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Fabrication of Combined Savonius-Darrieus Wind Turbine

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Abstract: A new wind turbine design has been developed by merging the lift-based Darrieus and drag-based Savonius designs. The Darrieus design is highly efficient but has uneven torque distribution, while the Savonius design has a self-starting mechanism but lower efficiency. The new design uses helically twisted Darrieus blades for even torque distribution and half-drum Savonius blades for self-starting. The turbine was tested for various wind speeds and found to perform better than the individual designs. This increased efficiency allows for more power generation with the same amount of wind energy, and the elimination of the need for external motors reduces production and maintenance costs. This innovative design has the potential to revolutionize the wind turbine industry and provide a sustainable source of energy for the future.
Index Terms: Wind, Highway, Rooftop, Solar, Generator, Spur Gear, Battery, Bulb

I. INTRODUCTION

Renewable energy sources are crucial in reducing the reliance on fossil fuels, which have a finite supply and contribute to environmental problems such as pollution and climate change. Unlike fossil fuels, renewable energy sources are not depleted when their energy is harnessed. Therefore, it is essential to develop technologies that can efficiently utilize these sources for human consumption.

Sunlight is an abundant source of renewable energy and is commonly used in solar photovoltaic panels to produce electricity. However, harnessing the sun's energy is limited by factors such as weather conditions, location, and technology efficiency. Similarly, wind energy has also seen significant technological advancements. Wind turbines have been designed to extract the kinetic energy from moving air masses, and the energy generated can be converted into electricity.

The wind is created when air masses move from areas of high pressure to areas of low pressure. These pressure differences are caused by irregular heating of the earth's surface by the sun. The temperature variations create forces that push air masses around to balance the global temperature and temperature differences between land and sea or mountains. As a result, wind energy is a clean and renewable energy source.

However, wind energy is not a constant source of power. Its strength varies depending on the location, time of day, and weather conditions. Typically, about half of the total energy produced is generated during just 15% of the operating time. This variability in wind energy production can cause economic effects, making it difficult to rely solely on wind energy for power generation.

To mitigate this variability, wind energy is best used in conjunction with other energy systems that can provide backup or reserve capacity. Hydroelectric power systems, for example, can store excess wind energy during periods of high production and release it during times of low production. Similarly, desalination plants can use wind energy to produce fresh water, which provides a reserve load for the energy system.

Renewable energy sources are essential for reducing the world's dependence on fossil fuels and mitigating the harmful effects of climate change. The use of wind energy has seen significant technological advancements, but its variability requires a backup or reserve capacity to ensure continuous power generation. By combining renewable energy sources and using them in conjunction with each other, we can create a more sustainable and reliable energy system for the future.

II. LITERATURE SURVEY

Pallotta, D. Pietrogiacomi, G.P. Romano, HYBRID – A combined Savonius-Darrieus wind turbine [1]: The paper presents wind tunnel tests on a hybrid Savonius-Darrieus vertical axis wind turbine. Particle Image Velocimetry was used to obtain velocity fields and fluid flow phenomena. The tests determined the global performance, efficiency, and best working conditions for each turbine and the combined turbine. The results showed good performance over an extended range of operative conditions, with detailed PIV measurements providing insights into increased performance and working ranges, especially at low tip speed ratios. [2]:

This paper presents a vertical axis (Darrieus) wind turbine with 3 blades designed to start solely from the low energy of the wind. The turbine incorporates a separate drag device (Savonius type turbine) mounted on top to make it self-start at low wind speeds. The turbine has a cut-in speed of 3 m/s, a cut-off speed of 20 m/s, and can generate up to 50 Watts of power at a wind velocity of 6 m/s. Testing with a permanent magnetic generator sponsored by the industry resulted in 35 Watts at 9m/s. Darrieus turbines have a higher power potential than horizontal axis turbines, but require an external energy source to start, making this self-starting design a promising solution. [3]: This paper proposes the design and manufacture of a small-scale (scale 1:250) Vertical Axis Wind Turbine (VAWT) prototype using additive manufacturing. The prototype is designed via CAD software. Different tests are performed to determine an adequate printing configuration, with the main focus on how layer height influences roughness and printing time. The methodology presented in this paper shows that it is possible to manufacture a wind turbine prototype that is flexible in design modifications, low in cost, and requires low time to obtain components with enough quality. The small size of the prototype allows it to be tested in a 40 cm x 40 cm wind tunnel. [4]: This paper addresses the limited power capture performance of Vertical Axis Wind Turbines (VAWTs) with fixed pitch blades due to changes in Tip Speed Ratio (TSR). The use of Circulation Control (CC) to increase power capture has been proposed, but a practical method to minimize CC usage has not been explored. Additionally, VAWTs are limited in power capture performance by a peak at a small set of TSR or wide operating TSR at fractions of the peak performance.

The paper proposes a method of dynamically using CC to perform a virtual solidity change, which reduces the required CC jet momentum and allows for control over power capture for a CC-VAWT. Simulation results show promising performance improvements. [5]: This paper investigates the impact of flow shear and unsteadiness on the power output of a Savonius windmill rotor. The study involved conducting measurements of speed, torque, and power at various streamwise locations on the rotor in two steady shear flows and in natural wind conditions. The bucket overlap ratio was varied across four values, and the study also considered important details such as flow velocity profiles and wind shear. The objective of the study was to determine how flow shear and unsteadiness influence the power-generating performance of the Savonius rotor. [6]: Wind is a natural and renewable source of energy that can be used to generate electricity. Wind turbines harness the kinetic energy present in the wind and transform it into mechanical energy, which can be utilized for various purposes or converted into electrical energy through the use of a generator.

A newer design, the Maglev wind turbine, uses magnetic levitation and frictionless bearings to operate, making it more efficient and requiring less maintenance than conventional wind turbines. This design was first unveiled in 2007 and uses vertically oriented blades that are suspended in the air, eliminating the need for ball bearings.

III. EXSISTING SYSTEM

The system handles two distinct models of wind turbines: Darrieus and Savonius. The Savonius model is a type of vertical turbine that operates through drag. It comprises two or three scoops, which create an "S" shape when viewed from above. The scoops are designed with a curved shape that allows them to experience less drag when moving against the wind compared to when moving with the wind.

The drawbacks of the separate wind turbines include, Darrieus turbines are not self-starting and require a small powered motor to initiate the rotation. Once the turbine reaches a sufficient speed, wind flows across the aerofoils, producing torque that enables the rotor to be driven in the direction of the wind. To facilitate the starting process in a Darrieus turbine, two mini Savonius rotors are placed on the shaft. Once the turbine is in motion, these rotors are no longer needed and can be removed, simplifying the device and making it easier to maintain.

The power generation will be comparatively lower than the combined wind turbine. The cost of maintaining two different wind turbines will be higher.

IV. PROPOSED SYSTEM

The proposed system stands out from the existing system by employing the combined solution of the Darrieus and Savonius model. The wind turbine is developed in a single frame where the rotors and blades of two different wind turbines are combined together. The combined model has higher power generation when compared with the separate models. The Savonius wind rotor, which operates through drag, has a better starting capability compared to the lift-based Darrieus wind rotor, which achieves higher efficiency over a wider range of operating conditions. To harness the benefits of both rotor types, they are mounted on the same axis, creating a hybrid or combined system.

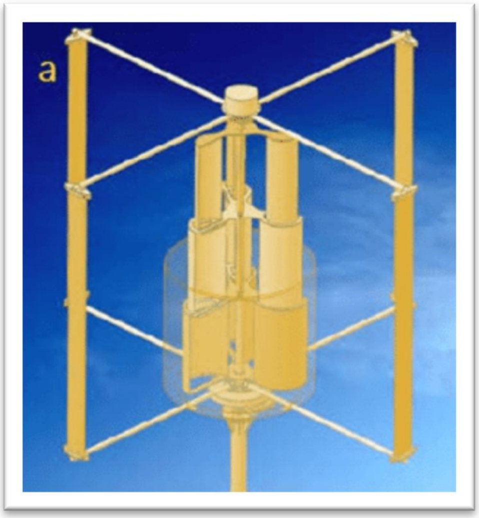

FIG:1 Combined Model

Combined blades are used in wind turbines instead of traditional blades, as they can be mounted at low altitudes and can effectively capture wind from any direction. When wind hits the blades of the turbine, they rotate and turn the windmill's shaft, which then rotates the gears to achieve a sufficient speed ratio in the smaller spur gear. The gear is connected to a generator, which generates power that is stored in a battery. To use the power, it must be inverted, so a suitable inverter circuit is provided and connected to a load, such as a bulb or a fan.

V. IMPLEMENTATION

The proposed system utilizes various components, including a Frame, Blades, Battery, Bearings, Spur gears, Generator, and Solar Panel.

A. Frame

The frame of the wind turbine is constructed using mild steel material, and all other components are mounted onto this structure with a suitable arrangement. During the manufacturing process, the bearing sizes are bored, and open bores are created in a single setting to ensure proper alignment of the bearings during assembly. Additionally, provisions are made to cover the bearings with grease to ensure smooth operation.

B. Blades

Blades are a basic and important component of the wind turbine. When the air strikes the blades it starts to rotate thereby creating energy. Without the blades, wind turbines cannot be operated.

C. Battery

Batteries are used to store the electricity generated and the batteries used are rechargeable batteries.

D. Spur Gears

Spur gears are a cost-effective means of transmitting motion and power between parallel shafts in power transmission systems. They are designed for efficient power transfer. They are simple cylindrical or disk-shaped gears with radially projecting teeth. The teeth have a special form, usually involute or cycloidal, to maintain a constant drive ratio. The edges of the teeth are straight and run parallel to the rotational axis.

E. Generator

To create a basic DC generator, the magnetic field can be generated by either a permanent magnet or an electromagnet. For the purpose of our current explanation, we will consider the use of a permanent magnet.

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F.   Solar Panel

A solar panel, also called a solar cell panel or solar electric panel, is a collection of photovoltaic solar cells that are mounted in a frame. These panels capture sunlight, which is then converted into electric energy by means of photo-voltaic (PV) technology. In other words, solar panels use radiant energy from the sun to generate electric power.

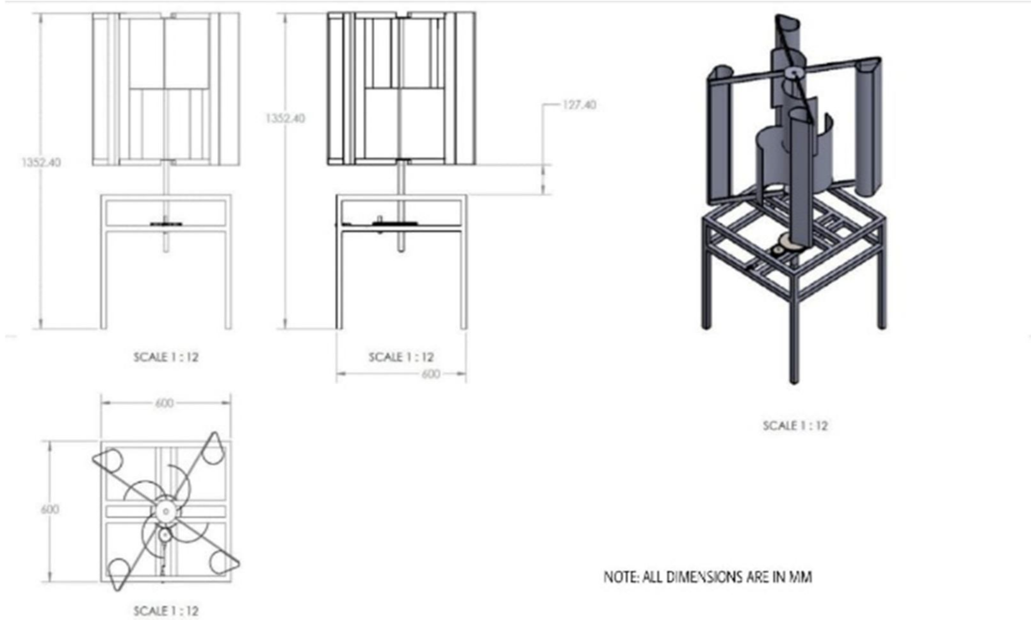

Figure2: Design of Combined model

G.   Bearings

In order to reduce friction and minimize power loss in machines and instruments, ball bearings are extensively employed. Although the idea of ball bearings can be traced back to the time of Leonardo da Vinci, their design and manufacturing process has evolved significantly, and has become exceedingly sophisticated.

Figure3: Original model

VI. CONCLUSION

The environmental impacts resulting from the construction of wind turbines are the most consequential phase for the environmental footprint of wind energy, whether for onshore or offshore wind power plants. In comparison to the overall environmental impacts of these power plants, any environmental effects caused during the transportation and operation phases are negligible and cannot be regarded as significant.

The Combined model of the Savonius-Darrrieus wind turbine helps generate electric energy from the easily available wind energy. By utilizing a variety of techniques, ball bearings can be adapted and improved to suit different applications.

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