoil Terminology: A number of terms are used to characterize an airfoil, as shown in Figure 3. It means camber line is the locus of points halfway between the upper and lower surfaces of the airfoil. The most forward and rearward points of the mean camber line are on the leading and trailing edges, respectively. The straight line connecting the leading and trailing edges is the chord line of the airfoil, and the distance from the leading to the trailing edge measured along the chord line of the airfoil. Finally, the angle of attack α is defined as the angle between the relative wind V_R and the chord line.

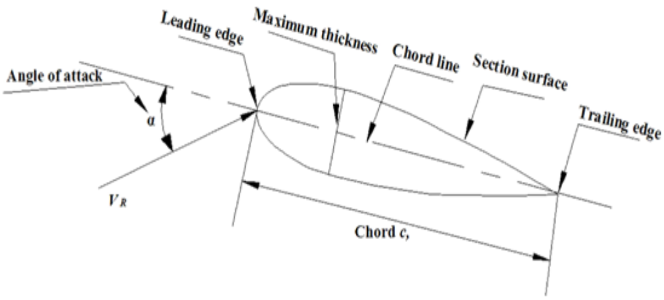

Fig.3: Airfoil nomenclature

Lift force– defined to be perpendicular to direction of the oncoming air flow. The lift force is a consequence of the unequal pressure on the upper and lower airfoil surfaces.

Drag force– defined to be parallel to the direction of the oncoming air flow. The drag force is due both to viscous friction forces at the surface of the airfoil and to unequal pressure on the airfoil surfaces facing toward and away from the oncoming flow.

Pitching moment– defined to be about an axis perpendicular to the airfoil cross- section.

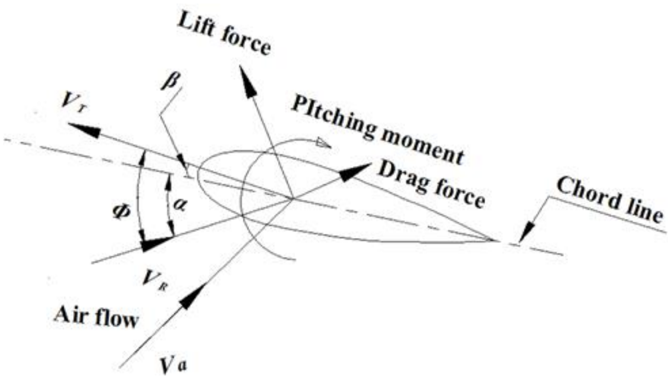

Fig. 4: Forces and moments on an airfoil section

II. LITERATURE REVIEW

VAWT are more suited to urban areas as they have low noise level and because of the reduced risk associated with their slower rates of rotation. The economic development and viable use of HAWT would in the future be limited, partly due to high stress loads on the large blades. The literature survey of both type of VAWT and HAWT are review as below as:

Horizontal axis wind turbine:

Lin et al., (2017): Blade design simulations are performed to study the 150 kW horizontal axis wind turbine. Reynolds-averaged Navier-Stokes equations and RNG k-ε turbulence model are applied for computational simulations to predict turbulent flow.

Chen et al., (2017): Focus on the mechanism design of the passive pitch control for the small horizontal axis wind turbine (HAWT). The system uses centrifugal force to make Pulley disk driven the pitch angle of the blade. It can achieve the effect of passive pitch control.

Otero et al., (2018): Gravity loads would also become more significant in future up-scaled machines due to the square-cube law relation between energy capture and rotor mass. We identify the different constructive factors and physical mechanisms which constitute the sources of the cyclic loads on the rotor,

Vertical axis wind turbine:

Toms Komass et al., (2015) Vertical axis wind turbine (VAWT) pitch system simulation model has been designed and verified using the MATLAB SIMULINK tool for blade aerodynamic force simulation.

Wang et al., (2018): Two counter-rotating straight-bladed VAWTs is used. This research indicates that performance of VAWTs can be greatly improved by properly choosing parameters of the deflector.

Zhang et al., (2018): Three-bladed H-rotor VAWT model with a geometric scale of 1:100 was used and fixed onto three floating platforms inspired by offshore oil rigs and floating wind turbine prototypes. The three platforms, i.e. single-spar, tri-floater, and hepta-spar, represent a deep draft, strong buoyancy, and a hybrid conceptual model, respectively.

Antonio Posa et al., (2018): Two values of TSR are investigated here, in order to discuss its influence on the wake structure. Lower TSRs are associated to boundary layer separation closer to the leading edge of the blades and larger rollers, during both upwind and downwind stall.

Rolin et al., (2018): Small scale vertical-axis wind-turbine (VAWT) is immersed in a boundary-layer in a wind tunnel. Two counter-rotating vortex pairs in the wake induce crosswind motion which reintroduces stream wise momentum into the wake which developed in order to obtain a theoretical basis from which to understand how the aerodynamic behaviour of VAWTs induces crosswind motion consistent with the production of counter-rotating vortex pairs.

Naccache et al., (2018): In this study of the turbine sensitivity to different incoming wind angles, turbine axes spacing, number of blades, aerofoil profile and blade mounting point. It was found that the D-VAWT has a low sensitivity to TSR, allowing the turbine to operate efficiently for a wide range of TSRs.

III. Conclusion

In this review paper, we can concluded that we development of the model in MATABL SIMULINK for performance analysis with the consideration of the variable pitch control using VP-approach to increase the peak torque coefficient of a straight-blade VAWT. The data of the VAWT is analyzed and compare the FP-blade and the VP-blade from four different characteristics, namely the AoA, lift, drag, and torque. In this paper we study of two-dimensional numerical simulation method in the prediction on the performance of H-type the vertical axis wind turbine that feasible through the application of the new approach which influenced by the lift and drag and Angle of Attack is produced in the cycle of the VP-blade.

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