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Design and Development of Vertical Axis Wind Turbine (VAWT)

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ABSTRACT: Vertical Axis Wind Turbine (VAWT) have a vertical rotor shaft and blades perpendicular to the ground, allowing them to capture wind from any direction without complex yaw mechanisms. They are thus ideal for urban settings and turbulent wind regions. Though they are less efficient than Horizontal Axis Wind Turbine (HAWT), VAWT are strengths like Omni-directional capability, low height requirement, ease of maintenance, and aesthetic appeal. However, they are surrounded by structural stress, inefficiency in larger-than-small sizes, and scalability. Ongoing research attempts to improve their performance as regards technology advances and hybrid renewable energy systems.

KEYWORDS: Renewable Energy, Rotor, Generator, wind Energy, Darrius turbine, vertical axis turbine

I. INTRODUCTION

Wind is a free and clean energy source. Big wind turbines are great, but they're usually placed in open areas with strong, steady wind. They also need to turn and face the wind to work properly. But what about places where the wind is weaker or keeps changing direction?

That's where **Vertical Axis Wind Turbines** come in. They can take wind from any direction and are easier to maintain. They're a good choice for rooftops, villages, and remote locations. This project focuses on making a simple, affordable VAWT that works even when the wind isn't strong.

II. OBJECTIVES

- Build a small wind turbine that starts easily and works well in low wind.
- Design blades that make good use of the wind.
- Use low-cost, lightweight materials.
- Actually build and test a working prototype.
- See how much power it can produce in real outdoor conditions.

III. PROBLEM STATEMENT

Most wind turbines need strong wind and complicated systems to turn toward the wind. That's not ideal for many places, especially rural areas. We wanted a solution that:

- Works in low and changing winds
- Starts on its own without extra help
- Is simple, affordable, and easy to build

IV. LITERATURE REVIEW

- **Savonius turbines:** Easy to start but not very efficient.
- **Darrieus turbines:** More efficient but don't start by themselves.
- **Hybrid designs:** Combine the best of both for better performance.
- Materials like **PVC** and **aluminum** are common in small turbines.
- Studies show that tweaking blade shape and speed can boost performance.

V. METHODOLOGY

Design Idea

We used a **hybrid blade**—Savonius on the outside and Darrieus inside. This helps the turbine start on its own and also produce more power.

CAD Design

We drew the turbine in **SolidWorks**, a 3D design software. Then we checked its strength and safety using **ANSYS** simulations.

Blade Details

- **Savonius blade:** Like a scoop, 200 mm radius and 1 m tall
- **Darrieus blade:** Curved like a wing, 300 mm wide and 1 m tall
- The Darrieus blade was twisted a bit so it could turn more smoothly

Materials

- **Blades:** Made from PVC and aluminum
- **Shaft:** Mild steel rod
- **Frame:** Steel angles for support
- **Generator:** 12V DC motor that turns wind into electricity

Building Process

We shaped the blades by hand, welded the frame, and mounted the generator at the bottom. Bearings were added so it could spin freely.

Testing It Out

We put the turbine on a rooftop and used tools to measure wind speed, RPM, voltage, and power. We collected data for two weeks.

VI. CALCULATIONS

Wind Power Available

At 5 m/s wind speed, the turbine has about **46 watts** of wind energy available.

Speed of the Rotor

With a tip speed ratio of 0.9, the rotor spins at about **143 RPM**.

Power Output

Assuming 20% efficiency, we get around **9.2 watts** of actual power output.

VII. COMPONENTS

Part	What It Is
Blades	PVC and aluminum, 1 meter tall
Shaft	Mild steel, 20 mm wide
Generator	12V DC motor (100W rating)

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Part	What It Is
Bearings	Standard ball bearings for smooth motion
Frame	Welded steel angles, 50×50 cm base

VIII. MODEL DIAGRAMS

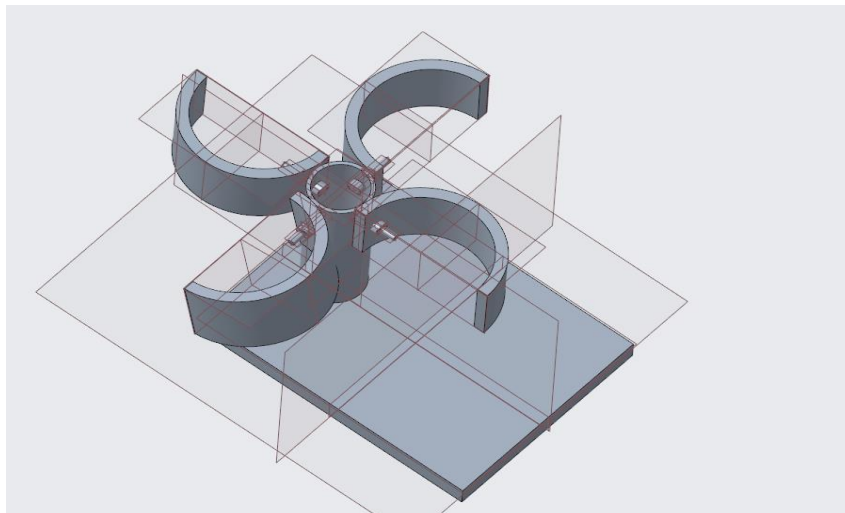


Fig-1.Vertical Axis Wind Turbine (Top View)

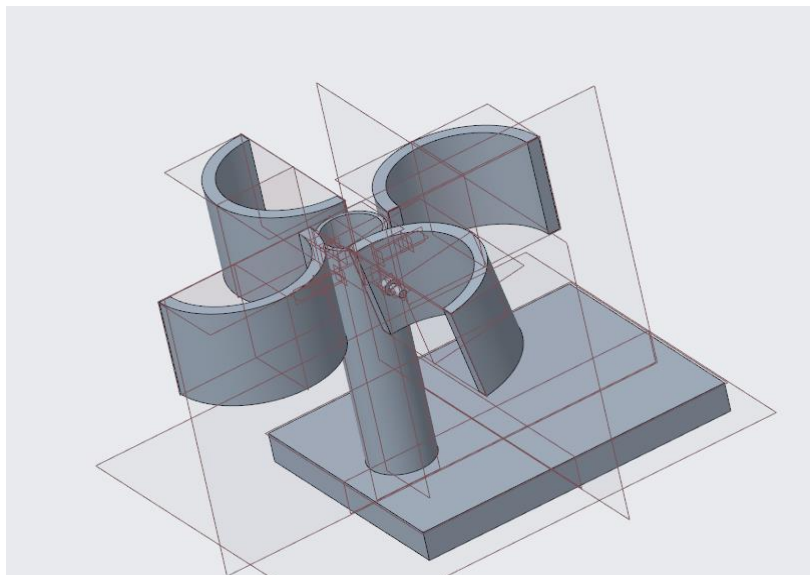


Fig-2.Vertical Axis Wind Turbine (Side View)

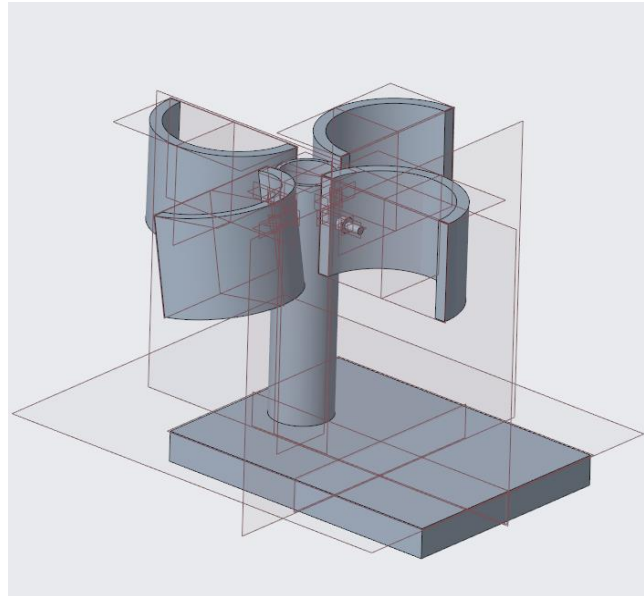


Fig-3. Vertical Axis Wind Turbine (FrontView)

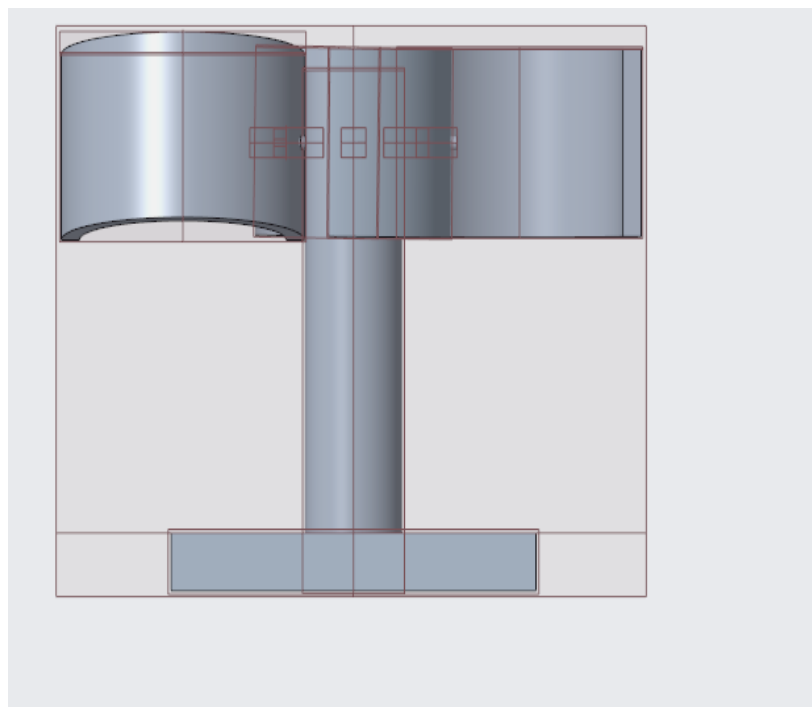


Fig-4 Vertical Axis Wind Turbine (Side View)

IX. RESULTS

- The turbine started spinning at **just over 3 m/s wind speed**
- At 5 m/s, it produced around **8–10 watts** of power
- Higher winds improved output, but the turbine vibrated a bit at over 8 m/s
- It was quiet, stable, and required almost no maintenance

- The hybrid design worked—easy to start and good performance

X. ADVANTAGES

- Works even when wind is slow
- Doesn't need to face the wind
- Simple to build and use
- Great for rooftops or small villages
- Safe and low noise

XI. APPLICATIONS

- Lighting in rural areas
- Charging small batteries
- Powering streetlights
- Pumping water for farms
- Teaching and student projects

XII. CONCLUSION

We showed that a simple and affordable **VAWT** can work well even in places with weak wind. By mixing Savonius and Darrieus blades, we got a turbine that both starts easily and gives decent power. It's perfect for small, off-grid uses. With some more upgrades, this design could be scaled up for bigger needs.

XIII. FUTURE SCOPE

- Add **remote monitoring** with IoT
- Try **stronger and lighter materials**
- Build bigger versions for small communities
- Use **CFD simulations** to improve blade shape
- Combine with **solar panels and batteries** for full-day power

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