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Power Generation Using Hybrid Force Driven Vertical Axis Wind Turbine

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ABSTRACT

Vertical Axis Wind Turbines (VAWTs) are a potential renewable energy source, yet it is always difficult to maintain their efficiency, which is typically between 30 and 40 percent. In order to significantly boost VAWT efficiency, we describe in this study a novel method for integrating hybrid forces, or combining stored battery power with wind kinetic energy. Our approach takes full advantage of the intermittent nature of wind energy and ensures continuous energy generation by seamlessly transitioning to battery use during wind lulls. By adding battery storage devices, we improve operational dependability and generate more energy while mitigating the impact of wind unpredictability on power output. Both theoretical analysis and practical validation demonstrate considerable efficiency gains over conventional VAWTs using our hybrid force integration approach. Advanced control algorithms for smooth energy management and an enhanced turbine design that allows battery integration without sacrificing aerodynamic performance are important components. Our study develops VAWT technology, providing a route to more dependable and sustainable power production and so contributing to a cleaner future with important implications for renewable energy generation.

Keywords: Hybrid Forces, Boost VAWT Efficiency, Battery, Sustainable power production.

INTRODUCTION

A turbine can be classified as a vertical wind turbine (VAWT) or a horizontal wind turbine (HAWT) based on the orientation of its blades, which can be parallel or normal to the ground. One of the most promising forms of renewable energy is VAWT. These turbines, which range in size from 1 to 10 m, seem to be lucrative for relative wind speeds of 3 to 20 m/s. [1]. The Darrius type vertical axis wind turbine (VAWT) has experienced significant growth in the past several years due to its noiselessness, ease of maintenance, and comparatively low cost. [2]. A mechanical speed increaser on the power flow to the generator rotor and a direct link between the generator stator and the wind rotor are integrated into a generalized dynamic modelling method of the mechanical system of a single-rotor wind turbine with counter-rotating DC generator. Additionally, they suggested a technique for determining the coefficients of the mechanical properties of the wind rotor based on wind speed [3]. A technique that uses blade-pitch angle servo control and torque error feed-forward control to enhance a wind turbine's dynamic responsiveness. The FAST code forms the basis of the mechanical system model, and a 5-megawatt wind turbine is used to validate the results [4]. Research has been done on the dynamic behavior of wind turbines during periods of high wind. The wind turbine dynamic model and the unstable aerodynamic model are coupled using beam theory by the authors in order to provide the system's dynamic response. The outcomes are simulated using two-megawatt wind turbines [5]. The various aspects of BLDC motor control is been referred and it covers the history and development of BLDC machines, highlighting their increasing popularity due to advantages like low maintenance and high speed. The survey reviews different control schemes, including the six-step commutation, Direct Torque Control (DTC), and Rotor Flux Oriented Control (RFOC), with a focus on sensorless control methods for cost and reliability benefits. It also examines the challenges of detecting back-emf at low speeds and proposes a model-based back-emf observer for high-speed applications. The survey suggests that while non-model based algorithms are suitable for high-speed operation, model-based algorithms offer better performance across a range of conditions, making them more suitable for low-power, high-inertia BLDC machines[6].A brushless DC (BLDC) motor control scheme using rotor position sensingus been analyed using a PIC microcontroller generates PWM signals to drive the power inverter bridge. The study describes the BLDC drive system, emphasizing its advantages such as high efficiency and low maintenance. Implementation and simulation results demonstrate the effectiveness of the developed motor drive, which allows for flexible control algorithms to enhance output characteristics[7].The H-Darrieus wind turbines are extremely efficient as they focus on their aerodynamics. These vertical axis turbines are suitable for environments with rapidly changing wind directions. The study discusses design challenges related to self-starting capability and efficiency. It also reviews past research on parameters like solidity, blade profile, and pitch angle, using both computational fluid dynamics (CFD) and experimental approaches. The paper suggests future research directions, emphasizing a deeper understanding of aerodynamic characteristics and self-starting mechanisms in these turbines[8].Hence, in order to improve the overall efficiency of the Vertical Axis Wind Turbine(VAWT) a novel method is proposed in the paper which aims to run the wind turbine even in the absence of wind by incorporating a booster motor.

The paper aims to fulfill the objectives:(a) The main aim of our project is to improve the present efficiency of the Wind Turbine through Hybrid Forces. (b) This Intricate effort is aimed at producing Electricity from the kinetic energy produced by the wind. (c) It is designed to harvest power from the wind turbine in the absence of wind for a short duration of time.

METHODS

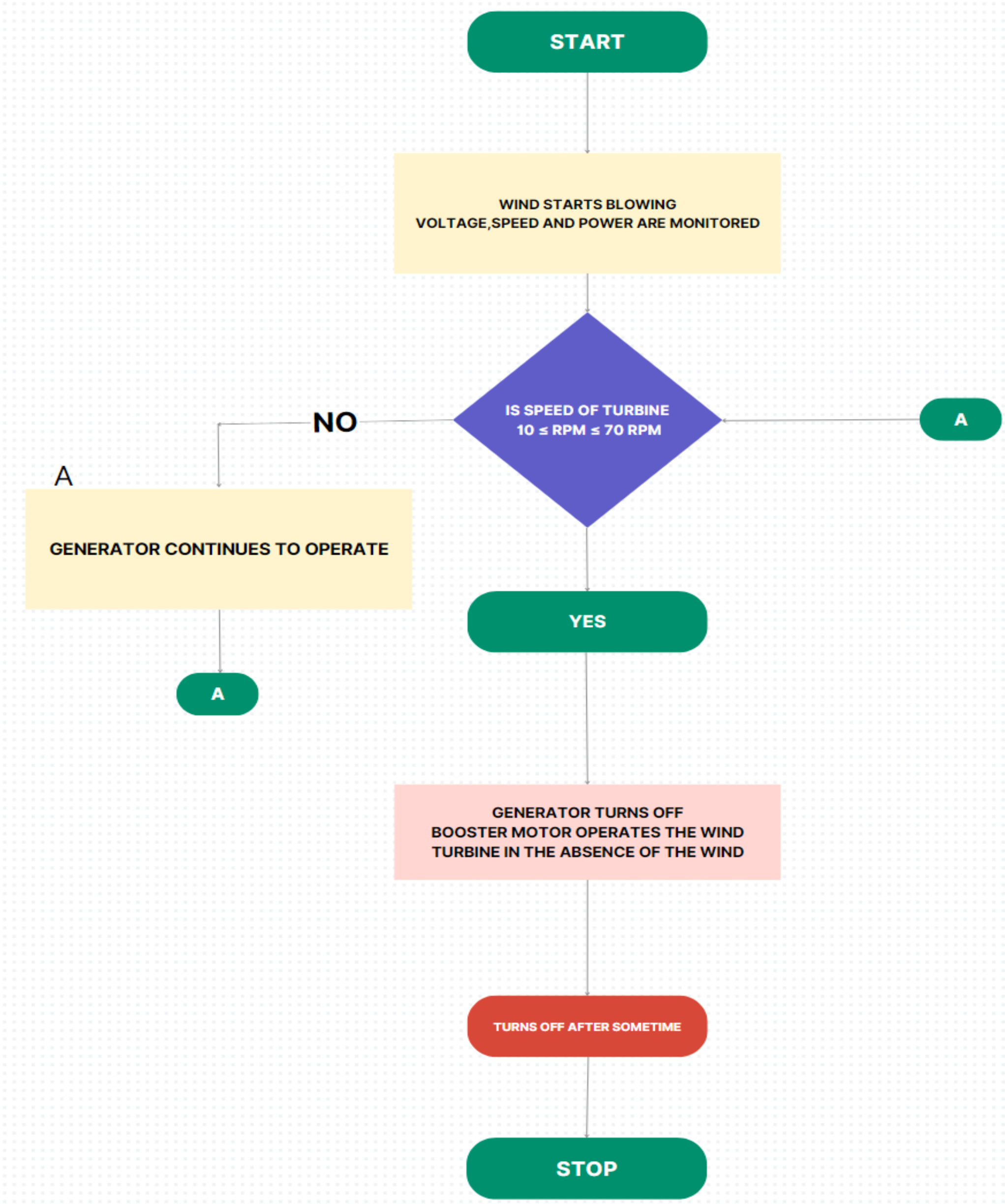

Fig 1. Flowchart of the proposed model

The Vertical axis wind turbine is to be installed on the dividers of Highways in order to harvest more power by utilizing the wind produced by the movements of vehicles. When the wind blows across the Turbine, it starts to rotate and thus has the speed of the wind increases, the blades tend to rotate faster. The voltage, speed and current are been tabulated to obtain the power. The turbine continues to rotate for different speeds of wind in rpm. In the proposed model, the higher bandwidth of the wind is set to 70rpm and the lower range of wind is set to 10 rpm, incase the wind range is greater than 10 rpm and within 70 rpm, the generator is turned off, the booster motor is turned on and thus for a certain duration until and unless the speed of the wind is greater than 70 rpm ,the booster motor keeps running and once the speed is restored to a higher level the generator operates the turbine. This procedure is a continuous process and thus monitoring of speed and power is extremely essential.

HARDWARE IMPLEMENTATION

In the hardware implementation, the heart of the proposed model is the Arduino Nano, which acts as bridge between the motor driver ESC, booster motor and the generator,thus controlling all the major parts of the model.

Fig 2. Arduino Nano

Fig 3. Hardware implementation of the model

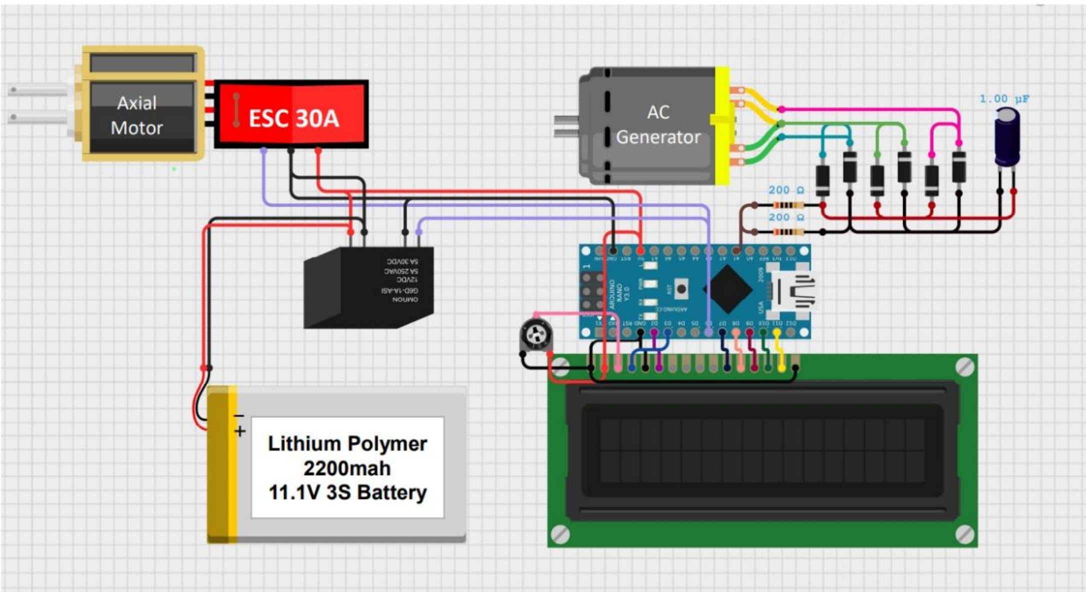

Fig 4. Circuit diagram for hardware implementation

RESULTS AND DISCUSSIONS

The desired result was obtained and the working of Vertical axis wind turbine was undisrupted in the absence of the wind. The output was measured in an indoors laboratory and thus the speed and the power measured is tabulated as below:

SPEED	VOLTAGE	CURRENT	POWER
56 RPM	2.26V	0.103	0.23
110	2.47	0.148	0.365
157	2.53	0.152	0.3754
206	3.12	0.160	0.3952
268	3.39	0.175	0.432
317	3.45	0.234	0.577

Table 1. Tabulated Results

In the above Table 1, the Speed if the wind turbine is measured in rpm, the voltage is measured in volts, the current is measured in amperes and the dc power is measured in watts.

CONCLUSION

In this paper, we have analyzed about the difficulties in harnessing of wind power continuously and thus have proposed a suitable model in order to overcome the problems. We have utilized a booster motor in collaboration with the generator, in order to run the wind turbine in the absence of the wind .Hence ,through our experimental results, we are successfully able to generate power from the wind turbine and the vertical axis wind turbine(VAWT) is been run continuously even in the absence of the wind.

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