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# HIGHWAY VERTICAL WIND TURBINE FEM DESIGN AND STRUCTURAL ANALYSIS

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***Abstract:*** We rely on energy in several ways throughout the day. Our population is growing, but the amount of resources we can consume remains constant. To meet the increasing demand for power without negatively impacting the environment is the primary motivation behind our efforts. The goal of this project is to develop a vertical wind turbine that can be used to harvest kinetic energy from passing cars. Highway traffic generates a significant pressure differential, which may be harnessed to generate wind energy. Using wind turbines with a vertical axis, this energy may be converted into electricity. In this study, we will use two materials to create a helical wind turbine. Stress, shear stress, and total deformation in static analysis and deformations at various frequencies in modal analysis are determined for Al 6061 and CFRP materials. A wind turbine with a vertical axis can be placed in the road's median to increase the effective wind speed acting on the turbine from the wind coming from both sides of the median. Lighting, traffic signals, toll booths, and other urban infrastructure may all benefit from this form of wind energy collection.

***Index Terms - ANSYS, Static Modal Analysis, Vertical pivot, stress, twisting, shear pressure, static and modular examination, CFRP.***

## I. INTRODUCTION

A windmill is a mill that converts the kinetic energy of wind into mechanical energy by means of rotating blades or sails. Windmills were commonly used to grind grain, siphon water, or do both hundreds of years ago. Because of this, they typically consisted of gristmills, wind siphons, or both. Most modern windmills are either wind turbines used to generate electricity or wind siphons used to draw water from the ground or surface water. Turbines harness the wind's kinetic energy and convert it into usable electricity. It's unclear why the word no longer refers to a rotary propeller powered by hydroelectricity. The technical term for such a device is an airfoil-powered generator.

The concept of the rigid sail has also been adapted to a variety of smaller vessels, although neither the large ships nor the smaller ones have received much recognition for using it. Using solar oriented power is another method to reduce ship fuel use. Thanks to recent developments in solar-oriented cells and photovoltaic modules, solar-based power is now a practical fuel-saving option for pleasure boats, yachts, and passenger vehicles. In any case, using solar power alone can only save a negligible amount of fuel on very large ships. As a result, the prospect of a solar-powered boat that is affordable at the present time looks implausible. Bringing the source of energy close to where it is really required and consumed is more important in the use of non-renewable resources. This is why it's so important to put up wind turbines in places where conventional energy production is dropping. From the last few years, a few trials and explorations have been conducted to plan a breeze turbine on a boat that overcomes the breezy wind, drag powers, choppiness, and to have perfect measures as for the energy interest and to that of boat to be silent and without vibrations without influencing the climate. Because of a few advantages over flat wind turbines in the marine and maritime climate, these requirements pave the way to vertical pivot wind turbines. Confined in nature The streamlined design of a VAWT allows it to perform well in winds of any direction, and the reduced weight makes it easy to transport the device to the deck, where it may be mounted. It doesn't have a huge impact on the boat's fuel use, but it does make some little improvements, and the infrastructure required to implement them isn't too expensive. Plans for wind turbines with an upward pivot, such as the darrieus, savonius, giromill, fluttering board, and so on, already exist. The use of flettner motors, skysail technology (towing kites), and the orcelle technique of exploiting energy component innovation are all viable options for harnessing wind power on boats.

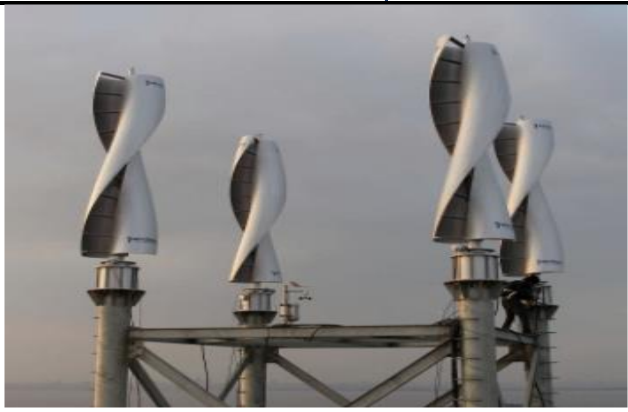

**Figure No 1.1: Vertical Helical Wind Turbine Blade**

**LITERATURE SURVEY**

In "Experiment Validation of Vertical AxisWind Turbine Control System based on Wind Energy Utilization Coefficient Characteristics," Chongyang Zhao and Jun Luo [1] write that an experimental platform for the wind power generating system is set up and that the exterior characteristics of wind generators are measured. Theoretical predictions for the wind energy utilization coefficient are in good accord with observed values. The available power is directly proportional to the wind speed, as stated by Aravind, Rajparthiban, Rajprasad in "Mathematical Toolbox and its application in the Development of Laboratory Scale Vertical Axis Wind Turbine", [2]. As opposed to horizontal turbines, vertical ones can function even when the wind is rather weak. A combined type straight-bladed vertical axis wind turbine (CT -SBV A WT) was designed in this study by installing a Savonius rotor with good starting performance into the SB-VA WT, as stated in Yan Li and Fang Feng's "Computer Simulation on the Performance of a Combined-type Vertical Axis wind Turbine" [3]. If a Savonius rotor set is installed in the SB-V A WT, the vehicle's starting ability is dramatically enhanced. According to Madani, Cosic, and Sadarangani's "A Permanent Magnet Synchronous Generator for a Small Scale Vertical Axis Wind Turbine" [4], a surface-mounted permanent magnet synchronous generator with concentrated windings is a feasible option for small-scale vertical-axis wind turbines. Both the air gap flux density and the induced voltage have low harmonic contents due to the design. Wind energy utilization coefficient characteristics and experimental validation of vertical axis wind turbine control system," by Chongyang Zhao.The exterior features of wind generators are measured, as stated in [5]. Wind turbine qualities and speed ratio are examined.

After the rectifier's output voltage varies, it must be converted by a regulator into a constant DC voltage. The outcome of our study was greatly aided by his exceptional intelligence and insight. Saha et al. (2009) of the United Kingdom note that Savonius rotors lag behind horizontal axis wind turbines in terms of technology due to their slow rotating speed and low power output. However, it is thought that the Savonius kinds of machines may be extremely beneficial for small-scale power demand with some design. Modification of the blades. As a result of preliminary research in this area, a novel, twisted blade form for the Savonius rotor span was created. When compared to more traditional blades, the twisted blade made from sheet metal has proven its worth. In this study, twisted blades made from bamboo strips were examined to determine their practicality in use. Trying out a rotor made of bamboo blades. Having a somewhat slower rotational speed than the twisted metal blades previously examined. But the low price and simplicity of production. These sheets are 550 mm by 350 mm in size, and have been expertly sewn around the edges to guarantee their longevity and robustness. For a smooth and professional look, we wrap both sides of the blades with paper. To achieve the desired curvature, holes were made in the upper corners of the blades and a thin wire was used to draw them into shape. Two more points along the blade height have also benefited from this method in order to keep the appropriate twist angle. A cylinder of solid mild steel serves as the shaft for the rotor. According to S. Rauta, et al. (2009), future energy demand may be met by harnessing wind power. Focus has been placed on the wind generator's and wind turbine's connection to the grid and the issues that arise from that connection. Power electronics and how they are implemented in the design have also been highlighted. Finally, a voltage stability study was performed relative to different types of wind turbines to determine the most effective method of clearing faults and achieving maximum production. Learn how to get the most out of your wind turbine by studying its features and characteristics. Power electronic circuitries have contributed significantly to the development of the idea of wind power. This would have been an impractical and very expensive idea without them. The introduction of thrusters and converters has not only improved the efficiency of operations, but has also greatly simplified them. The voltage stability analysis demonstrated the advantages of a doubly fed induction generator over a single fed one. The paper also detailed the challenges of connecting wind farms to the power grid, as well as possible solutions that may be used to improve efficiency. According to P N Sankar et al. (1998), an A5-inch high wind turbine with curved wooden blades was designed, fabricated, and multi-tested; this work was done on the analytical side, where a performance analysis was developed that allows for the estimation of the machines' capacities. This setup has a number of benefits, including the fact that VAWTs don't have to be aimed towards the wind and that generators and gearboxes may be located near to the ground, making these components easier to operate and repair. Pulsatory torque that may be created during each rotation and enormous bending moments on the blades were major problems for the early designs (Savonius, Darrieus, and giromill). Later versions utilized the helical twist of the blades, virtually identical to Gorlov's water turbines, to address the torque problem. For the same effect, you may tilt a VAWT such that its axis is perpendicular to the wind streamlines. "Transverse axis wind turbine" is a broader phrase that encompasses this choice. Both possibilities are included, for instance, in the first version of Darrieus's patent. Savonius rotors and other drag-type VAWTs often run at lower tip speed ratios than Darrieus rotors and cycloturbines, which rely on lift. Recently, a novel hybrid of the Darrieus and Savonius varieties of VAWT has been created and trademarked. The key advantages include a quieter turbine that can operate in residential areas, even at high wind speeds, and better performance at lower wind speeds.

## II. EXPERIMENTAL INVESTIGATION

A flat windmill of the Savonius type was first attempted to be constructed in the German town of Furstenburg in 1745, despite the fact that the original Savonius wind turbine was designed by the Finnish specialist Sigurd J. Savonius in 1922. They are seldom linked to electrical power systems nowadays. Applying and doing:Since the Savonius is a drag-type VAWT, its turning radius is limited by wind velocity. This means that the tip speed proportion is 1 or less, which is too low for a power generation turbine. Additionally, the productivity is quite low in comparison to other types, thus it may be used for other purposes, such as siphoning water or crushing grain. Most of the land that has been cleared is rather low to the ground, where the wind is weaker and where energy production as a whole is less practical. Among its many attractive features are its simplicity, dependability, and negligible impact on the environment. And because the force is so much greater under low-wind situations, it can function well there, too. However, the force isn't constant, thus enhancements like a helical form are used frequently. Savonius turbines are drag-type turbines typically used in applications requiring great reliability, such as ventilation and anemometers. Their inefficiency stems from the fact that they use a drag-type turbine. When it comes to self-starting and blustery environments, Savonius excel. It's a slow-moving, powerful machine that uses at least two scoops of unvarying quality.

Problem Identification & Objective are as follows:

AL 6061 materials, which were ill-advised, are a major burden and an effective failure. For this project, we needed a material with exceptional strength, therefore we settled on carbon fiber reinforced plastic (CFRP) after carefully analyzing all of the potential options. Much research work has been focused on the topic of landing vertical breeze turbines, as seen by this text. It has been determined that problems arise when requirements for things like strength and solidity of wind turbine, ability to endure the weight impact of the helical breeze turbine, and ability to avoid main damage when rotating quickly, all conflict with one another. Reasonable materials have been offered by scientists.

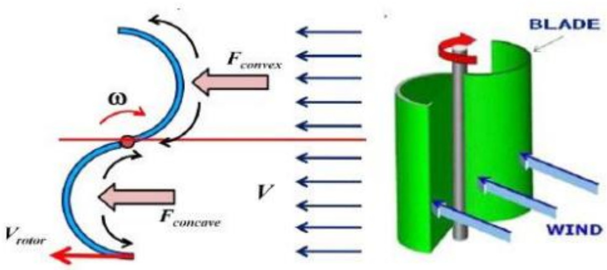


**Figure 3.1: Drag force acting on the wind turbine**

The Savonius wind turbine, one of the simplest types, functions thanks to the differential of powers applied to each of its pointed edges. The wind is caught by the concave section of the breeze bearing, which then turns the cutting edge around the vertical shaft at its center.Without the arc, the sharp edge would be blown off to the side and away from the shaft. As seen, the curved edges provide less drag while going against the wind (Fconvex) than when going with the wind (Fconcave). As a result, the elevated section has been replaced with a curved sharp edge with higher drag force.

## IV. RESULTS AND DISCUSSION

This project's goal is to determine which of the two materials, Al6061 and cfrp, is better suited for use in Vertical Wind Turbines by conducting static and modal testing. The calculated operating load for the helical vertical wind turbine is 31.585N. Vertical wind turbine alludes to this value. In the arrangement phase, the issue is organized according to the issue definitions. The PC does all the time-consuming job of defining and collecting lattices. Figures below show the values found for distortions, stress, and shear pressure.

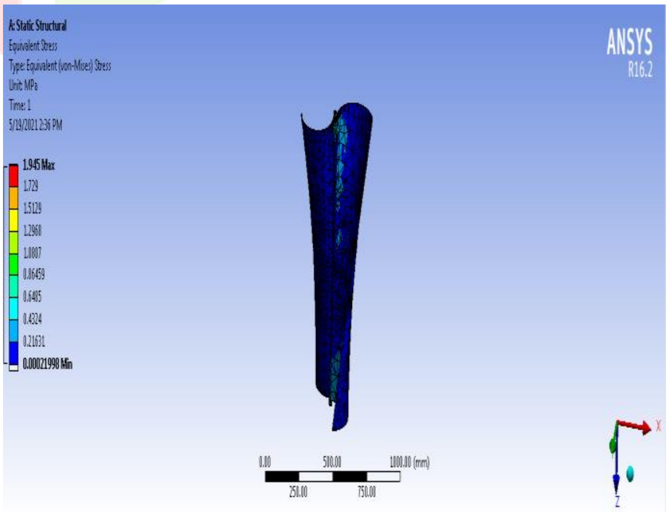


**Figure 4.1: Von-misses stress of Al 6061**

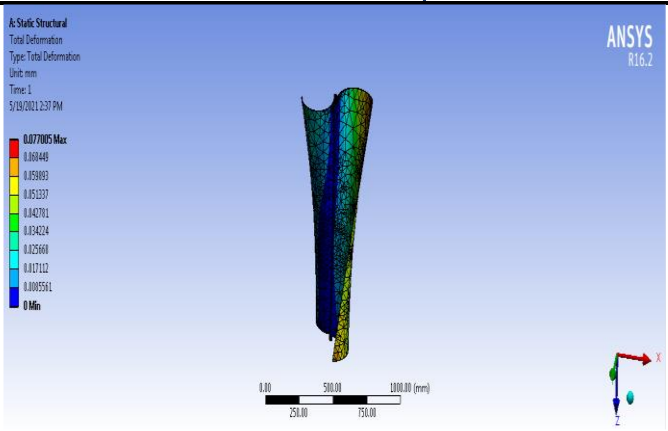


**Figure 4.2: Total Deformation of AL 6061**

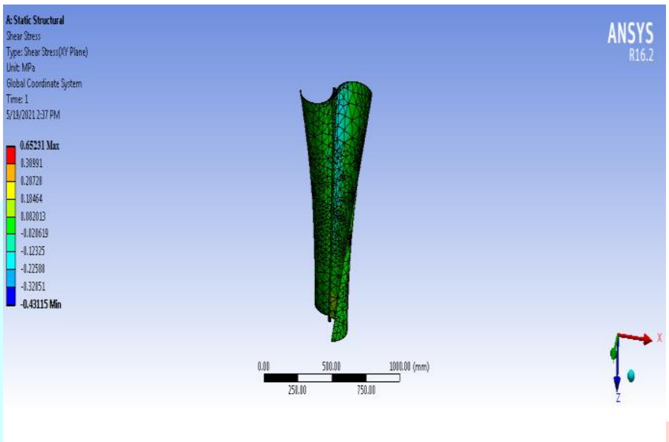


**Figure 4.3: Shear stress of Al 6061**

Finding the system's natural frequencies, damping factors, and mode shapes through modal analysis and then utilizing that information to create a mathematical model of the system's dynamic behavior is called modal analysis. Frequency and location are physical components that may be used to break down the dynamics of a structure.

## V. CONCLUSION

The catia program has been used to model and simulate a helical vertical turbine. Based on the results of the static analysis, we know that CFRP has a higher stress tolerance than aluminum 6061 and displays higher strength values under stress. The pressure differential caused by passing automobiles generates a significant quantity of wind energy. Vertical axis wind turbines are able to harness this wind energy and convert it into usable electricity. The goal of this project is to construct a helical wind turbine out of two materials (Al 6061 and CFRP) and then run static and modal analyses on it to determine its stress, shear stress, and total deformation as well as its frequency-dependent deformations. Installing a wind turbine with a vertical axis in the road median increases the effective wind speed acting on the turbine because the wind from either side of the median acts tangentially in the opposite direction on either side of the turbine. Lighting, traffic signals, toll booths, and other urban infrastructure may all benefit from this form of wind energy collection. Static study of a vertical wind turbine reveals that it is subject to significant strain, shear, and deformation. Composites (CFRP) are determined as appropriate material if we compare stress, corresponding deformations of the material.

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