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Design and Testing of Vertical Axis Wind Turbine

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Abstract: *This abstract introduces a novel approach to the design and implementation of a Vertical Axis Wind Turbine (VAWT) using PVC (polyvinyl chloride) pipes. The incorporation of PVC pipes in VAWTs presents unique advantages for renewable energy generation across various applications. This study focuses on investigating the feasibility of integrating PVC pipes into a VAWT specifically designed for highway applications.*

The paper emphasizes the potential of VAWTs with PVC pipes for highway settings, providing a cost-effective, flexible, and sustainable solution for generating renewable energy. By utilizing PVC pipes as a key component in the turbine design, this approach offers numerous benefits such as affordability, availability, and ease of installation. Furthermore, PVC's durability and resistance to environmental factors make it suitable for withstanding the challenges of highway environments.

The primary objective of this study is to shed light on the possibilities and opportunities associated with VAWTs using PVC pipes. Through rigorous research and analysis, valuable insights into the performance, efficiency, and scalability of this design are anticipated. These insights will serve as a foundation for future research and development endeavors, fostering advancements in clean energy technologies and sustainable infrastructure.

Keywords: Vertical Axis Wind Turbine, Design, Fabrication.

I. INTRODUCTION

There is no doubt that current trends in energy and the unreasonable use of planetary resources pose a serious threat to the planet. Unlimited growth, based on a limited amount of fossil fuels, is not only unrealistic, but also extremely damaging to the world's fragile systems. As sea ice continues to melt, and global temperatures continue to rise, the effects of human action are felt worldwide. Vertical Axis Wind Turbines (VAWTs) are innovative devices used to harness the power of wind energy and convert it into usable electrical power. Unlike traditional horizontal axis wind turbines, which have a propeller-like design, VAWTs feature a vertical axis of rotation, allowing them to capture wind from any direction without the need for reorientation. This also emphasizes the need to innovate in the sector, especially for small scale. The main motivation for this project is to take a step closer to a stable country, where human relationships are mutually exclusive.

II. PROPOSED MODEL

The proposed model aims to design and implement a Vertical Axis Wind Turbine (VAWT) system using PVC (polyvinyl chloride) pipes for renewable energy generation. This innovative model combines the advantages of VAWTs with the unique properties of PVC pipes to create a cost-effective and sustainable solution for clean energy production.

The VAWT system will be designed to be adaptable for various applications, with a specific focus on highway settings. By utilizing PVC pipes as the main structural component of the turbine, the model offers numerous benefits such as affordability, lightweight construction, and ease of assembly. PVC pipes are readily available, durable, and resistant to environmental factors, making them suitable for withstanding the challenges of highway environments.

The design will incorporate aerodynamic blades attached to a central shaft, which will rotate when exposed to wind. As the blades rotate, they will generate mechanical energy that will be converted into electrical energy by an alternator or generator. The electrical energy produced will be stored in a battery system for later use or fed directly into the power grid.

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The proposed model also considers factors such as wind direction and speed, as well as safety measures to ensure the turbine operates efficiently and reliably. Additionally, the model will be optimized to capture wind energy even in low wind speed conditions, maximizing energy generation potential.

This proposed model presents a cost-effective and sustainable solution for renewable energy generation, specifically targeting highway applications. By harnessing the power of wind through VAWTs constructed with PVC pipes, this model has the potential to contribute to the reduction of greenhouse gas emissions and the promotion of clean energy in transportation infrastructure.

Fig 1: Proposed Model of Vertical Axis Wind Turbine

III. ANTI GLARE BARRIER

Fig 2: Anti-Glare Barrier

Specifications of Anti-Glare Barrier
Height: 1070mm
Width
Upper: 610mm, Lower: 310mm

This is Anti-Glare Barrier which is placed on highways for restricting the opposite side headlights of vehicles. So we have taken reference from it to our model by taking its dimensions hence our project helps for restricting the headlights and also producing electric energy. And we can have used VAWT instead of Anti-glare barrier on highways.

IV. FABRICATION OF VAWT USING PVC

Blades

Fig 4- Blades

A key component of the proposed model is a PVC pipe with a diameter of 100 mm. To prepare the pipe for the wind turbine assembly, it is cut into dimensions of 100 mm x 500 mm. This cutting process ensures that the PVC pipe is appropriately sized for the specific design requirements.

Next, the PVC pipe is drilled at two locations, 100 mm and 500 mm from the top of the pipe. This drilling is performed with the aid of a drilling machine, and the diameter of the drilled holes is 3 mm. The drilling process creates openings in the PVC pipe, which will serve specific functions within the wind turbine system.

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Once the drilling is completed, the PVC pipe is connected to a Y-angle component using a nut and bolt arrangement. The Y-angle provides a stable connection point for attaching other turbine components, such as the blades and the central shaft. The nut and bolt securely fasten the PVC pipe to the Y-angle, ensuring a robust and stable assembly.

The utilization of PVC pipe in this manner offers several advantages. PVC is a lightweight and durable material that is readily available and cost-effective. It is also resistant to corrosion and can withstand various environmental conditions, making it suitable for outdoor applications like a wind turbine. The drilling and connecting process described above enable the integration of the PVC pipe into the overall wind turbine structure, facilitating the efficient conversion of wind energy into electrical power.Other components in assembly are;

Metal strip length= 270mm, Ring Dia = 20mm

Shaft: Shaft Dia = 25mm, length=800mm

AC generator = 50W & 150RPM

V. CALCULATIONS AND RESULTS

Input (Theoretical) :

$$p = \frac{1}{2} \times \varrho \times A \times v^3$$

$$p = \frac{1}{2} \times 1.205 \times 0.6 \times 0.6 \times 5^3 \times 0.593 \times 3.6$$

$$p = 57.879 \text{ kwh}$$

Table 1: Reading

Time in Min	Wind Data	Voltage (V)	Current(mA)
1	1.70	17.65	111.62
2	2.04	20.22	139.23
3	3.61	24.74	159.40
4	2.90	21.60	145.18
5	2.73	21.12	143.70
Average=	2.59	21.06	139.90

Where V = Wind velocity

A= Swept Area

Betz Coefficient = 0.593

Output (Practical) :

$$p = v \times I$$

$$p = 24.45 \times 149.87 \times 10^{-3} \times 3.6$$

$$p = 13.1915 \text{ kwh}$$

$$\eta = \frac{O/P}{I/P} = \frac{13.1915}{57.879}$$

$$\boxed{\eta = 22.791\ \%}$$

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VI. FUTURE SCOPE

The future scope of Vertical Axis Wind Turbines (VAWTs) utilizing PVC (polyvinyl chloride) pipes holds significant potential for advancements and widespread adoption in various applications. This project serves as a small step in the development of a small renewable energy generation sector. VAWTs can generate power even in unstable weather conditions like gusty wind and turbulence.

Here are some potential areas of future development and opportunities for VAWTs using PVC:

- Noise Reduction: Noise generated by wind turbines, especially in urban and residential areas, is a concern. Future studies can concentrate on reducing the noise levels associated with VAWTs using PVC pipes, making them more socially acceptable for installation in noise-sensitive environments
- Scaling Up: While PVC pipes offer scalability advantages, further research can explore the feasibility of larger-scale VAWTs using PVC. Up scaling the size of VAWTs while maintaining structural integrity and efficient energy conversion would open up new opportunities for commercial applications, including large-scale power generation.
- Urban Applications: VAWTs with PVC pipes are well-suited for urban environments due to their compact design and omnidirectional wind capture capability. Future developments can focus on integrating VAWTs into building structures, streetlights, and other urban infrastructure, enabling decentralized renewable energy generation and reducing dependence on the traditional power grid.

VII. CONCLUSION

In conclusion, the modified model presented in this paper provides a promising solution for fulfilling the small-scale energy demands in urban areas, particularly through the integration of an anti-glare barrier and a wind turbine on highway dividers. This innovative approach not only caters to the energy needs of neighbouring communities but also enhances road safety by mitigating glare for drivers.

The integration of a wind turbine within the anti-glare barrier presents a unique opportunity to harness clean and renewable energy from the plentiful wind resources available along highways. By capitalizing on the wind currents created by passing vehicles, the model efficiently converts this kinetic energy into usable electrical power, thereby contributing to the sustainable generation of electricity.

This combined system offers multiple advantages, including optimized space utilization, reduced environmental impact, and improved energy efficiency. By leveraging the abundant wind resources inherent to highways, the model harnesses a clean and renewable energy source that can contribute to a greener and more sustainable future.

However, it is essential to conduct further research and development to optimize the model's performance, efficiency, and reliability. Considerations such as maintenance requirements, cost-effectiveness, and scalability should also be thoroughly examined to ensure the practicality and long-term viability of this integrated approach.

In conclusion, the modified model presented in this paper demonstrates the potential of integrating an anti-glare barrier and a wind turbine on highway dividers to meet small-scale energy needs. This model showcases the effective utilization of wind resources to generate clean and renewable energy, highlighting the significance of sustainable energy solutions in our road infrastructure.

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