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A Review on Straight Bladed Vertical Axis H-Type Darrieus Wind Turbine

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ABSTRACT: Energy available in two different forms, first is non renewable energy and second is renewable energy. Wind energy is the most available clean energy in the form of renewable energy. Wind power is a major source of sustainable energy and can be harvested using both horizontal axis wind turbine and vertical axis wind turbine. In current scenario, the horizontal axis wind turbine is the recent trend for wind energy utilization for power generation. However, they are suitable for higher wind velocity and subjected to higher cost and complex system; which puts limitation in their applications for domestic applications. To overcome these problems and to utilize the wind energy even at low wind velocity and at low cost, vertical axis wind turbine is one of the attracting alternatives. After reviewing the various literature of the vertical axis wind turbine a symmetrical airfoil gives good performance.

KEYWORDS: Vertical axis wind turbine, H-Darrieus Turbine, Straight bladed wind turbine.

I. INTRODUCTION

Wind energy is one of the most cleanly and reliable sources of renewable energy. Wind is a natural resource and can be used as an alternative energy. A wind turbine is a machine that transfers wind energy in to mechanical energy with the use of blades and a shaft and converts that form of energy in to electricity with use of generator. The straight bladed Darrieus vertical axis wind turbine is very attractive because of its low cost and its simple design. The Darrieus wind rotor was originally invented by G.J.M Darrieus, a French aeronautical engineer in the year 1931[1]. There are mainly of two types of Darrieus rotors, first one is Eggbeater Darrieus rotor and H-Darrieus or H-rotor. Eggbeater type of Darrieus rotor consists of two or three rotor blades attached to the central shaft. The H-rotor also known as H-Darrieus rotor, has two or three blades designed as airfoils which are attached vertically to central shaft through support arms. The blades are mounted straight on supports. It uses lift forces to produce power and suitable for extreme wind condition. H-rotor is self-regulating in all wind speed reaching its optimal rotational speed shortly after its cut in wind speed [2]. The overall performance of a rotor is mainly influenced by: rotor geometry, rotational speed, airfoil shape, mean angle of attack, Reynolds number, turbulence levels and type of motion of blades [3].

II. VERTICAL AXIS WIND TURBINE

The axis of rotation of VAWT is perpendicular to the wind direction as seen from fig. the VAWT can receive wind from any direction. Hence complicated yaw mechanism can be eliminated. The generator can be housed at the ground level. The gearbox of system can also be housed ground level. These make the tower design simple and economical. The maintenance of these turbines can be done at ground level. In this system pitch control is not required when used for synchronous applications. The major disadvantage of VAWT is that they are not self starting. Some additional mechanism may be required to push and start the turbine if it is stopped. The term Darrieus describes a class of vertical axis wind turbine that is powered by lift force. This lift is created because of the shape of the airfoil. These blades cut through the air with an angle of attack to the wind which causing a pressure differential. The resulting pressure differentials cause a force called lift, which propels the blade forward.

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III. LITERATURE REVIEW

K.E. Swalwell, et al.[4] presented The Effect of Turbulence Intensity on Stall of the NACA 0021 Aerofoil. In this paper the authors have presented lift and drag data obtained from pressure taps on a NACA 0021 airfoil at Reynolds numbers of around 3.5×10^5 over a wide range of angles of attack. The airfoil was subjected to low turbulence flow of turbulence intensity 0.6% and turbulent flows of length scale 0.56 chords and intensities of 4% and 7%. The authors concluded that increasing the turbulence intensity to 7% delayed stall further.

Samaraweera K.K.M.N.P et al. [5], presented Development of Darrieus-type vertical axis wind turbine for stand-alone applications. In this paper a theoretical model for the design and performance simulation of Darrieus-type vertical axis stand alone wind turbine for small scale energy applications was developed. The model based on application of momentum theory and blade element theory to multiple stream-tubes. Results were used to analyze the effects of blade profile, rotor solidity, Reynolds number and aspect ratio on the maximum power and torque coefficients, optimum tip speed ratio, and ability to self start, which lead to design of optimum rotor configurations. It is found that when the number of blades of the turbine is increased, it can be seen an apparent improvement of self starting.

R. Mishra et al. [6], presented Effect of rotor blade position on Vertical Axis Wind Turbine performance. In this paper a numerical study is presented with the aim of evaluating the performance output of three Vertical Axis Wind Turbine (VAWT) configurations. The authors have used Computational Fluid Dynamics (CFD) a two-dimensional Multi Reference Frame (MRF) approach has been used to perform steady state simulations. For this purpose an inlet velocity of 4m/s has been used along with rotor blade Tip Speed Ratios (λ) in the range of 0 to 0.6. It has been found that within a typical rotor blade passage, maximum torque is obtained at a unique rotor angle. It can be seen that the torque output of the turbine decreases with an increase in rotor tip speed ratio (λ) for all rotor blade positions. The authors concluded that the VAWT power curve characteristics vary with relative rotor blade position and the torque output of the turbine decreases with an increase in rotor tip speed ratio (λ) for all three rotor blade positions.

Joseph P. Tillman [7], presented an improvement to vertical axis wind turbine blades to aid in self starting. In this study the authors have investigated, improvements in airfoil or blade design to aid in the starting of an H-rotor type vertical axis wind turbine (VAWT) and how these changes would affect the performance of an H-rotor VAWT. The authors concluded that the asymmetric airfoils can enable a VAWT to self start though airfoils with a greater cord and thicker cross section work better in the lower wind speeds and Reynolds number.

Javier Castillo[8], presented Small-scale vertical axis wind turbine design. The authors focused on the design of a small vertical axis wind turbine rotor with solid wood as a construction material. The aerodynamic analysis is performed implementing a momentum based model on a mathematical computer program. A three bladed wind turbine is proposed as candidate for further prototype testing after evaluating the effect of several parameters in turbine efficiency, torque and acceleration. It has found that wood is a suitable material for rotor construction. And it is also found that a three-bladed design is more efficient than a four-bladed rotor; a low solidity wind turbine may present self-starting problems as rotor efficiency is poor at low tip speed ratios.

Richard m. keslo et al. [9], presented performance variations of leading edge for distinct airfoil profiles. An experimental investigation has been undertaken to determine the influence of sinusoidal leading-edge protrusions on the performance of two NACA airfoils with different aerodynamic characteristics. Force measurements on full-span airfoils with various combinations of tubercle amplitude and wavelength reveal that when compared to the unmodified equivalent, tubercles are more beneficial for the NACA 65-021 airfoil than the NACA 0021 airfoil. The authors concluded that NACA 0021, which has maximum thickness at 30% of the chord, increased lift performance in the post stall regime.

R. Ramkissoon et al. [10], presented Increasing the power output of the Darrieus Vertical Axis Wind Turbine. In the case study a Vertical Axis Wind Turbine was built using the NACA 0018 airfoil type for the blade profile. The turbine consisted of three blades of length 3.05 meters and had a diameter of 6.10 meters. The authors concluded that the

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varying of the angle of Attack from 0 degrees to 10 and -10 degrees has no significant effect on increasing the output power from vertical axis wind turbine.

Ryan McGowan et al. [11], presented Optimization of a Vertical Axis Micro Wind Turbine for Low Tip Speed Ratio Operation. In this paper describes progress on a vertical axis wind turbine (VAWT) test bed aimed at the needs of a single family. VAWTs are potentially better suited than the more common horizontal axis wind turbine (HAWT) to meet the energy needs of homes and villages because of lower blade speeds and more benign failure modes; however, they are also more complex in operation. The authors concluded that the vertical axis wind turbine must operate at a tip speed ratio that is substantially greater than 1.

Franklyn Kanyako et al. [12], presented Vertical Axis Wind Turbine Performance Prediction, High and Low Fidelity Analysis. In this study the authors highlighted the progress made in the development of aerodynamic models for predicting the performance of straight-bladed, fixed-pitch vertical axis wind turbine blade profiles. An improved low-fidelity blade element momentum algorithm using a hybrid database was built to investigate the solidity of the turbine, by analyzing the effect of blade chord, radius, and number blades at different tip speed ratios. The authors have done 2-D numerical investigation to compare the performance prediction capability of the CFD and mathematical model. The authors concluded that negative and/or minimum CP and torque are generated at lower tip speed ratios, which implies that NACA 0015, NACA 0018, and NACA 0021 airfoils are not self-starting. Nevertheless, NACA0021 has shown to have better starting performance than the other two airfoils due to its thicker section.

Agnimitrabiswas et al. [13], presented performance study of a three bladed airfoil shaped H-rotor made from fiberglass rain forced plastics (FRP). In this study Wind rotor blades made from Fibreglass Reinforced Plastics (FRP) have got many advantages over the conventional rotor blades, such as light in weight, less bending stress on the supports, less chances of fatigue failure etc. The height of the blades of the rotor was 20 cm, and the chord length was 5 cm. The rotor was tested in an open circuit subsonic wind tunnel having wind speed adjustable between 0 to 35 m/sec for H/D ratios of 0.85, 1.10, 1.54, 1.80, 2.0 & 2.2. It is found that the maximum power coefficient of 0.46 was obtained at an optimum H/D ratio of 1.54. The authors concluded that Cp increases with the increase of tip speed ratio (TSR) to the maximum and then starts to decrease even if tip speed ratio is increased. Cp increases with the increase of H/D ratio up to a certain limit but then decreases even though the H/D ratio is increased. The authors also concluded that It can also be concluded that FRP would be an alternative option as blade material since it is light in weight having less chances of bending and fatigue failure and also has higher power coefficient compared to conventional rotor blades.

M. Jamil et al. [14], presented Experimental Study of a Combined Three Bucket H-Rotor with Savonius Wind Turbine. In this paper an experimental work have conducted to study the performance of a hybrid vertical axis wind turbine. A savonius wind turbine (WT) is combined with a three bucket H-rotor WT with DUW200 airfoils. Two sets of positions are examined for finding the best case for having the highest performance of the combined WT. It has been found that in the case that the two turbines (H-rotor and savonius) are combined, higher performance is obtained in compare with H-rotor. The authors concluded that Combining both savonius and H-rotor with each other makes an efficient wind turbine which has better self-starting ability besides higher power coefficient.

K.K. Sharma et al. [15], presented performance measurement of three bladed combined darrieus- savonius rotor. In this paper, an attempt is made to measure the performance of a three-bladed combined Darrieus-Savonius rotor, with Darrieus mounted on top of Savonius rotor, for overlap variations from 10.8% to 25.8%. Power coefficients (Cp) and torque coefficients (Ct) were calculated in a low range of Tip Speed Ratio for each overlap condition. It has been found that Cp increases with the increase of overlap. However, there is an optimum value of overlap for which, Cp is maximum, beyond this, Cp starts decreasing. The similar trend has been observed for Ct as well. The authors concluded that an optimum TSR at which the performance coefficients are the highest and an optimum overlap at which the performance coefficients are the highest.

MicolChigliaro [16], presented Effect of shaft diameter on darrieus wind turbine performance. The authors concluded that a marked reduction of overall rotor performance with the increment of its shaft diameter.

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IV. CONCLUSION

From this study, concludes that aerodynamic blade profile NACA 0012, NACA 0015, NACA 0018, NACA 0021, NACA 0025, NACA 0063 are suitable for Darrieus rotor. Many researchers have used these blade profiles for wind applications using different solidities and different models. It has been also observed from literature survey that blade profile NACA 0021 has better starting performance due to its thickness. It has been also observed that Combining both savonius and H-rotor with each other makes an efficient wind turbine which has better self-starting ability besides higher power coefficient. It has also observed that FRP would be an alternative option as blade material.

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