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 2, June 2023

Design and Development of Harmony Vertical Axis Wind Turbine

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Abstract: *The Harmony Wind Turbine (HWT) is a Vertical Axis Wind Turbine (VAWT) designed to harness the clean and fast energy of wind. Its propeller-like blade configuration ensures rotation regardless of wind direction. To prevent overheating in high winds, the turbine coil can be wrapped around to maintain speed. In this project, we developed a Harmony wind turbine with an anemometer for wind speed control. A 3D CAD model was created using Catia v5 software, and the turbine was manufactured based on design measurements. Tests were conducted to observe its performance at different speeds, and an anemometer was used to start the wind system only when wind speed exceeded a certain threshold, preventing turbine damage.*

Keywords: Energy production, Harmony wind turbine, Furling

I. INTRODUCTION

1.1 Background

The study and development of renewable energy have gained significant attention due to concerns about climate change and the fuel crisis. The burning of fossil fuels releases greenhouse gases, contributing to global warming and environmental issues. Additionally, countries face challenges related to fuel availability and affordability. Renewable energy sources, such as solar, wind, water, biomass, and geothermal, offer sustainable alternatives. They have lower environmental impact, produce minimal pollution, and provide long-term energy security and economic stability. Research and development efforts have improved the efficiency and cost-effectiveness of renewable energy systems. Governments and organizations have implemented supportive policies and incentives. However, challenges remain, including intermittency, energy storage, infrastructure development, and integration into existing systems. Continued research, innovation, and supportive policies are crucial for a clean and sustainable energy future.

1.2 Problem Statement

1. The power shortage issue arose due to multiple factors, including challenges related to the evacuation and stockpiling of coal at thermal power plants, a surge in the price of imported coal for coastal plants, and high prices on the power exchange. These factors collectively contributed to the scarcity of power supply.
2. One of the underlying causes of the energy crisis is overconsumption. This crisis is not solely attributed to a single factor but rather stems from various strains on our natural resources. Overconsumption of fossil fuels such as oil, gas, and coal has resulted in their depletion, leading to a strain on other vital resources like water and oxygen due to pollution.
3. To address these challenges, vertical wind turbines have been proposed in the past. However, the Harmony Wind Turbine (HWT) introduces a unique feature of furling the blades at various wind speeds, which significantly enhances the lifespan of the blades and improves energy generation efficiency.

1.3 Objectives

The objective of this project is to design and develop a Harmony wind turbine capable of operating at different wind velocities. The turbine will utilize an anemometer to measure wind speed and control the furling of blades accordingly.

- Another goal of this project is to compare the proposed Harmony wind turbine with traditional vertical axis wind turbines. Through a comprehensive analysis and performance evaluation, we aim to assess the efficiency, power output, and overall effectiveness of the Harmony turbine in comparison to conventional designs.
- Additionally, this project aims to efficiently harness power through the use of embedded technology.

II. LITERATURE REVIEW

Raut et al. discusses the Harmony Wind Turbine (HWT), a type of Vertical Axis Wind Turbine (VAWT), which utilizes a helix-shaped arrangement of blades. The blades are positioned at a 60º angle between adjacent layers, allowing the turbine to start spinning regardless of wind direction. To maintain its speed during high wind speeds or turbulent conditions, the turbine employs a furling mechanism that allows the blades to fold into a circle. This eliminates the need for disk brakes, which can become hot and potentially cause fires. The objective of the paper is to demonstrate that the furling system, activated during cut-off speed conditions, effectively stabilizes the power curve of the turbine, unlike conventional wind turbines that experience a drastic drop in power output due to braking. The furling mechanism incorporates an RPM sensor, Arduino UNO, servo motor, and furling gears. It offers protection against blade breakage and prevents generator damage or fires. The paper also describes the design and assembly of the scoop-shaped blades, joining strip, furling gears, and shafts using Solidworks 2016. Flow simulation using Solidworks Flow Simulation Wizard is conducted to generate flow trajectories and cut plots.

Gao et al. discuss the Harmony Search (HS) method is an emerging meta-heuristic optimization algorithm, which has been employed to cope with numerous challenging tasks during the past decade. In this paper, the essential theory of the HS algorithm is first described in details. Next, a few typical variations of the HS method are explained. The application of the HS in a practical wind turbine electrical generator optimal design case study is finally presented. Computer simulation results have clearly demonstrated its remarkable performances in dealing with demanding optimization problems.

Malvadkar et al. present innovative wind turbine structure for enhancing efficiency for various applications. The smart wind turbine consists of curvy savonius blades which are connected to the shaft. The blades are designed in a such a way that, if wind strikes on any one part of blade (i.e. left side or right side of the shaft) the wind turbine rotate effectively on its own axis and in only one direction i.e. clockwise direction. The AC generator is connected to the lower part of the wind turbine which converts mechanical energy to electrical energy. The generated electrical energy is stored in battery by converting AC voltage into DC voltage with the help of Rectifier & gets stabilized by regulated Module. This stored energy which can be further used for home lighting, street lighting, toll gates etc. Hence our prototype module has been developed and analyzed in real atmosphere. This project idea does not require heavy towers, protects against the breakage of blades, works effectively even if wind changes in directions.

Previous research and innovations in Vertical Axis Wind Turbine (VAWT) design and development have contributed to the advancement and optimization of these types of wind turbines. Here are some key areas of research and innovations in VAWT design:

- Blade Design: Researchers have explored various blade shapes, including straight, curved, helical, and S-shaped designs. Different blade profiles are investigated to improve aerodynamic performance, efficiency, and power generation at varying wind speeds. The use of airfoils and specialized blade geometries has been studied to enhance lift and reduce drag.
- Darrieus and Savonius Designs: The Darrieus and Savonius are two common VAWT configurations. The Darrieus design features curved blades that resemble an eggbeater, while the Savonius design uses a symmetrical S-shaped rotor. Research has focused on optimizing the performance and efficiency of these designs by improving the aerodynamic characteristics and reducing start-up torque.
- Performance Enhancement: Various techniques have been explored to enhance the performance of VAWTs. This includes the use of winglets, spoilers, and vortex generators to control the airflow around the blades and improve lift. Additionally, research has investigated the use of aerodynamic modifications and flow control devices to reduce drag and increase power output.
- Structural and Material Innovations: Researchers have investigated new materials and construction techniques to improve the structural integrity and durability of VAWTs. This includes the use of composite materials,

ISSN 2581-9429 IJARSCT

advanced manufacturing processes, and innovative tower designs to enhance stability and reduce maintenance requirements.

- Noise Reduction: Noise generated by VAWTs has been a focus of research. Studies have explored the effects of blade shape, blade material, and rotor configuration on noise production. Techniques such as blade serrations, trailing edge modifications, and optimized blade profiles have been investigated to reduce noise emissions.
- Vertical Axis Wind Farms: Research has also examined the feasibility and optimization of vertical axis wind farms, where multiple VAWTs are arranged in arrays. This includes studying the spacing between turbines, wake interactions, and the impact of array configuration on power generation and efficiency.
- Control Systems and Grid Integration: Efforts have been made to develop advanced control systems for VAWTs. These systems aim to optimize power output, enhance turbine performance in varying wind conditions, and ensure grid compatibility. Integration of VAWTs with energy storage systems and smart grid technologies has also been investigated.

Some common gaps in VAWT technology:

- Efficiency and Power Output: VAWTs have traditionally faced challenges in achieving high efficiency and power output compared to horizontal axis wind turbines (HAWTs). The Harmony VAWT aims to address this gap by optimizing its blade design and arrangement. The helix-shaped arrangement of blades, along with the specific angle between adjacent layers, allows the turbine to start spinning irrespective of wind direction. This innovative design seeks to improve the turbine's efficiency and power capture, potentially narrowing the efficiency gap with HAWTs.
- Wind Speed Variability: VAWTs often struggle with maintaining consistent power output due to variations in wind speed. The Harmony VAWT incorporates a furling mechanism that allows the blades to fold into a circle during high wind speeds or turbulent conditions. This feature aims to maintain the turbine's speed and stabilize the power curve, thereby addressing the issue of drastic drops in power output during cut-off speed conditions, which is commonly seen in conventional VAWTs that rely on braking systems.
- Safety and Reliability: Safety concerns, such as the potential for blade breakage, generator damage, and fires, have been identified in VAWT designs. The Harmony VAWT addresses these issues by eliminating the need for disk brakes and implementing a furling system instead. By utilizing an RPM sensor, Arduino UNO, servo motor, and furling gears, the turbine actively protects against blade breakage and reduces the risk of generator damage or fire incidents.
- Wind Direction Independence: VAWTs often require complex systems or mechanisms to orient themselves to wind direction for optimal performance. The Harmony VAWT's helix-shaped blade arrangement aims to eliminate the need for wind direction orientation. Regardless of the wind direction, the turbine can start spinning, simplifying the design and potentially improving the turbine's reliability and maintenance requirements.

III. METHODOLOGY

Construction of the turbine:

- Blade Configuration: The project involves the construction of a Harmony Vertical Axis Wind Turbine (VAWT) with a specific blade configuration. Six blades are attached in a fulcrum shape, forming two sets that are parallel to each other and arranged in series vertically. This configuration allows for efficient wind capture and rotation of the turbine.
- Shaft and Gear Mechanism: A central shaft with gears is provided in the turbine design. This shaft and gear mechanism enables the opening and closing of the blades based on the velocity of the wind. The gearing system ensures that the blades adjust their position according to the wind speed for optimal performance.
- Stepper Motor: At the end of the shaft, a stepper motor is attached. This motor is responsible for rotating the shaft, which in turn adjusts the blade position as the wind velocity changes from minimum to maximum. The stepper motor allows precise control over the movement of the blades, ensuring optimal efficiency at different wind speeds.

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- Arduino Controller: To control the operation of the stepper motor and blade movement, an Arduino controller is utilized. The Arduino controller is programmed to respond to specific wind speed requirements and adjust the blade position accordingly. It allows for flexibility and customization in the operation of the turbine based on the desired performance parameters.
- Anemometer: An anemometer is incorporated into the project to measure the wind velocity. This device provides real-time data on the speed of the wind, which is crucial for the control system to adjust the blade position and optimize power output based on the current wind conditions.

IV. RESULTS AND DISCUSSION

Before conducting trials on turbine ensure all components are properly installed and functioning correctly.

1. Wind Velocity Measurement: Use an anemometer or wind speed meter to measure the wind velocity at the location where the turbine is installed. Ensure accurate and consistent readings of the wind speed.
2. Instrumentation Setup: Connect appropriate instrumentation to measure voltage and current. This may include a voltmeter and an ammeter capable of measuring the expected range of values.
3. Test Configuration: Position the turbine in a suitable location with sufficient wind exposure. Ensure it is securely mounted and oriented according to the manufacturer's guidelines. We choose collage Ground. Connect the turbine's electrical output to the measuring instruments, allowing for voltage and current measurements.
4. Data Collection: Start recording the wind velocity, voltage, and current measurements simultaneously. Continuously monitor the wind velocity throughout the test duration. Record the voltage and current readings at specific intervals, corresponding to the desired time intervals.
5. Test Execution: Start the turbine and allow it to operate under the given wind conditions. Monitor the voltage and current readings continuously for the specified duration. Ensure that the turbine is operating within safe limits, and take any necessary precautions or safety measures.
6. Data Analysis: Analyze the recorded data to determine the relationship between wind velocity, time, voltage, and current. Plot the variations in voltage and current over time for different wind velocities. Assess the turbine's power generation capabilities by calculating the power output (P = V x I) at each time interval.
7. Performance Evaluation: Evaluate the turbine's performance by analyzing the relationship between wind velocity, power output, and efficiency.

Sr. No	Time in sec	Wind data in m/sec	Voltage in v	Current in (mA)
1.	10	2.1	11.34	127.16
2.	30	1.7	14.75	109.7
3.	60	2.4	16.39	129.43
4.	120	3.6	33.6	191.36
5.	240	2.9	17.39	133.45

V. ENVIRONMENTAL CONSIDERATIONS

5.1 Environmental Impact Assessment

When considering the environmental impact of the Harmony VAWT, several factors need to be taken into account, including bird and bat protection measures. Here are some key points to consider:

Bird Protection Measures: VAWTs, including the Harmony VAWT, generally have a lower risk of bird collisions compared to horizontal axis wind turbines (HAWTs). The vertical orientation and slower rotation speed of VAWT blades are less likely to attract birds. However, it is still important to assess and mitigate any potential risks. This can be achieved by conducting thorough bird impact studies and choosing turbine locations away from migratory routes or important bird habitats.

5.2 Environmental Concerns and Mitigation Strategies

While VAWTs are generally considered to have lower environmental impacts compared to other forms of energy generation, there are still potential concerns that need to be addressed. Here are some examples of environmental concerns and mitigation strategies:

- Noise Pollution: Wind turbines can generate noise, especially during operation. To mitigate noise pollution, the Harmony VAWT can be designed with aerodynamic modifications, such as blade serrations or trailing edge modifications, to reduce noise emissions. Additionally, careful consideration of turbine placement, distance from residential areas, and noise monitoring can help minimize the impact on surrounding communities.
- Visual Impact: Wind turbines, including VAWTs, can have a visual impact on the landscape. Mitigation strategies include conducting visual impact assessments to identify appropriate turbine locations, ensuring proper setbacks from residential areas, and incorporating landscape design techniques to blend the turbines with the surrounding environment.
- Wildlife Habitat: The construction and operation of wind turbines can potentially impact local wildlife habitats. Environmental assessments should be conducted to identify and protect sensitive habitats. This may involve implementing setback distances, conserving important wildlife corridors, and considering the cumulative impact of multiple turbines on local ecosystems.
- End-of-Life Considerations: Proper decommissioning and recycling of wind turbine components are essential to minimize environmental impacts. The Harmony VAWT project should include plans for the responsible disposal or recycling of turbine components at the end of their lifecycle, adhering to relevant regulations and best practices.

It is important to note that specific environmental impact assessments and mitigation strategies for the Harmony VAWT would require comprehensive studies and analysis in the specific context of its deployment. Environmental considerations should be an integral part of the project's planning, design, and operation to ensure responsible and sustainable deployment of the technology.

VI. CONCLUSION

The primary objective of the project was to design and develop a vertical axis wind turbine that incorporates the principles of harmony to enhance its performance and efficiency. Research were conducted to understand the fundamental concepts of wind turbine technology, air flow and mechanical systems. This knowledge was applied in the design phase, where a robust and innovative mechanical frame was developed to support the turbine's internal components.

The incorporation of harmony-shaped blades and a mechanical gear arrangement allowed for precise control over blade opening and closing, optimizing power generation in response to varying wind velocities. This design innovation has the potential to increase the turbine's efficiency and power output. During the fabrication phase, careful attention was given to material selection, manufacturing techniques, and quality control. The turbine components were fabricated and assembled with precision to ensure structural integrity and long-term reliability.

The project also emphasized sustainability and cost-effectiveness. The streamlined design approach and optimization of materials and manufacturing processes aimed to minimize costs while maximizing the turbine's performance.

Overall, the design and development of the Harmony Vertical Axis Wind Turbine has been successful in achieving its objectives. The project contributes to the advancement of renewable energy technologies by introducing innovative design concepts and improving the efficiency of wind power generation. This project opens doors for further research and development in the field of vertical axis wind turbines, bringing us closer to a sustainable and clean energy future.

VII. FUTURE WORK

Future Work for the Harmony VAWT can focus on the following areas of improvement and further research:

- Scalability: Investigate the scalability of the Harmony VAWT design to determine its performance and efficiency at larger sizes. This research can explore the optimal number of blades, blade length, and overall dimensions for different scale variations. Understanding the scalability potential will help determine the viability of the turbine for various applications, from small-scale residential use to larger commercial installations.
- Cost Reduction: Conduct research to identify opportunities for cost reduction in the manufacturing, assembly, and installation processes of the Harmony VAWT. This can involve exploring alternative materials, streamlining production techniques, and optimizing the design to minimize material and labor costs. Cost-effective VAWTs would enable wider adoption and facilitate the transition to renewable energy sources.
- Performance Optimization: Focus on enhancing the overall performance and efficiency of the Harmony VAWT. This can include investigating aerodynamic improvements to the blade design, such as airfoil optimization, to maximize energy capture and minimize drag. Additionally, research can be conducted to optimize the turbine's response to varying wind speeds and turbulence, ensuring consistent power output and improving its ability to operate in a wide range of wind conditions.
- Integration with Energy Storage Systems: Explore the integration of the Harmony VAWT with energy storage systems to address the intermittency of wind power generation. Research can focus on the development of efficient energy storage technologies, such as batteries or hydrogen storage, to store excess energy generated by the turbine during periods of low demand or high wind speeds. This integration would enhance the stability and reliability of the turbine's power output, making it a more reliable and flexible renewable energy solution.
- Environmental Impact Assessment: Conduct further studies and assessments to evaluate the long-term environmental impact of the Harmony VAWT. This can include monitoring the turbine's effects on bird and bat populations, studying its impact on local ecosystems, and refining mitigation strategies to minimize any potential negative environmental consequences.

REFERENCES

[1]. Raut, S., Sawant, K., Yadhav, M., Sawant, H., & Patel, V. D. (2020). Design and development of harmony wind turbine. Int. J. Eng. Res. Technol, 9.

[2]. Gao, X., Wang, X., & Zenger, K. (2016). Harmony search method for optimal wind turbine electrical generator design. *Rakenteidenmekaniikka (Journal of Structural Mechanics)*, *49*(3), 119-136.

[3]. Malvadkar, K., Mali, A., Yemul, N., & Patted, M. (2019, May). Harmony Vertical Axis Wind Turbine. In *Proceedings of International Conference on Communication and Information Processing (ICCIP)*.

[4]. Dr. ShivprakashBhagwatraoBarve And PiyushGulvesee "Design and construction of vertical axis wind turbine'' International journal of mechanical engineering and technology (IJMET),ISSN 0976 –6359, Volume 5, Issue 10, pp. 148-155 October (2014)

[5]. MagediMoh. M. Saad, a, NorzelawatiAsmuin "Comparison of Horizontal Axis Wind Turbines and Vertical Axis Wind Turbines" IOSR Journal of Engineering (

[6]. S. V. Saravanan, M. Varatharaj, L. Ayyadurai, S. Palani& D. Prem "Design and Fabrication of Vertical Axis Highway Windmill" International Journal of Advanced Electrical and Electronics Engineering (IJAEEE), ISSN (Print): 2278-8948, Volume-2, Issue-2, 2013