DEVELOPMENT AND FABRICATION OF A VERTICAL AXIS WIND TURBINE USING ARECA NUT NANOPARTICLE

Project Reference No.: *48S_BE_3278*

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Introduction:

The increasing demand for sustainable and renewable energy sources, wind energy has emerged as a critical component in meeting global energy needs. Wind turbines, specifically their blades, play a pivotal role in harnessing wind energy effectively. Traditionally, wind turbine blades are made from composite materials like fiberglass and carbon fiber, which, while efficient, can be costly and environmentally unfriendly during production and disposal. In recent years, the focus has shifted towards exploring eco-friendly, cost-effective alternatives. One promising material is areca fiber, a natural fiber obtained from the husk of areca nuts, which are widely grown in tropical regions. Areca fiber is biodegradable, lightweight, and has decent tensile strength, making it a potential candidate for use in wind turbine blade manufacturing. This project aims to explore the feasibility of using areca fiber for constructing vertical axis wind turbine (VAWT) blades. By leveraging areca fiber, the project seeks to contribute to the development of more sustainable and economically viable wind energy solutions. The scope includes material analysis, design optimization, and performance evaluation of the areca fiber- based blades in real-world conditions.

Objectives:

➢ To design, fabricate and develop VAWTG blades using areca nut Nano particles.

➢ To analyse and minimize weight of VAWTG blades by undergoing various structural tests to suit for low wind speeds.

Methodology:

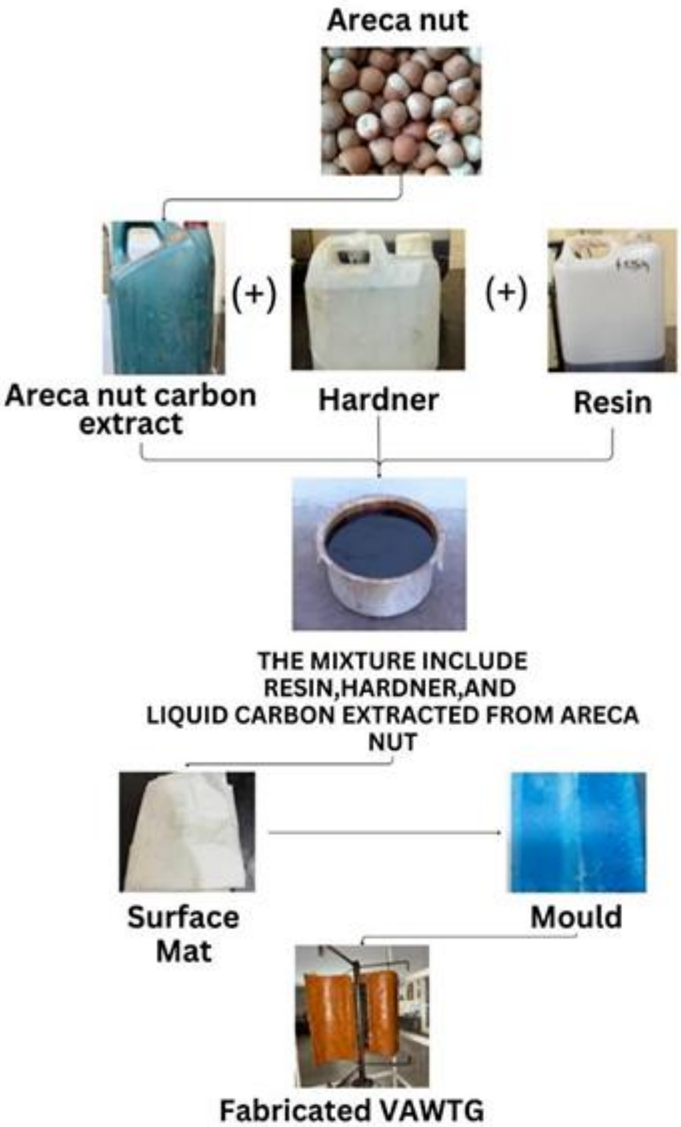

Fig 1. Methodology of the proposed project blades of VAWTG

The Methodology of Fig.**1** represents the development of the Vertical Axis Wind Turbine (VAWT) and illustrates the working principle of the project. The VAWT operates on the principle of converting wind energy into mechanical energy, utilizing Savonius-shaped blades. These blades rely on drag-based rotation, where the wind's force on the concave surfaces causes them to turn. This design is highly efficient in capturing wind energy from any direction and performs effectively even at low wind speeds, making it versatile for various environmental conditions. The blades are constructed from a composite material enhanced with carbon nanoparticles derived from areca nuts. These nanoparticles are produced by heating areca nuts at high temperatures, typically between 600-700°C, to extract carbon. The extracted carbon is then mixed with materials like resin, hardener, Durawax, and thinner to create a robust composite. This material significantly enhances the mechanical properties of the blades, such as tensile strength, flexibility, and resistance to environmental wear, ensuring durability and optimal energy capture.As the turbine rotates, the mechanical energy generated can be converted into electrical energy using a generator, depending on the system configuration. By incorporating areca nut waste in the production process, the project emphasizes sustainable practices, promoting eco- friendly innovation in renewable energy systems. This combination of aerodynamic efficiency, material sustainability, and energy conversion is central to the project's objective of developing a practical and environmentally responsible solution for small-scale energy generation.

Result and Conclusion:

The experimental results conducted at Basaveshwar Engineering College, Bagalkote, in the SCADA lab with variable wind speeds are given below.

SL.NO	Wind Velocity in m/s	Speed (in RPM)	Voltage in DC(V_{dc})	Current in DC (I_{dc})	Voltage in AC(V_{ac})	Wind Power (in W)	Power extracted (in W)
1	1	11	1.06	1.17	1.4	0.1078	0.063
2	1.5	11.3	1.13	1.55	1.6	0.363	0.214
3	2.5	11.6	1.21	3.23	2.5	1.684	0.993
4	3.5	20.5	1.33	4.31	3.7	4.621	2.726
5	4.6	36.6	1.46	5.65	4.5	10.492	6.190
6	6.5	43.2	1.7	6.63	7.8	29.604	17.466
7	7	49.1	1.77	9.29	8.6	36.975	21.815
8	7.2	52.3	1.89	14.03	9.6	40.236	23.739

Table 1. Illustrate the readings taken from the fabricated blades in SCADA Lab for different wind speed.

Experimental results of VAWTG

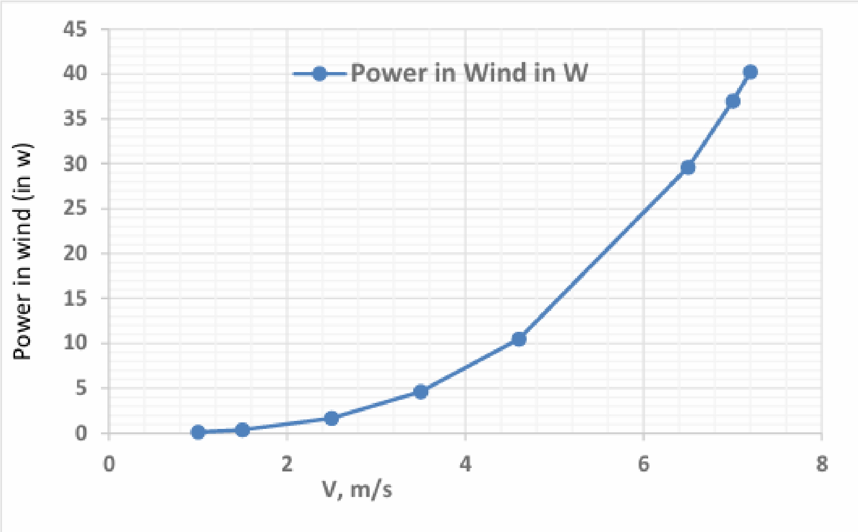

Fig.1: Graph of Wind Power in w vs wind velocity in m/s

Fig.1 The graph illustrates the relationship between wind speed and power in wind. As wind speed (V) increases, the power in wind (in watts) also increases significantly, indicating that wind is a potential source of energy.

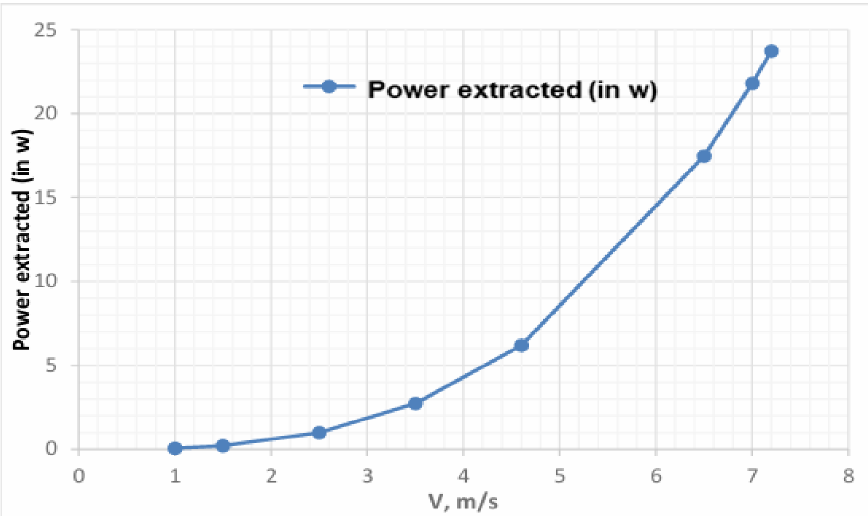

Fig.2: Graph of Power extracted (in W) vs Wind Velocity in m/s

Fig **.**2 graph demonstrates a clear positive correlation between wind speed (V) and the power extracted. As the wind speed increases, the power extracted also increases, suggesting that wind energy potential grows significantly with stronger winds.

Working Model

The project involved the development of a physical working model of Vertical Axis Wind Turbine (VAWT) blades using areca nut nanoparticles, followed by experimental testing under variable wind conditions.

Project Outcomes and Learnings:

Key Outcomes:

1. Lightweight, eco-friendly wind turbine blades were developed using areca nut material, offering improvements over earlier blades made from sisal and gongura fibers

2. The project showed that agricultural waste like areca nut can be used to make sustainable, low-cost materials for clean energy applications.

What we Learned:

1. we learned how to design and build wind turbine blades using natural materials, improving system performance through proper shaping and material selection.

2. we understood how testing and analyzing materials helps create stronger, more efficient blades suitable for real-world wind conditions.

3. we improved my teamwork, time management, and problem-solving skills while working through the design, fabrication, and testing stages of the project.

Future Scope

1. Material Optimization: Further research can be done to explore different compositions and treatments of areca nut carbon to enhance the strength, flexibility, and overall performance of the blades.

2. Design Improvements: Future work can involve refining the Savonius design and experimenting with other wind turbine shapes to optimize energy generation efficiency.

3. Environmental Impact Analysis: A detailed life cycle analysis of the material and energy savings could be conducted to understand the long-term sustainability of areca nut-based wind turbine blades.

4. Commercial Production: Scaling up the production process for mass manufacturing of areca nut-based blades, along with testing in various climatic conditions, would be beneficial for widespread use.

5. Hybrid Systems: Integrating these blades with hybrid energy systems that use both wind and solar power could provide a more reliable energy solution for rural areas.