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DESIGNING AND ANALYSIS OF HIGHWAY VERTICAL AXIS HELICAL WIND TURBINE BLADES USING VARIOUS MATERIALS

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ABSTRACT
With the world's population expanding at an exponential rate, so too are our energy needs. The energy needs are expected to quadruple over the next nine years, which presents a substantial problem. The impending danger of global warming, an existential catastrophe made worse by the rising carbon emissions brought on by human activity, exacerbates this problem. It is becoming more and more important to manage carbon emissions, the primary source of this environmental threat as our globe continues to warm. Notably, this situation is mostly caused by conventional energy producing techniques, especially those using nuclear power plants and fossil fuel-powered automobiles. Given the depletion of fossil fuel supplies, it is critical to investigate sustainable alternatives immediately in order to provide energy for the long term. Wind energy is a clean, sustainable energy source with a lot of potential. Although windmills have been a prominent feature of our landscapes for more than a century, there is still much to learn about vertical axial wind turbines (VAWT), particularly those of the Savonius type. This study explores the feasibility of Savonius-type VAWTs, presents a novel idea for twisted blades, and uses experimental methods to increase turbine efficiency.

Key words: Darieus, Savonius, VAWT, wind energy, and wind turbines.

INTRODUCTION
Every day, the rate of energy consumption is increasing due to technological advancements. Global energy consumption has increased by over a third since 2000 and is predicted to continue to do so for some time to come. The global energy consumption increased by 2.9% in 2018. In the event that nothing changes, it is predicted that by 2040, the world's energy consumption would have increased by 30% to 740 million tera joules. At this pace, producing energy from nonrenewable resources is becoming harder and harder. Wind turbines are used as a less dependent and more affordable form of intermittent renewable energy in several countries to counteract the growing expense of fossil fuels.

1.1 Vertical Axis Wind Turbine
The primary rotor shaft of a vertical-axis wind turbine is positioned vertically. One advantage of this layout is that the turbine does not need to face the wind in order to run, which is helpful in areas where wind direction is very changeable, such as when the turbine is incorporated into a building. A direct drive from the rotor assembly to the ground-based gearbox allows the generator and gearbox to be placed near the ground, improving accessibility for maintenance. There are many benefits that VAWTs have over horizontal-axis wind turbines. They don't need as much wind to create electricity since they may be placed closer to the ground, where the wind speed is lower. Because they are closer to the

ground, they may be put in a variety of environments and need less upkeep.

1.2 Types of Vertical Axis Wind Turbine

Savonius Wind Turbine

Vertical Axis Wind Turbine (VAWT) of drag type is the Savonius wind turbine. The typical design consists of a revolving shaft that catches the incoming wind with two or three scoops. It is utilized when dependability is more crucial than efficiency because of its straightforward and sturdy form and rather poor efficiency. Approximately only half of a Savonius wind turbine creates positive torque; the other half moves against the wind and produces negative torque, which contributes to the turbine's low efficiency.

Darrieus Wind Turbine

A vertical axis wind turbine (VAWT) of the lift type is the Darrieus wind turbine. A set of curved airfoil blades with their tips fixed to a revolving shaft were part of the original concept. On the other hand, other designs—known as Hrotor or Giro mill Derrius wind turbines—use vertical airfoils. Additionally, by distributing the torque uniformly throughout the revolution, the Darrieus wind turbine's blades can be formed into a helix to lessen the torque ripple impact on the turbine. The Darrieus wind turbines are lifttype devices, meaning they can harness wind energy more efficiently than drag-type wind turbines like the Savonius wind turbine.

2. Literature Review

1. Design and development of Vertical Axis Wind Turbine (2017)

Professors Samir Deshmukh and Sagar Charthal conducted an extensive investigation into the design and development of Vertical Axis Wind Turbines (VAWTs). Their study compares VAWTs with Horizontal Axis Wind Turbines (HAWTs), highlighting the growing popularity of VAWTs for power generation. While HAWTs have been utilized for many years, they require higher wind speeds for optimal performance compared to VAWTs, which can generate electrical energy efficiently even at lower wind speeds. The efficiency of VAWTs exceeds 70%, as demonstrated in this study.The paper elaborates on the intricate design of aerofoil blades, emphasizing their efficiency at various angles. Results indicate that the blades achieve maximum power output at a 90° angle. Additionally, the authors incorporate the concept of magnetic levitation at the shaft's base to suspend the turbine, thereby reducing friction.This research provides valuable insights into the design and fabrication of complex aerofoil blades for VAWTs. Vertical Axis Wind Turbines offer a promising future for wind power generation, surpassing the output of conventional HAWTs. Consequently, the paper concludes that VAWTs can generate more power with higher efficiency, even at low wind velocities, suggesting the potential for this technology to replace current wind farm technologies entirely.

2. Vertical Axis Wind Turbine for Highway Application (2016)

Saurabh Arun Kulkarni and Prof. M. R. Birajdar present a study in this paper focusing on the dimensions of various parts of a vertical axis wind turbine (VAWT), the materials used, and the fabrication process involved. The model was designed to capture wind from all directions and underwent testing, resulting in a power output of 28 watts at a wind speed of 6 m/sec. The paper suggests that the efficiency of the VAWT can be enhanced by altering the size and shape of the blades.

It is noted that this model has the potential to generate more energy on faster routes and can be utilized to power street lights. Notably, the model was constructed at a very low cost, primarily due to the use of plastic for the blades.

3. Power Generation by Using Highway Vertical Axis Wind Mill (2017)

N. Venkata Subbaiah and M.L.S Deva Kumar present a study in this paper focusing on the number of blades used in vertical axis wind turbines (VAWTs), the angle of the blades, and the maximum rotational speed of the blades. They find that a turbine equipped with three Savonius blades curved at an angle of 104° achieves a maximum speed of 473.5 RPM. The maximum speed of the generator is 500 RPM, which, when fully operational, yields an output of 14.5 kW. The authors suggest that implementing this method on all National Highways could result in significant power generation. They emphasize the importance of carefully selecting the blade profile to minimize losses and enhance power generation efficiency. Additionally, they propose hybridizing the model by adding solar panels on top to further increase its efficiency.

4. Design, modeling and economic performance of a vertical axis wind turbine (2018)

Sahishnu R. Shah, Rakesh Kumar, Kaamran Raahemifar, and Alan S. Fung explore the feasibility of implementing Vertical Axis Wind Turbines (VAWTs) in urban settings, such as on the ground or building roofs. They highlight that developing appropriate VAWT designs could lead to widespread acceptance of these machines on a large scale. The main aim of their research was to design and model a small-scale VAWT capable of meeting the power needs of low-demand applications.The study investigates two novel shapes of Savonius rotor blades, comparing their rotational performance with conventional straight and curved blades. MATLAB simulation is employed to create a mathematical model incorporating wind power coefficient, tip speed ratio, and various mechanical and electrical components. The model is validated using measured results from the developed turbine. Their objectives include analyzing turbine blade shapes, devising a mathematical algorithm, and evaluating the techno-economic performance of the new curved blade design. The model predicts that the proposed turbine can generate an annual energy output of 7838 kWh, resulting in an annual electricity cost saving of $846.51 in Ontario, based on an electricity price of $0.108/kWh.

3. Site selected for testing of model

3.1 General

Highways offer significant wind potential for turbine operation due to the high volume of vehicle traffic. This untapped energy source can be harnessed for power generation purposes. The turbines will be strategically placed on highway medians to capture wind flow from both directions effectively. Wind speed measurements were conducted using an Anemometer, a device designed to gauge wind speed and direction. All the parameters were gathered from the designated location, specifically "NH 48, Varsova Road, near Metro De Royale Multicuisine Family Restaurant," situated in Thane, Maharashtra.

3.2 Site Parameters

Table -1: Different Parameters of site

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Sr no.	Parameters	Results
1	Average Wind Speed	5.17 m/sec
2	Humidity	75% to 80%
3	Rainfall	More than 80mm
4	Average Temperature	35° Celsius
5	Number of vehicles passing per minute	30-41

4. Proposed Model

Fig -1: Proposed Model of Twisted blade Vertical Axis Wind turbine

Fig -2: Proposed Model of Curved blade Vertical Axis Wind turbine

5. Design Of Model

The design of model is based on the study of different research papers regarding Vertical Axis Wind Turbine.

Table -2: Detailed specifications of Vertical Axis Wind Turbine

Sr no.	Particular	Specifications & Material Used
1	Blade (twisted & curved)	230 mm x 900 mm Aluminium
2	Rod	1524 mm Mild Steel
3	Holding Frame	800 mm x 800 mm Aluminium square pipe
4	Aluminium square pipe	20 mm x 20 mm
5	Blade Holder	120° Mild Steel
6	Diameter of Bearing	Internal- 26 mm Outer – 47 mm Height -12 mm
7	Motor	24 DC, Rpm of 9000
8	Multimeter	DT830D - 1000V DC/750V AC Digital Multimeter
9	Gear	ratio 1: 2
10	Anemometer	Measures wind speed in mph, ft/min, Km/h, m/s

Fig -3: Curved Blade for Vertical Axis Wind Turbine

Fig -4: Twisted Blade for Vertical Axis Wind Turbine

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Fig -5: Holding Frame / Stand

Fig -6: Bearing

Fig -7: Gear Assembly

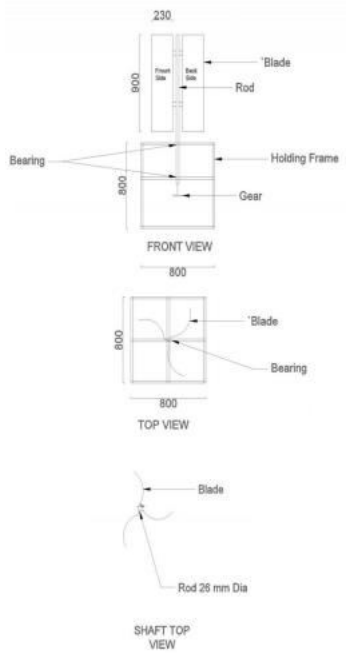

Fig -8: 2D Design of Vertical Axis Wind Turbine on AutoCAD

8. TESTING AND RESULTS

The tests were conducted for 15 minutes on the selected location.

Sr no.	Time	Average number of vehicles per minute per side	Average Wind speed (m/sec)	Voltage (V)	Current (A)	Watt (voltage x Ampere)	Watt (per minute)
1	02:30	40	4.2	1.77	0.16	0.283	16.98
2	02:31	37	5.4	1.85	0.165	0.305	18.3
3	02:32	41	4.5	1.81	0.162	0.293	17.58
4	02:33	34	5.2	1.83	0.164	0.3	18
5	02:34	38	3.2	1.6	0.169	0.271	16.27
6	02:35	43	3.8	1.73	0.163	0.282	16.9
7	02:36	36	4.2	1.78	0.165	0.294	17.64
8	02:37	38	5.5	1.86	0.167	0.31	18.62
9	02:38	39	6.3	1.92	0.173	0.332	19.92
10	02:39	41	6.6	1.94	0.179	0.347	20.83
11	02:40	30	4.8	1.81	0.163	0.296	17.76
12	02:41	34	5.5	1.86	0.167	0.31	18.62
13	02:42	31	3.4	1.64	0.17	0.279	16.75
14	02:43	39	3.9	1.75	0.161	0.283	16.99
15	02:44	42	6.5	1.93	0.178	0.344	20.64
Power Generated in 15 minutes							**271.8 Watt = 0.2718 KW**

Fig -9: Data Collected for Curved Blade VAWT

Sr no.	Time	Average number of vehicles per minute per side	Average Wind speed	Voltage (V)	Current (A)	Watt (voltage x Ampere)	Watt (per minute)
1	03:10	41	3.4	1.64	0.17	0.2788	16.728
2	03:11	45	3.9	1.75	0.161	0.2818	16.905
3	03:12	39	6.5	1.93	0.178	0.3435	20.6124
4	03:13	38	6.2	1.92	0.171	0.3283	19.6992
5	03:14	42	4.1	1.77	0.162	0.2867	17.2044
6	03:15	41	5.3	1.84	0.166	0.3054	18.3264
7	03:16	39	5.9	1.88	0.177	0.3328	19.9656
8	03:17	43	7.2	1.99	0.184	0.3662	21.9696
9	03:18	41	4.1	1.77	0.162	0.2867	17.2044
10	03:19	30	3.5	1.67	0.168	0.2806	16.8336
11	03:20	35	4.2	1.78	0.163	0.2901	17.4084
12	03:21	36	5.7	1.87	0.169	0.316	18.9618
13	03:22	42	6.6	1.94	0.179	0.3473	20.8356
14	03:23	32	5.7	1.87	0.171	0.3198	19.1862
15	03:24	37	4.3	1.78	0.165	0.2937	17.622
Power Generated in 15 minutes							279.463 Watt = 0.2794 KW

Fig -10: Data Collected for Twisted Blade VAWT

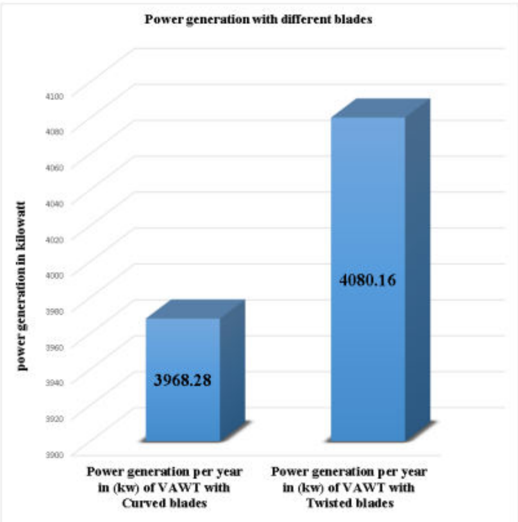

Chart -1: Comparison of Power Generation between Curved blade VAWT and Twisted blade VAWT

Calculations of power generated

• Curved Blade generates electricity of 1087.2 Watt per hour.

• So, if the model runs for 10 hrs. per day it generates electricity of 10872 watt per day.

• For 1 year = 10872 x 365 = 3968280 Watts =
3968.28 KW/ year.

• Twisted Blade generates electricity of 1117.852 Watt per hour.

• So, if the model runs for 10 hrs. per day it generates electricity of 11178.52 Watt per day.

• For 1 year = 11178.52 x 365 = 4080159.8 watts =4080.16 KW/ year.

• In India, the average rate per unit is Rs 5.3.

• Therefore,

• For curved blade,

• Rate of power generated per year = 3968.28 x 5.3 =Rs 21031.89

• For twisted blade,

• Rate of power generated per year = 4080.16 x 5.3 =Rs 21624.89

9. Cost Analysis

Sr no.	Parts of VAWT (vertical axis wind turbine)	Price (Rs)
1	Shaft	400
2	Aluminium sheet	700
3	Bearing	200
4	DC motor	300
5	Multimeter	350
7	Gear	200
8	Aanemometer	1000
9	Aaluminium square pipe	500
10	Fabrication work	2650
11	Transportation	200
	Total	RS 6500/-

Fig -12: Manufacturing cost of Vertical Axis Wind Turbine

The total manufacturing cost of this model is RS 6500/.

10. CONCLUSIONS

The research looked into and analysed two different types of blade designs for Savonius-type vertical axis wind turbines:

twisted and curved. To assess the model's effectiveness, it was put through extensive testing on the spot. The twisted blade VAWT works better than the curved blade model, producing 1117.852 Watt of power per hour as opposed to 1087.2 Watt per hour, according to the results. There is great potential for using twisted blade VAWT on highways, especially for lighting street lights.

Furthermore, the project's capacity to recover manufacturing expenditures in less than a year emphasises its economic feasibility. This indicates that the project has the ability to provide an affordable renewable energy option. The results highlight the importance of vertical axis wind turbines as a useful addition to the renewable energy environment.

This study's findings highlight the possibility of using different blade designs with vertical axis wind turbines to provide clean, sustainable electricity.

11. FUTURE SCOPE

Optimising the efficiency of vertical axis wind turbines (VAWT) requires a solid foundation. Hybridisation of VAWT may also be achieved by combining solar panels, which allows energy to be obtained from many renewable sources. In addition, adding a rain gauge to track the amount of precipitation at certain spots might provide useful information for system upkeep and optimisation. The turbine model may be protected by applying a thin layer of plastic coating to reduce the possibility of corrosion brought on by precipitation. These tactics seek to maximise the energy production of VAWT systems while improving their dependability and lifespan.

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