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Horizontal Axis Wind Turbine Driven by Hybrid Forces for Power Generation

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Abstract: To enhance the efficiency range of Horizontal Axis Wind Turbines (HAWTs), which is currently recognized to be between 20% and 40%, this review program aims to implement hybrid force techniques. The primary focus is on significantly improving the performance of HAWTs, crucial components in the renewable energy landscape, as they directly convert wind kinetic energy into electrical power. The main objective of the project is to boost the turbines' efficiency by introducing Magnetic Pistons in conjunction with a Permanent Magnet DC Generator. The central aspect of this work involves a thorough exploration of innovative methods to optimize HAWT performance, incorporating hybrid force principles to revolutionize their conventional design and operation. Through a comprehensive examination of cutting-edge technology and inventive approaches, the complex project seeks to maximize the conversion of wind energy into electrical power. Success in this endeavor could potentially surpass the current efficiency limitations of HAWTs, contributing to the development of a more sustainable energy ecosystem. Ultimately, the project aims to address the global demand for cleaner and more efficient energy sources, propel advancements in renewable energy technologies, and expedite the transition towards a more environmentally conscious future. This research aspires to play a pivotal role in guiding humanity towards a sustainable and eco-friendly energy paradigm by harnessing wind power effectively.

***Key Words* - Hybrid Forces, Electromagnetic Pistons, Permanent Magnet DC Generator, Horizontal Axis Wind Turbines.**

1. Introduction

The primary objective of this research is to increase current wind turbine efficiency by creatively using hybrid forces. Through sophisticated wind-kinetic energy harvesting, this project seeks to accelerate power production and transform the sustainable energy environment. Wind turbines are popularly employed for the use of renewable energy sources because of their remarkable capacity to transform wind energy into electrical power. Though these turbines play a crucial function, their present efficiency range of 20% to 40% indicates a strong scope for improvement. Wind energy is the primary source of motion for wind turbines, which in turn drives the generator's rotor. This process is essential to achieve the project's goal. Further driving of the turbine is then accomplished by an advanced system of electromagnetic pistons that are powered by the system's output. The foundation of our investigation into optimizing wind turbine efficiency is this complex dance of energy conversion.

The idea of using electromagnetic pistons in a magnetic configuration that is cyclically organized to mimic the stator's rotating magnetic field is central to this project. The proposed system entails the cyclical mechanical rotation of electromagnets inside the pistons, enabled by pole changes. The rotor shaft of the generator is greatly impacted by this cyclic magnetic order, which drives mechanical revolution and eventually maximizes the efficiency of the turbine. Through this novel approach, we hope to reconcile the concepts of electromagnetic dynamics and mechanical motion and create a system in which the generator's rotor is driven by the intricate rotation of electromagnets inside the pistons. In doing so, we hope to increase the efficiency of wind turbine operations and pave the way for sustainable energy solutions that go beyond traditional approaches. The proposed amalgamation of hybrid forces—utilizing wind energy as the driving force and employing electromagnetic dynamics to provide continuous mechanical motion—signals a fundamental change in wind turbine technology. A revolutionary step forward in the pursuit of improved renewable energy utilization is indicated by the cyclically organized electromagnets inside the pistons, which represent a combination of theoretical invention and real-world application.

2. Horizontal Axis Wind Turbine (HAWT)

Larger horizontal axis wind turbines (HAWT) exhibit higher efficiency than their smaller counterparts. Nevertheless, the significance of small HAWTs rises in rural and remote regions due to their affordability, ease of installation, and simple operation [3].

The wind turbine rotor holds utmost importance in the overall structure. Numerous approaches can be employed for designing the rotor blades, and one such method is the blade element momentum theory (BEMT). Despite its straightforwardness, BEMT yields highly accurate results. In the paper [2] the authors have designed for small horizontal axis wind turbine using Schmitz formulas for optimum rotor theory in conjunction with BEMT.

In the paper [4], the authors have designed and fabricated a three-blade HAWT. The blades are made of Poly Vinyl Chloride (PVC) pipe, with an eight-inch diameter PVC pipe utilized to create the desired wing-shaped curvature. A jig saw is employed for cutting the PVC pipe, and the resulting blade dimensions are illustrated in Figure 1.

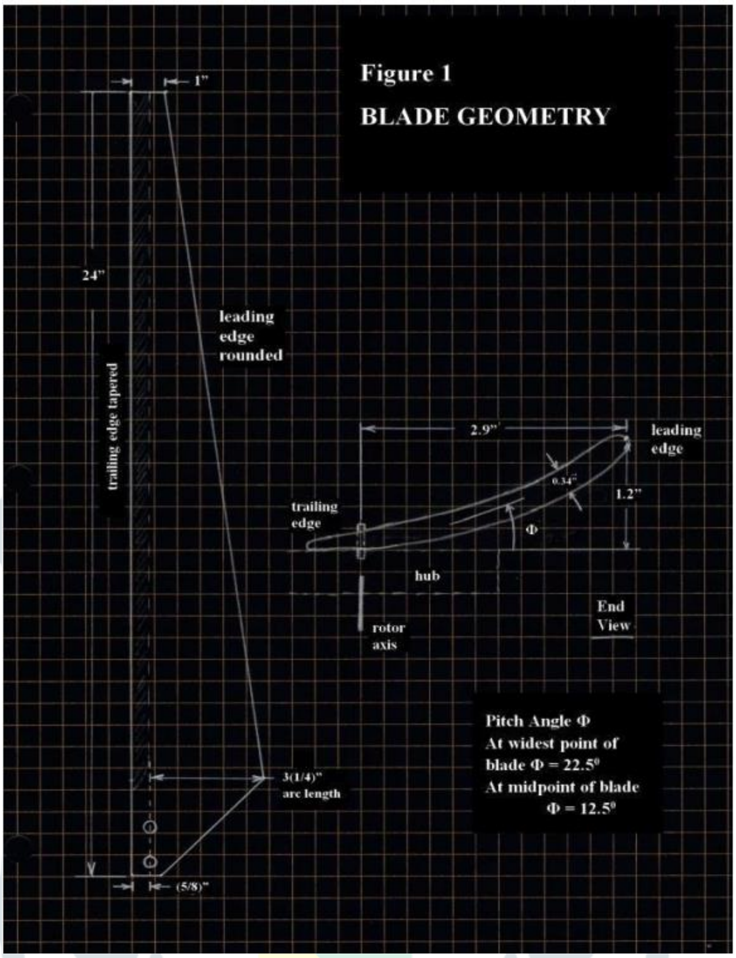

Figure-1 Blade geometry

From the paper [4] the design calculations are taken into considerations which is as shown below:
The power in the wind, Pw = 1/2ñAV3
Where V is the velocity of wind at the blades,
ñ is the density of the air;
A is the area of the blade.
Maximum extractable power from wind, Pmax = 16/27(1/2ñAV3).
Actual power developed by a propeller type wind turbine shows that power coefficient is strongly reliant on tip speed ratio. Tip speed ratio (TSR) is the ratio of the speed of the rotating blade tip to the speed of the free stream wind. As tip speed ratio of our wind turbine is expected to be 2.5 times that of incoming velocity, whereas for a high-speed wind turbine it attains a value of 8. Corresponding to this tip speed ratio power co-efficient, Cp will be 0.12 from the plot between power co-efficient Co and tip speed ratio. Therefore, practical power obtainable from wind is Po = 0.12 x çt x Pmax Where çt is transmission efficiency.

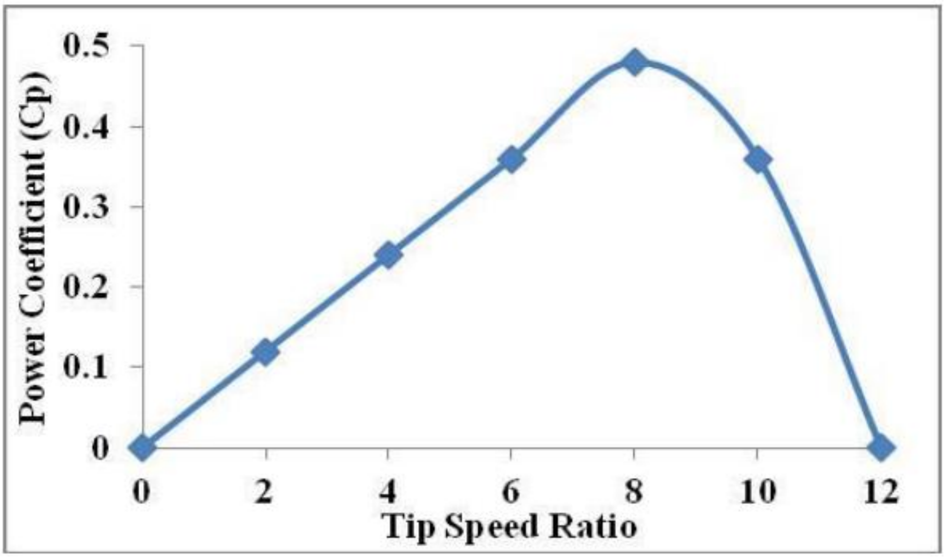

Figure-2 TSR vs Cp for wind turbines

Not all wind energy can be harnessed by the rotor, as it would result in a complete stillness of the air behind the rotor, preventing additional wind from passing through. The theoretical maximum efficiency of a rotor is 59%. Contemporary wind turbines typically operate within the 35% to 45% efficiency range.[4]

For a 100 w DC Generator the three blade HAWT dimensions are as shown below in figure-3 and table-1

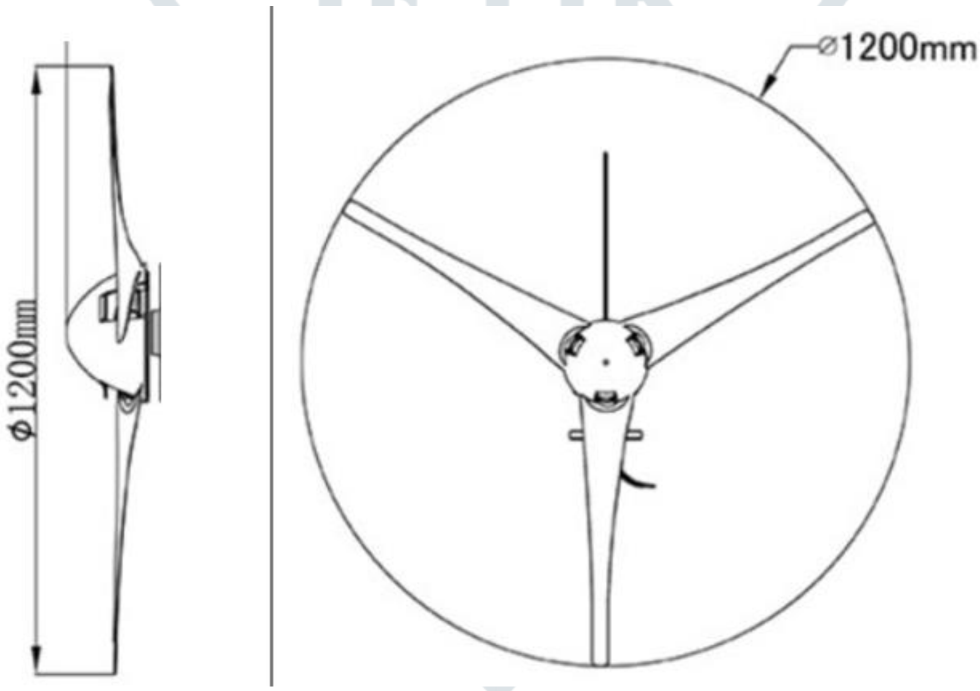

Figure-3 Dimensions of three-blade HAWT

Start Up Wind Speed	2.0 m/s
Rated Wind Speed	10 m/s
Survival Wind Speed	55 m/s
Wheel Diameter	1.2m
Blase Number	3/5
Blades Material	Nylon Fiber

Table – 1 Specifications of the three-blade HAWT

A MATLAB model and simulation of a wind turbine including blades, generator, and other parts is presented. The wind turbine's dynamics are simulated, encompassing the blade modelling that relies on blade element momentum theory. It is investigated how well the turbine performs at different wind speeds. The simulation results show that developed controllers may be used to regulate the rotor output voltage [9]. The design and implementation of an open-loop wind turbine emulator based on a wind turbine simulator modelled in MATLAB/Xilinx System Generation (XSG) environment. The emulator consists of a 300W DC motor powered by a DC/DC buck converter controlled by a pulse-width modulation signal from an FPGA board. The rotational speed of the motor is used to emulate different wind velocities. A hardware test bench was built to validate the simulation results. Linear and sinusoidal wind profiles were modelled and the static and dynamic characteristics of the wind turbine followed the wind profiles in simulations. Experimental results showed the emulator could react similarly to real wind conditions [13].

3. Electromagnetic Pistons

An electromagnetic engine's design and operation based on magnetic repulsion between a permanent magnet and an electromagnet. In this system, the permanent magnet is affixed to the piston head, while the electromagnet resides atop the cylinder.

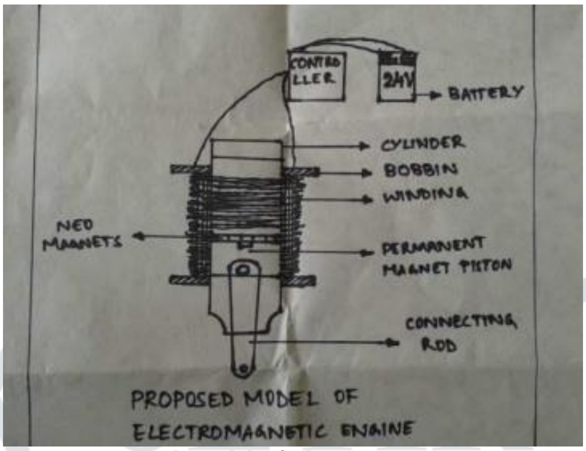

Fig 4. Proposed Model of Electromagnetic Engine

Activation of the electromagnet induces either attraction or repulsion, propelling the piston in an up-and-down motion, thereby rotating the crankshaft and generating power without relying on combustion. The paper delves into the electromagnetic engine's components, such as the permanent magnet, cylinder, and power generation system, offering calculations to ascertain maximum force and torque. Additionally, it conducts a comparative analysis of the engine's performance and advantages against traditional combustion engines [6]. A magnetic piston engine is made and operates. It is made up of several parts, including the electrodes, power source, magnetization unit, cylinder, piston, and bearing. The engine operates based on the attraction and repulsion of electromagnets and permanent magnets. The electromagnets' magnetic force acts onto the piston that is permanently magnetized as current flows through them, resulting in reciprocal motion that eventually transforms into rotary motion. The many parts, their construction, their method of operation, and its benefits—such as not using fossil fuels or causing pollution—are covered in the text. It also discusses future development possibilities and possible uses in vehicles, locomotives, power generation, etc. The study conducted to produce magnetic piston engine prototypes is presented in this academic publication. It highlights the research of several writers who have written in this field and examines them. Along with the main findings and outcomes, each study's aims and methods are discussed. Without utilizing any fuel, several writers were able to effectively develop, produce, and test simple engine models based on magnetic repulsion principles. The paper also describes the future scope and possible uses in cars, trains, and as generators [7]. Describes how a DC machine may be used to simulate a wind turbine's production curve. The system comprises of a variable frequency drive that gets the speed setpoint from a computer and uses it to control an asynchronous machine (ASM). A DC generator is mechanically connected to this ASM. To simulate the production curve of the turbine, the produced voltage of the DC generator is adjusted using a DC/DC converter. The ASM's speed replicates the properties of the wind resource. The mimicked curve is used to create a voltage for every speed point. Ultimately, a steady 48V DC bus is reached by regulating the voltage that the DC machine produces. There are descriptions of the DC generator and DC/DC converter models [8].

4. Conclusion

In this paper, the design considerations of the three-blade HAWT focusing on Blade Element Momentum Theory and the MARLAB model and simulation is being analyzed. The construction of Magnetic Pistons and the design of Electromagnetic Engine is studied. Thus, we aim to Improve the overall efficiency of the vertical axis wind turbine by analyzing the above papers and trying to implement the gap analysis in our project.

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