IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 7, May 2023

Power Generation in Highways using VAWT and Solar

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Abstract*: The main aim of the project is to electrify the country with a combination of wind and solar energy. Our goal is to build a wind turbine compact enough to suit road distribution. Therefore, we decided to build a Vertical Axis Wind Turbine (VAWT) on top of the Horizontal Axis Wind Turbine (HAWT). The advantages of VAWT over HAWT are compactness, low noise, easy installation and maintenance, and responsiveness to wind from all directions for the same power generation. A wind turbine is designed to produce enough electricity for domestic use.The electricity produced is stored in the battery and given to the load. The project focuses on low-cost use of electricity in remote areas, but load balancing must also be done to meet the needs of urban areas*

Keywords: Vertical axis wind turbine, Design, Battery swapping technology, Manufacturing plan, Draft sheet of design

I. INTRODUCTION

In the pursuit of sustainable energy solutions, wind power has emerged as a promising form of renewable energy. Among the many wind turbine models, the helical vertical axis wind turbine (VAWT) is popular for its unique and innovative design. Helical VAWTs differ from straight-wing VAWTs and have many advantages that make them a good choice for wind energy capture. Unlike a horizontal axis wind turbine (HAWT), whose blades rotate in a horizontal plane, a helical VAWT has blades that bend into a helical or twisted shape along a vertical axis. This design sets them apart and opens up new possibilities for capturing wind energy.The spiral shape has many advantages such as improved performance, improved directional wind trapping and is suitable for many areas.

A key advantage of Helical VAWTs over straight-wing VAWTs is their ability to self-start and generate electricity at low wind speeds. The helical blade configuration enables the turbine to draw energy from the wind, supporting smooth and efficient rotation. This self-start feature is particularly useful in medium to low wind areas, expanding the potential for wind power generation. The twisted or helical shape of the blade contributes to the turbine's excellent aerodynamic performance.The helical design allows the blades to maintain an angle of attack throughout their turn, increasing the turbine's ability to capture wind from all directions. This versatile wind capture capability makes helical VAWTs ideal for environments with turbulent or unusual wind patterns, allowing them to harness wind power regardless of the prevailing wind direction.

In addition, the helical shape of the wing provides a large swept area to capture the wind, increasing efficiency and improving power generation. The curved blade sweeps large volumes of air by absorbing kinetic energy and converting it into usable electricity. This performance makes spiral VAWTs a viable option for many applications, including urban and residential areas where space is limited and aesthetics is important.Although helical VAWTs have many advantages, challenges still need to be resolved. Twisted tooth configurations show any complexity and can require careful design and construction decisions. However, with continuous R&D studies, it is aimed to improve the helical design, improve performance and solve all competition problems.

In conclusion, the introduction of helical shape vertical axis wind turbines represents an exciting development in wind energy technology. The distinctive blade configuration of helical shape VAWTs provides improved performance, enhanced omnidirectional wind capturing capabilities, and increased efficiency. These turbines offer a compelling alternative to traditional wind turbine designs, with the potential to expand the reach of wind energy generation and contribute to a more sustainable and clean energy future.

II. LITERATURE REVIEW

"Design and Performance Analysis of Vertical Axis Wind Turbines" by S. W. Lee et al. (Renewable Energy, 2014): This study provides a comprehensive review of the design and operation of vertical axis wind turbines (VAWT). It discusses the aerodynamics, power characteristics and power generation characteristics of the VAWT, highlighting its advantages and limitations."A review of the design and development of small vertical axis wind turbines" by MI Othman et al. (Renewable and Sustainable Energy Review, 2016):

This review focuses on small VAWTs and provides insight into design considerations, aerodynamic analysis and recent developments. Discusses various blade designs, materials, and management techniques."Evaluation of Performance of Vertical Axis Wind Turbines: A Qualitative Analysis", V. S. Neelamani et al. (Renewable and Sustainable Energy Review, 2017):

This comprehensive review explores the performance of VAWTs through experiments, calculations and analysis. Discusses the impact of design, such as blade shape, ratio and power, on turbine efficiency and power output.A. Alzahabi et al. Design Optimization for Straight Axis Blade Wind Turbines. (Electrification and Management, 2018):

This study focuses on the optimization of a straight-wing VAWT design using CFD simulations. He examined the impact of various design factors on turbine performance and presented effective configurations to improve power generation. "Investigation of Construction and Research of Vertical Axis Wind Turbines", by F.Tzanakis et al. (Energy Science Research Review, 2018):

This review provides an in-depth review of the design trends of VAWTs, including Darrieus and Savonius-type turbines. It discusses aerodynamics, performance evaluation, and issues with VAWT and future research directions. "Evaluation of vertical axis wind turbine performance under turbulent flow condition", S. A.A. Waheed et al. (Enerji, 2019):

This experiment evaluates the performance of VAWT in turbulent wind conditions using a miniaturized wind source. It examines the effect of power consumption and different operating conditions on power turbine output and performance. "Design Optimization and Testing of Small Vertical Axis Wind Turbines", M.R. Islam et al. (Journal of Renewable and Sustainable Energy, 2020):

This study focuses on the design and testing of a small VAWT using CFD simulations and experimental measurements. He studied the effects of wing beam length, bending angle and stiffness on turbine performance and determined the design parameters. Investigation of Vertical Axis Wind Turbines: Drag, Lift, and Rotation," H.Y. Peng et al. (Energy Science Review, 2021):

This review discusses the drag, lift, and rotational characteristics of vertical axis wind turbines, focusing on the principles of aerodynamics, flow physics, and performance analysis. "Evaluation of Performance of Vertical Axis Wind Turbines Using Experiments and Numbers", A. Gholinia et al.Structural Analysis and Design of Right Axis Wind Turbine Blades: A Review, S. Li et al. (Review of Wind Turbine Science, 2020):

This review provides an overview of structural analysis and design considerations for vertical axis wind turbine blades, discusses different products, manufacturing and development processes. "Modelling and Optimization of Vertical Axis Wind Turbine Systems: A Review", S. A.Muhammed et al. (Reviews of the Scientific Review of Wind Turbine Systems, 2019):

This review article discusses modeling and optimization techniques for vertical axis wind turbine systems, including mathematical models, control strategies, and various types of optimization.

III. MAIN OBJECTIVES

Mechanical energy, which can then be used to generate electricity or perform other tasks. VAWTs have several advantages over traditional horizontal axis wind turbines (HAWTs) and are designed with the following objectives in mind:

- Efficiency: VAWTs aim to maximize energy capture by efficiently harnessing wind power from any direction, regardless of wind speed or turbulence. Their vertical orientation allows them to capture wind from all directions, eliminating the need for wind-tracking mechanisms.

- Scalability and Compactness: VAWTs are often designed to be compact and can be installed in various settings, including urban environments and areas with limited space. Their vertical orientation and smaller footprint make them suitable for rooftop installations or locations where horizontal space is limited.
- Noise Reduction: VAWTs typically operate at lower rotational speeds compared to HAWTs, resulting in reduced noise levels. This feature makes them more suitable for noise-sensitive environments such as residential areas.
- Safety and Maintenance: VAWTs have a lower risk of bird strikes compared to HAWTs, as the rotating blades are closer to the ground. Additionally, their design often allows for easier access and maintenance, as components can be located at ground level, reducing the need for climbing tall towers.

IV. HARDWARE COMPONENTS OF V.A.W.T

- Wing
- BLDC Motor
- Shaft
- Connecting rod (or) Connecting Shaft
- Mount
- Screws
- Wires
- Bearing
- Base

V. CAD AND 3D MODEL OF VERTICAL AXIS WIND TURBINE:

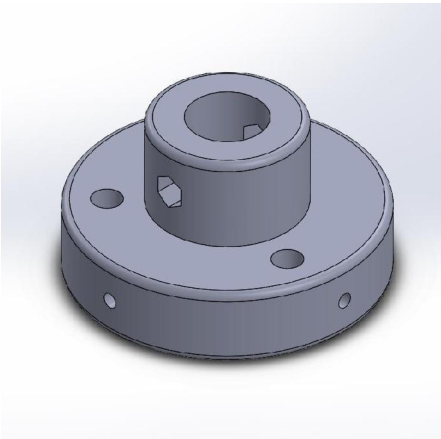

Fig.1 Model of base Mount

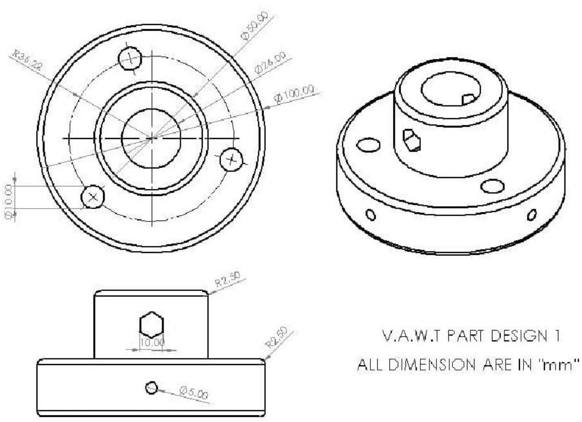

Fig.1 Sketch of base Mount

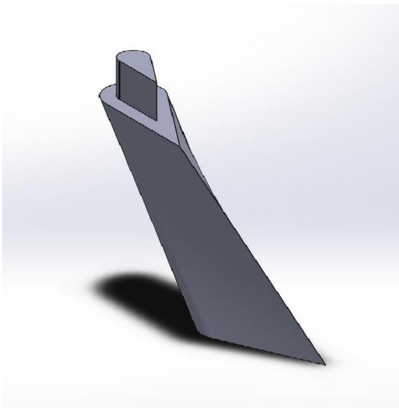

Fig.1 Model of Lower wing

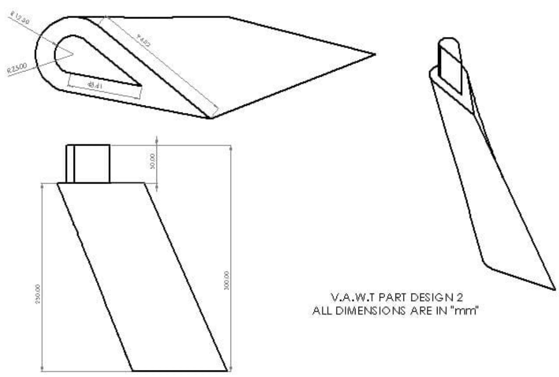

Fig.1 Sketch of Lower wing

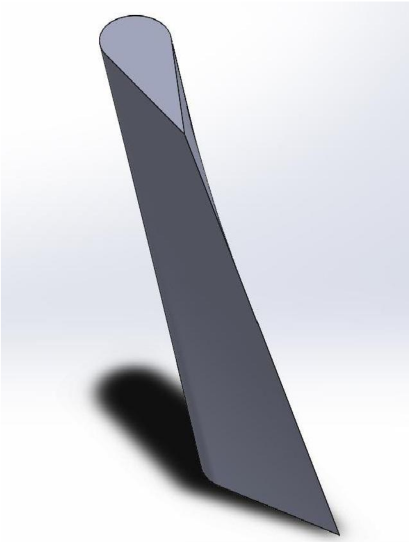

Fig.1 Model of Upper wing

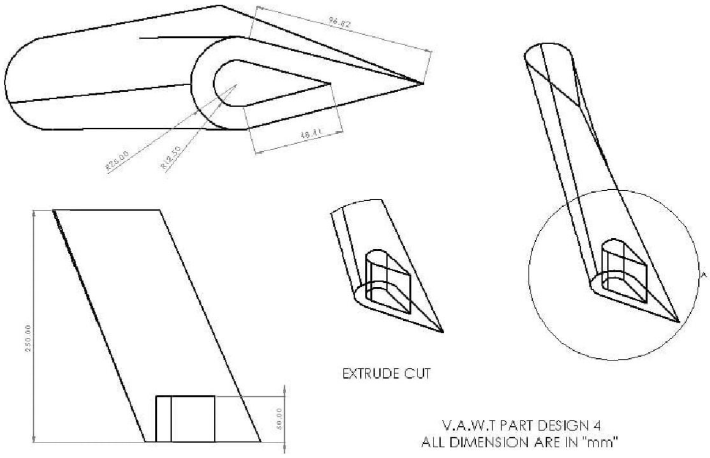

Fig.1 Sketch of Upper wing

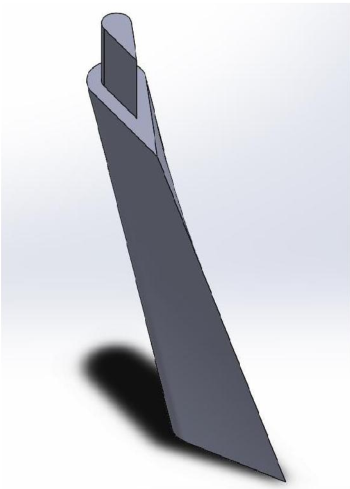

Fig.1 Model of Middle wing

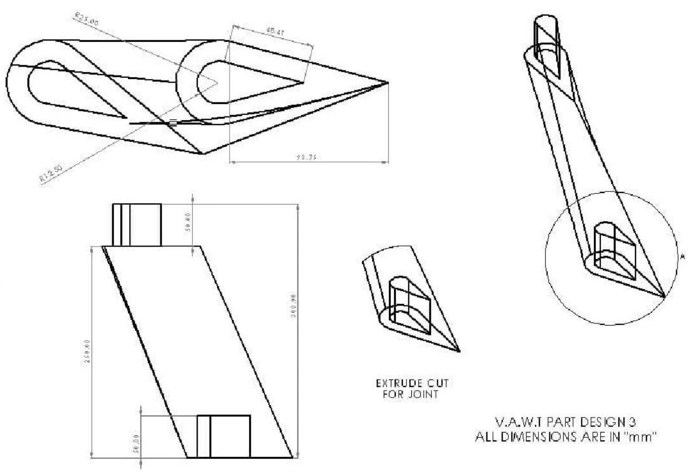

Fig.1 Sketch of Middle wing

VI. ANALYSIS OF V.A.W.T:

Maximum power output and rpm at any wind speed. Power transfer occurs when rpm is controlled to maintain a measured 170 rpm. Output control and speed control are the functions that IEC 61400-12-1 should use: "Measuring the power of wind turbines for energy production." They have used many methods to affect the safety of wind turbines.

Wind Velocity [m/s]	Rotation Speed [rpm]	Power Output [W]	C_p	Remark
~4	25.6	0.05	0.001	starting velocity 3.5 m/s
5	111	10.44	0.087	-
6	131	26.30	0.127	-
7	161	55.74	0.169	-
8	182	97.92	0.199	94.7 W (C_p = 0.192) at 170 rpm
9	215	160.2	0.228	114.7 W (C_p = 0.16) at 170 rpm
10	255	251.9	0.262	135.8 W (C_p = 0.14) at 171 rpm
11	258	304.4	0.238	156.2 W (C_p = 0.12) at 170 rpm

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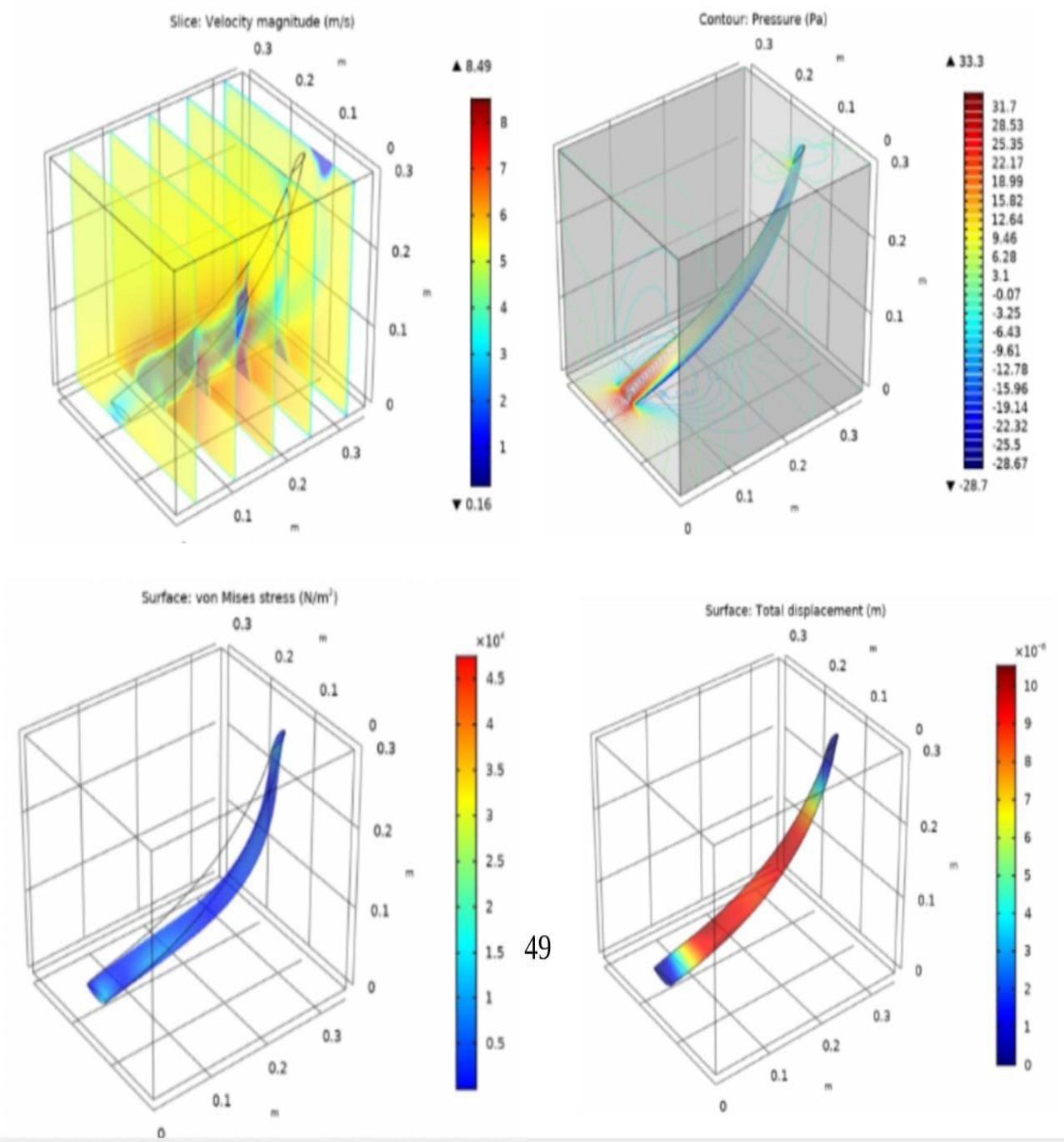
The figure shows the magnitude of the water velocity around the turbine for an outlet velocity of 5 m/s. The maximum speed is about 8.49 m/s and the circulation flow around the main channel and the wing can be seen. The picture shows that the fluid is around the teeth due to the surrounding flow.

The relative maximum is about 33.It can be seen from the picture. But the maximum displacement is small, about 1.05x10-7 meters. This indicates that the wing's strength effectively protects the wing from the wind current. The fluid loads at the current flow rate of the model are not sufficient to affect the blade design.The strength produced by the5083 aluminium alloy is satisfactory for the blade to be absolutely break free. The von Mises yield criterion is based on the von Mises stress in materials science and engineering.



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VII. BATTERY SWAPPING TECHNOLOGY:

Battery swapping technology has emerged as a groundbreaking solution to revolutionize the way electric vehicles (EVs) are recharged. With the aim of overcoming the limitations of traditional charging methods, battery swapping offers a convenient and time-efficient approach. By exchanging depleted batteries with fully charged ones at specialized swapping stations, EV owners can eliminate long charging times and range anxiety.

This innovative technology holds the promise of providing rapid replenishment, extended driving range, and enhanced convenience for EV users. However, its successful implementation requires infrastructure development, standardization, and careful consideration of cost and ownership models. As the industry continues to evolve, battery swapping technology has the potential to significantly enhance the adoption and usability of electric vehicles, contributing to a sustainable and efficient transportation future.

VIII. CONCLUSION

This model shows the analysis of the structure of the helical vertical axis wind turbine blade made of 5083 aluminum alloy installed at the airport. First, a CFD analysis of the fluid flow around the turbine blade is performed to calculate the velocity and pressure distribution around the blade.

Secondly, a stress test was performed in which the blades were exposed to strong winds at different speeds. Calculate the total displacement of the differential wind and the maximum von Mises stress at all points of the wing. Finally, the maximum von Mises voltage is calculated and displayed as a function of different airflow rates.Due to the fluid pressure, the old model of the turbine blade bent.

The biggest change occurs at the two tight ends in the middle of the teeth. The maximum displacement is small, which indicates that the power of the wing effectively protects the wing from the wind current. The greatest tension in the tooth occurs at the point closest to the tip of the hard tooth.

The force produced by the blade is so great that it can be considered that the blade is far from failing.The blade increases with increasing speed and von Mises tension. The fluid pressure on the structure of the current flow is not strong enough to affect tooth formation. The model developed in this study can be used to determine the best materials for wind turbine blades from different materials in different materials.

It can also be used to analyze the strength and stiffness of turbine blades made from selected materials of different wind turbines. In future studies, turbine design parameters such as turbine height and diameter, blade beam length and number of blades may be different and this model can be used easily.The simple design results in a large wind turbine rotor for a measured wind speed of 9 m/s, a tip speed ratio of 1.1 and aerodynamic power of 100 W.

The torque induced by the rotor rotation is calculated using the lift force. and drag force from 2D CFD results. Average output is calculated from 108.34 W meeting the target output of 100 W.More research should be done for the different geometric elements of the helical rotor.

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