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DESIGN AND DEVELOPMENT OF 30W HELICAL WIND TURBINE

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Abstract

In an effort to find solutions for global energy crisis, an analysis on a helical vertical axis wind turbine was conducted with the consideration of renewables and energy efficiency. This study was carried out in two steps: the realization of the analytical calculation of a helical wind turbine power output which then informed the design and construction of the rotor blades. The paper particularly aimed to address its use as the electricity supply for residential properties or any other places with less ideal economy conditions. The uncomplicated and highly accessible mechanism using basic materials is to give people to have a viable option on their own electricity production. The world is increasingly going green in its energy use. Wind power is a green renewable source of energy that can compete effectively with fossil fuel as a generator of power in the electricity market. For this effective competition, the production cost must be comparable to that of fossil fuels or other sources of energy.

Keywords—

Helical Vertical Axis Wind Turbine, Wind Power, Renewable Energy, Energy Efficiency, Power Output, Rotor Blade Design, Low-Cost Energy Solutions, Green Energy, Fossil Fuel Alternative.

I. INTRODUCTION:

Wind energy is a clean and inexhaustible energy source widely used as a working fluid for wind farms for centuries. However, its use as a means of electricity supply began modern era due to the rise of environmental concerns and fuel resources issues. The global demand for sustainable and renewable energy has created the necessity for research and the development of new technology. Hence, the wind energy has been the Focus of the industry and has considerably grown its use but just in a large scale production. In recent years, significant increase of more efficient, larger and expensive horizontal axis wind turbines (HAWT) appeared to create onshore and offshore wind-turbine fields. This study aims to produce electricity on a lower scale by using a small wind turbine in order to generate a house-hold electricity supply and build a cost-effective and accessible turbine for people who need an alternative option to cover their own electricity demand.

This report presents the rotor blade design, turbine construction and the results of the experimentation of a helical vertical axis wind turbine (VAWT). These turbines come with a few specific advantages over the horizontal ones, and those advantages make this kind of turbine a better option in a city or more challenging locations.

The wind energy is the kinetic energy of air in motion. When such energy passes through the turbine rotor, the kinetic energy is transformed into mechanical energy which makes the blades starting to move. The power output of the wind turbine is given by

Equation 1:

$$P= \frac{1}{2} = pAv^3 \text{...} (1)$$

(1) Where: P=Power output (W)

(2) A=Sweep area ($m2$)

(3) ρ =Air density (Kg/$m3$)

(4) v=Wind velocity (m/s)

τ air density and the turbine and generator efficiencies, hence, it is important to contemplate the turbine size to catch most out of the air mass, the installation place and the wind speed conditions [2].

Sweep area = $A = \pi r^2$..(2)

$$\rho \; dry \; air = \rho \frac{\rho}{\mathcal{R} \cdot T} \text{.............................} (3)$$

Where:

$\rho dry \; air \; = \; Density \; of \; dry \; air \; (kg/m^2)$

$\rho = air \; pressure(pa)$

$\mathcal{R} = Specific \; gas \; constant \; for \; dry \; air, 287.05 j/(kg.k)$

$$\vartheta = \frac{\mathbb{Q}}{A} \text{......................} (4)$$

V = air velocity (m/s)

Q = Air flow rate (m^3/s)

A = Duct cross-sectional area (m^2)

A wind turbine must be built under specific requirements according the purpose and usage. In this report, the objective is to produce a residential electricity supply, which is 1500 kW/per year on average. Using the power output equation and the environment conditions, it is possible to make an analytical calculation and determine the right rotor dimensions.

II. PROBLEM STATEMENT:

Conventional single-axis wind turbines are limited by unidirectional wind capture, high noise, and large space requirements. To address these issues, this project proposes the design and development of a **multi-axis windmill prototype** that captures wind from multiple directions, reduces noise, and improves efficiency—offering a compact and sustainable alternative for renewable energy generation.

III. OBJECTIVES:

The main objectives of the project include:

To design and fabricate a multi-axis windmill that can efficiently convert wind energy into electrical energy with a cost-effective and low-maintenance mechanism.

To minimize energy conversion losses and mechanical friction by adopting a multi-axis structure, resulting in significantly lower noise levels compared to conventional single-axis wind turbines.

To promote eco-friendly and sustainable energy solutions by providing a prototype that can be scaled for rural or residential use where traditional turbines may not be feasible.

To demonstrate time-saving and efficient assembly in the design to make the system easier to install and maintain.

IV LITERATURE REVIEWS

Sn. No	Paper Title	Author and Year	Objective	Technique	Results
1	Power Generation by Vertical Axis Wind Turbine	Niranjana S.J. (Year not specified)	To design and fabricate a VAWT that utilizes wind from highway vehicles to generate electricity, suitable for low-speed wind conditions.	VAWT modeling, fabrication, laboratory testing	The turbine generated up to 1W at 25 m/s and also operated in low wind speeds (4–35 m/s); showed suitability for decentralized power generation and potential for optimization.
2	Review on Vertical and Horizontal Axis Wind Turbine	C.M. Vivek, P. Gopi krishnan, R. Murugesh, R. Raja Mohamed	To review and compare the performance of VAWT and HAWT systems and propose a hybrid system to improve electricity generation.	Literature review, comparative analysis	A combined VAWT-HAWT system can optimize space usage, reduce installation cost, and improve overall electricity output.
3	Development and Analysis of Vertical-Axis Wind Turbines	Paul Cooper	To summarize the design evolution and aerodynamic analysis of major VAWT types including Savonius, Darrieus, and Giromill.	Double-multiple stream tube modeling, aerodynamic load analysis	VAWTs can match the efficiency of HAWTs; have advantages such as omnidirectional wind acceptance and ground-level maintenance, making them suitable for diverse applications.
4	Wind Turbine Blade Design	Peter J. (Year not specified)	To provide an in-depth overview of wind turbine blade design, including aerodynamic considerations, material evolution, and historical context.	Literature review, aerodynamic and structural analysis	Highlights the dominance of HAWTs in modern design but underscores the importance of blade geometry, material selection, and load distribution in optimizing wind turbine efficiency.
5	A Review of Research on Large Scale Modern Vertical Axis Wind Turbines at Uppsala University	Sandra Eriksson, Hans Bernhoff (Year not specified)	To review over a decade of VAWT research focused on large-scale applications, direct-drive systems, and electrical control methods.	Experimental setups, prototype testing, system modeling	Demonstrated a successful 200 kW and 12 kW VAWT system with PMSG and ground-based controls; suggested large-scale VAWT systems as viable alternatives to HAWTs, with ongoing work aimed at multi-MW systems.

6	Performance Analysis of Savonius Vertical Axis Wind Turbine with Modified Blade Geometry	M. Islam, D. S.-K. Ting, A. Fartaj (2008)	To evaluate the performance of Savonius turbines with modified blade geometries for improving energy output.	CFD simulation, experimental wind tunnel testing	Modified blade profiles improved power coefficient by up to 30% compared to traditional Savonius designs, enhancing low-wind speed performance.
7	Optimization of Horizontal Axis Wind Turbine Blade Using CFD	J. Kishore, M. Tiwari, P. Yadav (2013)	To optimize HAWT blade performance through CFD analysis and comparison of various NACA airfoil profiles.	CFD modeling using ANSYS Fluent, aerodynamic simulation	NACA 4412 and NACA 4415 airfoils showed optimal lift-to-drag ratios, and performance improved significantly by changing chord length and twist angle across the blade span.

V. PURPOSED METHODOLOGY

A research design is considered as the framework or plan for a study that guides and facilitates both data collection and analysis. The present study is analytical and descriptive in nature, based on an empirical approach. Data has been collected from both primary and secondary sources:

- Primary Data: Collected directly from relevant respondents through a predefined questionnaire.
- Secondary Data: Sourced from books, research articles, periodicals, newspapers, company records, websites, and official publications.

Design Concept Generation

Design concept generation involves the conceptualization phase of product development. It includes an approximate description of the technology, working principle, and form of the product. The aim is to meet customer requirements and solve existing design constraints.

For this project, multiple alternative concepts were generated and evaluated. The most suitable design, which offered the highest functional and structural benefits, was selected. This concept was then further refined and modeled using 3D design tools such as SolidWorks.

Key steps in the methodology include:

- Literature Review
- Identification of the Problem
- Formulation of the Problem Statement
- Design Concept Generation and Evaluation
- Product Design using CAD Tools
- Market Survey and Procurement of Components
- Fabrication and Assembly
- Testing and Experimentation
- Result Analysis and Documentation

Mechanical Design Overview

The proposed wind turbine comprises two key sub-structures:

Base Sub-Structure: A rigid metallic basement housing the battery bank, electrical converters, and structural supports. This ensures mechanical stability and provides a foundation for the overall system.

Turbine Sub-Structure: Includes turbine blades, a central shaft, and high-efficiency bearings. This lighter, visible structure converts wind energy into mechanical rotation.

The mechanical energy from the rotating turbine shaft is transferred to a motor through a gear system. This motor generates electrical energy, which is stored in a DC battery for later use.

DESIGN

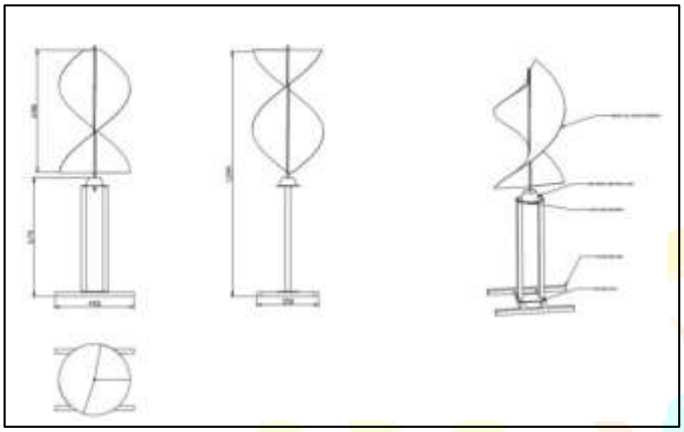

Figure1. Die Mention Off Blade

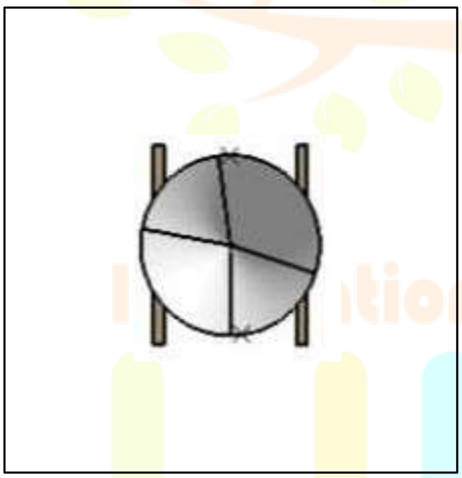

Figure 2. Top View

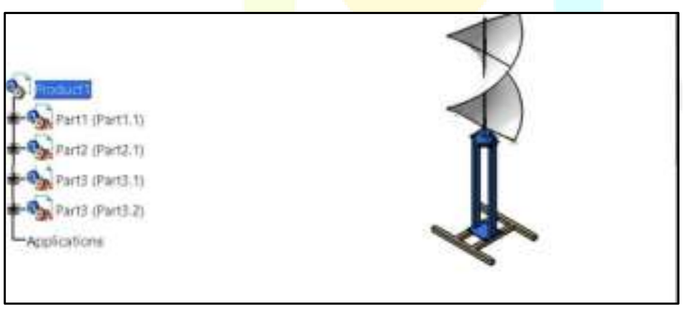

Figure 3. Front View

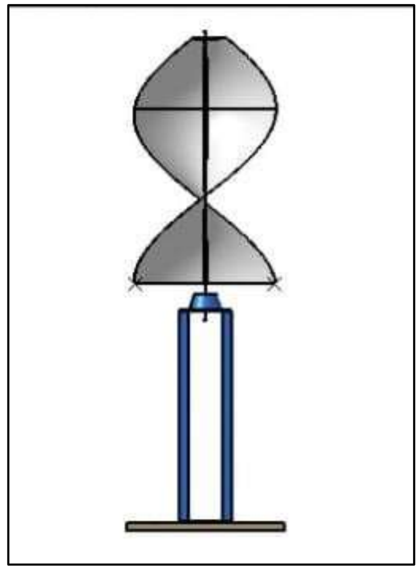

Figure 4. Side View

Bearing Specifications

To ensure smooth rotation and reduce mechanical losses, the turbine shaft is supported using SKF single row deep groove ball bearings. The detailed specifications are:

Specification	Details
Manufacturer	SKF
Type of Bearing	Single row deep groove ball
Internal Diameter	15 mm
Outside Diameter	35 mm
Width	11 mm
Rolling Element Material	Bearing steel
Cage Material	Steel
Race Material	Bearing steel
Kind of Bearing	Rolling
Bearing Seal	Metal plates, two-side
Radial Clearance	Normal

Table 1. Bearing Specifications

VI. APPLICATION

1. Agricultural Use

The multi-axis windmill can be effectively used in agricultural settings to power irrigation pumps, lighting systems, grain storage facilities, and cold storage units. It provides a sustainable energy source in rural areas where grid electricity may be unreliable or unavailable.

2. Commercial Electricity Generation

This system is suitable for small-scale industries, workshops, and commercial establishments. It helps in reducing electricity costs and promotes the adoption of clean energy, especially in areas with fluctuating power supply or high utility rates.

3. Residential Power Supply

In urban and semi-urban areas, the compact design of the windmill makes it ideal for residential installations—either standalone homes or housing societies. It reduces dependence on the central grid and provides a backup power source.

4. Educational and Research Institutions

Schools, colleges, and universities can implement this system as part of their sustainability initiatives or for research purposes. It offers practical learning opportunities in renewable energy and green technology.

5. Telecom and Remote Infrastructure

Windmills can be installed at telecom towers, remote weather stations, and off-grid monitoring posts to ensure continuous power supply. This is particularly useful in remote or difficult-to-access areas.

VII. CONCLUSION

The development of the 30W helical wind turbine marks a significant advancement in the pursuit of efficient, sustainable, and compact wind energy solutions. Unlike traditional single-axis windmills that rely heavily on consistent wind direction and often generate noise, this multi-axis helical design is capable of harnessing wind energy from various directions with minimal sound output. This not only increases energy capture efficiency but also makes it suitable for use in urban and semi-urban environments where conventional wind turbines are less practical.

The practical viability of this windmill has been demonstrated through successful prototyping and testing. It offers promising applications in areas such as agricultural water pumping, rural electrification, off- grid lighting, and even powering low-energy IoT-based systems. This model not only serves as a solution for remote and economically challenged regions but also contributes positively to the global push for renewable energy and reduced carbon emissions.

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