



Design and Implementation of a Levitating Frictionless Vertical Axis Windmill for Enhanced Energy Efficiency

Vishnu Agrawal¹, Khushal Paliwal², Dheeraj Menaria³, Amit Paliwal⁴, Virendra Suthar⁵

Professor¹, UG Scholars^{2,3,4,5}

Department of Mechanical Engineering

Geetanjali Institute of Technical Studies, Dabok, Udaipur (Raj.), India

Abstract- Wind energy is one of the renewable energy sources. Power generation by using wind energy is found to be multifold due to more demand and supply gap in electrical energy system. Magnetic levitation wind turbines have several advantages over conventional wind turbines. This paper presents the design, development, and analysis of a levitating frictionless vertical axis windmill (LF-VAW) aimed at maximizing energy efficiency by reducing mechanical losses due to friction. Utilizing magnetic levitation (maglev) technology, the windmill's rotor is suspended without contact, significantly minimizing wear and maintenance. This innovative approach to wind energy harvesting is especially suitable for low-wind-speed urban environments. The key innovation in this project lies in its levitating support system, which suspends the rotating shaft with the help of low-resistance mechanical components (such as air cushions, advanced bearing designs, or fluid dynamics-based supports), allowing the windmill to rotate smoothly with negligible friction. Experimental results demonstrate improved performance over conventional friction-based systems.

Index Terms: Levitating, friction less, non-contact, PVC blades.

1. INTRODUCTION

The Levitating Frictionless Vertical Windmill is a novel engineering solution aimed at improving the efficiency of wind energy systems by minimizing mechanical losses. Unlike traditional wind turbines that rely on bearings and suffer from friction-related wear and tear, this project introduces a frictionless rotation mechanism that supports the windmill's vertical axis with minimal physical contact.

The core design features a Vertical Axis Wind Turbine, which operates effectively regardless of wind direction—making it ideal for urban and low-speed wind conditions. The key innovation in this project lies in its levitating support system, which suspends the rotating shaft with the help of low-resistance mechanical components (such as air cushions, advanced bearing designs, or fluid dynamics-based supports), allowing the windmill to rotate smoothly with negligible friction.

2. PROBLEM STATEMENT

This project builds upon these concepts by creating a levitating-style, frictionless vertical windmill that excludes the use of magnets altogether. Instead, it focuses on precision turning (via lathe machining) of both fixed and rotating shafts, optimal alignment, and high-quality ball bearings to reduce mechanical friction. The effectiveness of this approach is validated by the successful generation of power to light a 9-watt LED bulb, even under relatively low wind conditions.

3. OBJECTIVES & SCOPE

The primary objective of this project is to design and develop a Vertical Axis Windmill that operates with minimal mechanical friction, thereby increasing the overall efficiency of wind energy conversion. By eliminating traditional contact-based rotating components such as ball bearings, the design focuses on achieving near-frictionless rotation through advanced mechanical arrangements.

4. LITERATURE REVIEW

Patel et al. (2020) emphasized the importance of material selection and shaft balancing in reducing friction. By carefully machining components like rotating and fixed shafts and ensuring alignment during fabrication, mechanical contact and energy losses can be minimized even without advanced technologies like magnetic levitation.

Ahmad and Amin (2017) investigated a small-scale vertical wind turbine that focused on low-friction axial design but relied on precision alignment and balanced loads rather than magnetics. Their research concluded that using well-machined rotating components and high-grade bearings can significantly reduce energy losses and improve startup performance.

5. METHODOLOGY

The development of the levitating frictionless vertical windmill followed a systematic and multi-phase engineering approach. The project began with conceptual design and feasibility analysis, where various configurations of vertical axis wind turbines were studied, and the most suitable rotor type was selected based on aerodynamic efficiency and simplicity. A detailed CAD model of the windmill was created using design software to visualize the structure and analyze mechanical balance.

The core innovation focused on eliminating friction in the rotating shaft by employing a low-contact support mechanism, such as air or fluid-assisted bearings, which allowed the rotor to rotate with minimal resistance. Precision components were fabricated to ensure accurate alignment and stable levitation of the vertical shaft. The windmill blades were crafted from lightweight materials to reduce inertial load, and a compact generator was coupled to the shaft for energy conversion. The assembled prototype was tested under natural and simulated wind conditions to measure performance parameters including rotational speed, torque, and power output. Data acquisition tools such as anemometers, RPM sensors, and voltmeters were used to evaluate the system's efficiency. Through iterative testing and refinement, the final design demonstrated a significant reduction in mechanical friction, confirming the viability of frictionless windmill systems for practical energy generation.

5.1 Components

5.1.1 Alternator: An alternator is used as the primary energy conversion device to transform the mechanical energy generated by the rotating windmill blades into usable electrical energy. The alternator functions based on the principle of electromagnetic induction, where the relative motion between a magnetic field and a conductor induces an electric current. The output from the alternator can either be stored in a battery via a rectifier (to convert AC to DC) or directly used to power low-voltage devices. Alternators are widely used in renewable energy systems due to their efficiency, compact size, and ability to generate electricity at various rotational speeds.



Fig. 5.1 Alternator

5.1.2 V-Belt Pulley: A V-belt pulley system is employed to transmit mechanical power from the rotating shaft of the vertical windmill to the alternator. The system consists of two grooved pulleys—one mounted on the windmill shaft and the other on the alternator—connected by a V-shaped rubber belt. The V-belt fits tightly into the pulley grooves, increasing the surface contact area and providing excellent frictional grip, which ensures efficient torque transmission with minimal slippage.

The use of a V-belt drive offers several advantages: it allows for flexible placement of the alternator, absorbs minor misalignments, reduces shock loads, and operates quietly. Moreover, it provides a simple way to increase or decrease the speed transferred to the alternator by adjusting the diameter ratio of the driving (windmill) and driven (alternator) pulleys. This speed variation is especially important in wind energy systems, where wind speed and turbine RPMs are inconsistent.



Fig. 5.2 V-Belt Pulley

5.1.3 Ball Bearings: In the design of the levitating frictionless vertical windmill, ball bearings were employed to support the rotating components and enable smooth, low-friction motion. Ball bearings are precision mechanical elements that reduce resistance between moving and stationary parts, thereby enhancing the efficiency and durability of rotating systems. In this setup, the inner race of the bearing is fixed to the stationary shaft, while the outer race is connected to the rotating shaft or rotor assembly. As the rotor spins, the hardened steel balls roll between the inner and outer races, allowing smooth rotation with minimal friction. This configuration allows the windmill's rotor to rotate freely while being properly supported and aligned.



Fig. 5.3 Ball Bearing

5.1.4 Fixed Shaft: The fixed shaft in the levitating frictionless vertical windmill serves as the stationary central axis around which the rotor assembly and other moving components rotate. This shaft is crucial in providing structural support to the entire windmill system while maintaining stability during operation. Typically made of high-strength steel or stainless steel, the fixed shaft is designed to withstand both the radial and axial loads generated by the windmill's rotating blades. Its diameter and length are carefully chosen based on the size of the rotor and the expected forces during operation. The fixed shaft is securely anchored to the windmill's base or frame, ensuring that it does not rotate, thus allowing the rotor, supported by ball bearings or other frictionless systems, to rotate smoothly around it.

5.1.5 Rotating Shaft: The rotating shaft in the levitating frictionless vertical windmill is a critical component that transmits the mechanical energy generated by the windmill's rotor blades to the power generation system (alternator or generator). Unlike the fixed shaft, the rotating shaft is designed to rotate around the fixed shaft, and it is directly responsible for converting the kinetic energy from wind movement into usable electrical energy.

Made from high-strength steel or alloy materials, the rotating shaft is engineered to handle both radial and axial loads. These forces are generated by the windmill blades as they rotate in the wind, and the shaft is designed to withstand these stresses without deforming or compromising performance. Its surface is often hardened or treated to reduce wear from friction, which is especially important in a design that aims to reduce frictional losses.

5.1.6 Blades: The PVC blades used in this project are designed for the vertical axis windmill (VAWT) to capture wind energy efficiently. Made from polyvinyl chloride (PVC), these blades are both cost-effective and lightweight, offering a practical solution for small-scale wind energy generation systems. PVC is a durable and weather-resistant material, making it ideal for outdoor applications where exposure to the elements is a concern. It is also relatively easy to fabricate and mold, allowing for customization of blade shape and size.

The blades are designed with an aerodynamic semi-circular shape, optimizing their ability to capture wind energy efficiently. The lightweight nature of PVC reduces the strain on the rotating components, ensuring smooth operation and reducing the mechanical load on the system. The blades are mounted securely on the rotating shaft, and their orientation and angle are designed to maximize lift while minimizing drag, which improves the overall efficiency of the windmill.



Fig. 5.4 PVC Blades



Fig. 5.5 Assembly

The Levitating Frictionless Vertical Windmill has a wide range of practical applications, particularly in the field of renewable energy generation. Its unique frictionless and vertical axis design allows it to operate efficiently even at low wind speeds and in environments with variable wind directions, making it highly suitable for urban, semi-urban, and remote areas. One of the key applications is in off-grid energy systems, where the windmill can be used to charge batteries or power small electronic devices, streetlights, and rural homes without relying on the conventional power grid.

CONCLUSION

The development of the Levitating Frictionless Vertical Windmill presents a significant step toward efficient and sustainable wind energy generation. By integrating a vertical axis design with low-friction components such as precision ball bearings and a fixed-rotating shaft mechanism, the system successfully minimizes mechanical losses and enhances energy conversion even at low wind speeds. The use of accessible materials like PVC for blades and a practical V-belt pulley mechanism makes the design both cost-effective and feasible for real-world implementation.

One of the most notable outcomes of the project is its ability to generate sufficient energy to power a 9-watt LED bulb, which serves as clear evidence of its functional effectiveness. The use of lightweight PVC blades, a compact alternator, and a stable metal support frame further enhances the system's efficiency and structural integrity.

REFERENCES

1. Wright, T.S.; Gotwals, A.W. Supporting Disciplinary Talk from the Start of School: Teaching Students to Think and Talk Like Scientists. *Read. Teach.* 2017, 71, 189–197. [CrossRef]
2. Amory, A. Game object model version II: A theoretical framework for educational game development. *Educ. Technol. Res. Dev.* 2006, 55, 51–77. [CrossRef]
3. Huang, Y.H.; Lai, C.S. A Study of the Effects of Science Play Instruction with Assisted Scientific Toys on the “Air” Unit Learning for Third-Grade Students. *Sci. Educ. Mon.* 2009, 318, 2–16.
4. Klopfer, E., Osterweil, S., Salen, K. (2009). *Moving Learning Games Forward*. Cambridge, MA: The Education Arcade.
5. Schell, J. (2008). *The art of game design: A book of lenses*. Morgan Kaufmann, Burlington, Massachusetts.
6. Granic, I., Lobel, A., & Engels, R. C. (2014). The benefits of playing video games. *American Psychologist*, 69(1), 66-78.
7. Bruns, B. 2015. Co-creating Water Commons: Civics, Environmentalism, and “Power With.” Paper presented at the Society for Applied Anthropology Annual Meeting, Pittsburgh, PA, March 24-28, 2015.
8. Bruns, B. and P. C. Bruns. 2004. Strengthening Collective Action. *Collective Action and Property Rights for Sustainable Development, 2020 Vision For Food, Agriculture, and the Environment*. Focus Brief 11, International Food Policy Research Institute, Washington, D.C.
9. Kerr, John (2007). Watershed management: Lessons from common property theory. *International Journal of the Commons*, 1(1), 89–109
10. Aragón, Y. Desarmando el poder antisocial de los video juegos. *REIFOP* 2011, 14, 97–103.
11. DelCastillo, H.; Herrero, D.; García, A.; Checa, M.; Mojelat, N. Desarrollo de competencias a través de los videojuegos deportivos: Alfabetización digital e identidad. *Rev. Ed. a Distancia*. 2012, 33, 1–22.
12. Cremers, A.; Stubbé, H.; van der Beek, D.; Roelofs, M.; Kerstholt, J. Does playing the serious game B-SaFe! make citizens more aware of man-made and natural risks in their environment? *J. Risk Res.* 2014, 18, 1280–1292. [CrossRef]
13. Johnassen, D. H. and Rohrer-Murphy, L.: Activity theory as a framework for designing constructivist learning environment, *Etr. & D.-Educ. Tech. Res.*, 47, 61–79, 1999.
14. Kirshen, P. H., Vogel, R. M., and Rogers, B. L.: Challenges in graduate education in integrated water resources management, *J. Water Res. Pl.-ASCE*, Editorial, 185–186, 2004.
15. Kolb, A. D.: *Experiential learning: Experience as the source of learning and development*, Prentice Hall, Englewood Cliffs, NJ, 1984.
16. Prensky, M. *Digital Game-Based Learning*; McGraw-Hill: New York, NY, USA, 2001.
17. Jääskä, E.; Aaltonen, K.; Kujala, J. Game-Based Learning in Project Sustainability Management Education. *Sustainability* 2021, 13, 8204. [CrossRef]
18. Foster, A.; Shah, M. Principles for Advancing Game-Based Learning in Teacher Education. *J. Digit. Learn. Teach. Educ.* 2020, 36, 84–95. [CrossRef]
19. Habgood, M.J. and Ainsworth, S.E. (2011). Motivating children to learn effectively: Exploring the value of intrinsic integration in educational games. *The Journal of the Learning Sciences*, 20(2), 169-206.
20. Lamb, R.L.; Annetta, L.; Firestone, J.; Etopio, E. A meta-analysis with examination of moderators of student cognition, affect, and learning outcomes while using serious educational games, serious games, and simulations. *Comput. Hum. Behav.* 2018, 80, 158–167. [CrossRef].