Fabrication of Vertical Axis Wind Turbine for Household Application

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Abstract- *Rapid increase in global energy requirement resulted in considerable attention towards renewable energy sources as there are shortages of fossil fuels. Wind energy is the most potential and clean renewable energy resource and available everywhere abundantly in free of cost. Vertical axis wind turbine is one of the important options to produce sufficient electricity for household's application at rural and urban area. research paper is aimed to explain the mathematical modeling and calculation of aerodynamic forces acting on blade of H- Darrious Vertical Axis Wind Turbine (VAWT) and its performance for generation of power for household application. Analytical and experimental investigation is carried out on fixed pitch H- Darrious VAWT using NACA0021 airfoil as a blade profile to evaluate its performance. H- Darrious VAWT with NACA0021 airfoil profile blade simulation model has been designed and verified using the MATLAB tool for blade aerodynamics analysis. H- Darrious VAWT using NACA0021 airfoil blade with chord c=95mm, height h = 600mm and turbine diameter D=600mm is been designed and fabricated and tested in the wind tunnel.*

Keywords- Windmill, Aerofoil Blade, Cam Base, Central ShaftSlider, Coupling, Spring Support, Support Frame and Flange Plate.

I. INTRODUCTION

The vertical axis wind turbine is simple in construction, low cost, self-starting at low wind speed and do not require yaw mechanism. It always Orient towards the wind direction. It is suitable for small power generation and also operates well in turbulent wind conditions. This makes it suitable for generating electrical energy for house hold application at rural and urban areas in many countries especially in India. In recent years, research work is carried out to increase the power coefficient of vertical axis wind turbine. Review of the papers show that, the CFD analysis and experiments are conducted in slow speed wind tunnel on various types of vertical axis wind turbines like Darrieus, H-type, and Savonius. In many research papers, the performance of the turbine is studied and investigated with varying design parameters such as number of blades, profile of blades, aspect ratio, and pitch angle. It is observed the power coefficient for Savonius turbine is varies from 0.12 to 0.19 and for Darrious turbine is from 0.12 to 0.35 with different operating parameters.

II. LITERATURE REVIEW

In Research paper named as "Analysis of Lift andDrag Forces at Different Azimuth Angle of InnovativeVertical Axis Wind Turbine [1]" which is published by author Abhijeet M. Malge and Prashant M. Pawar. From these Paper we concluded that the coefficient of power developed by the turbine depends upon lift force, drag force and pressure acting on the turbine blades and flaps at different azimuth positions at different tip speed ratio. Pressure on the upstream side of the turbine is maximum as compared to the downstream side of the turbine. This pressure difference between upstream side and downstream side causes lift force in the turbine which makes it to rotate. Velocity aggravates from centre to its periphery of the turbine.

The Research Paper "Limitations of fixed pitch Darrieus hydrokinetic turbines and the challenge of variable pitch [2]", made by "B.K. Kirke, L.Lazauskas". from paper we concluded that Variable pitch can generate high starting torque, high efficiency and reduced shaking but active pitch control systems add considerably to complexity and cost, while passive systems must have effective pitch control to achieve higher efficiency than fixed pitchsystems.

Zhenzhou Zhao, Siyuan Qian, Wenzhong Shen, Tongguang Wang, Bofeng Xu, Yuan Zheng, and Ruixin Wangpublished a paper entitled "Study on variable pitch strategy in H-type wind turbine considering effect of small angle of attack[3]" is about Variable-pitch (VP) technology is an effective approach to upgrade the aerodynamics of the blade of an H-type vertical-axis wind turbine (VAWT). At present, most of the research efforts are focused on the performance improvement of the azimuth angle owing to the large angle of attack (AoA). The purpose of this novel approach is to widen the band of azimuth positions with high performance and eventually enhance the power efficiency of the overall VAWT. Compared with the fixed-pitch (FP) blade, the VP-blade has a wider zone of the max AoA and tangential force in the upwind half-circle and yields the two new larger max values in the downwind half-circle.

The Research Paper "Aerodynamic models for Darrieus-type straight-bladed vertical axis wind turbines", made by "Mazharul Islam, David S.-K. Ting, Amir Fartaj[4]" Several aerodynamic models have been analyzed in this paper which are applied for better performance prediction and design analysis of straight-bladed Darrieus-type VAWT. At present the most widely used models are the double-multiple stream tube model, free-Vortex model and the Cascade model. It has been found that, each of these three models has their strengths and weaknesses. Though among these three models, the Vortex models are considered to be the most accurate models according to several researchers, but they are computationally very expensive and, in some cases, they suffer from convergence problem. It has also been found that the double-multiple stream tube model is not suitable for high tip speed ratios and high-solidity VAWT. On the other hand, the Cascade model gives smoothconvergence even in high tip speed ratios and high solidity VAWT with quite reasonable accuracy.

III. SYSTEM DESCRIPTION

System Parts:

1. Windmill
2. Aerofoil Blade
3. Cam Base
4. Central Shaft Slider
5. Coupling
6. Spring Support
7. Support Frame
8. Flange Plate
9. Bottom Support Plate
10. Middle Support Plate
11. Top Support Plate

IV. WORKING

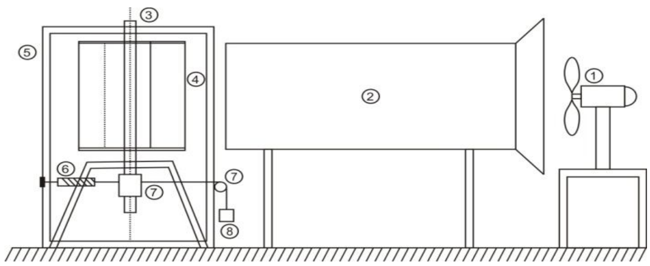
A vertical-axis wind turbine's (VAWTs) main rotor shaft is set vertically and the main components are located at the base of the turbine. Among the advantages of this arrangement are that the generator can be placed close to bottom of the turbine, which makes these components easier to service. The air foils (or blades) are suspended perpendicular to the ground and in the case of ArborWind's design are connected at the top and bottom of the rotor shaft and form a natural parabolic shape. Because the blades are connected at both ends, instead of a cantilevered airfoil with a traditional propeller wind turbine, the blades undergo much less stress and can be much lighter and lower cost. VAWTs also do not need to be pointed into the wind since the blade arrangement is omni-directional. This considerably reduces the cost and complexity of equipment and controls needed for orientation. With a three-axis rotor design, the turbine is Self-starting and can produce power at low wind speeds.

V. PROBLEM STATEMENT

- Despite the advantages, VAWTs have several drawbacks including low power coefficient, poor self-starting ability, negative torque and the associated cyclic stress at certain azimuth angles.

- To overcome this, we have developed the mechanism to change the pitch angle of airfoil blade for this turbine at the best lift of airfoil blade to improve the power coefficient and its performance and also developed an individual active aerofoil blade pitching control mechanism for H-Darrieus turbine to improve its performance and power coefficient.

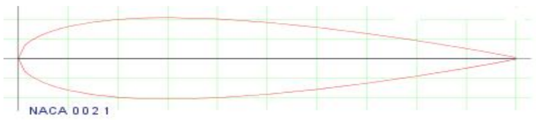
VI. DESIGN OF VAWT



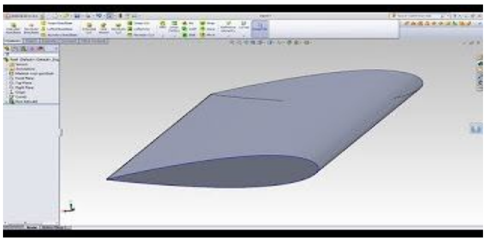
Schematic diagram of experimental setup

Prototype of a three bladed H- Darrieus VAWT

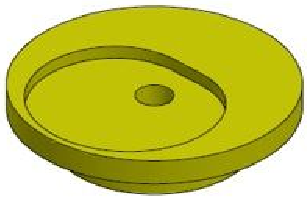
Airfoil blade



NACA021 airfoil



Straight blade profile for H-Darrieus turbine designed



Cam Profile

VII. CONCLUSION

- The NACA0018 aerofoil profile gives maximum power coefficient at top speed ratio 2 compared to other profile.
- The best position pitching blade variation in the amplitude allows for the maximum power extraction for wide range of tip speed ratios.
- Best position of blade with higher pitch amplitudes are preferred at lower tip speed ratios, while best position of blade with lower pitch amplitude produces better performance at higher tip speed ratios.
- Four blades give more stability by reducing fluctuation of net forces acting on blades.
- The Matlag result shows that, NACA0021 aerofoil gives the best power coefficient over the wide range of tip speed ratio from 0.5 to 2.0 compared to other aerofoil profile. The NACA0018 aerofoil profile gives maximum power coefficient at Top speed ratio 2 compared to other profile.

REFERENCES

[1] Abhijeet M. Malge, Prashant M. Pawar, Analysis of Lift and Drag Forces at Different Azimuth Angle of Innovative Vertical Axis Wind Turbine, International Journal of Energy and Power Engineering 2015; 4(5-1): 12-16.

[2] B.K. Kirke, L. Lazauskas, Limitations of fixed pitch Darrieus hydrokinetic turbines and the challenge of variable pitch, Elsevier, Renewable Energy 36 (2011) 893e897.

[3] Mazharul Islam, David S-K. Ting and Amir Fartaj, Aerodynamic models for Darrieus-type straight-bladed vertical axis wind turbines, Renewable and Sustainable Energy Reviews, Science Direct, Elsevier, 12 (2008) 1087-1109.

[4] Morgan Rossander, Eduard Dyachuk, SenadApelfröjd, KristianTrolin, Anders Goude, Hans Bernhoff and Sandra Eriksson,Evaluation of a Blade Force Measurement System for a Vertical Axis Wind Turbine Using Load Cells, Energies 2015, 8, 5973-96;doi:10.3390/en8065973, ISSN 1996-1073

[5] J.F. Manwell, J.G. Mcgowan, A.L.Rogers, Wind energy Explained, second edition, Wiley Publication.

[6] D. I. Eryomin, N.I. Yagfarova, Review of Vertical Axis Wind Turbines, Proceedings of 35th The IIER International Conference, Bangkok, Thailand, and ISBN: 978-93-85465-89-5.

[7] KianooshYousefi, Reza Saleh, The Effects of Trailing Edge Blowing on Aerodynamic Characteristics of The NACA 0012 Airfoil And Optimization Of The Blowing Slot Geometry, Journal Of Theoretical And Applied Mechanics 52, 1, pp. 165-179, Warsaw 2014.

[8] Paraschivoiu I, Double-multiple Stream tubeModel for studying Vertical Axis windTurbine, J. Propulsion, 1987; 4:370-377.

[9] Mazharul Islam, David S-K. Ting and Amir Fartaj, Aerodynamic models for Darrieus-type straight-bladed vertical axis wind turbines, Renewable and Sustainable Energy Reviews, Science Direct, Elsevier, 12 (2008) 1087-1109.

[10] Habtamu Beri, Yingxue Yao, Double Multiple Stream Tube Model and Numerical Analysis of Vertical axis wind Turbine, Scientific Research, Energy and Power Engineering, 2011, 3,262-270.