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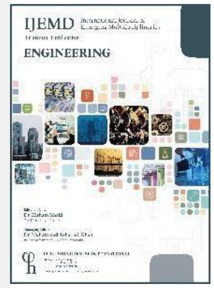

A Novel Bladeless-Spinal Wind Turbine Design for Efficient Energy Generation in Low wind Speeds

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Abstract

Wind energy is a widely used and renewable source for electricity generation. However, traditional wind turbines facechallenges such as large footprints, noise, high costs, and efficiency limitations. To address these issues, bladeless wind turbines (BWTs) have gained popularity, and extensive research is being carried out to develop efficient designs.In this work, we propose a novel BWT design, inspired by the spine structure found in human bodies. The BWT architecture is modular, autonomous, and robust, making it suitable for small, portable, and small-scale applications.Our BWT design was inspired by the spine structure found in the human body and other vertebrates. The BSWT architecture is modular, autonomous, and robust. Detailed 3D models were created using Fusion 360 and SolidWorkssoftware to refine and iterate the design. Our BWT features a complete electrical system with an energy harvesting base, a rectifier, converter, and a storage battery. The stored energy is then converted to AC and connected to the load.Our design utilizes oscillating rods divided into sections, enabling energy generation even at low wind speeds. The casing protects the rods from shear stresses and corrosion. While practical applicates involve a spine design with multiple sections, our experiments primarily focus on a single turbine.

Keywords: Bladeless wind turbines, Vortexes, Spinal cord design, Renewable energy.

Introduction

The technique of capturing wind energy and transforming it into useful mechanical and electricalpower is known as wind power. Today, turbines are huge windmills that provide most of the windenergy used. The wind turns two or three of the turbine's propeller-like blades around the turbine'srotor. The Wind Turbine is a type of solar power. Sunlight produces variations in surfacetemperature, and these variations in surface warm air to rise and produce winds

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Therefore, one of the functions of solar power is to capture the energy from these winds. Unfortunately, installing wind turbines and using wind power may be expensive and require a lotof land. Turbines can be noisy and/or unattractive when placed close to residential areas. Additionally, depending on the wind conditions each day, the quantity of energy produced by windpower can change.

Figure 1: Wind Turbine with Blades

To solve these imperfections, they used a bladeless wind turbine. Bladeless wind turbines are simpleto install in urban locations and can even be incorporated into the general design of buildings. The benefits of this strategy include reduced noise, avoidance of the consequences of intermittent shade,and protection of migrating bird populations [5] . The maintenance costs of what isknown as a solid-state wind energy transformer are typically cheaper than those of traditional windturbines. A hybrid system that combines BWT with solar energy panels could be taken into consideration to increase electrical power generation and boost the system's overall efficiency. BWTcould therefore be viewed as a sustainable alternative for wind energy in cities.

Figure 2: Bladeless Wind Turbine

However, there are more efficient ways to apply the bladeless wind turbines into multiple fields, generating more energy in the process. Our idea combines the cost-effective nature of BWT but making it more versatile and reliable in many fields. It is a novel bladeless-spinal wind turbine or BSWT for short. We took inspiration from the spinal cord in the human body and created a BWT that has many sections making it lighter, cheaper, and mobile.

Methodology:

Prior to commencing the project, we brainstormed several ideas and ultimately settled on developing a bladeless wind turbine (BWT) that would be simple, functional, cost-effective, and efficient. To gain a better understanding of BWT technology, we conducted extensive research and watched informative videos. With aclear vision in mind, we proceeded to sketch our desired design. Our concept involved a segmented structureinspired by the human spinal cord, aiming to make the BWT lighter, more affordable, and easily transportable.

The initial design consisted of multiple sections that would collectively contribute to the overall functionalityof the bladeless wind turbine. We visualized a streamlined shape, considering dimensions and proportions thatwould optimize its performance. The idea is a lighter design that uses less materials and easily generates electricity, even with low wind speeds. Using Fusion 360 and then solid works software, to further enhance the design, we created detailed 3D models allowing us to refine and iterate the design as needed.

We started off with a base that ideally acts as the harvesting unit for our BWT, the generated mechanical energy is initially converted into alternating current (AC) electricity. This AC electricity is then fed into a rectifier, to convert the fluctuating AC power into direct current (DC) electricity, so that DC can be stored ina battery.

Once the electricity is converted into DC, it is directed through a DC-DC converter. The role of the DC-DC converter is to step up the voltage to a higher level, which is a critical process for efficient power transmissionand storage. By increasing the voltage, we can reduce energy loss that occurs during the transportation of electricity and improve the overall efficiency of the system.

Following the voltage step-up, the electricity is stored in a battery system. The battery acts as an energy reservoir, ensuring that the power generated by the BSWT is available on demand. When the stored energy is needed, it is discharged from the battery and passed through an inverter. The inverter's function is to convert the DC back into AC, which is the standard form of power for most appliances and the grid. This inversion process allows for the integration of the electricity generated by our BSWT system into the existing electricalinfrastructure, enabling it for smaller applications like powering streets and traffic lights or even households.

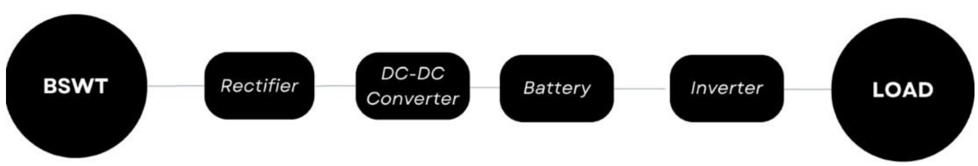


Figure 3

The basic idea of this design is for the oscillating rods to be divided into three sections. The three rods are connected to the harvesting unit at the base. Having these three lighter and smaller rods rather than one hugerod, we can generate energy even on days where we have low wind speeds. It will be encased in a casing to help protect the rods from shear stresses and even corrosion. It is important to note that for practical applications the spine design where the bladeless turbine is divided into sections, will be used. But our experiments will be mainly focusing on a single turbine seen in figure 4 below.

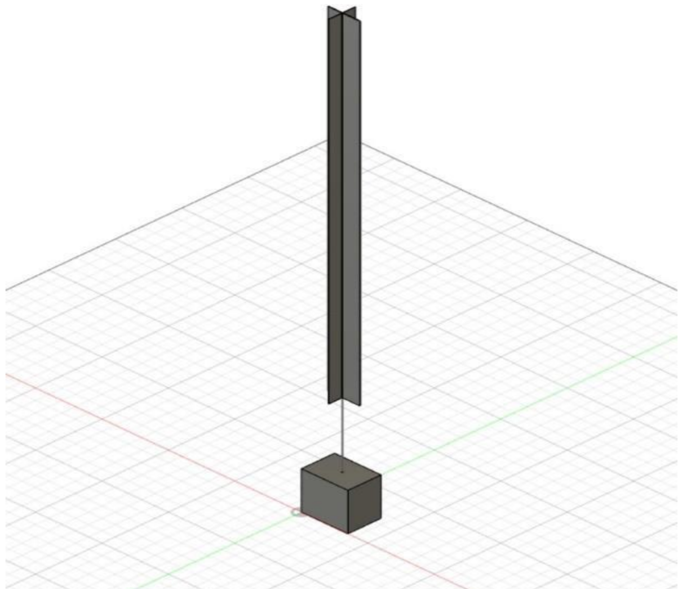


Figure 4: New Bladeless Wind Turbine (BSWT)

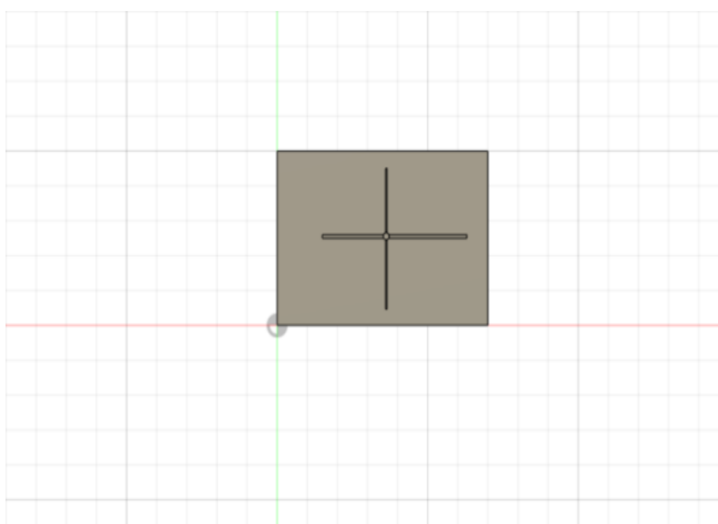


Figure 5: Top view (BSWT)

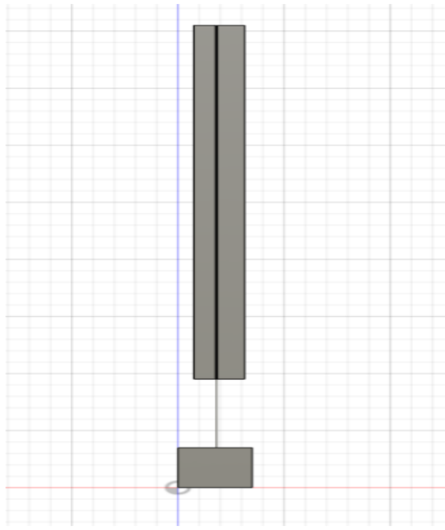


Figure 6: Front view (BSWT)

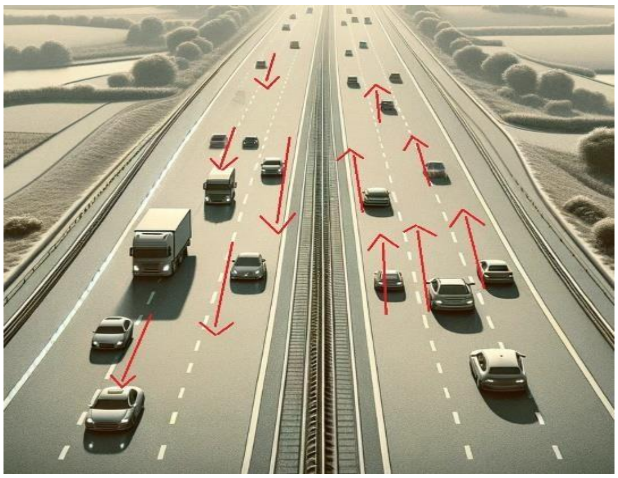
Material Selection:

As far as material selection goes, considering the design we created. We had a couple of ideas of what to use for the rods. Since it does not matter whether it is conductive or not our first option that came to mind was stainless steel. Stainless steel provides crucial structural stability and ease of fabrication. However, aluminumis lightweight, corrosion-resistant, and offers good conductivity. It is often used in bladeless wind turbine designs for structural components, such as supporting frames or housing elements. Aluminum's properties makeit suitable for reducing weight while maintaining structural integrity. Copper or other conductive metals are commonly employed in the turbine's electrical components, such as the generator or wiring. These materials facilitate efficient energy conversion by offering high electrical conductivity and low resistance, ensuring minimal power loss during the generation and transmission of electricity. Bladeless wind turbines may also incorporate composite materials. We thought of using composite materials in the casing, a combination of polymer plastics fiberglass and carbon fiber, to achieve a balance between structural strength, weight reduction,and aerodynamic performance. Various coatings and surface treatments can be applied to the casing and other turbine components to enhance their performance and used for protection purposes [13]. Thesecan include anti-corrosion coatings, anti-icing coatings, or even surface textures designed to control airflow and reduce drag.

Applications:

Our research introduces a groundbreaking approach to wind energy generation through a novel bladeless windturbine design, tailored for installation along highways, that would be one of the applications of this design. This design capitalizes on the kinetic energy produced by the movement of vehicles, enabling the turbine to generate electricity even under low wind conditions. Unlike other bladeless turbines that require more wind speeds to be effective, our bladeless model utilizes the airflows created by passing vehicles to initiate movementand energy production. This innovative method promises a substantial increase in the viability of wind energygeneration in areas previously considered unsuitable due to insufficient natural wind speeds. The choice of bladeless turbines for this application is particularly noteworthy. Traditional wind turbines can be inefficient in low wind speeds and are sometimes criticized for their environmental and aesthetic impacts. In contrast, your bladeless design promises to reduce visual and noise pollution, aligning with broader environmental andsocial sustainability goals. This aligns with the increasing demand for energy solutions that not only contributeto reducing carbon emissions but also minimizes other negative impacts associated with energy production. This advancement in wind turbine technology can greatly expand the scope of renewable energy infrastructure,tapping into the untapped energy potential of highway corridors. By integrating this technology, we can diversify our renewable energy sources, reduce greenhouse gas emissions, and move towards a more sustainable and energy-secure future. The development and deployment of our bladeless wind turbine design represents a promising step forward in harnessing wind energy more effectively and efficiently, even in low wind speed conditions.

Figure 7: Application of BS



One of the standout applications for our BWT is along highways as seen in figure 7 above. Our design capitalizes on the airflow generated by moving vehicles on highways, which results in a series of air currents.Our bladeless wind turbine is engineered to be highly efficient in low-wind conditions, such as those created by the traffic flow. Additionally, the micro-vibrations transmitted through the road due to vehicular motion canfurther stimulate the oscillatory motion of our turbine [7] . This approach enables our BWT to generate electricity even in environments where traditional wind turbines or even some other bladeless wind turbine may not be able to operate.

Equations:

For this blade-less wind turbine design, there is no specific formula for calculating the power output of this model. Instead, there is a general formula that meets the same conditions we are looking for and have. The formula may not be as straightforward as the traditional bladed turbine, but it is a simplified version where thepower output of a wind system can be calculated in watts (W).

$$P = \frac{1}{2} \rho A V^3 \eta$$

Eq. 1

This equation can also be used to find the efficiency of the system represented as (η) in the equation. However,computing the value of the efficiency or even the power output value for that matter, could be difficult without an actual fabricated or 3D printed model, computational modeling and several experiments. We need specific parameters to plug in this equation to find the value of our BWT design's power output. This equation is basedon the Betz limit, that states that the max power can never exceed 59.26 % even with ideal systems (Hamad, 2022).

Final Design :

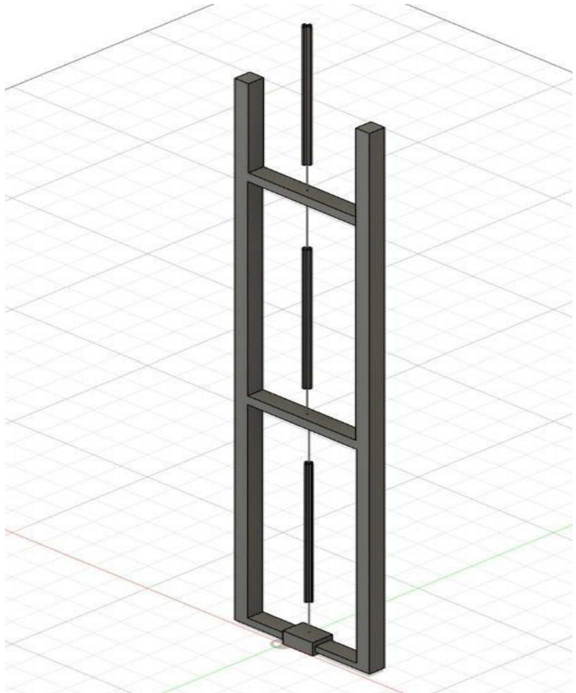


Figure 8: Scalable 3-level BSWT design

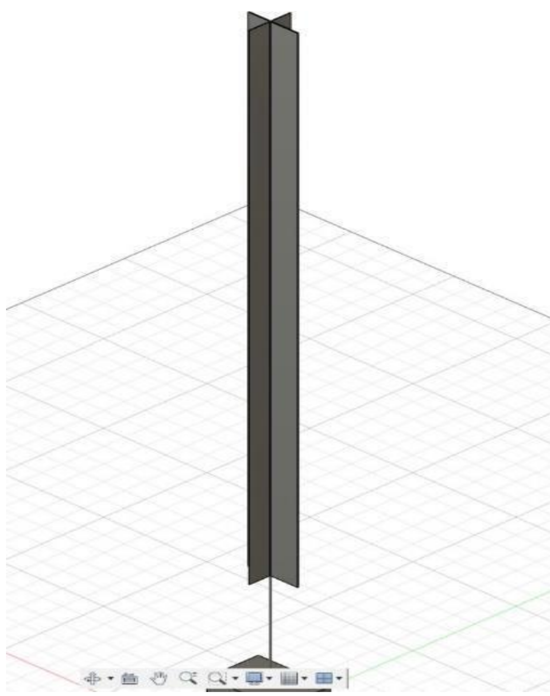


Figure 9: Single Turbine used in the BWS

Conclusion

In conclusion, our new design for a BWT presents a promising advancement in wind energy generation. Our design aims to be lighter, more affordable, and easily transportable. The segmented structure of the turbine allows it to be versatile and reliable in various fields. The design optimizes power transmission, storage, and integration into existing electrical infrastructure, making it suitable for applications such as traffic lights and households. Material selection for the BSWT considers factors such as structural stability, conductivity, corrosion resistance, weight reduction, and aerodynamic performance. TheBSWT design offers several advantages over traditional wind turbines, including reduced noise, avoidance of intermittent shade, protection of migrating bird populations, and improved efficiency in low wind speed conditions. Its integration along highways harnesses the kinetic energy produced by moving vehicles, enabling energy generation even in areas previously considered unsuitable for wind turbines. The BSWT design represents a significant step forward in harnessing wind energy effectively and efficiently, making it a promising solution for the challenges associated with traditional wind turbines and opening new possibilities for renewable energy generation.

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The author(s) declare no competing inter